# Condition Assessment of a 100-year Old Well Station

City of Spokane Hoffman Well Station

AWWA PNWS Annual Spring Conference

Tacoma, WA

**April 27-29, 2022**

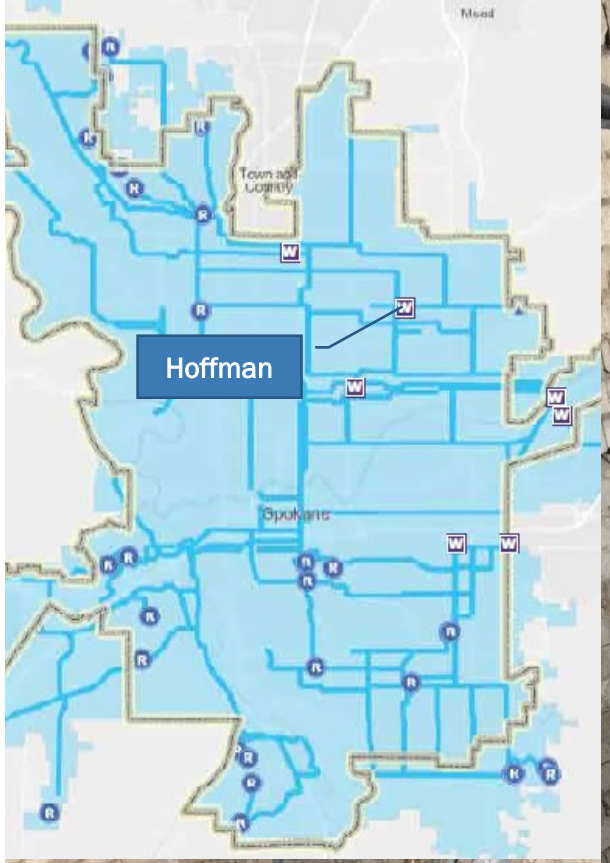
GSI Water Solutions, Inc.

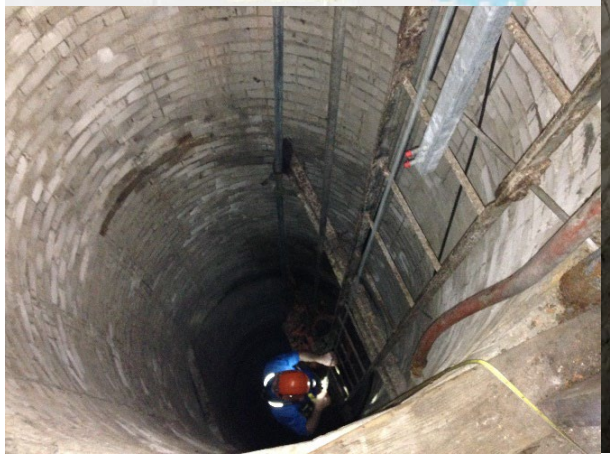
murraysmith

Hoffman Well Station, photograph by Charles Libby 1957.

# Presentation Focus

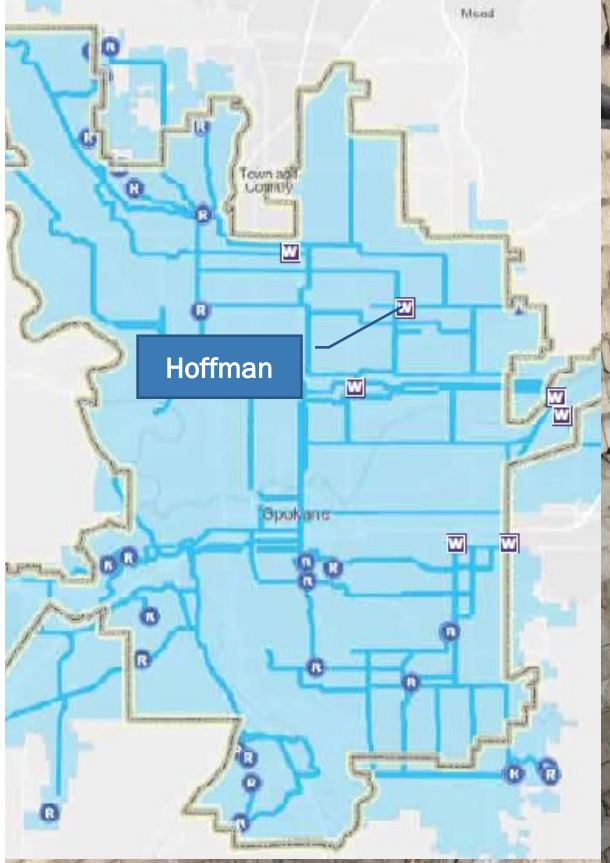
- ## Hoffman Well Station
  - Two open caisson production wells
  - Constructed in 1920 as supply source for Great Northern Railway
  - City acquired in 1938
  - Well 2 out of service since 1993
- ## Objective
  - Determine if (and to what extent) repairs are needed to bring Well 2 back online



# Presentation Outline

- Introduction
  - Background
- Hoffman Well Station
  - Well construction
- Existing Conditions
  - Well 1
  - Well 2
- Repair Alternatives Evaluated
- Concept Plan for Selected Alternative

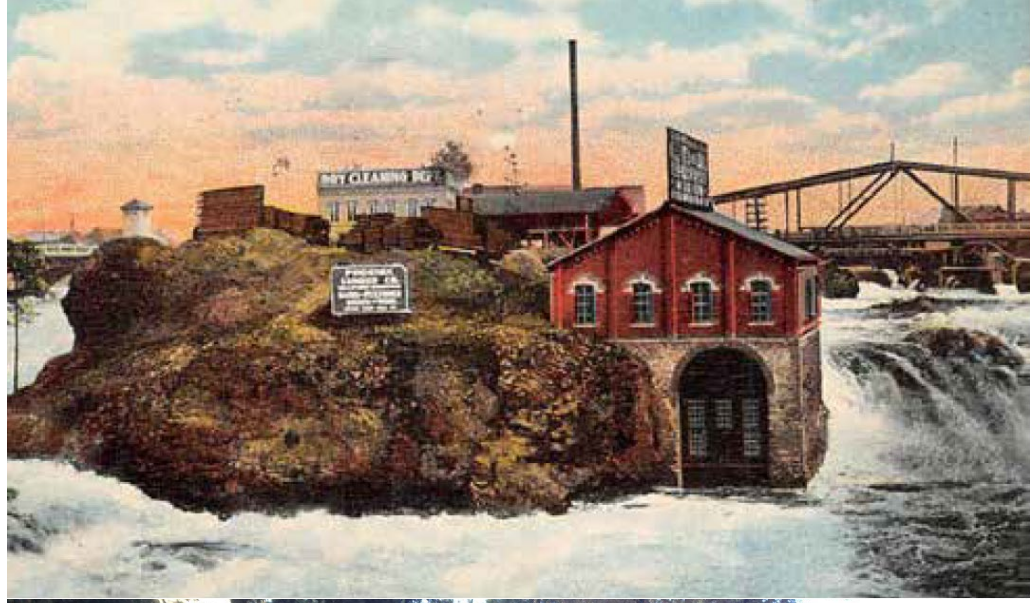



# Introduction

Hoffman Well Station, photograph by Charles Libby 1957.

# Water System History

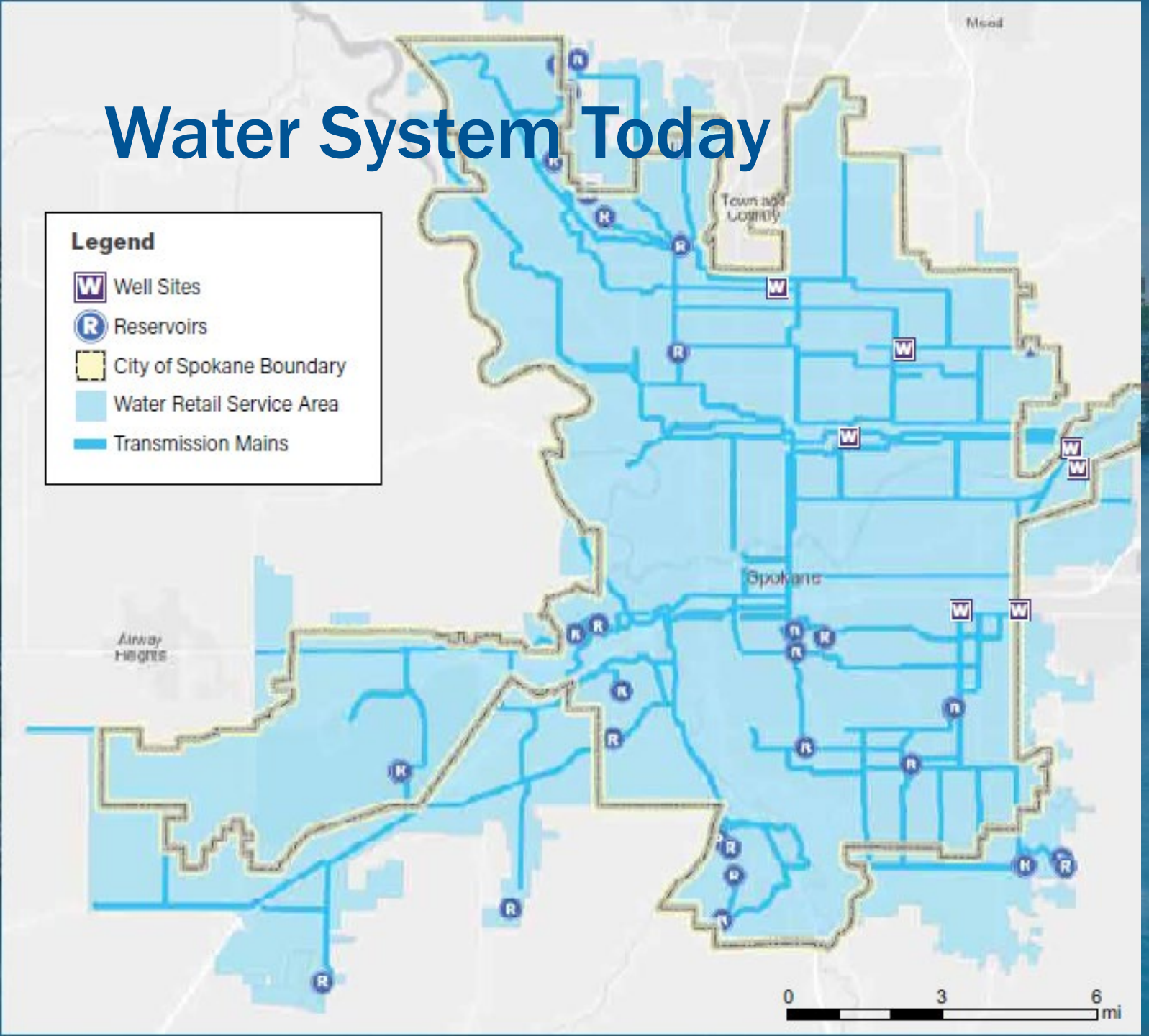
- City of Spokane water service began circa 1883
  - Water source = Spokane River
- Groundwater encountered in 1894 during construction of Upriver Dam and rediscovered in 1905
- City began transitioning to groundwater in 1907 due to poor surface water quality
- Well Electric Well Station, Wells 1 and 2

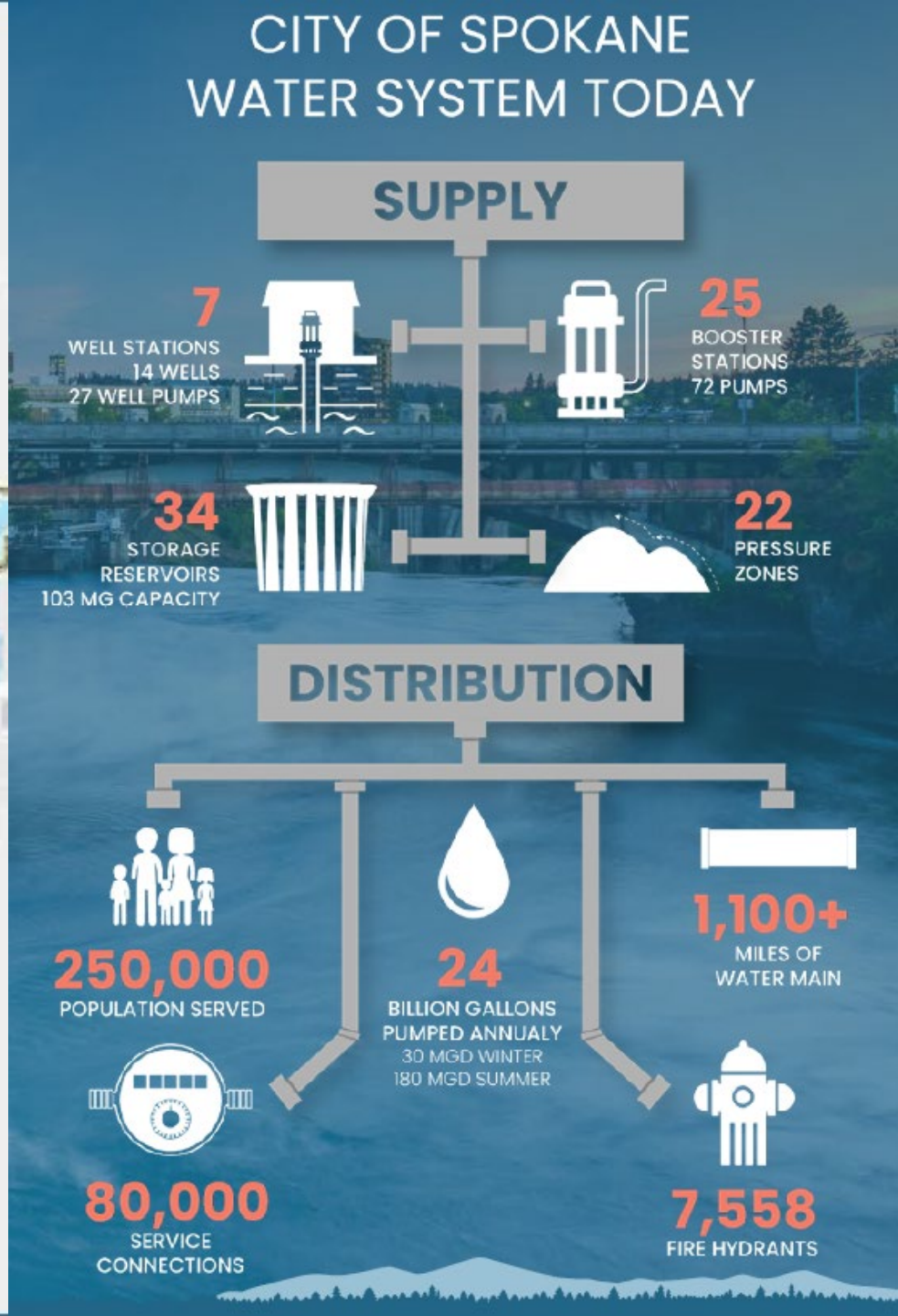


# Well Electric WS Well 1

- Offline and preserved as an educational/historical display
- Capacity = 56 mgd
- City permanently discontinued use of river as its municipal supply source
- Five caisson wells constructed at the site over the years
- Wells 2 and 3 decommissioned
- Wells 4 and 5 remain in operation today


# Water System Today



# AVERAGE PERCENT OF WATER PRODUCED BY CITY WELL STATIONS

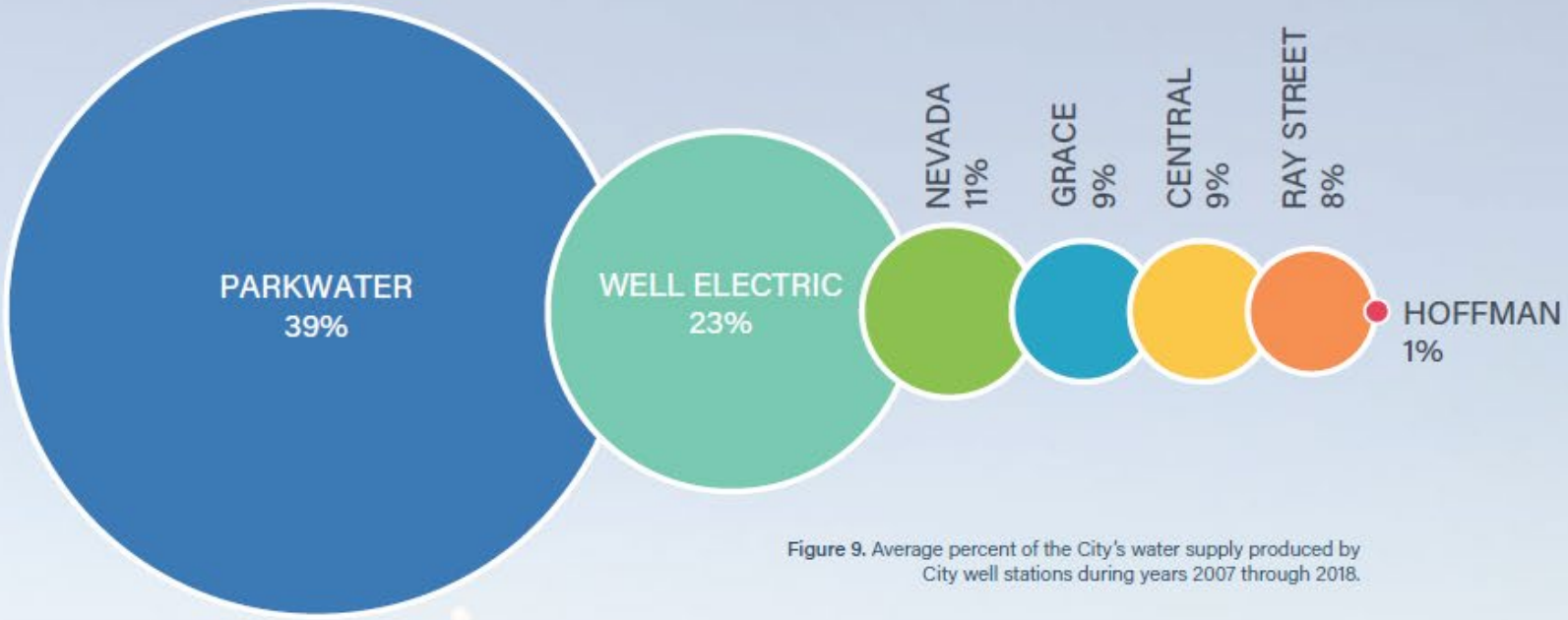
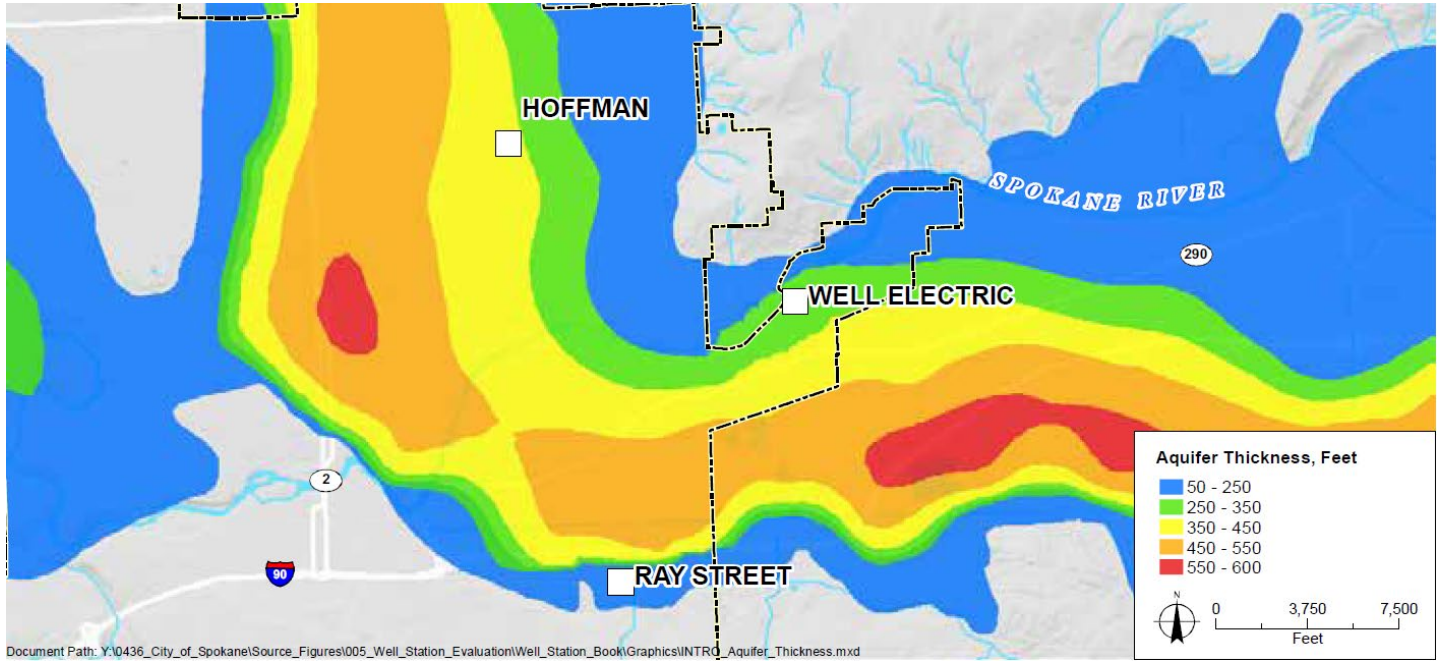



**Figure 9.** Average percent of the City's water supply produced by City well stations during years 2007 through 2018.

# SVRP Aquifer

- Spokane Valley – Rathdrum Prairie (SVRP) Aquifer
- Exclusive source of water supply for City
- Unconfined, highly productive, and highly transmissive
  - Production rates up to tens of millions of gallons per day
  - Hydraulic conductivity of 2,500 to 3,000 feet per day; 15,000 feet per day in some areas
- Underlain and laterally bounded by bedrock and low-permeability clay (Latah FM)
- Recharge primarily from infiltration of rainfall and snowmelt runoff and seepage from surface water bodies




# Hoffman Well Station

Hoffman Well Station, photograph by Charles Libby 1957.

# Well Construction

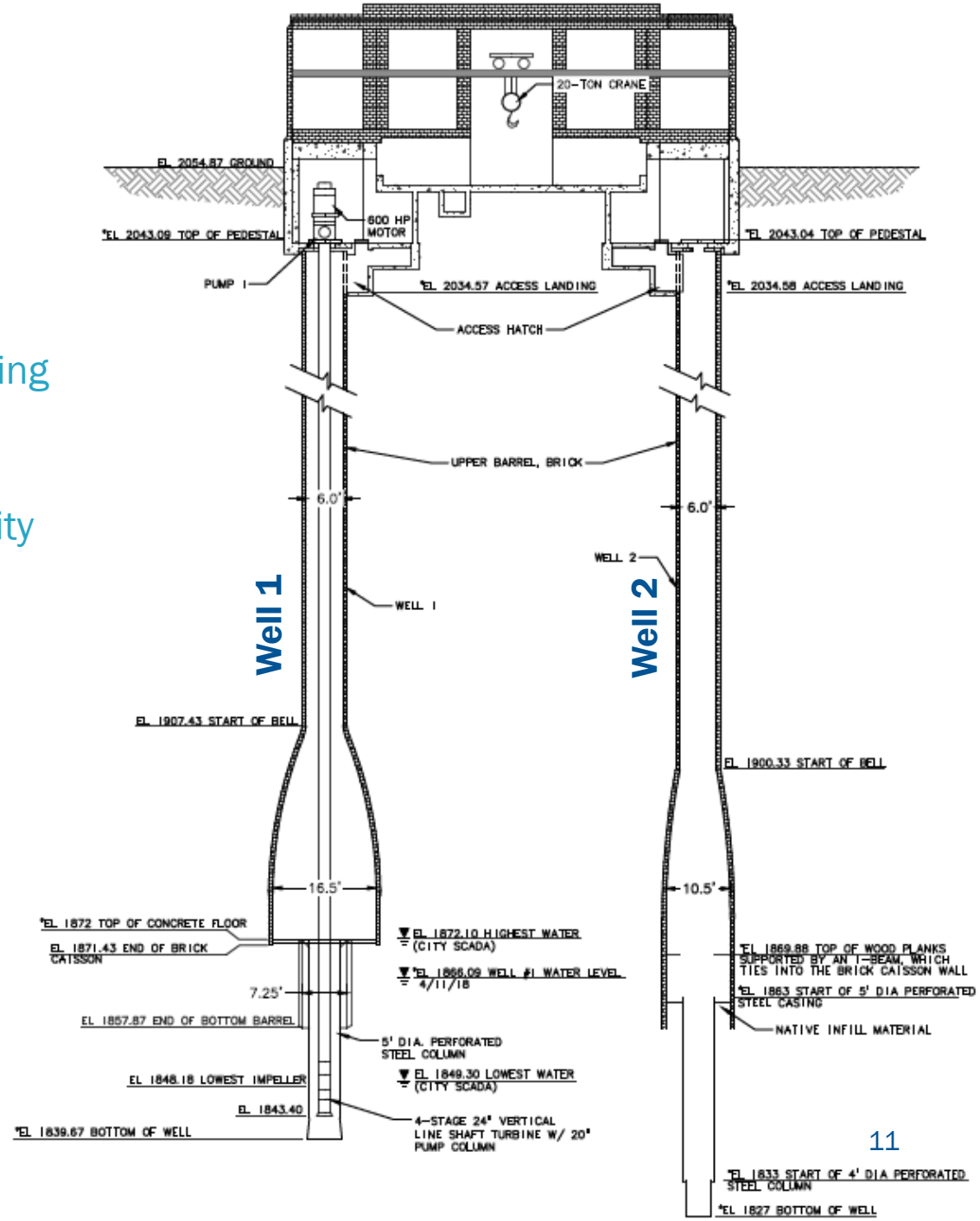
## Hoffman Well 1

- 6- to 16.5-foot diameter caisson well dug to 215 feet
- Currently operational
- Production capacity ≈ 5,500 gpm
- Specific capacity ≈ 815 gpm/foot of drawdown

## Hoffman Well 2

- 6- to 10.5-foot diameter caisson well dug to 230 feet
- Well taken offline and pumping system removed in 1993
- Past production capacity ≈ 5,500 gpm

- Two wells: Well 1 and Well 2
- Upper brick-lined, bell-shaped caisson; lower perforated steel casing
- Supplies water to North Hill PZ
- Total well station production capacity ≈ 11,000 gpm
- SWL ≈ 185 feet bgs
- No documentation of surface seal



# Existing Conditions

Hoffman Well Station, photograph by Charles Libby 1957.

# Condition Assessment

- Objectives:
  - Characterize existing conditions
  - Verify well construction information
  - Evaluate facility modifications needed to access existing wells for repair/alteration

- Approach/Methods:
  - Compiled and reviewed available data
    - e.g., well/building construction, well performance, pumping rates, water levels, prior studies, etc.
  - Identified data gaps and prepared field investigation
  - Completed above- and below-water surveys, using personnel and underwater methods
  - Completed above-water visual structural inspections
  - Conducted 3D laser mapping survey

# Condition Assessment – Findings

## Well 1:

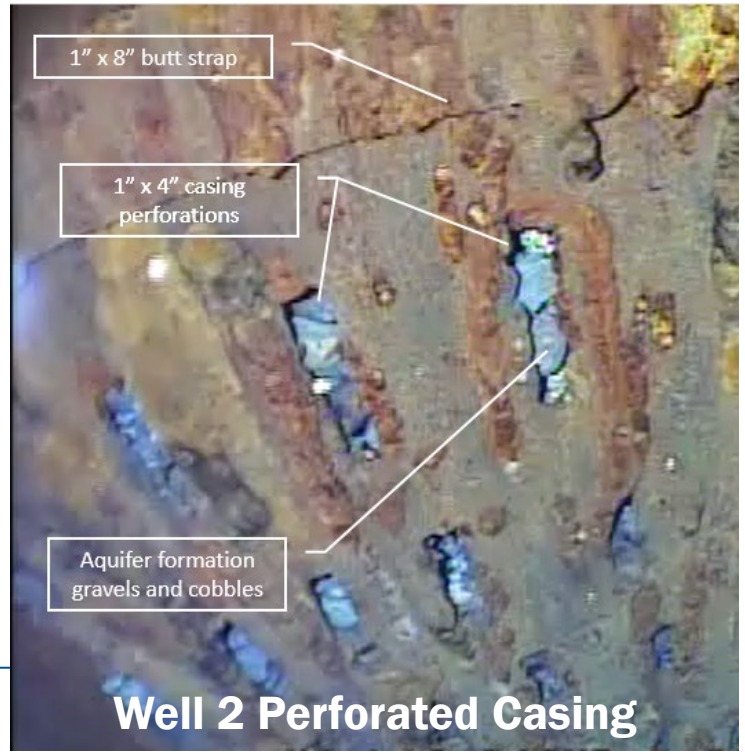
- Currently operational
- Visible portions of brick caisson appear in generally good condition
- Some missing bricks, likely remnants of old platform framing
- Areas of possible deformation in roundness of caisson wall, patched with mortar
- Pumping system obstructed access for below-water video surveys


# Condition Assessment – Findings

## Well 2:

- Offline since 1993 and not equipped with pumping system
- Some cracks in brick caisson wall observed at a few locations
  - Up to 1-1½ inches wide with some to no surface offset
  - Some cracks filled with black mortar
- Middle section of caisson wall contained a few hairline cracks
- Some evidence of past minor water seepage; no active seepage was observed at the time of the survey.
- Bell of caisson coated with gunite
- Some minor deformation has taken place since 1993 inspection, particularly in the middle and lower portions
- Minor encrustation of casing perforations
- Generally in good condition overall

Well 2 Brick Caisson Wall



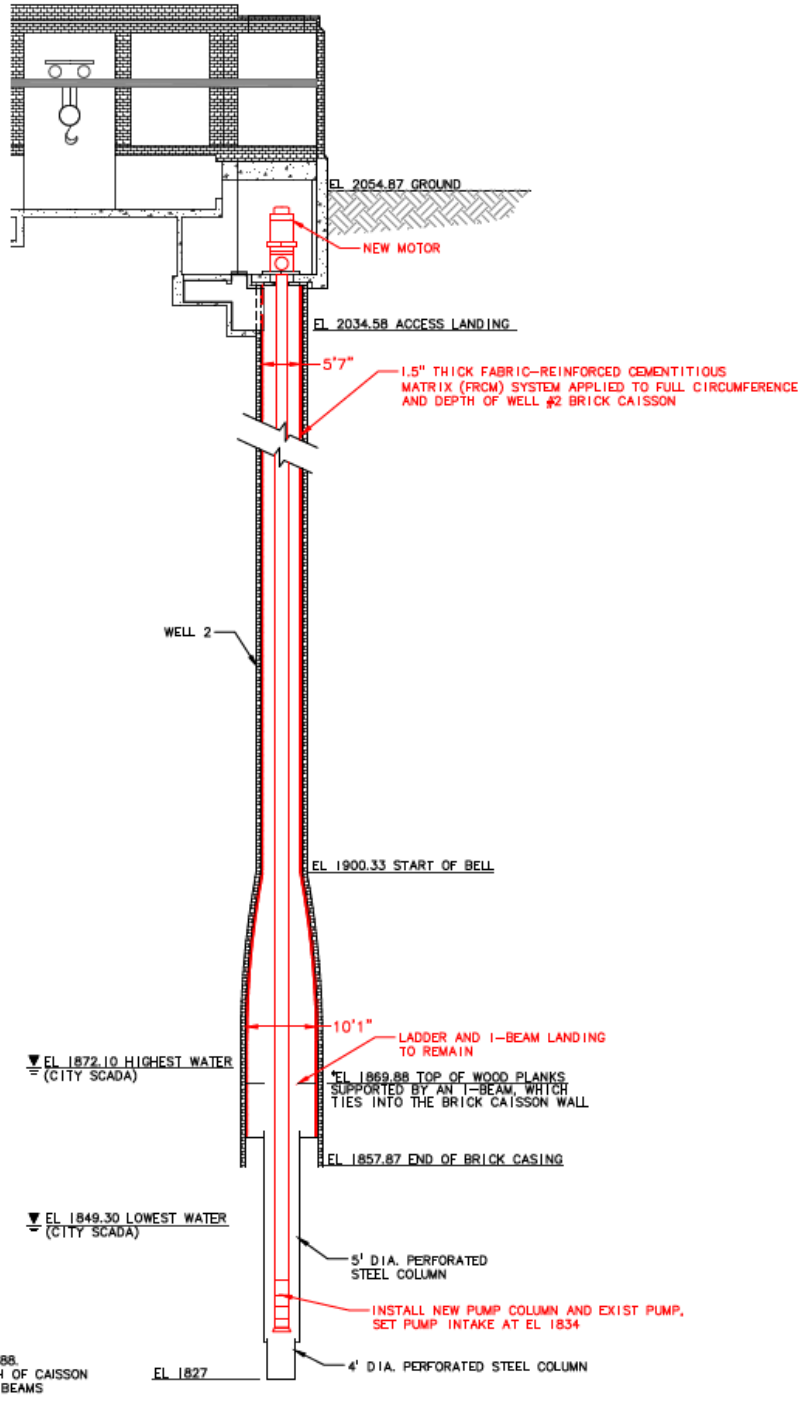

Well 2 Perforated Casing

# Repair Alternatives Evaluated

Hoffman Well Station, photograph by Charles Libby 1957.

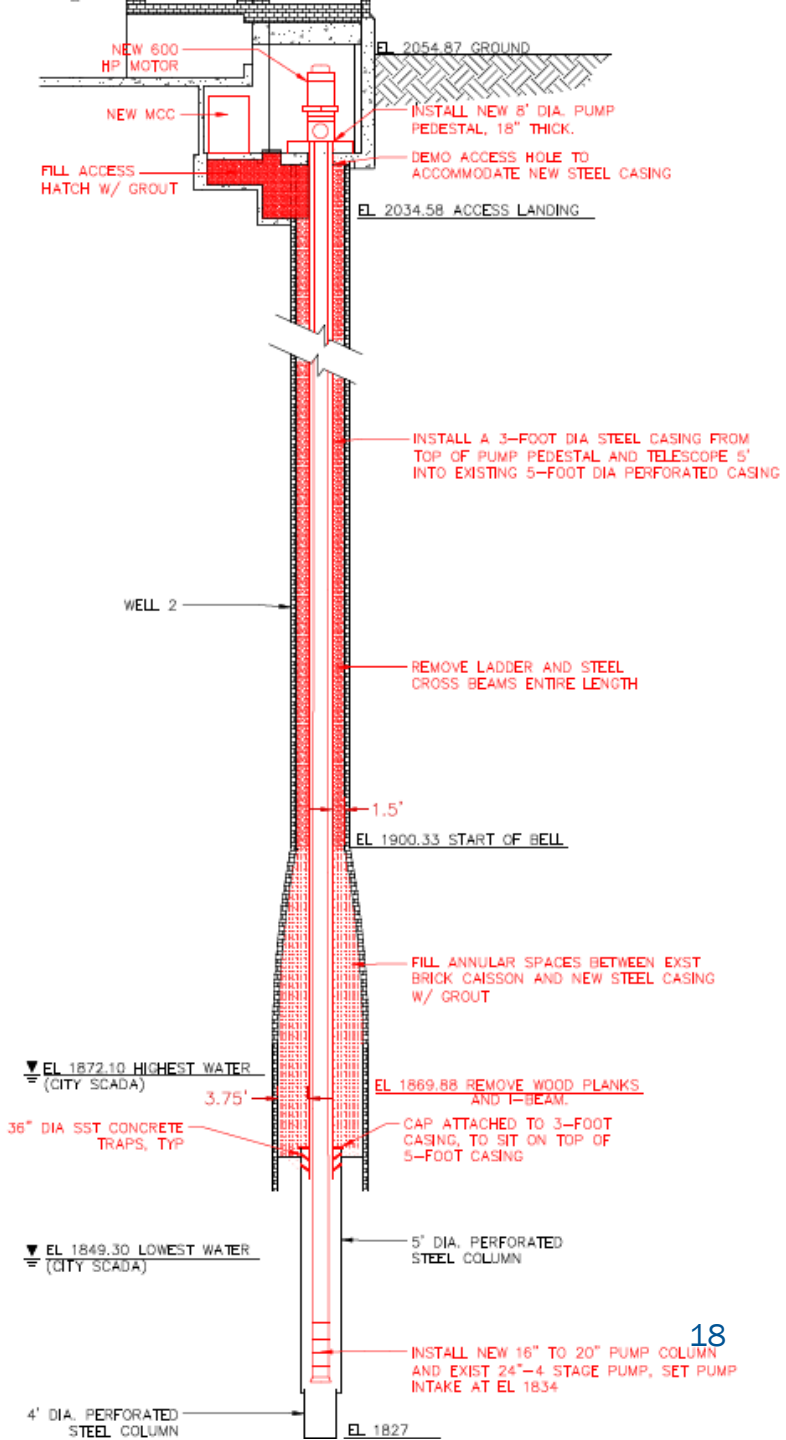
# Alternative 1 – Line Brick Caisson Wall

- Fabric-Reinforced Cementitious Matrix (FRCM)
  - Composite lining for structural support
  - Two-layer grid system:
    - ½-inch cementitious matrix
    - Carbon fiber reinforced grid w/ strong axis vertically oriented
    - Second layer of ½-inch cementitious matrix
    - Carbon fiber reinforced grid w/ strong axis horizontally oriented
    - Final layer of ½-inch cementitious matrix
- Install new pump column and existing pump/motor
- Will improve structural integrity of the caisson and prevent water intrusion
- Planning-Level Cost (2018):
  - $770,000 - $1,645,000



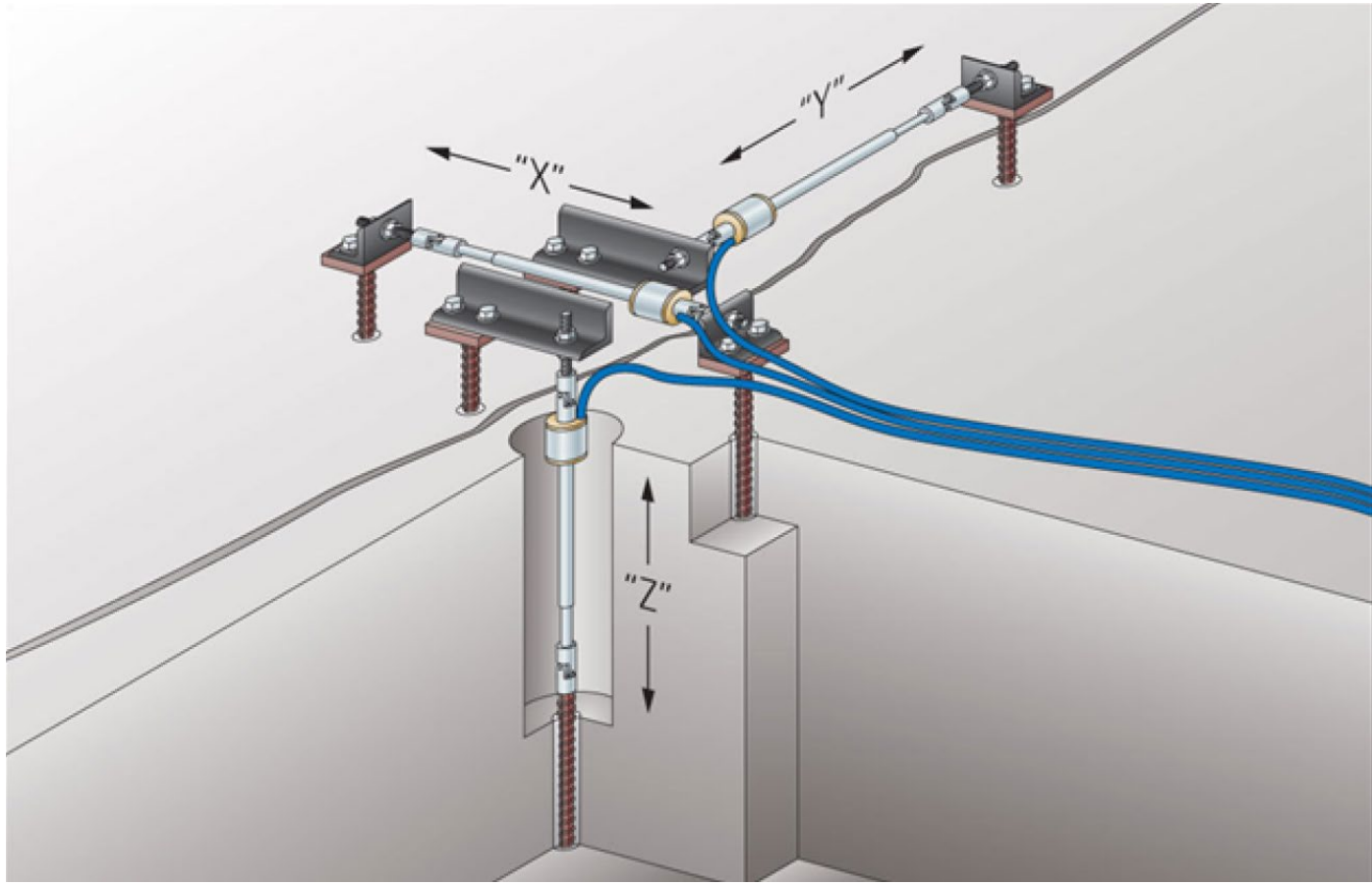
# Alternative 2 – Install and Seal Casing Liner Extension

- Install 3-5-foot diameter steel casing liner
- Extend casing liner inside existing 5-foot diameter casing
- Bottom portion of liner equipped with formation packers and steel coupler
- Seal coupler and base of liner extension with concrete and let cure
- Fill remaining annular space with grout seal in short lifts and let cure
- Install new pump column and existing pump/motor
- Will improve structural integrity of the caisson and prevent water intrusion
- Planning-Level Cost (2018):
  - $855,000 - $1,830,000



# Alternative 3 – Crack Monitoring

- Use transducers to continuously monitor 3D displacement over time to understand:
  - Settlement/deformation rates
  - How external forces may be contributing to observed deformation (e.g., pump/motor operations)
- Install new pump column and existing pump/motor
- Assess whether to continue using Well 2, or implement alternative repair option
- Will not improve structural integrity of the caisson or prevent water intrusion
- Planning-Level Cost (2018):
  - $405,000 - $870,000



# Concept Plan for Selected Alternative

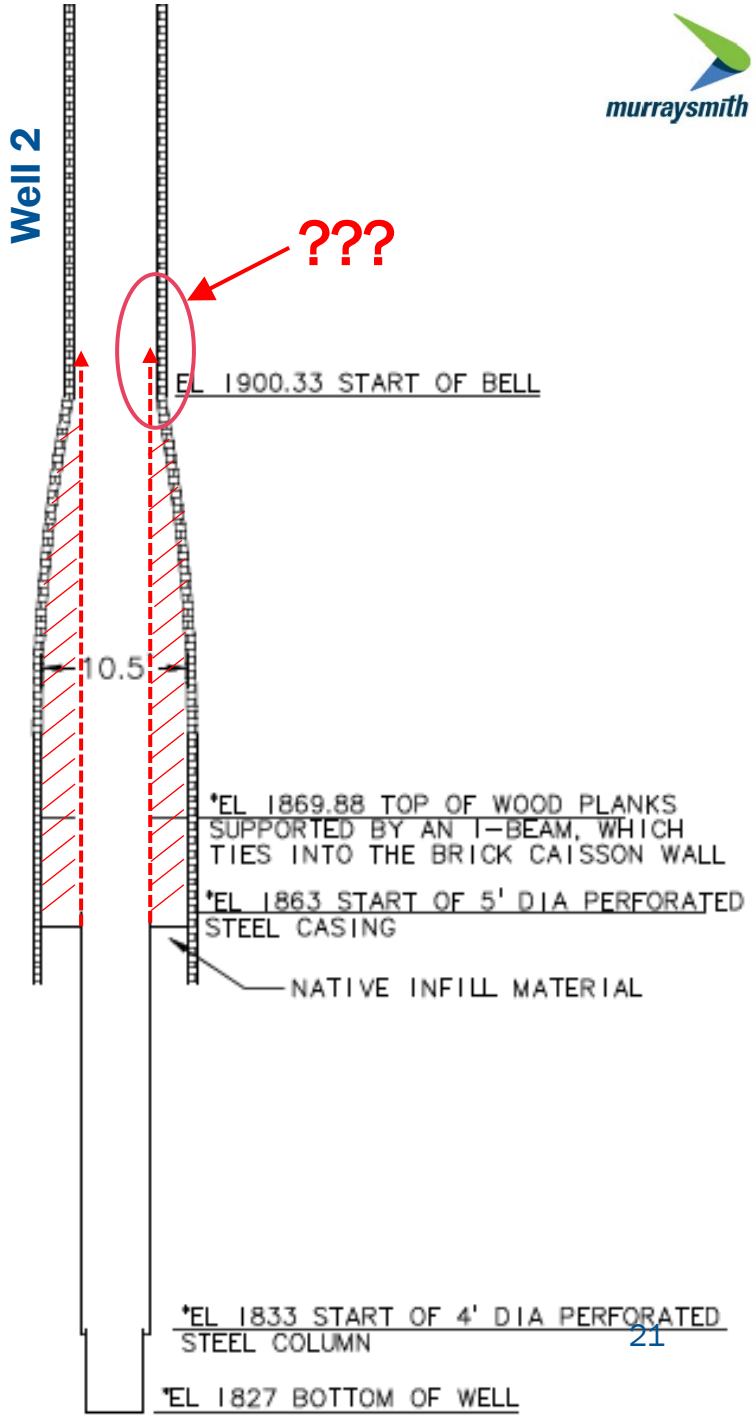
Hoffman Well Station, photograph by Charles Libby 1957.

## Alternative 2 – Install and Seal Casing Liner Extension

**Hoffman Well 2**

# Preferred Alternative

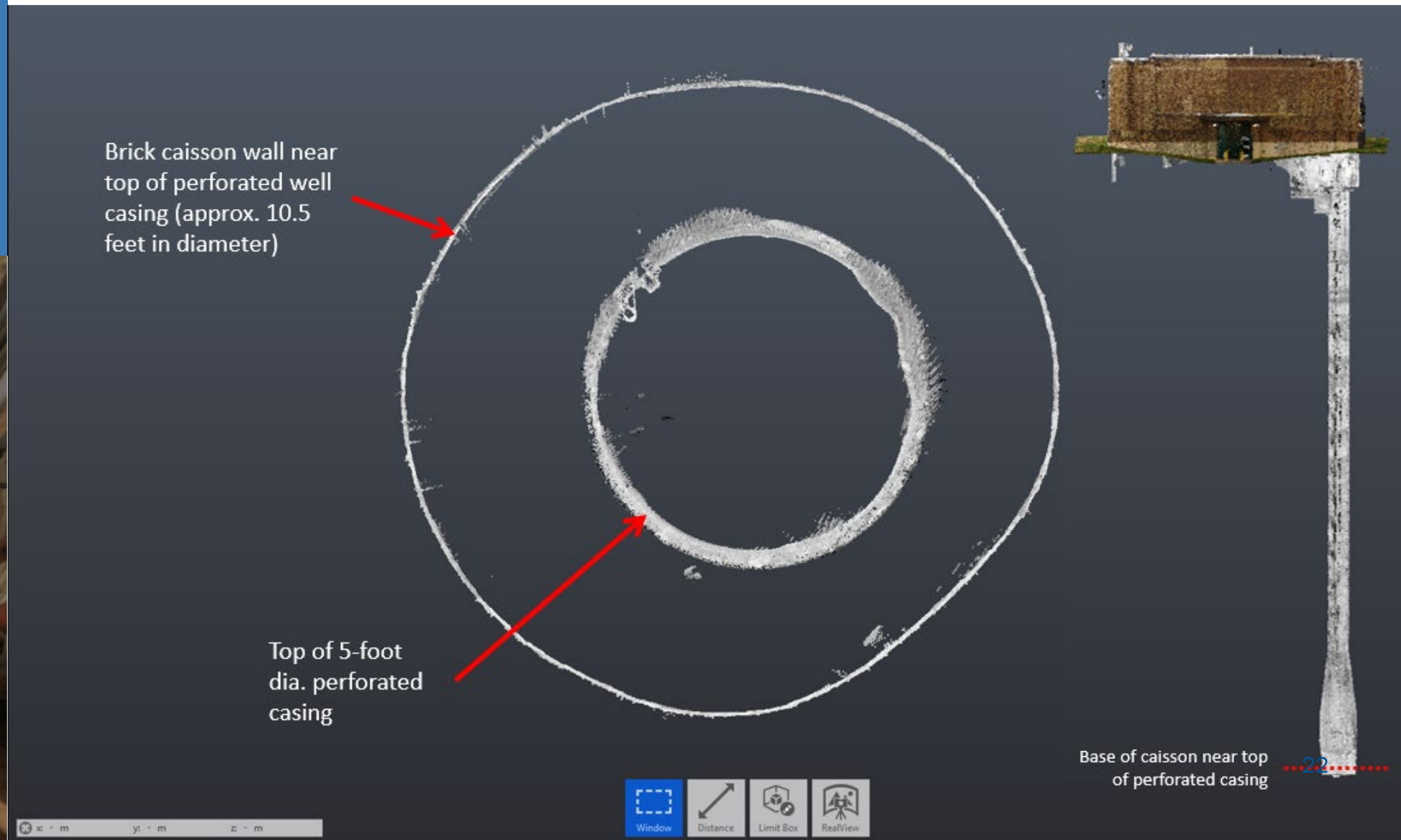
- Preferred repair alternative:
  - Install casing liner and extend to surface
  - Seal the annular space
- Uncertainty:
  - Will there be enough clearance for an adequate seal?
- Needed to conduct a plumbness and alignment test
- Traditional P/A test methods not valid
- Traffic accident reconstructionist and certified forensic photographer to the rescue!
  - Jeremy Bauer, Bauer Forensics, LLC



Alternative 2 – Install and Seal Casing Liner Extension

**Hoffman Well 2**

# Plumbness and Alignment Test Results



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**Hoffman Well 2**

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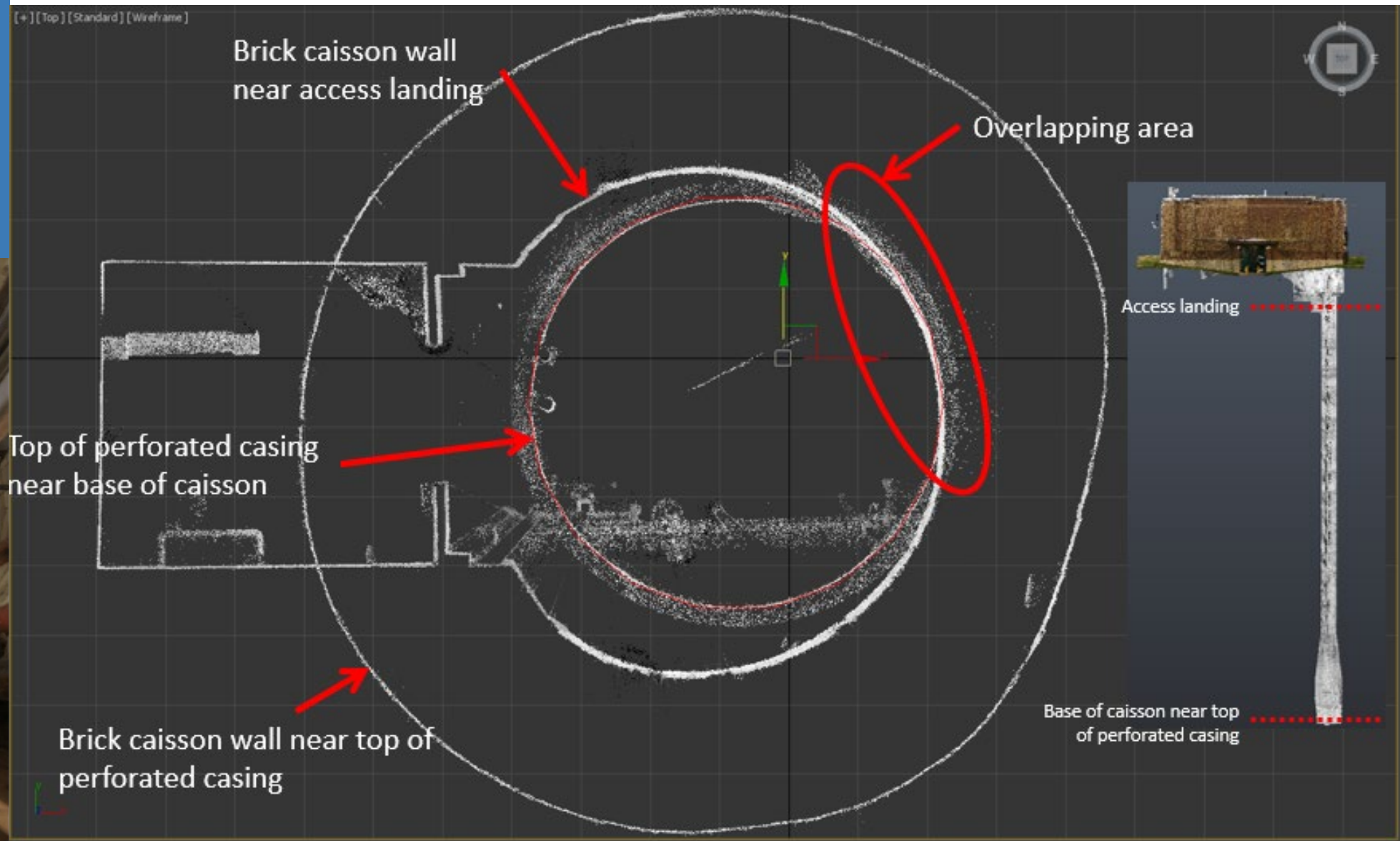

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**Hoffman Well 2**

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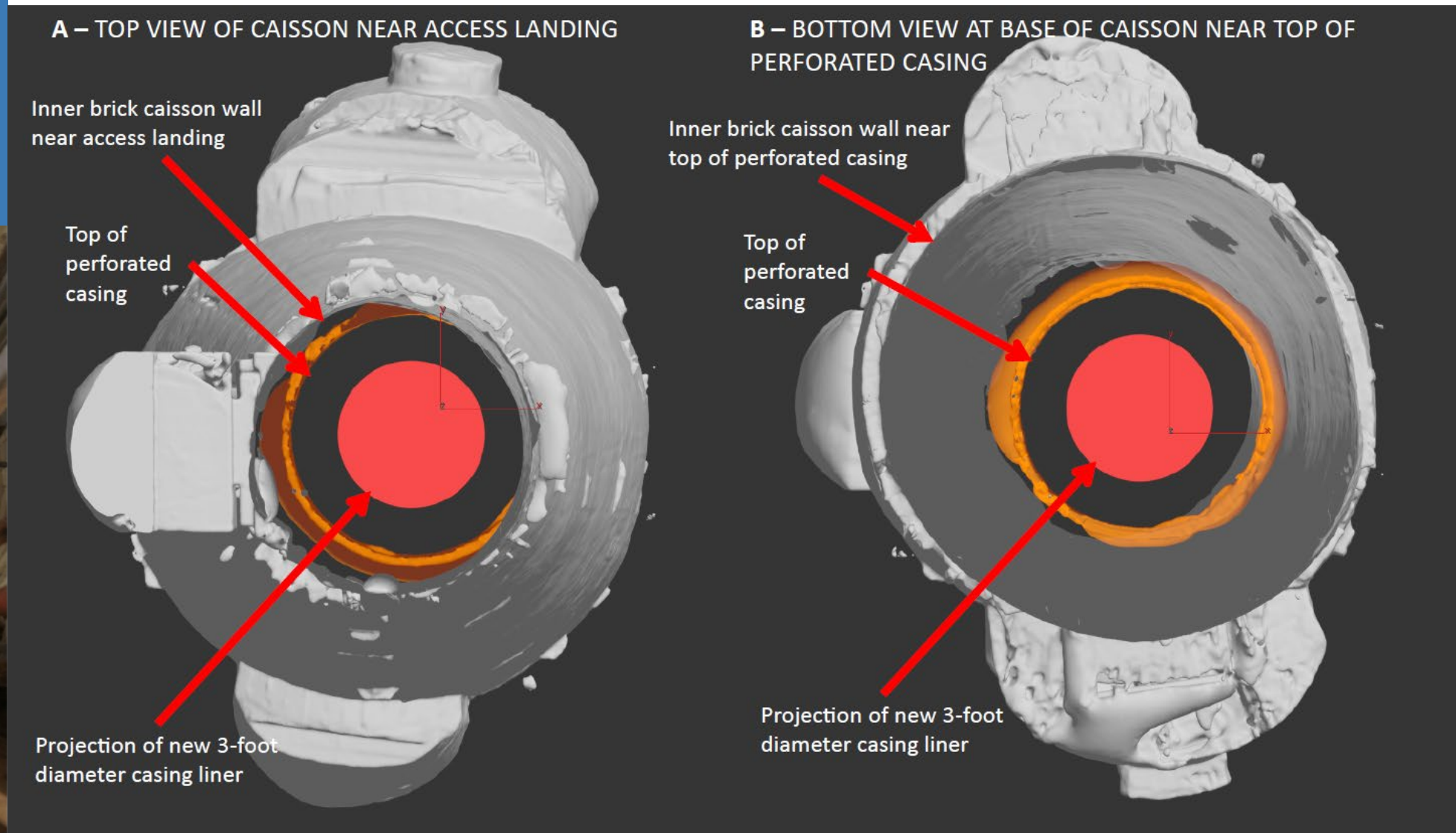
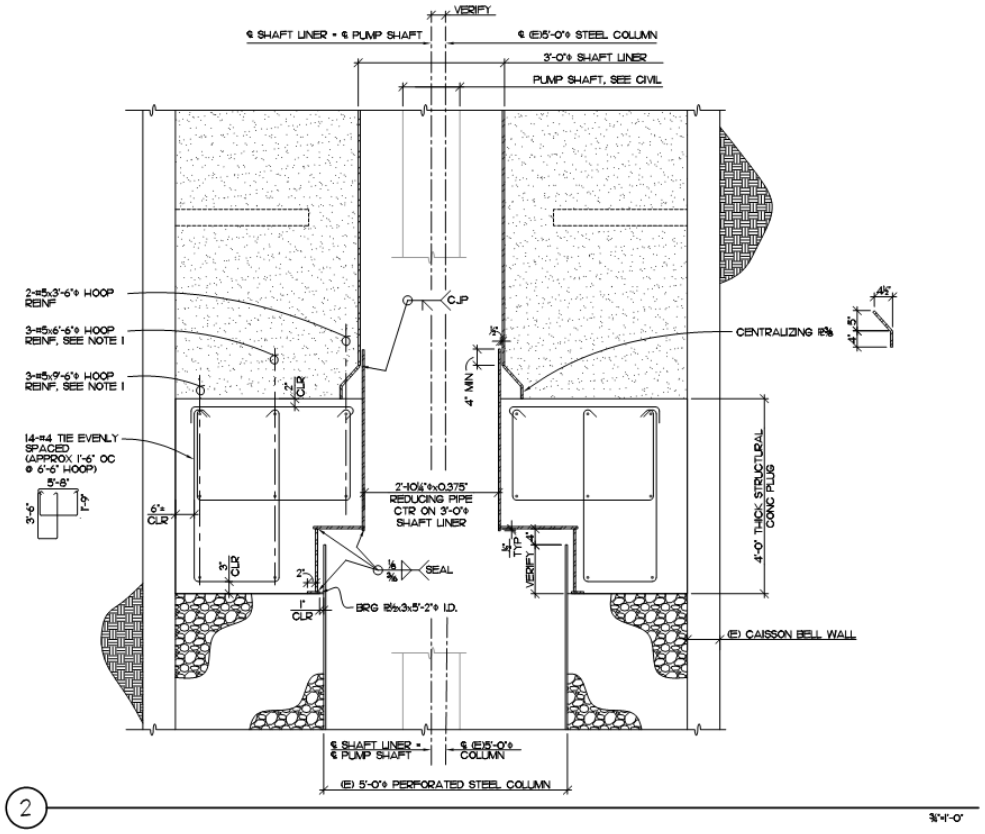


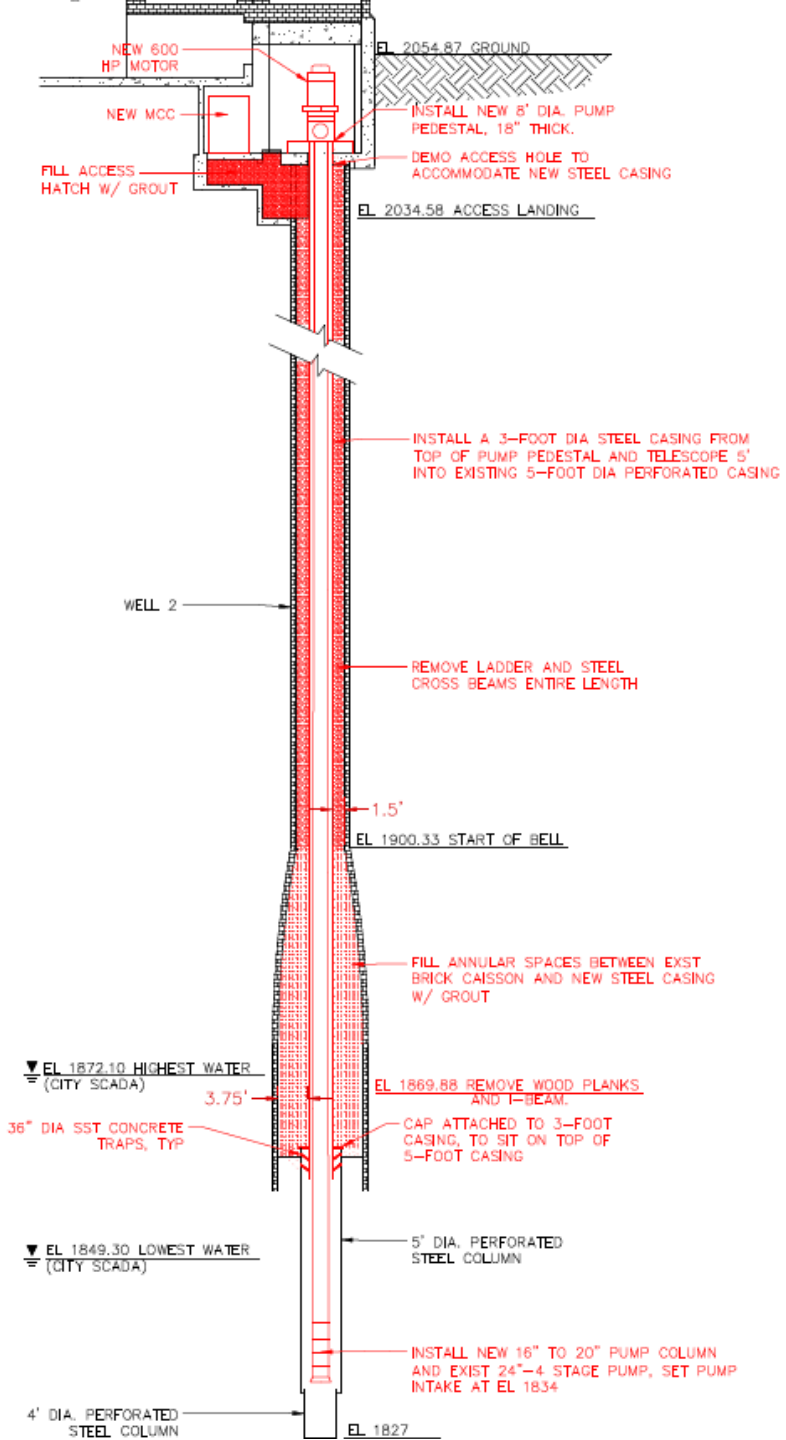
# Alternative 2 – Install and Seal Casing Liner Extension

**Hoffman Well 2**

# Preferred Alternative

- Unique Considerations
  - Steel Casing Transition
  - Pump Intake Location
  - Well Construction Access



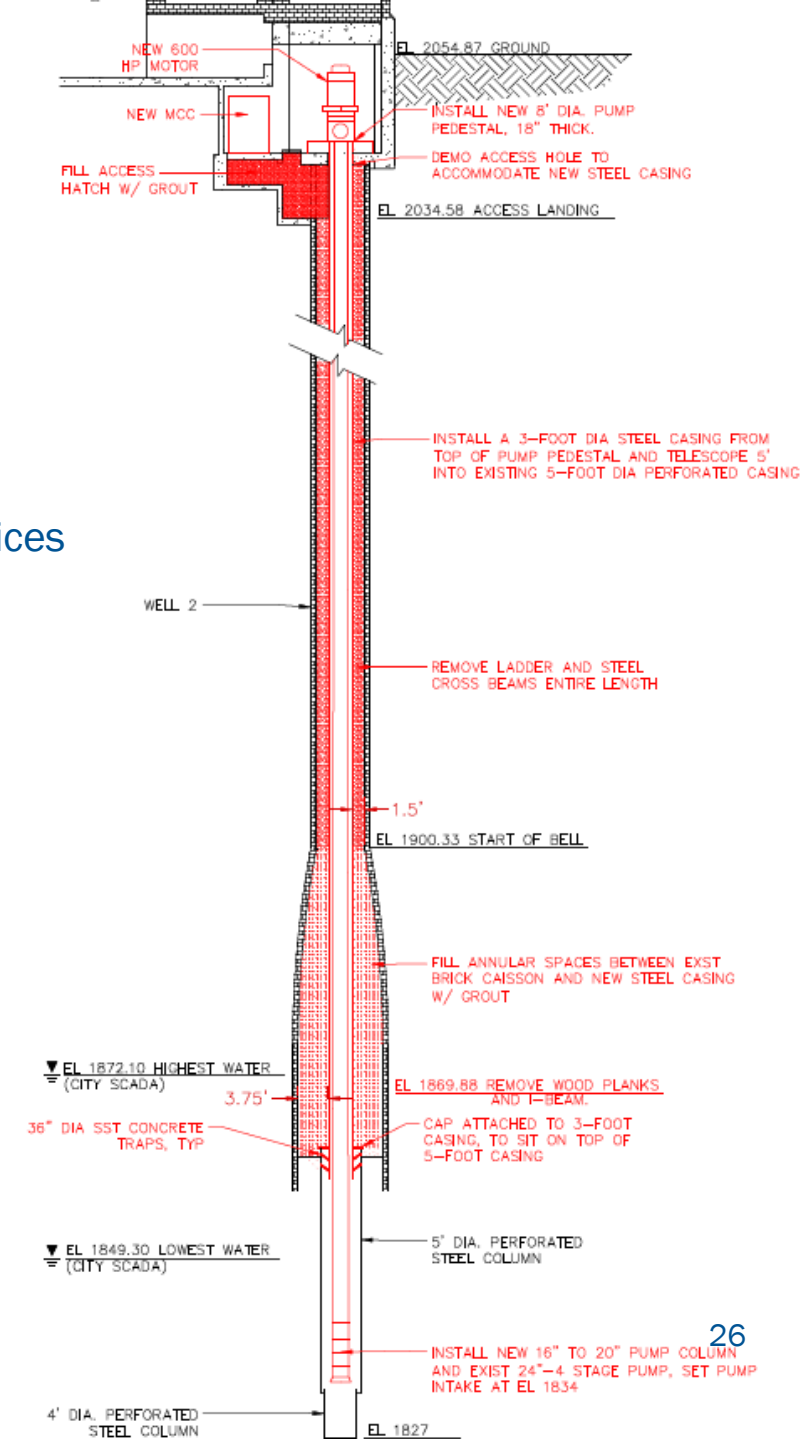
## Alternative 2 – Install and Seal Casing Liner Extension

**Hoffman Well 2**

# Preferred Alternative

Progress update:

- Currently in Construction
- Project Bid: June 2021
- Final Design: City of Spokane Engineering Services
- Low Bid: LARIVIERE INC
- City Engineers Estimated Cost: $2,635,821.00 (Low Bid $2,407,635.00)



# Acknowledgements

GSI Water Solutions, Inc.

murraysmith

CITY OF SPOKANE

LANDAU ASSOCIATES

LSB CONSULTING ENGINEERS

BAUER FORENSICS, LLC

Hoffman Well Station, photograph by Charles Libby 1957.

# Questions?

Kenny Janssen RG/LG, GSI Water Solutions, Inc.
kjanssen@gsiws.com

Joe Foote PE, Murraysmith, Inc.
Joe.Foote@murraysmith.us

Hoffman Well Station, photograph by Charles Libby 1957.