West Basin Facility Plan Project 7054

PART 3 - TECHNICAL MEMORANDUM 9

Conveyance – Seismic Resiliency

FINAL / October 2025

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Clean Water Services

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Abbreviations

TM	Technical Memorandum
DOGAMI	Oregon Department of Geology and Mineral Industries
EPA	United States Environmental Protection Agency
WRRF	Water Resource Recovery Facility
R&R	Repair and Replacement
O&M	Operations and Maintenance
GIS	Geographic Information System
PACP	Pipeline Assessment Certification Program
HDPE	High-Density Polyethylene
CIPP	Cured-in-Place Pipe
DIP	Ductile Iron Pipe
PVC	Polyvinyl Chloride
CSP	Corrugated Steel Pipe

CONVEYANCE – SEISMIC RESILIENCY

9.1 Objective

This technical memorandum (TM) summarizes recommendations on seismic resiliency for the conveyance system for Clean Water Services (District).

The objective of this TM is to summarize the following:

- General approach to understanding system vulnerability to potential earthquake damage.
- Perspectives for seismic resiliency planning including preventative, preparedness, response, and recovery planning.
- Oregon Department of Geology and Mineral Industries (DOGAMI) mapping showing landslide susceptibility and liquefaction potential (primarily near creeks and rivers) for the conveyance system.
- The best engineering design practices for pipeline bridges associated with creek and river crossings.
- Inspection guidance for pipeline bridges.
- Inventory of District pipeline bridges with preliminary inspection information.

9.2 References

This TM references the following:

- PART 3 – TM 8 – Conveyance Capital Improvement Implementation Plan

9.3 System Vulnerability and Seismic Resiliency

Washington County is at risk of earthquakes related to the Cascadia Subduction Zone (offshore fault) and other local faults. Local faults include the Portland Hills fault zone, Gales Creek fault zone, and Mount Angel fault zone. The Cascadia Subduction Zone has a risk of an earthquake of magnitude 8 or greater and local fault zones have a risk of 6.8 or greater (washingtoncountyor.gov/emergency/earthquake). Earthquakes can damage critical infrastructure, especially sanitary sewers, limiting available sanitation until emergency planning services can aid or infrastructure can be repaired or replaced.

Typical planning for seismic resiliency can be viewed from four perspectives as described below and shown in Figure 9.1.

- Prevention: Efforts to minimize impacts to infrastructure during a seismic event.
  - » Vulnerability assessments based on infrastructure location and design.
  - » Capital investment to reduce risk including strengthening vulnerable assets.
- Preparedness: Storing commodities, materials, and planning for work immediately following a seismic event.
  - » Plans for resources (temporary sanitation) and short-term options to bring infrastructure back online.
  - » Public education and communication.
  - » Equity considerations for vulnerable communities.

- Responsiveness: Work to bring basic and critical facilities back online.
  - » Adaptability considerations (variable scenarios and alternative plans).
  - » Critical services first (hospitals and other dedicated gathering places).
  - » Practicality of solutions including definition of short term and longer-term objectives.
- Recovery: Longer-term efforts to replace and rebuild infrastructure.
  - » Consider priorities by total population served, vulnerable populations, critical service restoration for secondary services (critical businesses, schools, etc).
  - » Align replacement with longer-term opportunities to improve operations, capacity, materials or other targeted efficiencies for improved infrastructure life cycle and resiliency.

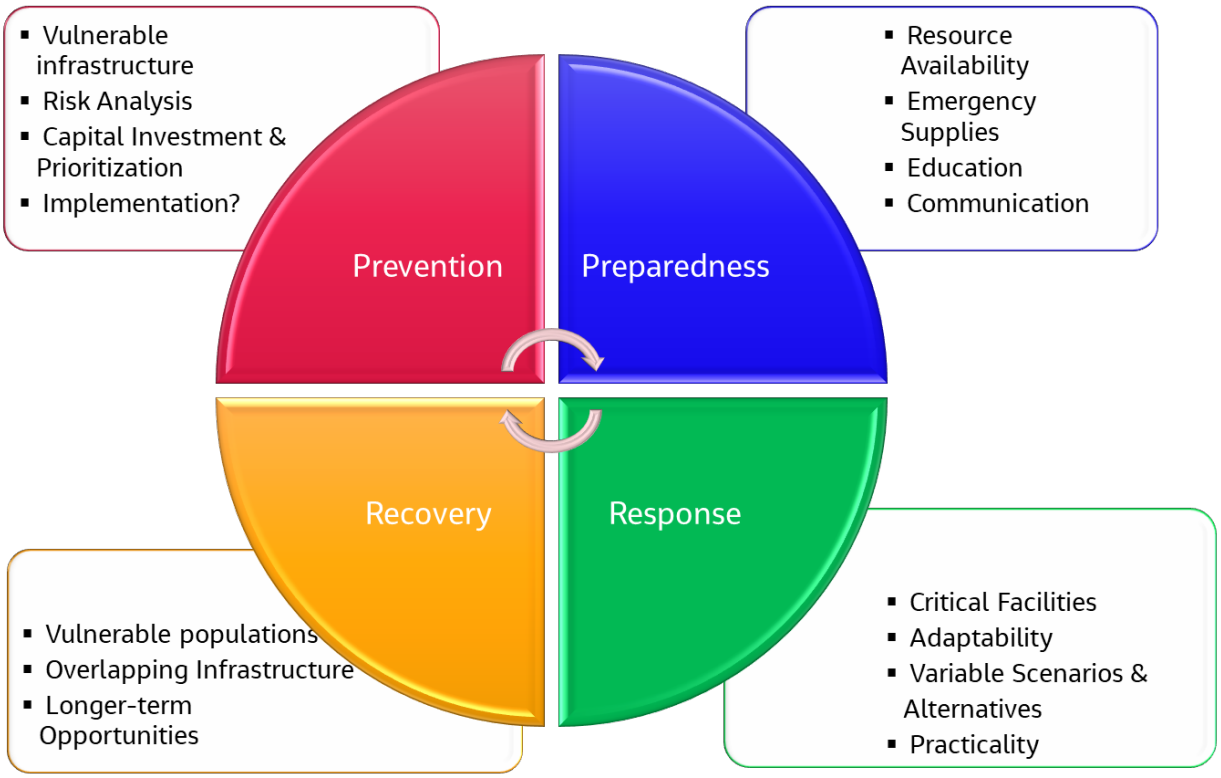

Figure 9.1 Perspectives on Seismic Resiliency Planning

Planning efforts for seismic resiliency may be aligned with guidance from the United States Environmental Protection Agency (EPA), *Earthquake Resilience Guide for Water and Wastewater Utilities* (https://www.epa.gov/sites/default/files/2018-02/documents/180112-earthquakeresilienceguide.pdf).

9.4 Seismic Risk Mapping (DOGAMI)

The Oregon Department of Geology and Mineral (DOGAMI) produces risk mapping for the state of Oregon showing areas of low to high landslide susceptibility and low to high liquefaction probability. Landslides and liquefaction may be introduced in high-risk areas during a seismic event. Figures 9.2 and 9.3 show the DOGAMI risk mapping related to the District sanitary sewer infrastructure for landslide susceptibility and liquefaction probability respectively.

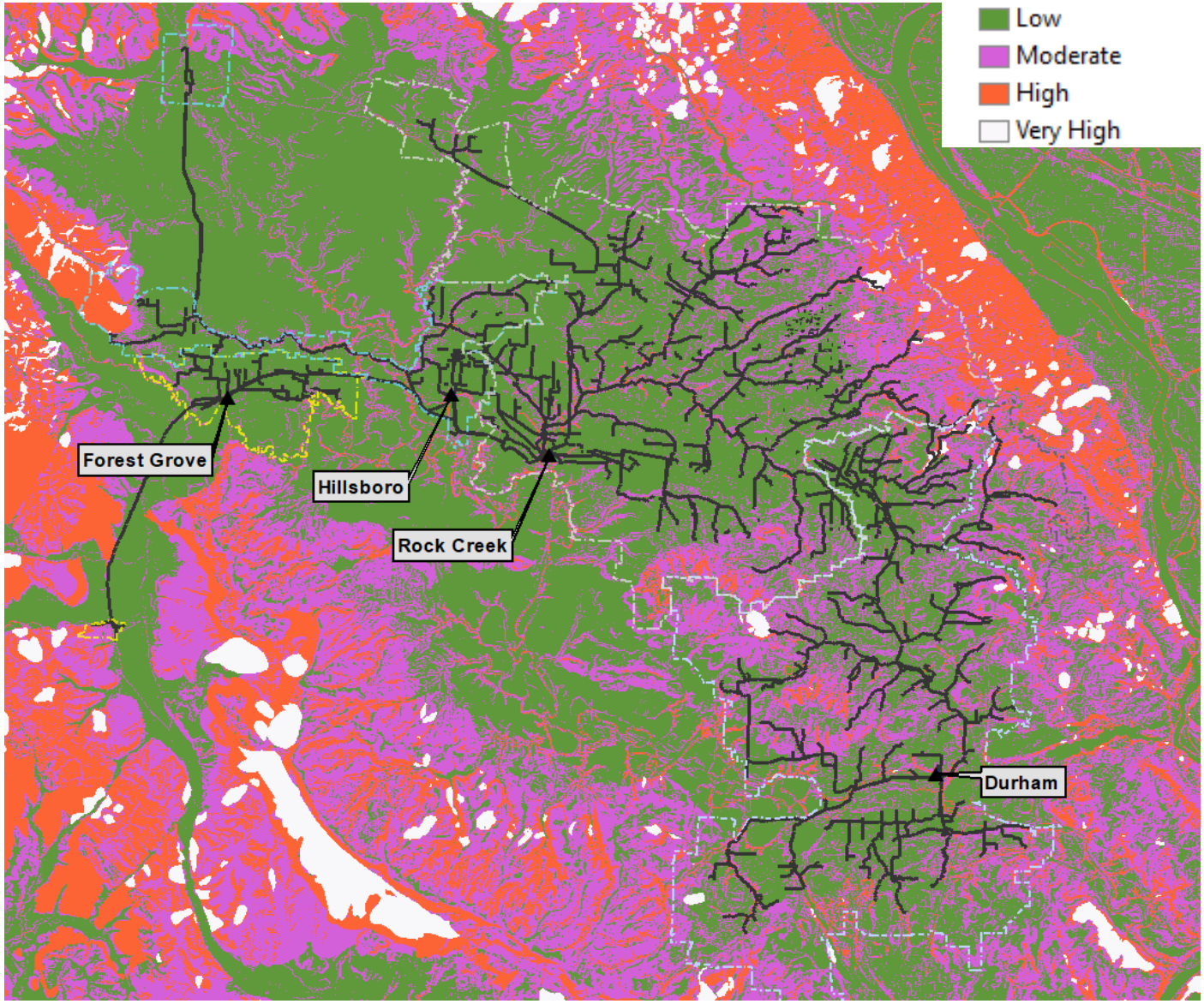

Figure 9.2 Landslide Susceptibility (DOGAMI mapping) and District Sewer Infrastructure

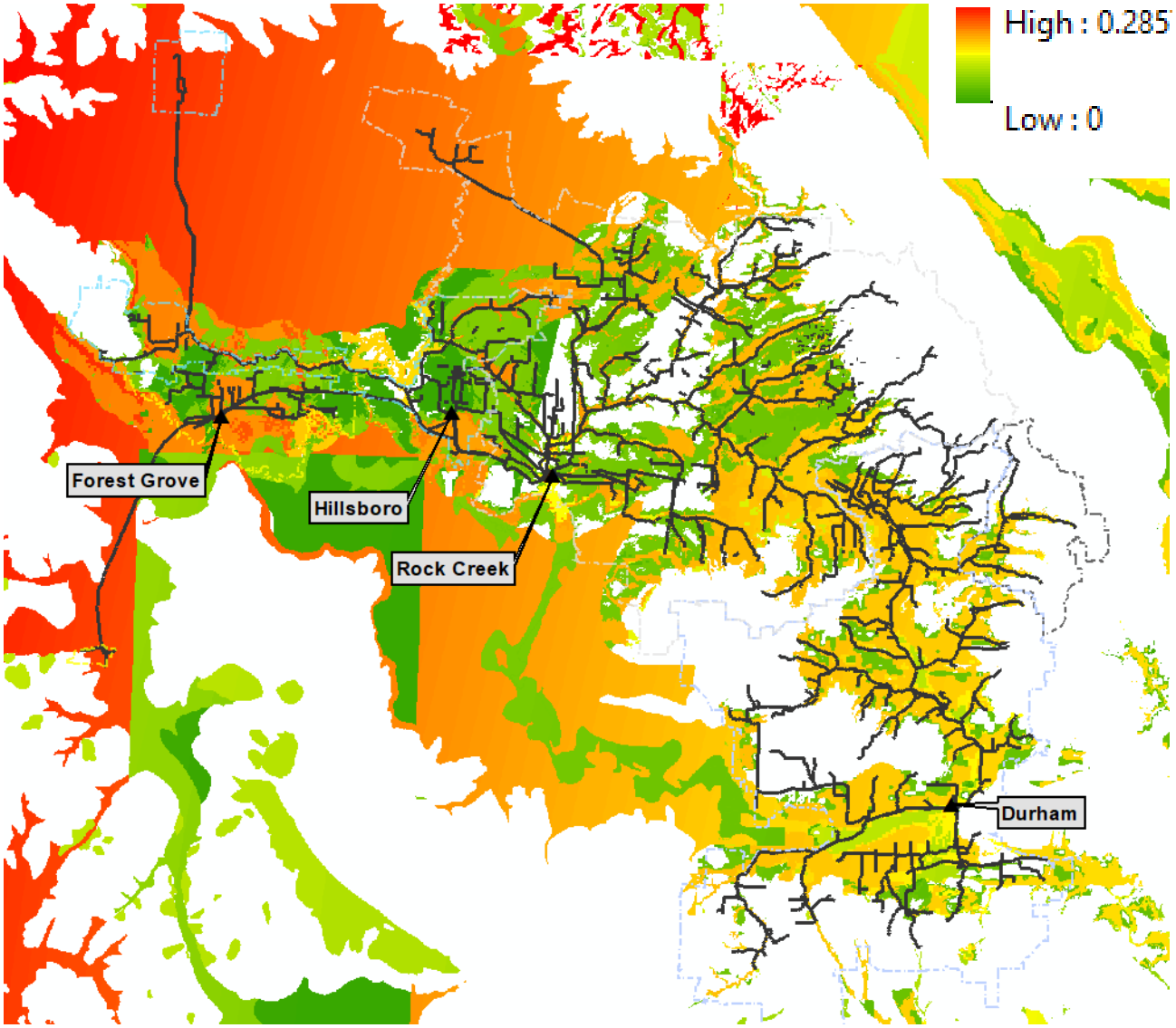

Figure 9.3 Liquefaction Probability (DOGAMI mapping) and District Sewer Infrastructure

Landslide susceptibility is a moderate risk for sanitary sewer infrastructure in Washington County within or adjacent to creek beds. Landslides can leave shallow pipelines exposed and vulnerable to damage including falling debris.

Liquefaction probability is a moderate to high risk for sanitary sewer infrastructure in Washington County. When soil becomes liquefied during an earthquake, it can behave as a liquid causing lateral movement and infrastructure displacement including pipe rupture. This is of particular concern for pipe bridges where the bridge structure and pipeline may experience movement during a seismic event. There are vulnerable areas particularly near the Hillsboro WRRF (adjacent to wetlands), west Forest Grove (due to soils and topography), and adjacent to the Forest Grove WRRF. The cities of Banks, Gaston, and North Plains are also at higher risk due to topography and soil conditions.

9.5 Focused Prevention for Pipe Bridges

For new infrastructure, the District may consider routes that minimize locations of high liquefaction probability. For existing infrastructure, preventative measures are most effective for pipe bridges.

9.5.1 Types of Pipe Bridges

Types of pipe bridges are described below.

- Above ground pipe bridges (see Figure 9.4).
  - » Type of bridge (beam, suspension, cable, rack)
  - » Floating (uncommon)
  - » Pipe support (clamps, saddles, hangers, blocks, rack)

https://bridgebrothers.com/pipe-bridges/

https://commons.wikimedia.org/wiki/File:Pipe_bridge_over_Jihlava_river_in_Jihlava_001.jpg

Figure 9.4 Above Ground Pipe Bridge (Bridge Support Pipeline Only)

- Pipe attached to pedestrian or vehicle bridge (see Figure 9.5).
  - » Type of bridge (beam, suspension, cable, truss)
  - » Bridge characterization (vehicle, pedestrian)
  - » Pipe support (clamps, saddles, hangers, blocks)

https://www.urecon.com/applications/municipal_bridges.html

https://inoacusa.com/solution/bridge-spanning-pipe-aipoly-guard/

Figure 9.5 Pipeline Attached to a Vehicle or Pedestrian Bridge

9.5.2 Seismic Damage for Pipe Bridges and Mitigation

Damage to pipe bridges during a seismic event may include:

- Structural damage to beams, supports, or foundation of the bridge.
- Pipe rupture.
- Alignment shift or pipe dislodged.

Mitigation and prevention for potential damage of pipe bridges includes the following (see Figure 9.6):

- Improve bridge supports, materials, and foundations.
- Add flexible joints and connections for pipelines.
- Add appropriate anchoring and restraints (prevents lateral shifts).

https://www.mcwaneductile.com/

https://www.romac.com/fj-restraint-2

Figure 9.6 Mitigation and Prevention (left = anchoring to prevent lateral shifts; right = flexible joint to allow movement without rupturing pipe)

9.5.3 Bridge and Pipe Bridge Inspection

Regular inspection of bridges and pipe bridges is beneficial for minimizing risk of failure and prioritizing improvement. The following items should be considered when inspecting both bridges and pipe bridges for likelihood of failure and seismic risk. A sample field form is provided for inspection in Appendix 9A.

- Pipe Characterization
  - Number of pipes, sizes, materials, install year
- Pipe Construction
  - Expansion Joints
  - Type of Support
- Pipe Condition
  - Noticeable movement
  - Exterior damage
  - Insultation damage
  - Interior (PACP ratings, structural)
- Bridge Characterization
  - Type
  - Approximate Length
  - Number of Spans
  - Construction year
- Bridge Condition
  - Spalling of concrete or erosion from scour (see Figure 9.7)
  - Exterior damage (cracks)
  - Corrosion
  - Noticeable movement
  - Previous repair
  - Excessive vegetation around piers

https://www.dot.state.oh.us/

Figure 9.7 Bridge Damage (exposed rebar/spalling)

9.5.4 Pipe Bridge Inventory and Field Inspection

The District performed an initial site visit to inspect all locations of pipe bridges for condition and seismic resiliency. The inventory and inspection data are presented in Table 9.1.

Table 9.1 Pipe Bridge Inventory and Field Inspection (12/2023)

EdgeID	Diameter (in)	Material	Intersecting streets	Dual force mains	Type	Type of Pipe Crossing	Type of Bridge	Number of Bridge Spans	Type of Pipe Support	Pipe Flexible Joints and Connections	Pipe Fittings	Structural Damage to Bridge	Bridge Exterior Corrosion	Bridge Damage Notes	Vegetation Around Bridge Piers	Creek/ River Bank Erosion	Pipe Structural Damage	Pipe Joints/ Fittings Damage	Pipe Insulation Damage	Pipe Support Condition	Pipe Support Corrosion
Confirmed																					
812417	8	DIP	Travels along SW Geiger Rd Bridge location (1400' East of SW Fern Hill Rd)	No	Reuse	Pipe on bridge (Vehicle)	Beam	3	Hangers	No	Flange	No	No		Sparse	Low	No	No	N/A	Good	Yes
812402	8	DIP	Travels along SW Fern Hill Rd Bridge location (800' South of SW Geiger Rd)	No	Reuse	Pipe on bridge (Vehicle)	Beam	1	Hangers	No	Flange	No	No		Excessive	Medium	No	No	N/A	Good	Yes
820466	10	DIP	NW Jackson School Rd and NW Meek (3000' South of Meek Rd)	Yes	Force Main	Pipe on bridge (Pedestrian)	Beam	4	Saddles	Yes	Bell	Uncertain	No		Sparse	Low	No	Uncertain	N/A	Fair	No
820469	11	DIP	NW Jackson School Rd and NW Meek (3000' South of Meek Rd)	Yes	Force Main	Pipe on bridge (Pedestrian)	Beam	4	Saddles	Yes	Bell	Uncertain	No		Sparse	Low	No	Uncertain	N/A	Fair	No
838401	20	DIP	Heather St in Cornelious	No	Sani Gravity Main	Above ground pipe bridge	Truss	1	Saddles	Yes	Bell	No	Yes		Sparse	Low	No	No	N/A	Good	No
838420	20	DIP	S 15th Ave & S Fawn Ct	No	Sani Gravity Main	Above ground pipe bridge	Truss	1	Saddles	Yes	Bell	No	Yes		Sparse	Low	No	No	N/A	Good	No
820939	24	DIP	NE Brookwood Pkwy and NE Veterans Dr. (800' South of NE Veterans Dr)	Yes	Force Main	Above ground pipe bridge	Truss	1	Saddles	Yes	Bell	No	No		Sparse	Low	No	No	No	Good	No
820940	25	DIP	NE Brookwood Pkwy and NE Veterans Dr. (800' South of NE Veterans Dr)	Yes	Force Main	Above ground pipe bridge	Truss	1	Saddles	Yes	Bell	No	No		Sparse	Low	No	No	No	Good	No
40829	24	CSP	Fanno Creek Trail & SW Johnson St	No	Sani Gravity Main	Above ground pipe bridge	Other	1	Blocks	No	Uncertain	No	No	North head wall completely exposed	Excessive	High	No	No	N/A	Poor	No
29974	8	DIP	Bohman pky	No	Sani Gravity Main	Above ground pipe bridge	Other	3	Clamps	Yes	Bell	No	N/A	Voids behind head wall	Sparse	Medium	No	No	N/A	Good	Yes
835927	16	DIP	SW Scholl's Ferry Rd and Roy Rodgers Rd (2000' South on Roy Rogers Rd)	No	Force Main	Pipe on bridge (Vehicle)	Beam	8	Saddles	Yes	Bell	No	No		Sparse	Low	No	No	N/A	Good	No
28552	8	DIP	Wesdale	No	Sani Gravity Main	Pipe on bridge (Pedestrian)	Beam	3	Clamps	No	Clamp	No	No		Excessive	Low	No	No	N/A	Good	No
31171	6	DIP	SW Foothill Dr & SW Hilldale Ave	No	Sani Gravity Main	Pipe Exposed (No bridge support)	Other	1	Other	No	Bolted flange	No	Yes	Broken head wall one side, exposed portion of pipe is corroded	Sparse	High	No	No	N/A	Poor	No
64001	8	DIP	NW Pinyon St & NW 115th Ave	No	Sani Gravity Main	Pipe on bridge (Pedestrian)	Beam	5	Hangers	Yes	Bell, coupler	No	No		Excessive	High	No	No	N/A	Good	No

EdgeID	Diameter (in)	Material	Intersecting streets	Dual force mains	Type	Type of Pipe Crossing	Type of Bridge	Number of Bridge Spans	Type of Pipe Support	Pipe Flexible Joints and Connections	Pipe Fittings	Structural Damage to Bridge	Bridge Exterior Corrosion	Bridge Damage Notes	Vegetation Around Bridge Piers	Creek/ River Bank Erosion	Pipe Structural Damage	Pipe Joints/ Fittings Damage	Pipe Insulation Damage	Pipe Support Condition	Pipe Support Corrosion
36878	8	DIP	Hwy 47 and B St 200' (West of B St)	No	Force Main	Pipe on bridge (Vehicle)	Suspension	3	Saddles	No	Mechanical joint, mega lugs	No	No		Sparse	Low	No	No	Yes	Good	No
36829	8	DIP	Hwy 47 and B St 2170' (East of B St)	No	Force Main	Pipe on bridge (Vehicle)	Beam	3	Saddles	No	Mechanical joint, mega lugs	No	No		Sparse	Medium	No	No	Yes	Good	No
829198	14	PVC	West of Kiser and Ridgeline	No	Sani Gravity Main	Pipe on bridge (Pedestrian)	Suspension	3	Rack/Cage	No	Outside casing is welded. Interior pipe is gas keyed joint	No	No		Sparse	Low	No	No	N/A	Good	No
Access Issues																					
39072	8	CSP	SW Ridgeway Dr & SW Parkway Dr	No	Sani Gravity Main																
40105	8	DIP	SW 92nd Ave & SW Brooks Bend Ln	No	Sani Gravity Main																
30714	24	CSP	Fanno Creek Trail	No	Sani Gravity Main																

9.6 Design and Condition Repair Best Practices for Seismic Resilient Systems

The following standards may be considered during new pipeline design and pipeline rehabilitation to improve seismic resiliency.

- Interceptors or trunk lines (backbone to system, consider resilience for new trunk lines)
  - » Jointless and seamless pipeline segments (avoid points of weakness in the pipeline).
  - » High-Density-Polyethylene (HDPE) pipe materials (greater structural integrity and flexibility to withstand ground motion, fused joints).
  - » For rehabilitation, Cured-in-Place Pipe (CIPP) has been tested to withstand ground motion and maintain structural integrity.
- Manhole floatation (anchors or bracing)
- Flexible pipe connection manhole (see Figure 9.8)

https://hotcore.info/babki/flexible-pipe-connection-manhole.html

Figure 9.8 Flexible Pipe Connection Manhole

- Pipe bridges
  - » HDPE for short span
  - » Ductile iron for longer span
  - » Flexible joints
  - » Lateral bracing
  - » Steel casing (when concerned about bridge structural integrity)
  - » Re-routing options
  - » Restrained couplings for material transitions (to/from bridge crossing)
- Pump Stations
  - » Yard and Internal Piping (material selection)
  - » Electrical and control panel anchoring

9.7 Repair and Replacement Program

The District is developing a program to fund repair and replacement (R&R) of existing gravity pipelines as assets reach the end of their useful life. Individual projects were not defined but a program cost was estimated based on available age, material, and condition data. Future program work will include more detailed risk assessment of assets and prioritization of funding for assets with the highest risk for structural failure, increased O&M requirements, and seismic risk. Pump station asset replacement and costs are also tracked by District staff and were not documented within the West Basin Master Plan. $200 million is allocated to the District's R&R Program (2025-2050).

As part of the R&R program, the District has also inventoried pipe bridge crossings A portion of the R&R program budget will be used to improve the pipe bridge crossings for seismic resiliency. Projects will be prioritized as common vehicle or pedestrian bridges are being retrofitted for seismic resiliency.

APPENDIX 9A

FIELD INVENTORY SAMPLE FORM FOR INSPECTING PIPE BRIDGES

Clean Water Services

Pipe Bridge and Pipe Crossing Field Form, Sample (October 2023)

	Description of Input
Date:	
Location:	Cross Streets, River/Creek Name, Jurisdiction (City/County)
Asset IDs:	Manhole IDs, Pipe IDs
Pipe Characterization:	From GIS, Asset Database
Number of Pipes	
Pipe Sizes (Diameter, inch)	
Materials	
Install Year	
Length (feet)	
Other notes from field	
Pipe Condition (if available):	From GIS, Asset Database, CCTV
PACP structural rating	
PACP O&M rating	
PACP combined rating	
Condition notes (if available)	
Crossing Characterization:	From site visit
Type of pipe crossing	above ground pipe bridge, pipe on bridge (pedestrian, vehicle, transit), pipe exposed (no bridge support)
Type of bridge	beam, suspension, cable, truss, pipe rack/cage, floating (uncommon)
Number of bridge spans	
Type of pipe support	clamps, saddles, hangers, blocks, rack/cage, other (describe)
Pipe flexible joints and connections	Yes/No/Unknown for expansion joints (photo)
Pipe fittings	Coupling for material transition, elbows (~angle), etc
Observable Condition (Bridge):	From site visit
Structural damage to bridge	Yes/No/Uncertain, exterior damage to beams, supports, foundation
Bridge exterior corrosion	Yes/No/Uncertain, note potential corrosion on concrete or metallic materials
Bridge damage notes	spalling of concrete (rebar noticeable), erosion of concrete from scour, exterior cracking of concrete; note whether damage is related to beams, support, foundation
Bridge movement	note any observable movement
Bridge repairs	note any repairs and whether repairs are holding up
Vegetation, Bridge Piers	note excessive vegetation around piers
Creek/river bank erosion	note erosion around piers and banks of creek
Observable Condition (Pipe):	From site visit

Structural damage to pipe	Yes/No/Uncertain, exterior damage including rupture, deformities
Damage to joints, fittings	Yes/No/Uncertain, exterior damage including rupture, deformities
Damage to pipe insulation	Yes/No/Uncertain, insulation damage with potential pipe exposure; hazardous materials (asbestos)
Pipe movement	note any observable movement, pipe dislodged from bridge or supports
Pipe support condition	note loose or failing supports
Pipe/support exterior corrosion	Yes/No/Uncertain, note potential corrosion on concrete or metallic materials

Take multiple photos showing pipe crossing, bridge, supports, exterior pipe condition, bridge condition (beams, support, foundation), etc