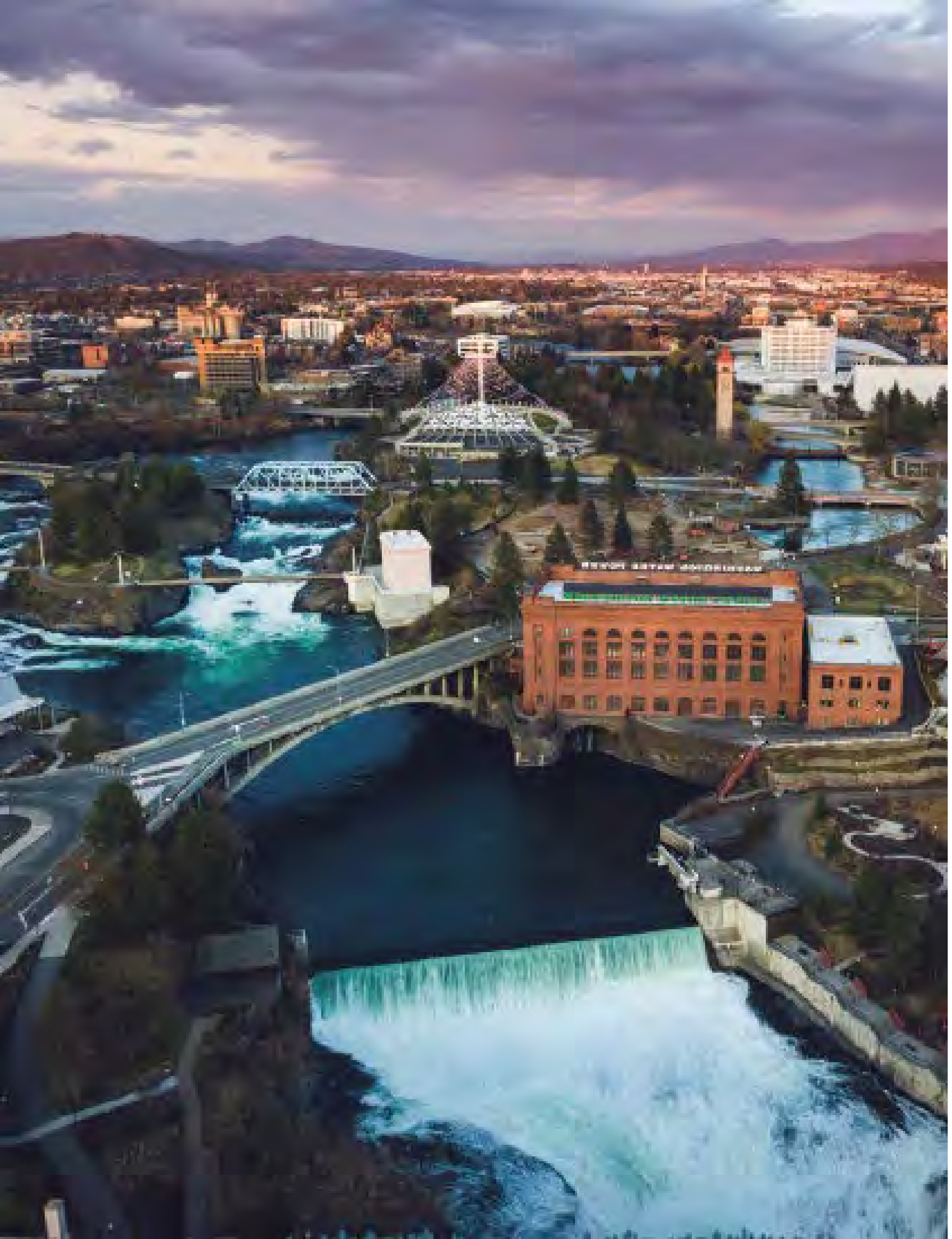


City of Spokane

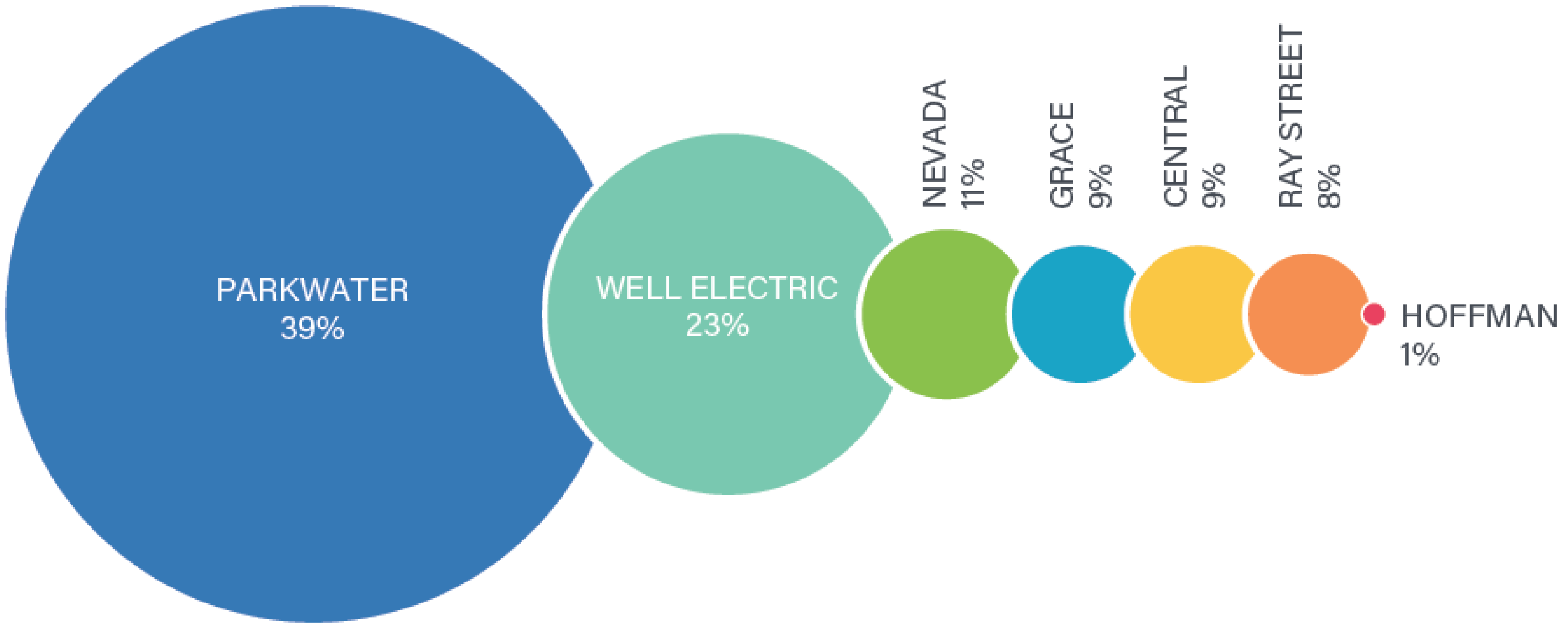
Groundwater Supply Source Assessments

Water Station Infrastructure Evaluations Leading Capital Decisions

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

Spokane River Forum Conference
Wednesday April 26, 2023

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

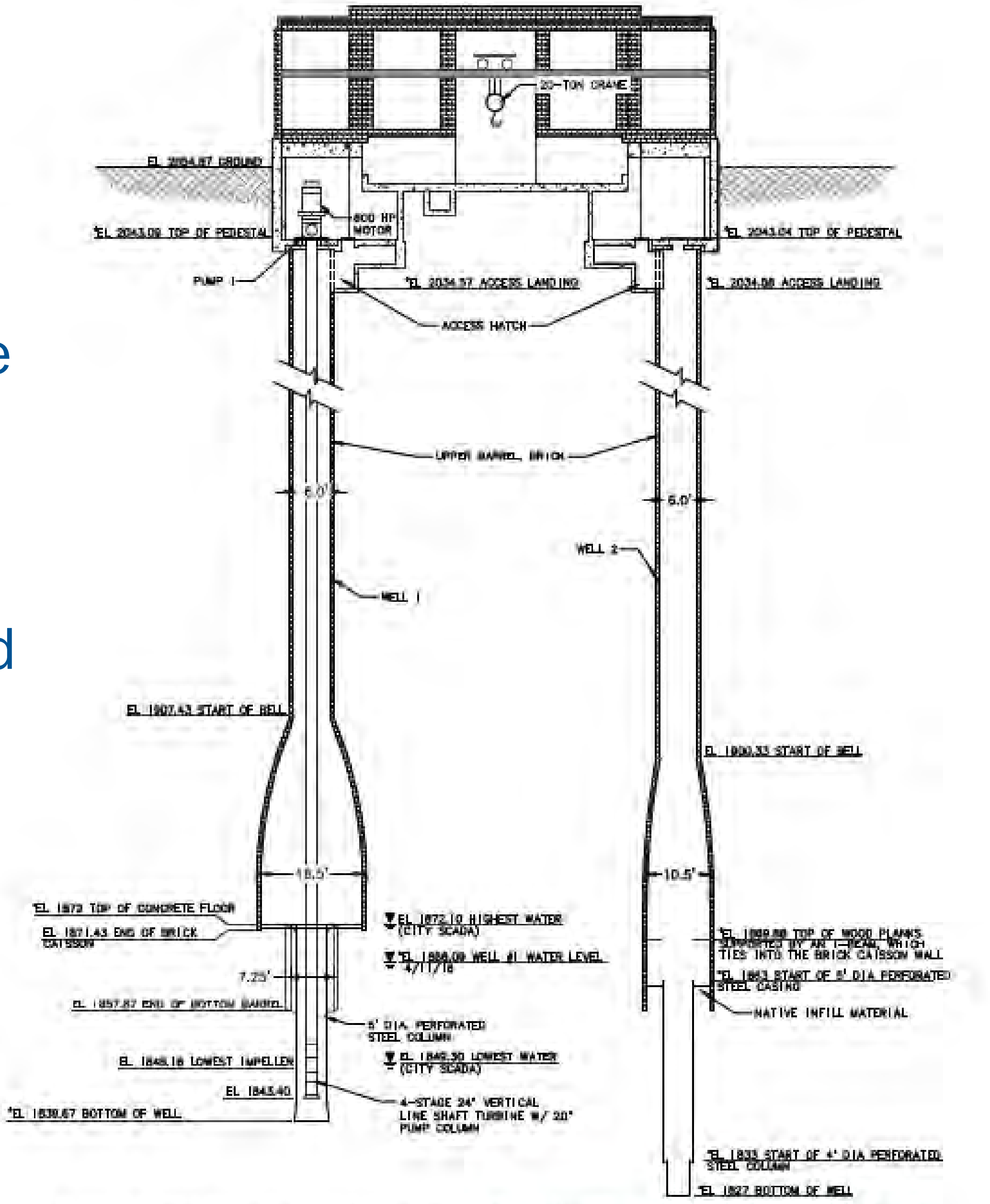
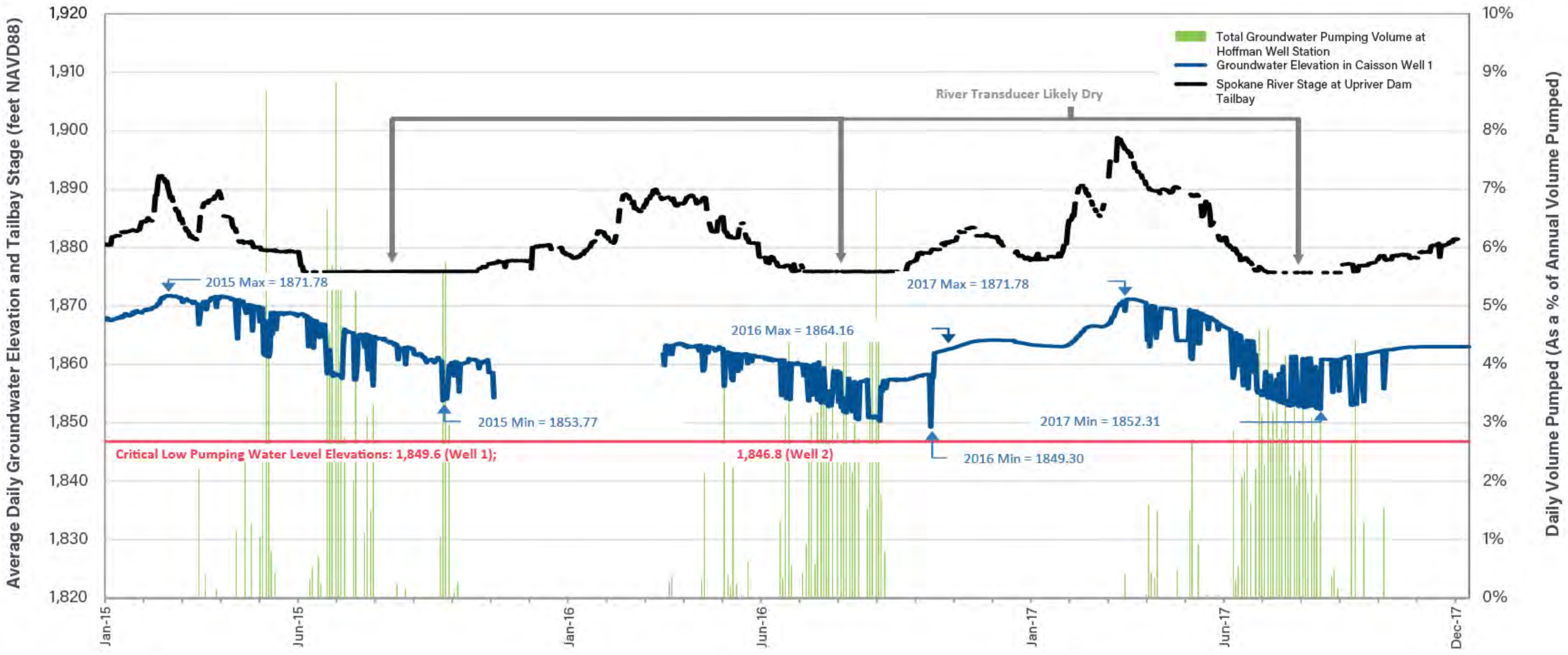


Figure 18. Well construction schematic for Hoffman Well Station Well 1 (left) and Well 2 (right)
Courtesy of City of Spokane and Murraysmith, Inc

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

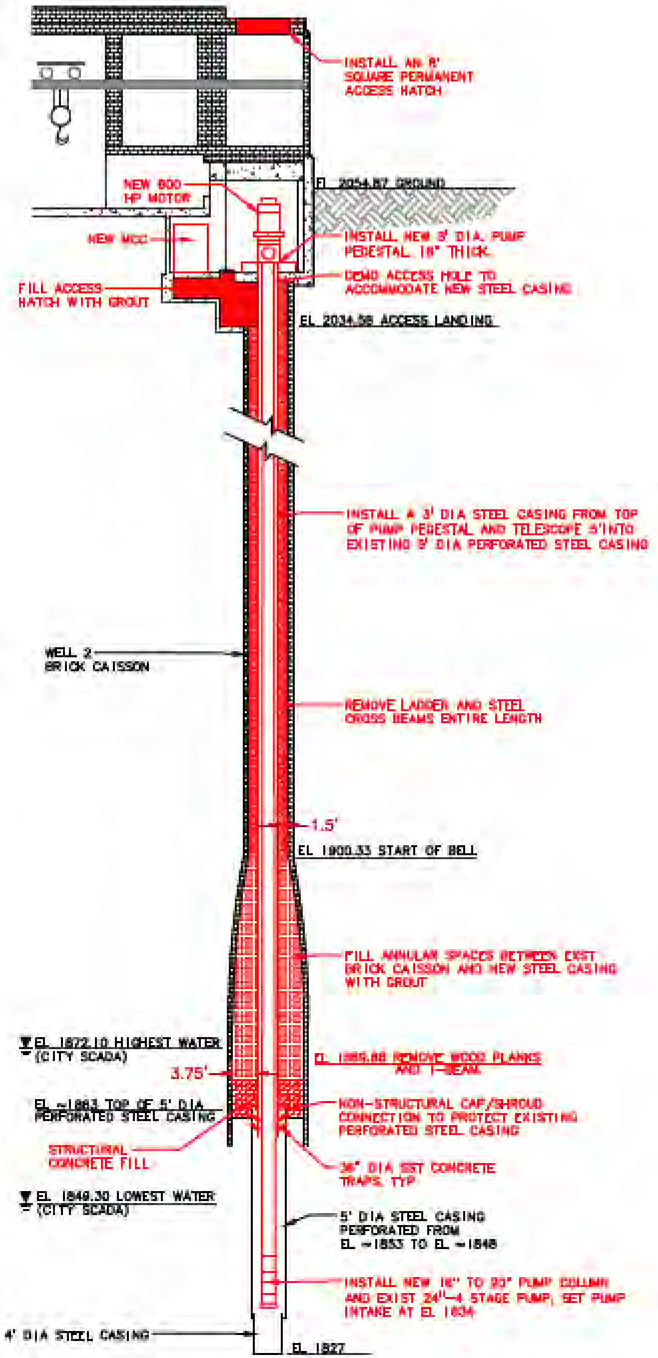
1) Install a 3-foot diameter, solid steel casing liner that is telescoped inside the 5-foot diameter perforated steel casing and extends 180 feet upwards to the pump pedestal.
2) Fill the annular space between the liner and the caisson wall with grout seal material above the perforated steel casing.

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.

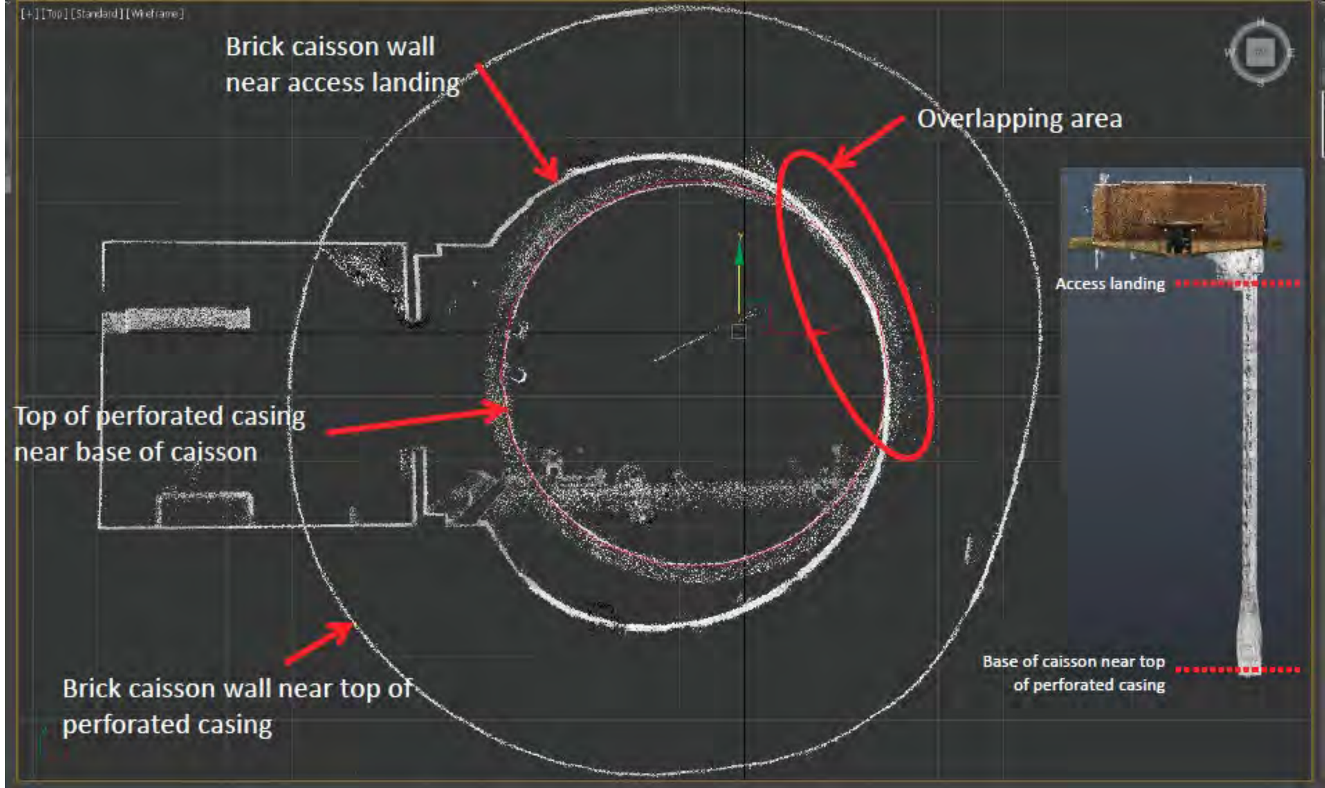
Increase in maximum achievable production capability would be 7.86 mgd

- 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

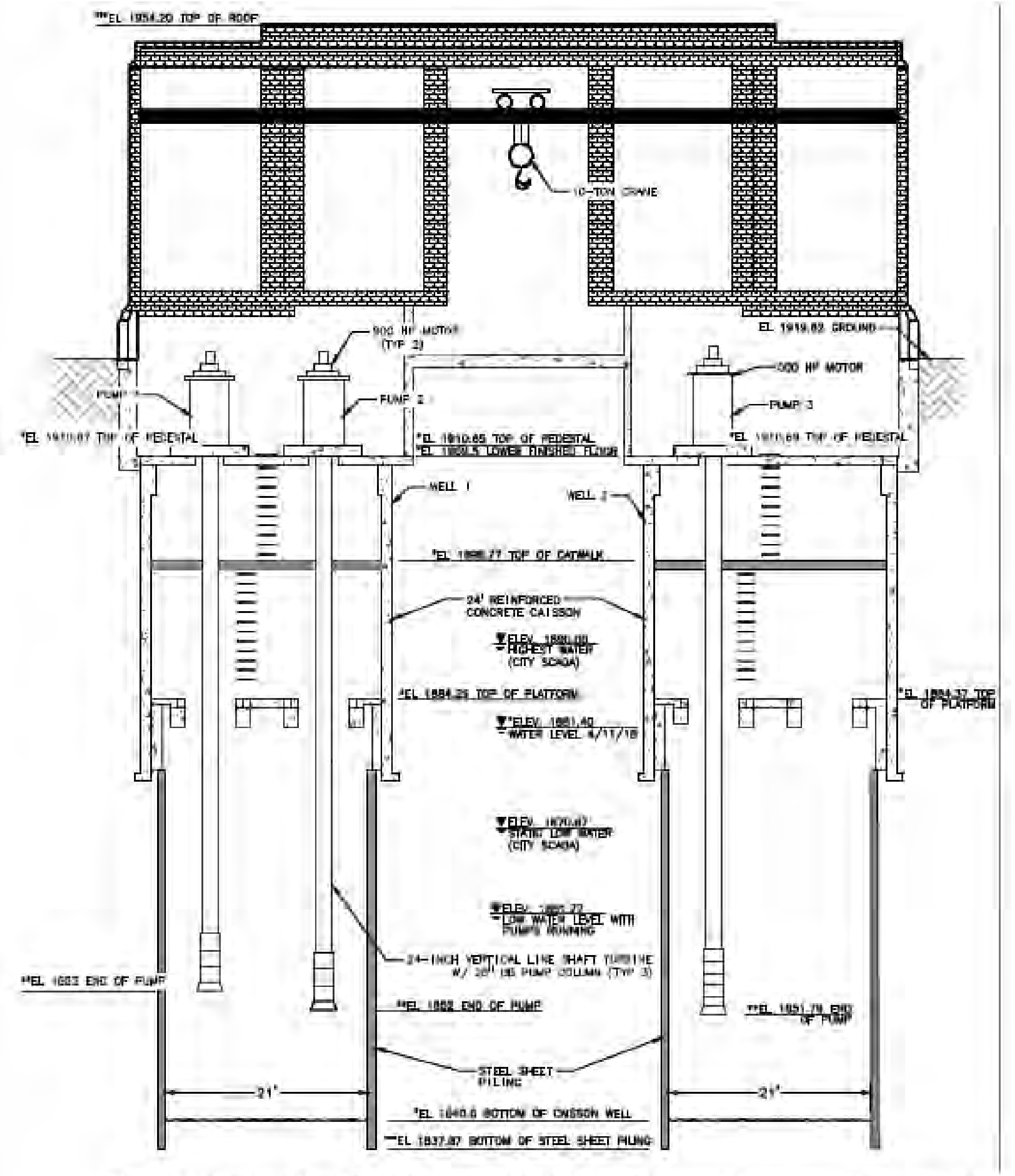
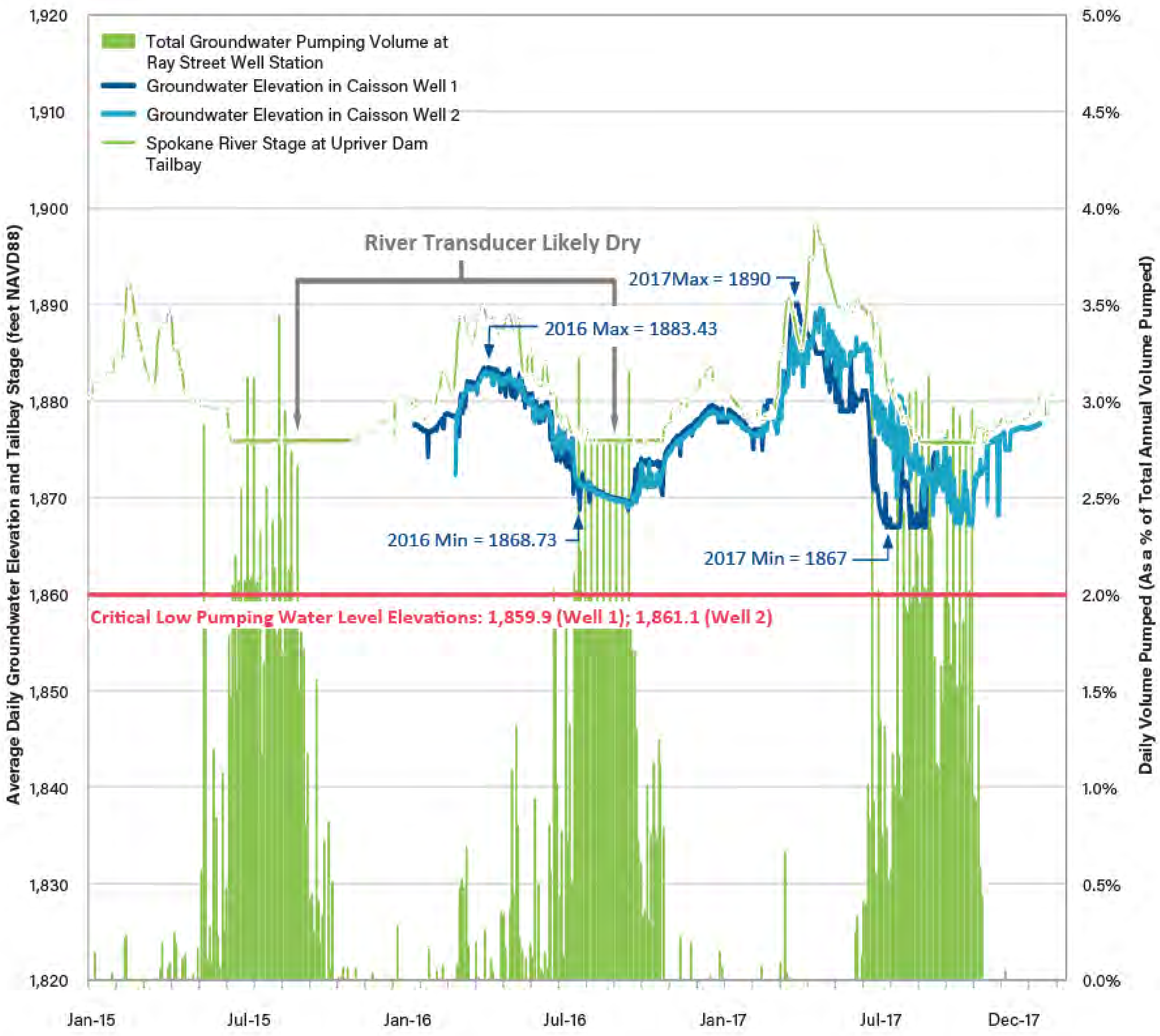


Figure 27 - Profile of Ray Street Well Station Well 1 (left) and 2 (right). Courtesy of Murraysmith, Inc.

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.
- 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 the property



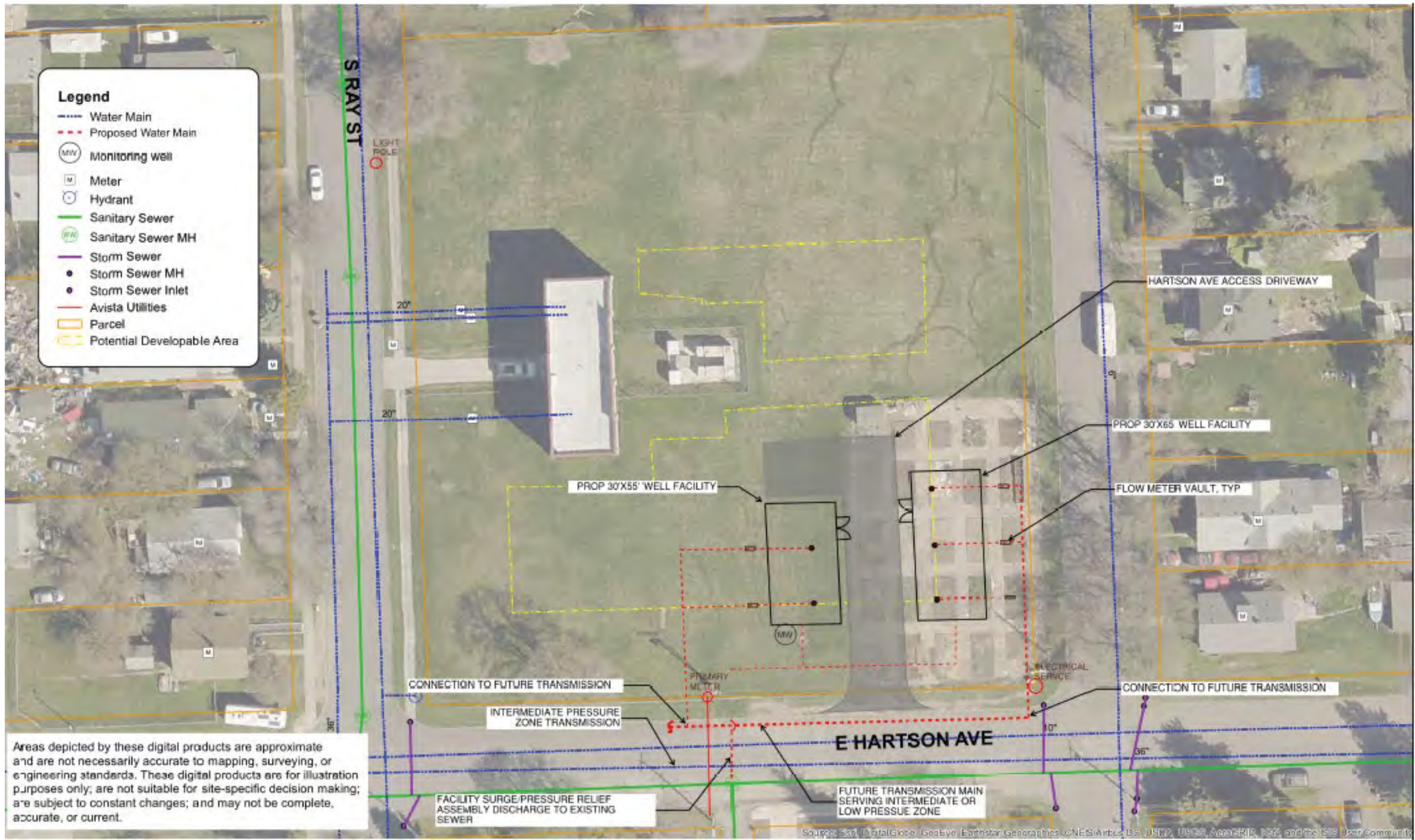
Ray Street Well Station

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

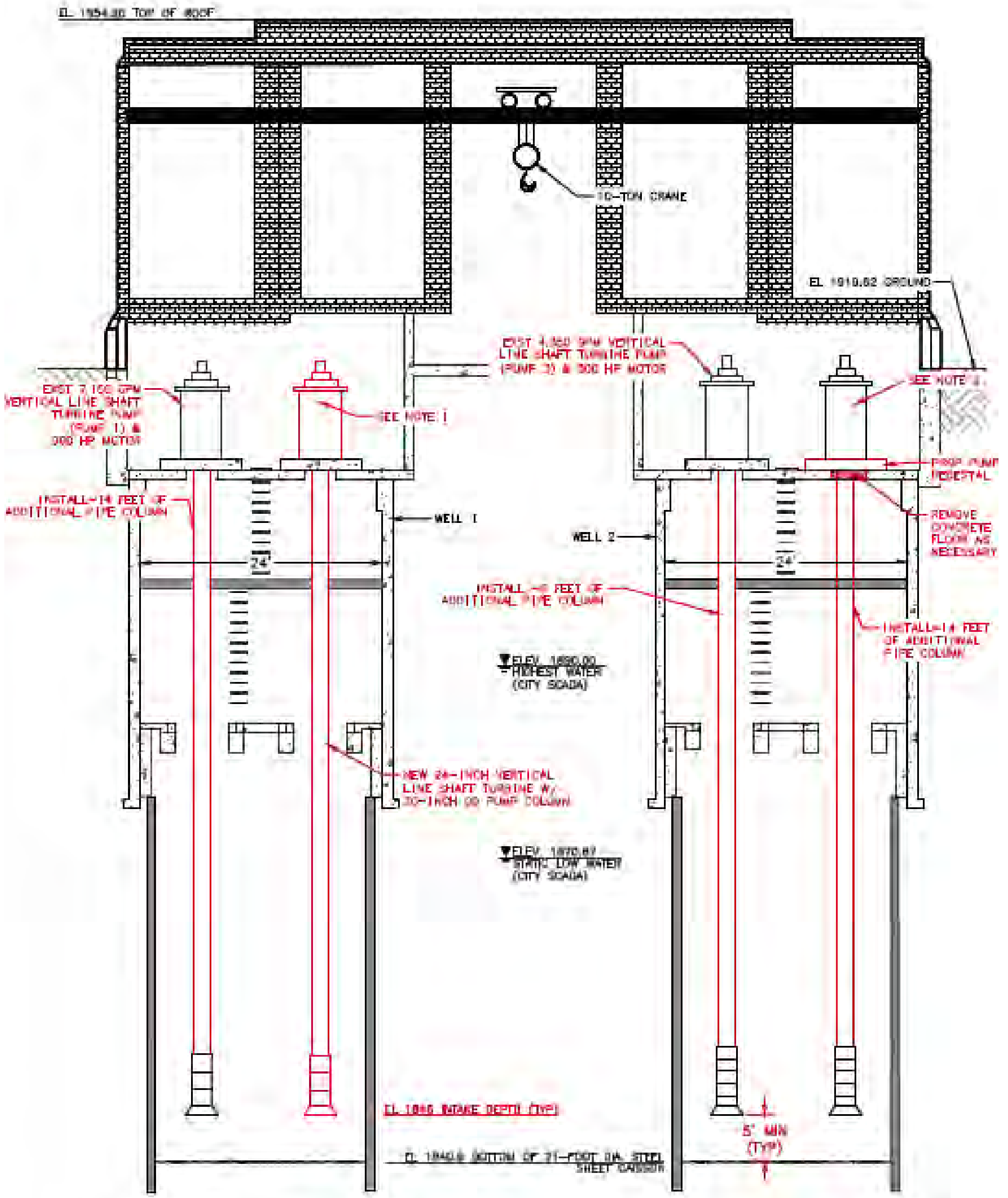
- Current: 23.3 mgd
- Future: ~58 mgd



Ray Street Well Station

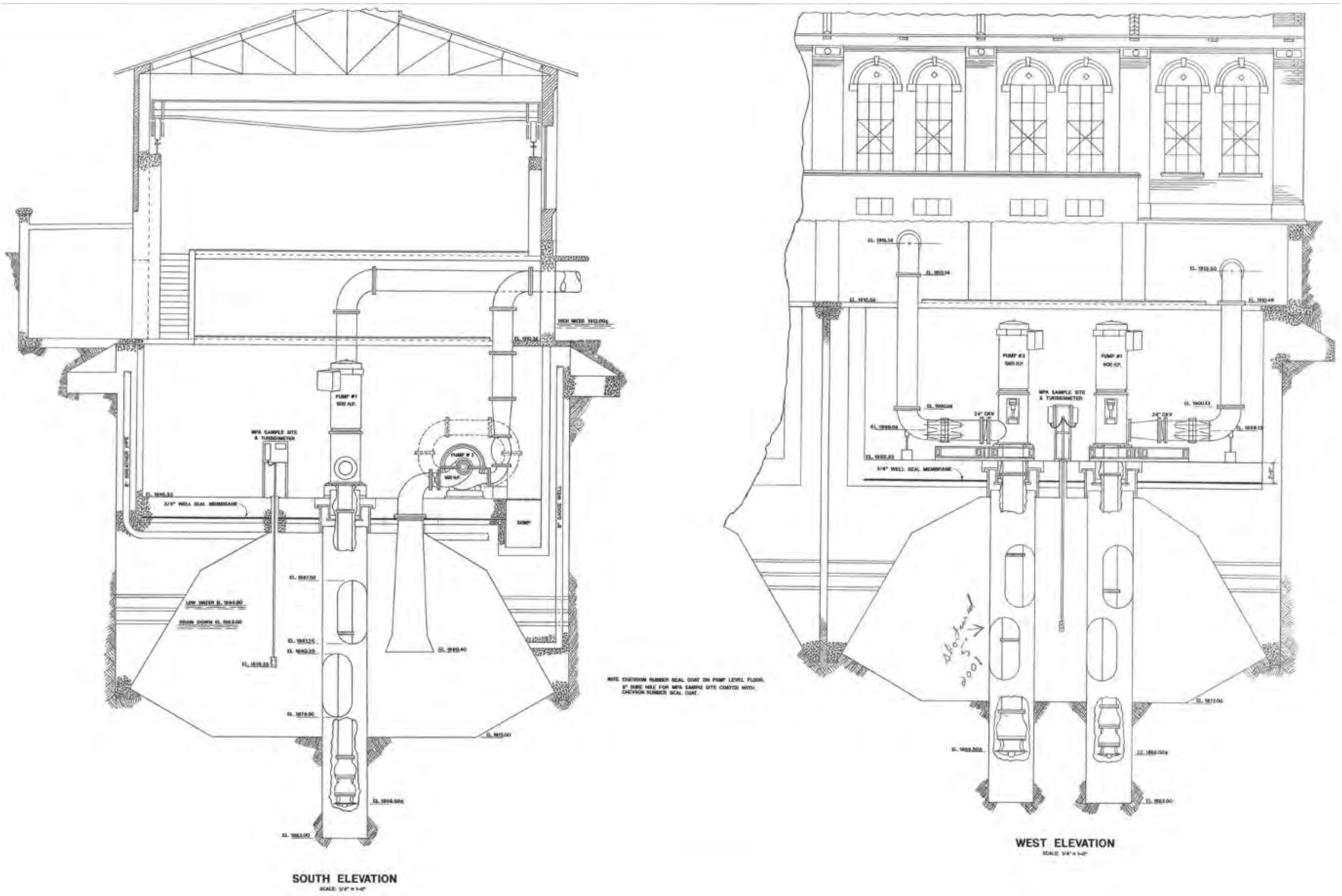
Modifications to the existing caisson wells consist of modifications to their pumps (line-shaft vertical turbines):

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

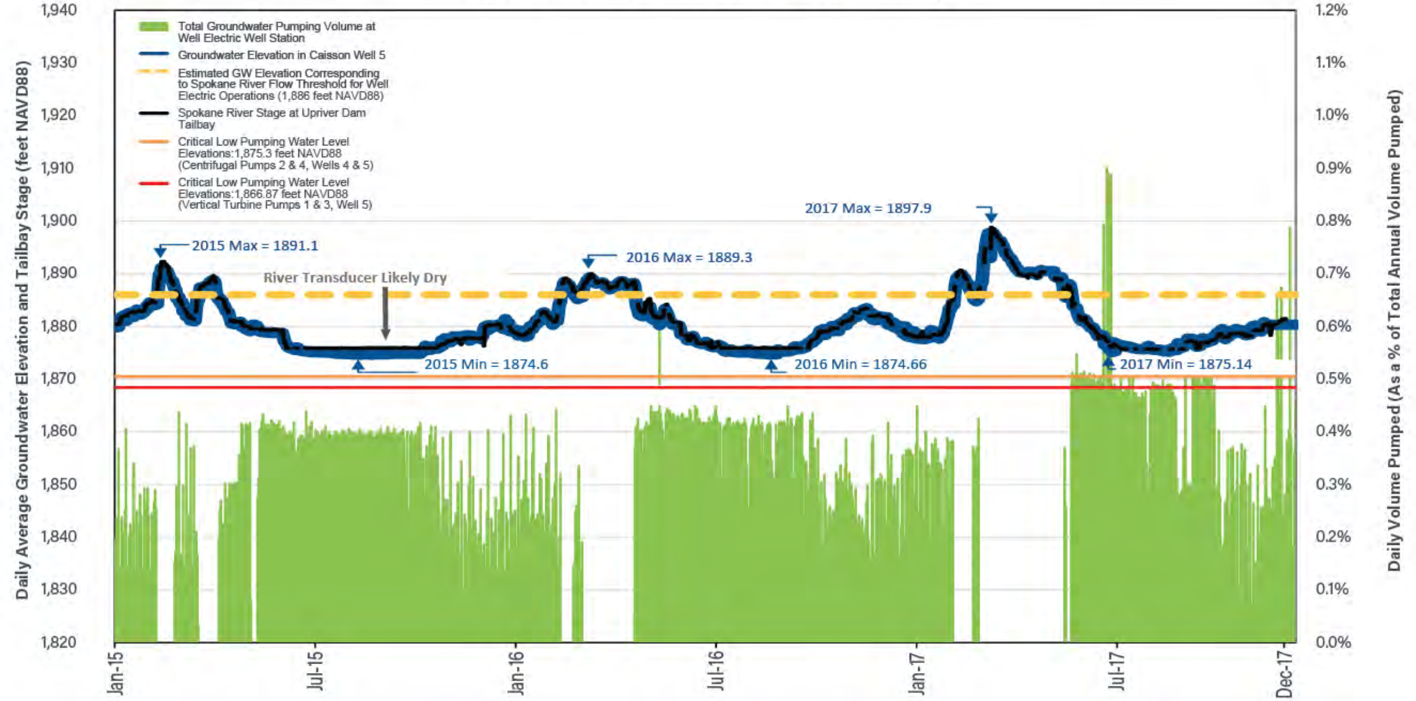
- Two 24’ caisson wells 40’ and 45’ deep, constructed (hand dug) in the early 1920s
  - Wells 4 and 5
  - Older wells 1, 2, 3 have been offline for many decades
- Bell-shaped caissons up to 45’ diameter
- Perforated steel casings installed, probably in the 1990s (records are scant)
  - Well 5 perforations 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

DAILY AVERAGES OF GROUNDWATER ELEVATIONS, VOLUMES PUMPED, AND SPOKANE RIVER STAGES (2015-2017)

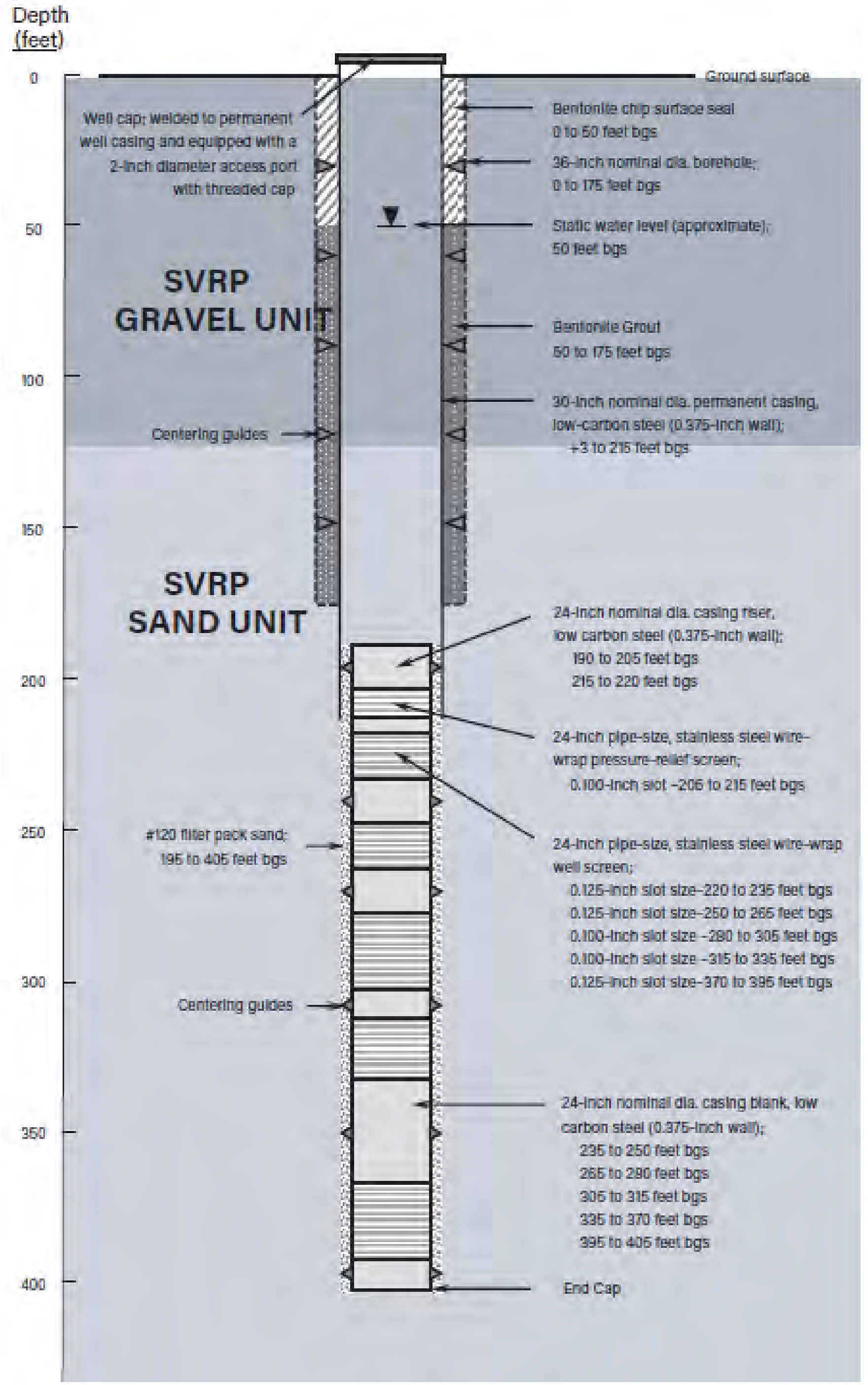


Layered Aquifer System

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.

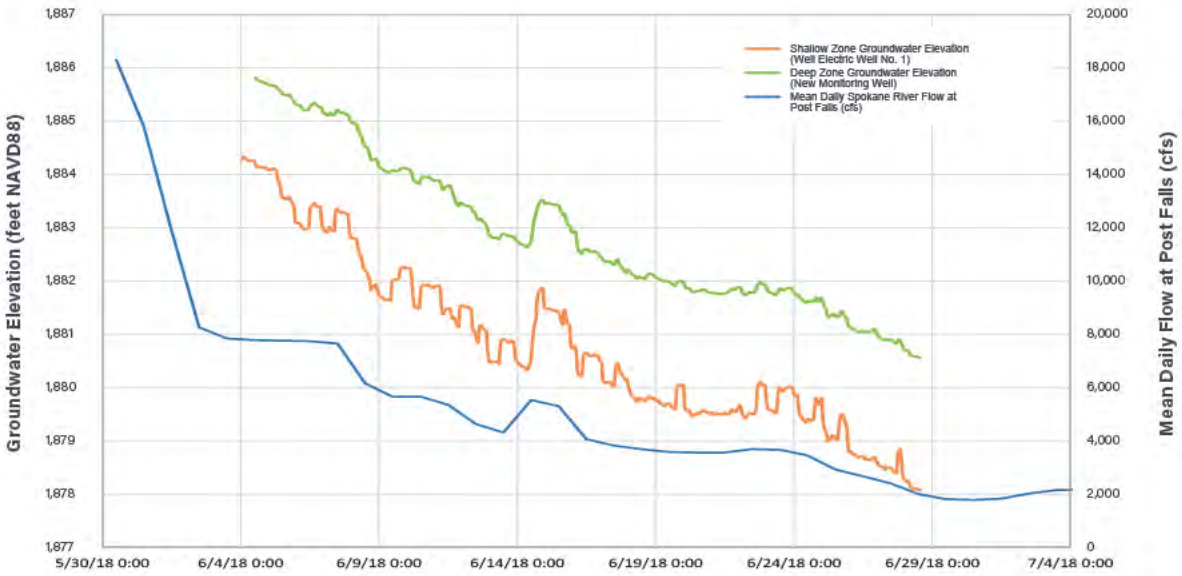
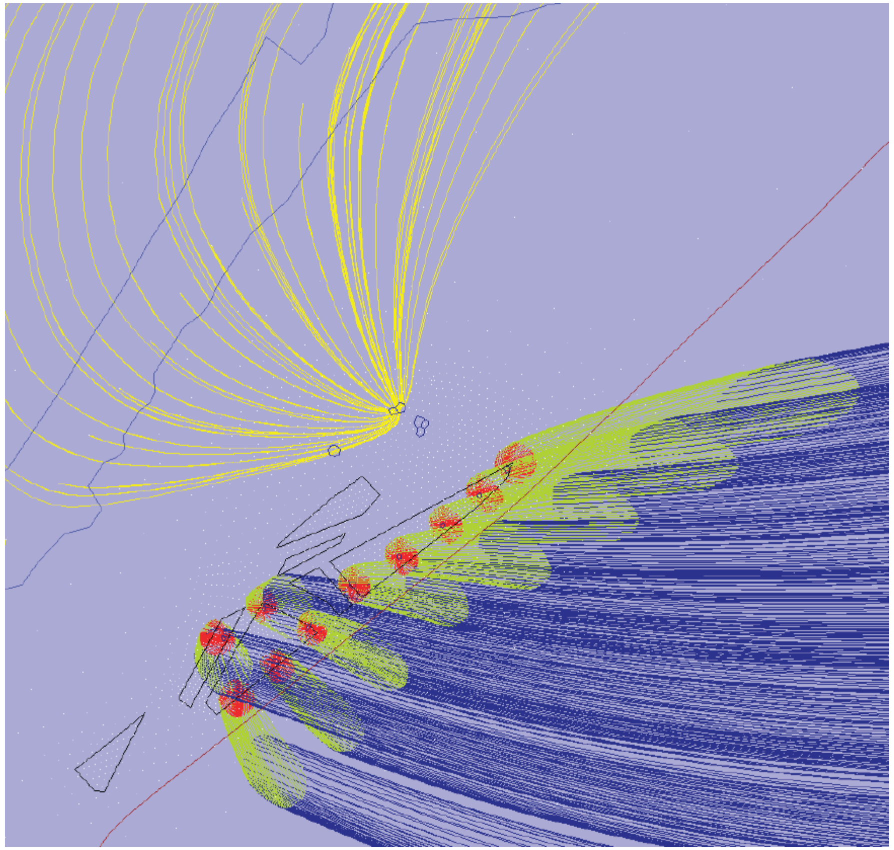


Figure 35. Monitoring at the newly constructed, deep monitoring well and at a nearby, shallow observation well (Well 1) during summer 2018 illustrate that (1) groundwater levels in both units fluctuate in response to changes in Spokane River stage and (2) an upward hydraulic gradient exists from the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

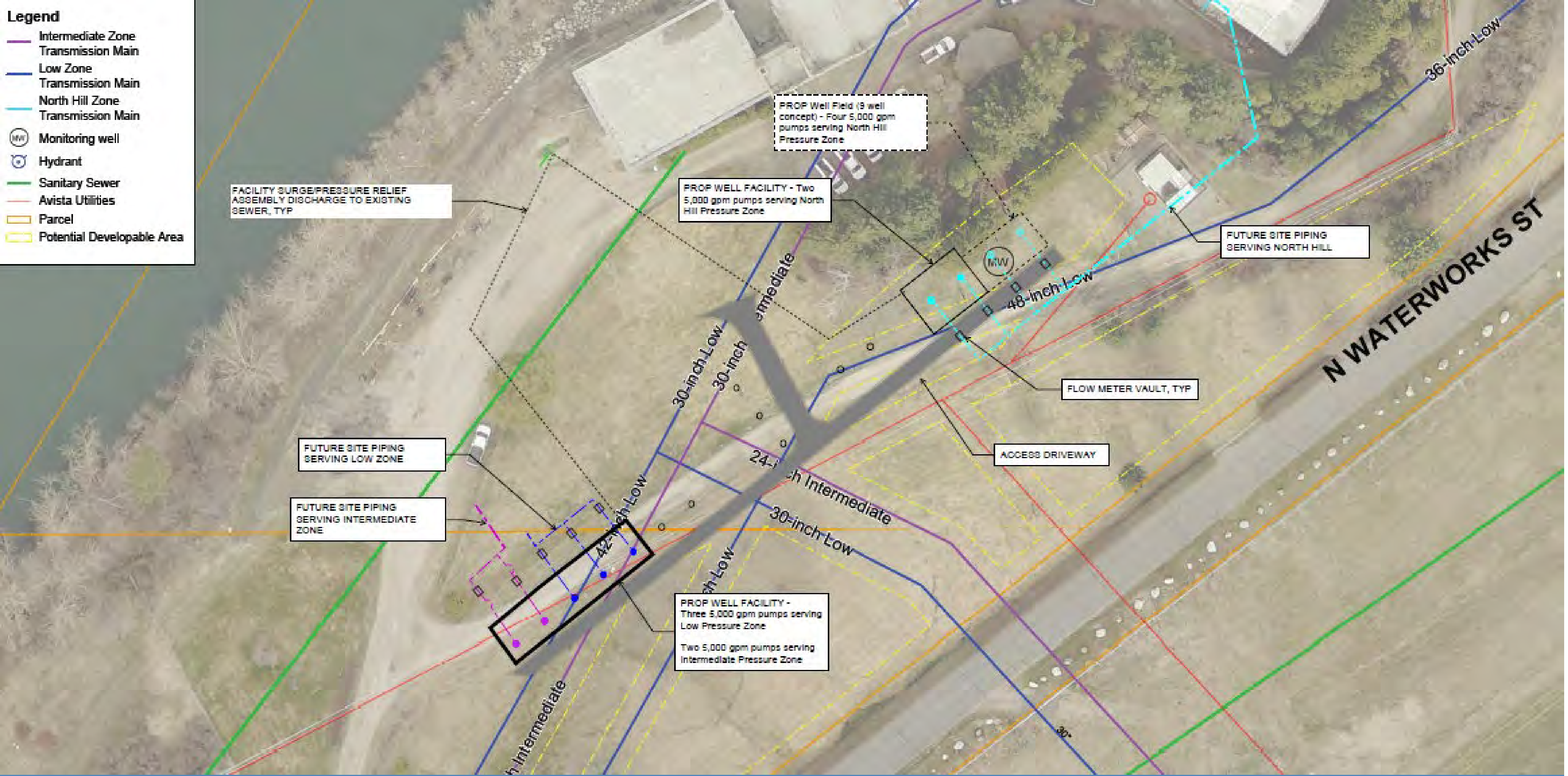
Potential Groundwater Capture by Shallow Caissons vs. Deep Production Wells



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

CITY OF SPOKANE

GSI Water Solutions, Inc.

Vulnerability Assessment for Yellowstone Pipeline

Spokane River Forum

4/26/2023

Yellowstone Petroleum Pipeline

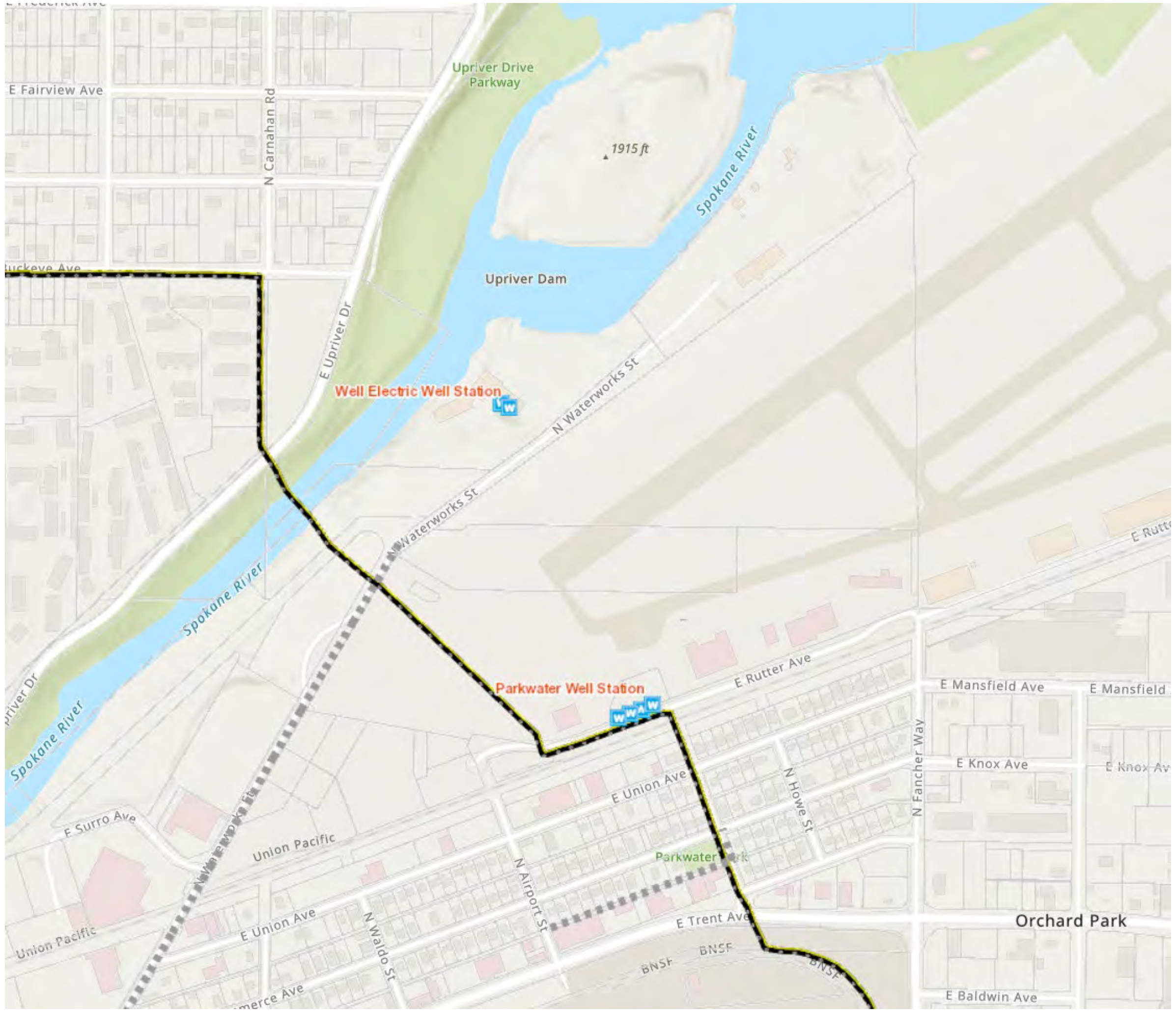
Proximity to Wells

Well Electric

23% of Water Production

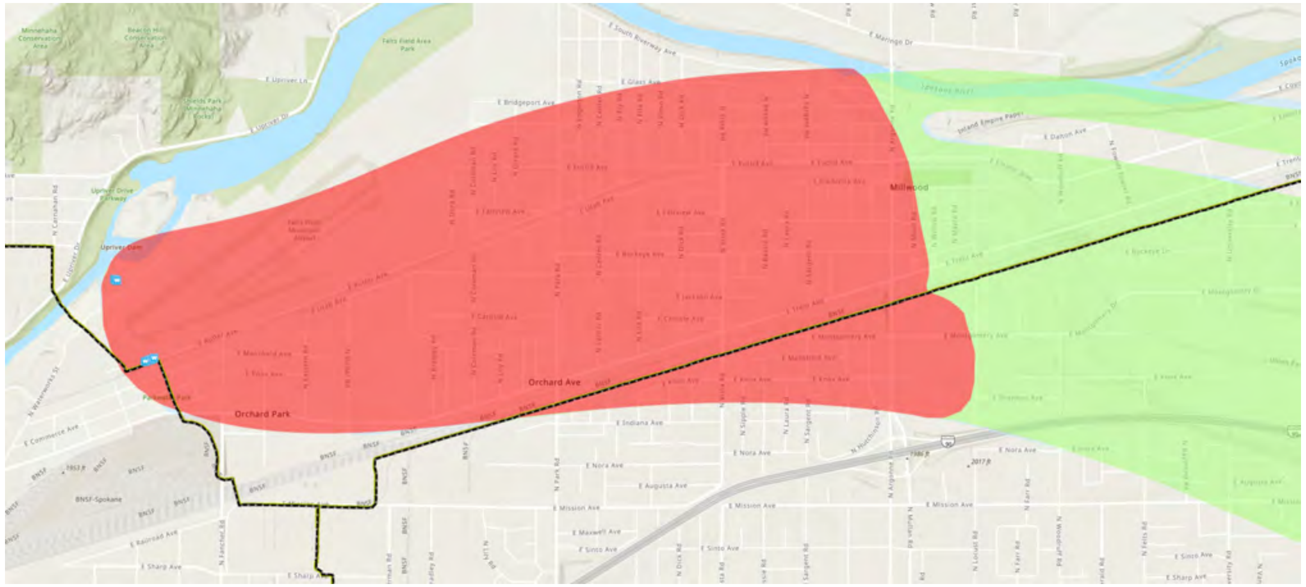
Parkwater

43% of Water Production



Establish Baseline Operating Conditions

- Reestablish capture zones under seasonally varying conditions
- Update water demands to account for future growth



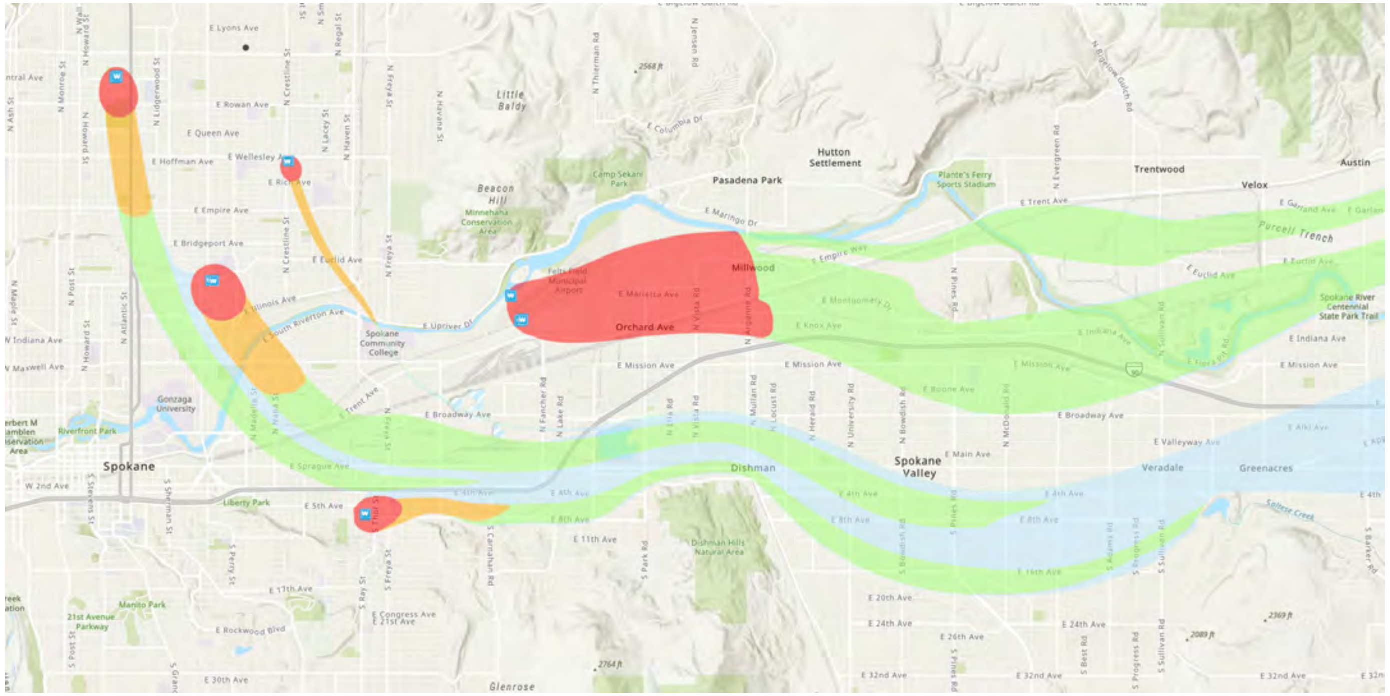
Petroleum Release Scenarios

- Identify locations of potential release
  - Small-Scale Release
    - E.g., releases at pipe delivery/booster stations
  - Large-Scale Release
    - Pipeline ruptures
    - Pipeline damage due to natural disaster
- Compare locations to reestablished Capture Zones
  - Run scenarios to understand impact on wells for different release scenarios

CITY OF SPOKANE

Emergency Operations

- Alternate Well Scenarios
  - New well head capture zones for alternate pumping scenarios
- Distribution system modeling
  - Evaluate feasibility and limitation in the water transmission system



Contamination Risks

- Evaluate the relative differences in contamination risks of the different petroleum products that are thought to be conveyed in the pipeline (considering aquifer specific and chemical-specific behavioral indicators).

Subsurface Monitoring Plan

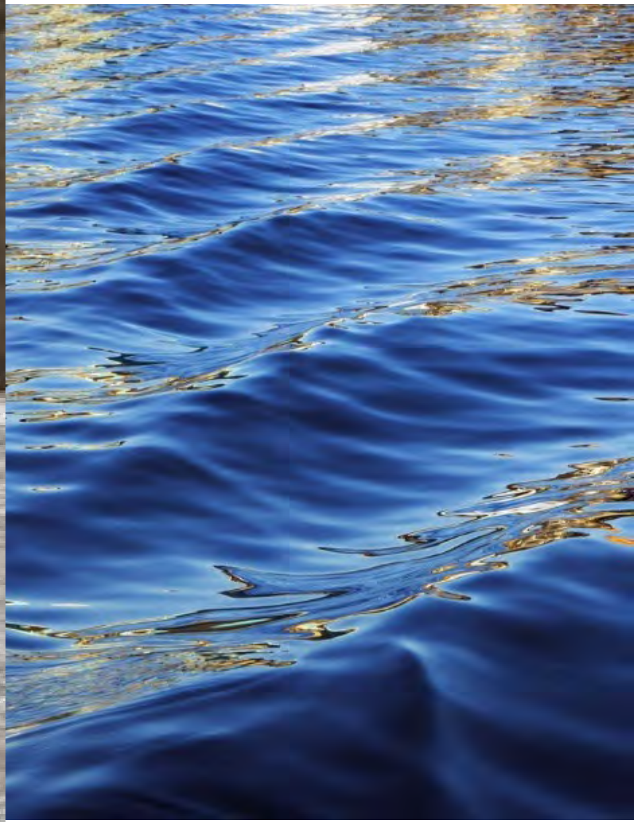
- Develop concept plan for construction and operation of monitoring system
- Detect releases near vulnerable locations for City’s well stations

Emergency Response Plan

- Document findings of study to incorporate into the City's Emergency Response Plan
- Operating procedures for release detection
- Operating procedure for alternate pumping operations during and after an emergency release event

Spokane Aquifer Joint Board Aggregate Quarry Risk Analysis

Spokane River Forum, April 26th, 2023



Outline

- Problem
- Open Pits
- Funding Source
- Analysis & Next Steps

Problem

- Exposed sole-source aquifer
- Land Uses adjacent
- Potential contamination
- Current and future wellhead capture zones intersect
- Jurisdictional ???
- Post-mining reclamation plans

Quarry	Exposed Acres	Distance to Railroad	Intersecting Well Capture Zones
Lawrence B Stone Lake	5.96	235 feet	2
CPM - Havana	9.67 & 7.02	260 feet	1
Broadway/Sprague	59.5	200 feet	6
CPM - Sullivan	67.1	275 feet	16

"…e Lake"

…ish stocking

Broadway & Sprague

Visible from I-90

Very Deep

Reports of fish stocking

CPM - Havana

CPM - Sullivan

Active operations with floating dredge

Funding

- SAJB applied for a Washington State Department of Health – Source Water Protection Grant
- Was awarded $30,000 to complete the analysis
- Should be completed in May/June

Analysis

Deliverables

- GIS layers of historical and active quarries over the SVRP, land use, hazardous material storage, municipal well capture zones, etc.
- Inventory permitted mines and reclamation status
- Highlight potential risks to drinking water sources
- Potential strategies to increase source water protection

Next Steps

- SAJB will engage & convene meetings with interested parties to develop collaborative approaches to protecting the water in these open pits.

➔ **Anne Lynch and Gemma Dunn**
GHD Project Manager

Spokane River Forum

Creating a resilient water strategy in the context of an uncertain future

Wednesday April 26, 2023

Welcome

Water Strategy

- → **Project Context**
- **Project Goals**
- **Project Approach**
- **Project Outcomes**
- **Strategy Outline**

Project Context

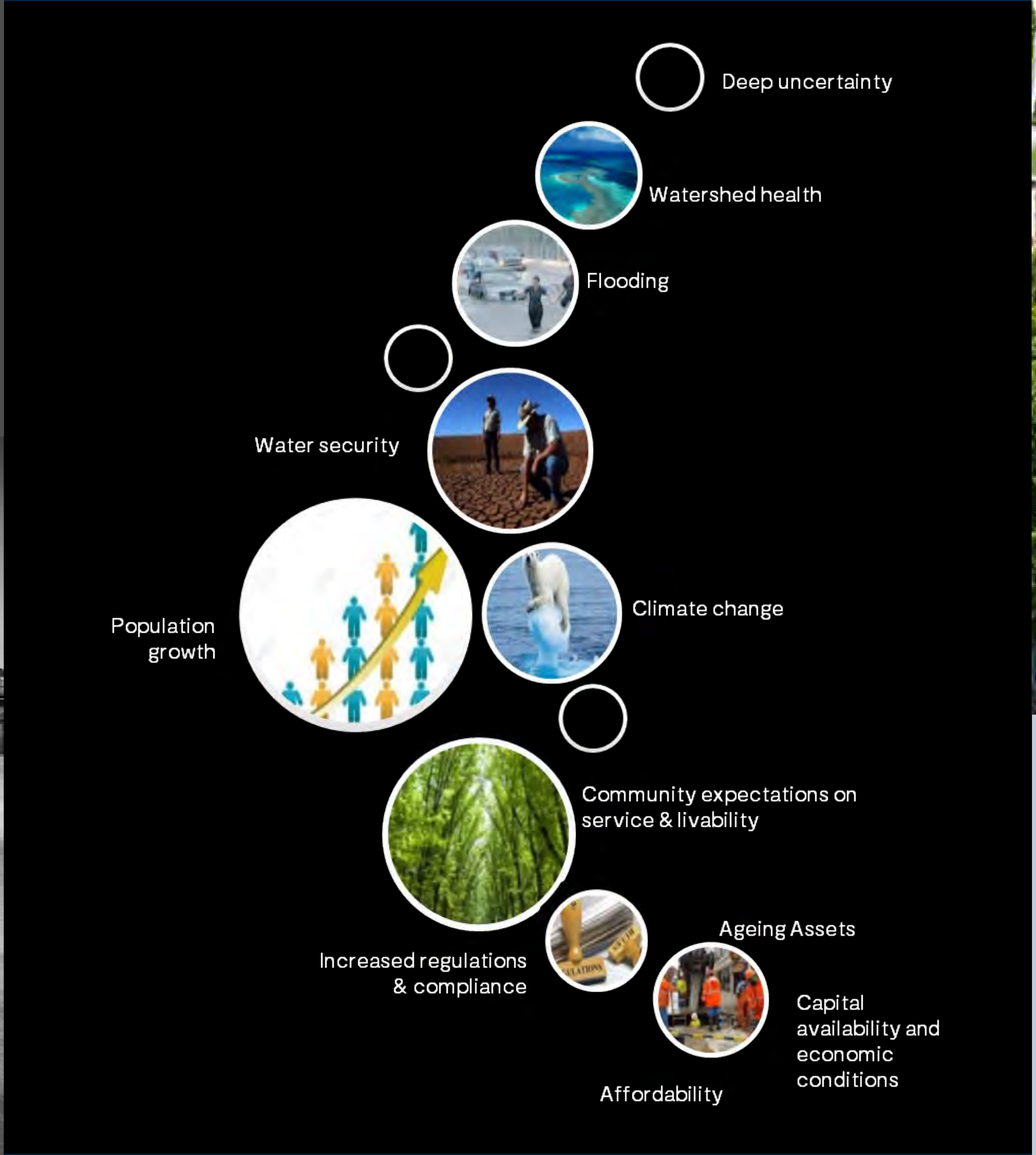
→ Broader Context informing the Strategy Development

Our water choices define where we live





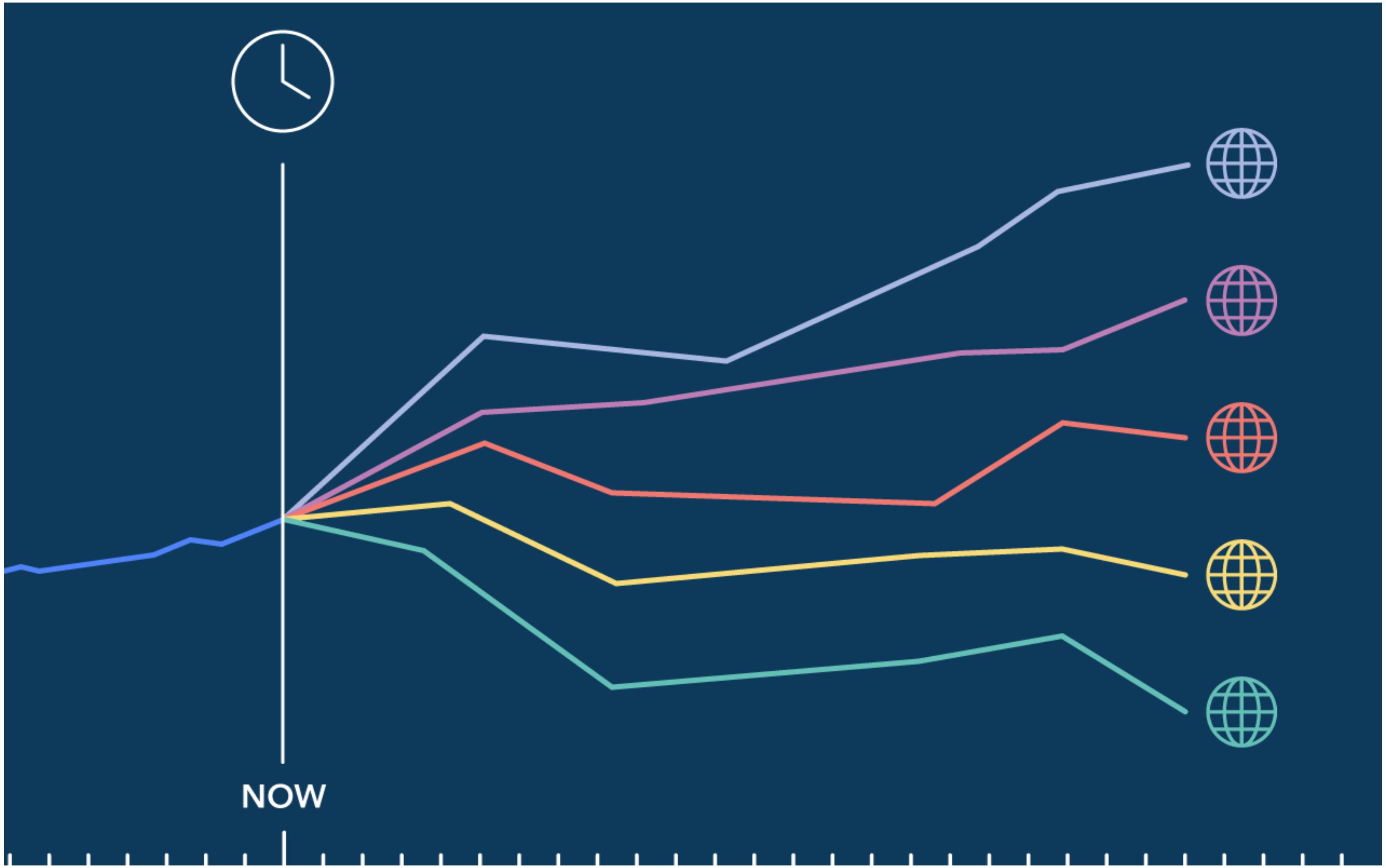

↓ Today



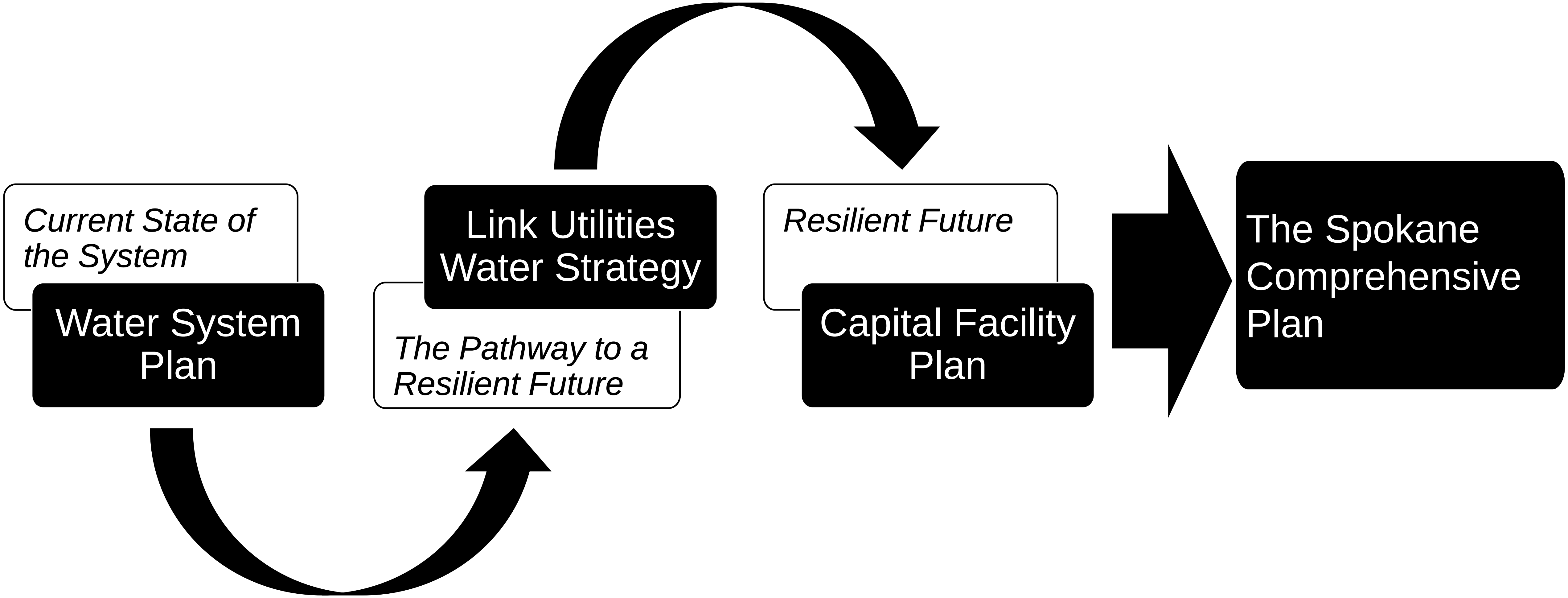
2050 ↑

Sustainable / Affordable / Social responsible

Planning with Deep Uncertainty



Three Interconnected Plans

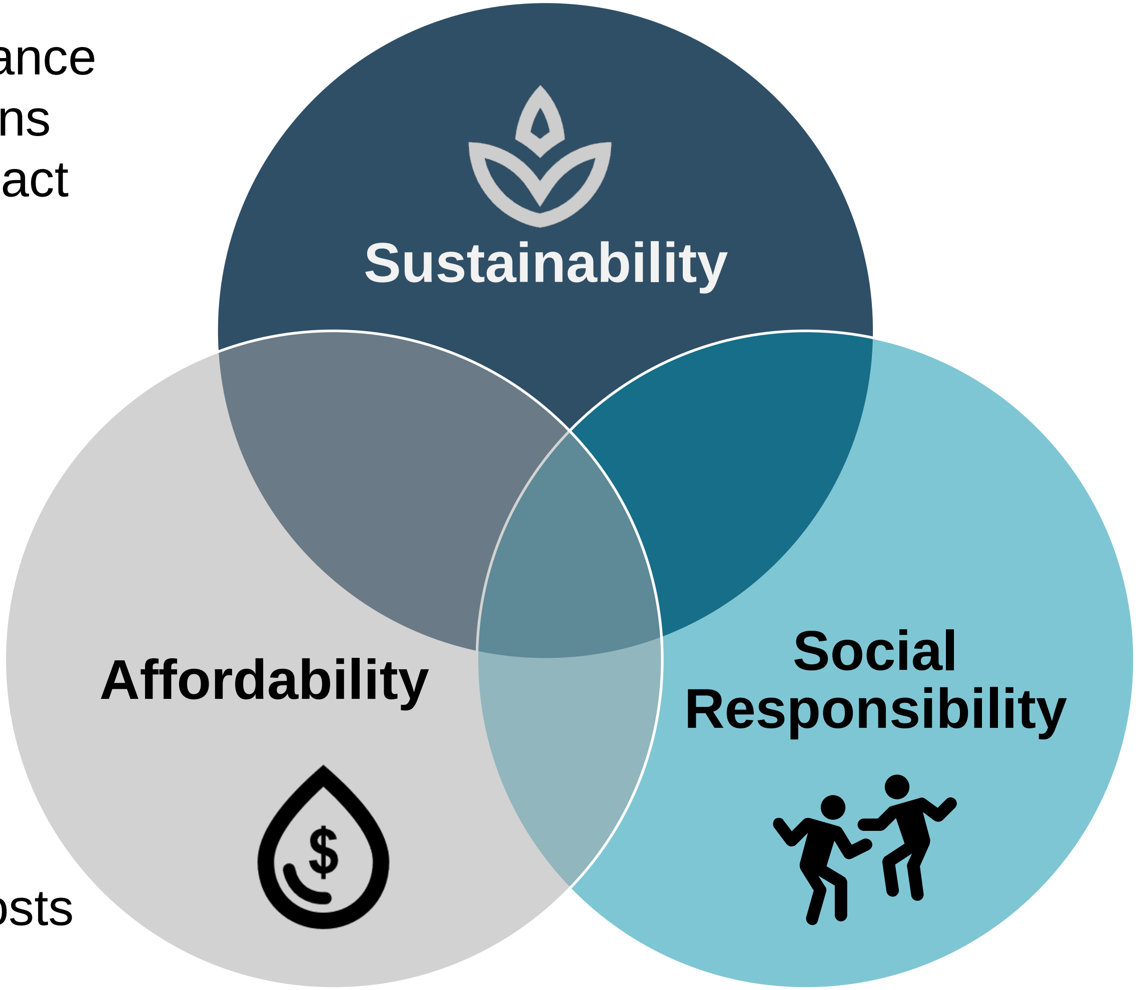


Project Goals

→ **City of Spokane’s Long-Term Goals**

City of Spokane’s Goals

Regulatory compliance
Regulatory violations
Environmental impact



Health & safety
Levels of service
Public image

Direct / indirect costs
Equity

 Source: [Adapted] City of Spokane Water Conservation Master Plan, 2020

Project Approach

→ **Four Core Stages**

Project Approach

Background Information

- City goals
- Identify challenges and opportunities
- Identify risks and impacts
- Define customer service commitments

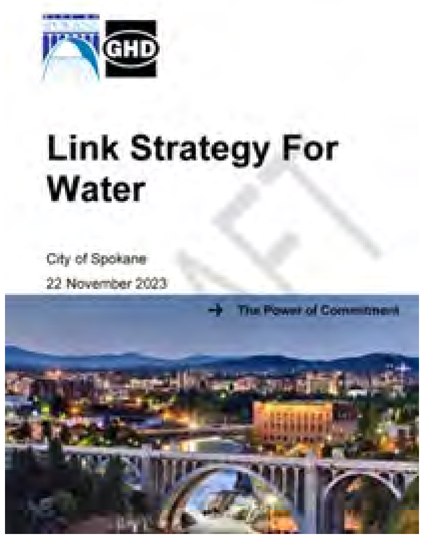
Identify Needs and Actions

- Identify projects
- Evaluate and prioritize projects
- Layout projects over time horizons

Develop Investment Strategies

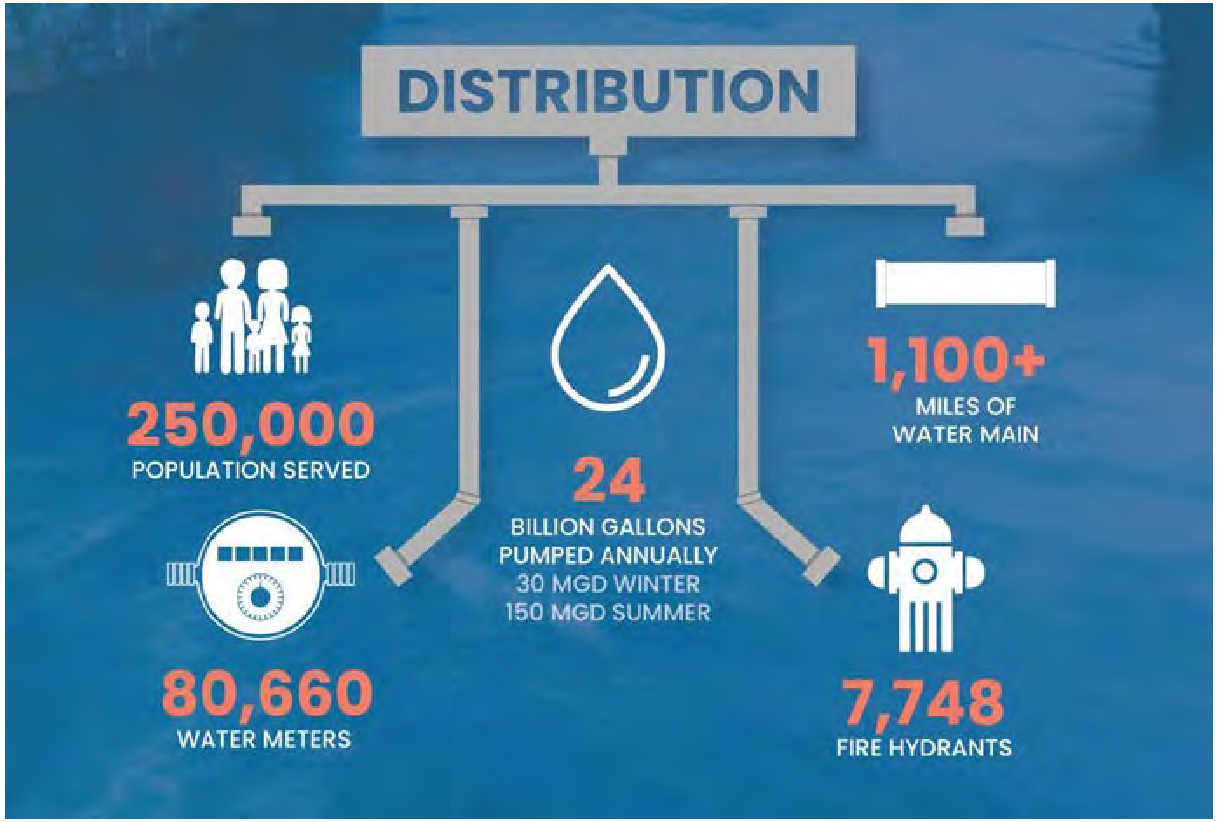
- Define scenarios
- Develop capital investment strategies

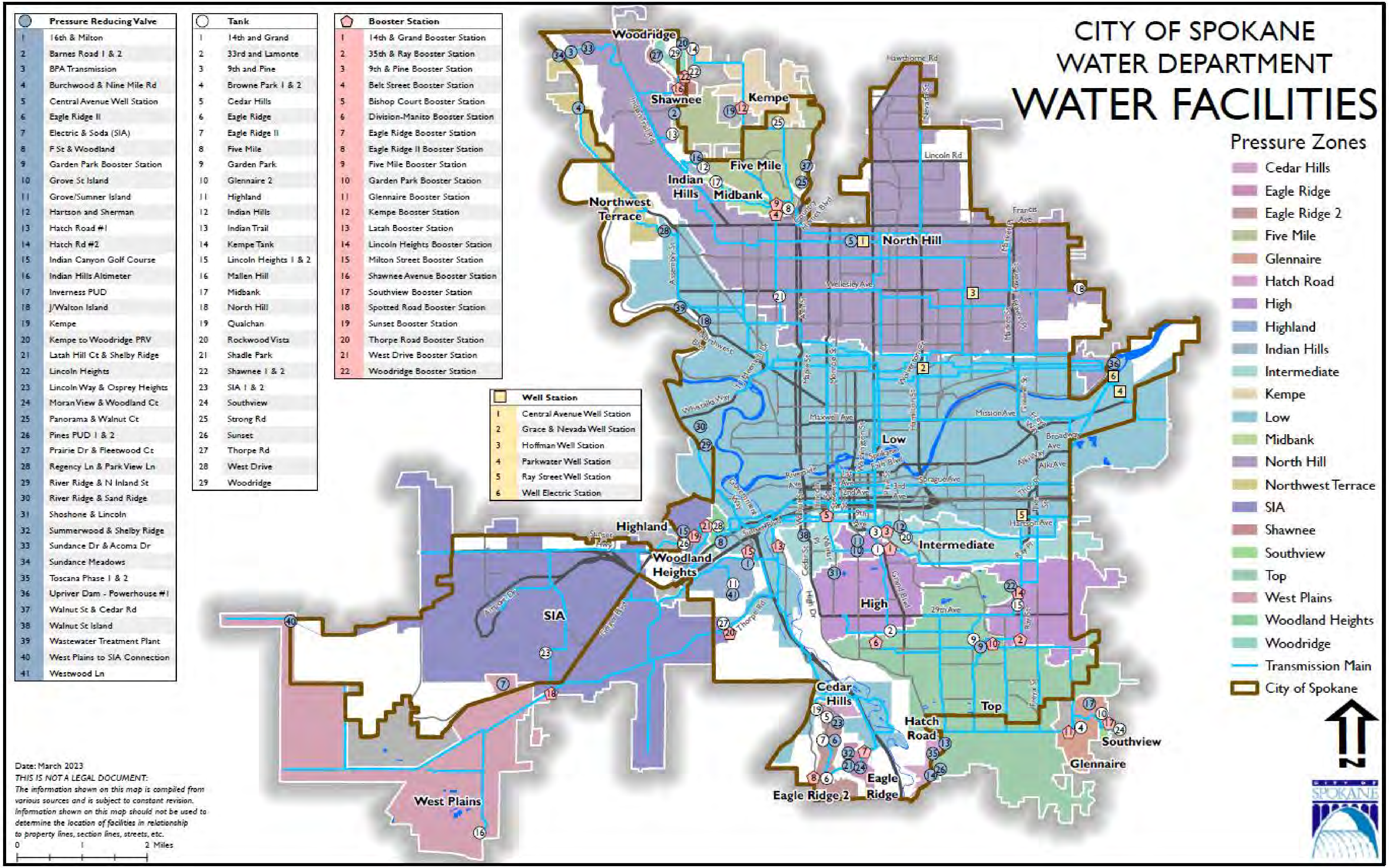
Final Water Strategy



Stakeholder engagement (incl. interviews and internal and external advisory committees)

Understanding the System




CITY OF SPOKANE
WATER DEPARTMENT
WATER FACILITIES
Pressure Reducing Valve
1 16th & Milton
2 Barnes Road 1 & 2
3 BPA Transmission
4 Burchwood & Nine Mile Rd
5 Central Avenue Well Station
6 Eagle Ridge II
7 Electric & Soda (SIA)
8 F St & Woodland
9 Garden Park Booster Station
10 Grove St Island
11 Grove/Sumner Island
12 Hartson and Sherman
13 Hatch Road #1
14 Hatch Rd #2
15 Indian Canyon Golf Course
16 Indian Hills Altimeter
17 Inverness PUD
18 J/Walton Island
19 Kempe
20 Kempe to Woodridge PRV
21 Latah Hill Ct & Shelby Ridge
22 Lincoln Heights
23 Lincoln Way & Osprey Heights
24 Moran View & Woodland Ct
25 Panorama & Walnut Ct
26 Pines PUD 1 & 2
27 Prairie Dr & Fleetwood Ct
28 Regency Ln & Park View Ln
29 River Ridge & N Inland St
30 River Ridge & Sand Ridge
31 Shoshone & Lincoln
32 Summerwood & Shelby Ridge
33 Sundance Dr & Acoma Dr
34 Sundance Meadows
35 Toscana Phase 1 & 2
36 Upriver Dam - Powerhouse #1
37 Walnut St & Cedar Rd
38 Walnut St Island
39 Wastewater Treatment Plant
40 West Plains to SIA Connection
41 Westwood Ln
Tank
1 14th and Grand
2 33rd and Lamonte
3 9th and Pine
4 Browne Park 1 & 2
5 Cedar Hills
6 Eagle Ridge
7 Eagle Ridge II
8 Five Mile
9 Garden Park
10 Glennaire 2
11 Highland
12 Indian Hills
13 Indian Trail
14 Kempe Tank
15 Lincoln Heights 1 & 2
16 Mallen Hill
17 Midbank
18 North Hill
19 Qualchan
20 Rockwood Vista
21 Shadle Park
22 Shawnee 1 & 2
23 SIA 1 & 2
24 Southview
25 Strong Rd
26 Sunset
27 Thorpe Rd
28 West Drive
29 Woodridge
Booster Station
1 14th & Grand Booster Station
2 35th & Ray Booster Station
3 9th & Pine Booster Station
4 Belt Street Booster Station
5 Bishop Court Booster Station
6 Division-Manito Booster Station
7 Eagle Ridge Booster Station
8 Eagle Ridge II Booster Station
9 Five Mile Booster Station
10 Garden Park Booster Station
11 Glennaire Booster Station
12 Kempe Booster Station
13 Latah Booster Station
14 Lincoln Heights Booster Station
15 Milton Street Booster Station
16 Shawnee Avenue Booster Station
17 Southview Booster Station
18 Spotted Road Booster Station
19 Sunset Booster Station
20 Thorpe Road Booster Station
21 West Drive Booster Station
22 Woodridge Booster Station
Well Station
1 Central Avenue Well Station
2 Grace & Nevada Well Station
3 Hoffman Well Station
4 Parkwater Well Station
5 Ray Street Well Station
6 Well Electric Station
Pressure Zones
Cedar Hills
Eagle Ridge
Eagle Ridge 2
Five Mile
Glennaire
Hatch Road
High
Highland
Indian Hills
Intermediate
Kempe
Low
Midbank
North Hill
Northwest Terrace
SIA
Shawnee
Southview
Top
West Plains
Woodland Heights
Woodridge
Transmission Main
City of Spokane
Woodridge
Shawnee
Kempe
Five Mile
Indian Hills
Midbank
Northwest Terrace
North Hill
Low
Highland
Woodland Heights
Intermediate
SIA
High
Cedar Hills
Hatch Road
Top
Southview
Glennaire
Eagle Ridge 2
Eagle Ridge
West Plains
Hawthorne Rd
Lincoln Rd
Francis Ave
Wellesley Ave
Maxwell Ave
Mission Ave
Broadway Ave
Sprague Ave
29th Ave
Date: March 2023
THIS IS NOT A LEGAL DOCUMENT:
The information shown on this map is compiled from various sources and is subject to constant revision. Information shown on this map should not be used to determine the location of facilities in relationship to property lines, section lines, streets, etc.
0 1 2 Miles
N
SPOKANE

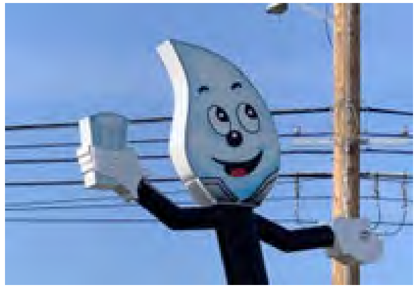
Key issues and challenges

Operations & Maintenance

Water Supply and Availability

Water Affordability and Equity

Water Quality



Public Engagement And Communication

City People, Policy, Process & Planning

Development & Population Growth

Public Safety & Fire Protection

Economic Development

Climate Change & River Flows

Environmental Health

Outdoor Water Use

Project Outcomes

→ Planning for the Future

Desired Outcomes

- Understanding and endorsement of the process and framework behind the Strategy development
- Deeper understanding of water system and its issues
- Deeper understanding of the cost to deliver water
- **Understanding and endorsement of Link Strategy for Water**

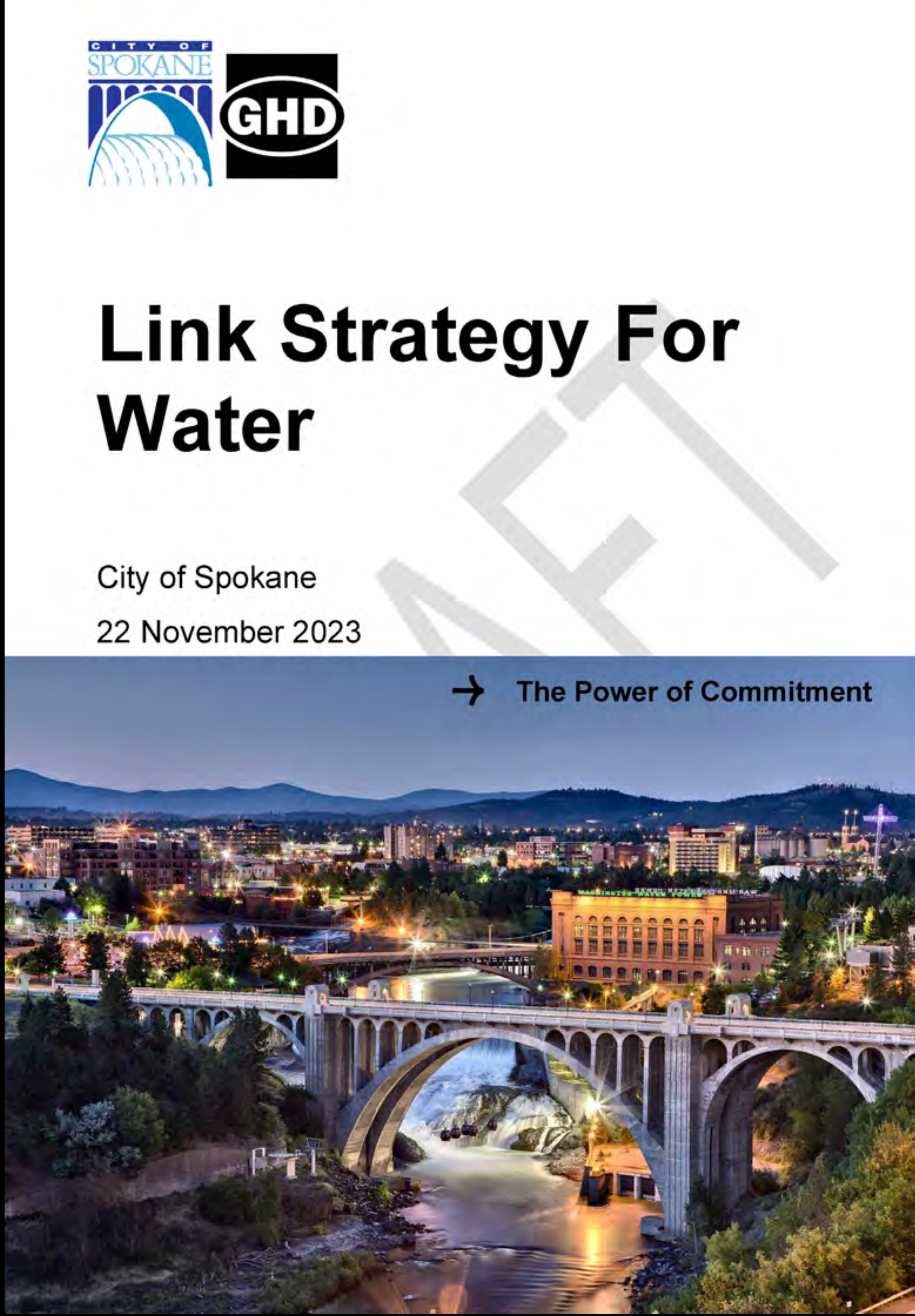
Link Strategy for Water Plan Outline

Telling the Story of….

- How the aquifer/river basin system functions
- How Spokane's water infrastructure functions
- What are the water system challenges and needs

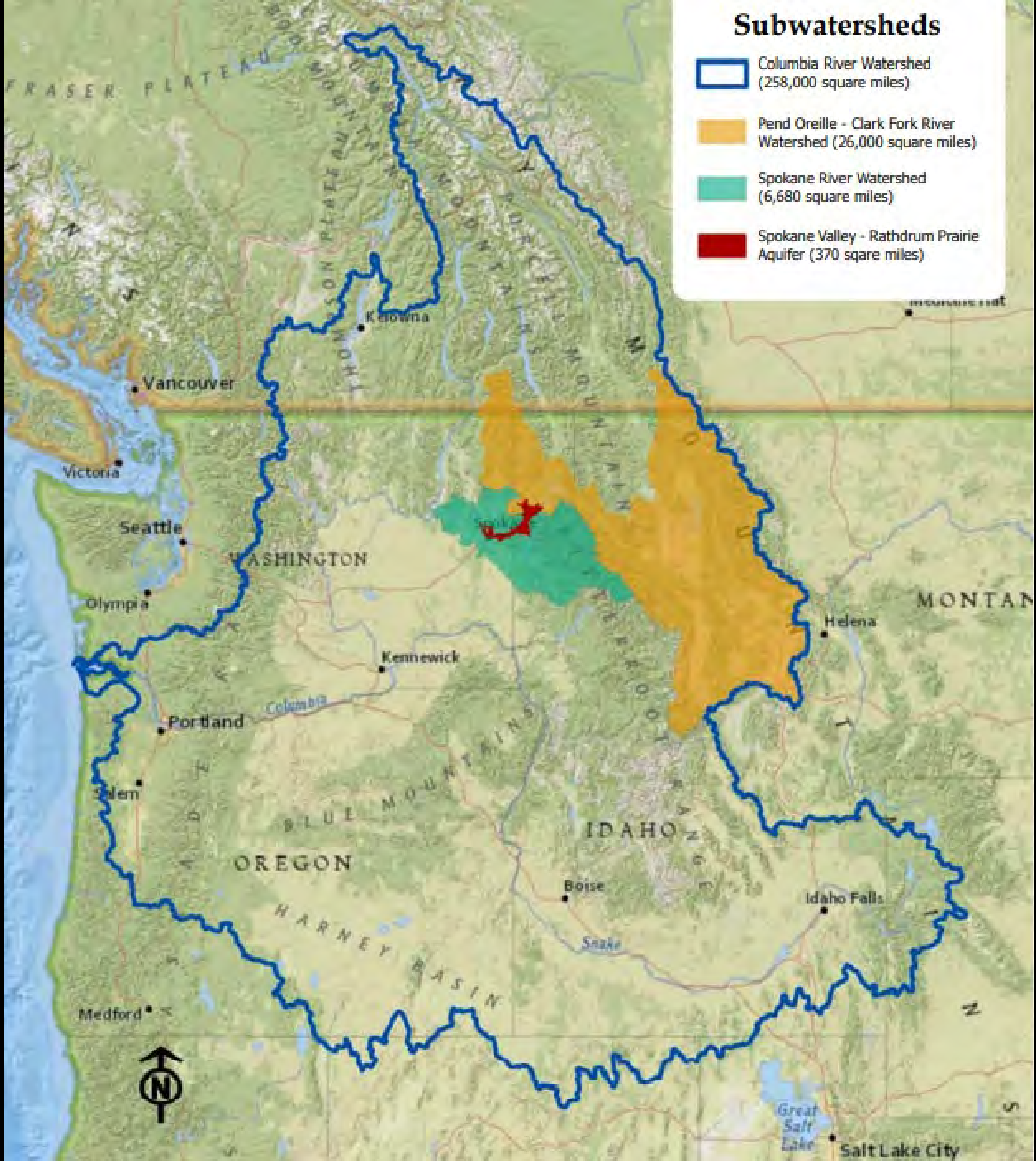
To build the case for the….

- Strategy for the Future



Aquifer/River Basin System

- Value of the aquifer/river (natural) system to the community
- Description of aquifer and river systems
  - History and management
  - How the system works
  - Human impacts to system
  - Climate change impacts to system



Spokane’s Water System

- History of infrastructure development in City
  - Changing demographics
  - Changing demand
- How system works today
  - Infrastructure
  - Risk

Spokane's Water System Needs

- Community expectations
- Current asset condition/risk
- System needs
- Interties and development
- System costs and actions

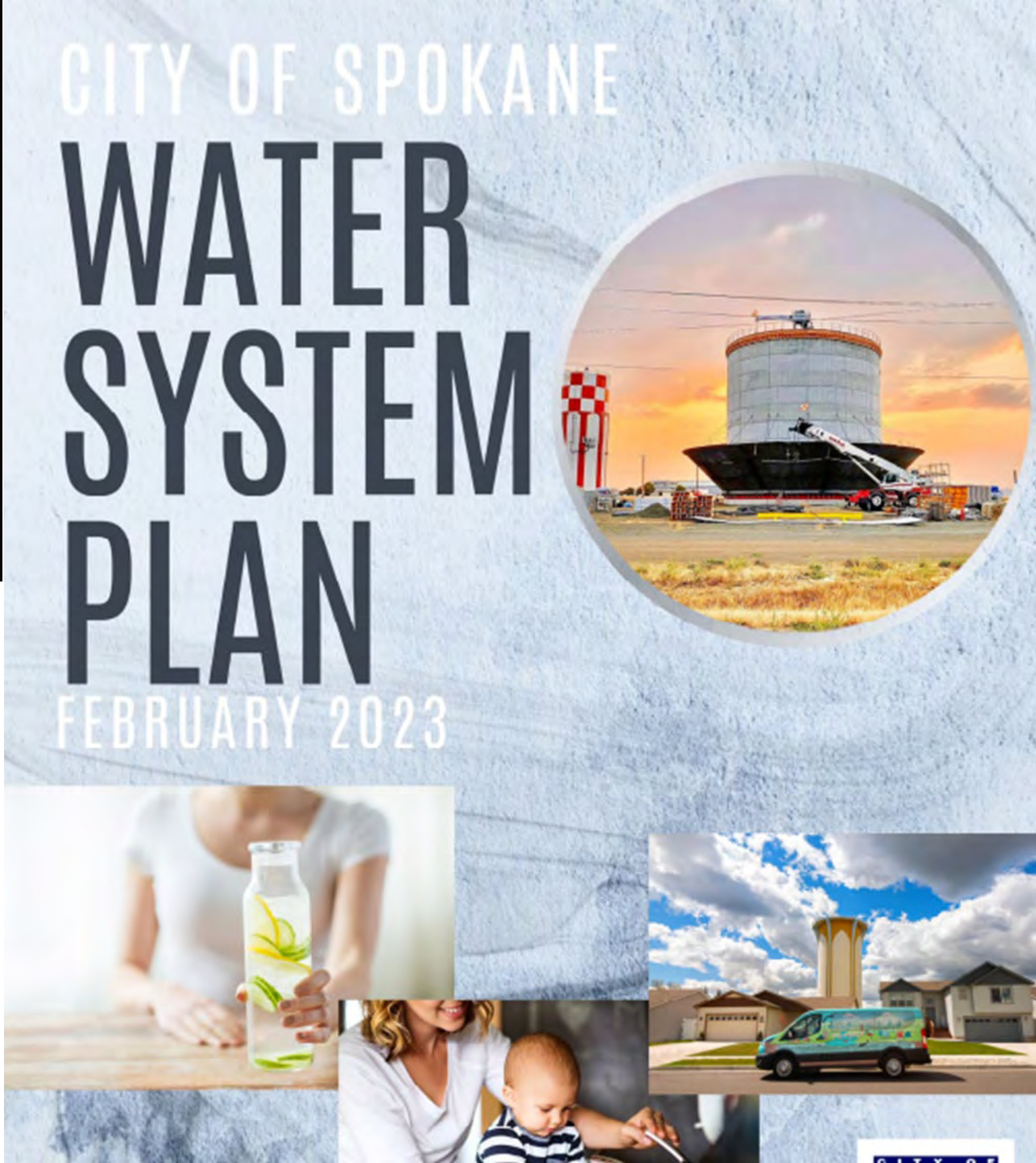
Planning for the Future

- Goals and objectives for the system/plan
  (Sustainability, Social Responsibility, Affordability)
- Planning for uncertainty
  - Population/development
  - Climate
  - Regulation
  - Water quality
  - Water rights
  - Funding

Planning for the Future

- Planning for the Future
  - Solutions to meet system management needs
  - Options for the Future
  - Preferred approach
  - Capital and operational costs
- Recommendations for the future implementation

Learn More



Visit City's Website:

- Public Meetings
- Reports
- https://my.spokanecity.org/projects/link-spokane/
- https://static.spokanecity.org/documents/publicworks/water/draft-water-system-plan-feb-2023.pdf

* Thank You

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