

Groundwater Resource Evaluation, Fraser Valley Watershed

A collaboration between the Colorado School of Mines and UCWET

Upper Colorado Watershed Environment Team (UCWET)

Representative Board Member: **Dean D Stoughton**

Colorado School of Mines

Lead: **Claudia Corona**, Research Assistant Professor, Civil & Env. Engineering



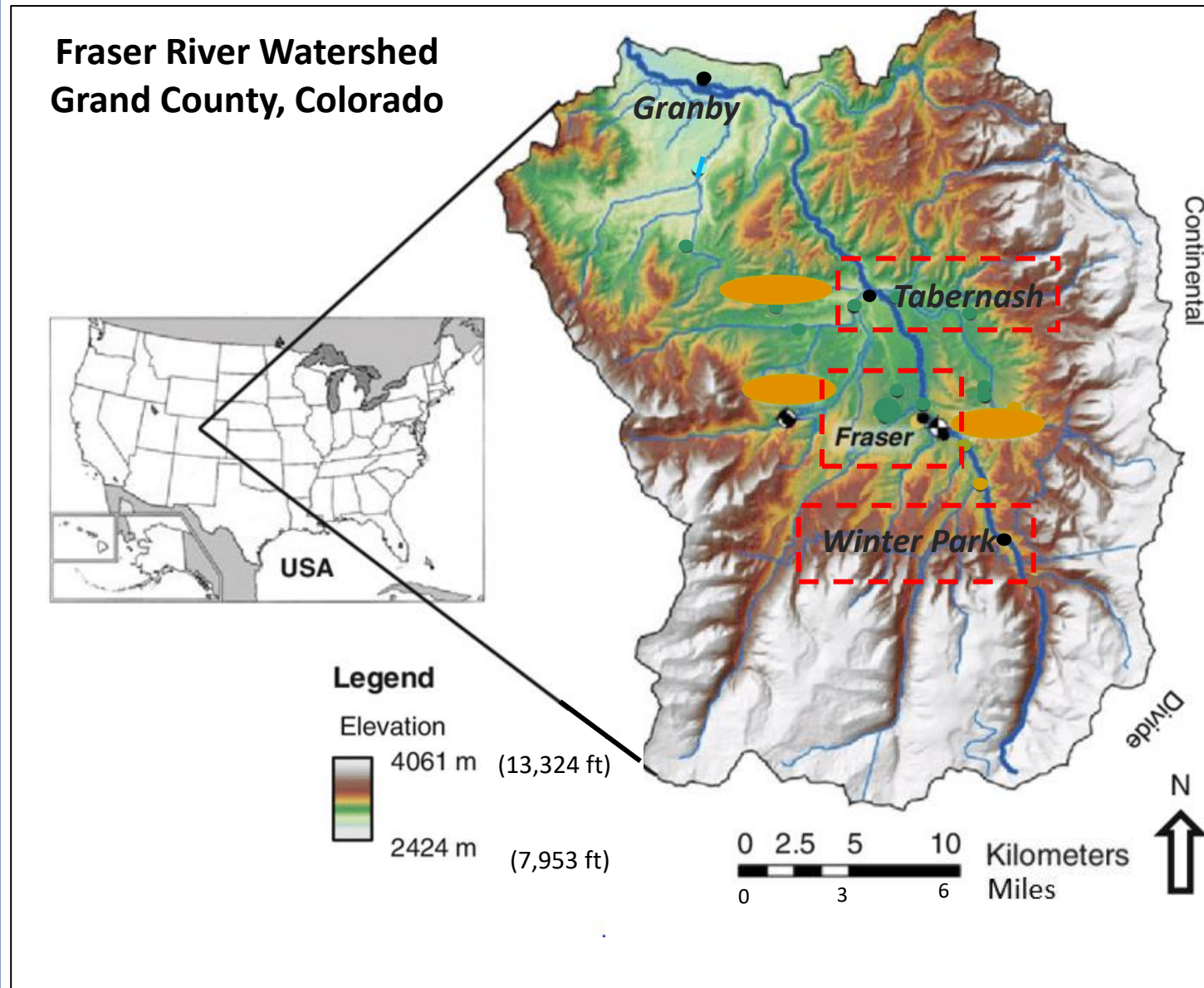
Outline

1. **Project area – Theme**
2. Groundwater aquifer(s) and resource stress factors
3. Project goals and execution plans
4. Personnel and summary



Fraser River Watershed Grand County, CO

- Headwaters of CO River Basin
- Includes communities of Fraser, Winter Park, and Tabernash
- Ecologically unique area within high mountain valley
- Diverse interests involving businesses in tourism, ranching and recreation



Stoughton, D., Rosenberry, D., 2024



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The Planning Question:

How do groundwater–surface water processes in the Fraser River watershed respond to drought, diversions and water use stressors in ways that matter for watershed health and resilience planning?

The project aims to produce information that planners can use to **evaluate options, understand risks, and identify priorities**, without prescribing specific actions or solutions.



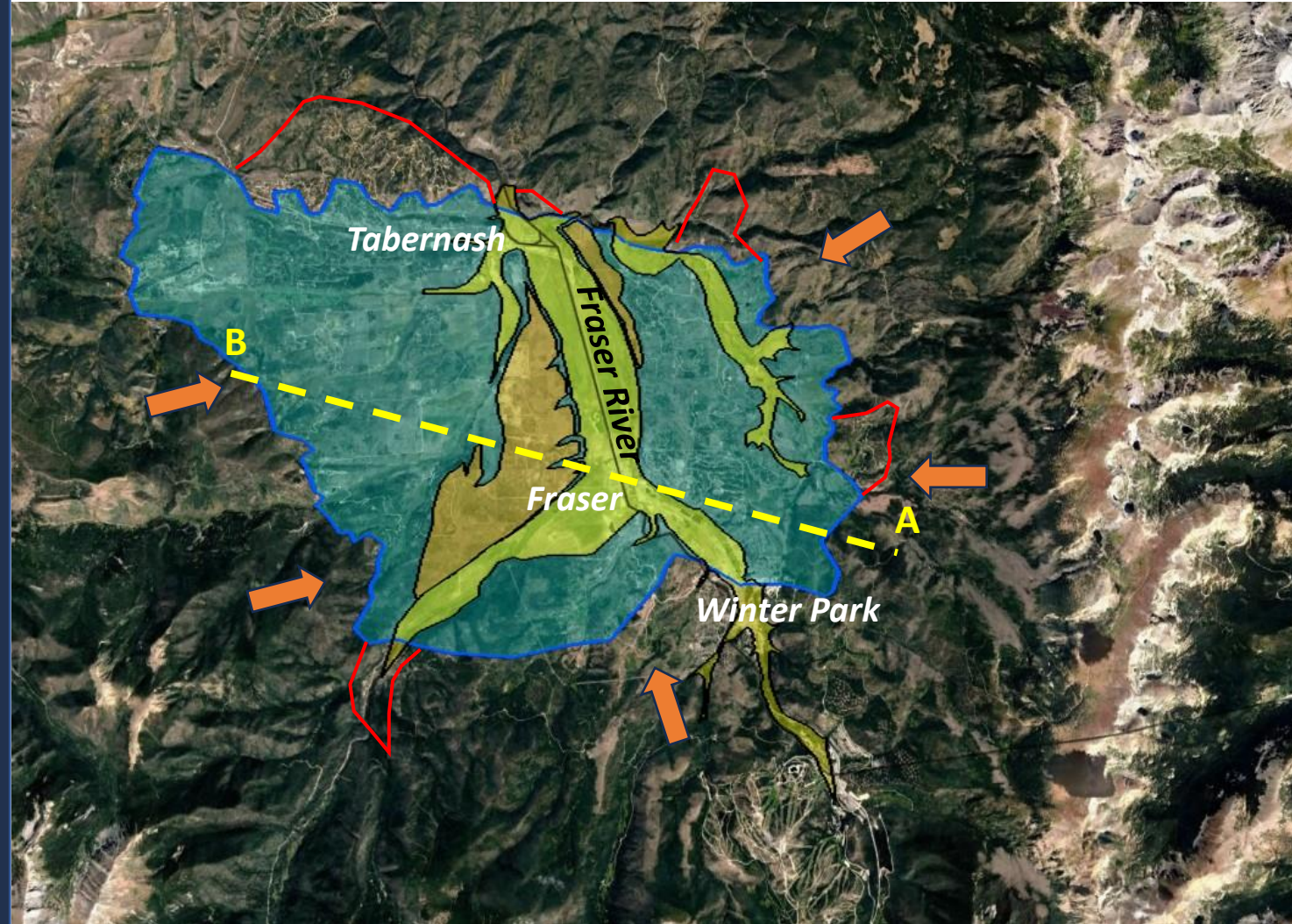
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Fraser Valley Watershed Groundwater Aquifers

- Three main groundwater sources
- **Alluvial Aquifer** –
Relatively thin – Supplies water to municipalities
- **Troublesome Aquifer** –
Much thicker – Water for private wells along margins of valley
- **Fractured Granite** –
private wells in highland areas above valley floor



Fraser Valley - Main Groundwater Sources

Alluvial Aquifers



Troublesome Aquifer



Fractured Granite

Modified From: Shroba, R.R., et al, 2010

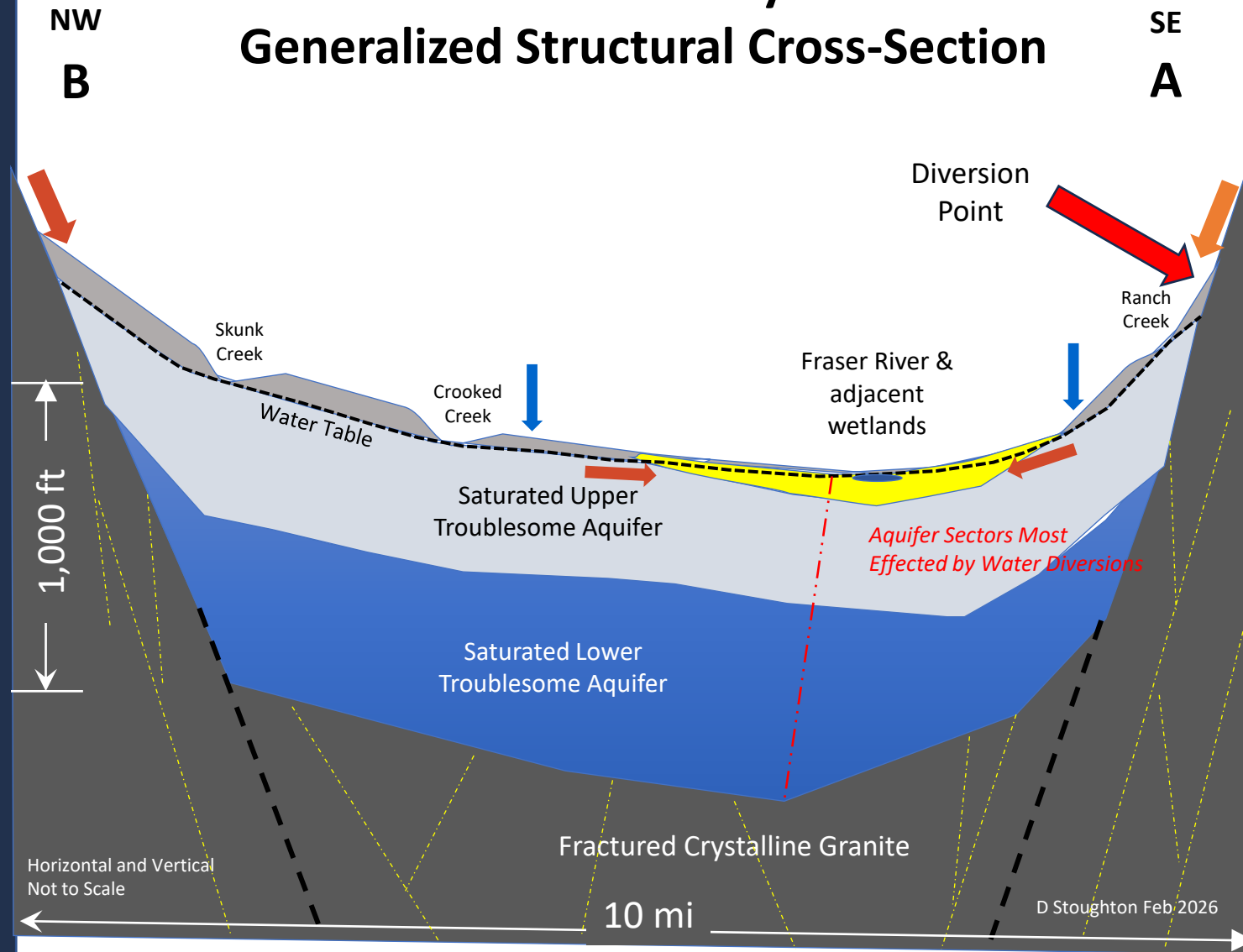


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Fraser Valley Watershed Groundwater Aquifers

- Groundwater is not static but moves in a dynamic manner and interacts with surface water
- Each type of aquifer has uniquely different water storage, yield and hydraulic flow properties – thus productivity varies widely
- Aquifer recharging relies largely on snowmelt from small streams & seepage along valley margins
- Groundwater moves downward and discharges into lower streams and Fraser River

Fraser Valley Generalized Structural Cross-Section



Fraser Valley - Main Groundwater Sources

Alluvial Aquifers



Troublesome Aquifer



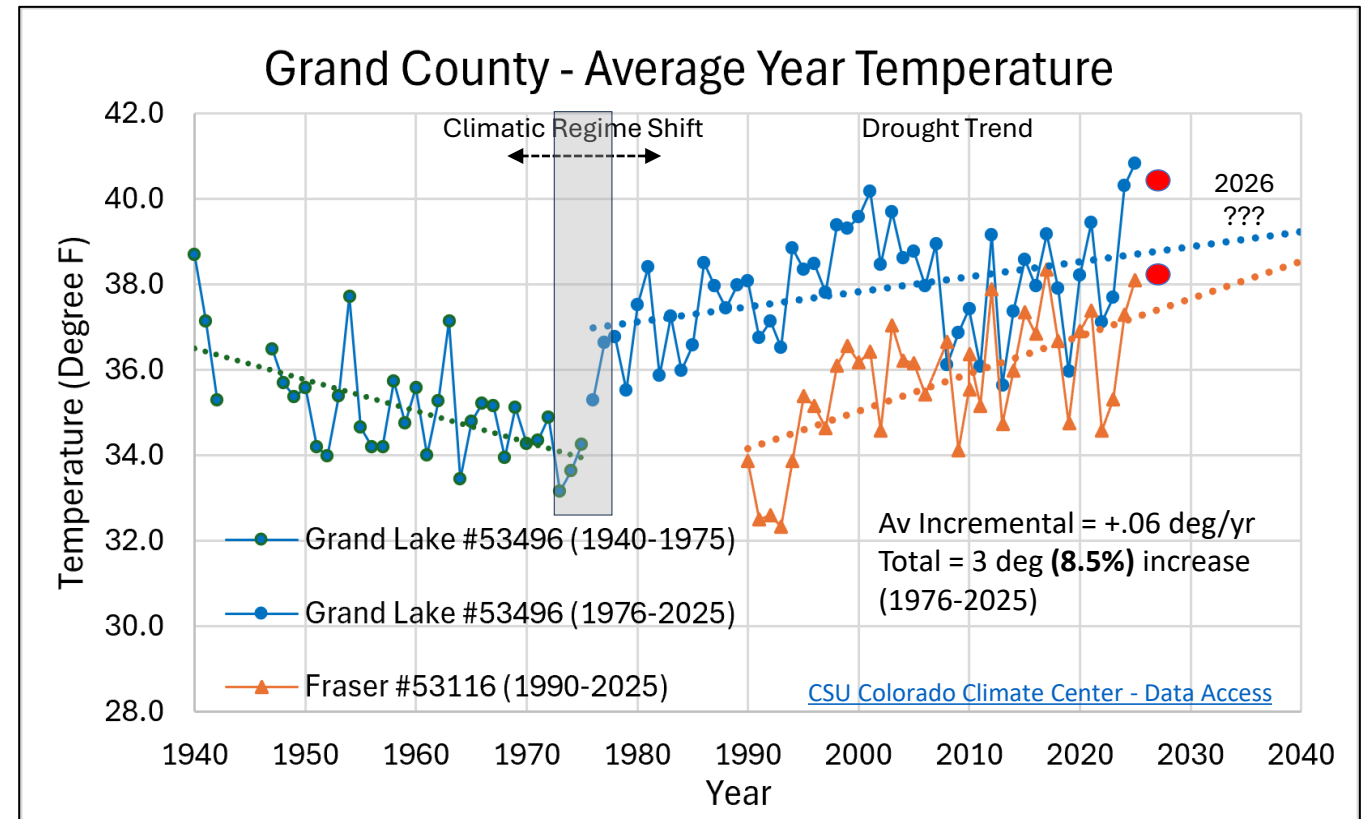
Fractured Granite



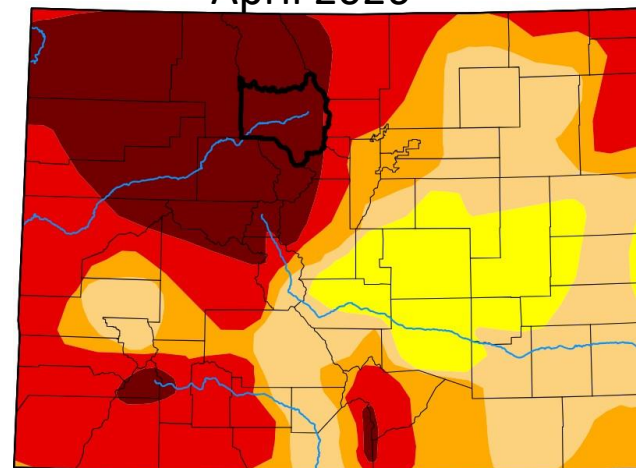
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Fraser River Watershed Temperature Trend

- Based on two weather stations
Grand Lake station (1940-2025)
Fraser station (1990-2025)
- A major world “Climate Regime Shift” has occurred in the mid 1970’s and reflects the well documented **1976–77 Pacific Decadal Oscillation (PDO) Shift**.
- Since PDO shift, local 50-year trend increased avg yearly temps by 3 degrees or 8.5%



April 2026



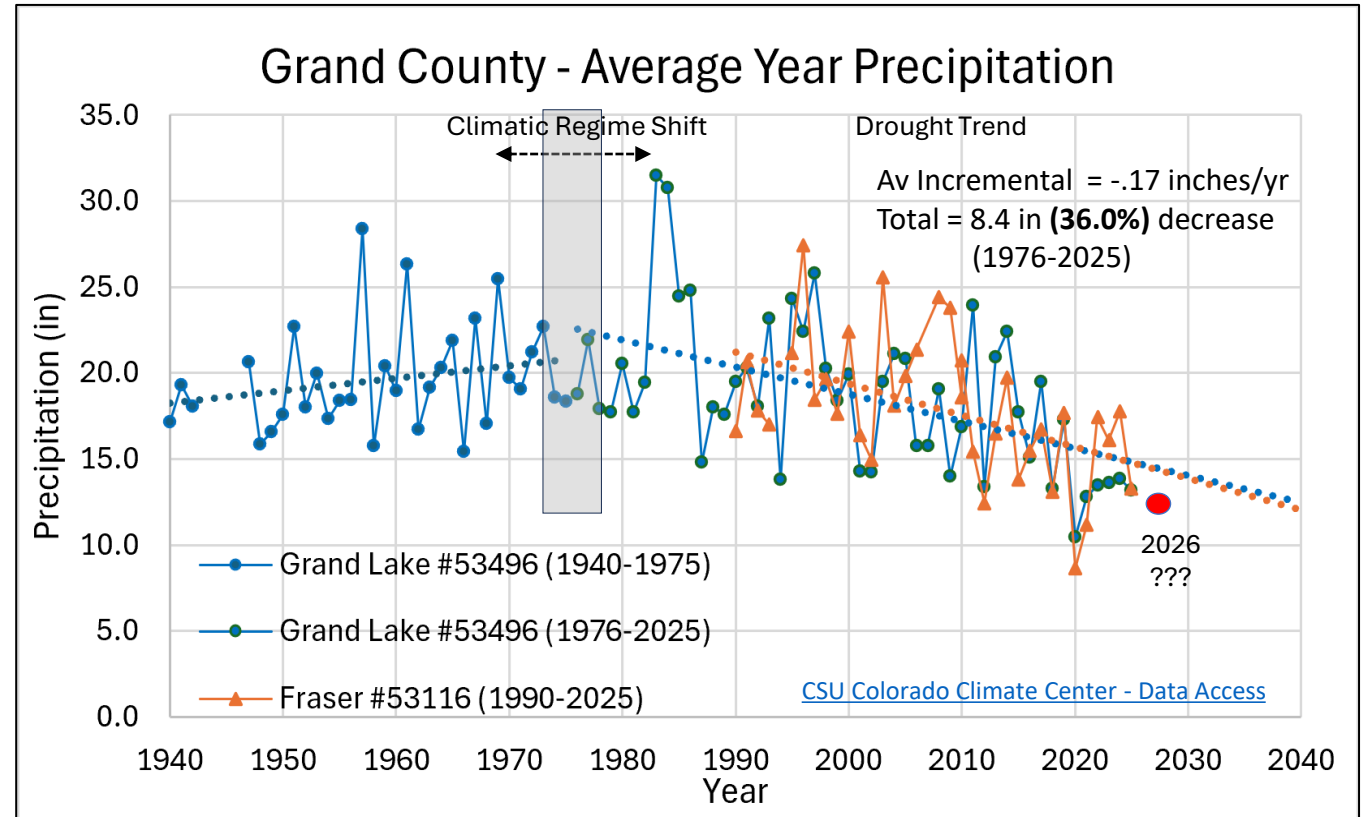
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)

[Grand County, CO | U.S. Drought Monitor](#)

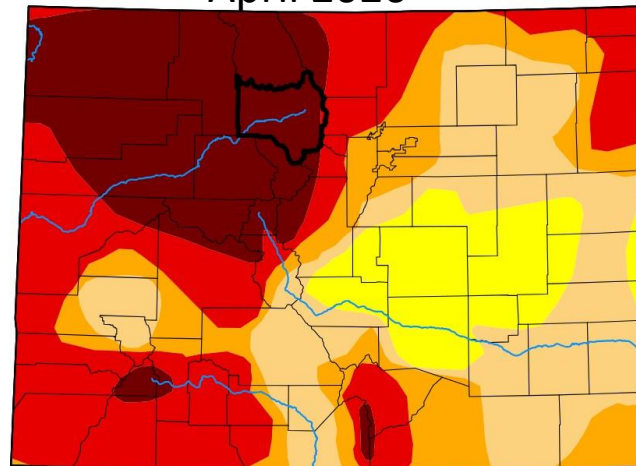


Fraser River Watershed Precipitation Trend

- Annual avg precipitation continues to decline since PDO
- The watershed is experiencing a 50-year drought trend with an average decrease of 36% precipitation since 1976
- If drought trend continues the decrease in precipitation will be 47% by 2040 (2026 is heading toward the worst precipitation year on record)



April 2026



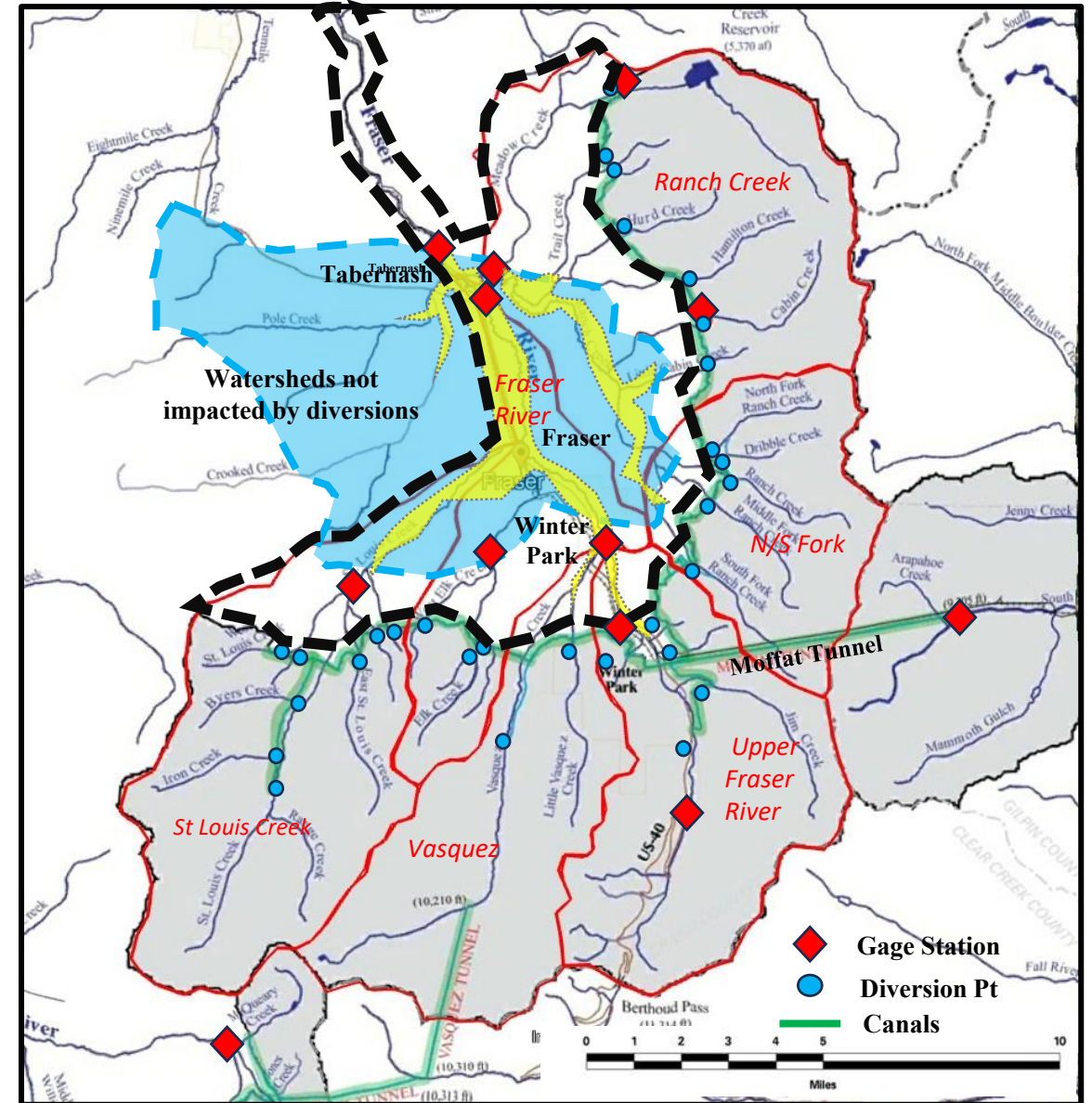
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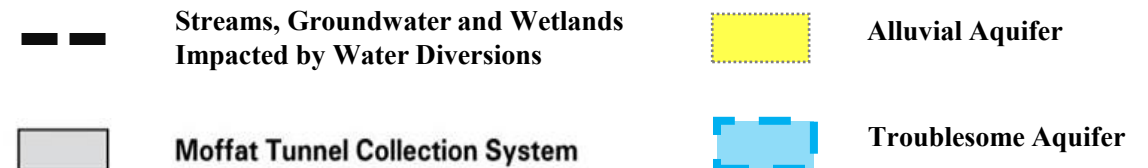


Fraser Valley Watershed Water Diversions

- Water diversions account for reductions of 50 percent of natural flow of main surface streams / up to 100% of small tributaries (Moffat Collection EIS Sec 3.1.5.1)
- Current drought combined with diversions will affect groundwater recharge and available water resources – to what extent?
- Wetlands, riparian and aquatic life have been and will continue to be impacted – private and municipal wells?
- Tourism, recreation, agriculture?

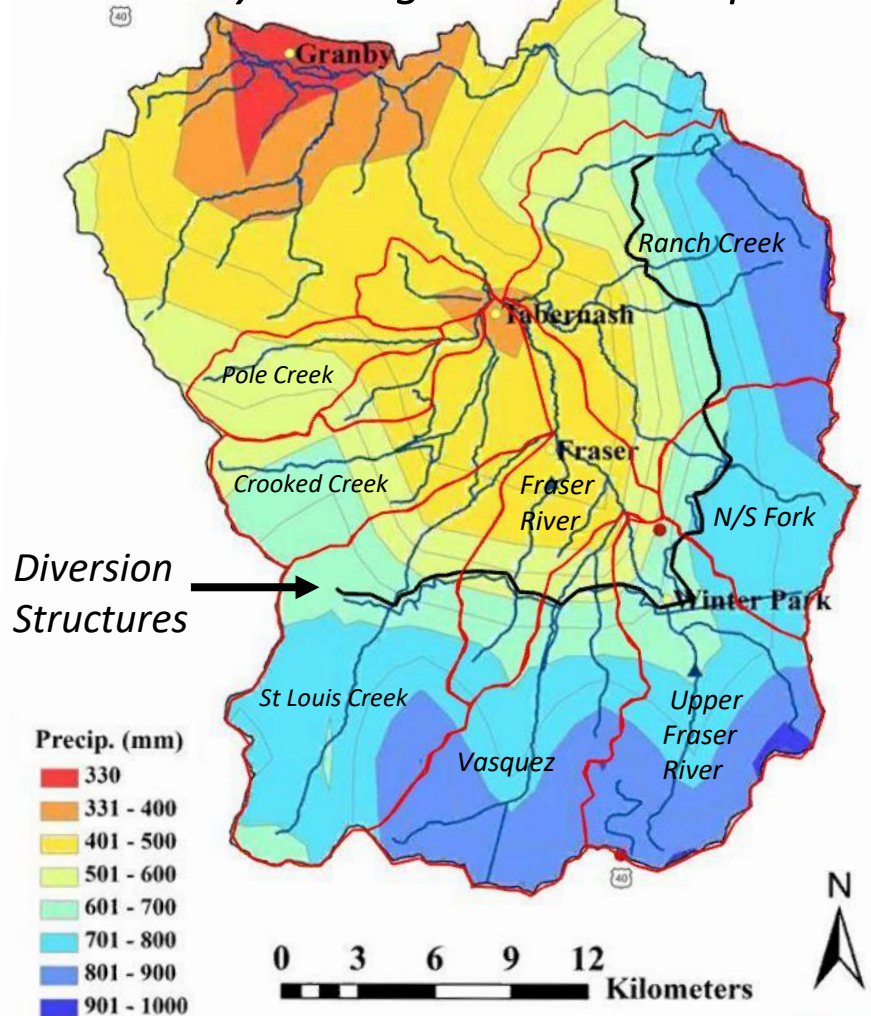


Modified From: US Army Corp of Engineers, 2014, Moffat collection system project:

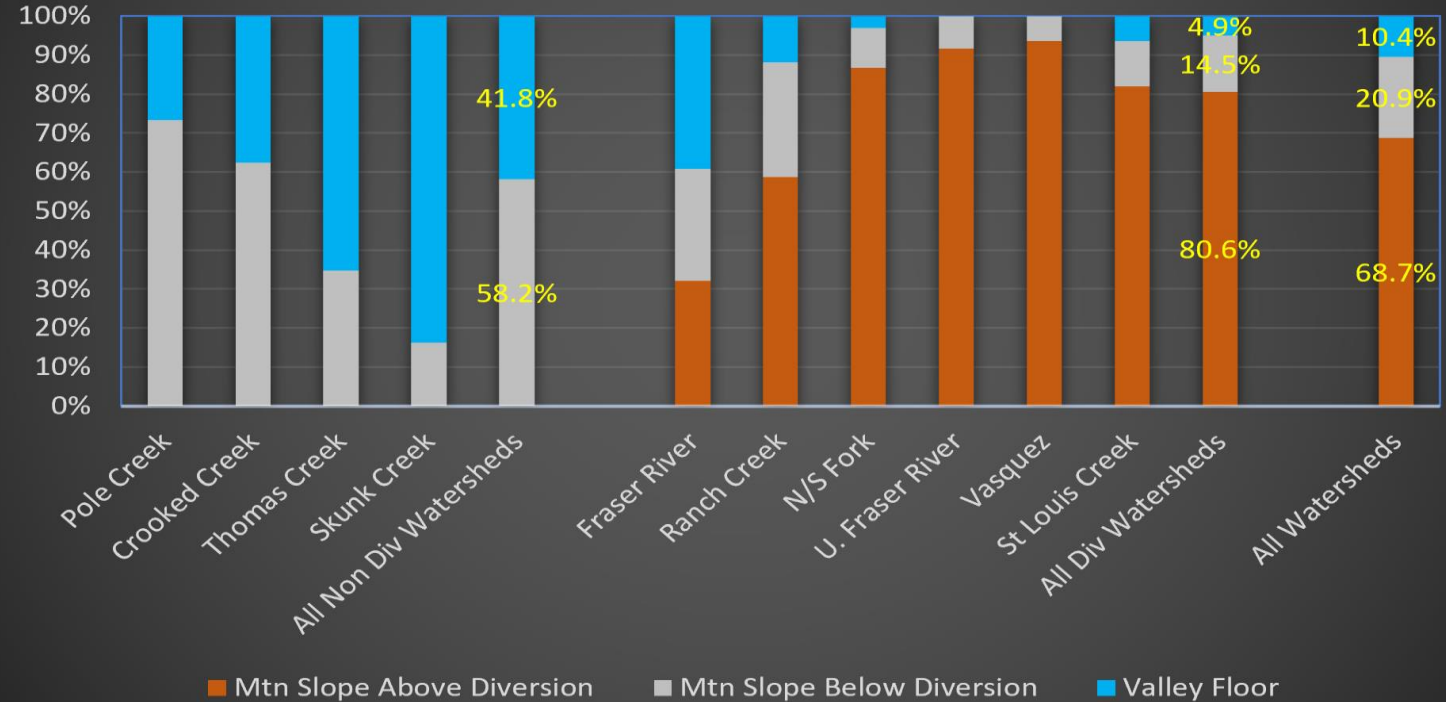


Fraser Valley Watershed Water Diversions

Fraser Valley Average Annual Precipitation



Percent of Water Availability From Precipitation
Fraser Valley Watersheds Sectors



- Water volumes necessary for aquifer recharge sourced from adjacent mountains have been significantly reduced by an average of **80%** within eastern and southern portions of the Fraser Valley
- Groundwater recharging reduction effects may not be immediately noticed since groundwater flows very slowly
- Rigorous groundwater flow modeling and monitoring are necessary to adequately estimate the impact on the subsurface aquifers



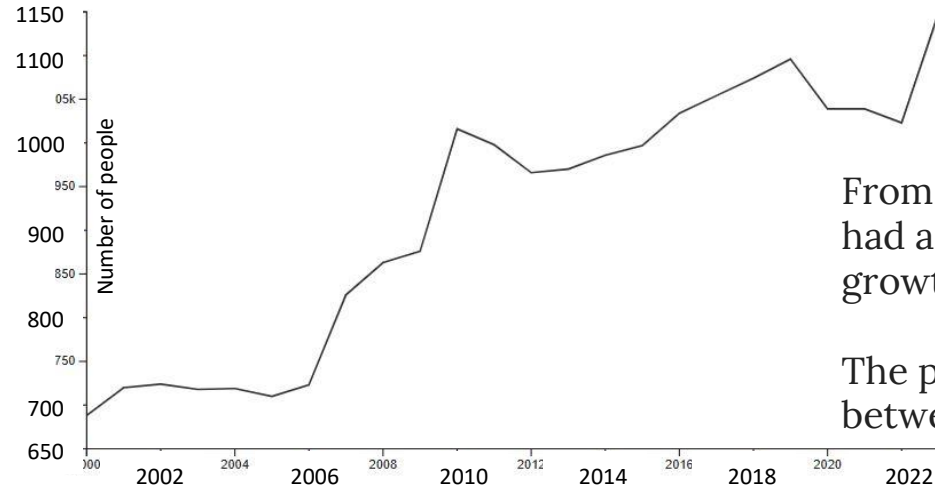
Fraser Valley Population Growth

- Winter Park, Fraser and Tabernash have experienced significant growth since year 2000
- All rely on groundwater resources from the Alluvial Aquifer through municipality suppliers
- The number of rural homes with private wells have increased by **60%** since year 2000 tapping the Troublesome Aquifer and fractured granite sources



Winter Park's population from 2000 to 2023.

The estimated population at the end of 2023 was 1,149.



Source: U.S. Census Bureau (Population Estimates Program).

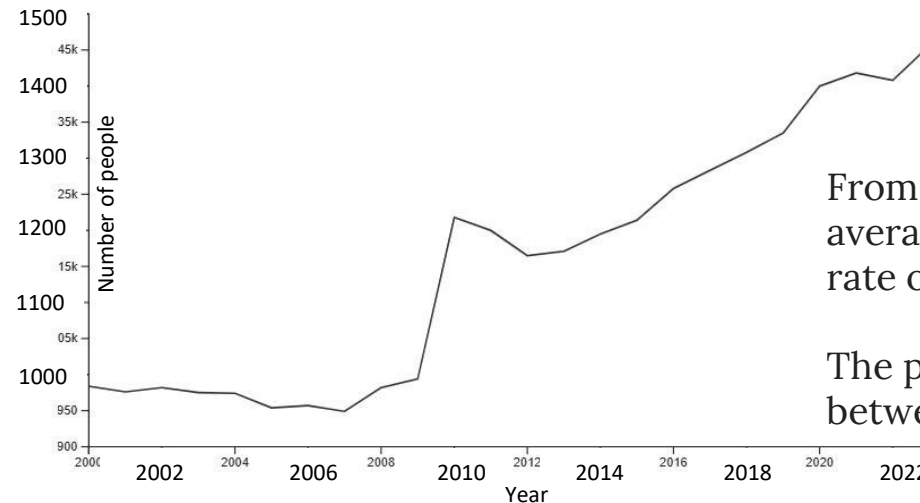
From 2000 to 2023, Winter Park had an average annual population growth rate of **2.91% per year**.

The population grew **67.01%** between 2000 and 2023.

[Winter Park, CO Population by Year - 2024 Update | Neilsberg](#)

Fraser's population from 2000 to 2023.

The estimated population at the end of 2023 was 1,456.



Source: U.S. Census Bureau (Population Estimates Program).

From 2000 to 2023, Fraser had an average annual population growth rate of **2.09% per year**.

The population grew **47.97%** between 2000 and 2023

[Fraser, CO Population by Year - 2024 Update | Neilsberg](#)

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Proposed Project Goals - Data Base Collection and Integration

- **Previous studies, surveys, investigations and well data**
- **Comprehensive precipitation records** within watershed inclusive SNOTEL historical statistical measurements – establish trends
- **Surface stream flows** (Lotic stream volume accounting study)
- **Water diversions** (Moffat Tunnel, diversion points along collection system)
- **Consumption estimates** (municipal, private wells, irrigation, etc.)

Proposed Project Goals - Investigative Assessments

- **Build hydrogeologic model over entire watershed** - updated aquifer hydraulic parameters
- **Conduct numeric modeling of groundwater base stream flow** - precipitation and water diversion projections – Assess groundwater sustainability and deliverability to consumers
- **Detailed time variant water table mapping** - entire Fraser Valley and identify anomalous areas
- **Test several stress scenarios** - impact on the holistic hydrology of Fraser Valley
- **Water Quality** – Initial assessment of the interaction of groundwater flow and surface water effecting water quality with natural occurring geo-chemicals and temperature variations

Project Timeline & Readiness to Proceed

24-month Planning Grant

- Involves supporting Mines MS graduate student(s)
- Direct oversight by Mines professor / hydrologist
- Advisory and mentoring by UCWET members and Mines staff
- Tasks sequenced and overlapping
- No permitting, land access, or regulatory dependencies
- Uses existing, publicly available data sources



Planning Outcomes & Project Risk

Primary Deliverables

- Watershed-scale planning report
- Scenario-based hydrologic insights
- Public, transferable datasets
- Briefings for grant(s) personnel and basin stakeholders

Planning-focused, non-prescriptive outputs

Risks managed by:

- Using existing datasets
- Conservative scope
- Advisory input with extensive local expertise

Identifies data gaps to support **future restoration or protection efforts.**



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CSM Lead Investigator

Claudia R. Corona (Ph.D., M.Sc., BA) – Full time
Hydrologist - Research Assistant Professor, Colorado School of Mines

[Claudia R. Corona, PhD | LinkedIn](#)

UCWET Technical Advisory Team (Grand County Residents)

Dean Stoughton (M.Sc., BS) – Retired
Geophysicist / Engineer – O&G Industry (Domestic & International)
[Dean Stoughton | LinkedIn](#)

Pierre Glynn (Ph.D., M.Sc., BA) - Retired
Hydrologist – USGS and Affiliated Scholar Arizona St University
[Pierre Glynn | LinkedIn](#)

David Phillip Guertin (Phil) (Ph.D., M.Sc., BS) – Retired
Hydrologist - USGS and Prof Univ of Arizona
[Phil Guertin | LinkedIn](#)

Link: [About UCWET](#)



Grant Alignment - Summary

- Watershed-scale planning study
- Supports protection of land–water connections
- Identifies vulnerabilities and sustainability of the groundwater resource accessed by municipal and private wells
- Integrates past and current/pending studies
- Financially and technically feasible
- Solicits local stakeholder support and collaboration
- Produces public, transferable planning products for informed decisions



Additional Slides

Previous studies

References

Water well data base

Other technical



Past Groundwater Flow Studies

(See reference slide(s) for publication details)

- ❑ **1999 - Apodaca, L.E. and J.B. Bails, Fraser River Watershed, Colorado – Assessment of Available Water-Quantity and Water-Quality Data Through Water Year 1997 – USGS publication**

Summary: Emphasis of study was water quality within the Alluvial Aquifer. cursory estimates of groundwater water reserve volumes with parameters taken from previous publications, rudimentary water table mapping with acknowledged high uncertainties with relatively few (129) available wells.

- ❑ **2004 - Bauch, N.J. and Bails, J.B., 2004, Water-quality characteristics and ground water quantity of the Fraser River watershed, Grand County Colorado, 1998-2001 – USGS publication**

Summary: Expanded effort with emphasis on water quality within the Alluvial Aquifer and estimates for groundwater quantity within the Alluvial and Troublesome Aquifers. Alluvial mapping based on 291 wells and surface geologic map (now outdated, see update - Shroba, et. al, 2010). Calculated estimated water volumes for both aquifers with coarse assumptions along with integrating one water level monitoring site. No groundwater flow evaluations.



Past Groundwater Flow Studies

(See reference slide(s) for publication details)

- ❑ **2012 - Aigler, B. and Ge, S., Evaluation of groundwater withdrawal from mountain watershed, Colorado (Fraser Valley) – Subset publication of MS Thesis**

Summary: Derived hydraulic properties from various well data for the Alluvial and Troublesome Aquifers. Constructed a numeric model over the Fraser River watershed and generated a broad scale, but coarse, groundwater flow simulation and a steady state water budget. Input precipitation parameters based on pre- 2008 data. Performed detailed groundwater flow simulations around Winter Park Ranch municipal wells from water extracted from the Alluvial Aquifer.

- ❑ **2014 - US Army Corp of Engineers, Moffat collection system project: Final environmental impact statement, (Sections 3.4, 4.64, 5.5)**

Summary: Report provided general overview water diversion system and affected areas within the Fraser watershed and referenced water table mapping from previous USGS study. Four supplemental detailed groundwater level monitoring surveys were conducted along potentially affected stream segments of the Fraser River and St Louis Creek in October 2010. These were subsequently evaluated for ground water variance near stream and adjacent wetlands. Report contains discussion on the inferred minimal effects on groundwater – all based on pre 2010 data and non-drought conditions.



Past Groundwater Flow Studies

(See reference slide(s) for publication details)

- ❑ **2024 - Stoughton, D., Rosenberry, D., Hydrogeology of the Troublesome Aquifer in the Greater Pole Creek Basin, Grand County, Colorado. – Self published book**

Summary: Synthesized all previous studies for Alluvial and Troublesome Aquifers including hydraulic properties. Groundwater evaluations concentrated on the Troublesome within the northwest portion of the Fraser Valley watershed (not affected by diversions) and included detailed statistical analyses of the Troublesome aquifer sand vs silt properties. Completed comprehensive water table mapping with over 260 wells and time variant hydraulic gradients. Additional investigations included water quantity, quality, consumption estimates, surface stream flows and drilling issues within the Troublesome.

- ❑ **2026? – Newman, C, et. al. , Dye Tracing Study - Fraser River – USGS pending publication**

Summary: Field operations October 2024 - Pending report completion est late 2026 - The study is part of the USGS's ongoing research to identify potential groundwater inflow locations and estimate groundwater contributions to the Fraser River. These estimates can be used to understand the sustainability of streamflow and groundwater flow under changing climatic conditions. Eight test locations on Fraser River between the towns of Winter Park and Fraser.



References

Aigler, B. and Ge, S., 2012, Evaluation of groundwater withdrawal from mountain watershed, Colorado (Fraser Valley): Environmental Earth Sciences, v. 69, p. 1901-1913, <https://doi.org/10.1007/s12665-012-2022-3>.

Apodaca, L.E. and Bails, J.B., 1999, Fraser River watershed, Colorado — Assessment of available water-quantity and water-quality data through water year 1997, U.S. Geological Survey Water-Resources Investigations Report 98-4255, <https://doi.org/10.3133/wri984255>

Bauch, N.J. and Bails, J.B., 2004, Water-quality characteristics and ground water quantity of the Fraser River watershed, Grand County Colorado, 1998-2001, U.S. Geological Survey Water-Resources Investigations Report 03-4275, 57 p., ., <https://doi.org/10.3133/wri034275>

Colorado Division of Water Resources: [Grand County, Colorado Well Data Download](#)

Colorado State University, 2022, Colorado Climate Center: Accessed November 2022 at https://climate.colostate.edu/data_access_new.html.

Newman, C, et. al. , 2026, Dye Tracing Study - Fraser River – USGS pending publication
[Media Alert: USGS Dye Tracing Study in Fraser River | U.S. Geological Survey](#)

Newman, C, et. al. , 2026, Quantifying groundwater recharge and discharge dynamics in the Upper Colorado River Basin – USGS pending publication
[Quantifying groundwater recharge and discharge dynamics in the Upper Colorado River Basin | U.S. Geological Survey](#)



References

Shroba, R.R., Bryant, B., Kellogg, K.S., Theobald, P.K., and Brandt, T.R., 2010, Geologic map of the Fraser 7.5-minute quadrangle, Grand County, Colorado, U.S. Geological Survey, USGS Scientific Investigation Map SIM-3130, https://ngmdb.usgs.gov/Prodesc/proddesc_94346.htm

Shroba, R.R., Bryant, B., Kellogg, K.S., Theobald, P.K., and Brandt, T.R., 2010, Geologic map of the Fraser 7.5-minute quadrangle, Grand County, Colorado, U.S. Geological Survey, USGS Scientific Investigation Pamphlet SIM-3130, <https://pubs.usgs.gov/sim/3130/>.

Stoughton, D., Rosenberry, D., 2024, Hydrogeology of the Troublesome Aquifer in the Greater Pole Creek Basin, Grand County, Colorado, Amazon website: [Hydrogeology of the Troublesome Aquifer in the Greater Pole Creek Basin, Grand County, Colorado](#)

US Army Corp of Engineers, 2014, Moffat collection system project: Final environmental impact statement, US Department of the Army Corp of Engineers Digital Library, <https://usace.contentdm.oclc.org/digital/collection/p16021coll7/id/795>.

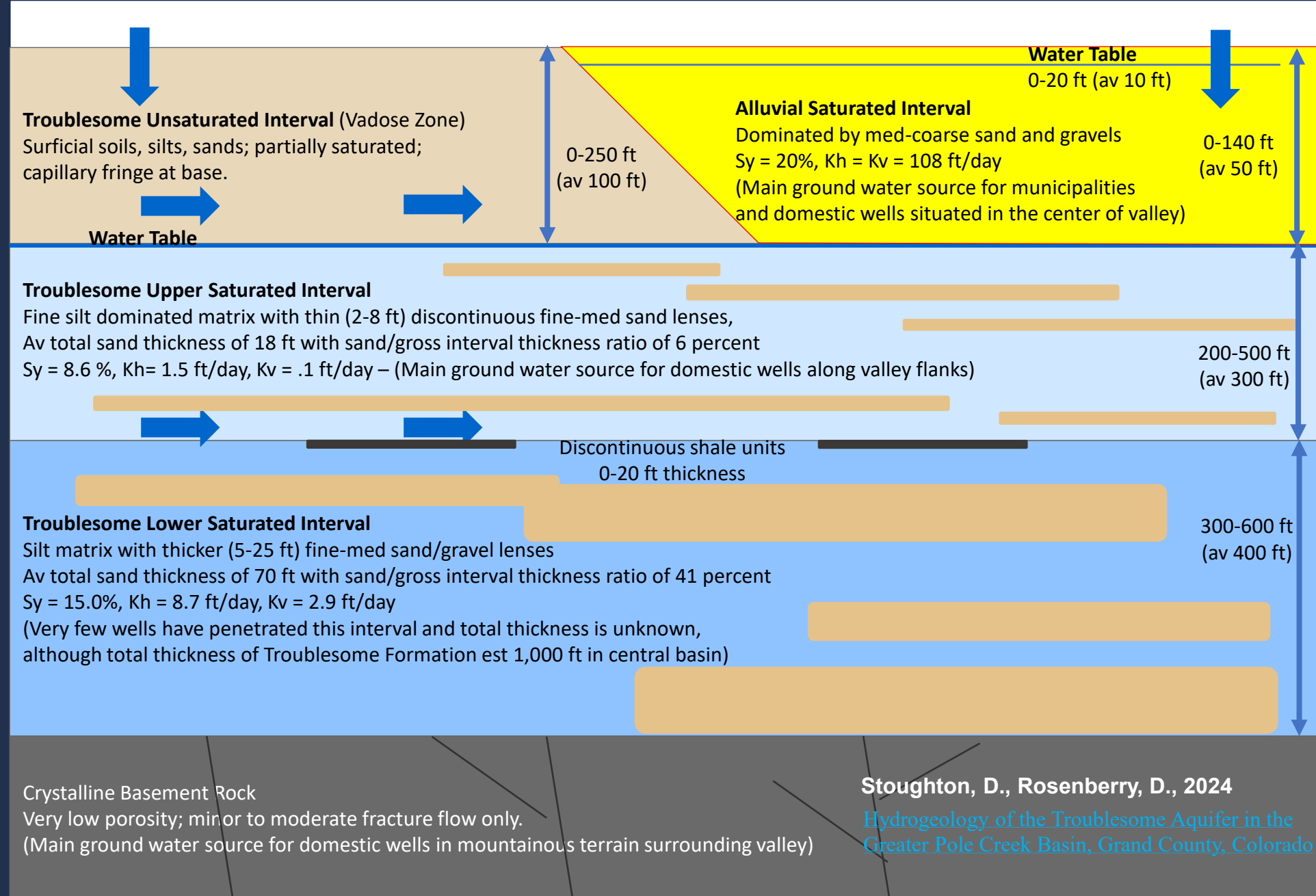
USGS National Water Dashboard, [USGS | National Water Dashboard](#)



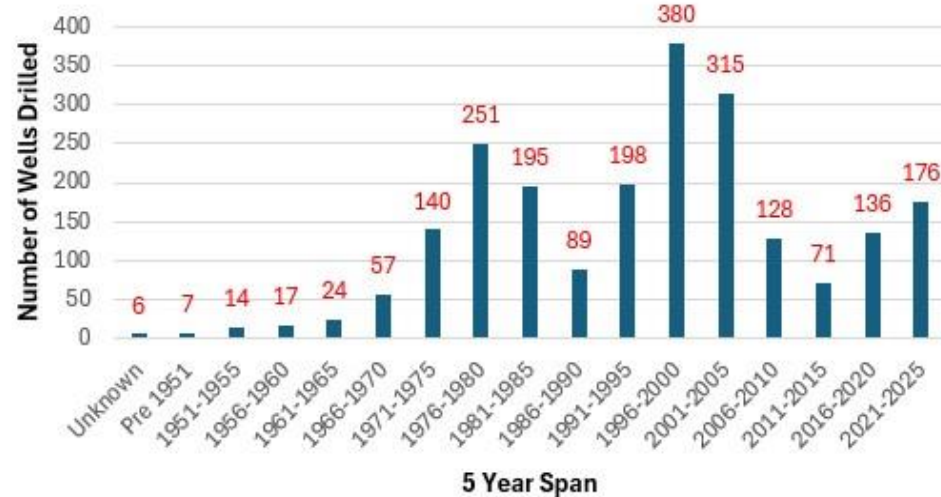
Conceptual Stratigraphic Profile

Unconfined Alluvial and Troublesome Aquifers

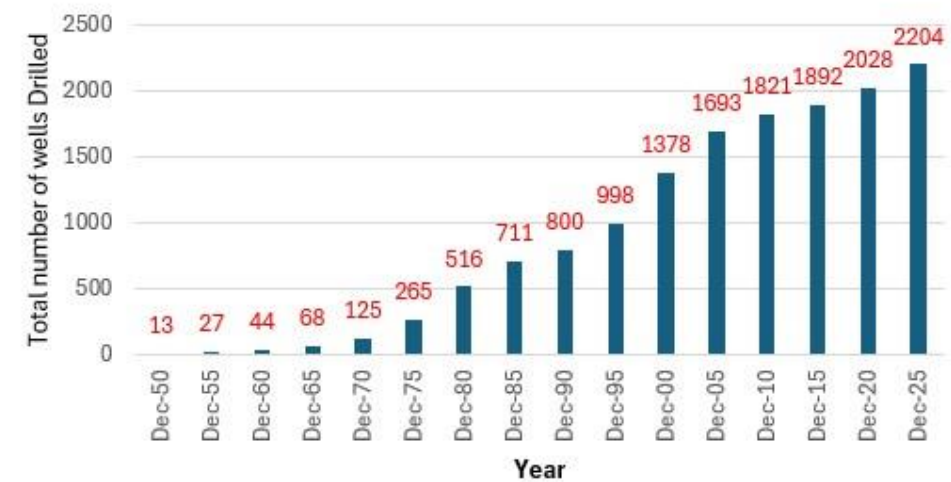
Four-Layer System with Hydraulic Properties and Thickness Ranges



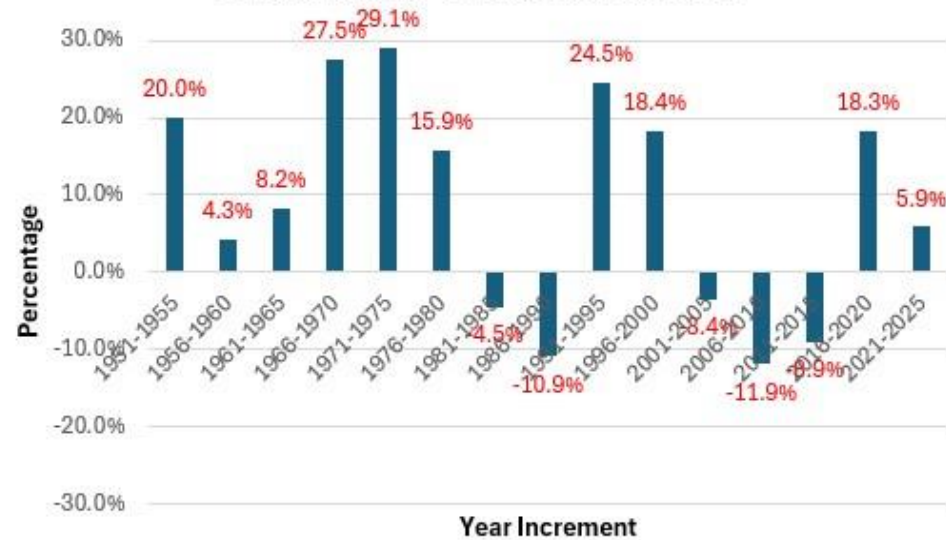
Fraser Valley Water Well Drilling History



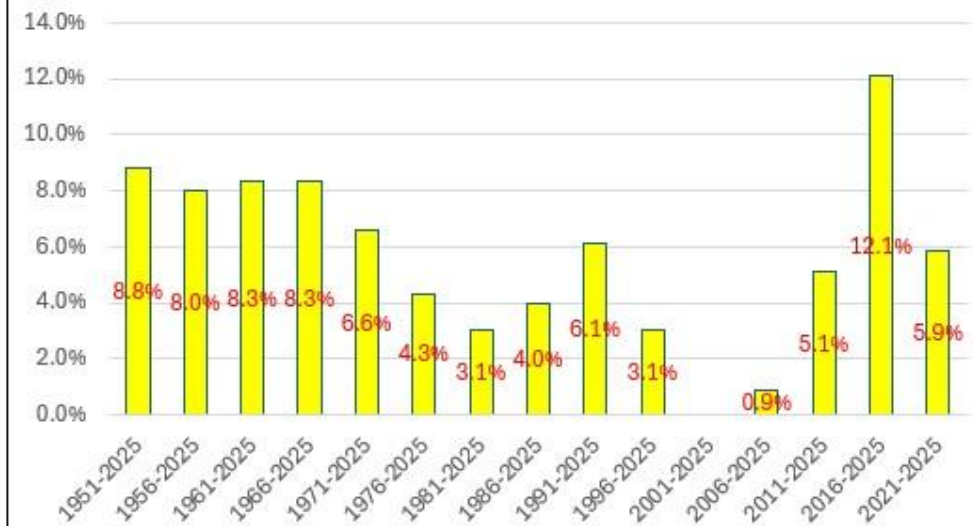
Cumulative Water Wells Drilled in Fraser Valley



Growth Rate - 5 Year Increments



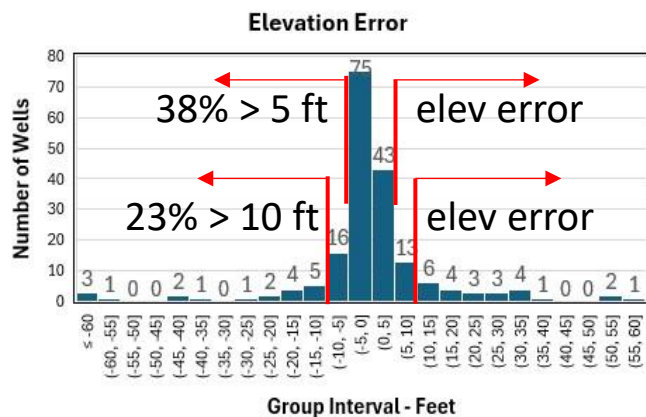
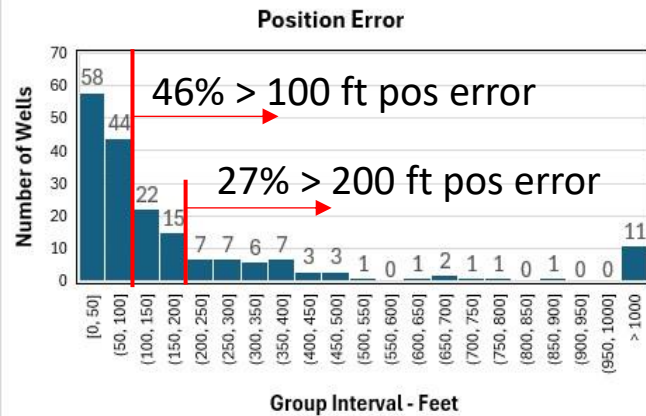
Growth Rate From Historical Year thru 2025



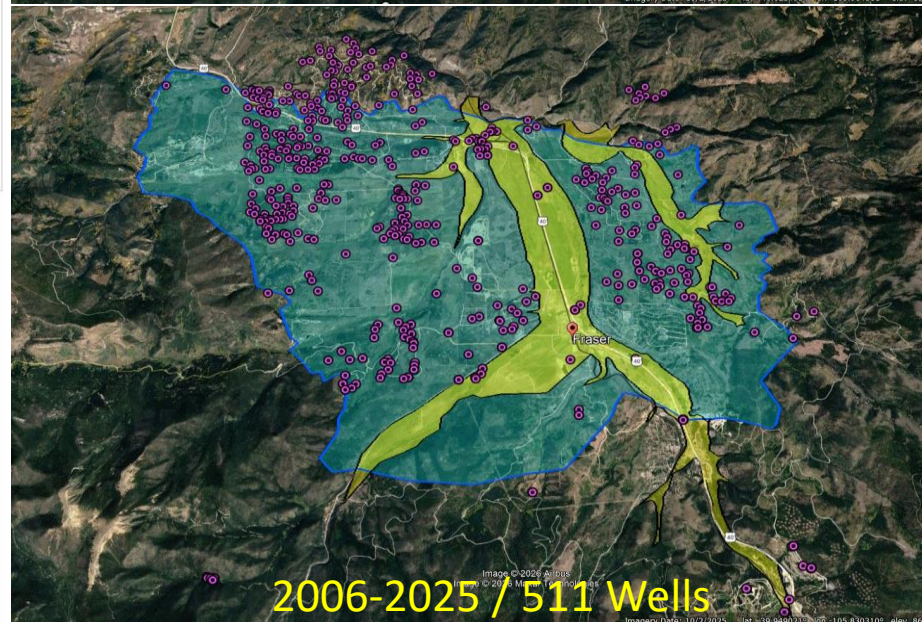
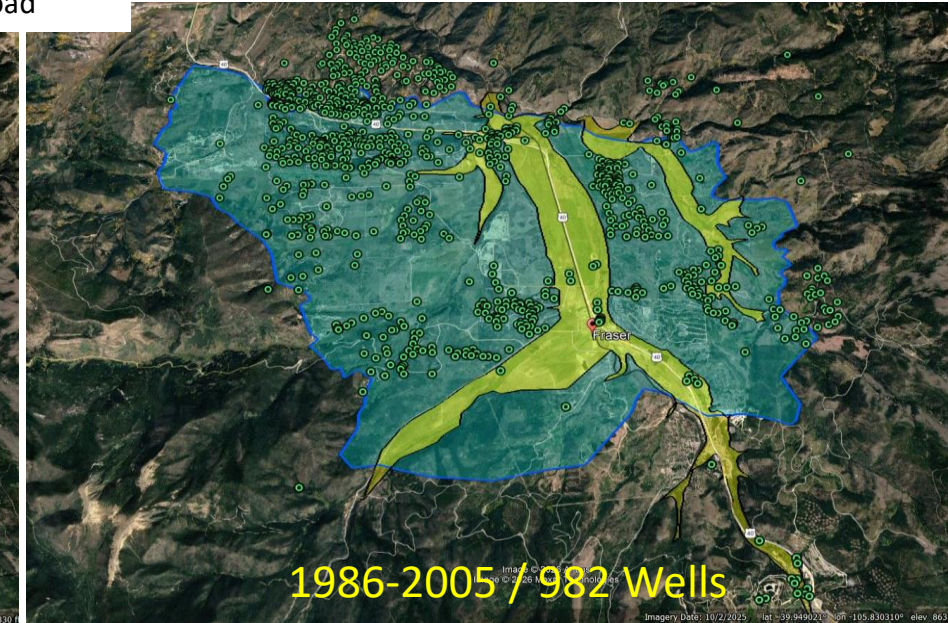
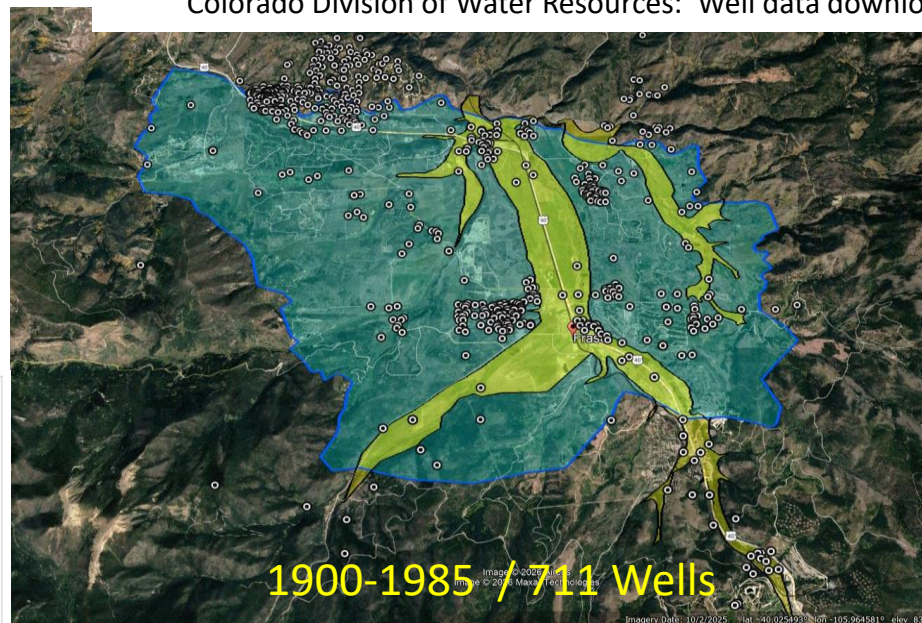
Colorado Division of Water Resources: Well data download



Well position and elevation corrections for a sample of 190 wells from around the Fraser Valley
(Calibration using Grand County Parcel Viewer and DWR Map Viewing websites, both using high resolution satellite imagery)



Colorado Division of Water Resources: Well data download



Fraser Valley Well Construction – Historical Distribution

- Substantial statistical data base - 2,204 wells
- Requires calibration for position and elevation for wells included in study
- Underground water static level in wells should be taken at time of pump installation (not after well construction)
- Time variant Water Table Mapping
- Hydraulic Gradient Variations