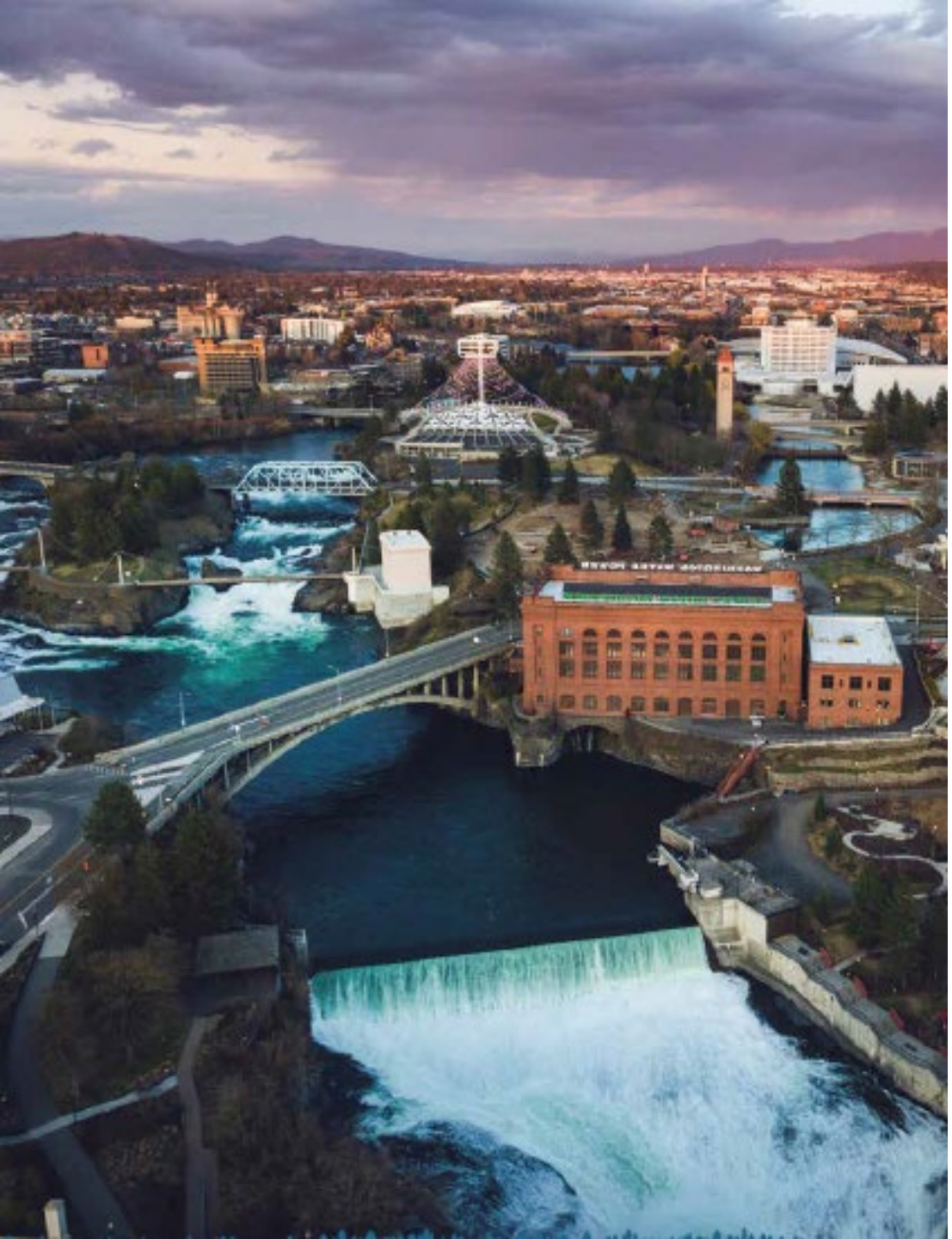


City of Spokane

Groundwater Supply Source Assessments

Water Station Infrastructure Evaluations Leading Capital Decisions

Prepared by Dan Kegley and John Porcello
GSI Water Solutions, Inc.

AWWA Pacific Northwest Section Conference
Kennewick, Washington

Thursday May 4, 2023

GSI Water Solutions, Inc.

CITY OF SPOKANE

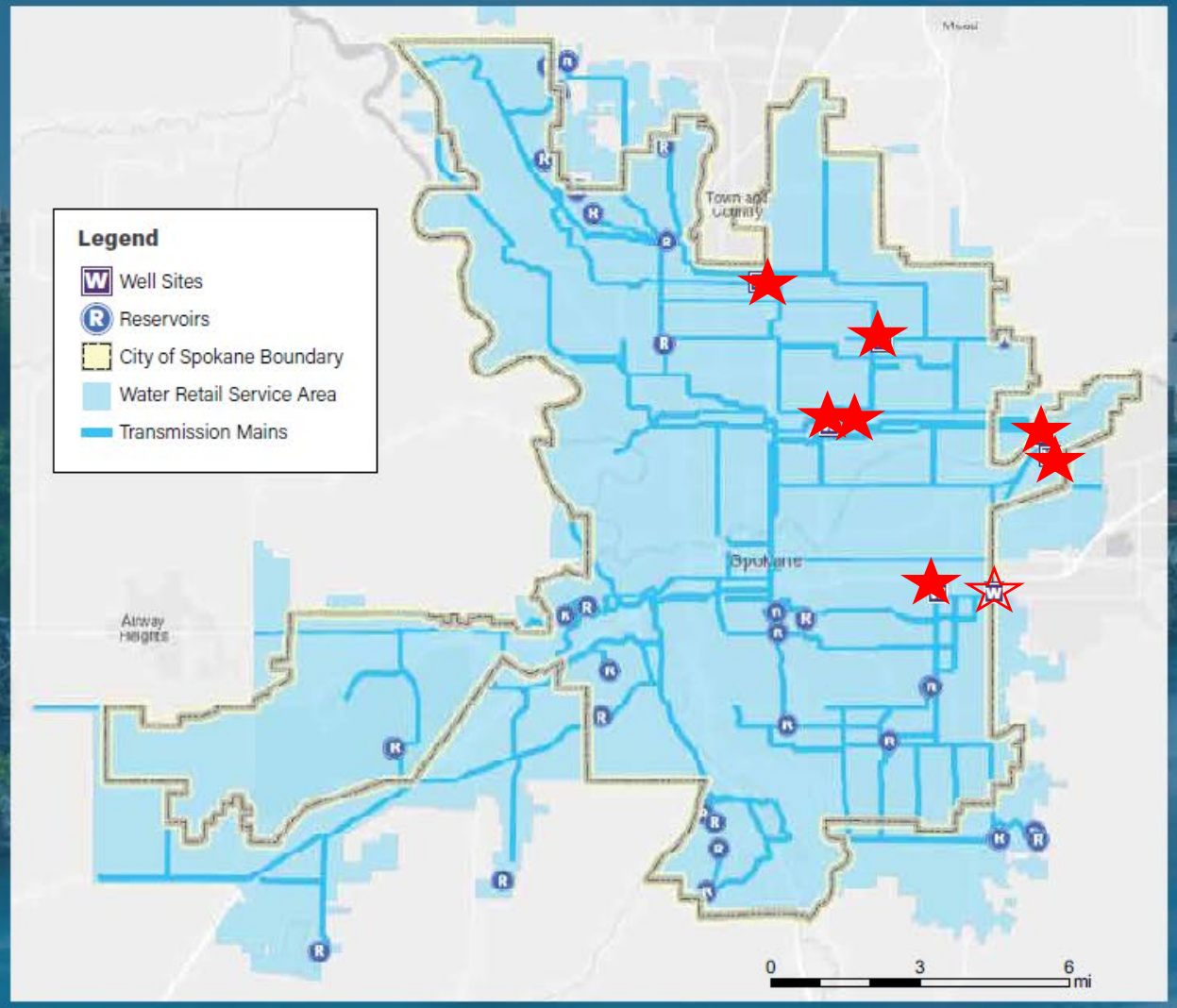
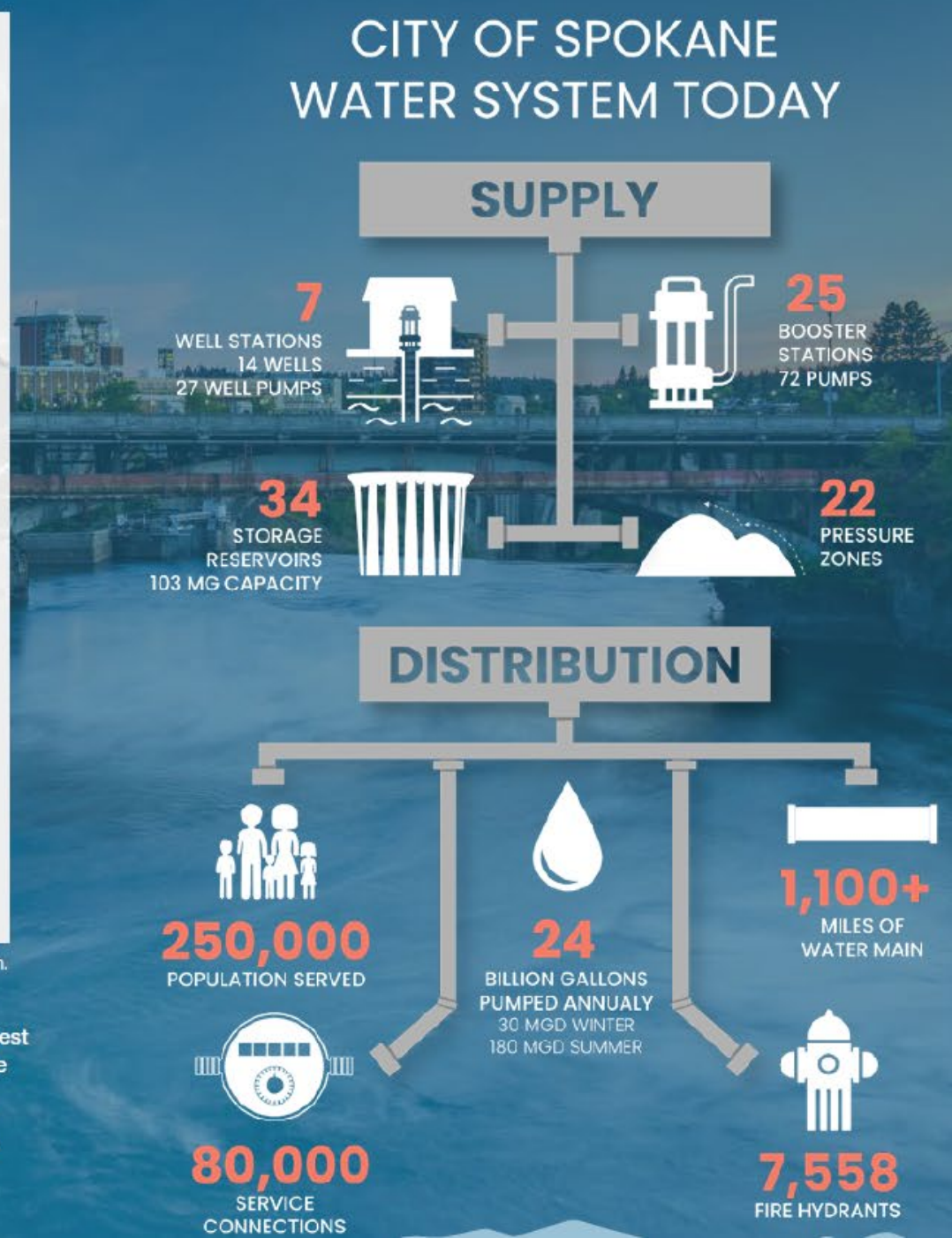
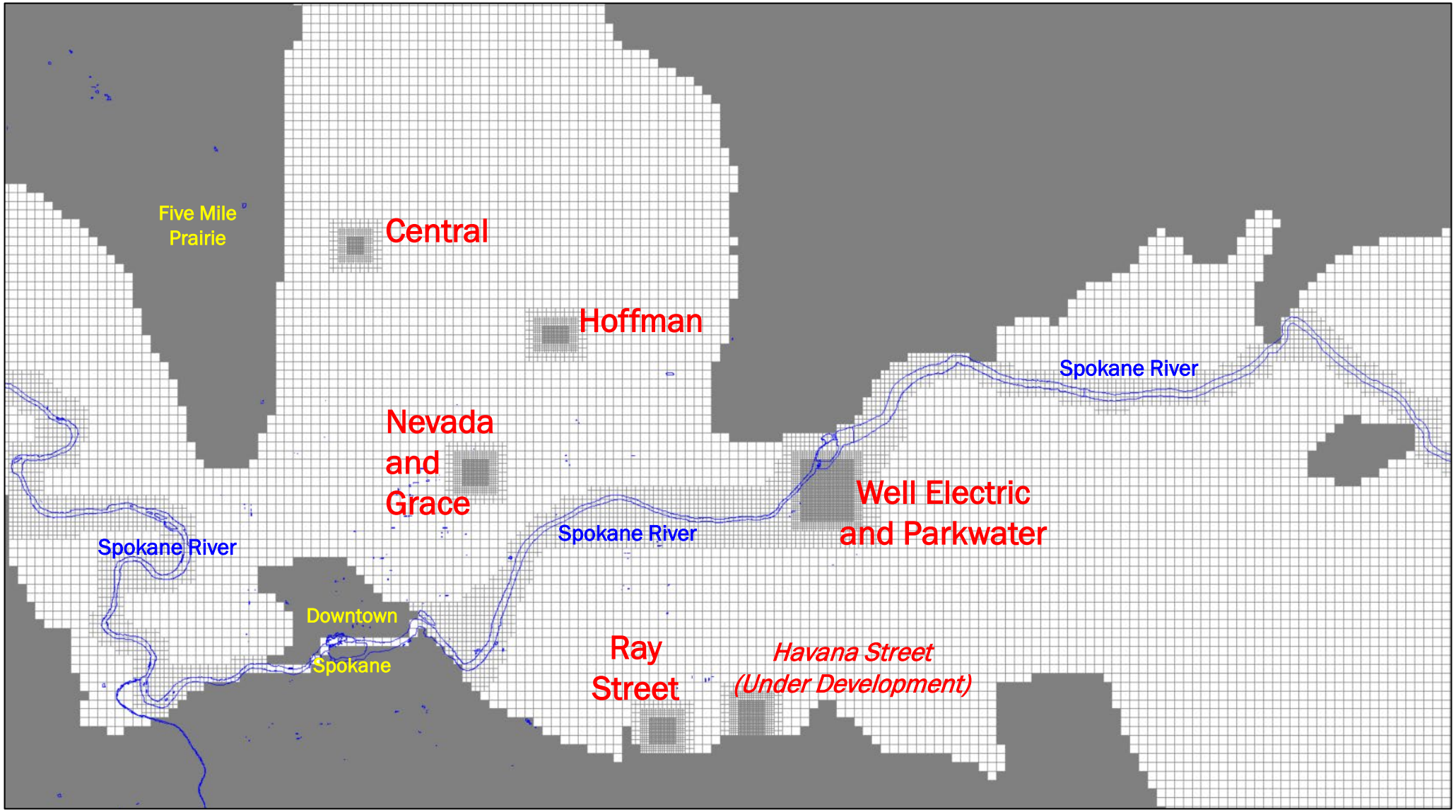


Figure 7. City of Spokane water system.

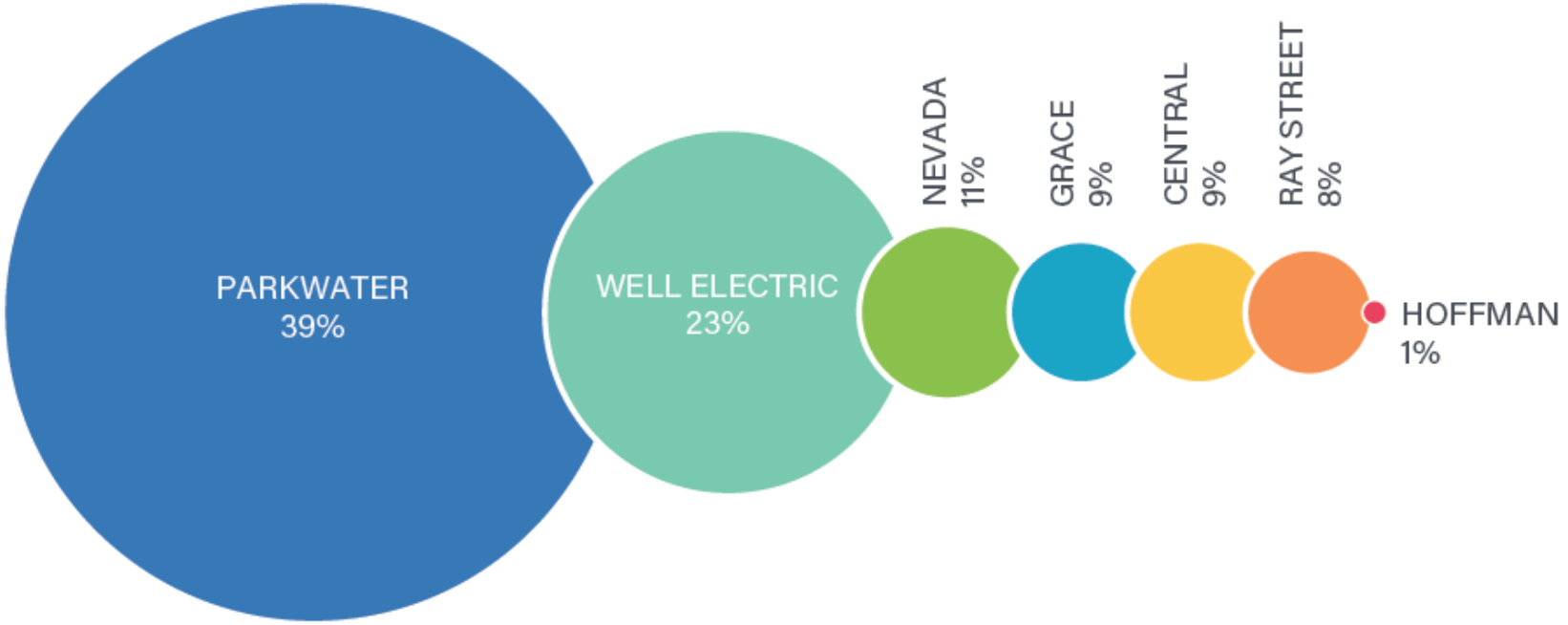
As Spokane grew, new well pumping stations, booster pump stations, reservoirs, transmission mains, and distribution mains were constructed to keep pace with the population's demand for water. In 1967, at the request of land developers, the Water Department began water service to customers outside the city limits. Today, the City of Spokane continues to use the Spokane Valley-Rathdrum Prairie Aquifer as its sole source of potable water. The water system has 7 well stations with 14 wells and 27 well pumps, 25 booster pump stations with 72 booster pumps, 22 pressure zones with 34 reservoirs, and more than 1,100 miles of water pipes. Spokane's rugged terain and substantial elevation changes necessitated the division of its distribution system into 22 pressure zones, each consisting of its own pumps, reservoirs and distribution mains.



Groundwater Model Grid at City Well Stations



AVERAGE PERCENT OF WATER PRODUCED BY CITY WELL STATIONS



7 Well Stations Provide the City's Water Supply

This Presentation: Detailed Infrastructure Assessments for Three Well Stations (2018–2019)

HOFFMAN WELL STATION

- Serves the North Hill System
- One well offline since 1993

RAY STREET WELL STATION

- Serves the Intermediate System
- Pumping interference during periods of regionally low groundwater levels

WELL ELECTRIC WELL STATION

- Production volume impacts when Spokane River flow/stage is high
- Utilizes power from Upriver Dam

Hoffman Well Station

- Well 1 in service providing 5,460 gpm
- Well 2 out of plumb and out of service due to concerns about structural integrity of the brick caisson (hairline cracks 2 to 15 feet long)
- Both wells impacted by lower river and aquifer levels during the high demand season
- Expected capacity of both wells 10,920 gpm

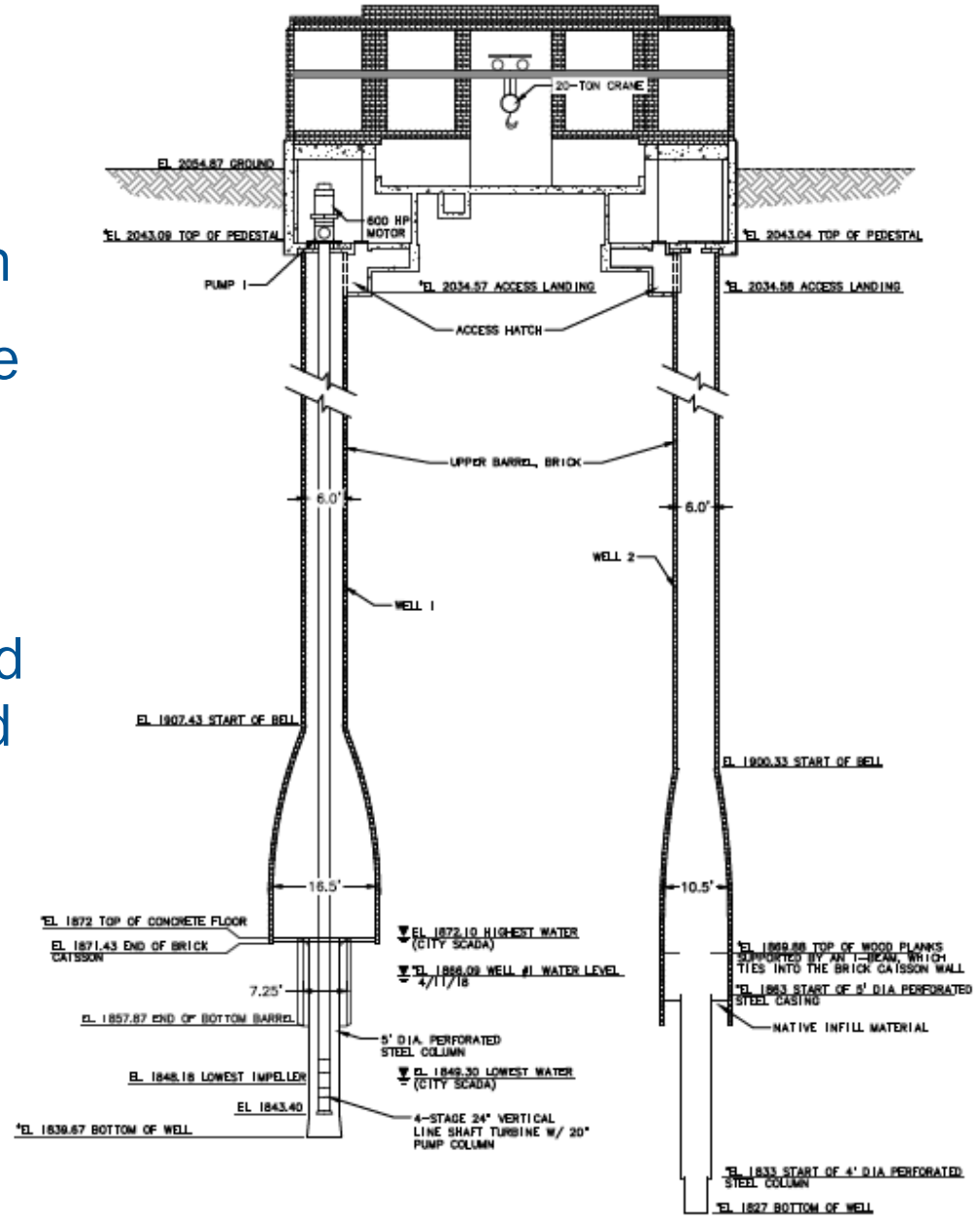
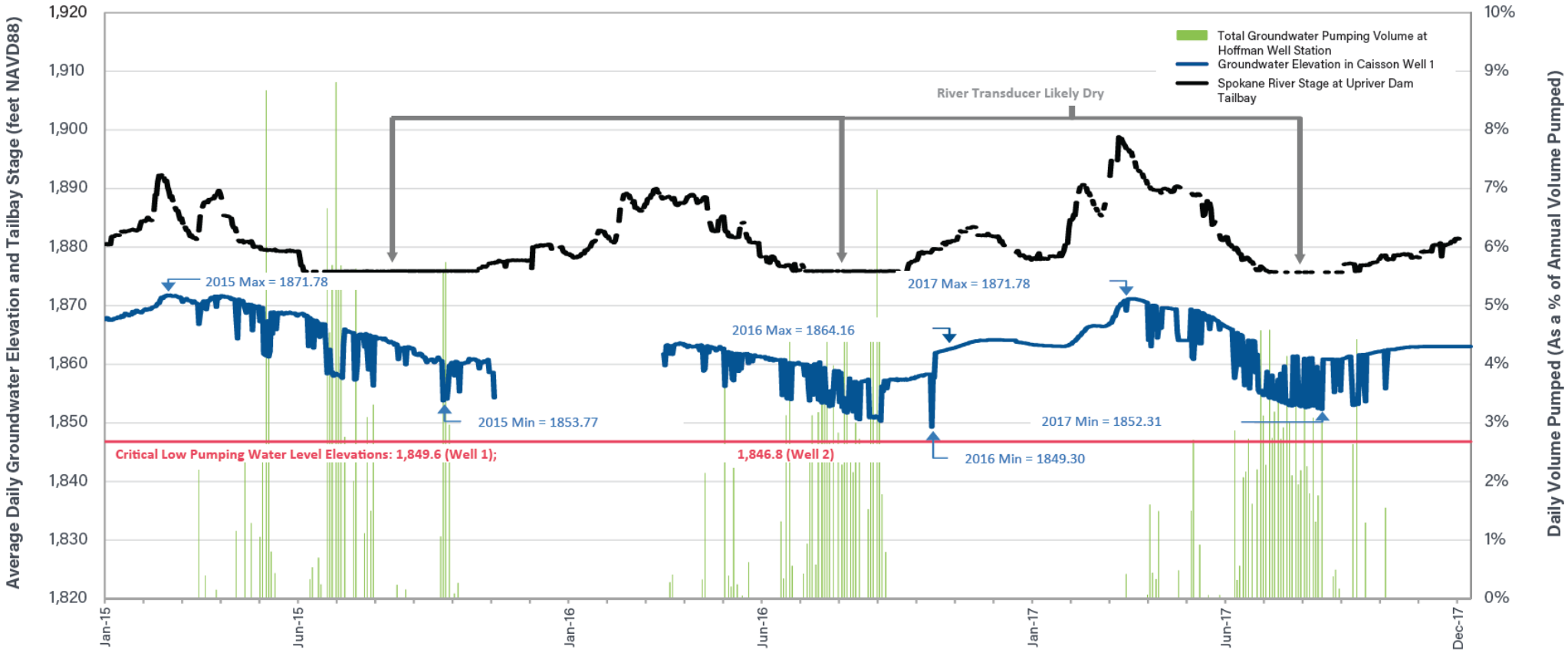


Figure 18. Well construction schematic for Hoffman Well Station Well 1 (left) and Well 2 (right). Courtesy of City of Spokane and Murraysmith, Inc.

Hoffman Well Station

- Well 1 is used primarily from May through September.
- During summer 2016, the groundwater level during pumping of Well 1 dropped to the critical level for pump operations in Well 1 and was only a few feet above the critical level in Well 2 (which was out of service).



Hoffman Well Station

Two Alternatives Considered for Cracks in Well 2

1) Implement Automated Crack-Monitoring Program

   Use displacement transducers and a data logger system to monitor crack movement over time.

2) Line the Brick Caisson Wall

   Repair and strengthen the inside surface of the brick caisson wall using a two-layer carbon fiber reinforced grid with a high-performance sprayable mortar to create a new structural layer.


Photo 5


Photo 6


Photo 7


Photo 8


Photo 9


Photo 10

Hoffman Well Station

A Third Alternative for Well 2: Install and Seal a Casing Liner Extension

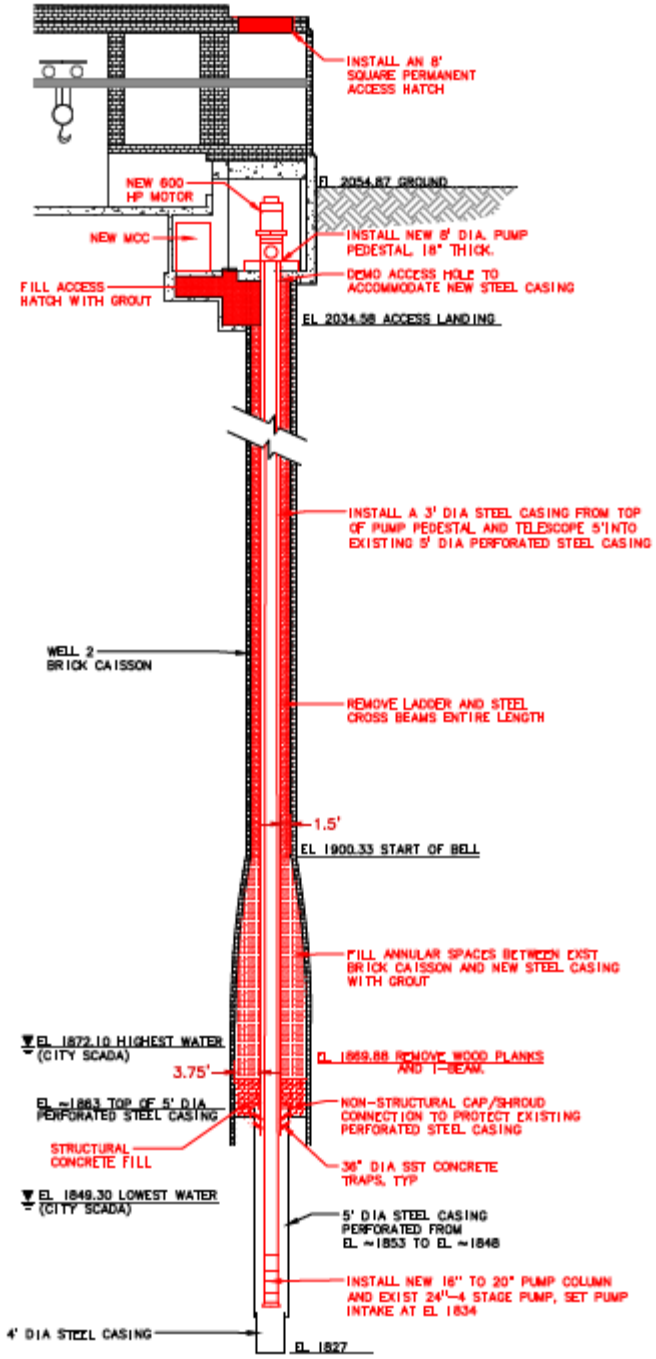
1) Install a 3-foot diameter, solid steel casing liner that is telescoped inside the 5-foot diameter perforated steel casing and extends 180 feet upwards to the pump pedestal.
2) Fill the annular space between the liner and the caisson wall with grout seal material above the perforated steel casing.

This required 3D laser scanning mapping of Well 2 to select the diameter of the liner.

- Purpose: Understand the alignment between the upper 6’ diameter brick caisson wall and the lower 5’ diameter perforated casing.

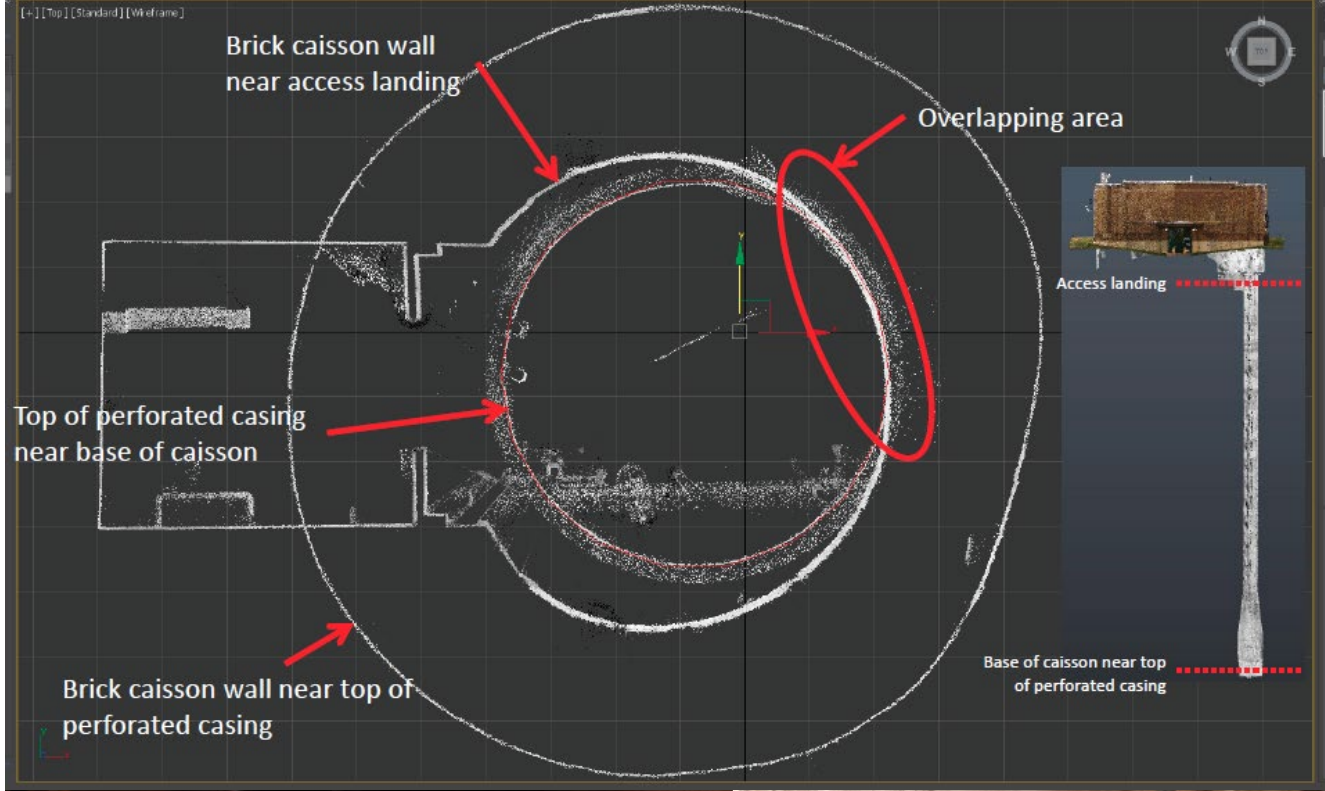
Increase in maximum achievable production capability would be 7.86 mgd

- Current: 7.86 mgd
- Future: 15.72 mgd



Hoffman Well Station

Selecting the diameter of the liner required understanding of the alignment between the upper 6’ diameter brick caisson wall and the lower 5’ diameter perforated casing.



Ray Street Well Station

- Two 24’ caisson wells approximately 80’ deep
- Steel casing is 21’ in diameter and is constructed of 52 sheet piles forming a circular base under the concrete caissons
- Every fourth sheet pile is perforated with 1’x6” slots to serve as intakes to the well
- Well 1 has two 900-hp vertical line shaft turbine pumps
- Well 2 has one 500-hp vertical line shaft turbine pump
- Combined nameplate pumping rate is 18,700 gpm

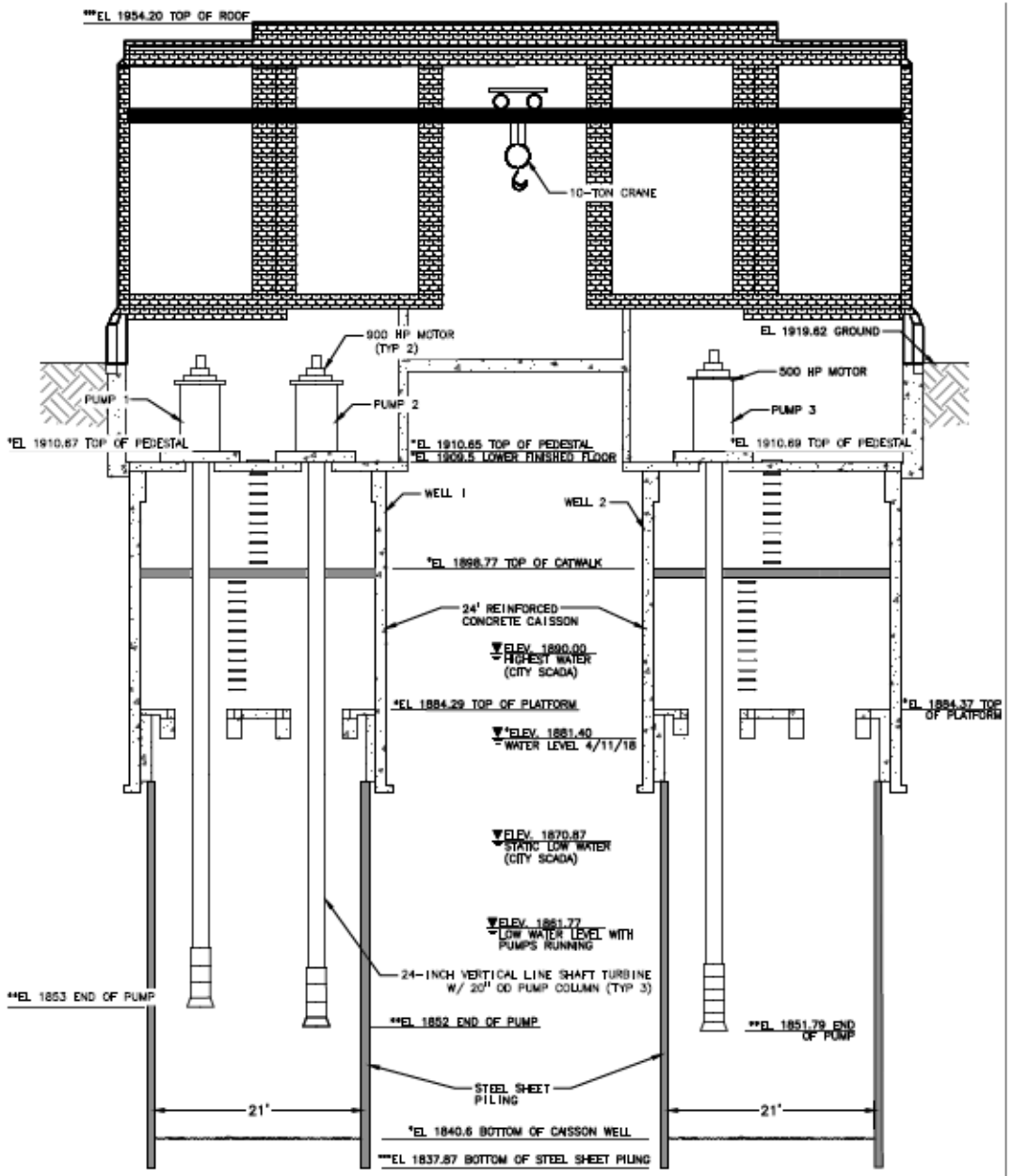
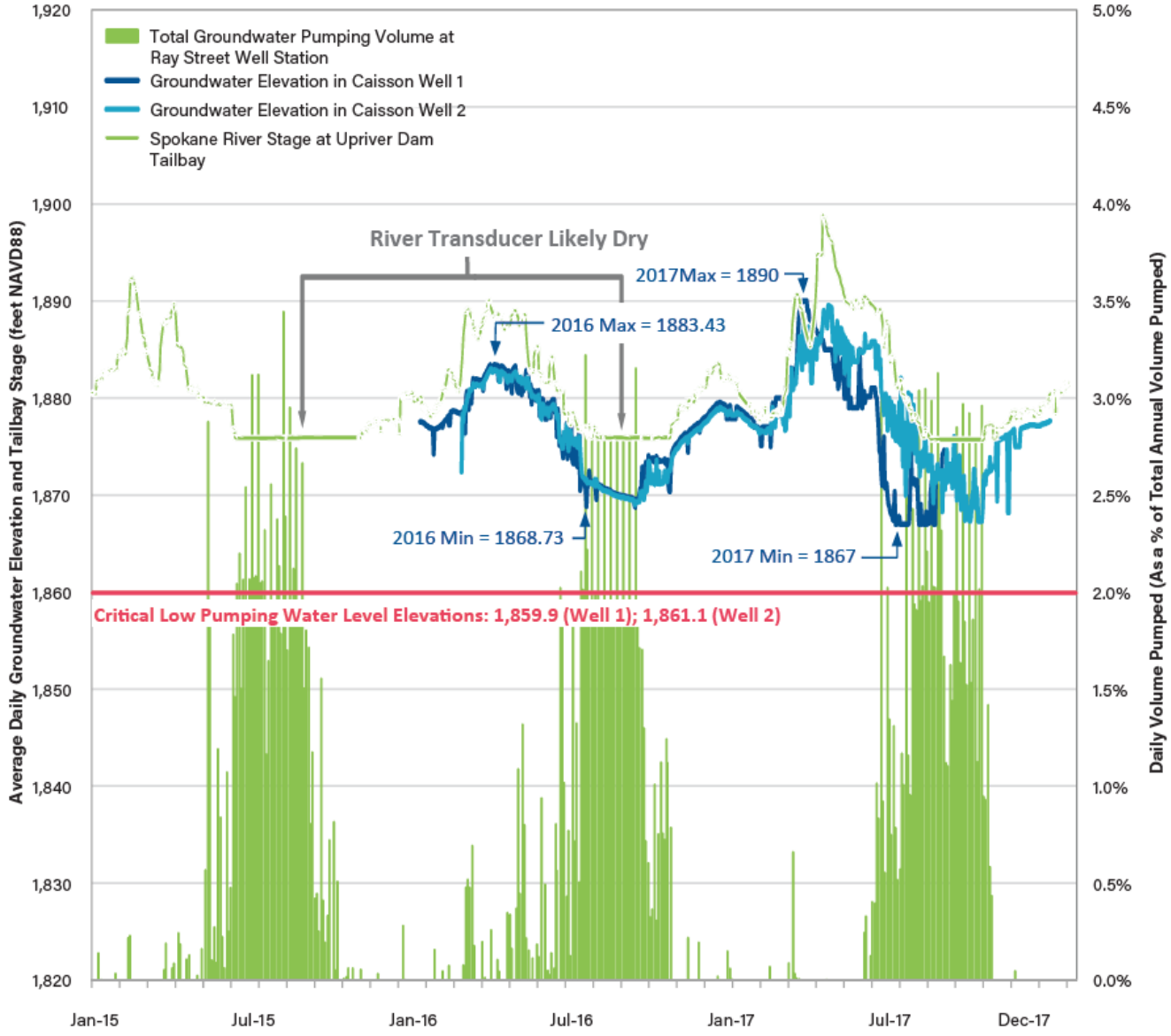


Figure 27 - Profile of Ray Street Well Station Well 1 (left) and 2 (right). Courtesy of Murraysmith, Inc.

Ray Street Well Station

- Water level sounders were too shallow to record minimum water levels in each caisson.
- Older City records indicate water levels likely have dropped to within 2 to 4 feet of the critical level for pump operations.



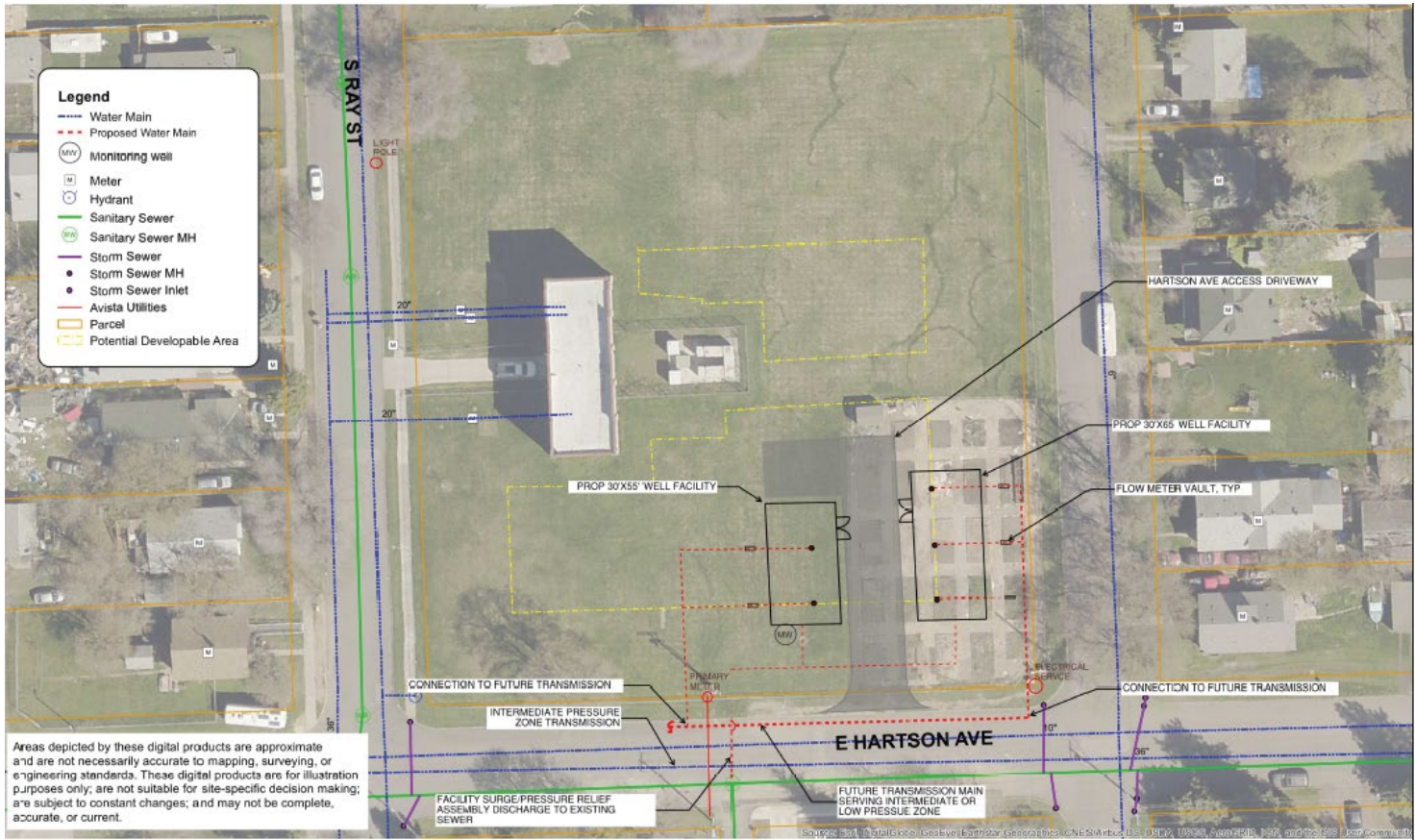
Ray Street Well Station

Two components to the preferred concept for facility upgrades/modifications:

1. Modify the pumping systems in both caisson wells
2. Install a new wellfield in the southeast corner of this large property
   - Five traditional 24” diameter vertical wells screened in depth interval 75-100 feet

Increase in maximum achievable production capability is ~35 mgd

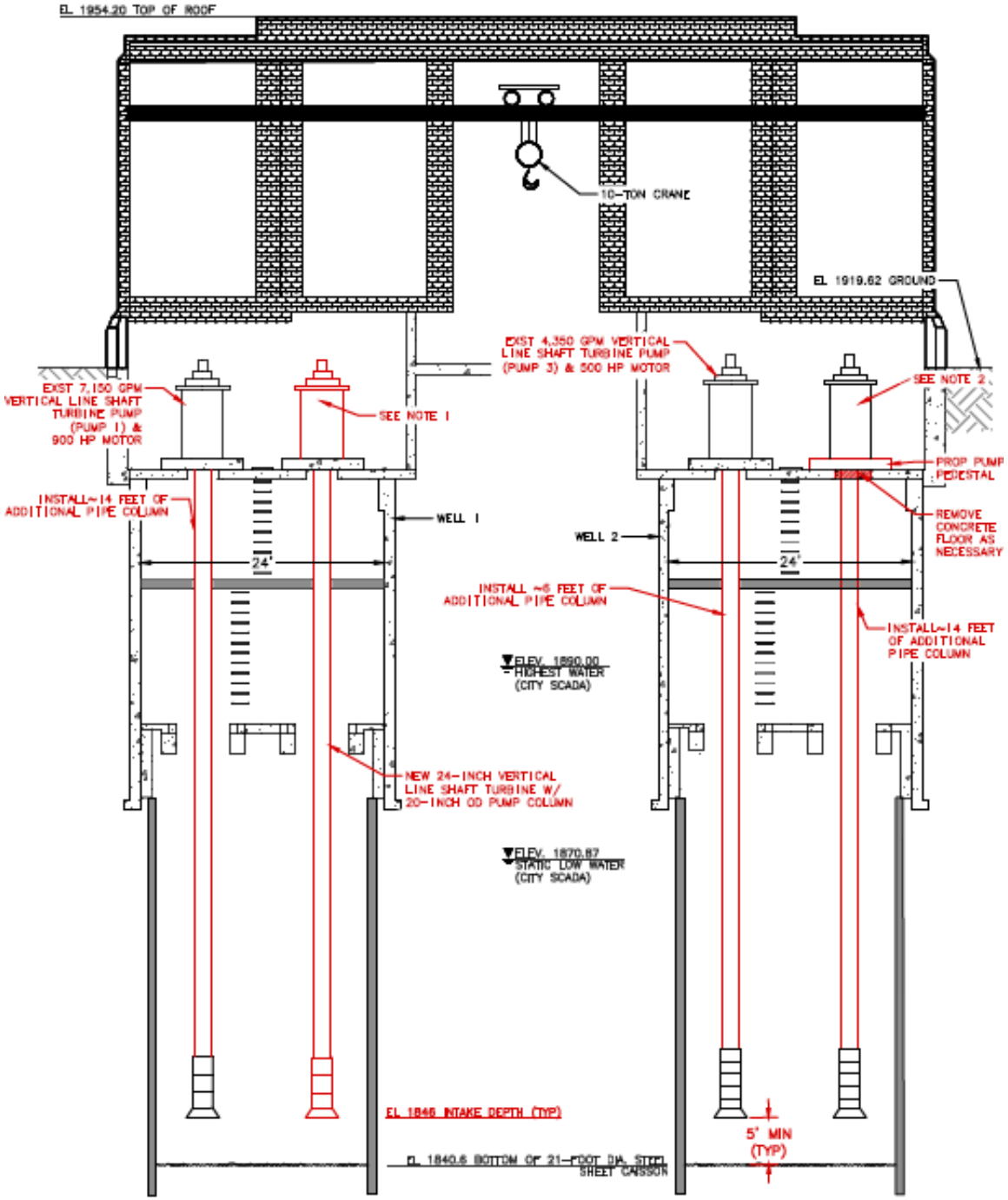
- Current: 23.3 mgd
- Future: ~58 mgd



Ray Street Well Station

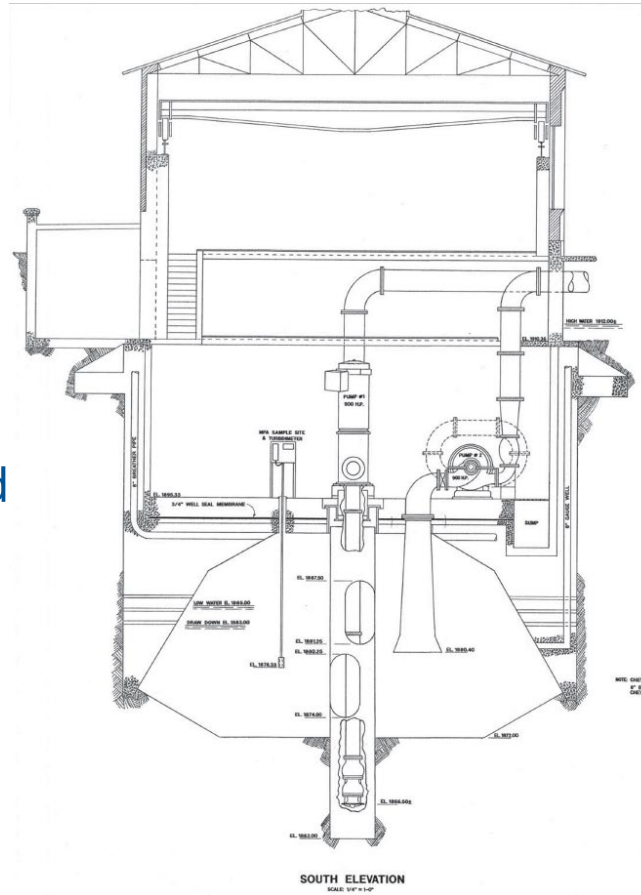
Modifications to the existing caisson wells consist of modifications to their pumps (line-shaft vertical turbines):

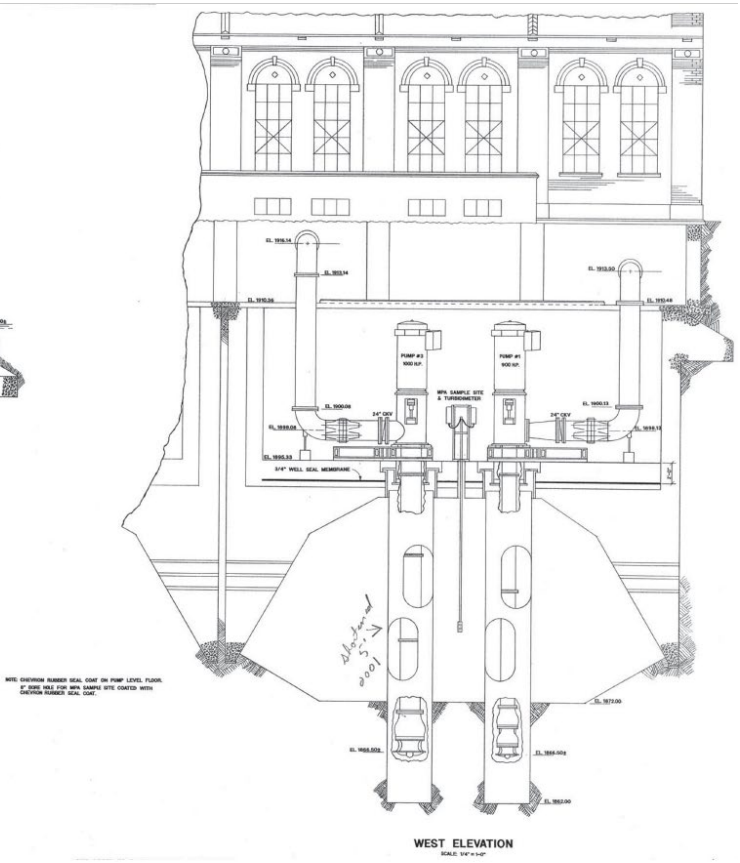
1. For the three existing pumps, lower the intakes by 14 feet for two of the pumps and by 6 feet for the third pump.
2. Redistribute the pumping capacity in each caisson well
   a. Move one of the 900-hp pumps from Well 1 to Well 2
   b. Add a 500-hp pump in Well 1
   c. Result: Both wells have a 500-hp pump and a 900-hp pump.



Well Electric Well Station

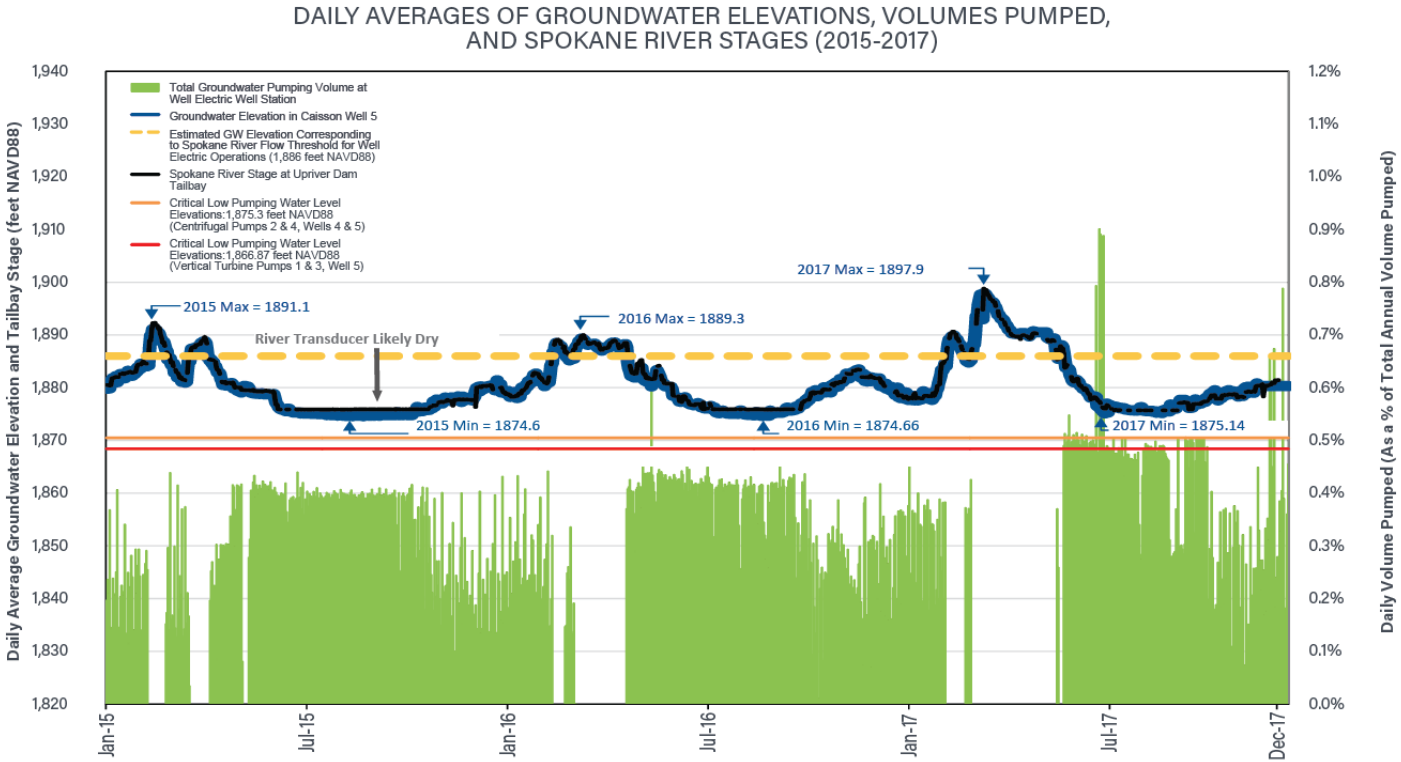
- Two 24’ caisson wells 40’ and 45’ deep, constructed (hand dug) in the early 1920s
  - Wells 4 and 5
  - Older wells 1, 2, 3 have been offline for many decades
- Bell-shaped caissons up to 45’ diameter
- Perforated steel casings installed, probably in the 1990s (records are scant)
  - Well 5 perforations are 6’ L and 20-30” W
- Well 4 has a single 900-hp centrifugal pump consisting of two single-stage double suction pumps that are coupled
- Well 5 has three pumps (one centrifugal and two line-shaft vertical turbines)
- Combined nameplate pumping rate is 39,300 gpm (56.6 mgd)





Well Electric Well Station

- Groundwater levels in caisson mimic river stage below Upriver Dam
- Pumping (green) stops when river stage rises above 15,000 cfs during spring freshet
- Corresponds to groundwater elevation and river stage of approx. 1,886 feet (NAVD 88)
- During 2015 and 2016, the summer-season low water levels were 0.7 feet below the critical low water level for operation of the centrifugal pumps in Wells 4 and 5

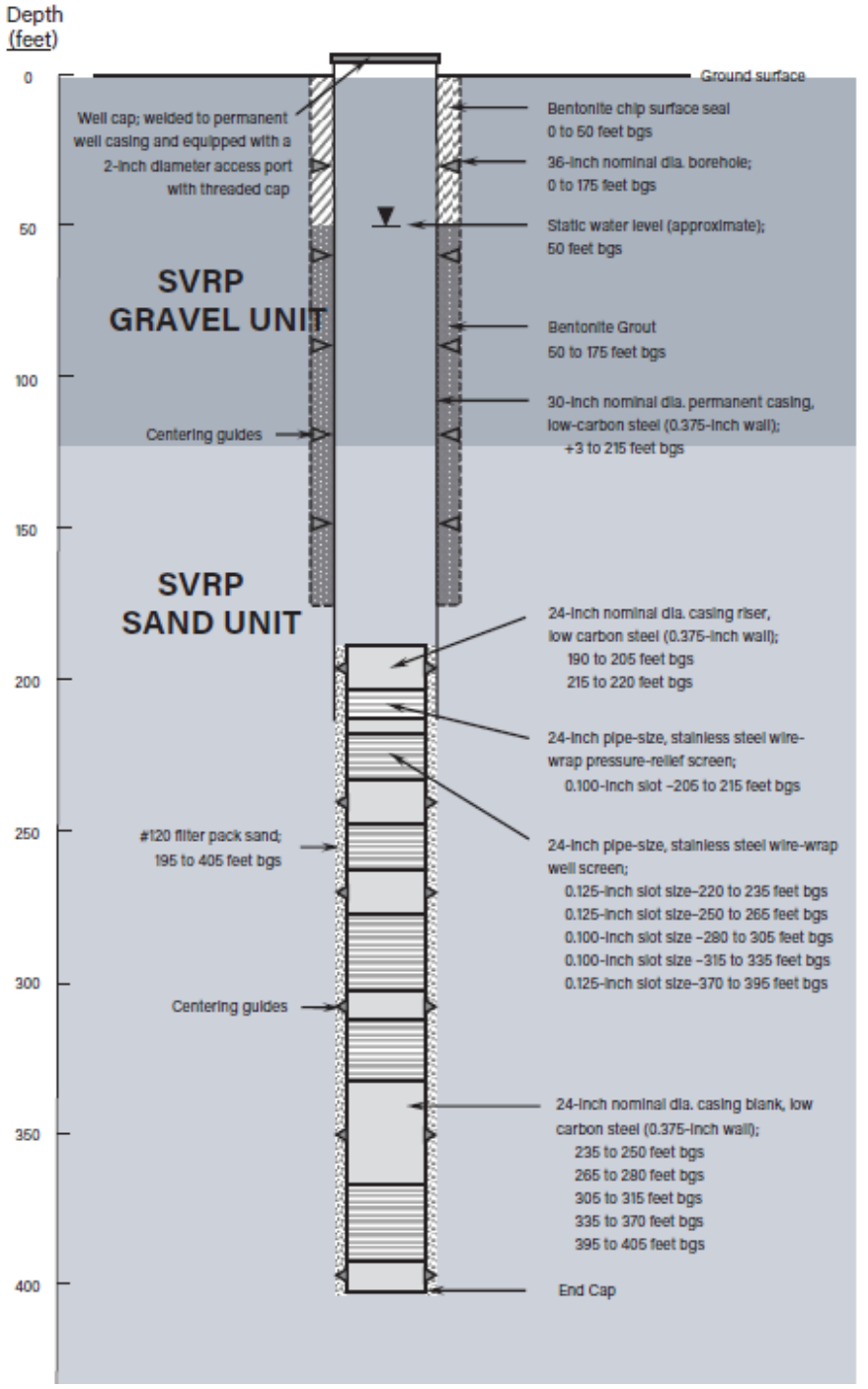


Layered Aquifer System

An exploratory borehole revealed that the typical SVRP gravel-dominated sediments are present in only the upper portion of the SVRP beneath the Well Electric property.

A thick sequence of sand with little to no gravel was identified and was found to be at least 275 feet thick at the drilling site.

The areal extent of this deep sand unit currently is unknown (both within and beyond the Well Electric property).



Upward Gradient from Deep Sand Unit to Shallow Gravel Unit

A monitoring well was constructed in the deep borehole and has been monitoring water levels in the deep sand unit (green line on this hydrograph) since mid-2018.

The water levels in the deep sand unit are higher than in the shallow gravels (the orange line, which presents measurements in Well Electric Caisson Well 1).

This means there is an upward vertical gradient from the deep sand unit into the shallow gravel unit,. Subsequent monitoring has shown this to be the prevailing condition (not infrequent or intermittent).

This raises the possibility that deep production wells may be a viable means of producing water without influence from the river when river flows and stages are high during the spring freshet season.

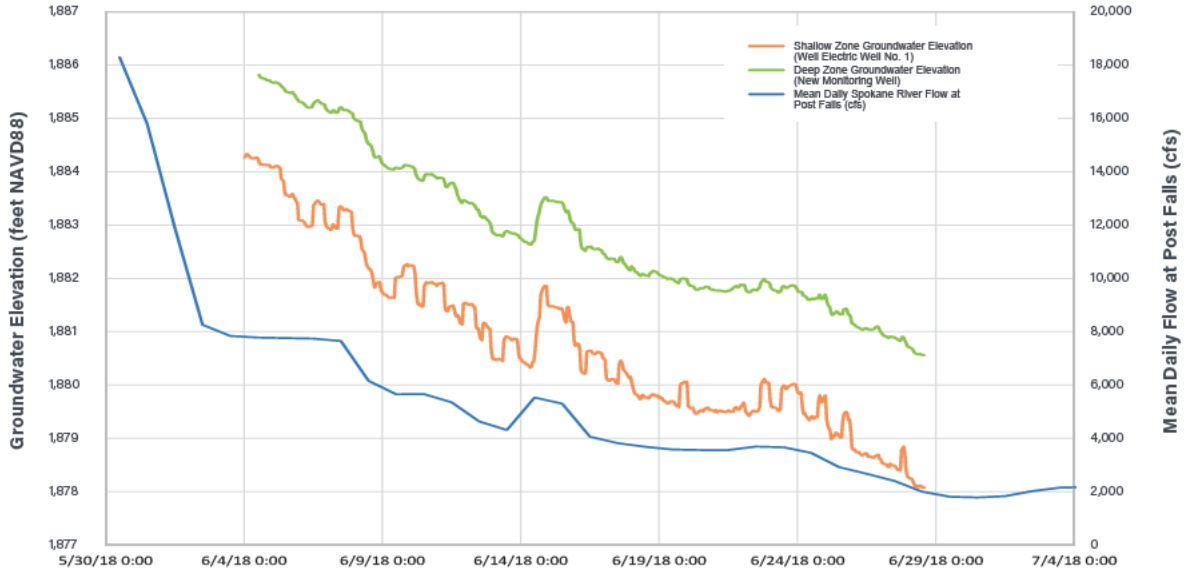
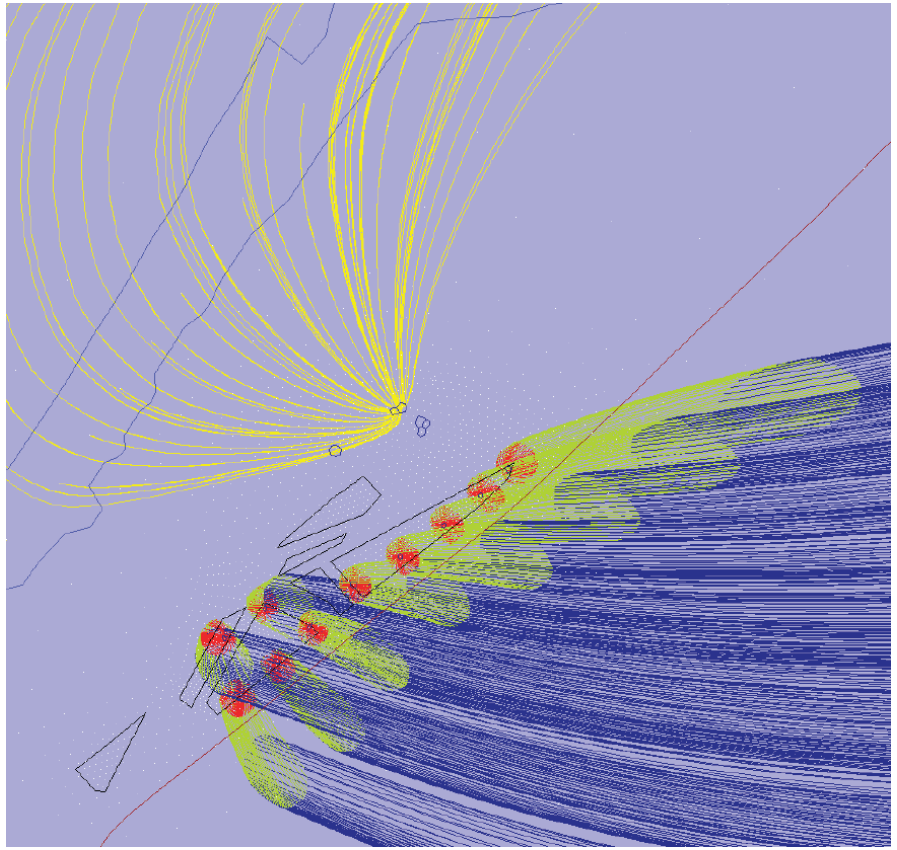


Figure 35. Monitoring at the newly constructed, deep monitoring well and at a nearby, shallow observation well (Well 1) during summer 2018 illustrate that (1) groundwater levels in both units fluctuate in response to changes in Spokane River stage and (2) an upward hydraulic gradient exists from the deep sand unit to the shallow gravel unit in this general area. Courtesy of GSI Water Solutions, Inc.

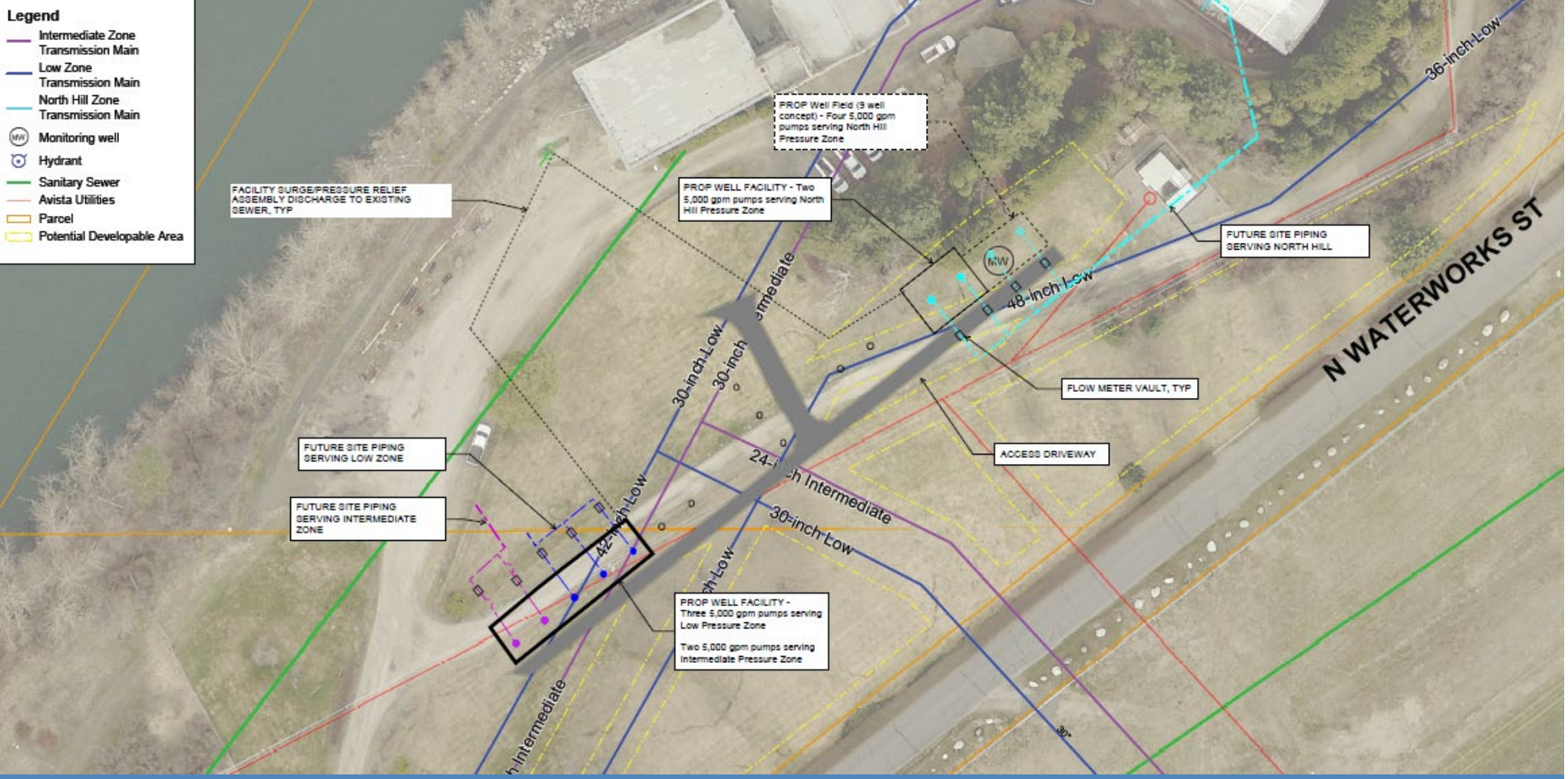
Potential Groundwater Capture by Shallow Caissons vs. Deep Production Wells



Groundwater modeling of a hypothetical pumping concept for caisson wells (shallow gravel unit) and deep production wells (deep sand unit)

Yellow lines show that the capture area for shallow caisson wells passes beneath/through the river.

Red/green/blue lines show that the capture area for deep production wells does not pass beneath the river in this area.



Concept Plan for Layout of a Wellfield Consisting of Deep Wells

Next Steps:

- Further exploratory drilling onsite and across the river to the north, to understand the areal extent and thickness of the deep sand unit beneath the Well Electric property
- Conduct a multi-day aquifer test in a test well constructed in the deep sand unit
- Use the test results to confirm whether a vertical wellfield makes sense to install and to design the layout and operating plan for a vertical wellfield

Well Station Booklet

Well Station Evaluation Study

CITY OF SPOKANE

HOFFMAN, RAY STREET, AND WELL ELECTRIC

This booklet is available online:

Prepared by the City of Spokane, with assistance from GSI Water Solutions

THANK YOU

QR Code for Well Station Booklet

Available online at
https://static.spokanecity.org/documents/publicworks/water/well-station-evaluation-booklet-2021-04-30.pdf

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