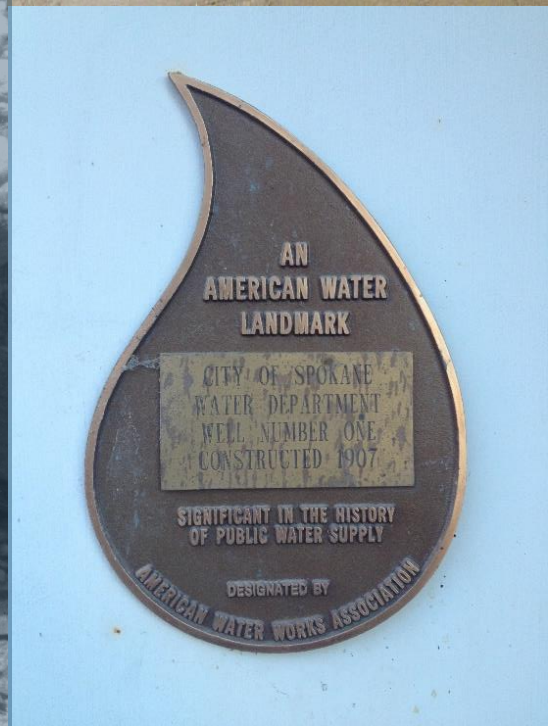
Getting to Informed Water Supply Planning Using a Feedback Loop of Systems Analysis, Data Collection, and Intentional Learning: A Spokane Case Study

John J. Porcello, LHG (Washington), RG (Oregon)

AWWA-PNWS Annual Section Conference 2024
Spokane, WA
Thursday May 2, 2024



GSI Water Solutions, Inc.

Topics

- Description of Spokane Valley–Rathdrum Prairie Aquifer (SVRP)
- Descriptions of 6 feedback loops
  - 5 loops I've observed over 30 years
  - 1 big example that preceded me
- Past and ongoing resiliency and reliability planning efforts by the region's local water providers
  - The region's water providers are on top of it!

Acknowledgements

Thank You!

The Local Water Purveyors in Washington

CITY OF SPOKANE

SAJB
Spokane Aquifer Joint Board

Other Supporting Entities

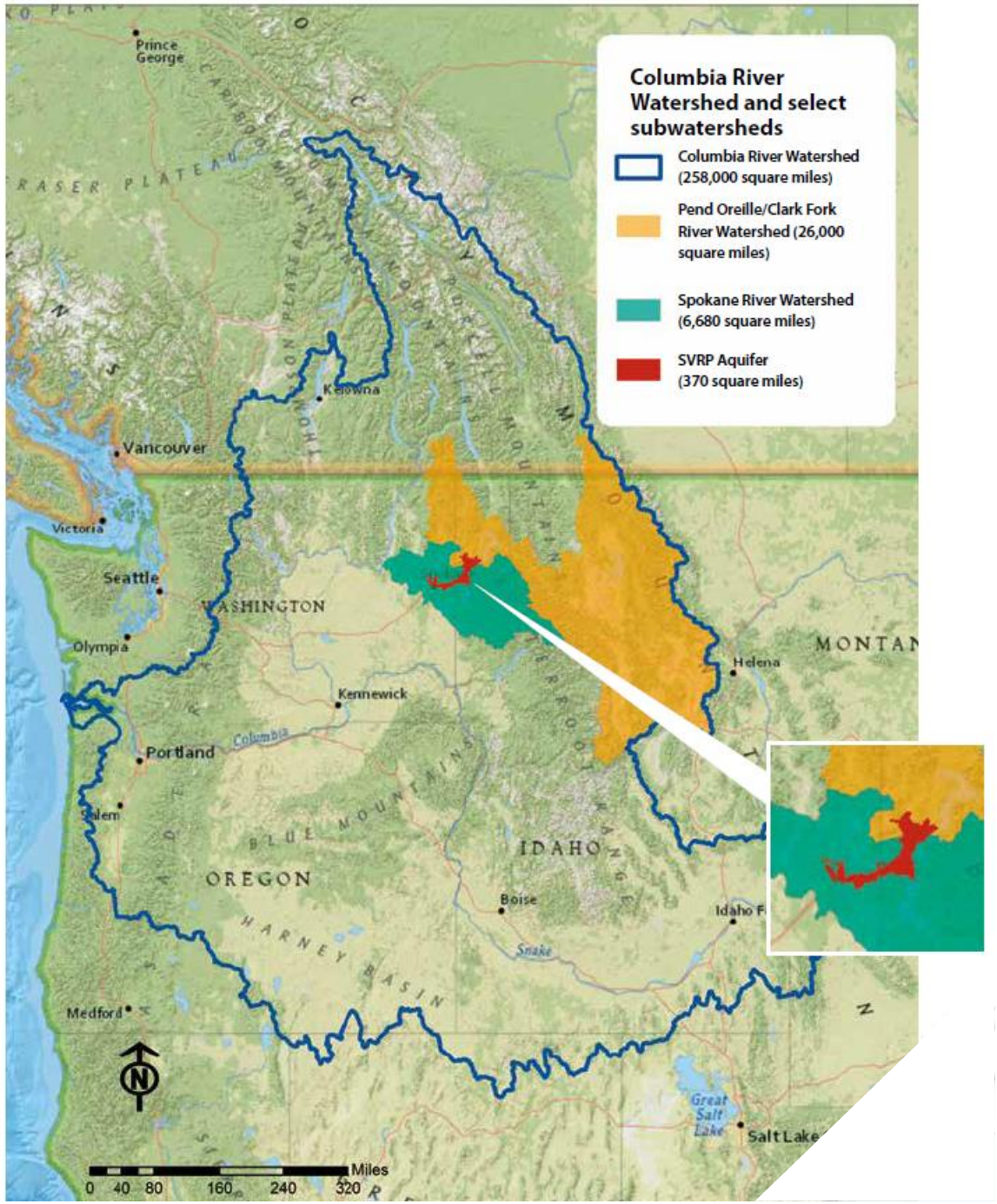
Other Local Water Providers and Water Resource Managers
Spokane County Water Resources Department, WA
Idaho-Washington Aquifer Collaborative

State and Local Agencies
Washington State Department of Health
Washington State Department of Ecology
Idaho Department of Water Resources
Idaho Department of Environmental Quality
Panhandle Health District, ID

Research Community
U.S. Geological Survey
USDA Natural Resources Conservation Service
Idaho Water Resources Research Institute
University of California, Merced

Other Professionals
Dr. Dale Ralston
Landau Associates
Consor North America
CH2M HILL
GSI Water Solutions

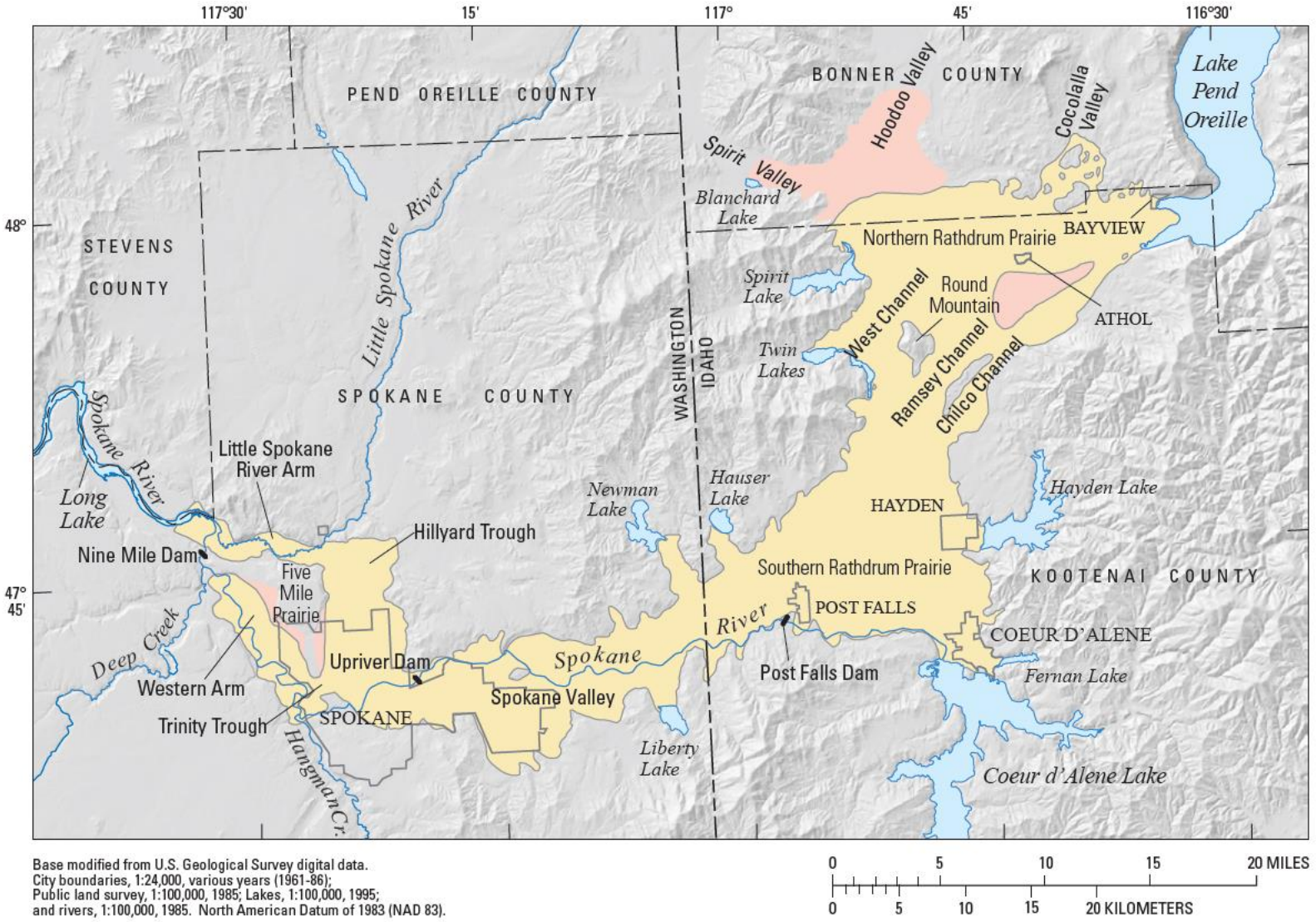
Location Map



Source: Spokane Valley-Rathdrum Prairie Aquifer Atlas, Fifth Edition (2023)

A Collaboration of:
City of Post Falls, ID
City of Spokane Water Department, WA
Idaho Department of Environmental Quality
Idaho Washington Aquifer Collaborative
Liberty Lake Sewer & Water District, WA
Panhandle Health District, ID
Spokane Aquifer Joint Board, WA
Spokane County Water Resources, WA
Washington State Department of Ecology

Location Map



EXPLANATION

Extent of Spokane Valley-Rathdrum Prairie aquifer ground-water flow model

Area of Spokane Valley-Rathdrum Prairie aquifer as defined by Kahle and others (2005), that is excluded from ground-water flow model

Source: Figure 1 from the USGS Bi-State Model Report (Hsieh et al., 2007).

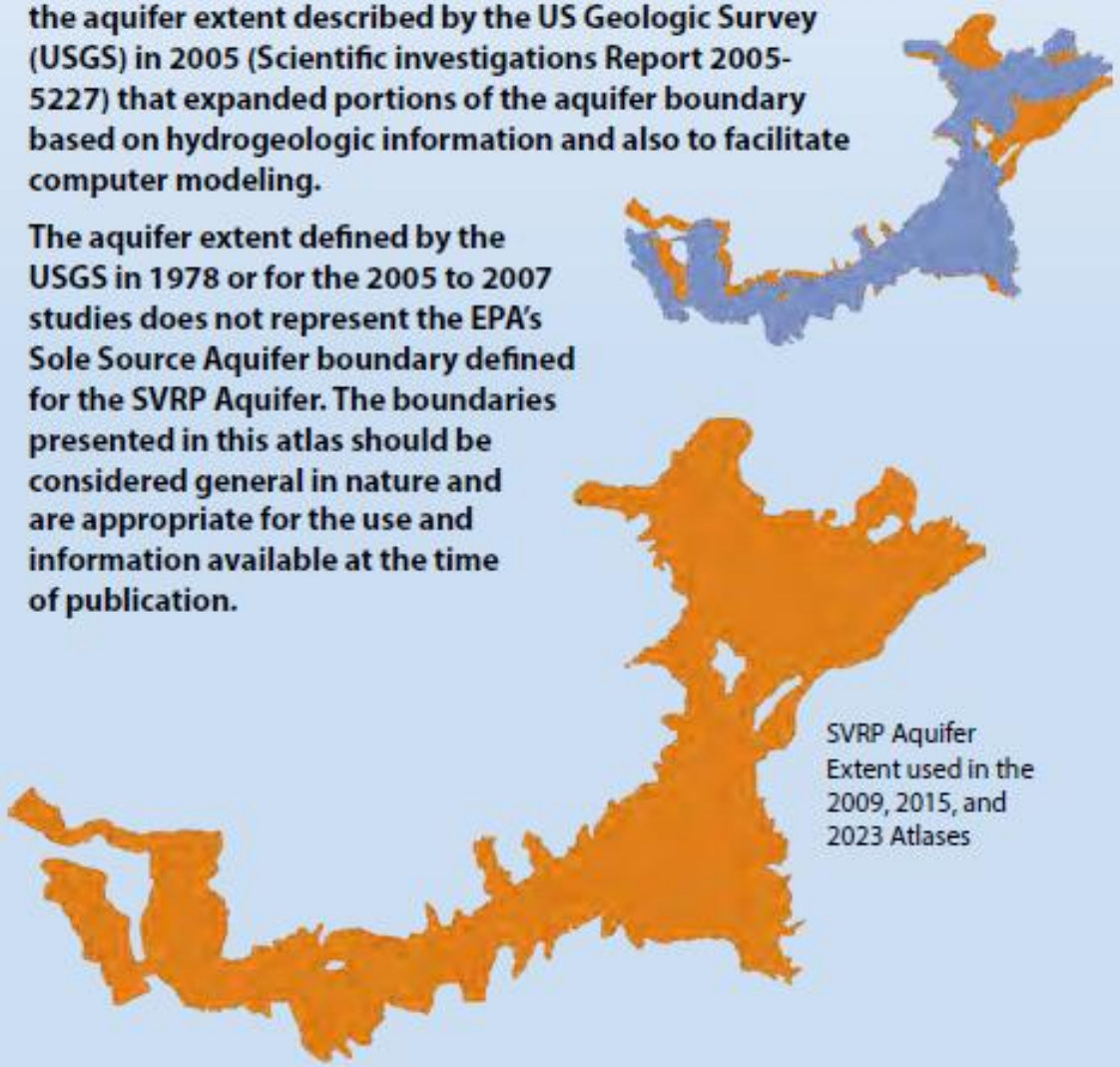
Hsieh, P.A., M.E. Barber, B.A. Contor, Md.A. Hossain, G.S. Johnson, J.L. Jones, and A.H. Wylie. 2007. Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho. U.S. Geological Survey Scientific Investigations Report 2007-5044, 78 p.

Areal Extent of the SVRP Aquifer

Setting Boundaries:
The SVRP Aquifer Extent

The boundary of the SVRP Aquifer has been defined differently by various investigators over time. The 2000 and 2004 aquifer atlases used the aquifer boundary adopted by the Environmental Protection Agency (EPA) in 1978. The boundary used in this document is the aquifer extent described by the US Geologic Survey (USGS) in 2005 (Scientific investigations Report 2005-5227) that expanded portions of the aquifer boundary based on hydrogeologic information and also to facilitate computer modeling.

The aquifer extent defined by the USGS in 1978 or for the 2005 to 2007 studies does not represent the EPA's Sole Source Aquifer boundary defined for the SVRP Aquifer. The boundaries presented in this atlas should be considered general in nature and are appropriate for the use and information available at the time of publication.



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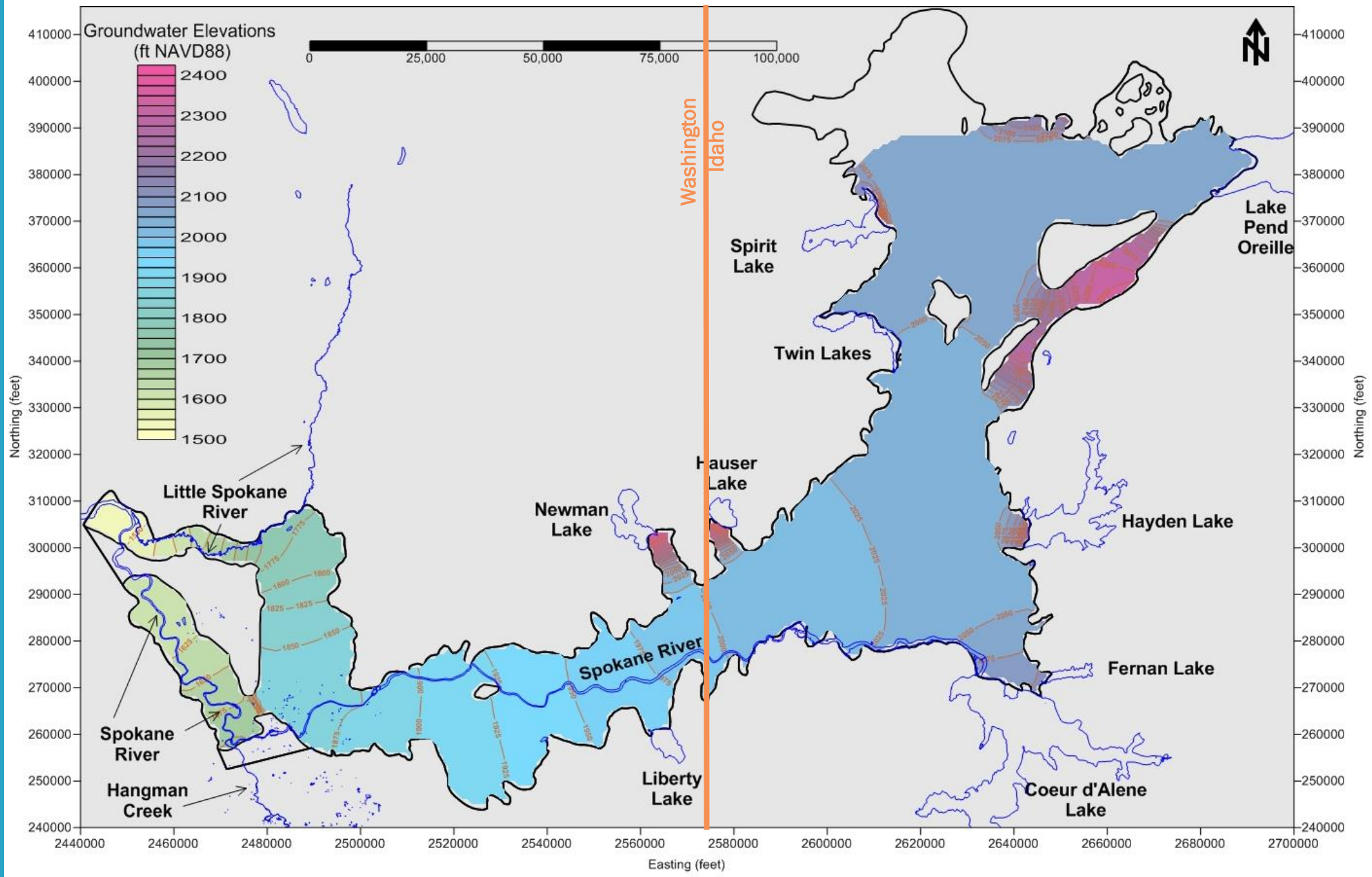
Washington State Department of Ecology

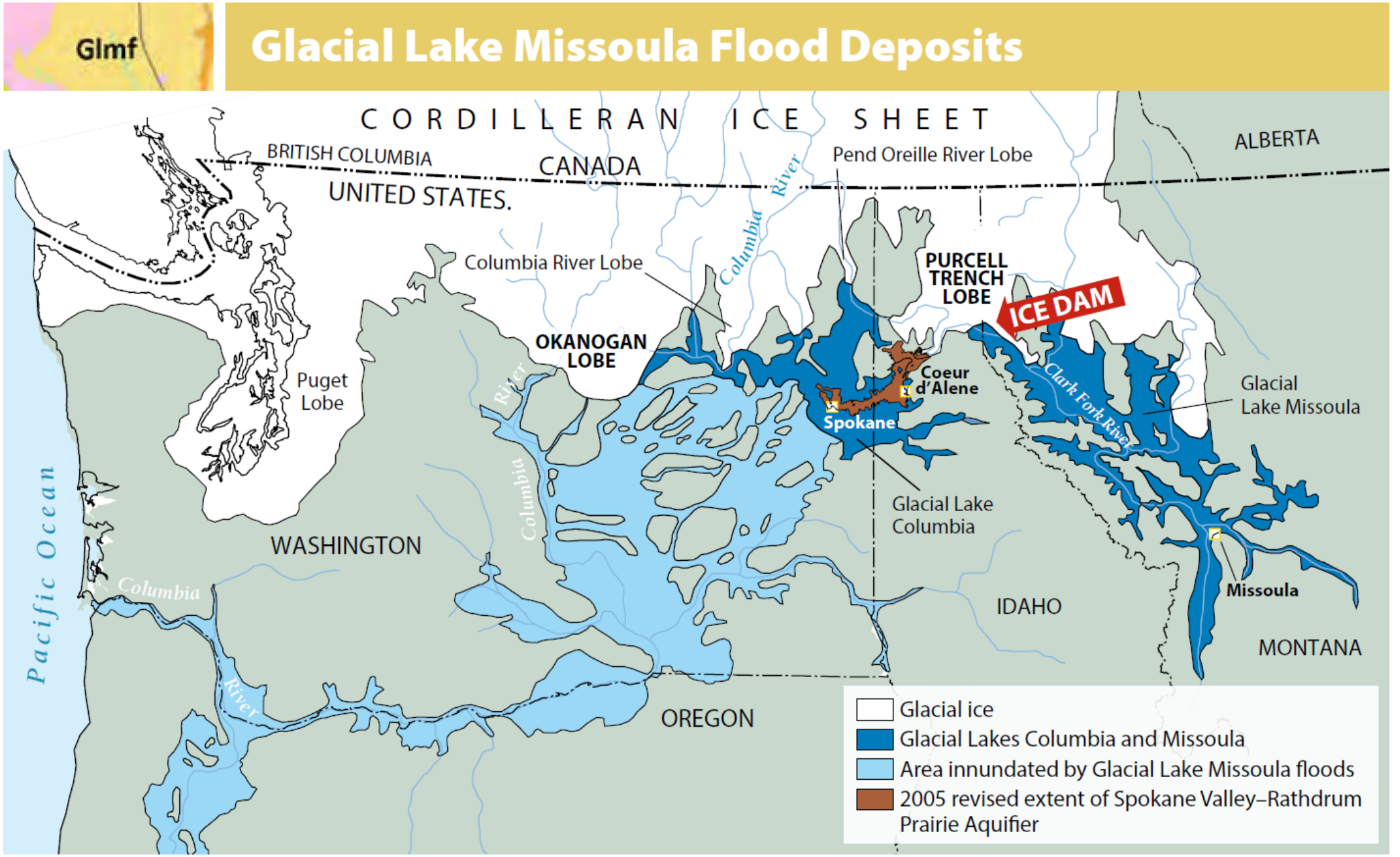
Aquifer Extent in Washington Purveyors' Ground-Water Flow Model *(Since 2012)*



Source: GSI Water Solutions, City of Spokane, and Spokane Aquifer Joint Board (SAJB)

At Least 40 Massive Glacial Floods Formed the SVRP Aquifer

Glacial Lake Missoula Flood Deposits

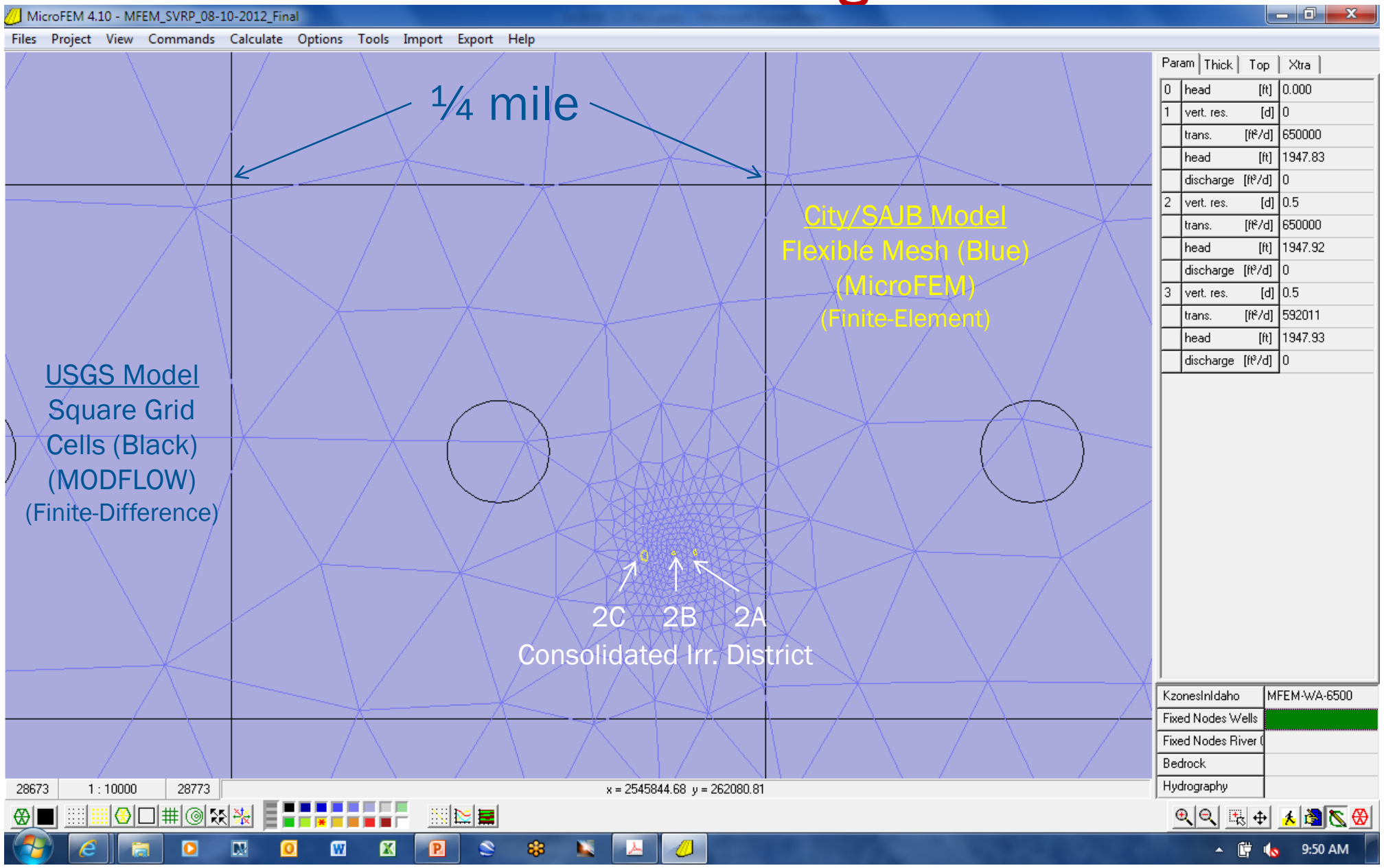


Source: Spokane Valley-Rathdrum Prairie Aquifer Atlas, Fifth Edition (2023)

Wells Are Close Together!

The Result:

A Massively Productive Aquifer and Very High-Yielding Wells



Source: Spokane Aquifer Joint Board (SAJB) and GSI Water Solutions

The Result:

A Massively Productive Aquifer and Very High-Yielding Wells

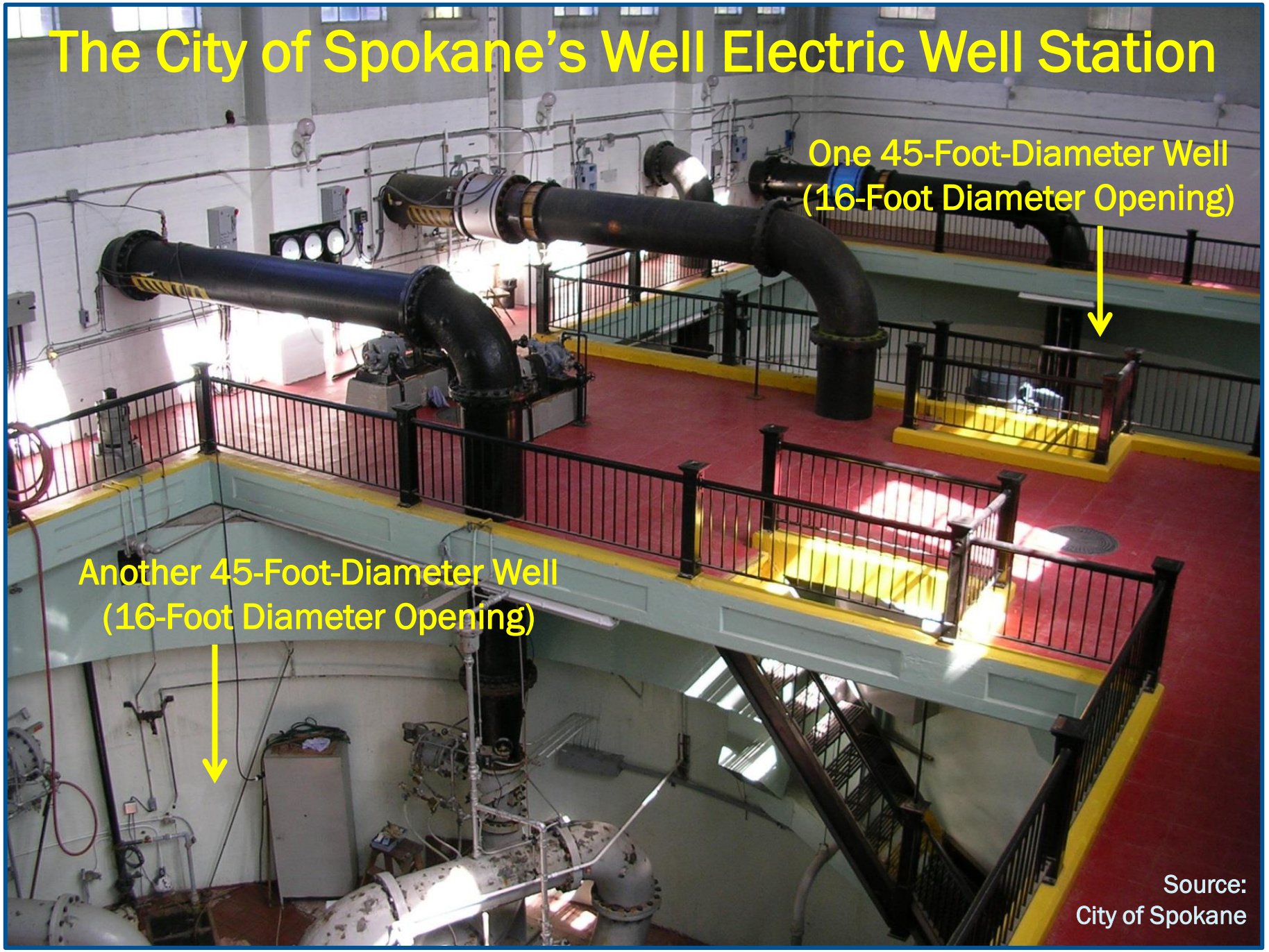
Wells Are Close Together!

(The City of Spokane's Well Electric Well Station)

Source: City of Spokane

The Result:

A Massively Productive Aquifer and Very High-Yielding Wells



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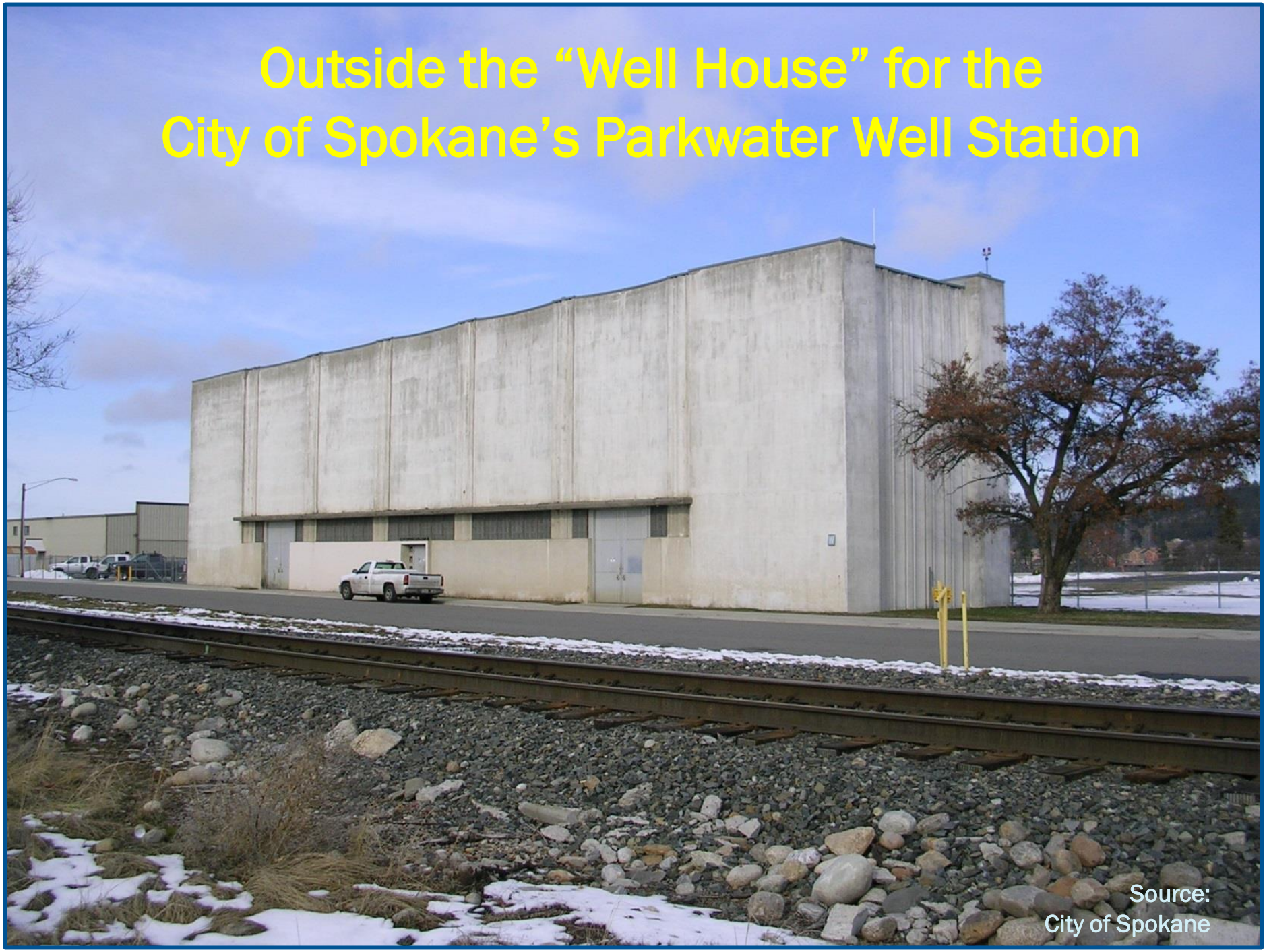
A Massively Productive Aquifer and Very High-Yielding Wells



The Result:

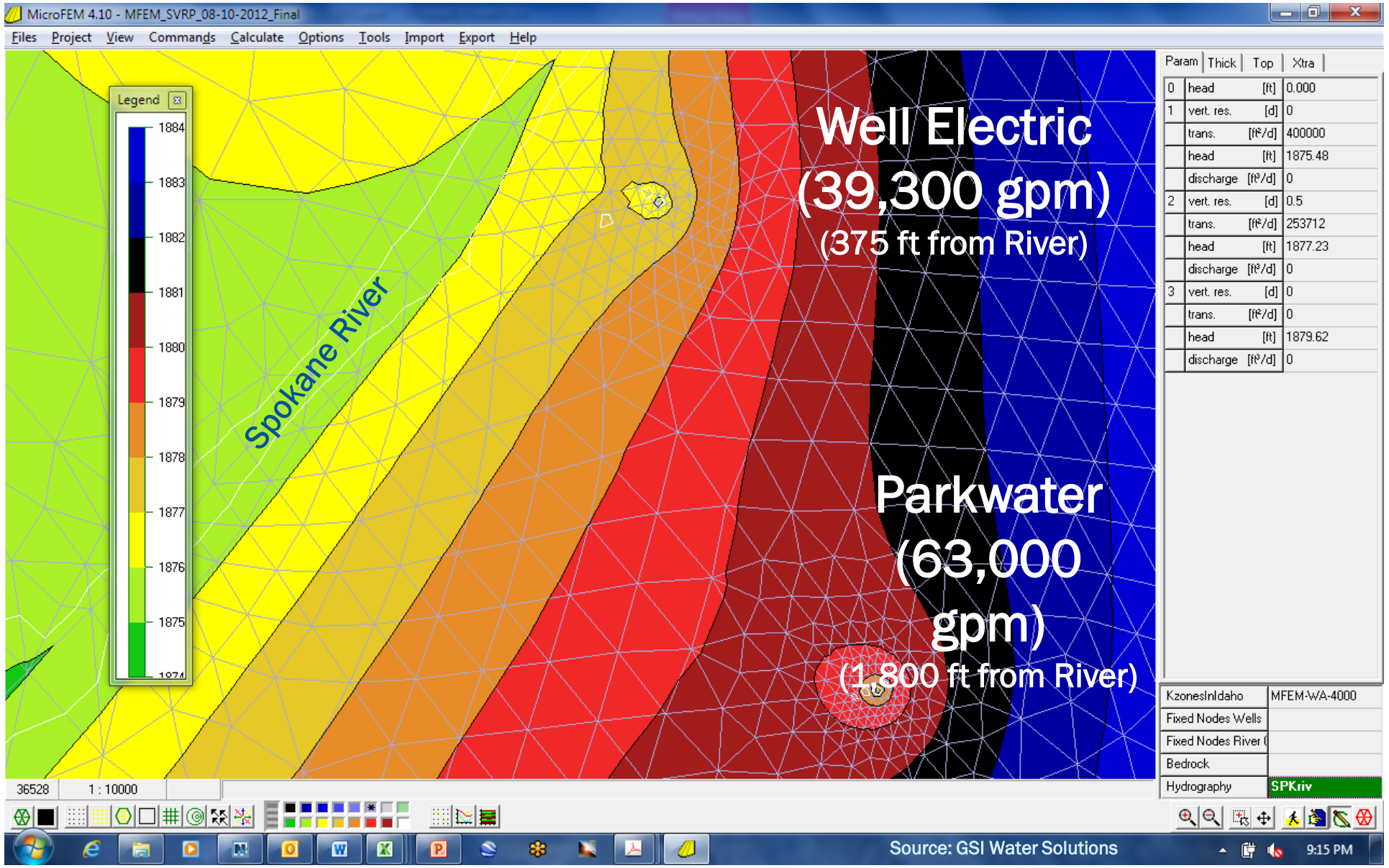
A Massively Productive Aquifer and Very High-Yielding Wells

Model: Pumping Produces Minimal Drawdown

(Map View)

The Result:

A Massively Productive Aquifer and Very High-Yielding Wells

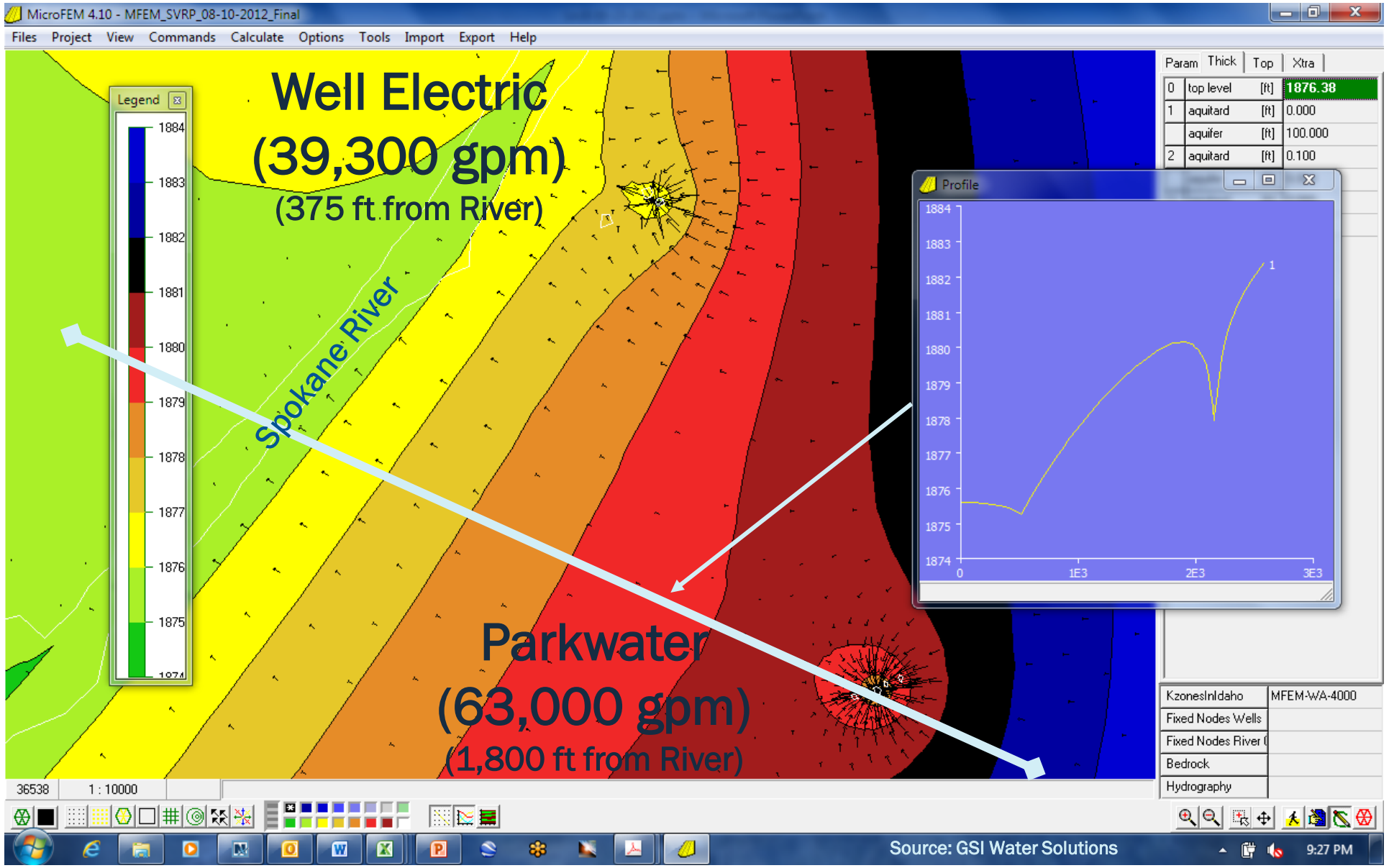


Model: Pumping Produces Minimal Drawdown

(Section View)

The Result:

A Massively Productive Aquifer and Very High-Yielding Wells

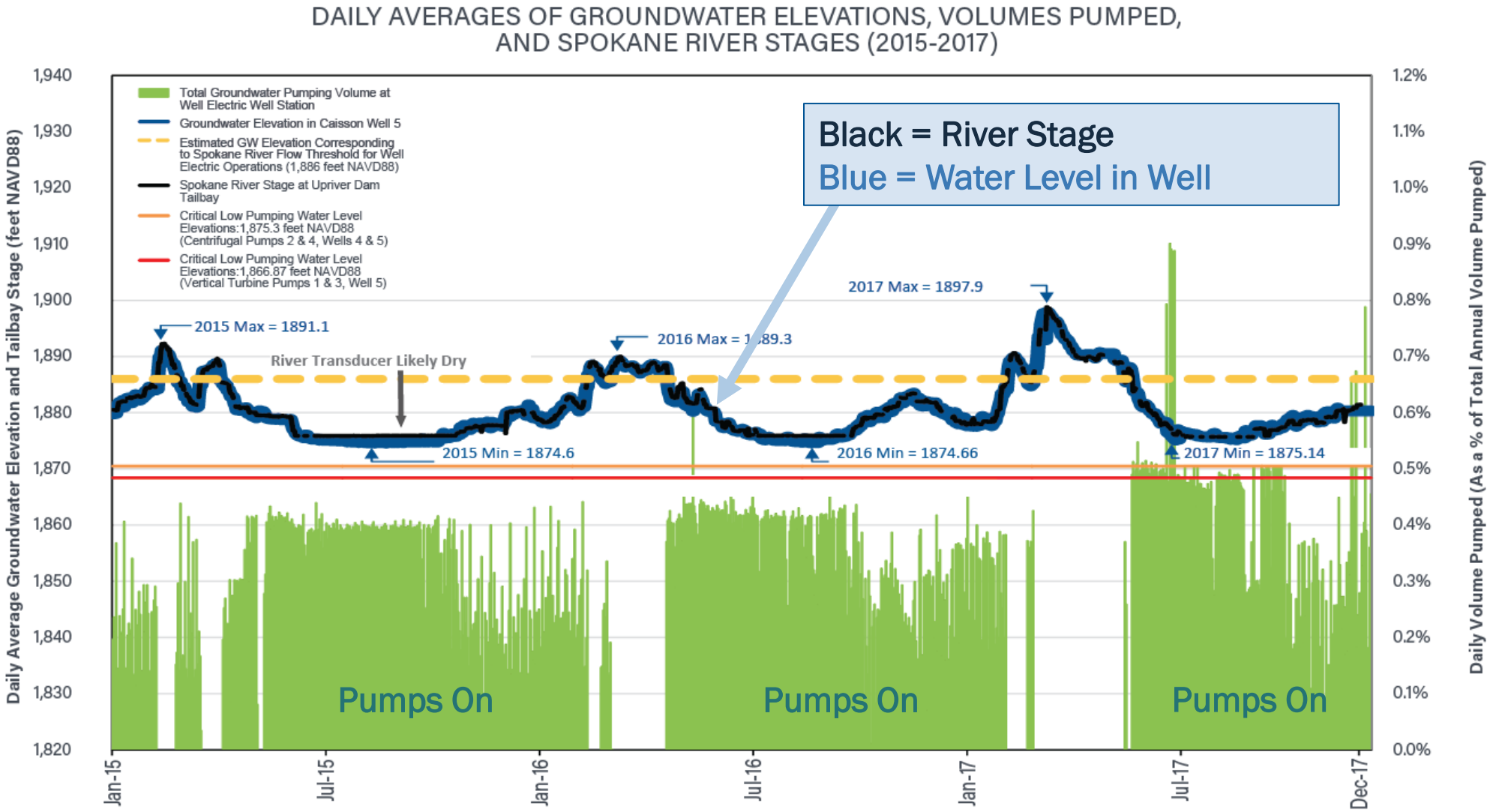


Field Data: Pumping Produces Minimal Drawdown

(Well Electric)

The Result:

A Massively Productive Aquifer and Very High-Yielding Wells



Source: GSI Water Solutions and City of Spokane

Feedback Loop 1:
Overcoming Early Model Calibration Difficulties

USGS Water Table Map
May 1978

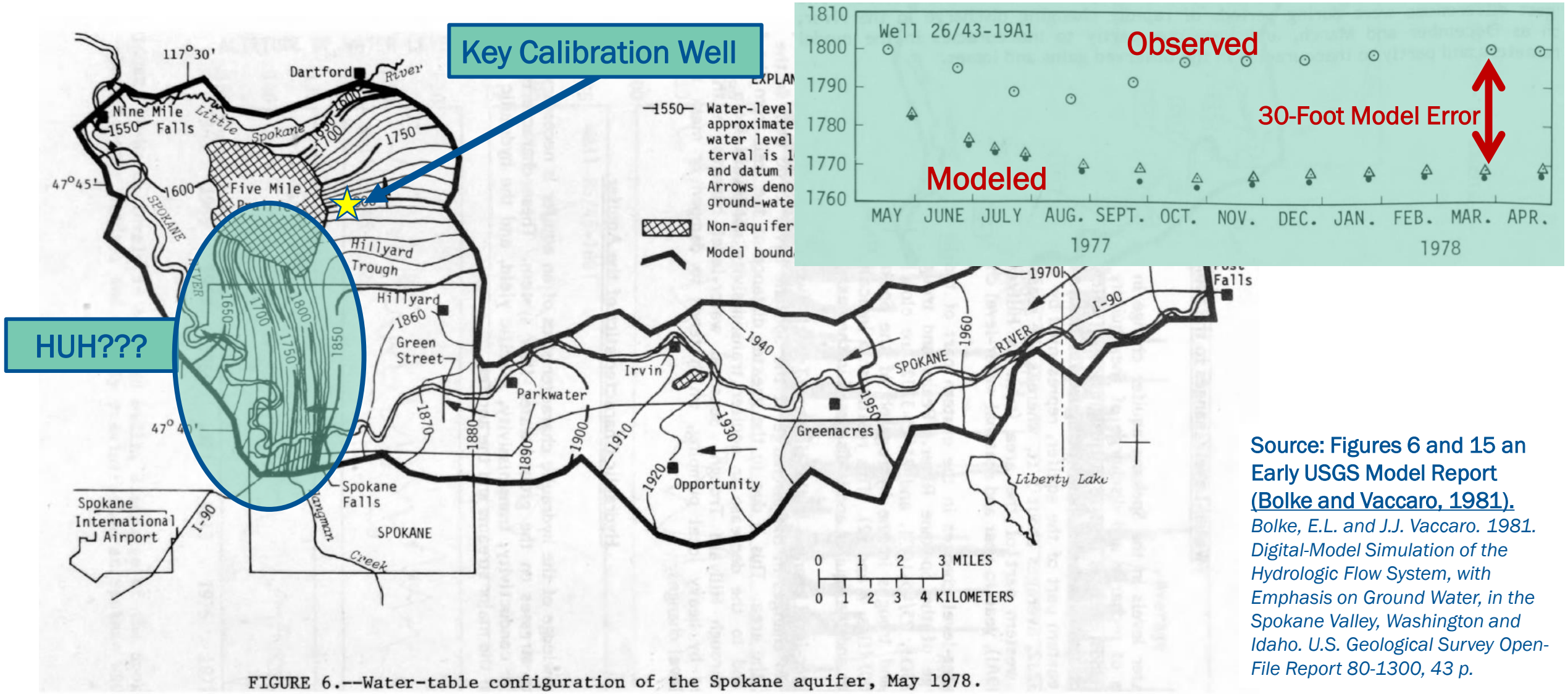


FIGURE 6.--Water-table configuration of the Spokane aquifer, May 1978.

Source: Figures 6 and 15 an Early USGS Model Report (Bolke and Vaccaro, 1981).

Bolke, E.L. and J.J. Vaccaro. 1981. Digital-Model Simulation of the Hydrologic Flow System, with Emphasis on Ground Water, in the Spokane Valley, Washington and Idaho. U.S. Geological Survey Open-File Report 80-1300, 43 p.

Feedback Loop 1:
Overcoming Early Model Calibration Difficulties

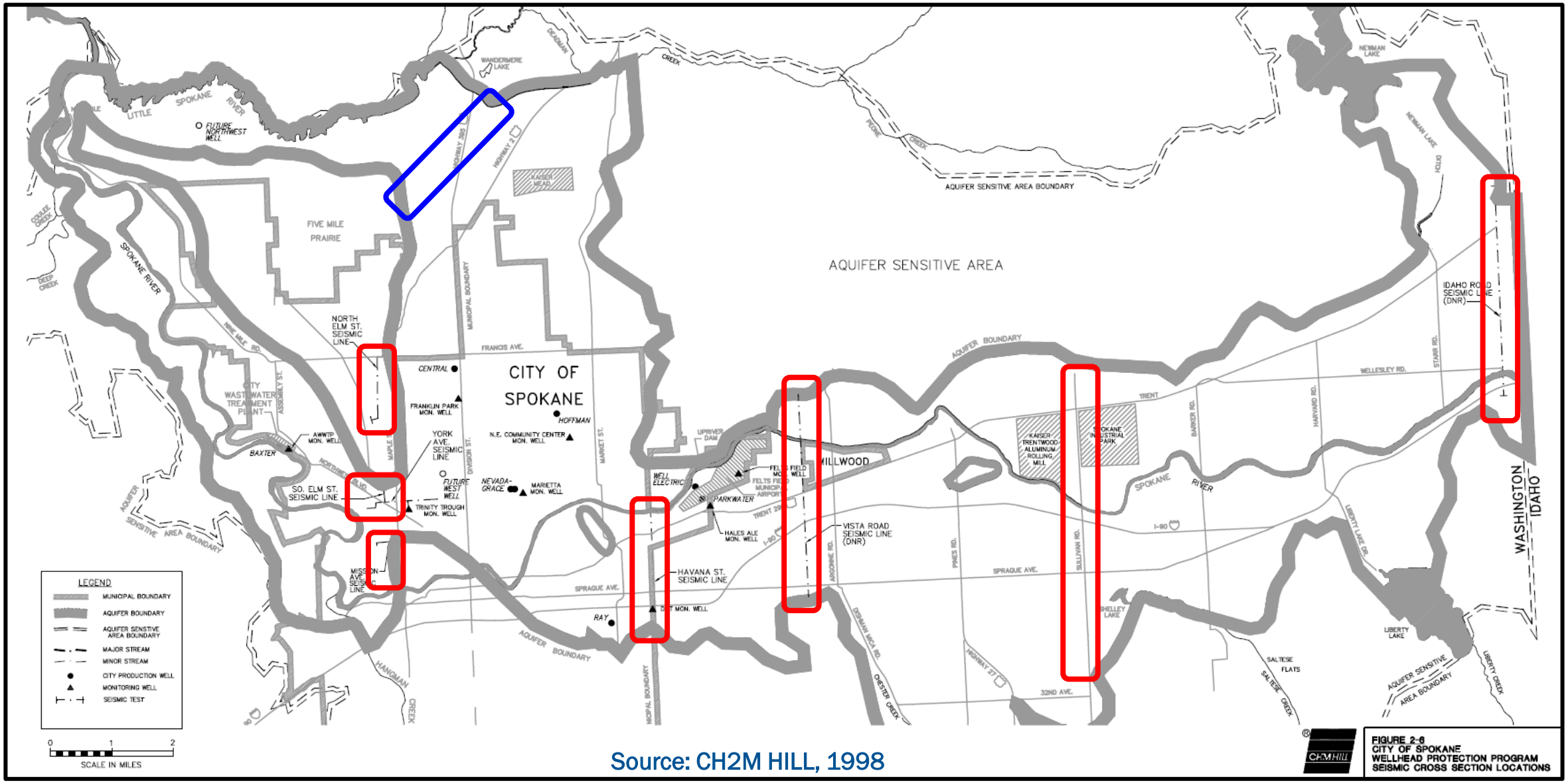
1. Why the sudden steep slope in the water table in the western part of the City?
2. Why does the model under-estimate groundwater levels north of the City?

It's the mid-90s. Time for a Focused Field Investigation!

- Two efforts never before conducted in this aquifer
  - Geophysical surveys (seismic profiling and micro-gravity methods)
  - Synoptic groundwater and stream stage measurements (Spring and Fall)

Seismic Profiling (Red) and Micro-Gravity Surveys (Blue)

City of Spokane and SAJB, Mid-1990s



Source: CH2M HILL, 1998

Seismic Profiling

City of Spokane and SAJB, Mid-1990s

SAJB

Local Water Utilities
United for Safe Drinking Water

Carnhope Irrigation District No. 7
Consolidated Irrigation District No. 19
East Spokane Water District No. 1
Hutchinson Irrigation District No. 16
Irvin Water District No. 6
Liberty Lake Sewer/Water District
City of Millwood
Moab Irrigation District No. 20
Model Irrigation District No. 18

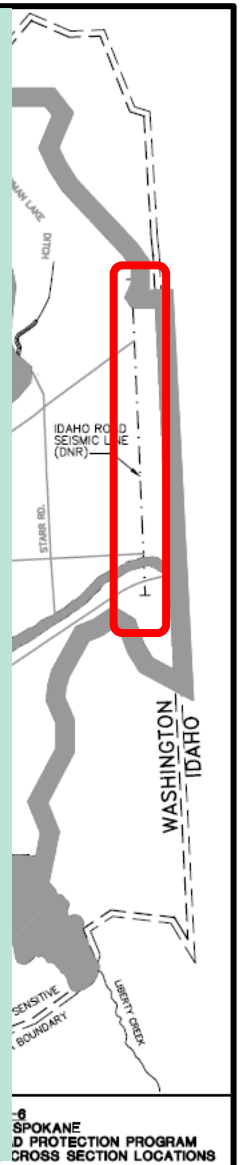
For Immediate Release

Contact: Ty Wick
Spokane Aquifer Joint Board
(509) 536-0121

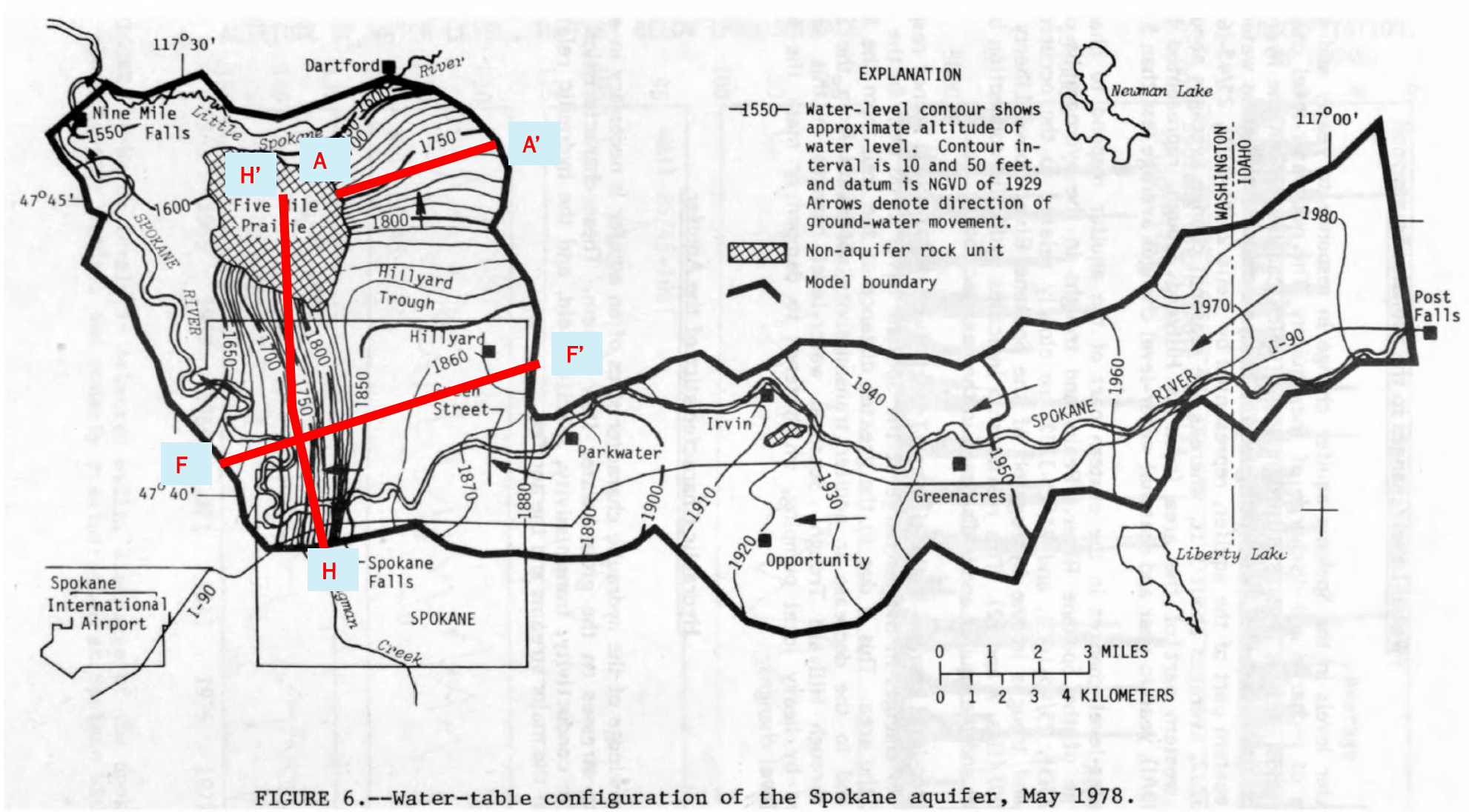
"SUPERMAN EYES" WILL HELP IDENTIFY CHARACTERISTICS OF THE SPOKANE AQUIFER

SPOKANE, Wash.-- Researchers will use "Superman eyes" in their efforts to probe Spokane's Aquifer as part of a wellhead protection program.

The "Superman eyes," technically known as seismic reflection profiling, is one of several tests being conducted on the aquifer by the Spokane Aquifer Joint Board (SAJB), during the month of



USGS Water Table Map
May 1978



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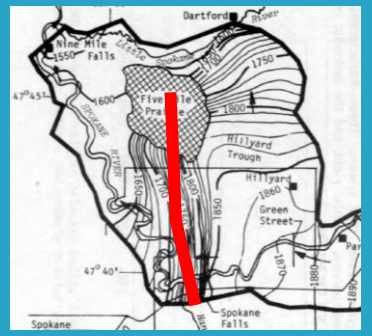
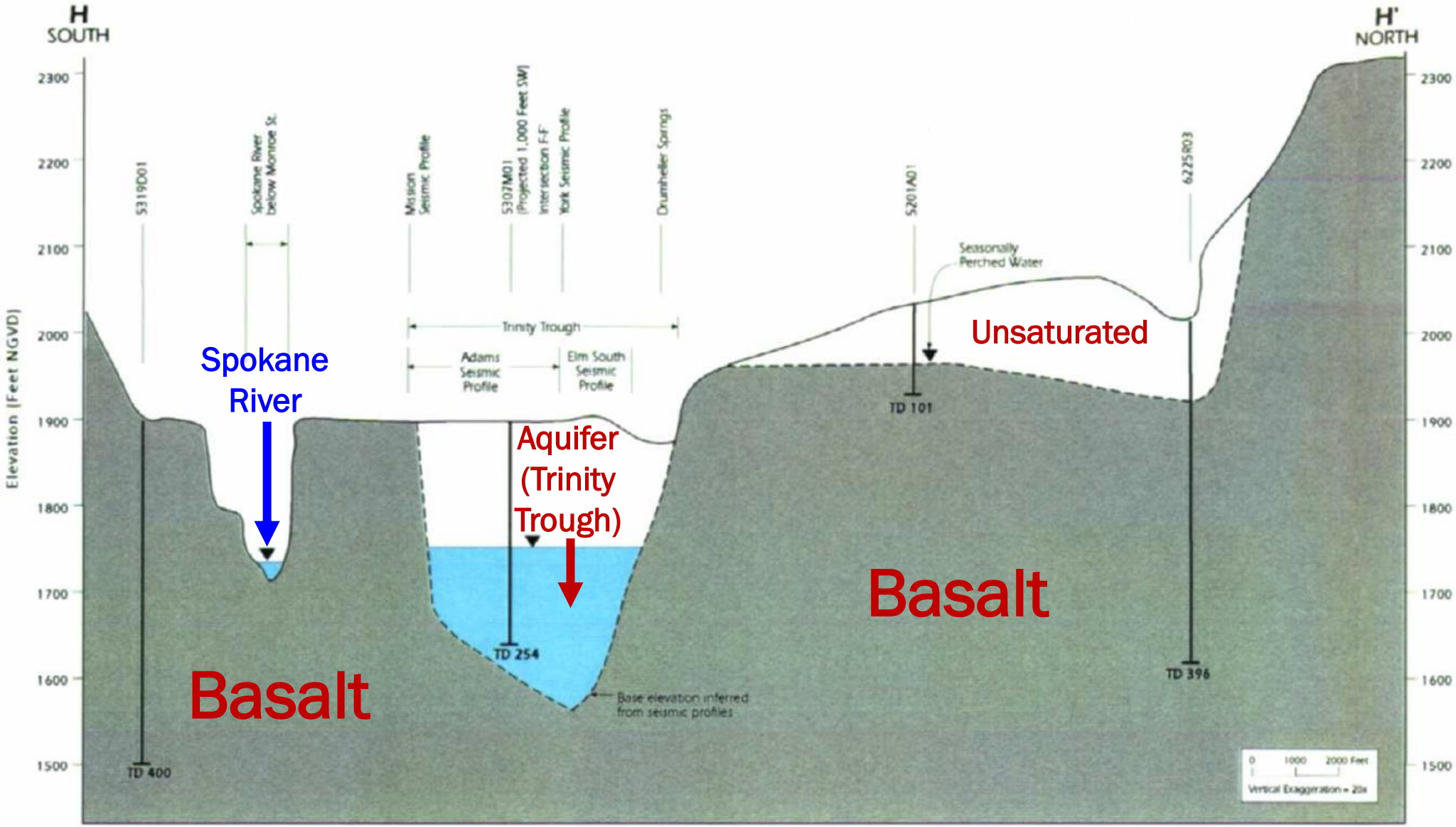
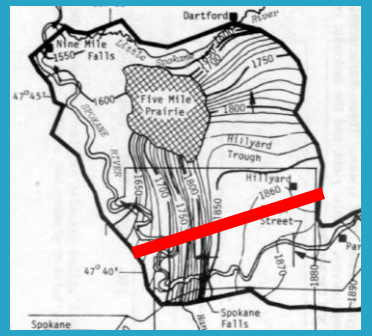


South-North Cross Section at the Narrows (Trinity Trough)

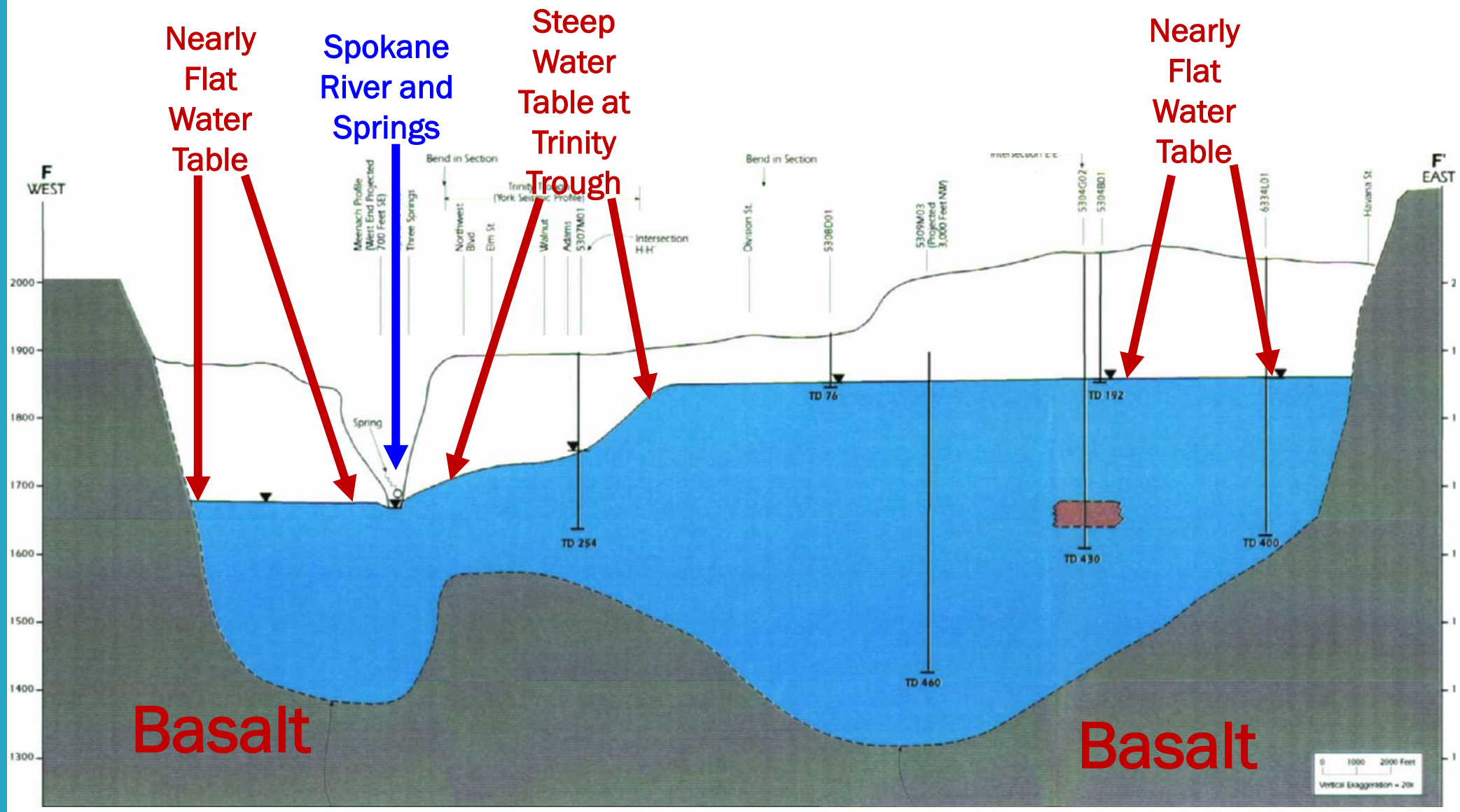


Source: Figure E-8 from the City of Spokane Wellhead Protection Report (CH2M HILL, 1998).

CH2M HILL. 1998. City of Spokane Wellhead Protection Program Phase 1 – Technical Assessment Report. Prepared in association with Dally Environmental, Fujitani Hilts and Associates, and SeisPulse Development Corporation. February 1998.



West-East Cross Section at the Narrows (Trinity Trough)



Source: Figure E-6 from the City of Spokane Wellhead Protection Report (CH2M HILL, 1998).

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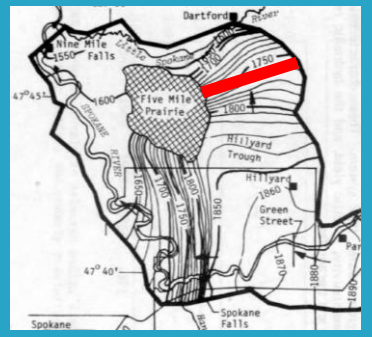
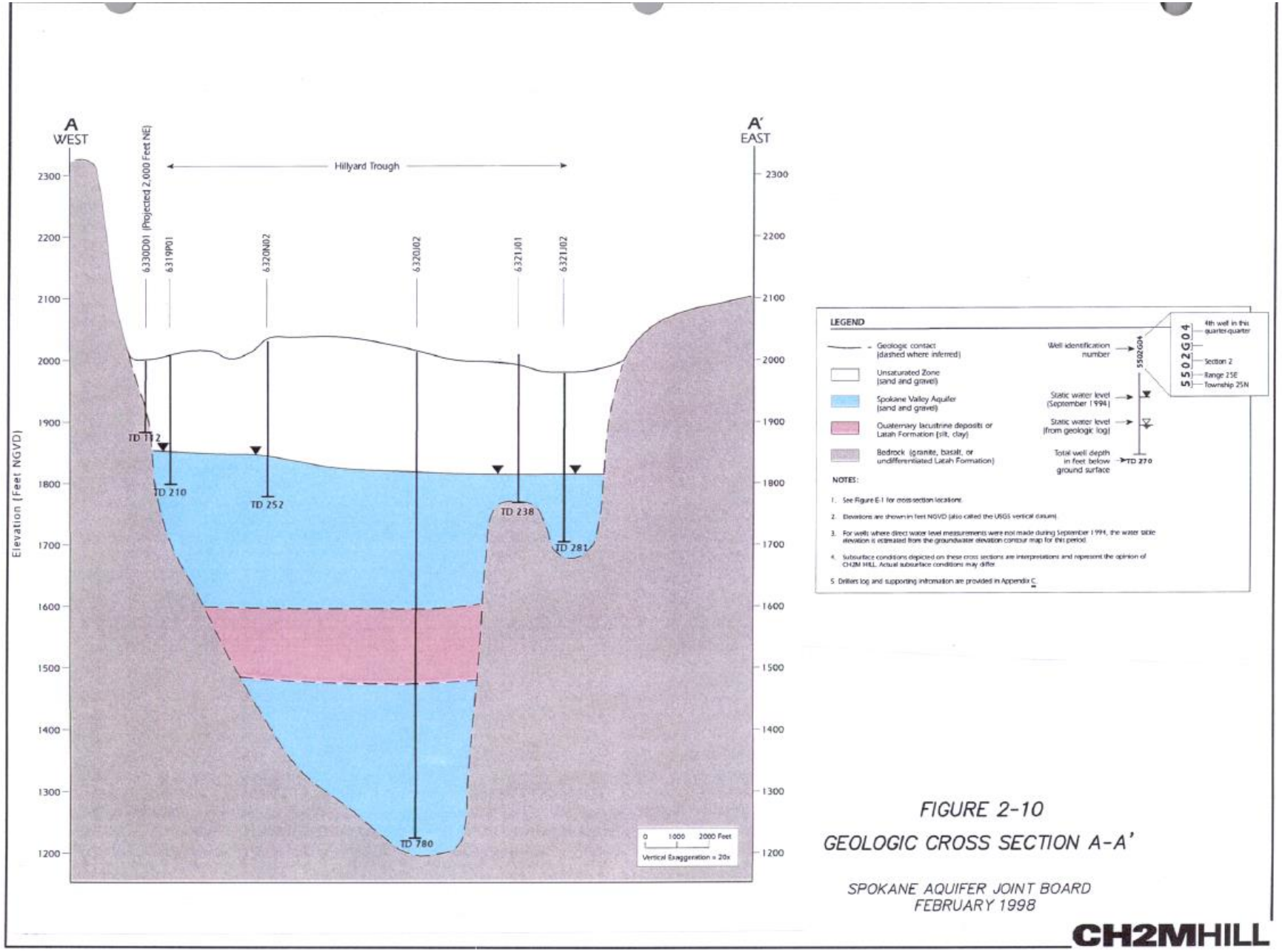


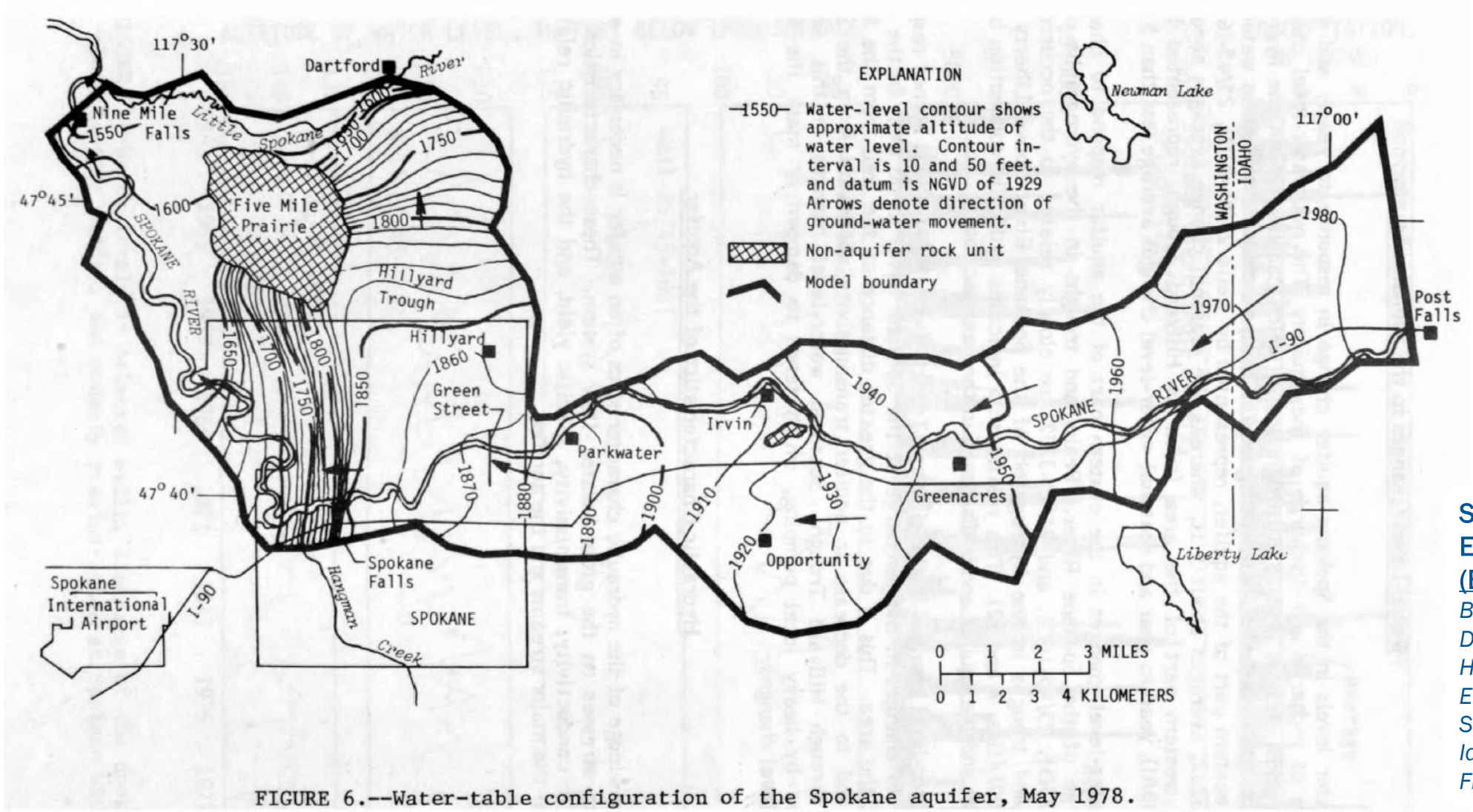
Follow-On Studies for SAJB (2000) in the Northern Part of the Aquifer



Source: Figure 2-10 from the Spokane Aquifer Joint Board (SAJB) Wellhead Protection Report (CH2M HILL, 2000).

CH2M HILL. 2000. Spokane Aquifer Joint Board Wellhead Protection Plan – Volume 1.

USGS Water Table Map
May 1978



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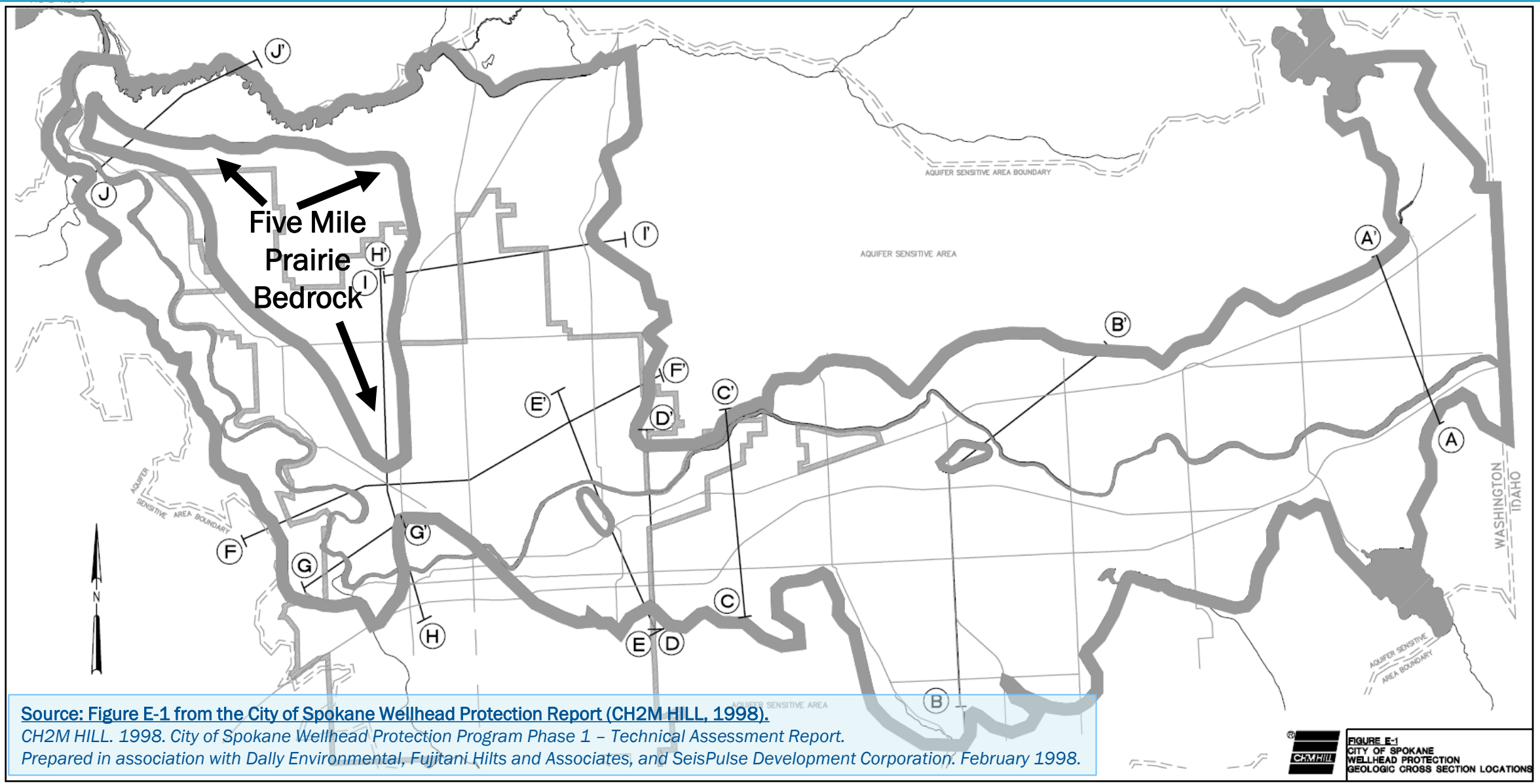
Revised Mapping of Five Mile Prairie Subsurface Bedrock

1990s

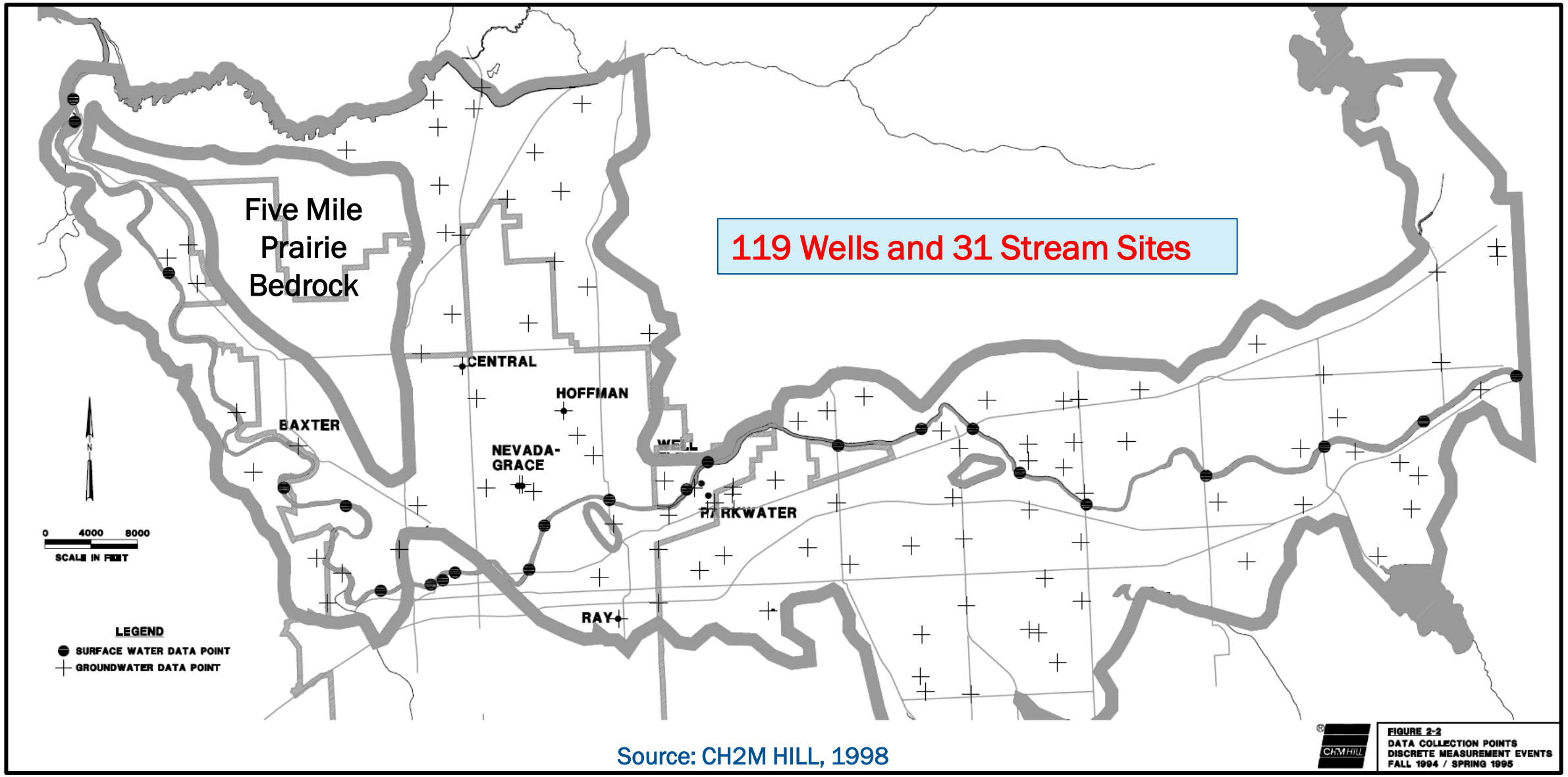


Source: Figure E-1 from the City of Spokane Wellhead Protection Report (CH2M HILL, 1998).

CH2M HILL. 1998. City of Spokane Wellhead Protection Program Phase 1 – Technical Assessment Report. Prepared in association with Dally Environmental, Fujitani Hilts and Associates, and SeisPulse Development Corporation. February 1998.

Groundwater and Stream Synoptic Monitoring Points

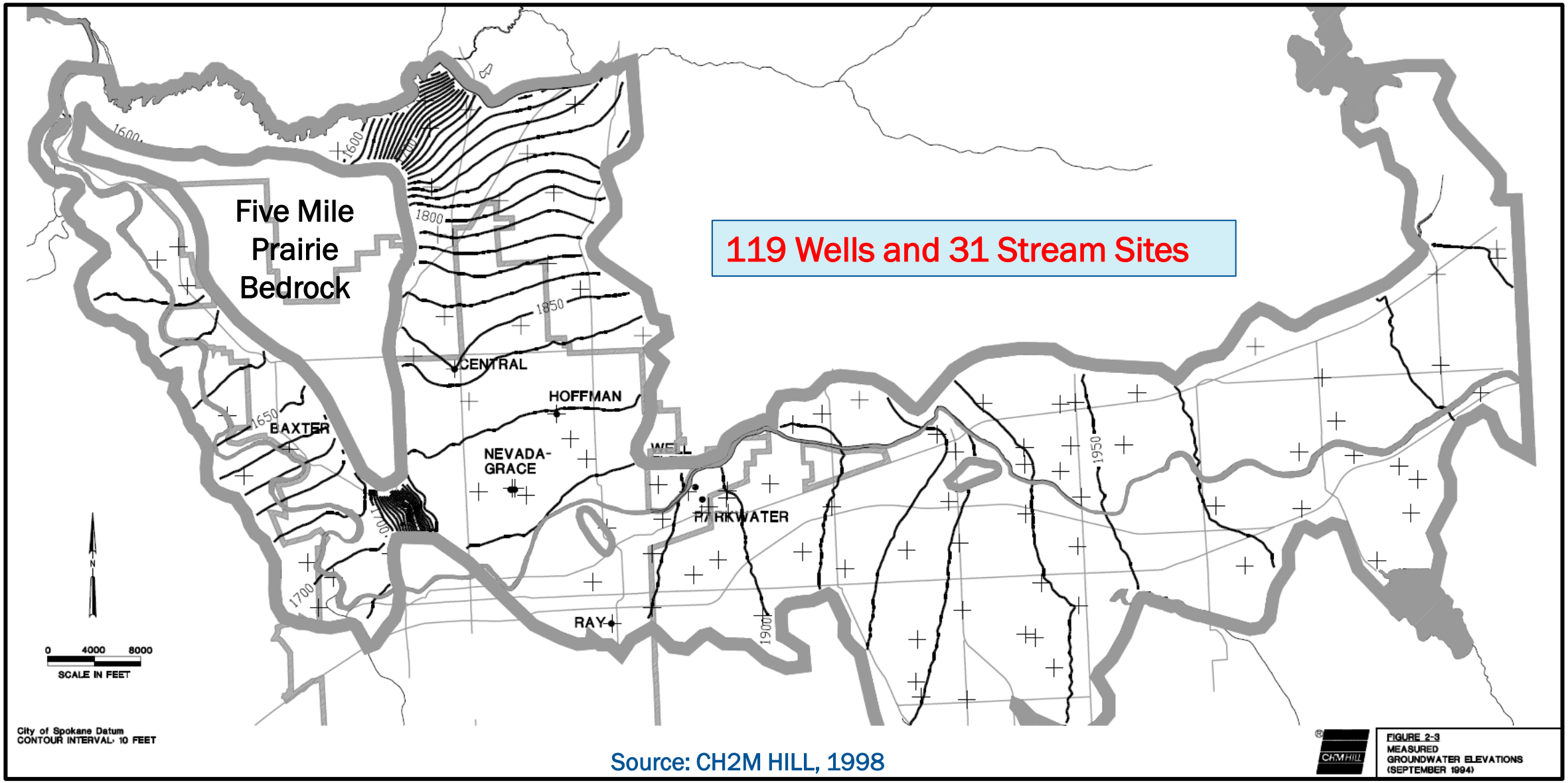
City of Spokane, Fall 1994 and Spring 1995



Source: CH2M HILL, 1998

Synoptic Groundwater Elevation Map for Fall 1994

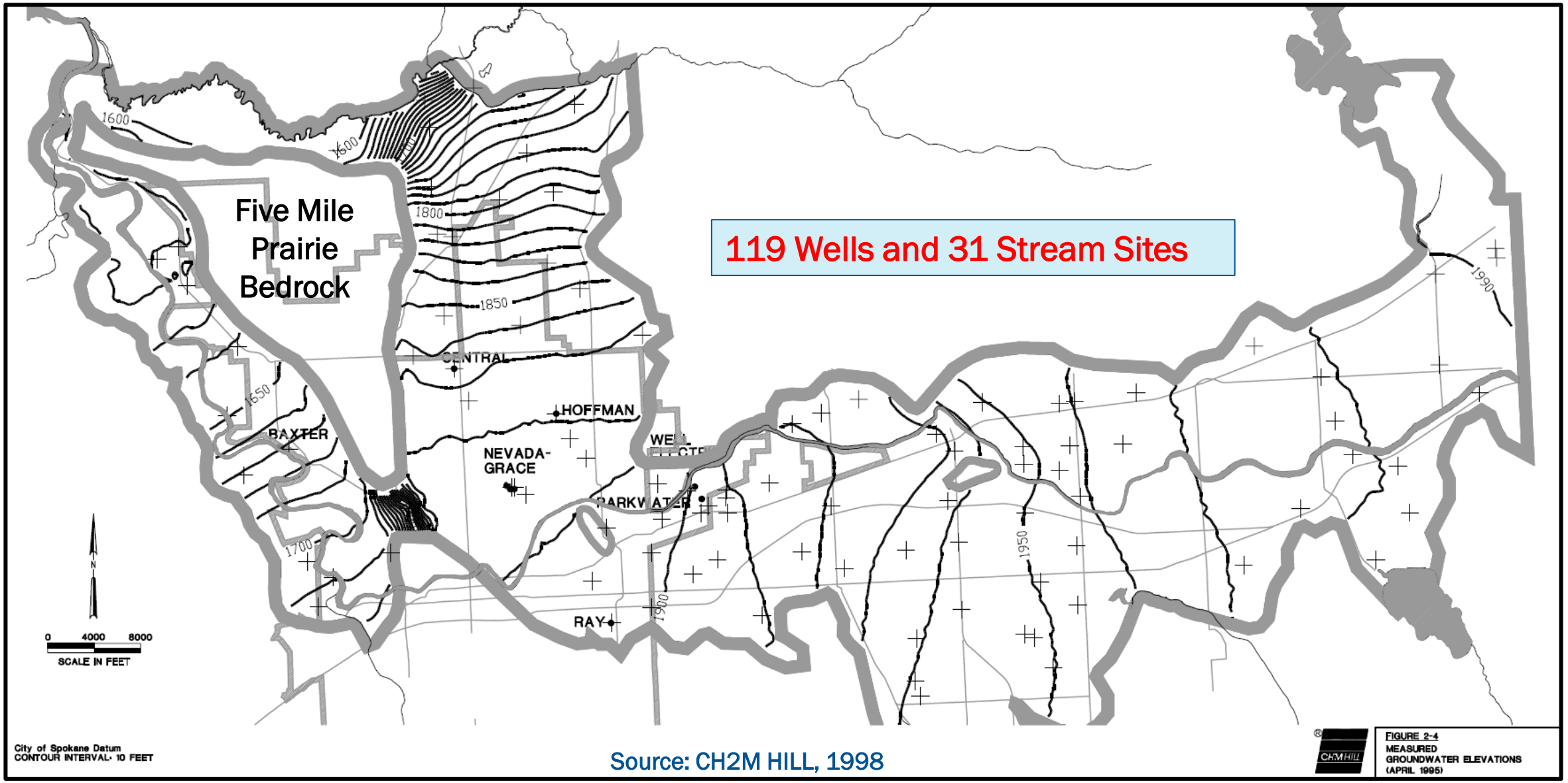
City of Spokane



Source: CH2M HILL, 1998

Synoptic Groundwater Elevation Map for Spring 1995

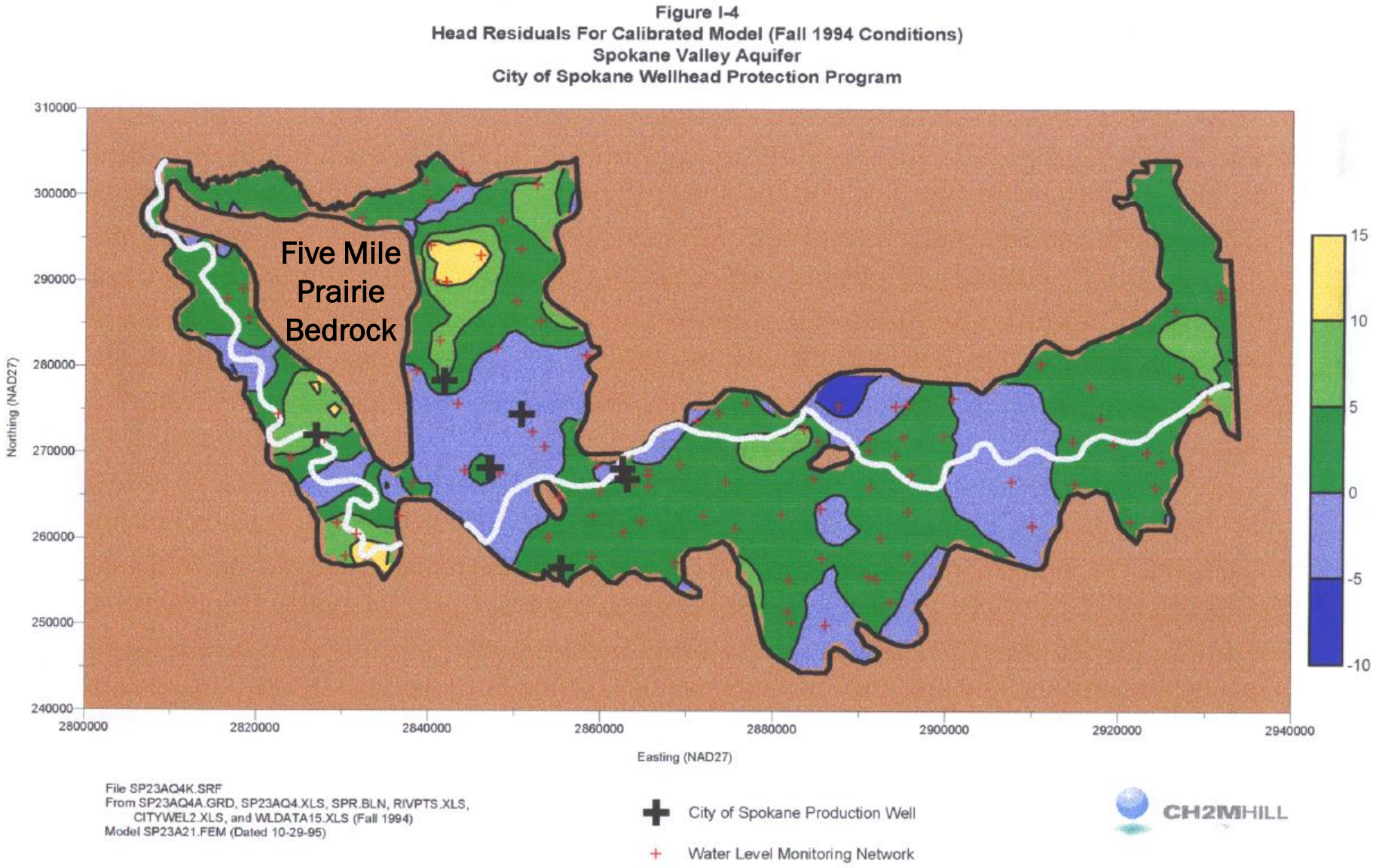
City of Spokane



Source: CH2M HILL, 1998

Model Calibration Error After Focused Field Investigations

City of Spokane, 1998



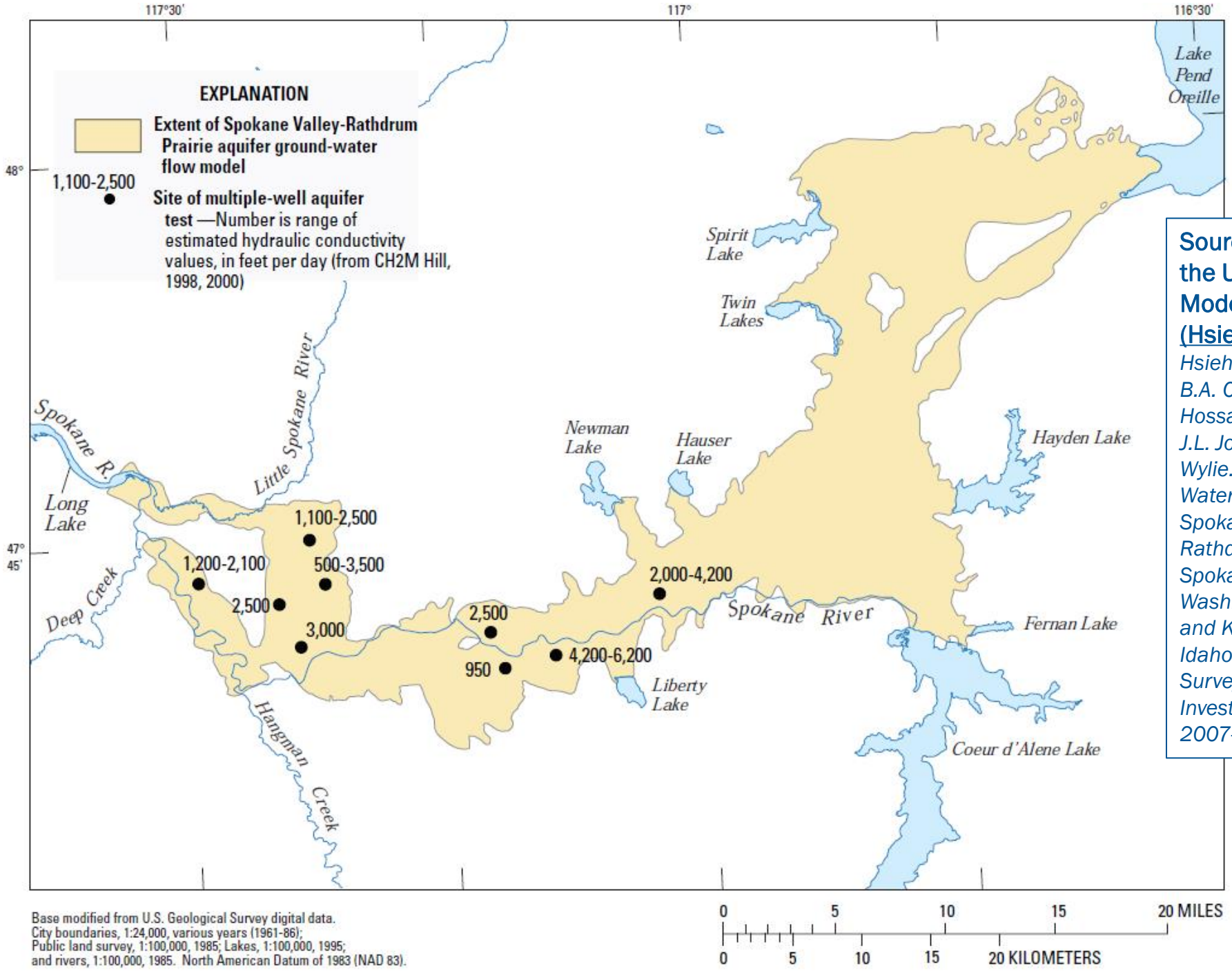
Source: Figure I-4 from the City of Spokane Wellhead Protection Report (CH2M HILL, 1998).

CH2M HILL. 1998. City of Spokane Wellhead Protection Program Phase 1 – Technical Assessment Report. Prepared in association with Dally Environmental, Fujitani Hilts and Associates, and SeisPulse Development Corporation. February 1998.

Feedback Loop 2: Hydraulic Conductivity of the SVRP Aquifer

- We know it's high. But just how high is it?
  - At the state line:
    - 7,000 ft/day (1998 estimate by CH2M HILL/City of Spokane)
    - 12,000 ft/day (1978 estimate by USGS)
    - 22,000 ft/day (2007 estimate by USGS)
  - Elsewhere:
    - 1,500 to 2,000 ft/day north of City of Spokane (CH2M & USGS)
    - 7,500 to 9,500 ft/day in east Spokane (2007 estimate by USGS)
    - 12,000-17,000 ft/day in Idaho (2007 estimate by USGS)

Locations of Multi-Well Aquifer Test Sites During the 1990s



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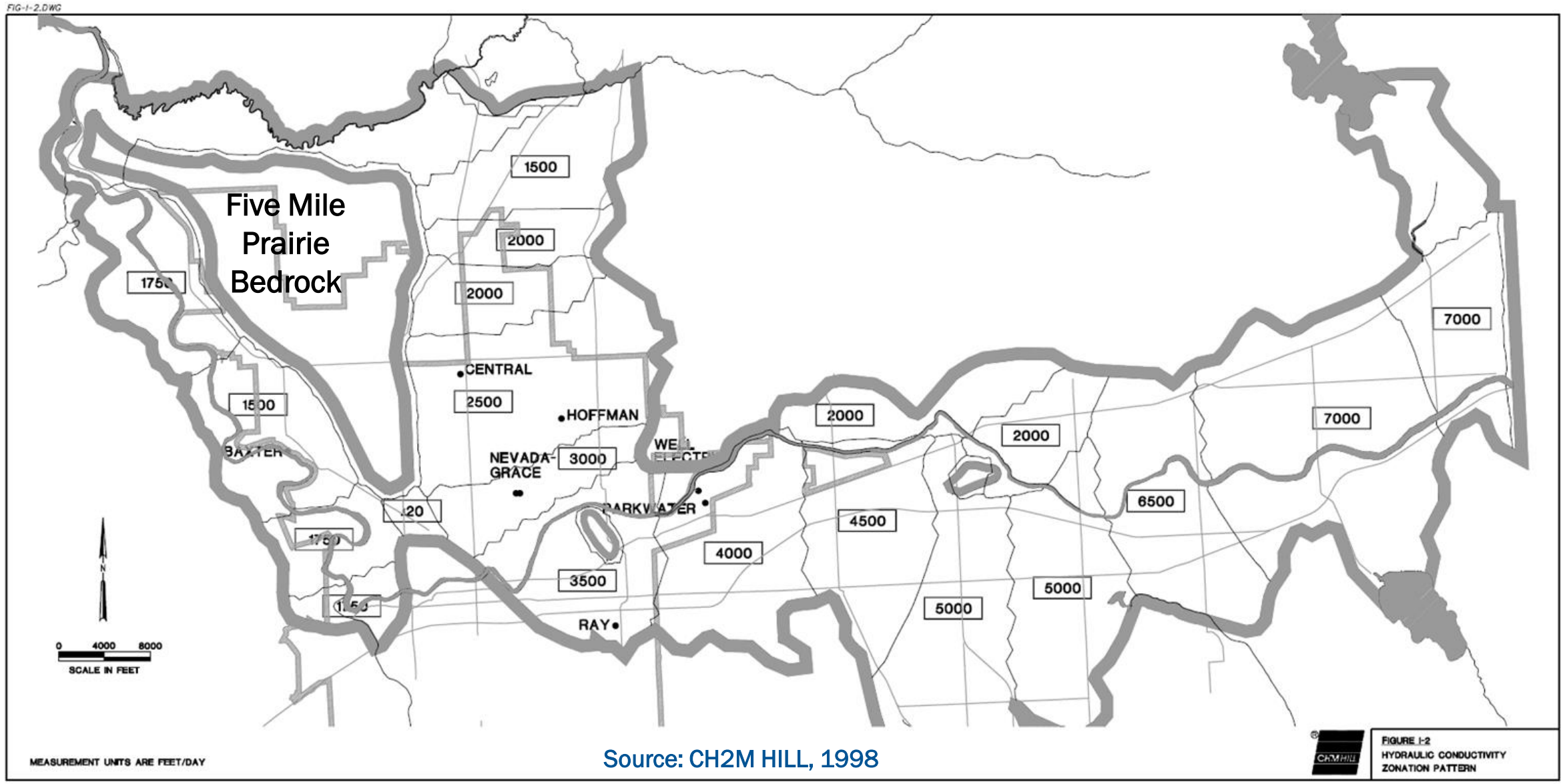
SVRP Hydraulic Conductivity

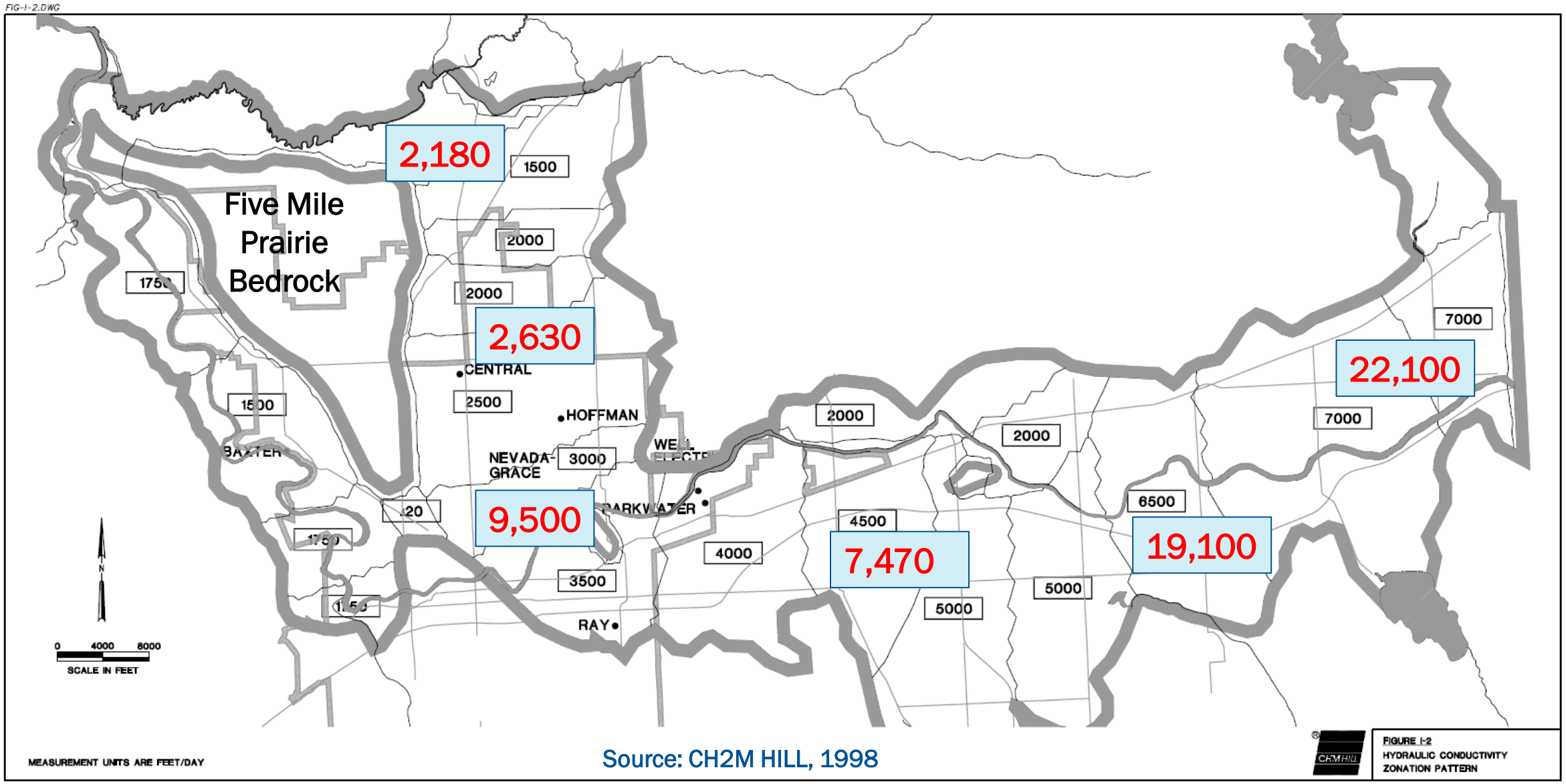
City of Spokane, 1998



Source: CH2M HILL, 1998

SVRP Hydraulic Conductivity

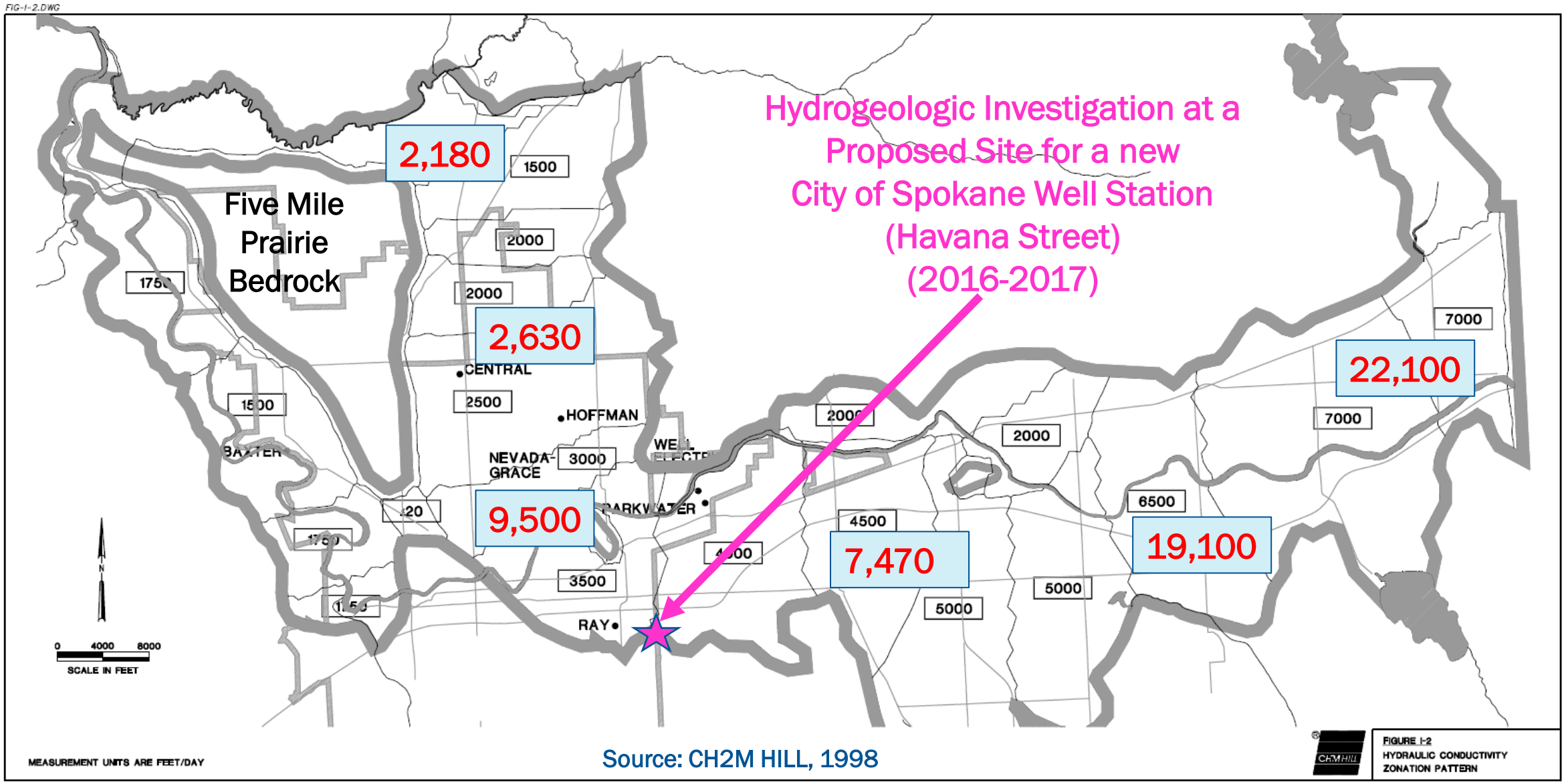
City of Spokane, 1998 versus USGS, 2007



Source: CH2M HILL, 1998

SVRP Hydraulic Conductivity

City of Spokane, 1998 versus USGS, 2007

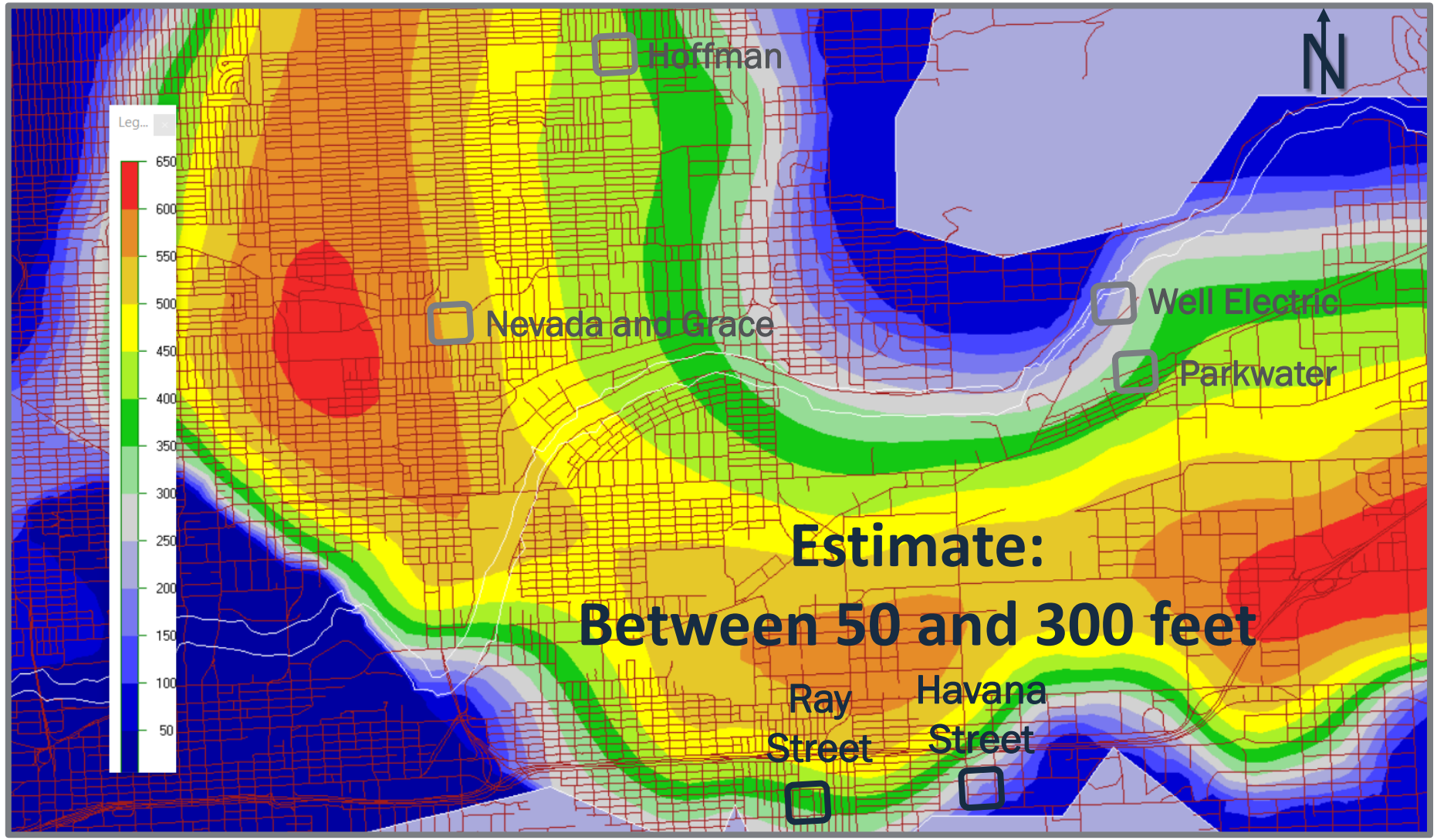


Source: CH2M HILL, 1998

The Situation at the Havana Site

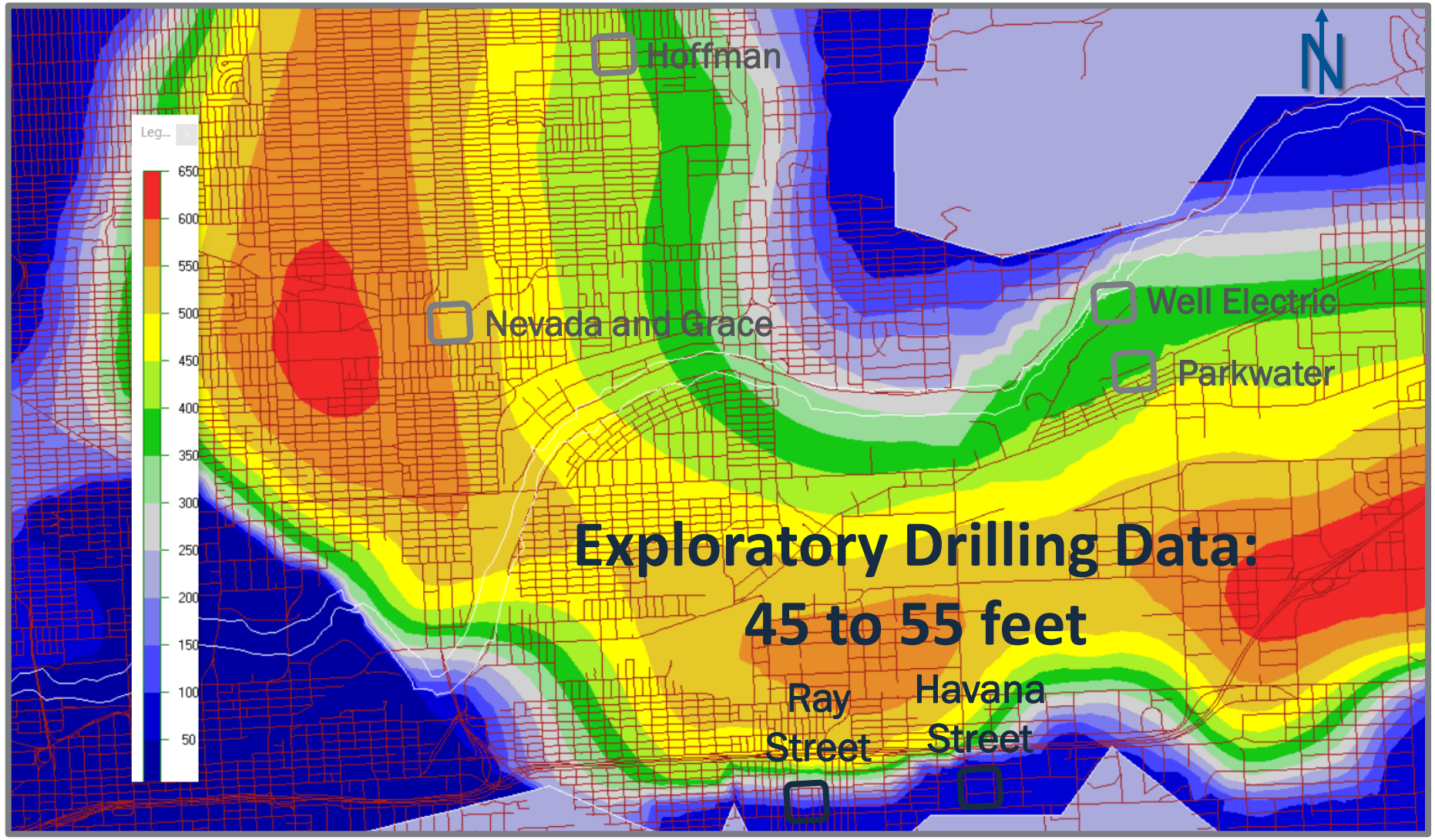
- City seeking new source to serve southern part of City
- Property owner willing to sell, but on short timeline
- Parcel size is small (¼ of a City block)
- Close to southern edge of aquifer
    - Is the aquifer thin, or is it thick?
    - Too low-permeability? Too low-yielding?
- Conclusion: Need to characterize the site-scale hydrogeology before a purchase decision is made

Aquifer Thickness



Source: GSI Water Solutions

Aquifer Thickness



Source: GSI Water Solutions

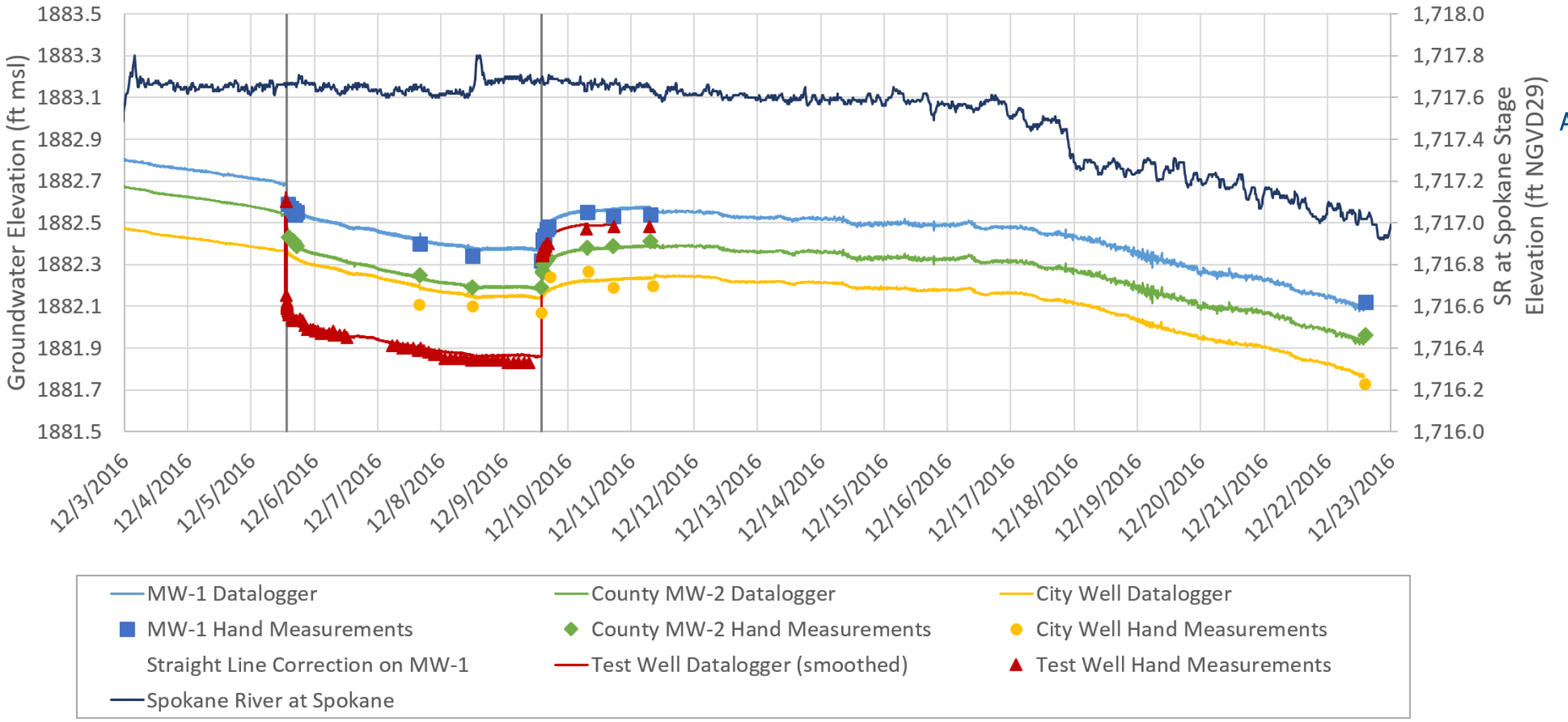
Core Samples

Core Samples Show Much Sand, Even Some Silt

Not Encouraging!

Havana Site Groundwater Elevations

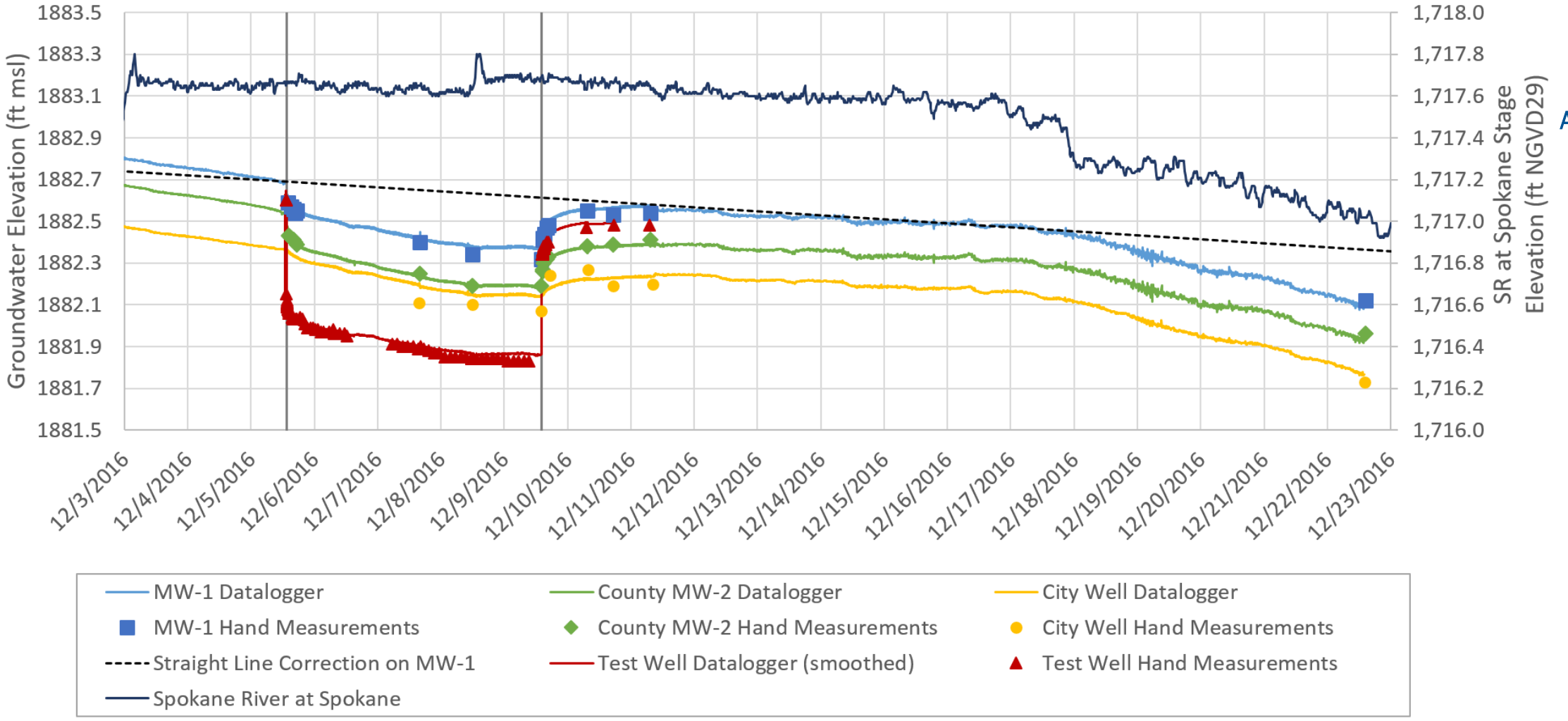
Before, During, and After 1,600 gpm Constant-Rate Aquifer Test



Source: Landau Associates, 2017

Havana Site Groundwater Elevations

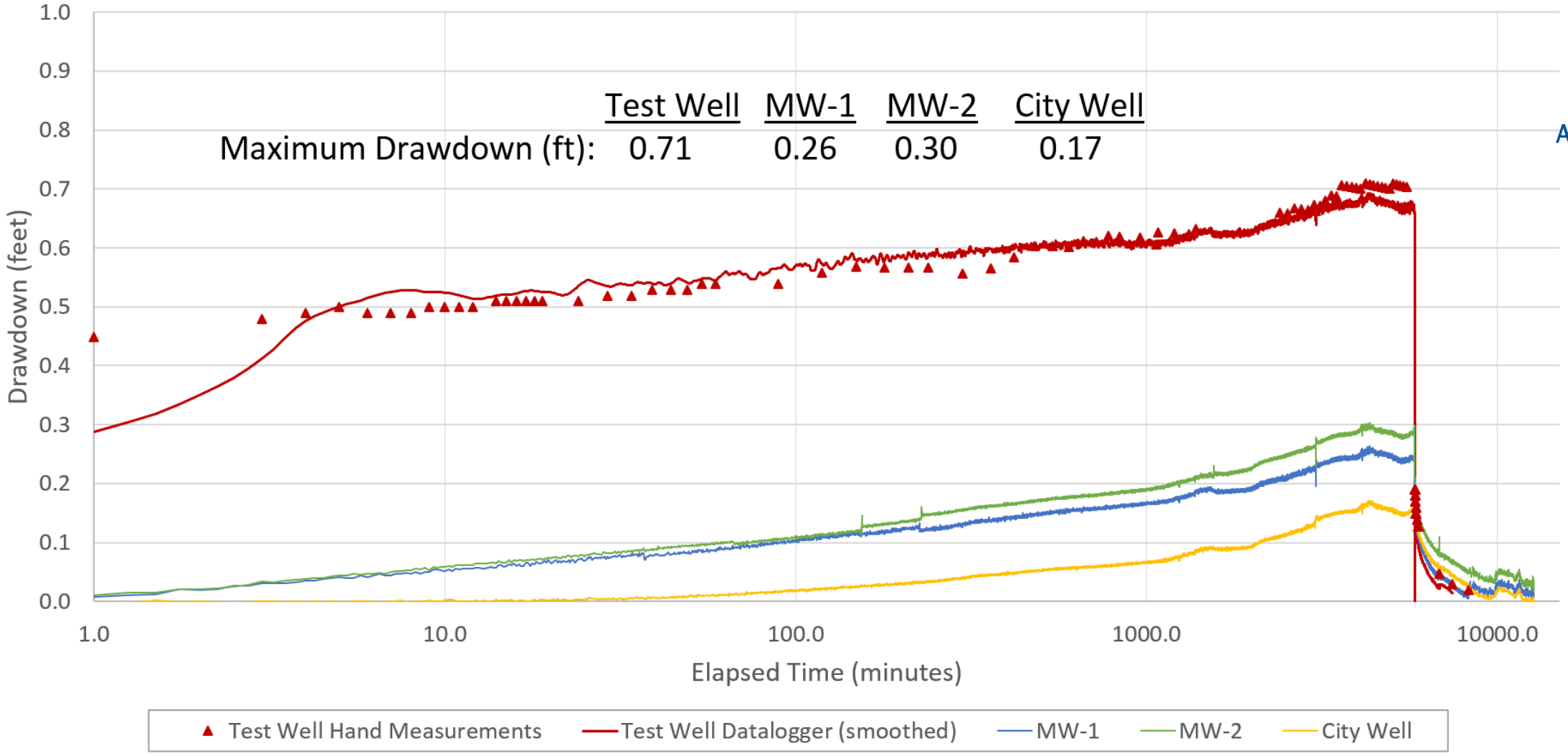
Calculating Background Trends in Groundwater Elevations



Source: Landau Associates, 2017

Havana Drawdowns in Test and Observation Wells

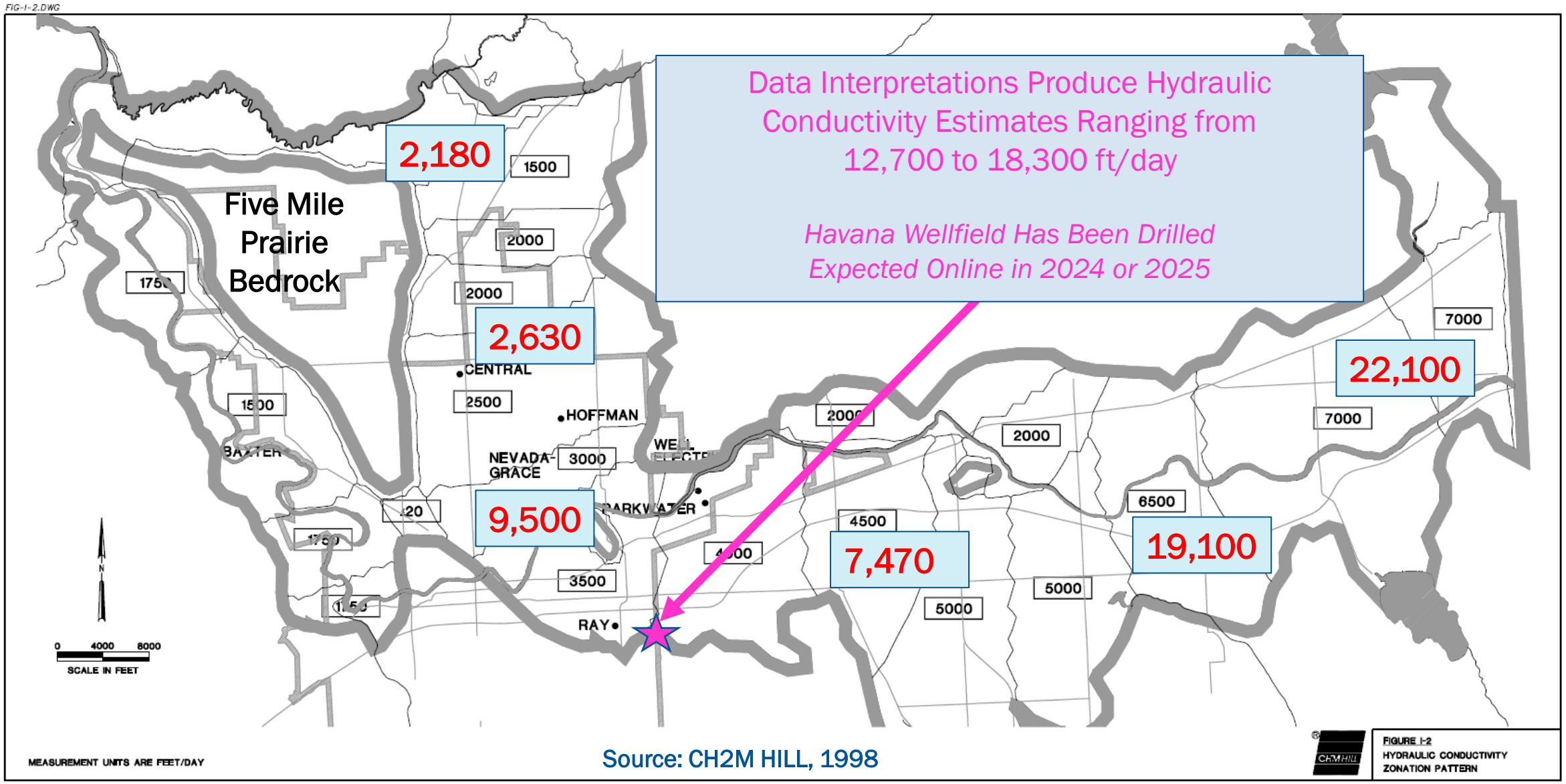
After Adjusting for Background Trends



Source: Landau Associates, 2017

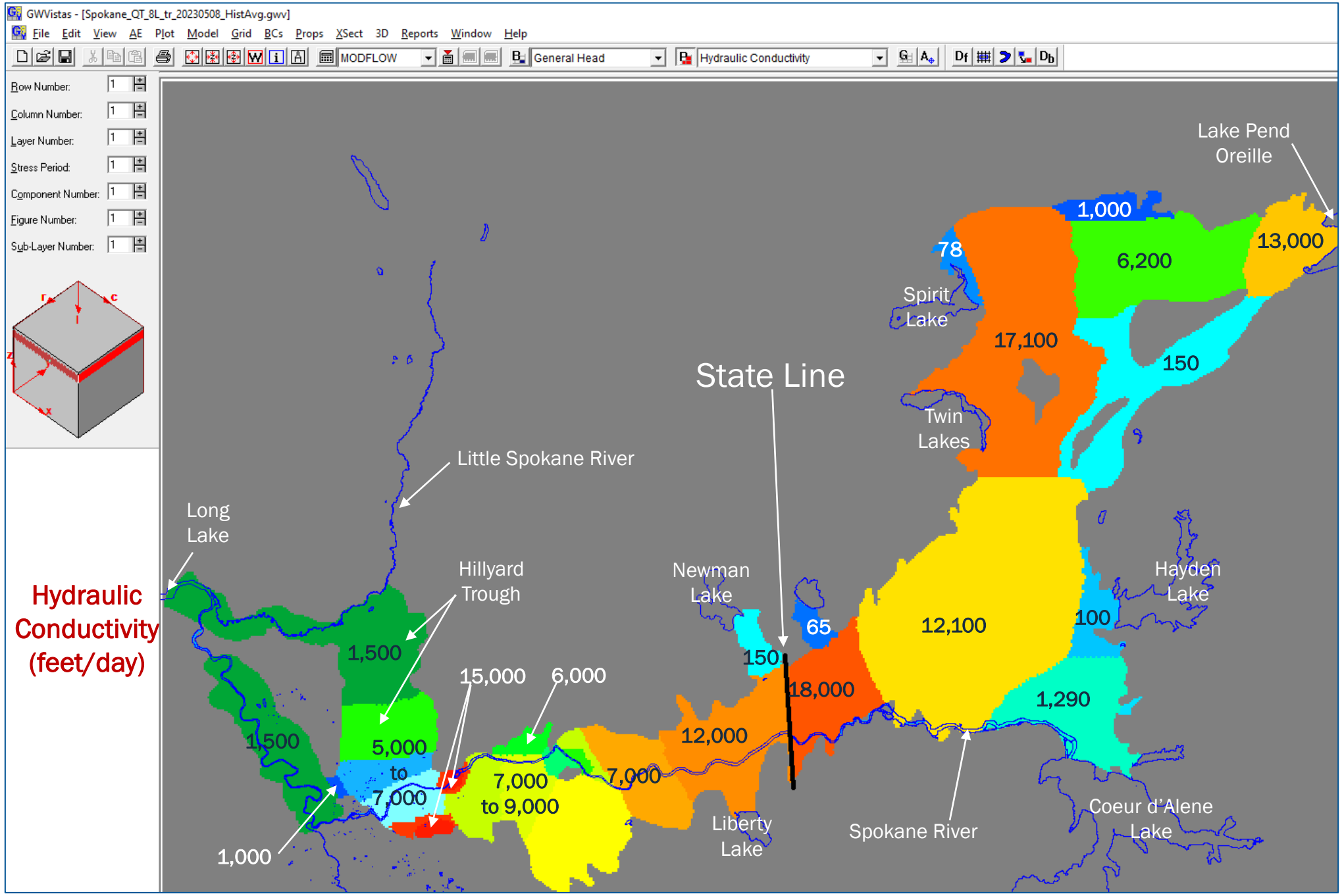
SVRP Hydraulic Conductivity

City of Spokane, 1998 versus USGS, 2007



Source: CH2M HILL, 1998

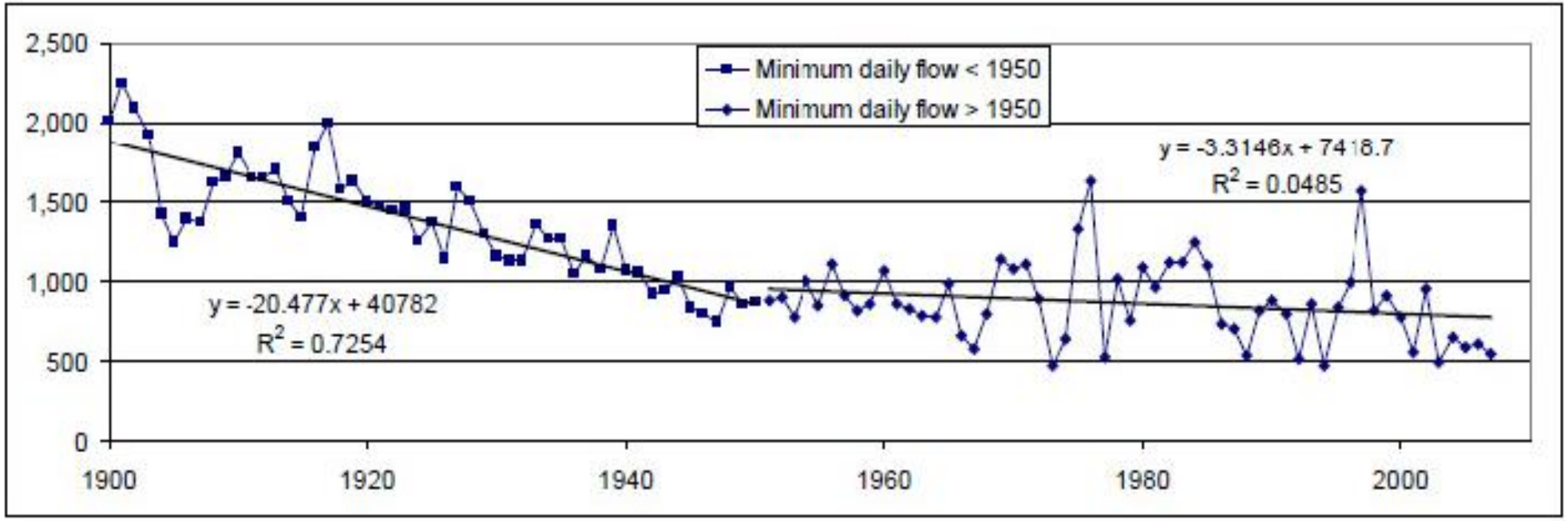
Newest City/SAJB Model (2023)



Source: GSI Water Solutions

Feedback Loop 3:
Declining Summer Streamflows in Spokane River

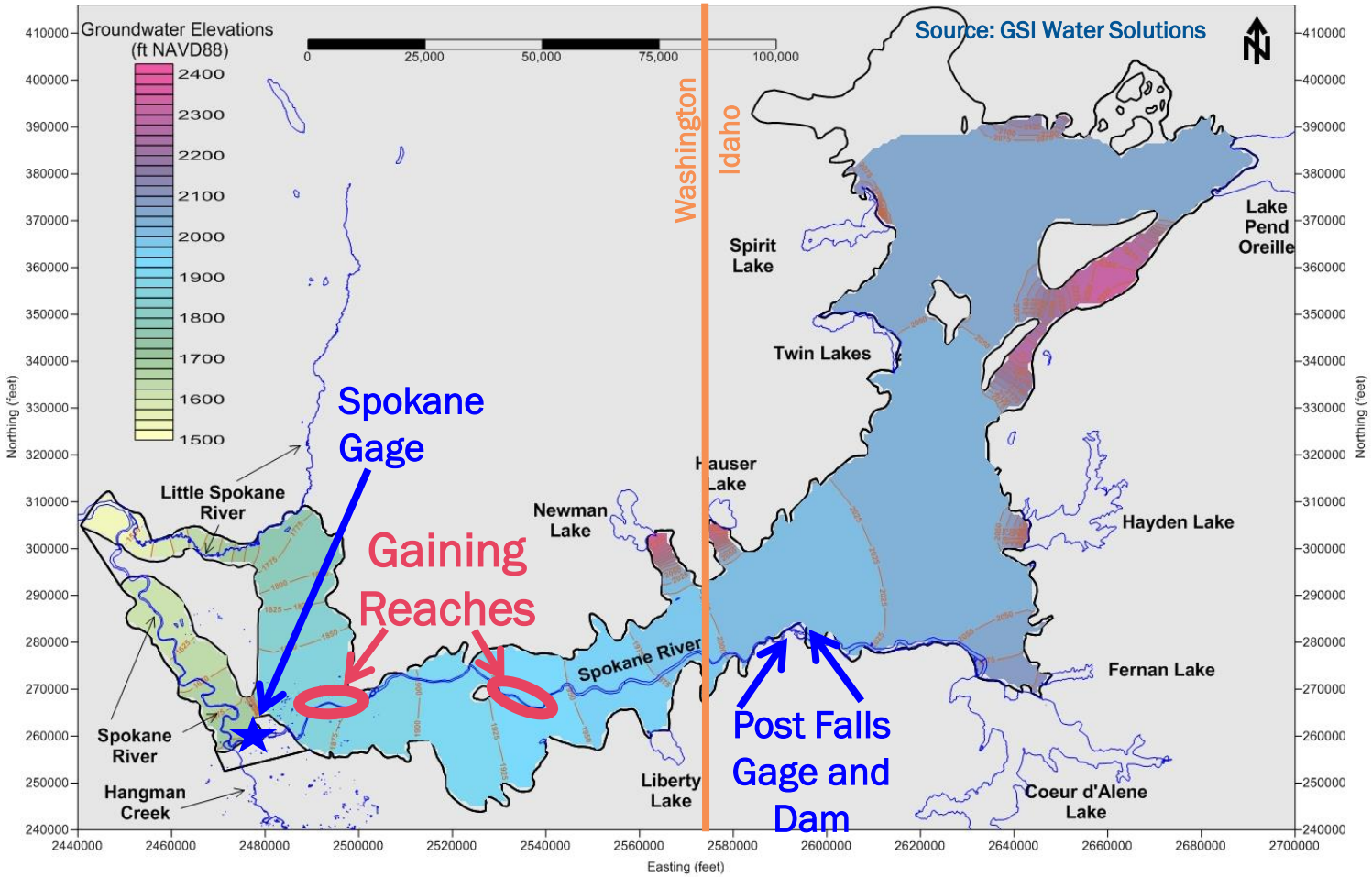
- Gage in downtown Spokane still shows declines
- USGS (2005) says watershed inflows are not declining



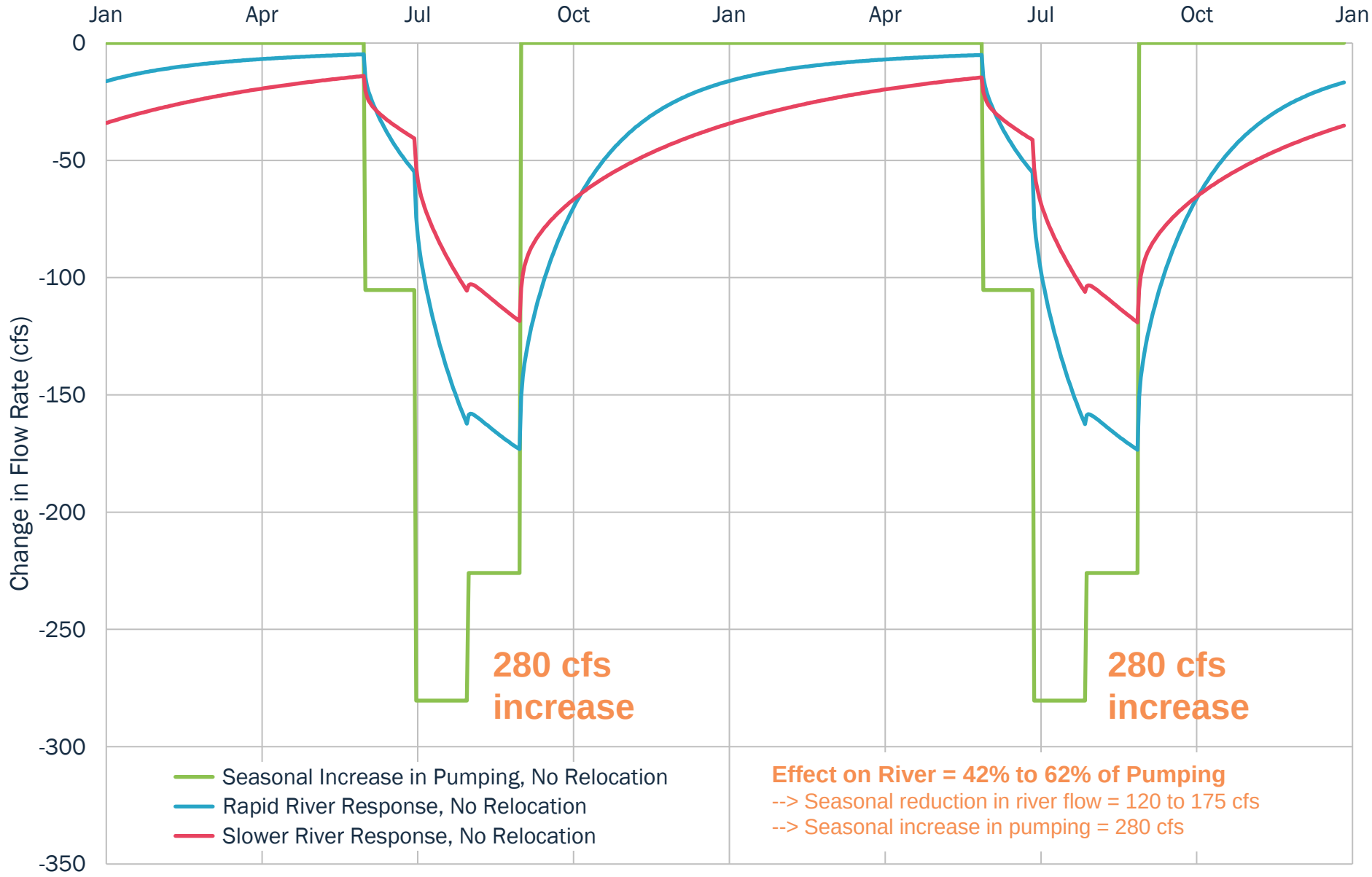
Source:
Figure 3 from Barber et al., 2011.
Barber, M.E., Md.A. Hossain, C.J. Poor, C. Shelton, L. Garcia, and M. McDonald. 2011. Spokane Valley-Rathdrum Prairie Aquifer Optimized Recharge for Summer Flow Augmentation of the Columbia River. Submitted to Washington State Department of Ecology Office of Columbia River, Yakima, Washington. April 1, 2011.

Feedback Loop 3: Declining Summer Streamflows in Spokane River

- If there is no change occurring in the upstream watershed (in and above Coeur d'Alene Lake), then what is occurring inside the SVRP's footprint to cause the declines?
  - Is groundwater pumping "drying up" the river?
  - Have groundwater pumping volumes continued increasing?
  - Are groundwater levels decreasing over time?



Modeling the Effect of Peak-Season Pumping by SAJB Purveyors on Spokane River Flows



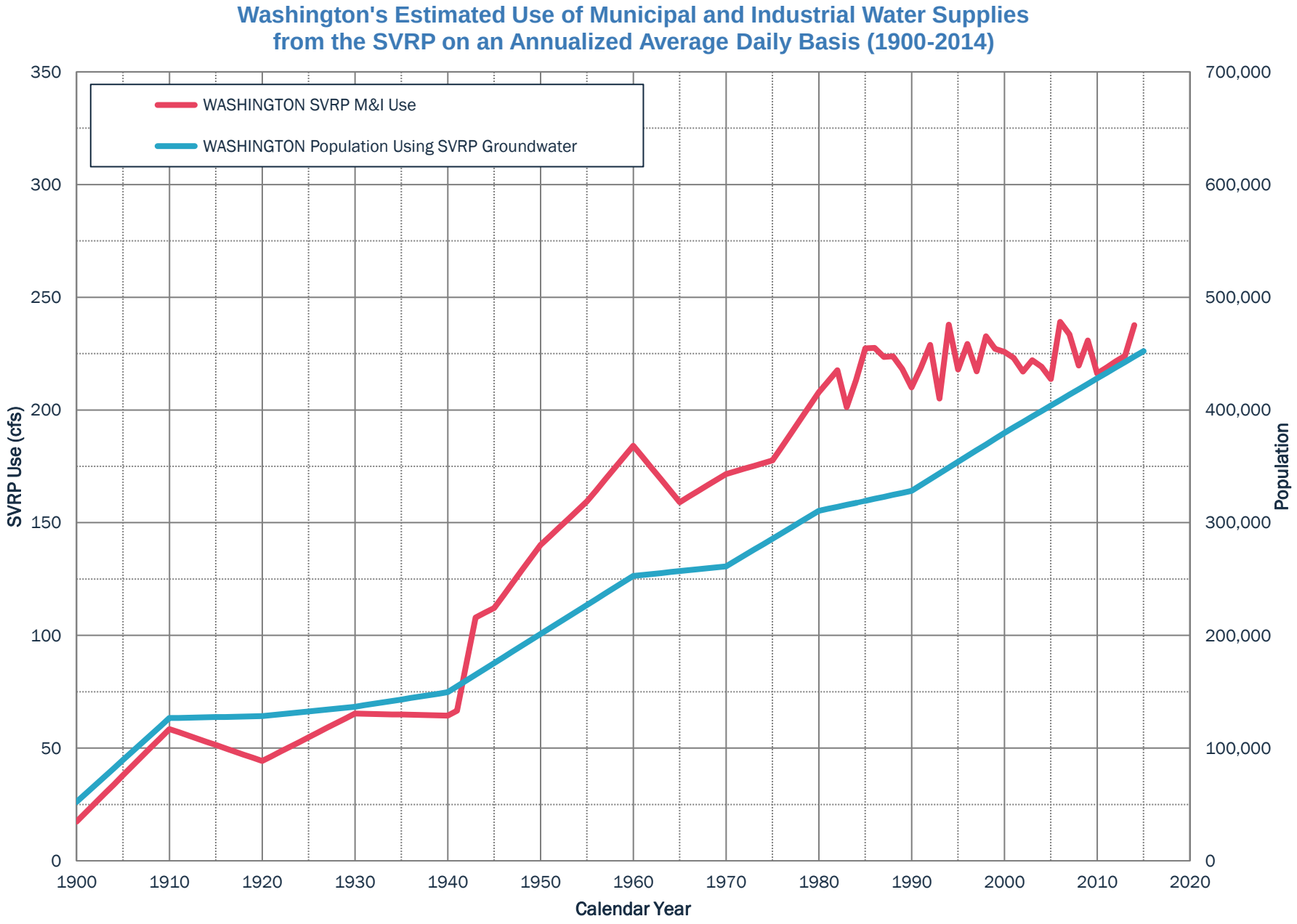
Source: GSI Water Solutions

Evaluating All Hydrologic and Water Use Processes Occurring Within and Upstream of the SVRP's Footprint

Which Hydrologic Processes Are Causing the Continued Decline in River Low Flows?

Processes Within the River-Aquifer System	Processes Upstream of the River-Aquifer System
Past agricultural diversions from river	Water level management at Coeur d'Alene Lake
Groundwater use	Watershed climate and runoff
Diversion of water around Spokane Gage (pumping above, wastewater return flows below)	
Effect of increased urbanization on fate of stormwater	
River water temperature (affects riverbed seepage rates east of Spokane)	

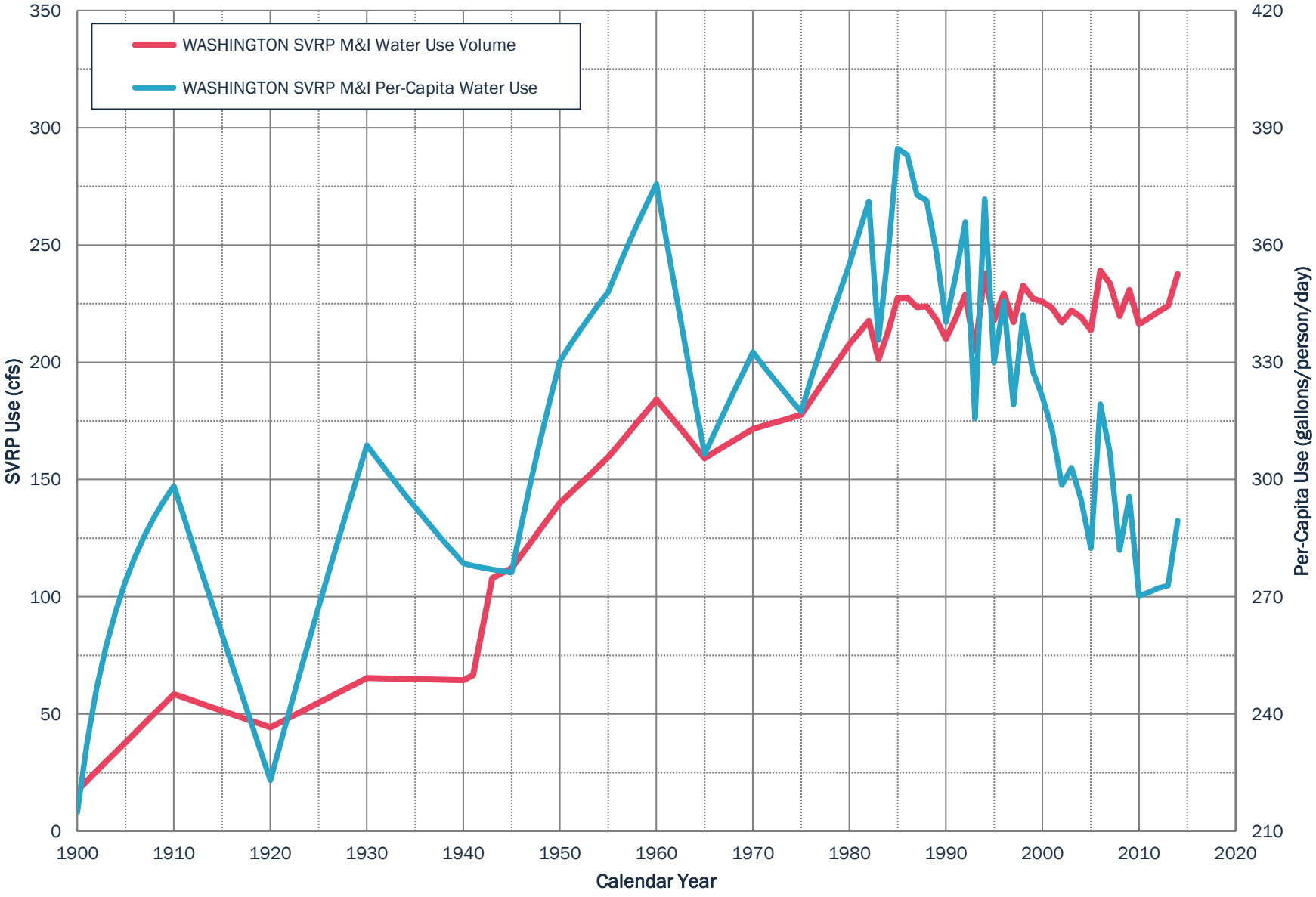
Evaluating the Uses of Water Supplies



Source: GSI Water Solutions

Evaluating the Uses of Water Supplies

Washington's Estimated Per-Capita Use of Municipal and Industrial Water Supplies from the SVRP on an Annualized Average Daily Basis (1900-2014)



Source: GSI Water Solutions

The Largest Agricultural Canal Diversion from the Spokane River (the Corbin Ditch)

Evaluating the Uses of Water Supplies

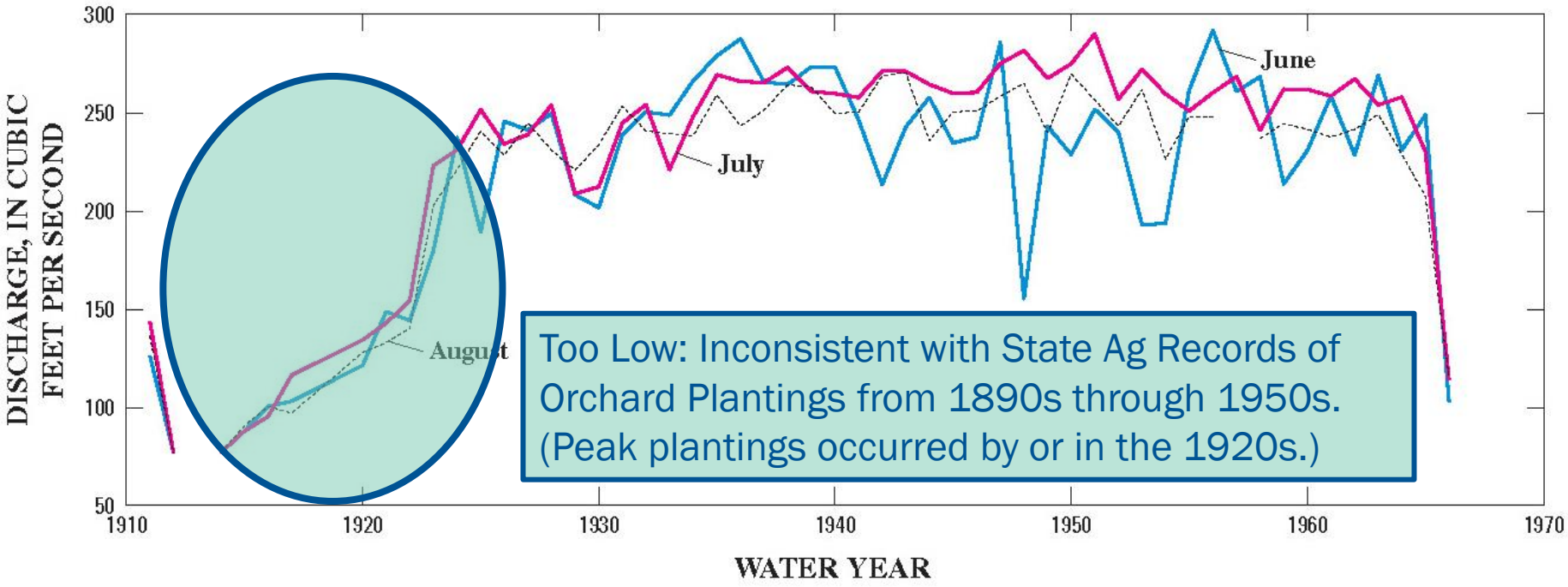


Figure 7. Monthly mean streamflows for the Spokane Valley Farms Canal at Post Falls, Idaho, June, July, and August, 1911–1966.

Source:

Hortness, J.E. and J.J. Covert. 2005.
Streamflow Trends in the Spokane River and Tributaries, Spokane Valley/Rathdrum Prairie, Idaho and Washington.
U.S. Geological Survey Investigations Report 2005-5005, 17 p.

Evaluating the Uses of Water Supplies

The Corbin Ditch in 2002

(West of its Headworks at Post Falls, Idaho; Looking Upstream to the East)

Source: Renk, N.F. 2002. *National Register of Historic Places Registration Form and Continuation Sheet: Spokane Valley Land and Water Company Canal.* Prepared by Flume Creek Historical Services. Photo #5 taken by Nancy F. Renk on June 12, 2002.

The Corbin Ditch Today at its Headworks in Falls Park

(City of Post Falls)

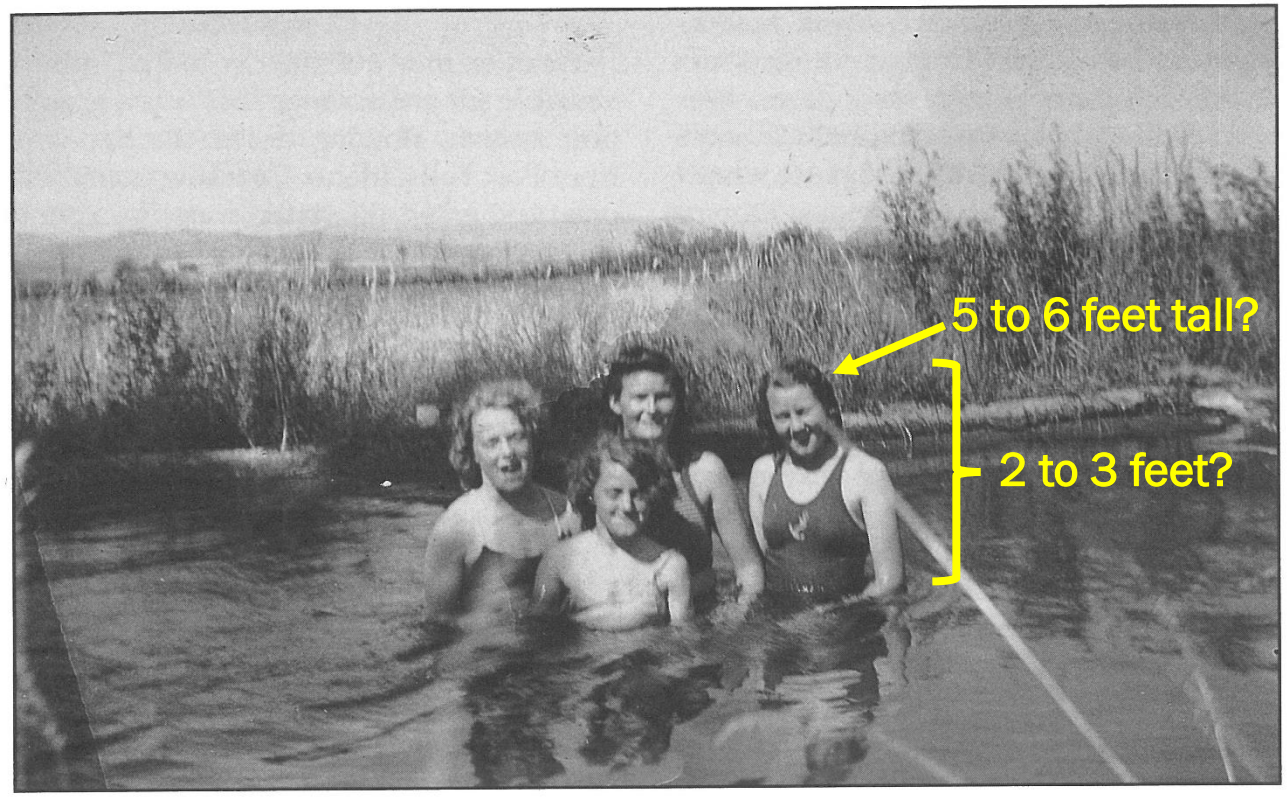
Source:
John Porcello/GSI Water Solutions
April 30, 2024

Source:
John Porcello/GSI Water Solutions
April 30, 2024

Evaluating the Uses of Water Supplies

The Corbin Ditch During Peak Ag Years

How Much Flow?



SWIMMING IN THE CORBIN DITCH, 1940
The "ditch" brought water from the Spokane River to irrigate the area north of the river. Much of the "ditch" was a three-by-five foot wooden aquaduct that crossed the Valley on frame trusses, dipping beneath roads in square concrete ducts. (Left to right) Sally (Sampson) Fox, Mary Lou Sampson (Rice), Mavis Smith (Baum), Betty (Sampson) Strong.
Courtesy of Sarah Fox.

Source: Boutwell, F. 1995. *The Spokane Valley: Volume 2, A History of the Growing Years, 1921-1945.* The Arthur H. Clark Company, Spokane, Washington, 224 pp.

Corbin Ditch Flow Estimate During Ag Years

Evaluating the Uses of Water Supplies

Manning's Formula (Open Channel Flow)

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [SI]$$

Variables and Results

S = channel slope = 200 feet / 34 miles
= 200 ft / 179,500 ft
= 0.0011

A = cross section area = 48 ft^2
(based on 3-ft to 4-ft water depth)

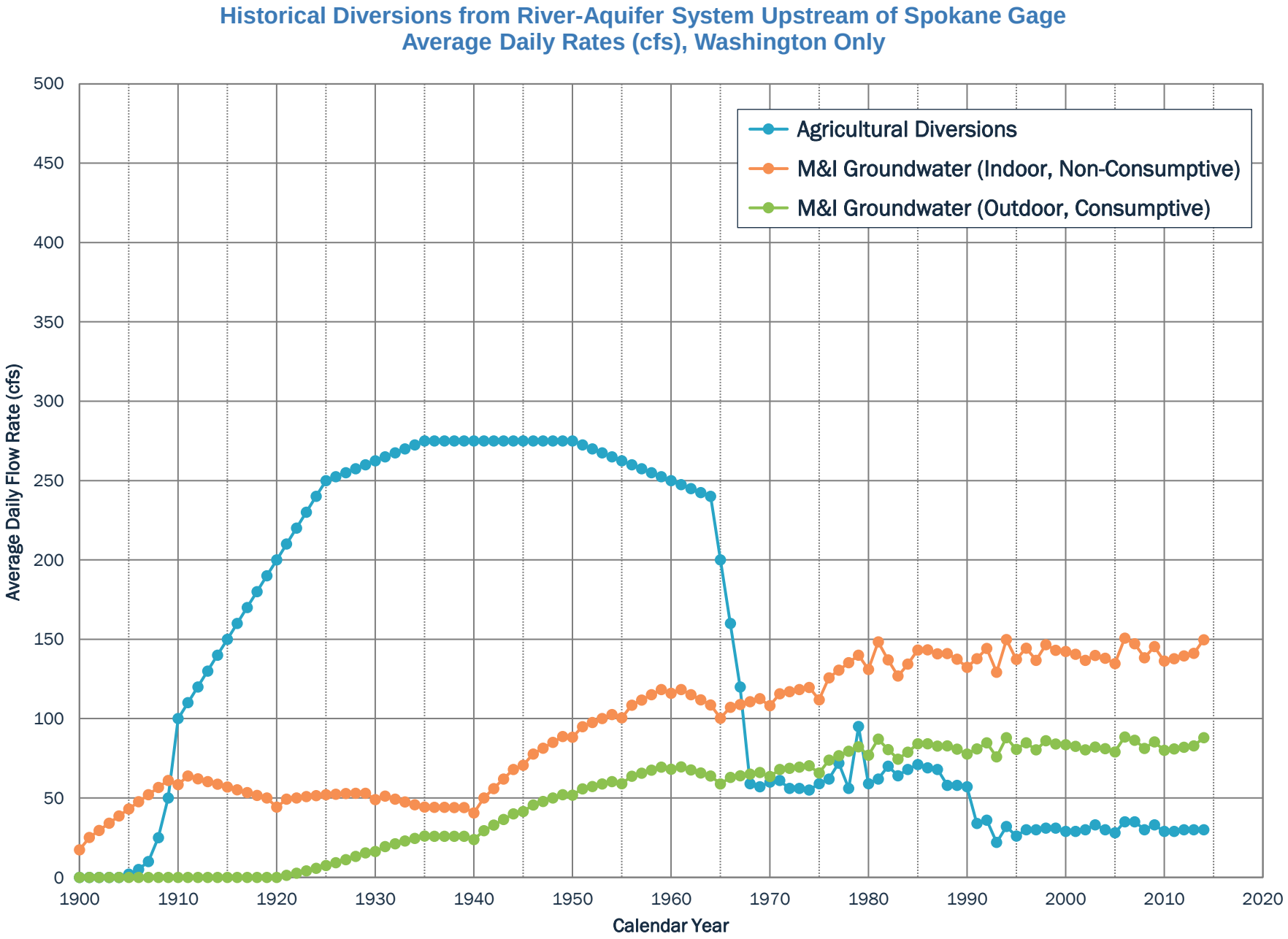
R = hydraulic radius
= A / wetted perimeter

n = Manning's roughness coefficient
= 0.03 for weedy earth channel
= 0.02 for a perfectly lined channel

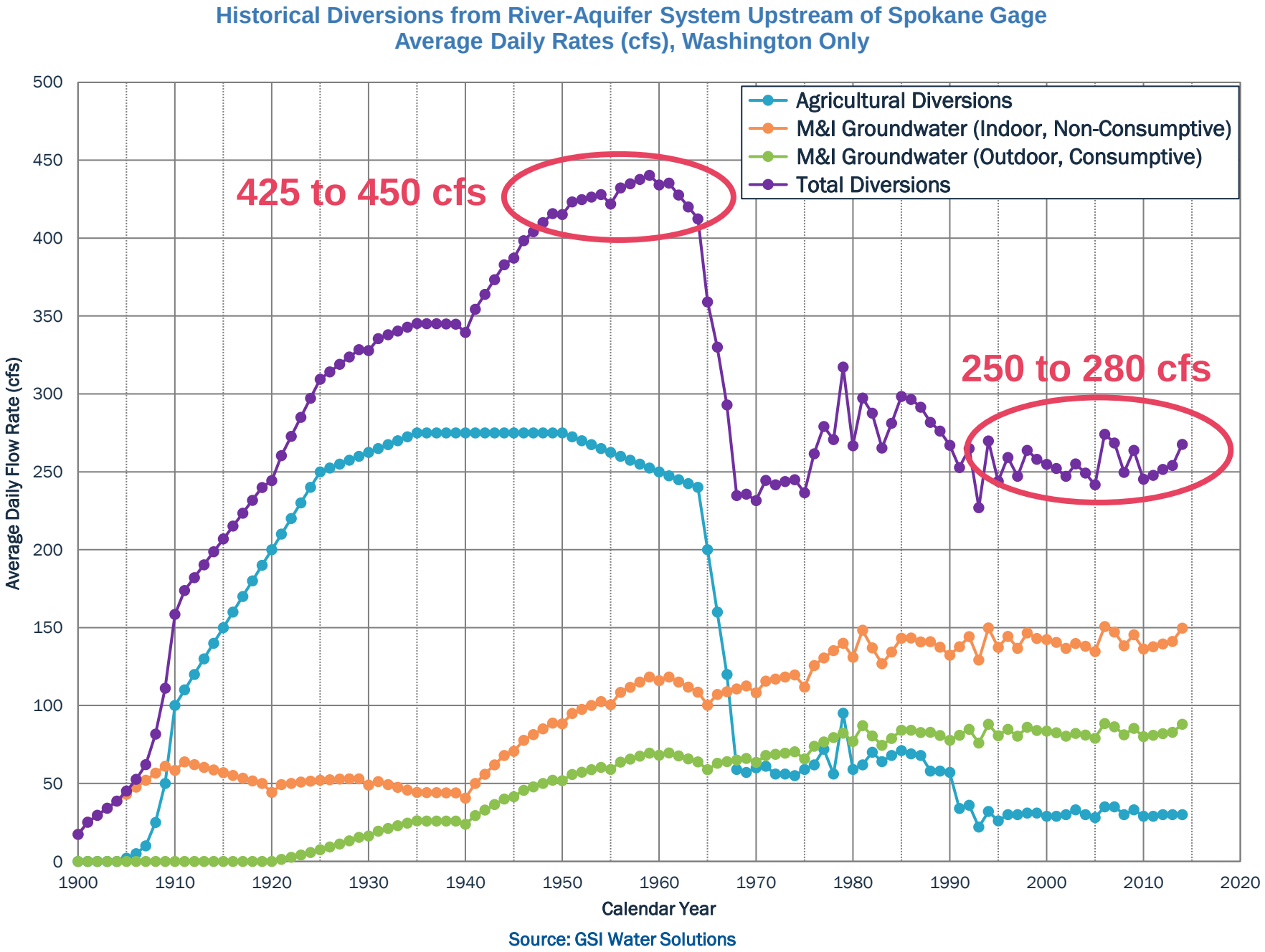
Q = 125 to 225 cfs (weedy earth channel)

Q = 185 to 330 cfs (perfectly lined channel)

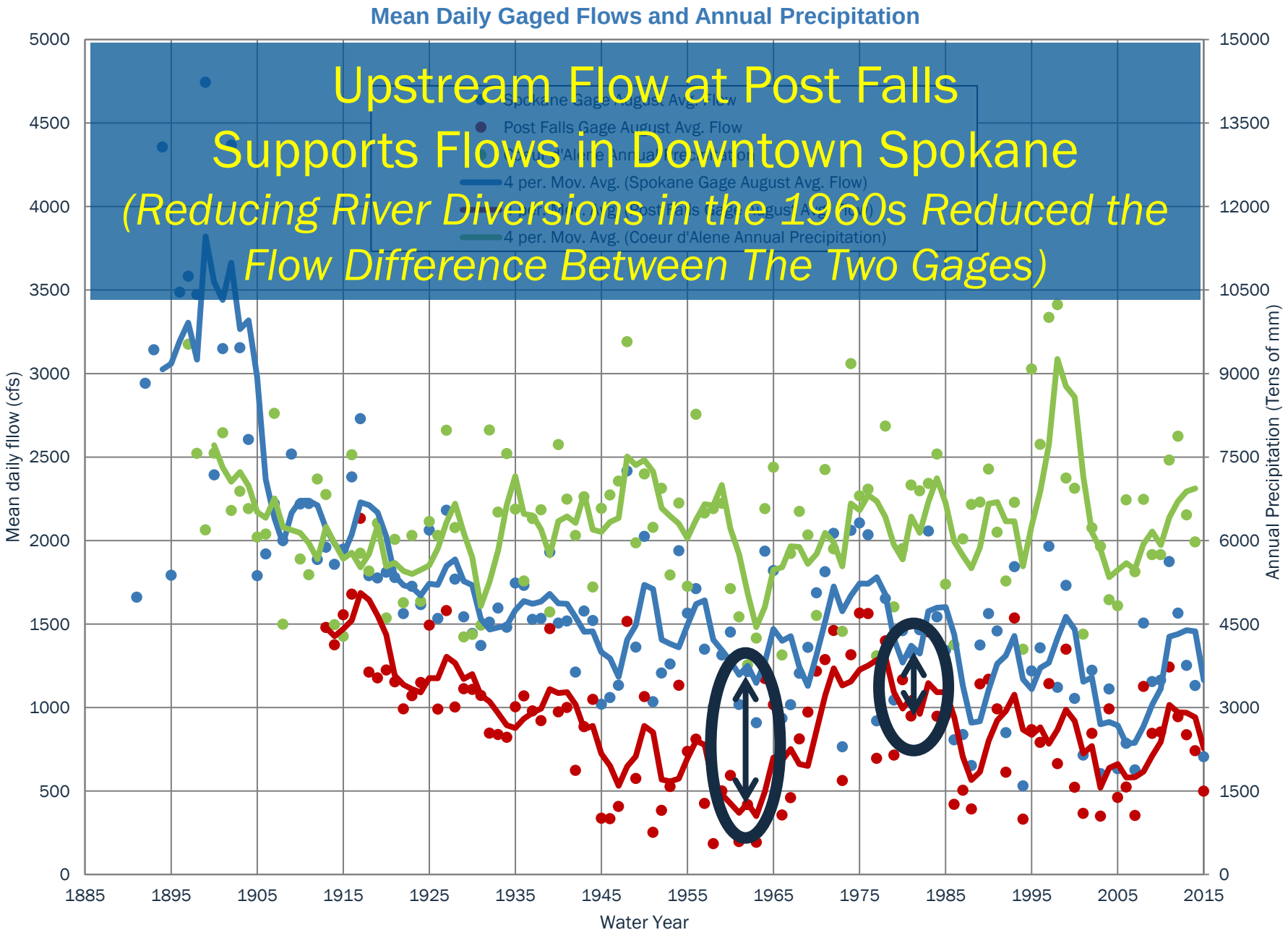
Evaluating the Uses of Water Supplies



Evaluating the Uses of Water Supplies



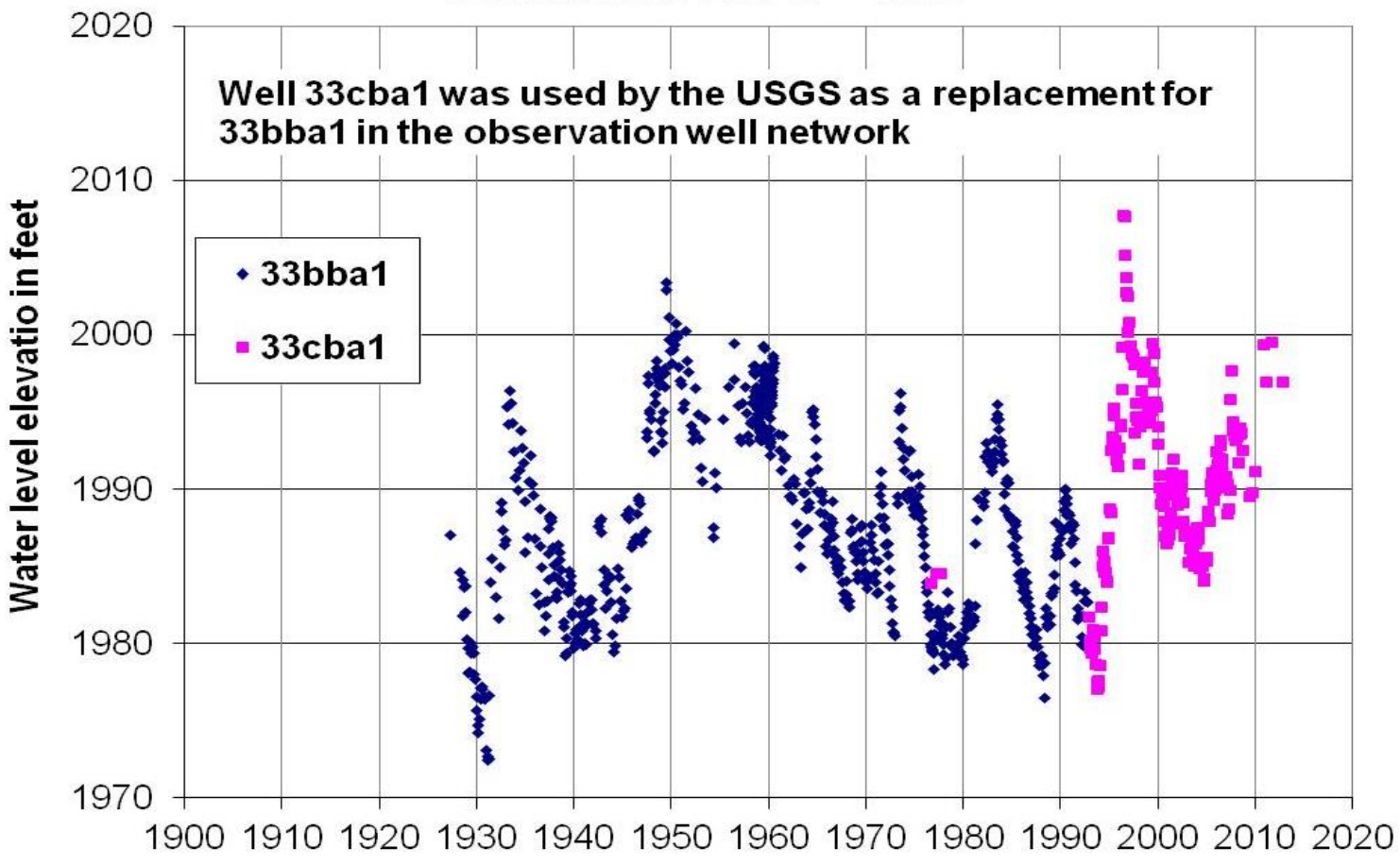
Evaluating Stream Flow Difference Between Post Falls and Downtown Spokane



Source: GSI Water Solutions

Checking Trends in Ground-Water Levels

Washington
Late 1920s through 2013

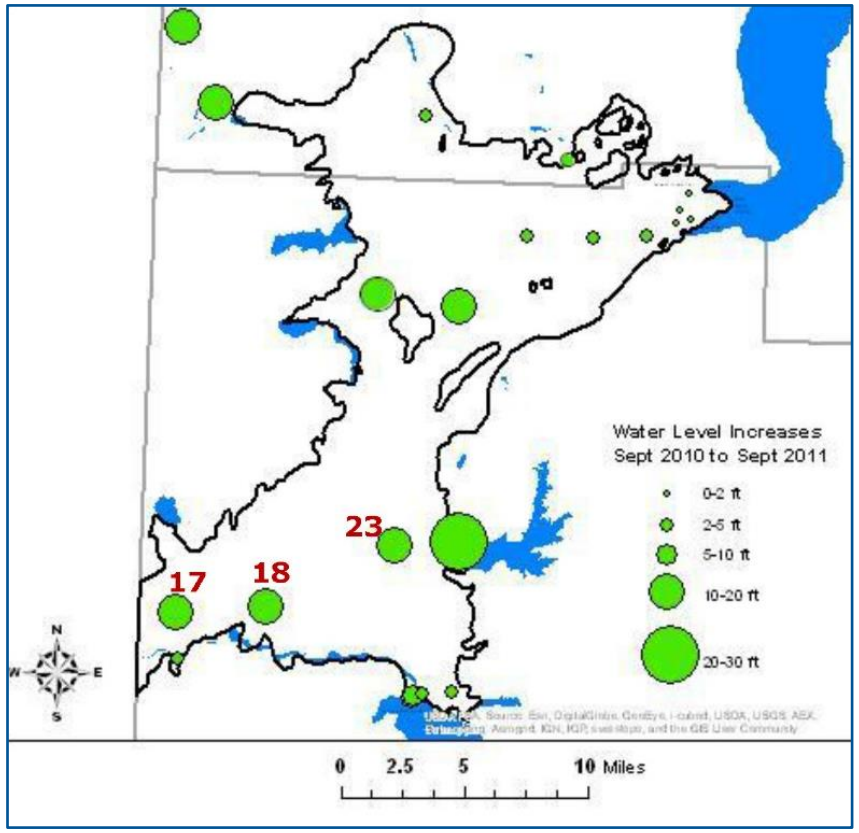


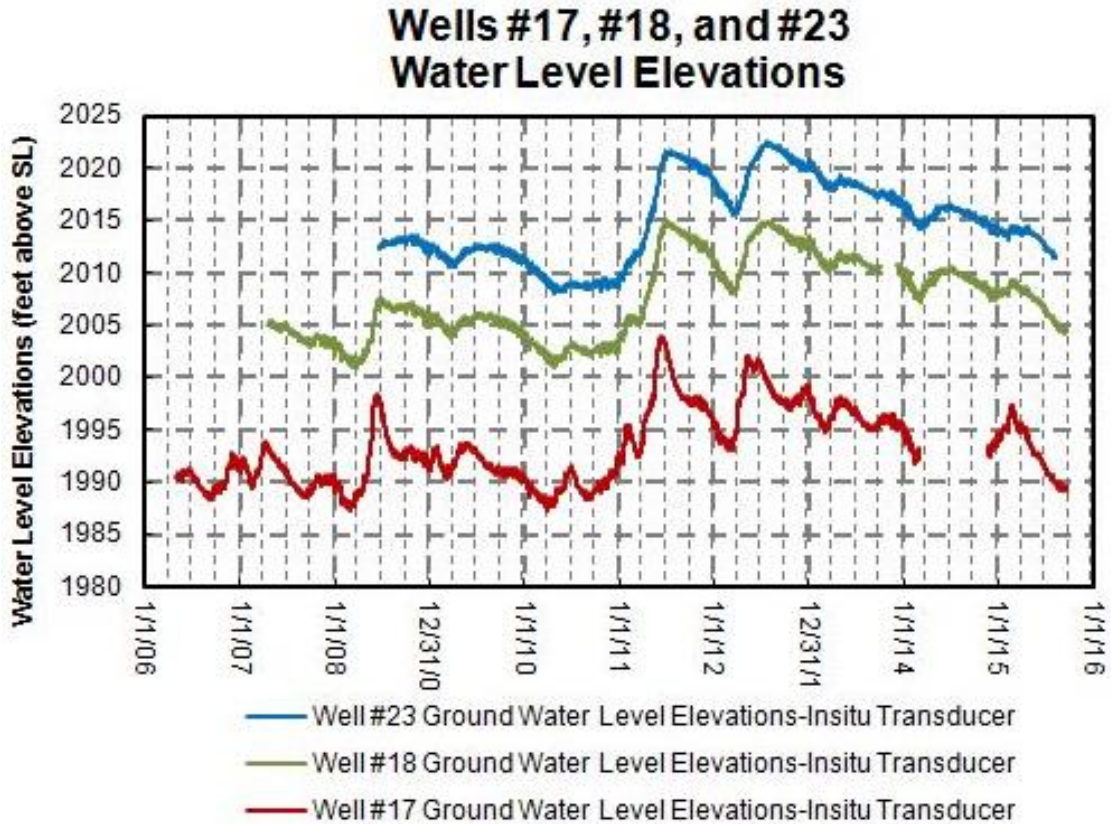
Hydrograph for Two Wells Near Post Falls, Idaho in T51N R5W

Source of Plot
Hydrogeology: Ground Water Pumping and River Flows, Part 1
Presentation by Ralston Hydrologic Services, Spokane River Forum, November 19, 2014

Idaho
2006-2015

Checking Trends in Ground-Water Levels





Source
Kenneth Neely, Idaho Department of Water Resources, February 2016

Evaluating All Hydrologic and Water Use Processes Occurring Within and Upstream of the SVRP's Footprint

Which Hydrologic Processes Are Causing the Continued Decline in River Low Flows?

Processes Within the River-Aquifer System	Processes Upstream of the River-Aquifer System
~~Past agricultural diversions from river~~ *(no longer have the direct diversions, nor the small return flow and high consumptive use)*	Water level management at Coeur d'Alene Lake
~~Groundwater use~~ *- Washington (no) - Idaho (minor)*	Watershed climate and runoff
~~Diversion of water around Spokane Gage (pumping above, wastewater return flows below)~~ *(minor)*	
~~Effect of increased urbanization on fate of stormwater~~ *(no changes to peaks or shape of river hydrograph)*	
~~River water temperature (affects riverbed seepage rates east of Spokane)~~ *(minor)*	

Feedback Loop 3:
Declining Summer Streamflows in Spokane River

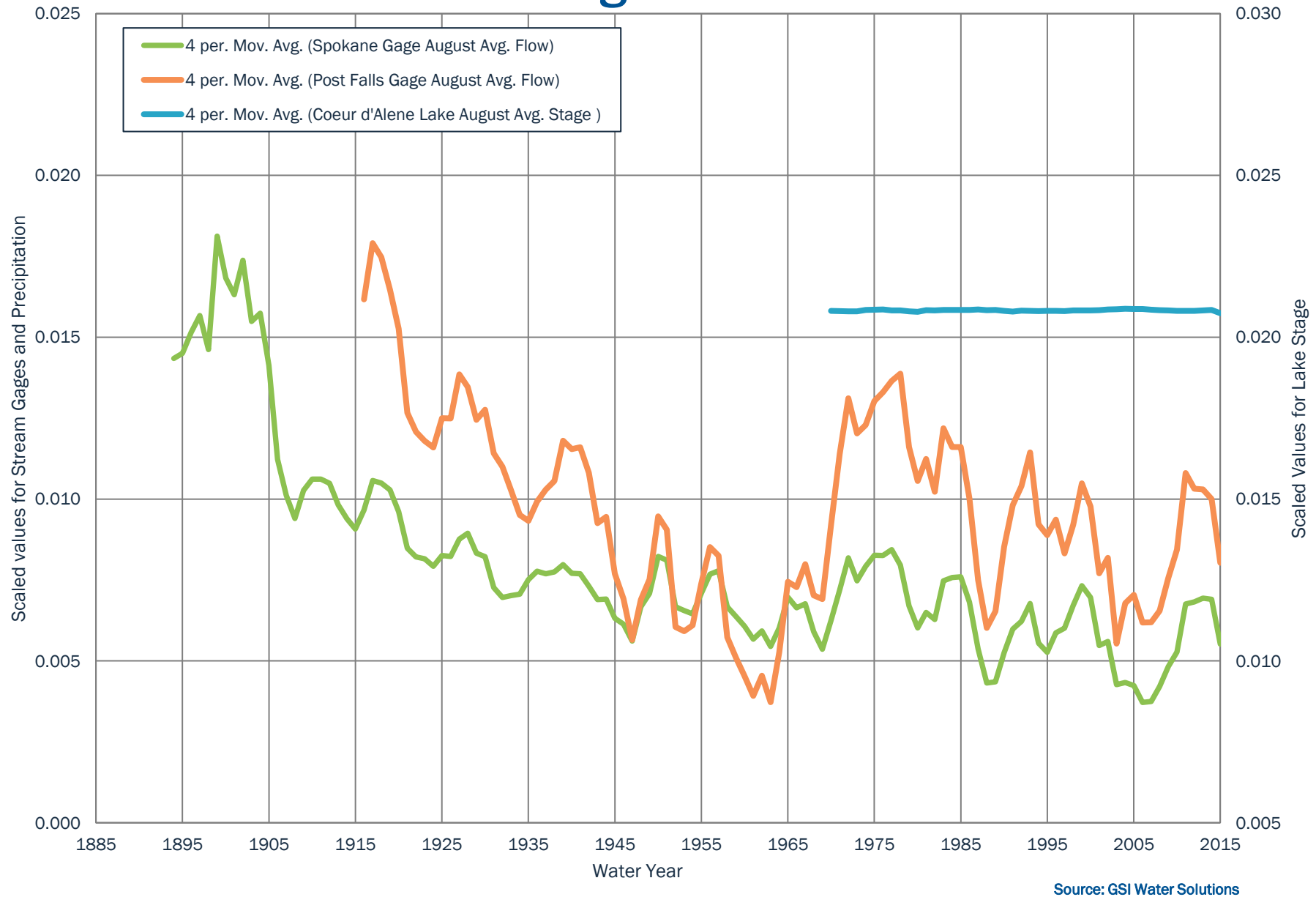
Feedback Loop 4:
Finding Something We Were Told Wasn't Occurring

- What is going on in or above Coeur d'Alene Lake?
  - The 2005 USGS study used data from 1968 through 2002
  - But it's 2016, so we have data through the spring of 2015

Variability in Summer Hydrology

River Flows and Stage of Coeur d'Alene Lake

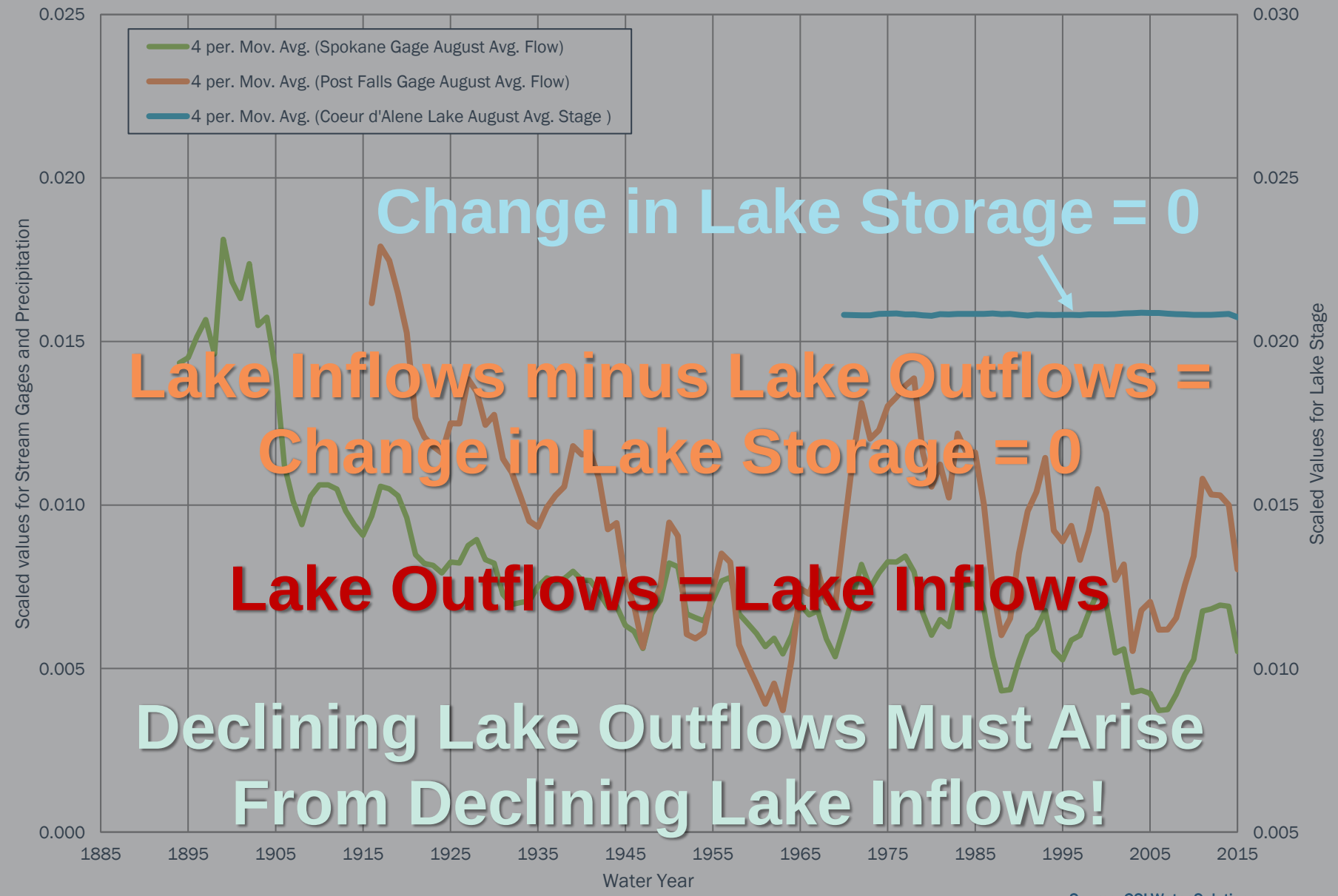
Using Scaled Statistics to Examine Degree of Variability



Source: GSI Water Solutions

Identifying the Causes of the Streamflow Declines

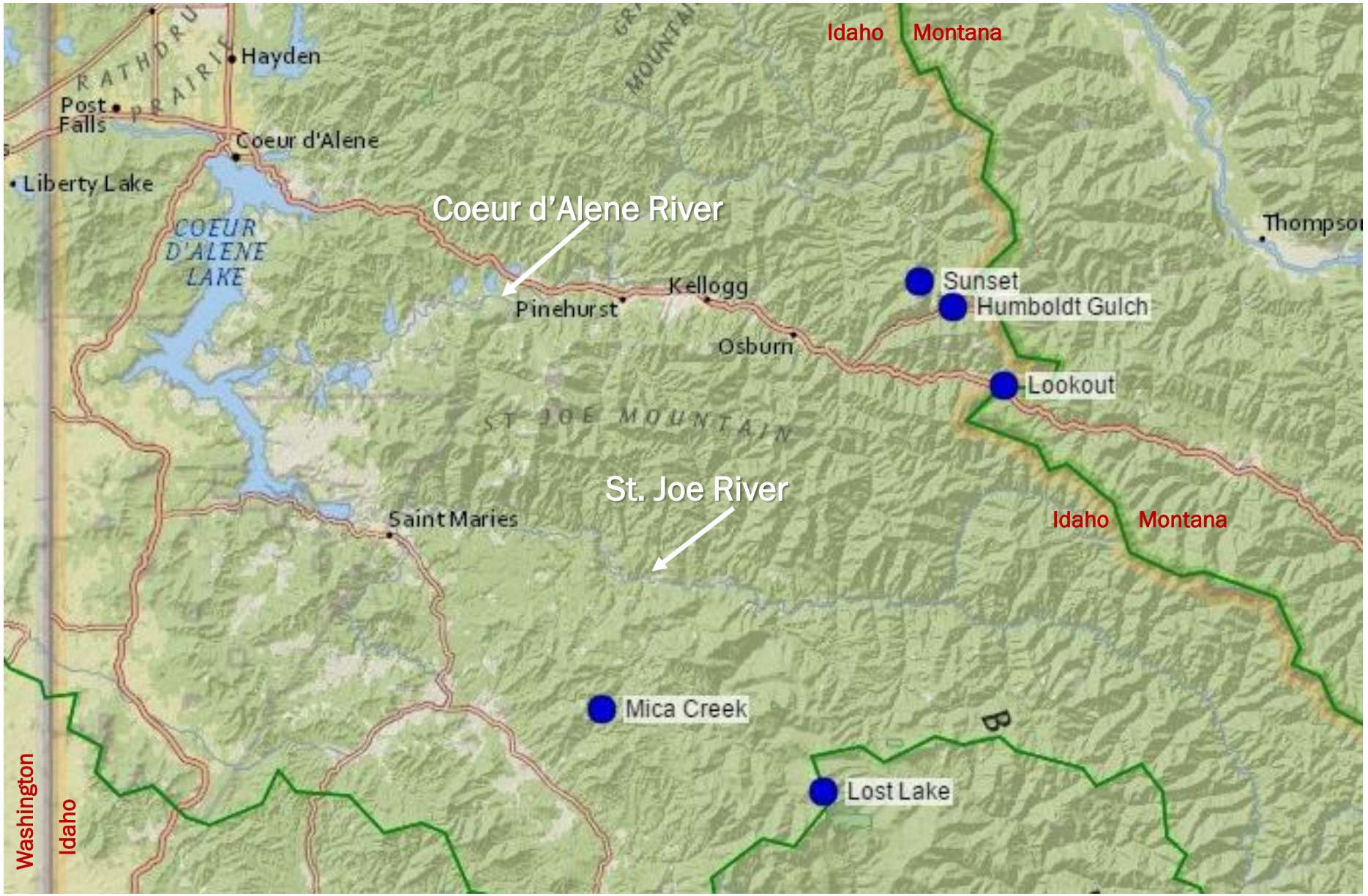
Using Scaled Statistics to Examine Degree of Variability



Source: GSI Water Solutions

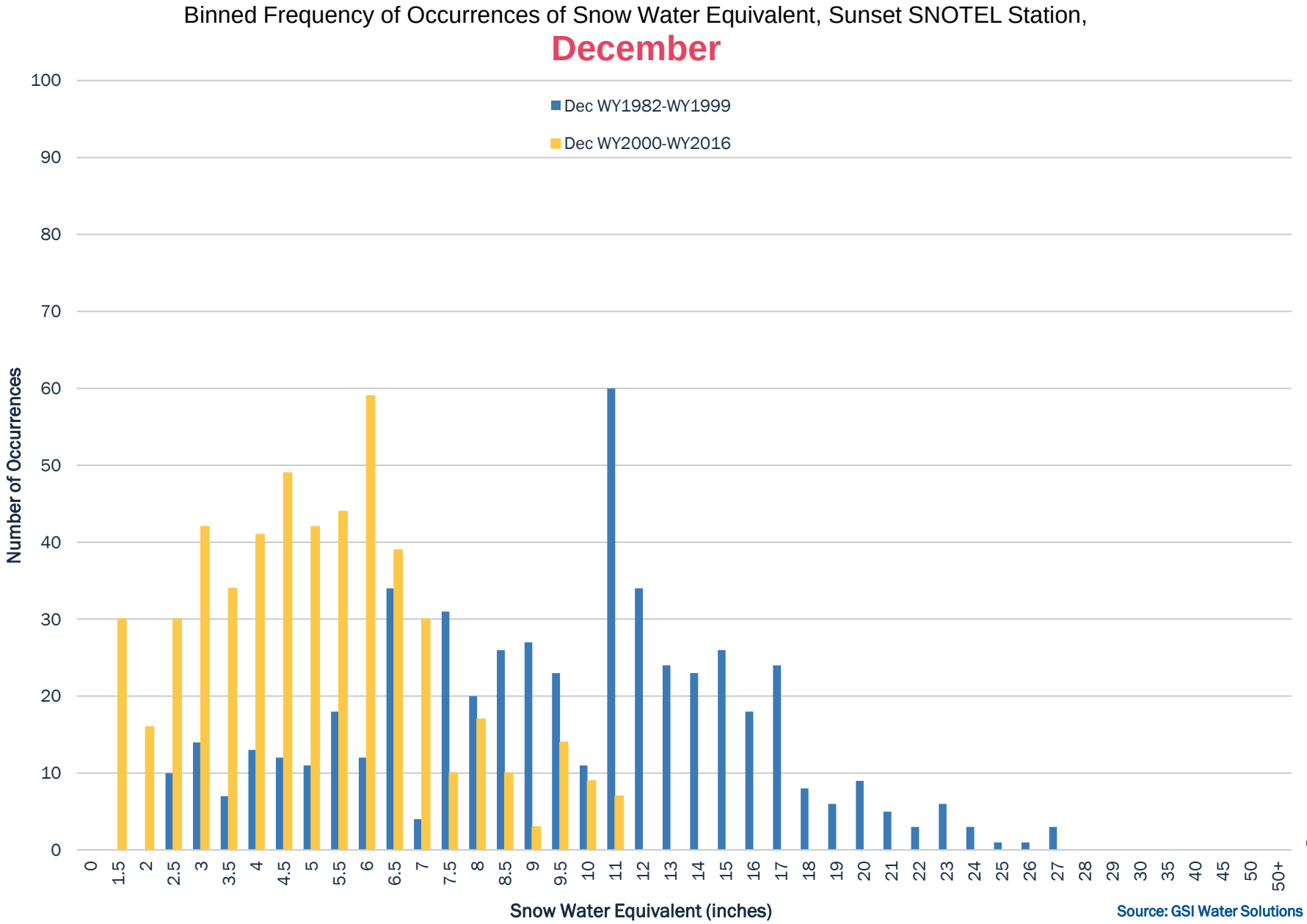
Analyzing SNOTEL Data in the Watershed

Examining the Watershed



Examining the Watershed

Trends In Snow Water Equivalent



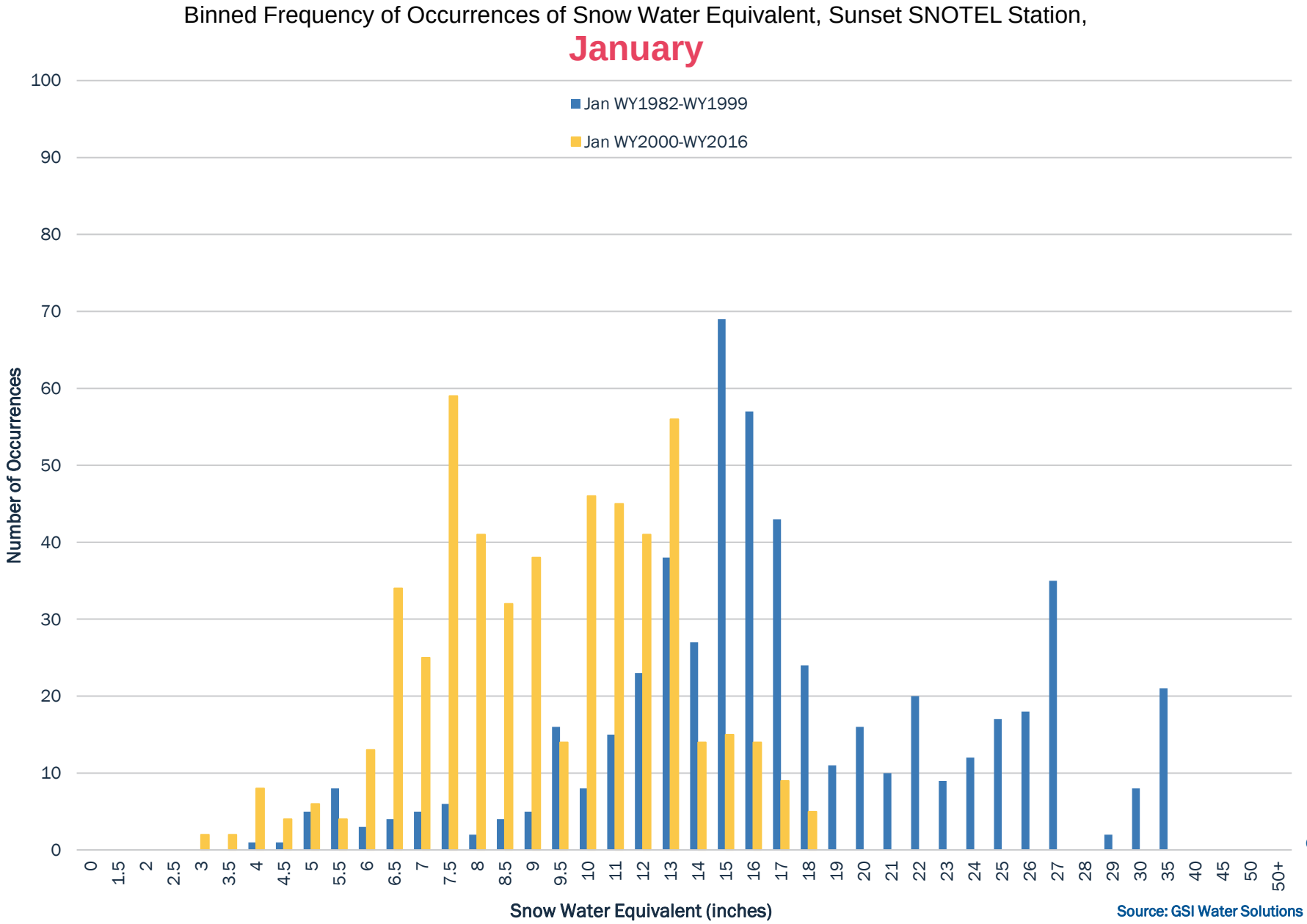
Data Source: USDA NRCS

Source of Plot: GSI Water Solutions

Source: GSI Water Solutions

Examining the Watershed

Trends In Snow Water Equivalent



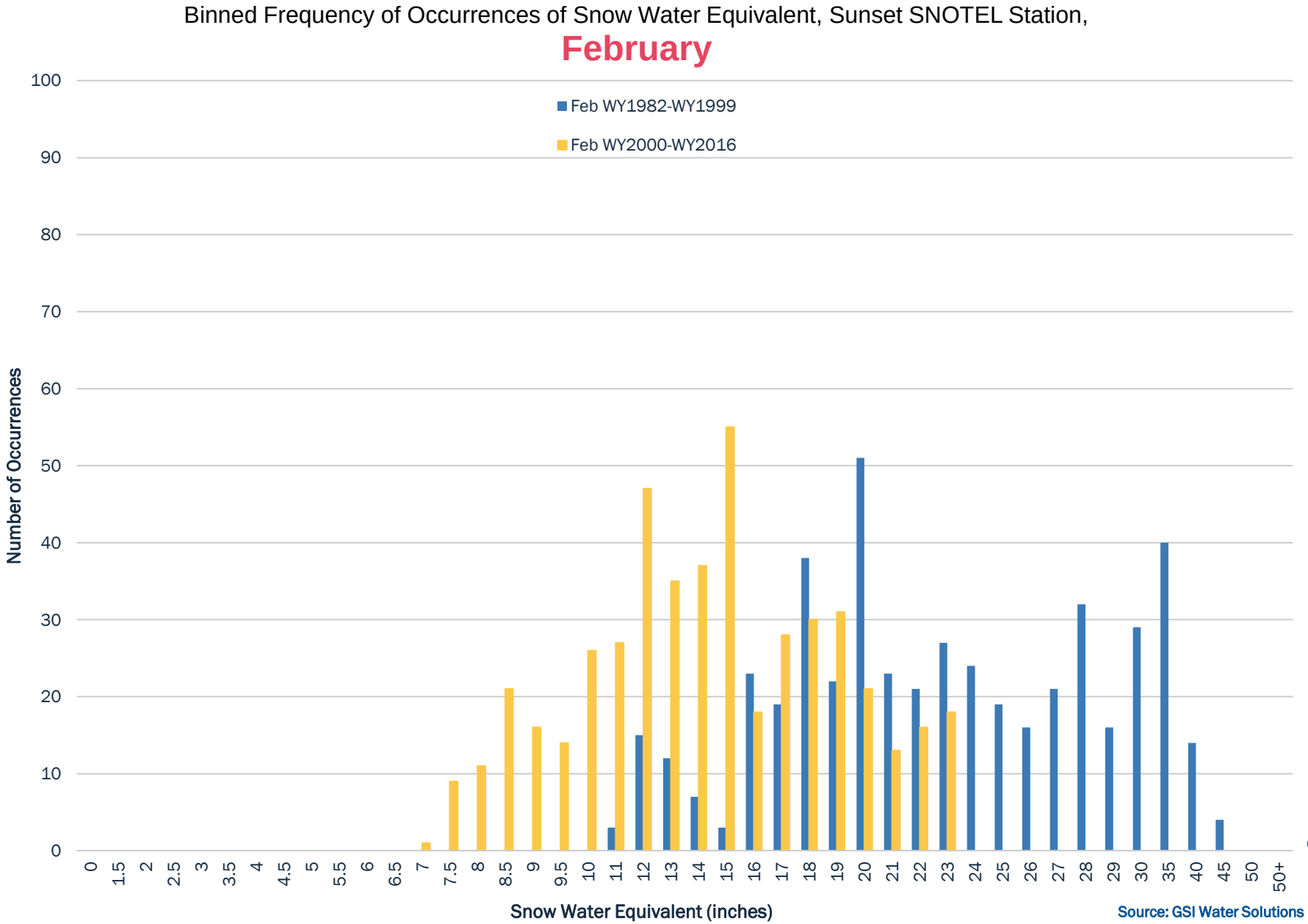
Source: GSI Water Solutions

Data Source:
USDA NRCS

Source of Plot:
GSI Water Solutions

Examining the Watershed

Trends In Snow Water Equivalent



Data Source: USDA NRCS

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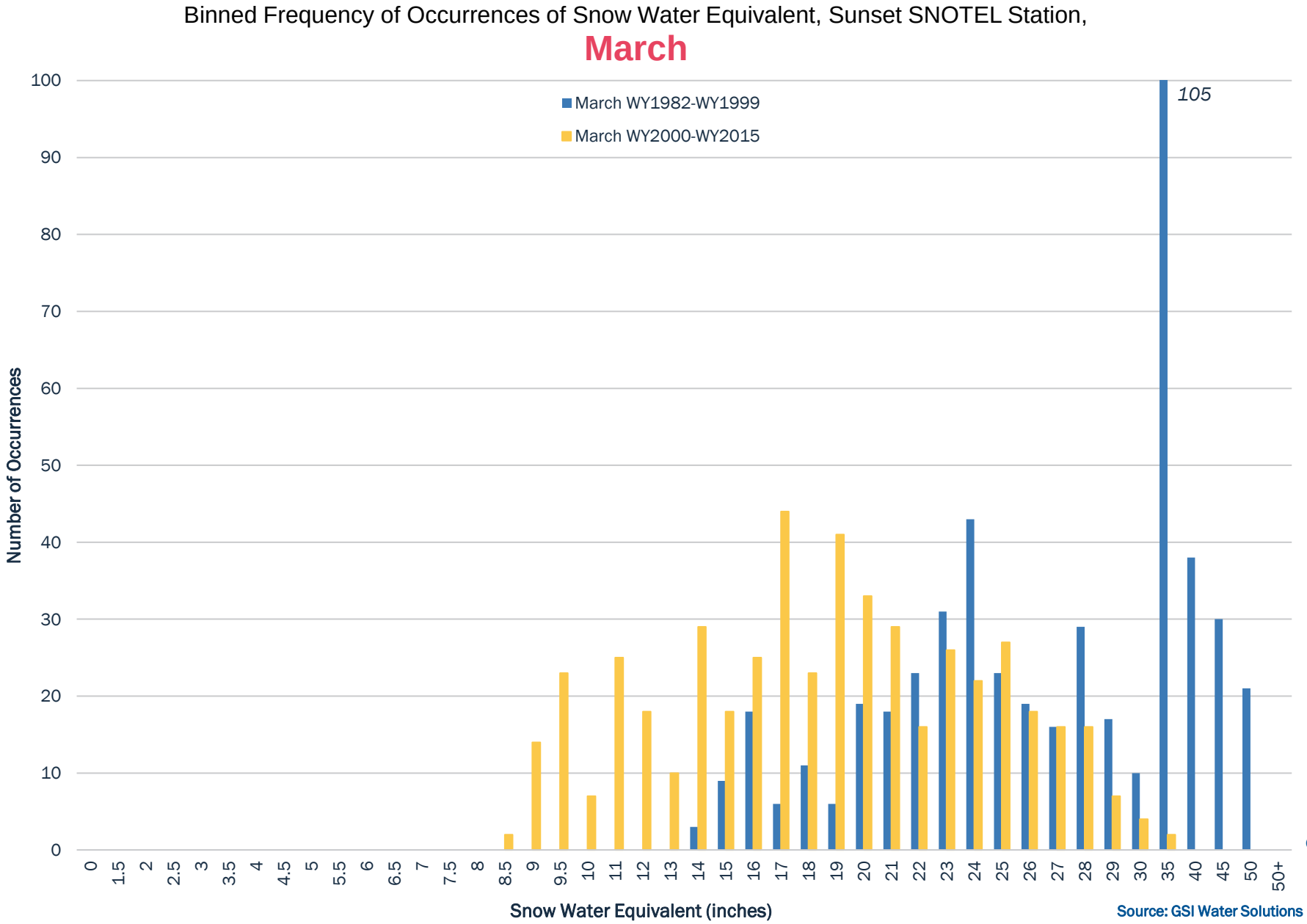
Examining the Watershed

Trends In Snow Water Equivalent



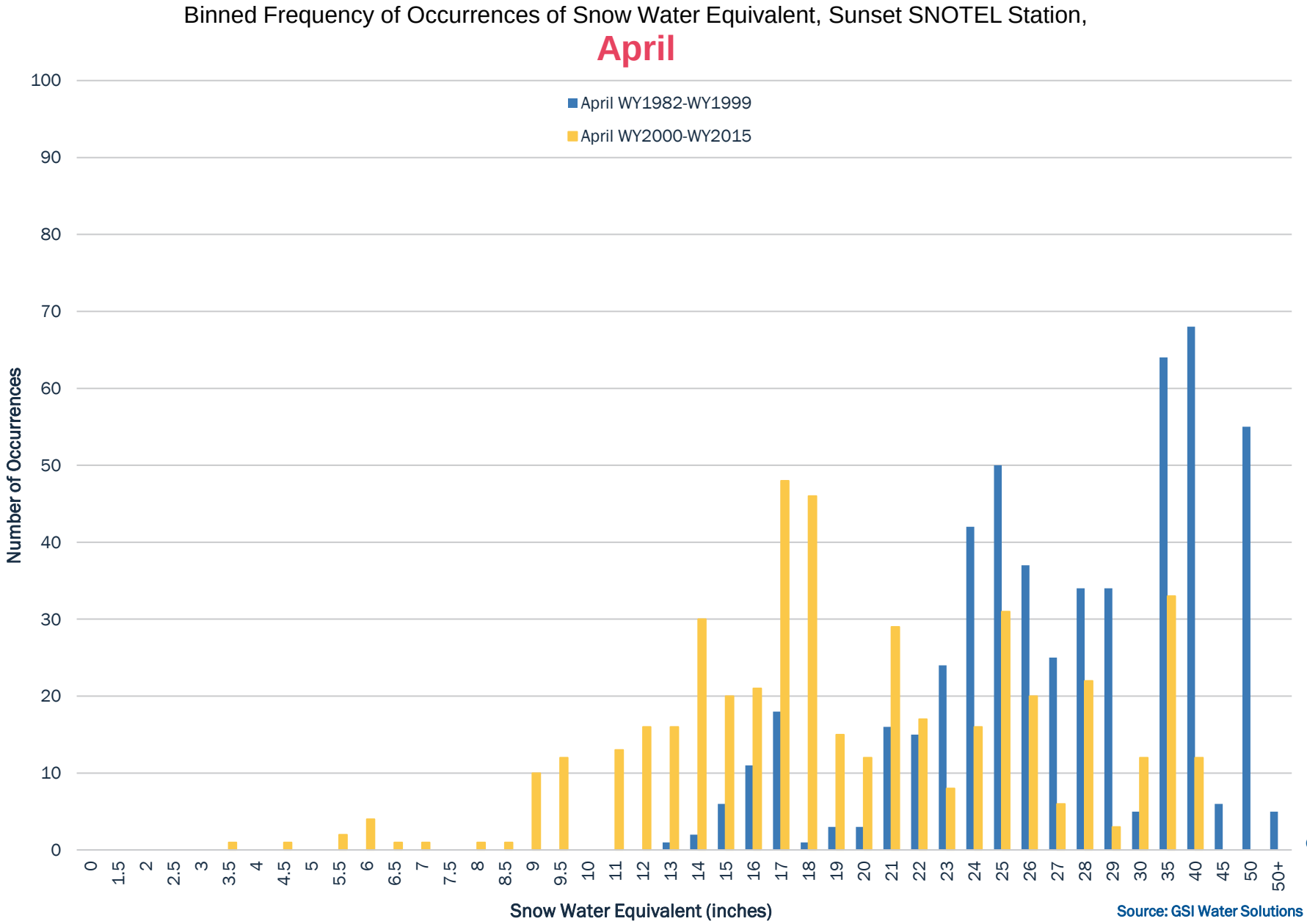
Source: GSI Water Solutions

Data Source:
USDA NRCS

Source of Plot:
GSI Water Solutions

Examining the Watershed

Trends In Snow Water Equivalent



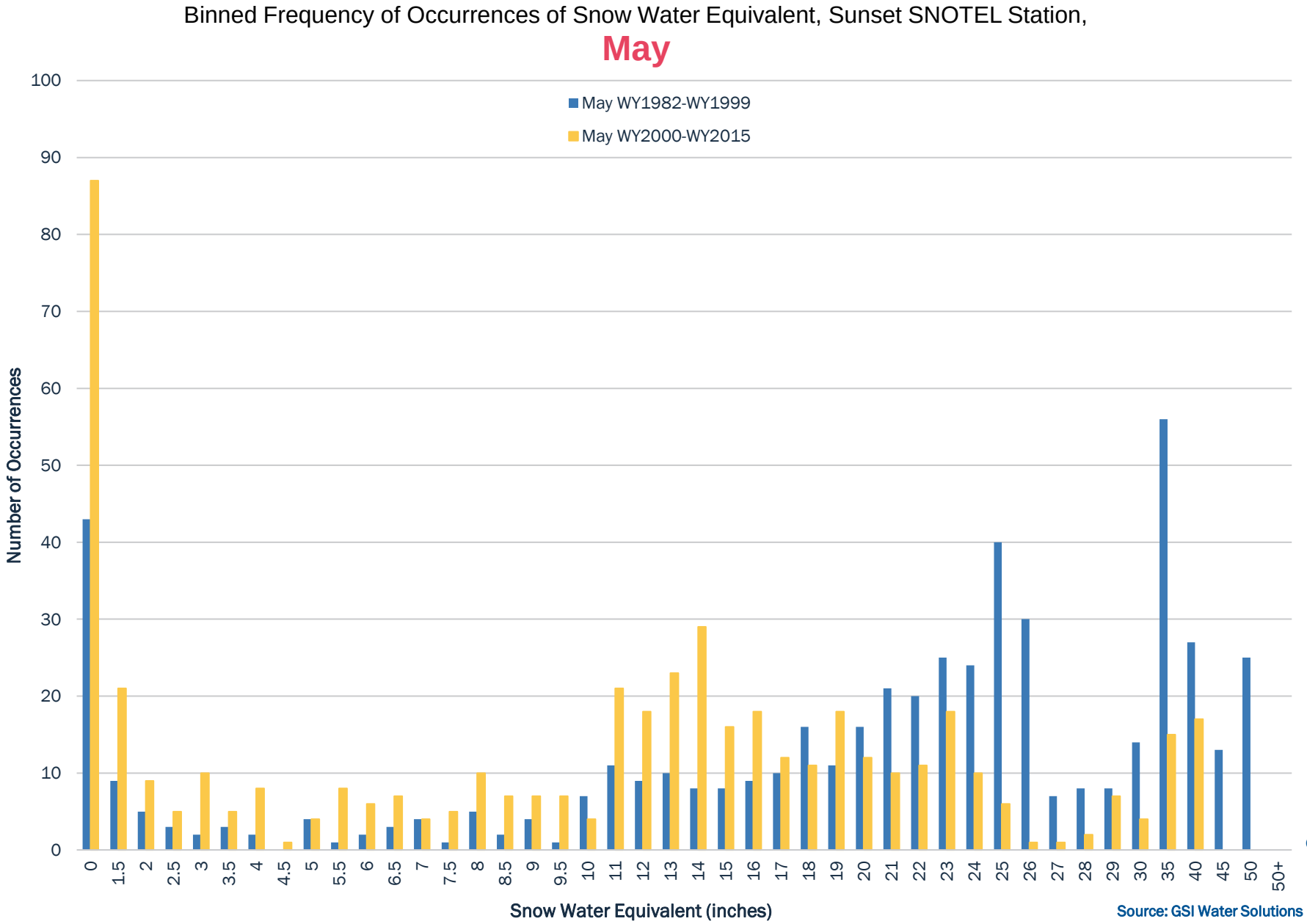
Data Source: USDA NRCS

Source of Plot: GSI Water Solutions

Source: GSI Water Solutions

Examining the Watershed

Trends In Snow Water Equivalent



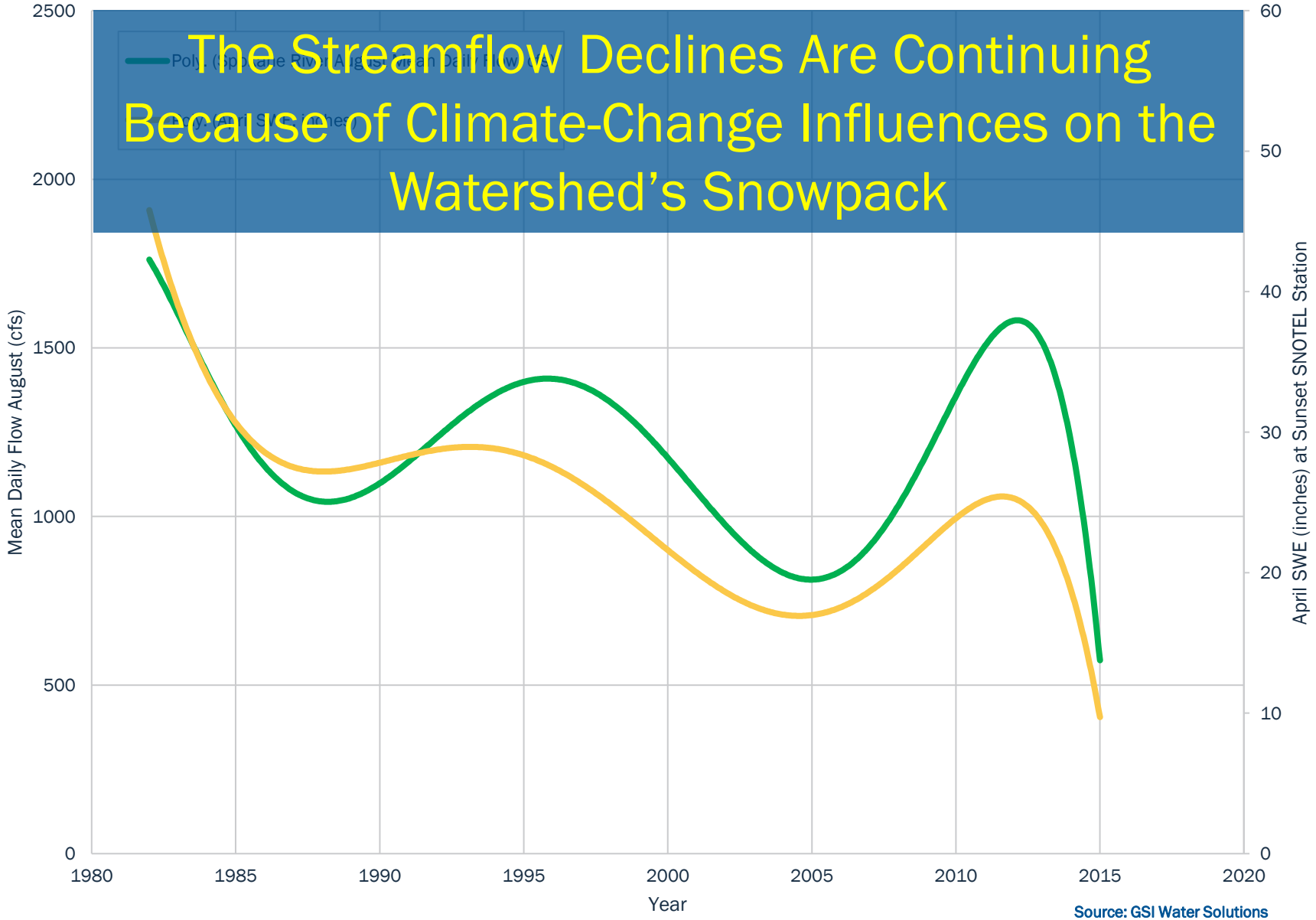
Data Source: USDA NRCS

Source of Plot: GSI Water Solutions

Source: GSI Water Solutions

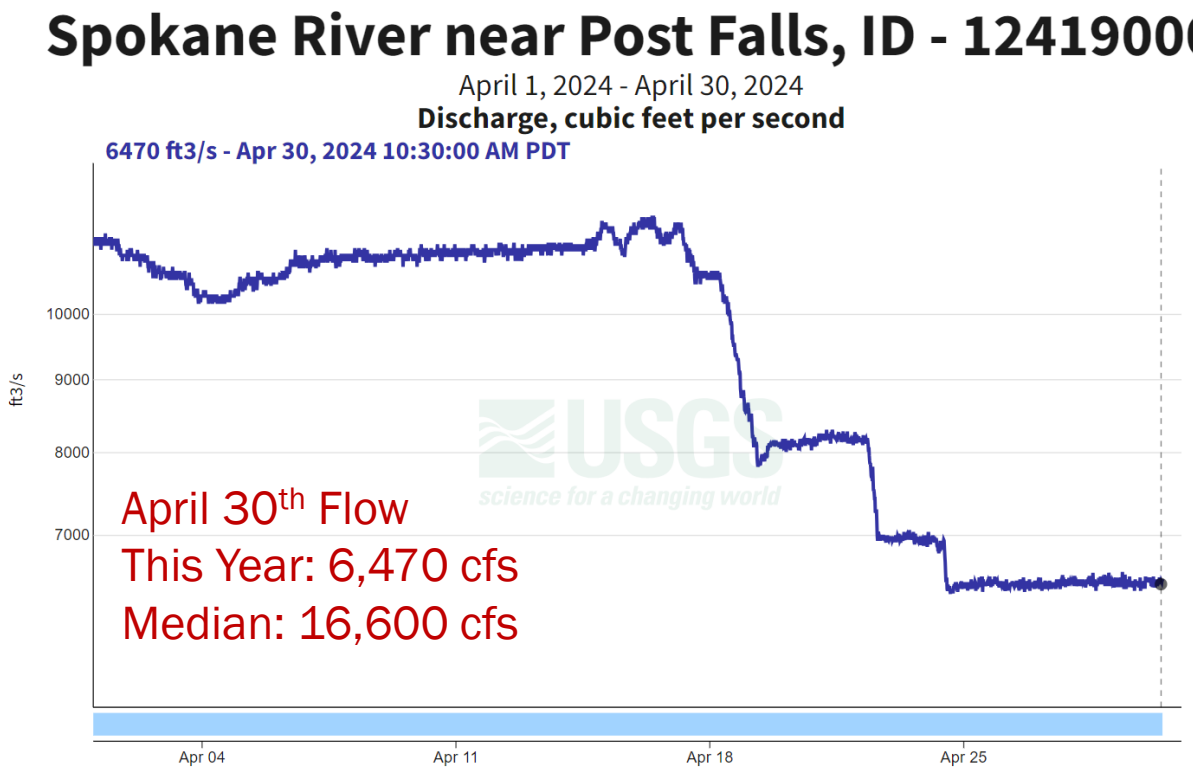
Examining the Watershed

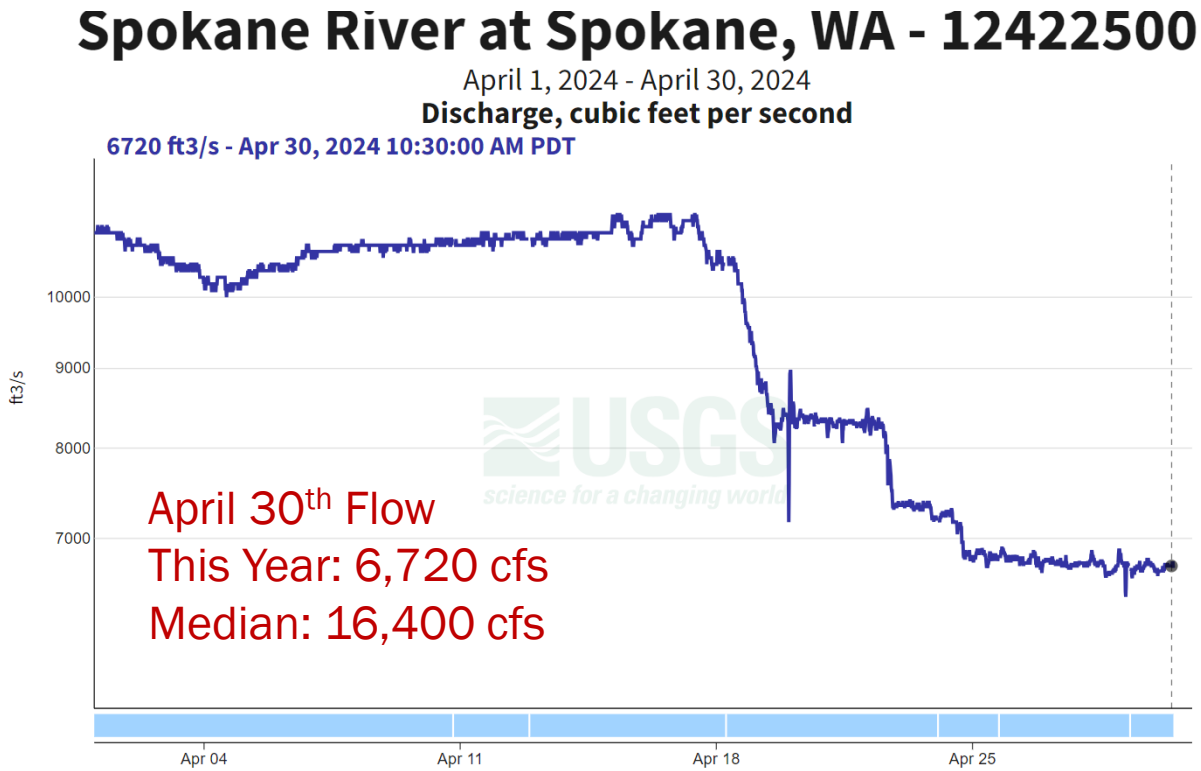
April Snow Water Equivalent and August Mean Daily Streamflow in Downtown Spokane *(1982-2015)*



Source: GSI Water Solutions

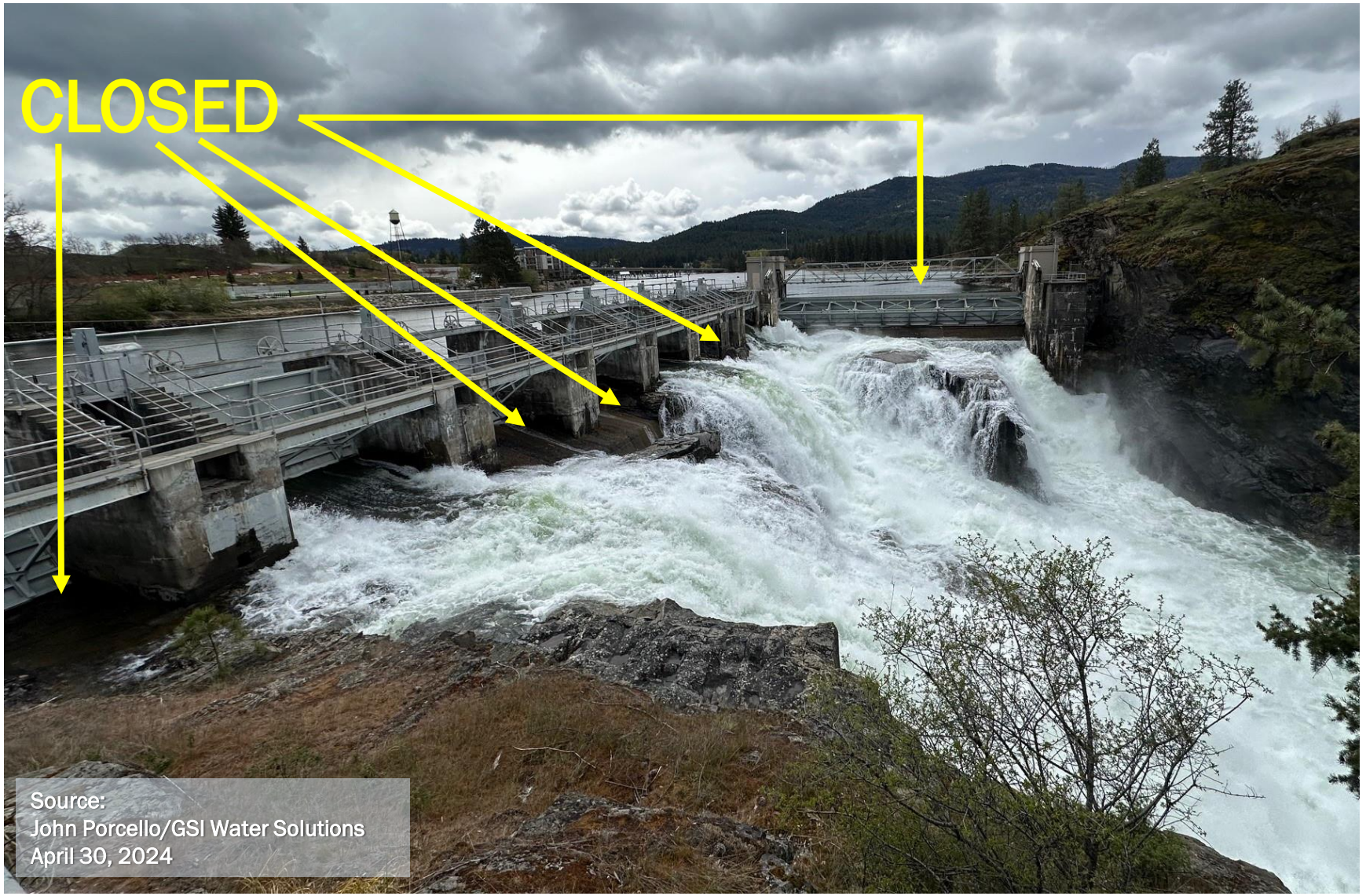
April 2024 Streamflows Upstream at Post Falls and Downstream in Downtown Spokane





Source: USGS (https://waterdata.usgs.gov)

Spillways at Post Falls North Dam (April 30, 2024)



Feedback Loop 3:
Declining Summer Streamflows in Spokane River

Feedback Loop 4:
Finding Something We Were Told Wasn't Occurring

Feedback Loop 5:
It's Time to Evaluate the Implications of that Thing We Were Told Wasn't Occurring

Feedback Loop 5:
It's Time to Evaluate the Implications of that Thing We Were Told Wasn't Occurring

- What do climate and snowpack changes (and changes in flows into and out of Coeur d'Alene Lake) mean for the aquifer and for providing reliable groundwater supplies?
- Examine supply resiliency using the groundwater model
  - River flows and leakage into the aquifer
  - Inflows from tributary valleys
  - Changes in urban demands for groundwater
    - Growth-related
    - Changes in timing and amounts of outdoor water use

Why Use a Ground-Water Model for Resiliency Planning?

It's better to use a model than to wing it!

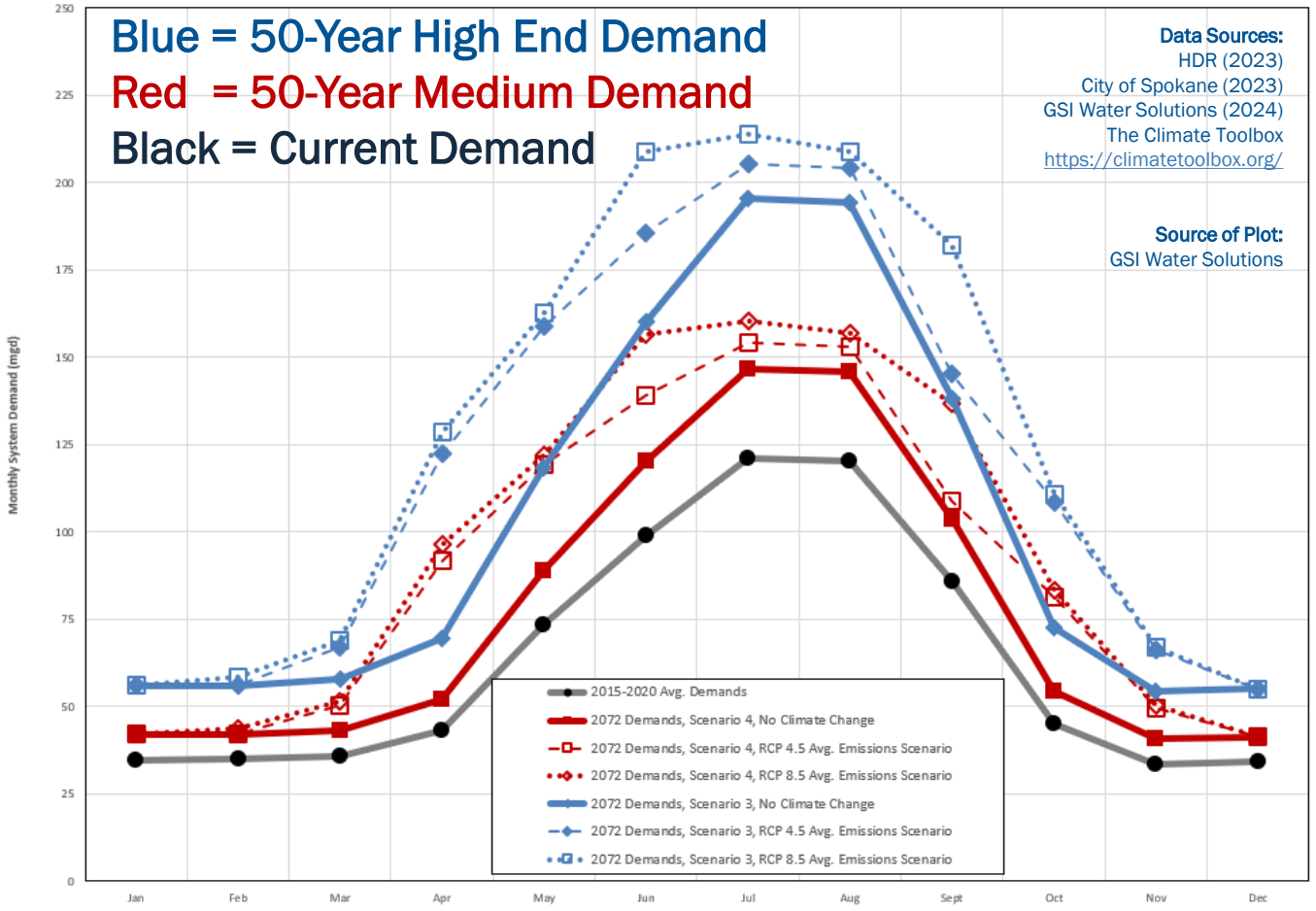
How Does a Regional Aquifer Model Help with Water Supply Resiliency Planning?

- Simulates the two key physical aspects of the aquifer
  - The plumbing
    - Geology
    - Permeability of aquifer soils and streambeds
  - The water in the plumbing
    - Recharge locations, rates, monthly/seasonal/annual variability
    - Natural mechanisms for groundwater to flow out of the aquifer
    - Groundwater withdrawals (pumping for water supply needs)
    - Exchanges with Spokane River and Little Spokane River

How Does a Regional Aquifer Model Help with Water Supply Resiliency Planning?

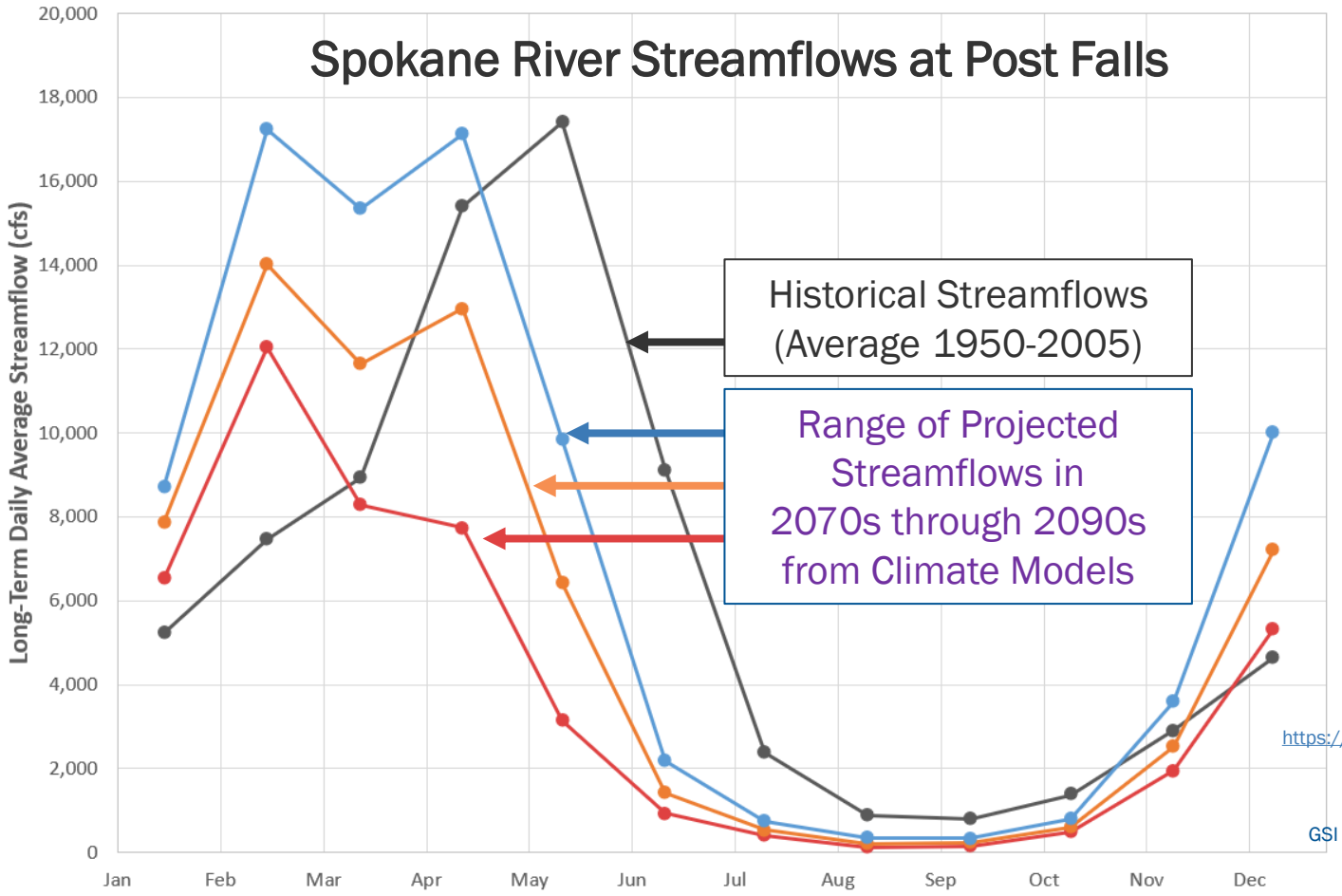
We can change pumping demands

- Locations
- Volumes
- Monthly/seasonal variations
- Climate effects on demands



How Does a Regional Aquifer Model Help with Water Supply Resiliency Planning?

We can change the natural hydrologic inputs that are affected by a changing climate

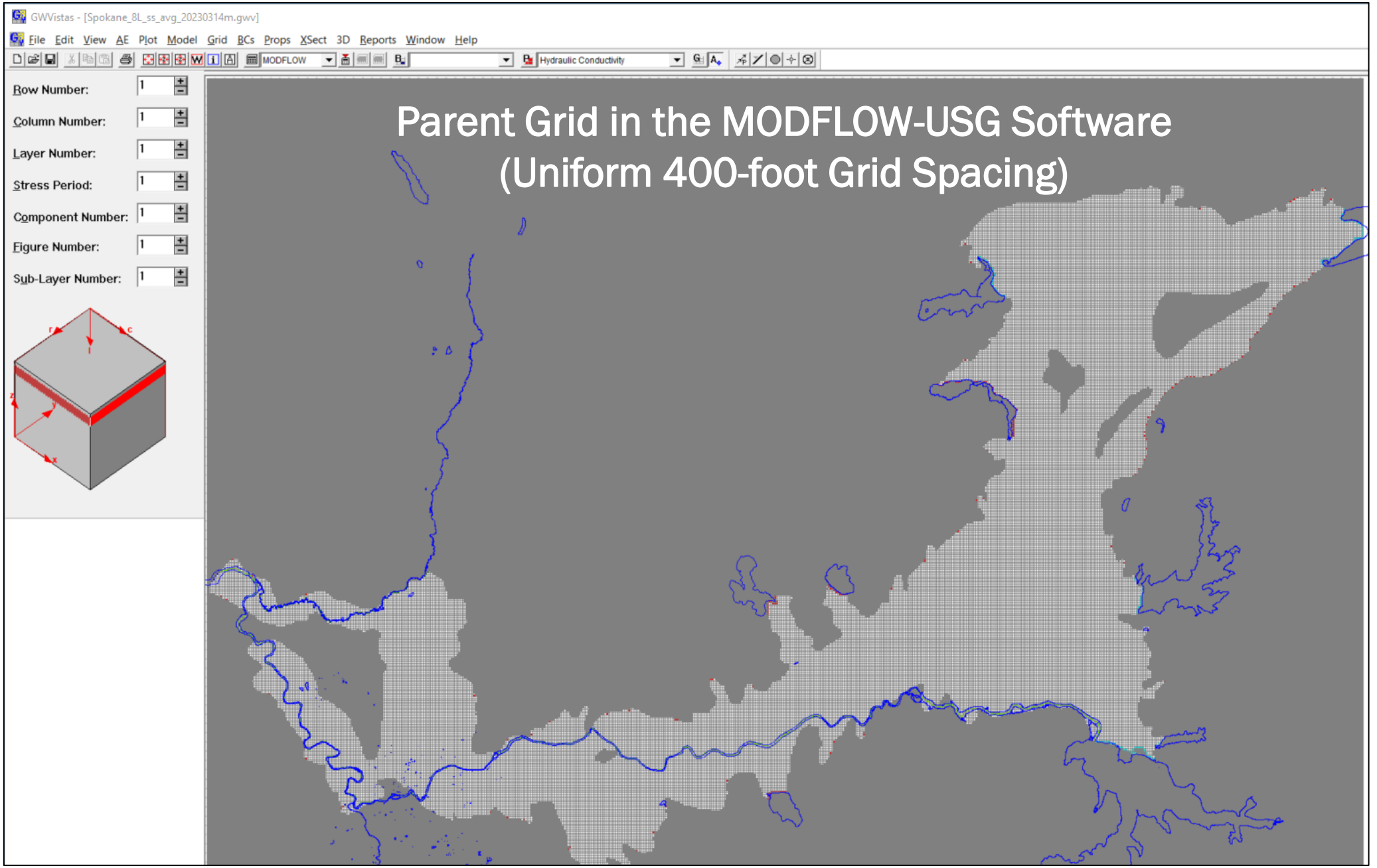


Data Source:
The Climate Toolbox
https://climatetoolbox.org/

Source of Plot:
GSI Water Solutions and City of Spokane

Spatial Resolution

Newest Model for City of Spokane in 2023



Source: GSI Water Solutions and City of Spokane

Spatial Resolution

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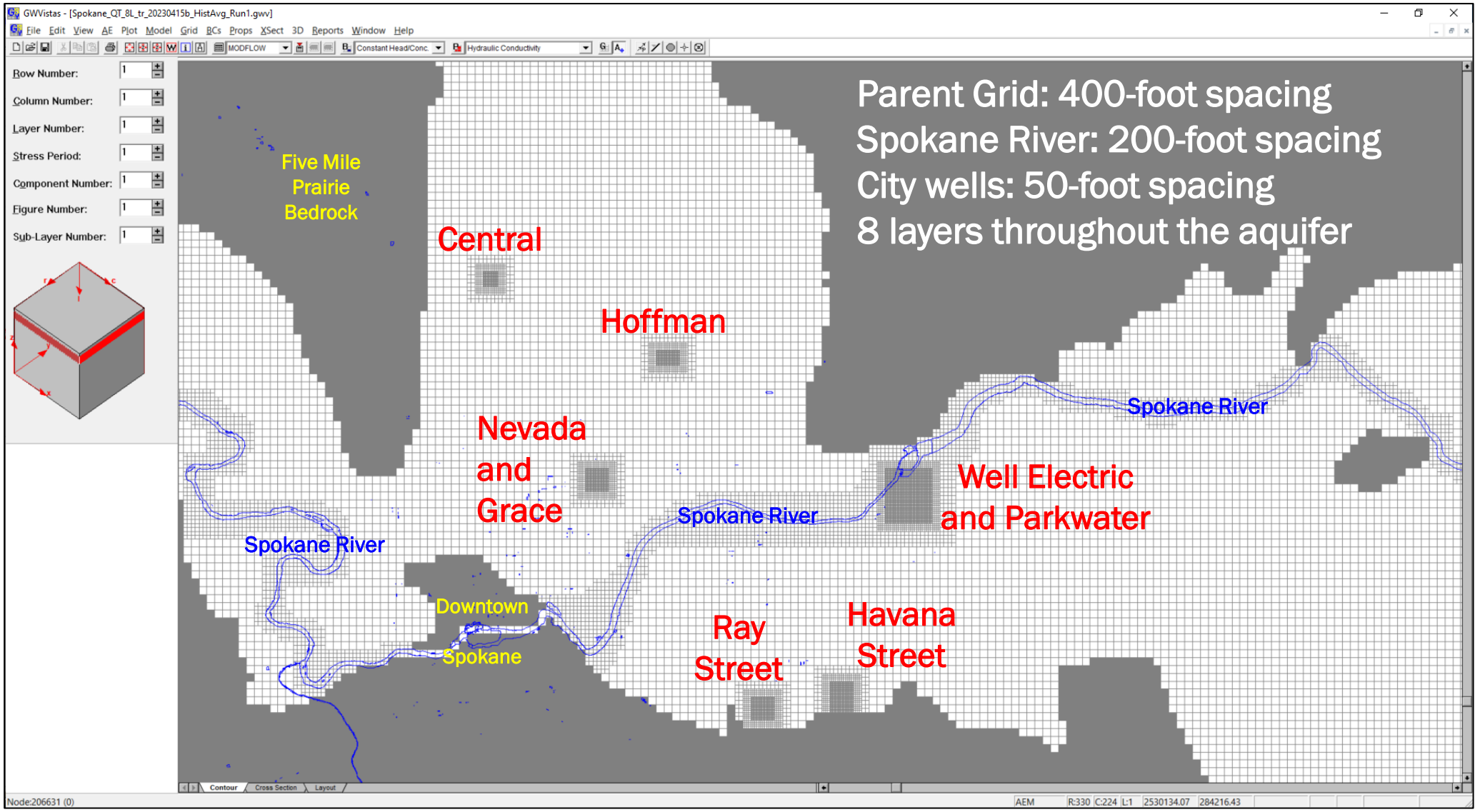

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Spatial Resolution

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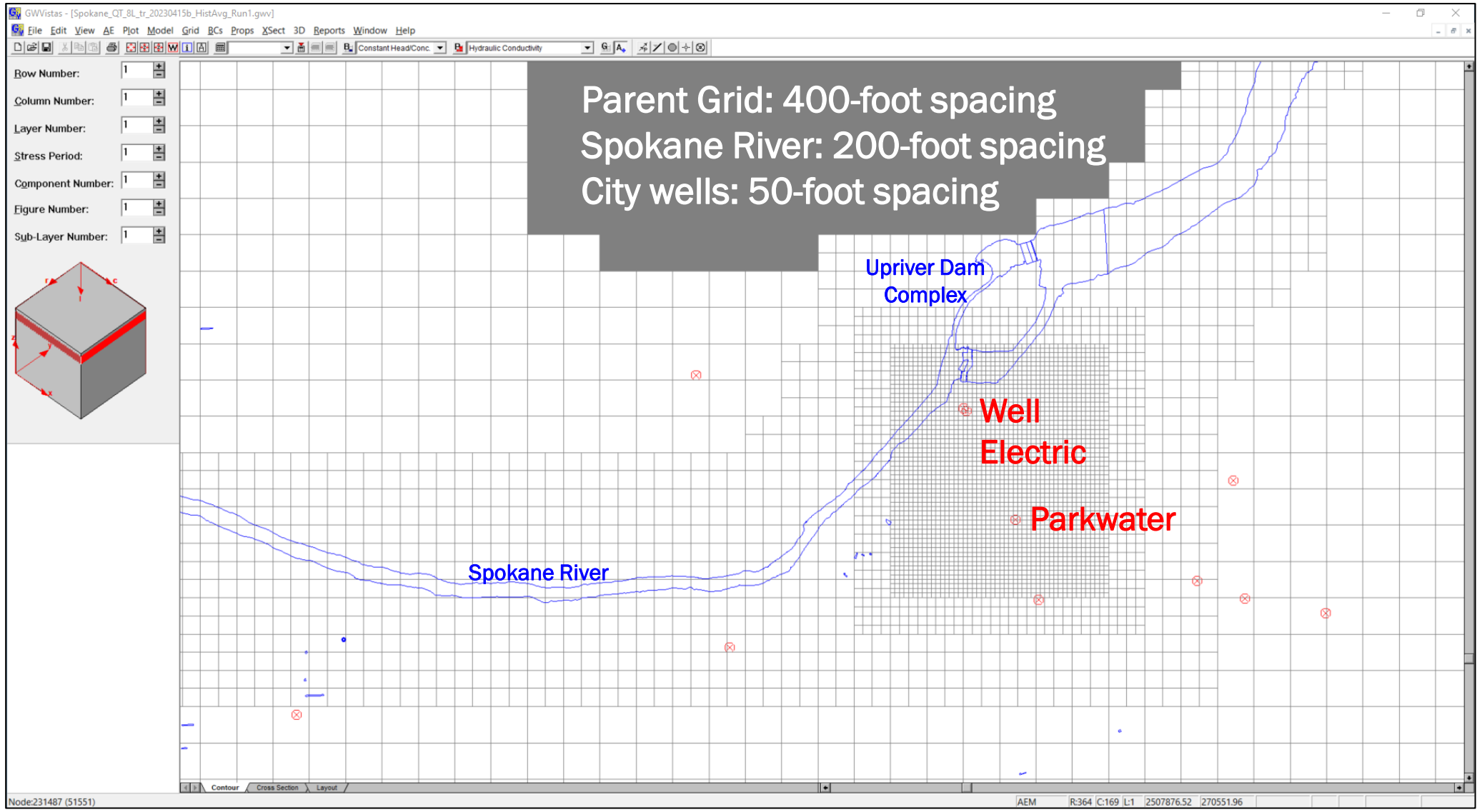


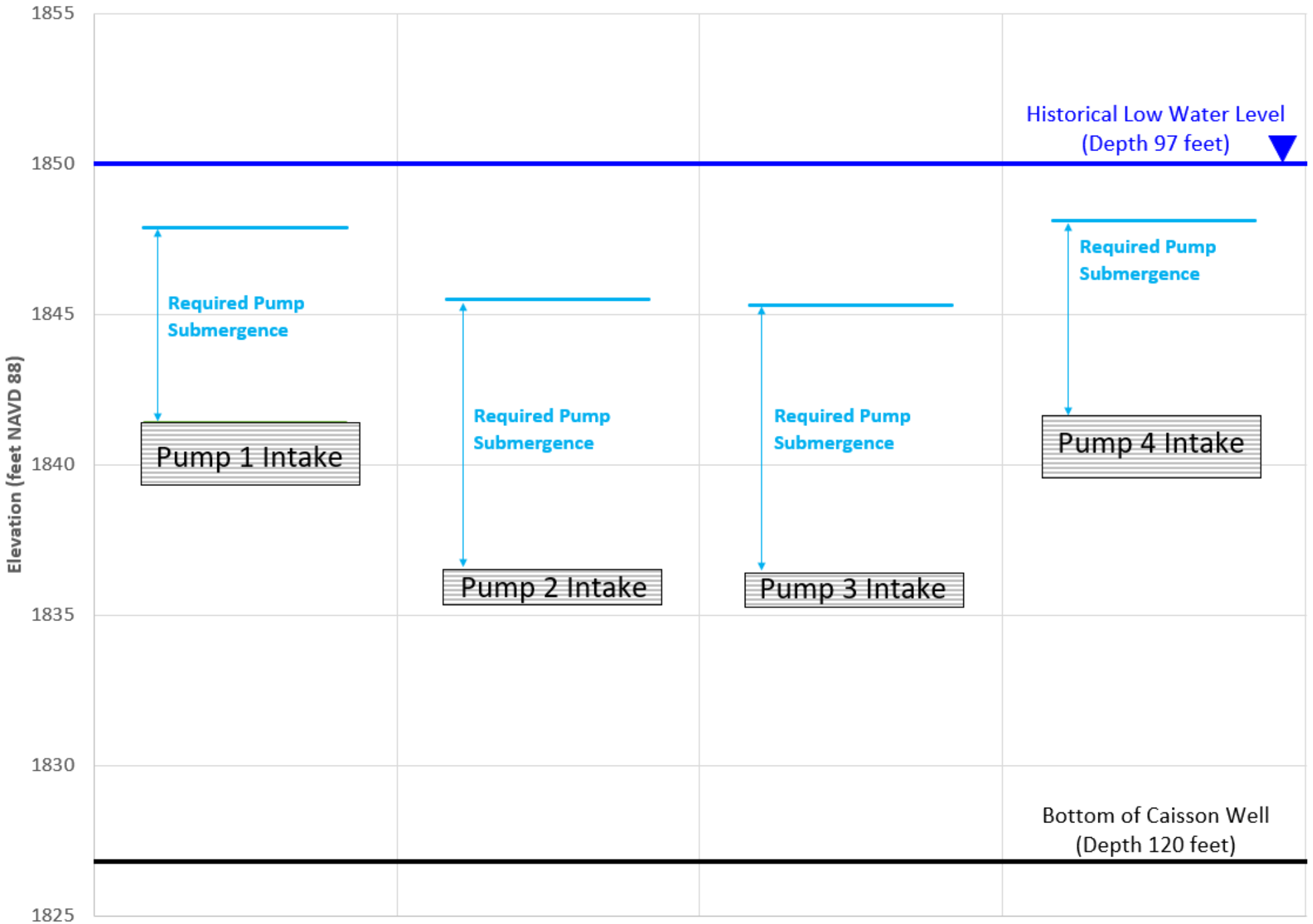
Source: GSI Water Solutions and City of Spokane

Resiliency Planning Analysis by City of Spokane (Climate Change and More)

- Six elements
  - Groundwater modeling
    - Model upgrades
    - Projections of long-range demands (50 years out)
    - Climate-change analyses for each well station
  - Infrastructure assessments of existing well stations
  - Hydrogeologic investigations at selected well stations
  - Other vulnerability assessments
    - Contamination threats, transmission system limitations
- Goal: Increased resiliency, responsible capital planning

Case Study:

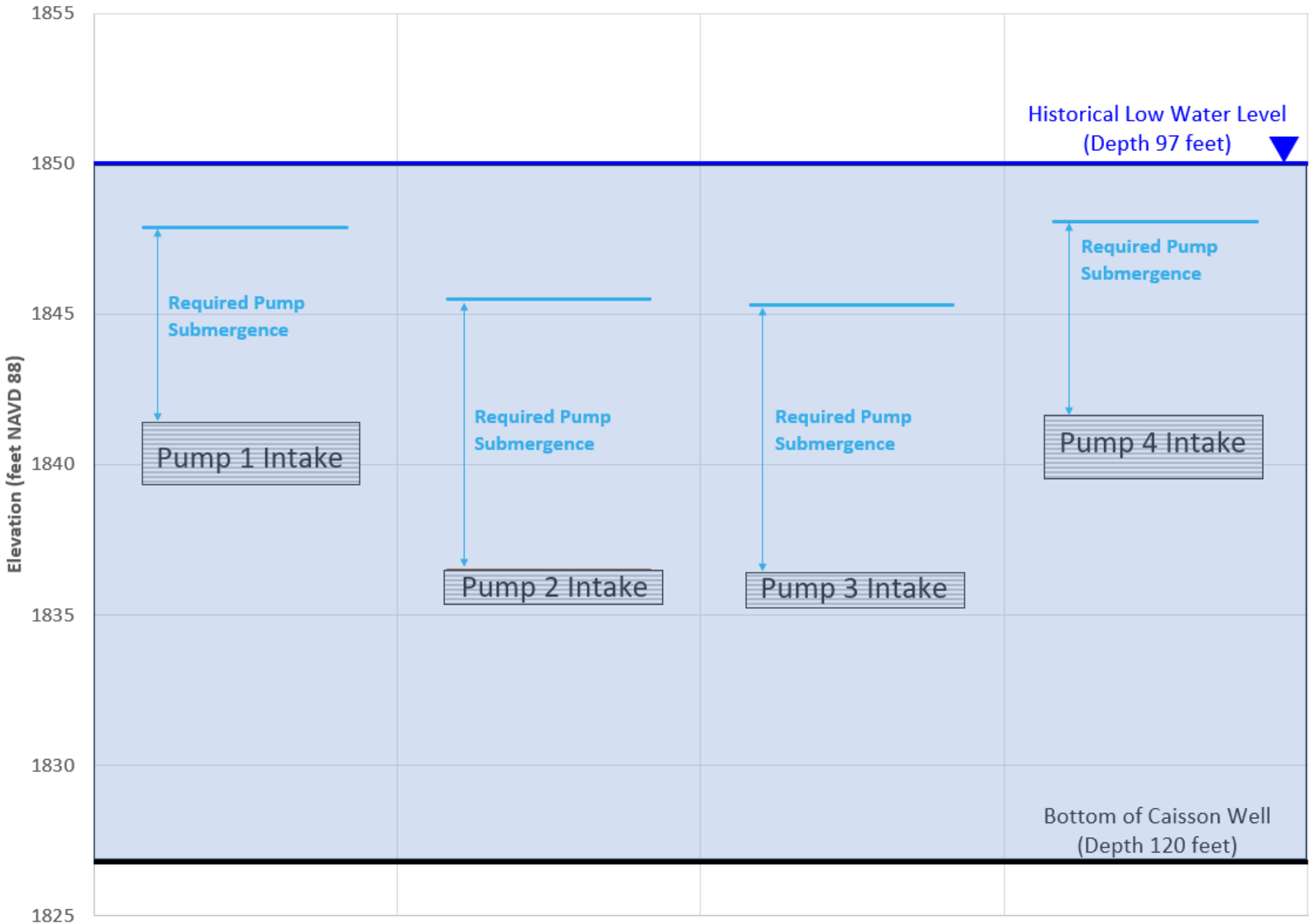
Assessment of Long-Term Pumping Feasibility for the Nevada Well Station



GSI Water Solutions

Case Study:

Assessment of Long-Term Pumping Feasibility for the Nevada Well Station



CITY OF SPOKANE

GSI Water Solutions

Case Study:

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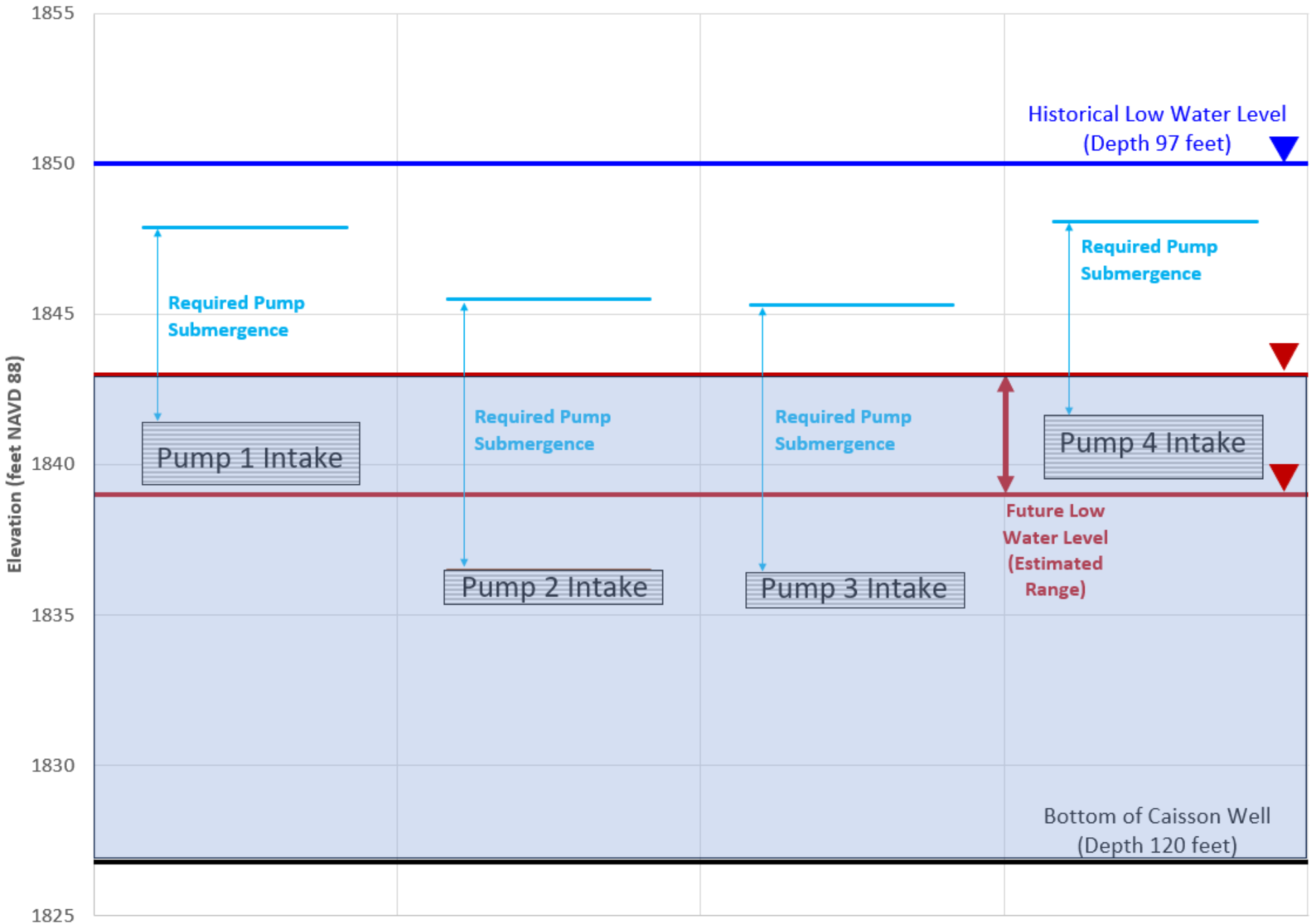

CITY OF SPOKANE

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Case Study:

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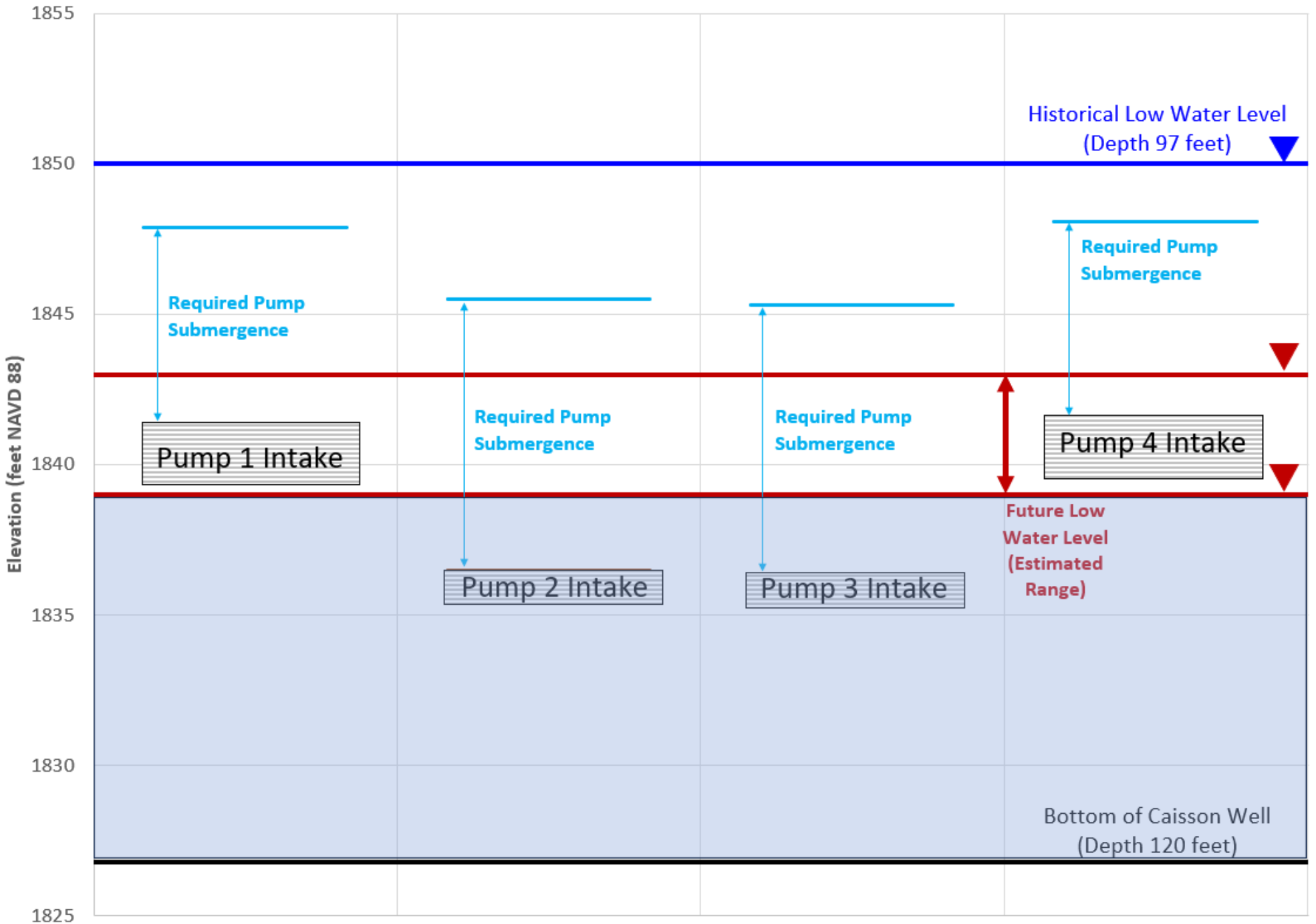
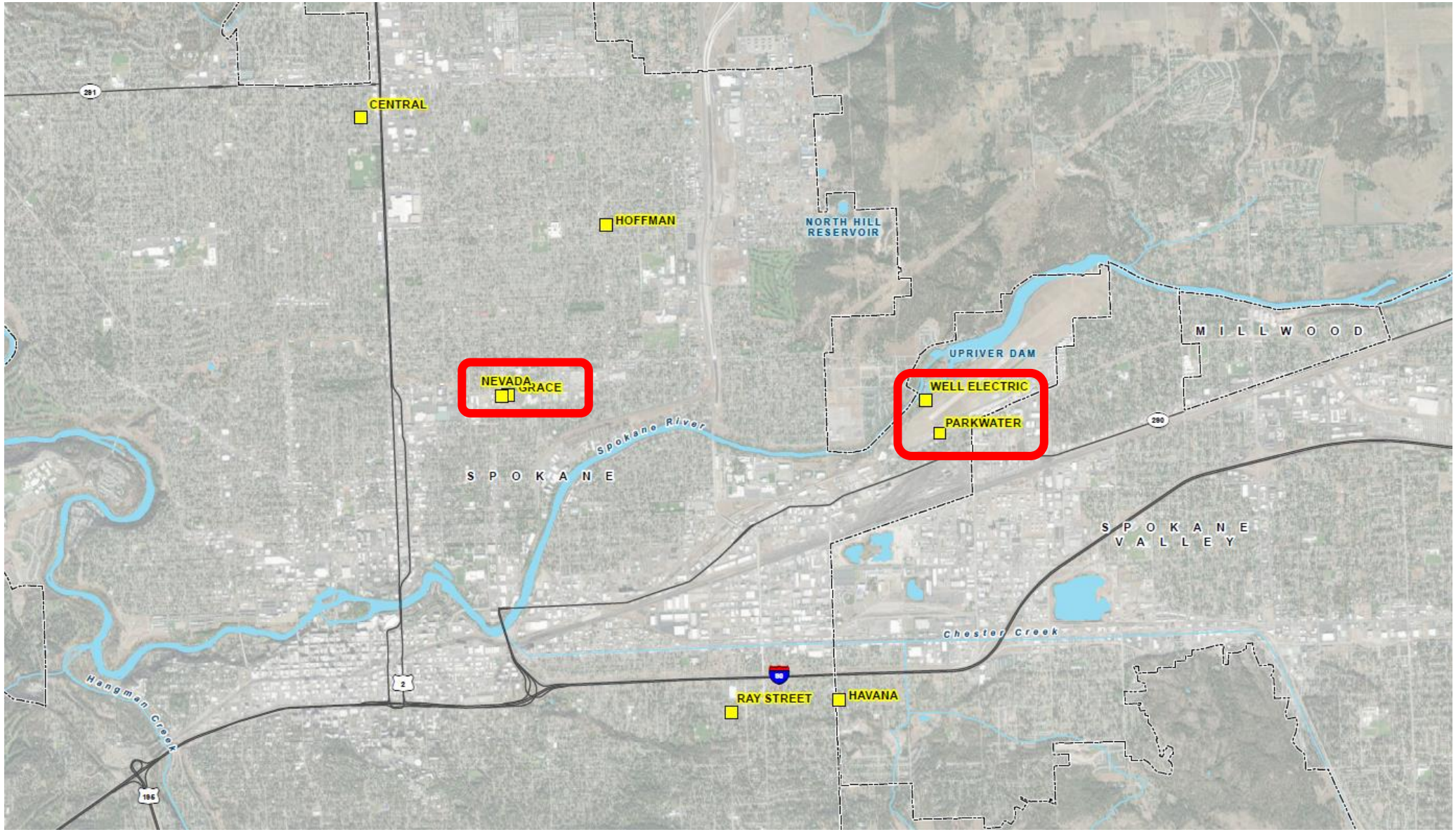


CITY OF SPOKANE

GSI Water Solutions

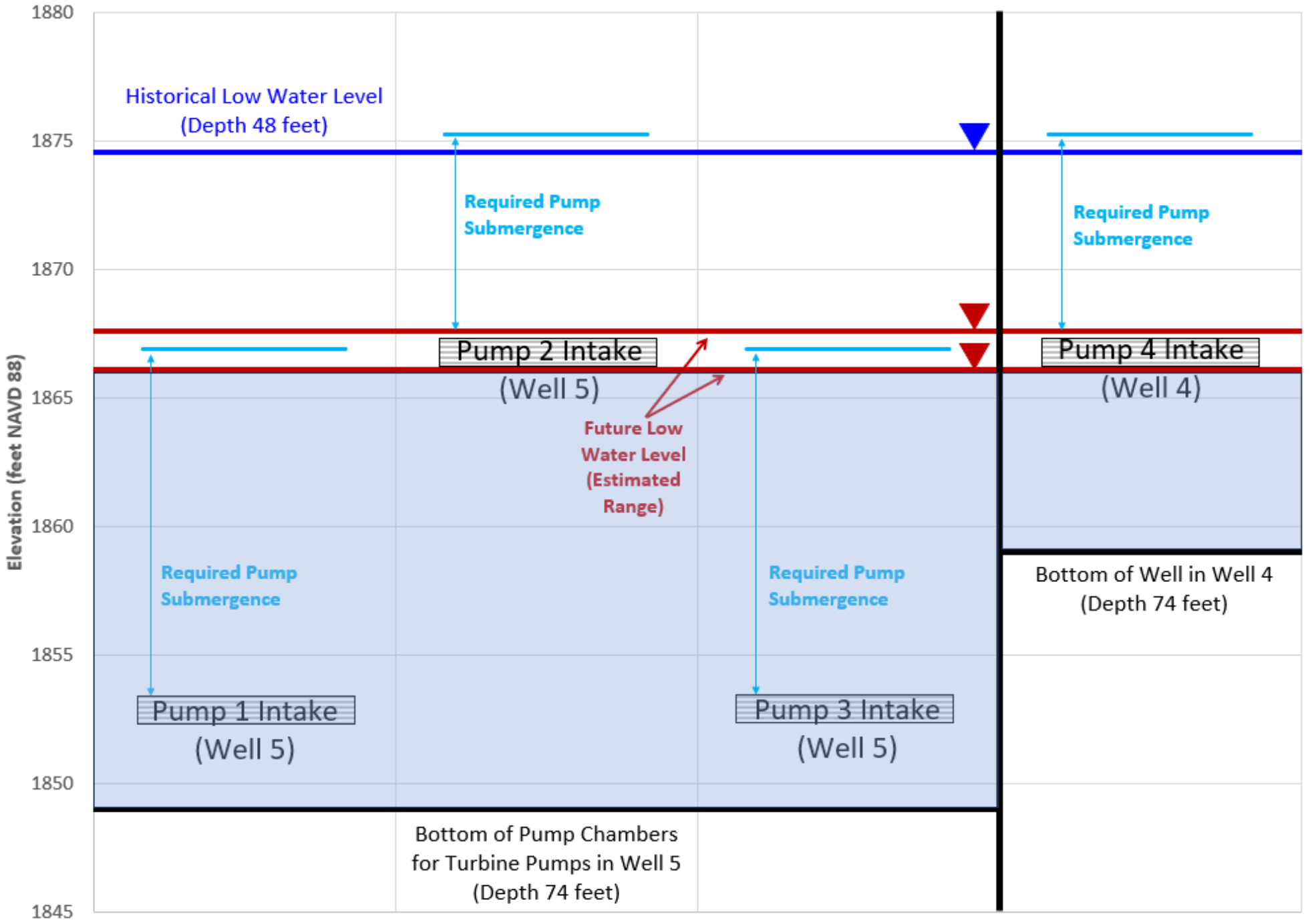
City of Spokane Well Station Locations



Source: GSI Water Solutions

Case Study:

Assessment of Long-Term Pumping Feasibility for the Well Electric Well Station



CITY OF SPOKANE

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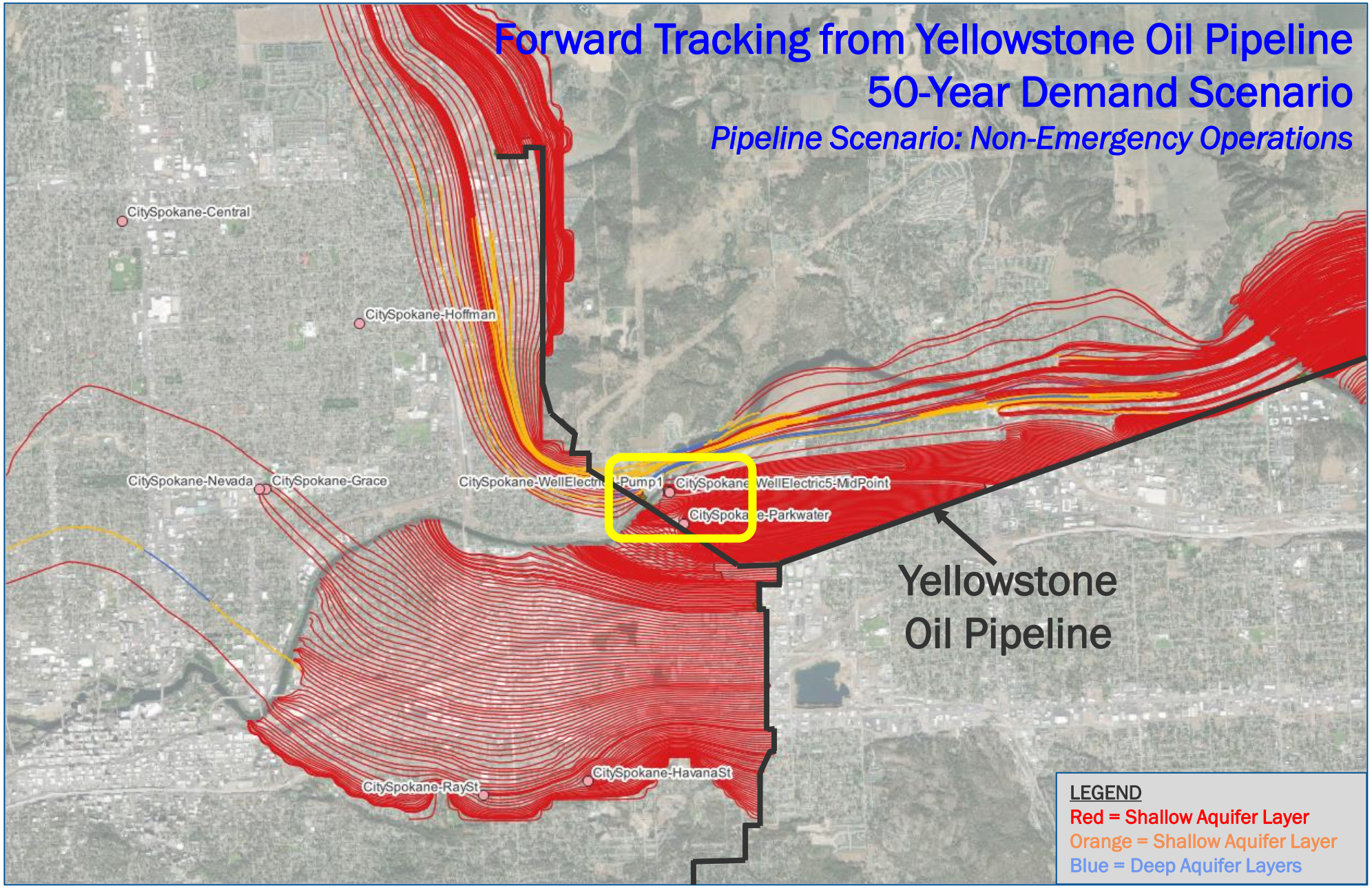
Example of Contamination Threats:

Modeled Groundwater Flowpaths Away from the Yellowstone Pipeline



Source: GSI Water Solutions

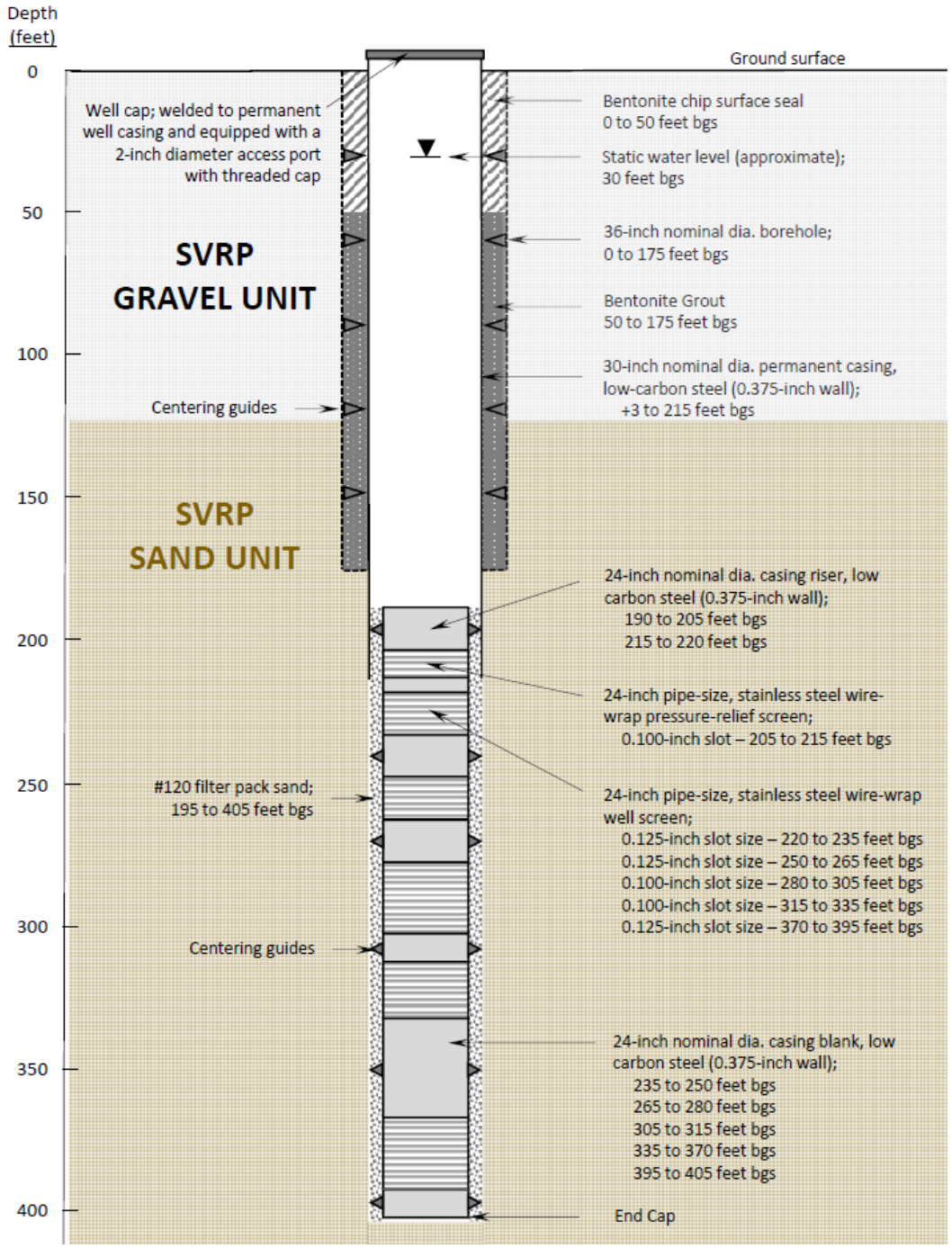
Estimated Travel Time for Groundwater and Contaminants

From Yellowstone Pipeline to Well Stations

Parkwater Critical Well	• **1 - 2 DAYS** (pipeline segment to south) • 2.5 – 3 months (pipeline segment to east)
Well Electric Critical Well	• 6 – 7 months
Havana St.	• 3 – 4 months
Ray St.	• 6 – 7 months
Nevada and Grace	• 12 months
Central and Hoffman	• 9 - 18 months

Feedback Loop

Constructing New Deep Wells is Now Under Evaluation



Source: GSI Water Solutions

Feedback Loop 3:
Declining Summer Streamflows in Spokane River

Feedback Loop 4:
Finding Something We Were Told Wasn't Occurring

Feedback Loop 5:
It's Time to Evaluate the Implications of that Thing We Were Told Wasn't Occurring

Past and Ongoing Resiliency Planning by Local Water Providers

- City of Spokane
  - Developed first model useful for water planning (1998)
    - Wellhead protection was the initial focus
    - Washington only
  - Expanded the model into Idaho in 2012 (entire SVRP Aquifer)
  - Established Integrated Capital Management group in 2014
    - Water, sewer, and street infrastructure projects
    - Works with Water Department on resiliency and capital planning
    - Has funded infrastructure studies at nearly all City well stations

Past and Ongoing Resiliency Planning by Local Water Providers

- Spokane Aquifer Joint Board (SAJB)
  - 21 Washington water purveyors
    - 2 cities (Spokane, Millwood)
    - 5 water districts
      - Includes Spokane County, which also conducts water resources planning and monitoring
    - 2 water and power companies
    - 9 irrigation districts now providing municipal water supply
    - 3 large businesses (private well owners)
    - All rely solely on the SVRP Aquifer for their water supply

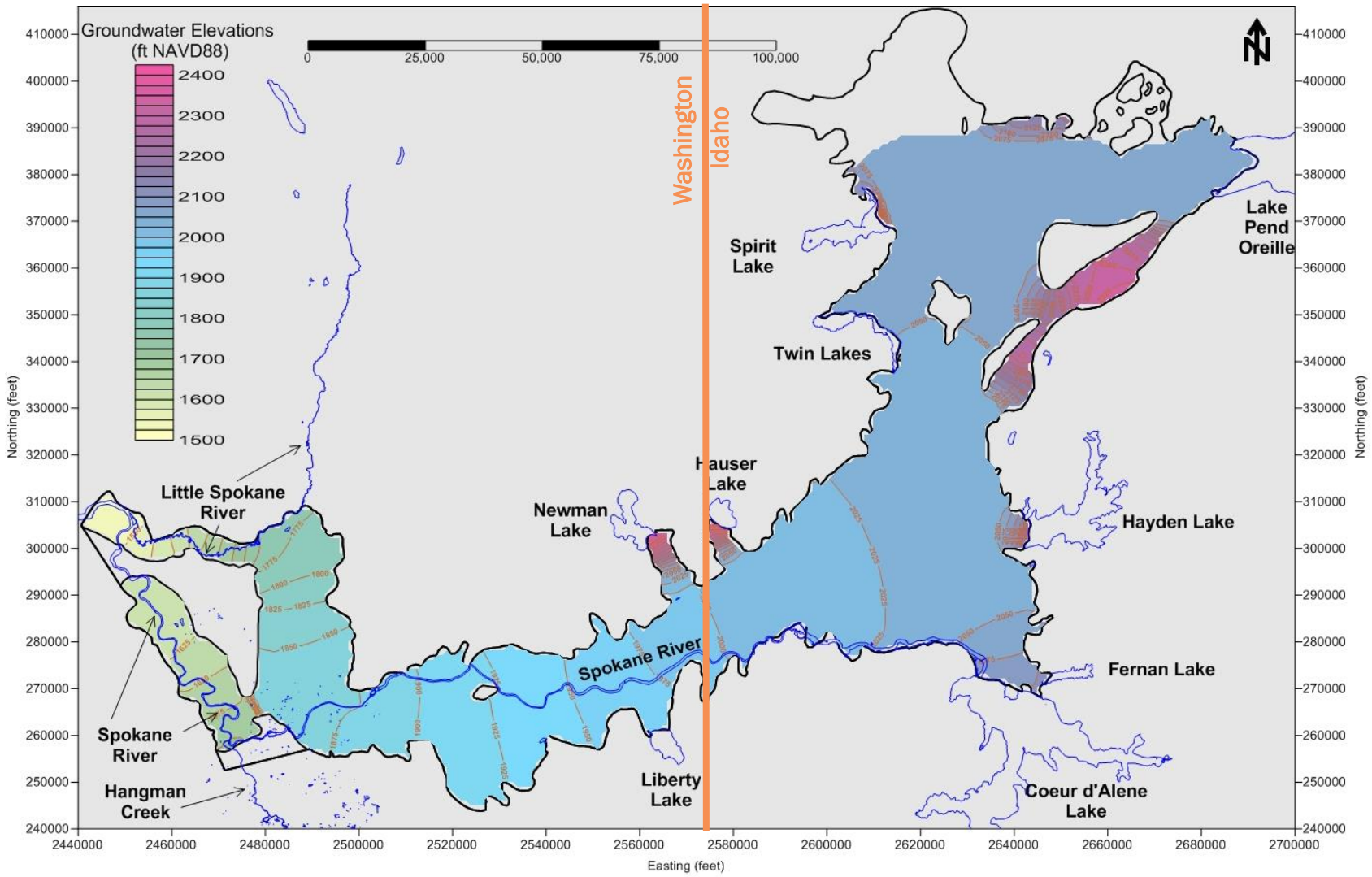
Past and Ongoing Resiliency Planning by Local Water Providers

- Spokane Aquifer Joint Board (SAJB)
  - Formed in 1995 to develop and implement regional-scale wellhead and groundwater quality protection programs
  - Also funds focused water-resources studies

Past and Ongoing Resiliency Planning by Local Water Providers

- Idaho-Washington Aquifer Collaborative (IWAC)
  - 19 members (all water purveyors)
  - Five advisory members (water resources specialists)
  - Mission:
    - Develop management strategies protective of the SVRP Aquifer
    - Facilitate regional dialogs and technical studies
  - Special focus:
    - Education and outreach on water use efficiency
    - Developing standards for irrigation and landscape design

Thank You!



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