Water Distribution System Master Plan

City of Fort Bragg

November 21, 2025

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ACRONYMS AND ABBREVIATIONS

AACEI	Association for Advancement of Cost Engineering International
AC	Asbestos Cement Pipe
ADD	Average Daily Demand
AWWA	America Water Works Association
BABA	Build America, Buy America Act
CAD	Computer-Aided Design
CALFIRE	California Department of Forestry and Fire Protection
CDBG	Community Development Block Grants
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CGS	California Geological Survey
CIP	Capital Improvement Program
City	The City of Fort Bragg
CMMS	Computerized Maintenance Management System
CNDDB	California Natural Diversity Database
CoF	Consequence of Failure
DTSC	Department of Toxic Substances Control
DAC	Disadvantaged Community
DIP	Ductile Iron Pipe
DPS	Distinct Population Segment
DWSRF	Drinking Water State Revolving Funds
EDA	Economic Development Administration
EDS	Energy Dispersive X-Ray Spectroscopy
EFBPZ	East Fort Bragg Pressure Zone
EIR	Environmental Impact Report
ENR CCI	Engineering News-Record Construction Cost Index
EPA	Environmental Protection Agency
EPS	Extended Period Simulation
ERDIP	Earthquake Resistant Ductile Iron Pipe
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
ESU	Evolutionarily Significant Unit

FEMA	Federal Emergency Management Agency
FFY	Federal Fiscal Year
FME	Feature Manipulation Engine
GIS	Geographic Information System
GP	Georgia Pacific
GPR	Green Project Reserve Funding
GPD	Gallons per Day
GPM	Gallons per Minute
HGL	hydraulic gradient line
HUD	U.S. Department of Housing and Urban Development
HWY 20	Highway 20
IIJA	Infrastructure Investment and Jobs Act
IPaC	Information for Planning and Consultation
IS	Initial Study
ISO	International Organization for Standardization
IUP	Intended Use Plan
LoF	Likelihood of Failure
LOI	Letters of Interest
MDD	Maximum Daily Demand
MESA	Mendocino Emergency Services Authority
MG	Million Gallons
MGD	Gillion Gallons per Gay
MHI	Median Household Income
MinDD	Minimum Day Demand
MND	Mitigated Negative Declaration
MWELO	Model Water Efficient Landscape Ordinance
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOE	Notice of Exemption
NOFA	Notice of Funding Availability
OPC	Opinion of Probable Cost
O&M	Operations and Maintenance
PE	Polyethylene Pipe

PEIR	Program Environmental Impact Report
PHD	Peak Hour Demand
PVC	Polyvinyl Chloride Pipe
QA/QC	Quality Assurance and Quality Control
Saas	Software as a Service
SCADA	Supervisory Control and Data Acquisition
SDAC	Small Disadvantaged Community
SOC	Statement of Overriding Considerations
SRF	State Revolving Funds
TM	Technical Memorandum
UN	Utility Network
USDA	United States Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WIFIA	Water Infrastructure Finance and Innovation Act
WDMP	Water Distribution Master Plan
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

Background

The water distribution system includes 41 miles of pipeline, four storage tanks, one pump station, and one pressure zone. The oldest facilities were constructed in the 1960s and are approximately 65 years old or older, while newer sections are estimated to be 20 years old or newer. The City's largest water main (20-inches in diameter) delivers treated water from the 2.2 million gallons per day (MGD) capacity, Fort Bragg Public Works Water Treatment Plant (WTP), and the City's four above-ground storage tanks to an 18-inch-diameter trunk main in Sherwood Road/Oak Street and is then distributed to customers from a network of pipe ranging from four to 16 inches in diameter composed of primarily asbestos cement pipe (AC), but also some Polyvinyl Chloride Pipe (PVC) or other material.

The City's water distribution infrastructure currently operates successfully with minimal breakages or service interruptions. However, the system is aging, and many factors like population, land use, and climate will change over time. The City anticipates a need to plan for overall system renewal, and investment in resilience and expansion. This 2025 update to the Water Distribution Master Plan (WDMP) will develop and document a transparent, data-driven, and repeatable capital planning process. The WDMP will identify and prioritize capital projects to promote water distribution system resilience, with adequate water facilities to meet current and future demand.

Key planning factors include:

- Evaluating hydraulic pressure, valve isolation, and looping dead ends.
- Re-zoning and development of the City's industrial areas.
- Identifying strategies to improve system resilience in response to anticipating seismic, climate, and other environmental threats.

Key Master Plan Components

The development of this capital planning strategy is built on multiple actions, including:

- CHAPTER 2 – System Mapping - Development of GIS feature sets to support hydraulic modeling, risk analysis, and current and future capital planning
- CHAPTER 3 – Current & Projected Water Demand - Current and future demand analysis
- CHAPTER 4 – Hydraulic Model Development - Hydraulic model of the system
- CHAPTER 5 - Geotechnical, Environmental, and Climate Risks & Resilience - Geotechnical, environmental, and climate risk and resilience assessment
- CHAPTER 6 - Water System Capital Improvement Program - CIP plan including a pipeline replacement strategy
- CHAPTER 7 - Funding Opportunities - Analysis of potential funding opportunities

- CHAPTER 8 - CEQA Compliance - CEQA compliance strategy
- CHAPTER 9 – Asset Management - Asset management strategy and recommendations for implementation

Capital Improvement Plan

A more detailed version of Table 1 is provided in CHAPTER 6, showing the 10-year capital improvement plan for the water distribution system. Projects included represent priority capacity, operational, and asset renewal improvements needed to meet existing and future demands, facilitate system operations, and keep the current system performing at expected levels of service.

Table 1 – 10 Year Capital Improvement Plan

Priority Ranking	CIP ID	Project Name	Total Pipe Footage (FT)	Time Frame (years)	Risk Score	Category	Escalated Project Cost
1	PS-1	Pump Station Upsize	-	< 5	-	Capacity or Fire Flow Deficiency	$ 8,141,000
2	V-1	Oak Street Valves	930	< 5	1.746	Operational Improvements	$ 93,000
3	P-1	Cedar Street Water Line Replacement	4,248	< 5	1.646	Capacity or Fire Flow Deficiency	$ 3,357,000
4	T-1	Tank 1 Upgrade	-	< 5	0.988	Asset Renewal	$ 8,955,000
5	P-2	North Fort Bragg Water Main Extension	2,144	< 5	0.98	Capacity or Fire Flow Deficiency	$ 1,384,000
6	PL-1	System Renewal-Pipe Replacement	5,000	< 5	-	Asset Renewal	$ 2,830,000
7	O-1	Opportunistic Pipe Sampling	-	< 5	-	Other	$ 69,000
8	O-2	CIP Update	-	< 5	-	Other	$ 110,000
9	O-3	CMMS Needs Analysis	-	< 5	-	Other	$ 39,000
						Next 5 Year Sub-Total	**$ 24,978,000**
10	P-7	East Laurel Street Water Main Replacement	539	5 to 10	2.194	Capacity or Fire Flow Deficiency	$ 354,000
11	P-3	Noyo Center Water Line	4,018	5 to 10	2.018	Capacity or Fire Flow Deficiency	$ 2,985,000
12	P-6	North Main Street Water Main Replacement	5,429	5 to 10	2.014	Capacity or Fire Flow Deficiency	$ 4,016,000

Priority Ranking	CIP ID	Project Name	Total Pipe Footage (FT)	Time Frame (years)	Risk Score	Category	Escalated Project Cost
13	P-13	East Alder Street Water Main Replacement	717	5 to 10	1.784	Capacity or Fire Flow Deficiency	$ 470,000
14	P-10	Chief Celeri Dr Water Main Replacement	1,362	5 to 10	1.622	Capacity or Fire Flow Deficiency	$ 951,000
15	P-4	Noyo Point Road Water Main Replacement	651	5 to 10	1.416	Capacity or Fire Flow Deficiency	$ 455,000
16	P-8	Maple Street Water Main Loop	313	5 to 10	1.34	Capacity or Fire Flow Deficiency	$ 206,000
17	P-5	East Elm Street Water Main Loop	194	5 to 10	1.33	Capacity or Fire Flow Deficiency	$ 145,000
18	P-9	East Chestnut Street Water Main Replacement	472	5 to 10	1.182	Capacity or Fire Flow Deficiency	$ 330,000
19	P-11	Spruce Street Water Main Replacement	1,330	5 to 10	1.156	Capacity or Fire Flow Deficiency	$ 873,000
20	PL-2	System Renewal-Pipe Replacement	5,000	5 to 10	-	Asset Renewal	$ 3,280,000
21	O-4	Opportunistic Pipe Sampling	-	5 to 10	-	Other	$ 80,000
22	O-5	CMMS Acquisition & Implementation	-	5 to 10	-	Other	$ 191,000
23	O-6	CIP Update	-	5 to 10	-	Other	$ 127,000
						5-10 Year Sub-Total	**$ 14,463,000**
						Total	**$ 39,441,000**

Capacity & Fire flow Deficiency related capital projects were identified by evaluating current water demands, near-term water demand projections (over the next 10 years), and expected demands at buildout that includes development of the GP Mills site, five additional undeveloped lots within the City, APN: 01821029, APN: 01809002, APN: 01809016, APN: 01811303, and APN: 01811301 (See Section 3.6.1 and Figure 12), and the future annexation areas (See Figure 13).

Operational improvements are recommended to maintain or increase the City's ability to efficiently manage the system. These projects are designed to enable the City to perform regular maintenance and repairs on the system while minimizing the impact on customers and the community

Asset renewal projects include infrastructure replacement and rehabilitation of existing infrastructure to keep the current system operating as expected. These projects are focused on aging infrastructure and infrastructure that is in poor condition. An annual replacement rate of 1%

has been established to be able to replace the entire system in the next 100 years (which is consistent with current industry standards).

Other capital projects include planned condition assessment efforts, and other studies to continue to evaluate environmental, geotechnical, and climate change risks and resilience opportunities. Condition assessments will be used to plan and prioritize upcoming capital projects (such as pipeline replacements) and the environmental studies will help the City anticipate changes in environmental factors and adjust capital plans to address these changes in the future.

Capital Plan Funding

Chapter 7, Funding Opportunities, provides a summary of some of the grants and funding options from state and federal sources that may be considered for funding projects. Each funding program has specific requirements surrounding permits and project timelines. Each program's process, timeline, and requirements should be reviewed within the context of the City's overall goals, financial situation, project timelines, and debt policies.

It is important to note that funding levels and eligibility requirements are prone to yearly changes. This Master Plan report provides initial funding guidance, but updated funding availability and program requirements should be reviewed before developing an application. Long-term, water rate increases may be needed to recover revenue for projects that do not closely align with grant priorities.

Environmental Compliance

The California Environmental Quality Act (CEQA) was passed in 1970 and was intended to:

1. Inform governmental decision makers and the public about potential, significant environmental effects of proposed activities.
2. Identify the ways that environmental damage can be avoided or significantly reduced.
3. Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible.
4. Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

CHAPTER 8 - CEQA Compliance outlines the recommended environmental review requirements for the projects in the capital plan.

Hydraulic Model Development

The table below can be found in CHAPTER 3 - Current & Projected Water Demand and summarizes the existing, near-term and buildout water demand projections for the City based on average daily demand (ADD) and maximum daily demand (MDD). See CHAPTER 3 for an explanation of how these projections were developed.

Table 2 – ADD and MDD Water Demand Projections for Existing, Near-Term, and Buildout

Description	Residential ADD (mgd)	Non-residential ADD (mgd)	Water Loss (mgd) (2)	Total ADD (mgd)	Total MDD (mgd) (3)
Existing Usage (1)	0.428	0.156	0.11	0.58	1.01
Existing + Near Term Usage	0.440	0.165	0.11	0.61	1.05
Existing + Near Term + Buildout Usage	0.717	0.641	0.24	1.36	2.35

(1) GP Mill site area not included in the existing and near-term projections since it will only have water demand during buildout.
(2) Water loss calculated assuming that water loss remains the same as 2021 average (i.e., 18%).
(3) MDD water demand projection calculated based on the selected MDD:ADD peaking factor of 1.73.

Geotechnical, Environmental, and Climate Risk and Resilience

The City's infrastructure faces more challenges than just meeting fire flow and aging. The distribution system also faces geotechnical, environmental, and climate risks.

Geotechnical risks are related to the topography and geology of a location. The City is located on a seismically active, uplifted coastal terrace and faces key geotechnical risks such as:

- **Seismic Risk** – although there are no fault lines crossing the City's service area, differential movement, especially at bridge crossings, may pose risks to the distribution system. Mitigation strategies may include use of articulating joints or earthquake resistant ductile iron pipe (ERDIP) for highly critical infrastructure.
- **Densification** – Significant settlement due to soil spreading or groundwater fluctuation could damage the system.
- **Landslides & Bluff Erosion** – Differential settlement or pipe lengthening due to landslides pose a risk to the distribution system.
- **Soil Corrosivity** – Terrace deposits are acidic (corrosive) and become more so towards the coast.

Environmental Risks are risks stemming from natural hazards or contamination that can directly impact or require specific infrastructure. Key environmental risks include:

- **Flooding/Extreme Weather Events** - The City is susceptible to flooding and severe winter storms.
- **Fire** – Significant fires have occurred in Northern California in the last few years, and the City's fire hydrant system is critical infrastructure for public safety
- **Chemically Impacted Sites** – Several chemically impacted sites are located within the City of Fort Bragg. Many of these sites are identified as having been remediated to meet standards set forward by regulatory agencies. It should be noted that there may be residual chemically impacted soils that may require special testing and handling to determine material

reuse or disposal. The Department of Toxic Substances Control (DTSC) GeoTracker website should be referenced during future system upgrades or rehabilitation projects.

Climate Risks are risks driven by long-term changes in climate patterns that may increase the frequency or severity of environmental risks. Key climate change impacts include:

- **Hotter Temperatures** – Hotter weather adds demand and stress to the water system and can exacerbate wildfire threat to infrastructure. Storage tanks may be vulnerable to wildfire.
- **Variability in Precipitation** – Extreme weather like drought can threaten water availability and more frequent/more intense weather events may increase landslide risk and erosion.
- **Sea-Level Rise** – Sea-level rise can increase risk of landslides and erosion and may also result in higher salinity within rivers.

CHAPTER 1 INTRODUCTION

1.1 Master Plan Purpose & Goals

This 2025 update to the Water Distribution Master Plan (WDMP) develops and documents a transparent, data-driven, and repeatable capital planning process to provide the City of Fort Bragg (City) with a master plan and 10-year capital improvement plan that identifies and prioritizes improvements and other planning actions for the water distribution system. While there currently are not many issues with the water distribution system, the City anticipates that more focus and resources will be needed in the near term as the system continues to age. The WDMP will help the City identify and prioritize these needs before they become emergencies. Projects that are defined from these efforts will be used for the basis of annual capital planning in the coming years. The WDMP will identify and prioritize capital projects to promote water distribution system resilience, with adequate water facilities to meet current and future demand. In the development of the WDMP, the City weighed available budget with many factors, including aging infrastructure, technological advances, community growth, and seismic, environmental, and climate risk.

Key planning factors include:

- Evaluating hydraulic pressure, valve isolation, and looping dead ends.
- Re-zoning and development of the City's industrial areas.
- Identifying strategies to improve system resilience in response to seismic, climate, and other environmental threats.
- Evaluation of existing infrastructure and planned renewal/replacement

The master plan provides defensible justification, supporting data, a transparent process, and assesses impacts to the City if the projects are not completed. This will provide the City with a balanced view to compare these needed water distribution projects with other, more visible civil projects to support budget approval.

1.2 The 1986 Master Plan

The City's previous master plan was finalized in April 1986 and was based on 1980 General Plan data that projected development through the year 2000. The purpose of the study and master plan was to evaluate several aspects of the water supply and distribution system, including present and future water supply sources; water treatment plant components; bypassing Newman Reservoir; physical improvement of existing sources; and computer simulation of the existing and future distribution systems using the University of Kentucky's "Computer Analysis of Flow in Pipe Networks". Many of the recommendations from the 1986 plan have been implemented.

1.3 Water Distribution System

It is important to understand the boundaries of what is addressed in the WDMP. The WDMP draws its boundary downstream from the outlet of the WTP and assesses the current state of and primary threats to the use and integrity of the treated water distribution system, which includes 41 miles of pipe, four storage tanks, one pump station, and one pressure zone (Figure 1).

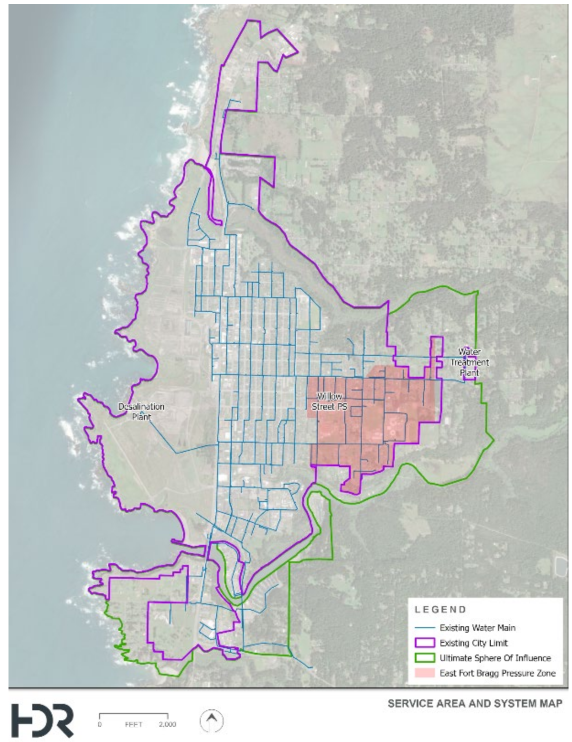


Figure 1 – Service Area and System Map

The oldest facilities were constructed in the 1960s and are approximately 65 years old or older, while newer sections are estimated to be 20 years old or newer. A 20-inch-diameter water main delivers treated water from the 2.2 million gallons per day (MGD) capacity, Fort Bragg Public Works Water Treatment Plant (WTP), and the City's above-ground storage tanks to an 18-inch-diameter trunk main in Sherwood Road/Oak Street. This 18-inch-diameter main reduces to a 10-inch-diameter main at Wall Street. There are 12-inch-diameter mains in Harold Street and Redwood Avenue north of Oak Street and in the Southern section of the distribution system along Highway 20 near the Highway 20 Storage Tank.

The East Fort Bragg Pressure Zone (EFBPZ) is located in the eastern portion of the City service area and is shown in **Error! Reference source not found.**. The EFBPZ includes elevations that are too high to be served via the gravity system and is served by a pump station located on Willow Street. The majority of the City's water distribution system is composed of 6-inch- and 8-inch-diameter mains. Treated water storage tanks range in size from 1.47 MG to 1.62 MG.

1.4 Water Supply

Capital planning for water resources, including sources, reservoirs, and transmission lines upstream of the WTP, are not within the scope of the WDMP. However, understanding the context and components of the City's water supply is important. Therefore, an overview of the City's water supply and ongoing measures to address water resource needs are provided below.

The City receives its raw water from three main sources:

- Newman Gulch
- Waterfall Gulch
- Noyo River

Since 1994, most of the City's water supply has been provided by diversions from the Noyo River. The Noyo River experiences high salinity caused by tidal influence during late summer. The City has a small desalination plant that has been intermittently operational since 2021 to treat the brackish water before it is processed through the City's WTP prior to distribution. Newman Gulch and Waterfall Gulch are spring-fed tributaries to the Noyo River and Hare Creek, respectively, that divert water via gravity flow to the WTP. During drought years, the City relies on diversions from Waterfall Gulch to make up for shortages in its other supplies. This source of water has historically been less impacted by drought than the City's other water supply sources. However, between 2015 and 2021, the City experienced a steady decline in available flow at Waterfall Gulch, making it a less reliable water supply source.

The Urban Water Management Planning Act of 1983 requires water suppliers that serve more than 3,000 connections or produce over 3,000 acre-feet of treated water annually to prepare a formal Urban Water Management Plan (UWMP). An UWMP evaluates and demonstrates the reliability of a supplier's water resources. The City of Fort Bragg does not currently meet these thresholds and is therefore not required to maintain a formal plan.

In the absence of a formal UWMP, the City has implemented several measures to evaluate the adequacy and reliability of its raw water supply and storage. Examples of these efforts are outlined below.

- **Water-Supply Model (2015)** - In 2015, the City partnered with Lawrence & Associates to develop a Water-Supply Model which helps Fort Bragg evaluate water-supply scenarios by simulating how changes in demand, river flow, and new sources (like reservoirs or groundwater) affect availability. This model relies on historical hydrologic data from 1973 through 2015 and actual demand records and predicts future supply reliability under varying conditions, including drought.
- **Summers Lane Reservoir (2016)** - In 2016 the City constructed the 45 acre-ft Summers Lane Reservoir adjacent to Newman Gluch. The Summers Lane Reservoir is filled via the Waterfall Gulch source and serves as a hydraulic break for the pipeline.
- **Water Resource Capital Planning (2025)** - The City is also undertaking studies to assess capital water resource options to improve the resiliency of the City's raw water supply. In January 2025, the City developed a preliminary engineering report outlining the plans for three 45-acre-foot reservoirs which would be connected to the existing raw water transmission system. The reservoirs would be filled with the City's existing water rights via the existing transmission system, which currently feeds into the Fort Bragg Water Treatment Plant (FBWTP). And are planned to be built on parcels currently owned by the City.

The City will continue to monitor and evaluate the reliability of its raw water sources. While the climate change impact assessment included in this WDMP addresses some key factors affecting raw water supply, the other sections in this document remain focused on components of the treated water distribution system, as defined in Section 1.3 above.

1.5 Report Organization

The following sections are provided in the WDMP:

- CHAPTER 1 Introduction – Describes the WDMP purpose and goals, provides an overview of the water distribution system, and describes the report organization.
- CHAPTER 2 System Mapping – Discusses the development of the geographic information system (GIS) data needed to support hydraulic modeling and other master planning analyses.
- CHAPTER 3 Current & Projected Water Demand – Summarizes the development of current and future water demands needed to assess system capacity.
- CHAPTER 4 Hydraulic Model Development – Presents the development of the hydraulic model and discusses the modeling results.
- CHAPTER 5 Geotechnical, Environmental, and Climate Risks & Resilience – Analyzes the current and future environmental risks associated with the water distribution system.
- CHAPTER 6 Water System Capital Improvement Program – Presents the recommended capital projects and the 10-year capital improvement plan (CIP). Water System Capital Improvement Program
- CHAPTER 7 Funding Opportunities – Discusses potential funding opportunities and potential environmental compliance needs to implement the CIP.
- CHAPTER 8 CEQA Compliance – Presents the recommended level of effort to achieve environmental compliance.
- CHAPTER 9 Asset Management – Provides recommendations for the City to implement an asset management strategy to improve system reliability and optimize the City's investment in infrastructure.
- CHAPTER 10 Conclusion & Summary of Recommendations – Summarizes the recommendations, conclusions, and findings of the master planning effort.

CHAPTER 2 SYSTEM MAPPING

2.1 Introduction

The first step in the master planning effort was the evaluation of the City's mapping resources (Computer-Aided Design (CAD) and Geographic Information System (GIS)) and their suitability for master plan hydraulic modeling analysis. This evaluation determined that the GIS required significant improvements in order to provide the necessary up-to-date water distribution infrastructure information needed to support the majority of the master planning analysis. Various systems of record for the water distribution system, sewer collection system, and stormwater collection system were combined and integrated into one standardized GIS Utility Network dataset. The dataset was then reviewed and verified by the City to identify final corrections and accurate improvements. The standardized dataset was used as the foundation for the hydraulic model outlined in this master plan, provided the basis for many of the master planning analyses, and was the source for many of the maps and figures provided. Continued updates to the dataset will be incorporated in future asset management planning.

This section describes the process for development of the GIS datasets and provides recommendations for keeping the data accurate and up to date.

2.2 GIS Conversion Approach

One of the primary sources of data for the GIS was the existing CAD files maintained by the City. These data files were converted into a geodatabase (GIS-compatible data file). The staging file geodatabase was created using a prebuilt data schema for water, sewer and storm utilities based on the industry standard for water utility networks (Environmental Systems Research Institute (ESRI) Solutions Utility Network). Applicable descriptions of how the GIS data was used are provided in the chapters below.

HDR used feature manipulation engine (FME) software to perform the conversion and introduce additional geometry improvement processes. Geometry processes were included to enable use in the hydraulic model and to allow accurate tracing in the utility network. The migrated data has been added to a Utilities ArcGIS Pro Project (aprx) file that is incorporated with the ESRI Solutions Utility Network map templates. Additional information and technical details are provided in Appendix A.

2.3 GIS Updates

Once the geodatabase was created, additional updates were performed to accurately portray current infrastructure conditions. Several updates to the GIS were made based on cross-checking the GIS with other data sources and additional review with City staff. These updates were necessary for the development of the hydraulic model and included as-built project information that was not present in the original CAD source file. Projects incorporated into the GIS include

- Pudding Creek water main relocation project, 2022. This update included abandoning the old Pudding Creek water line crossing and adding the new water main crossing on the Highway 1 Pudding Creek bridge.

- Water treatment plant upgrades, 2024. This update included revisions to the water main piping, valves, and meters during upgrades to Fort Bragg WTP.
- Danco project updates, 2020. This update added the main service line additions and connection for the Plateau Housing Project.

2.4 Continued Maintenance

To ensure proper maintenance of the GIS system, a standard workflow should be established that helps the City keep the infrastructure data accurate and up to date. At the time of this Master Plan, the City's authoritative spatial data is managed in AutoCAD and is supported by several maintainers variously proficient in AutoCAD and ArcGIS Desktop. Upon delivery of the GIS Utility Network Geodatabase, the GIS should become the authoritative source of spatial information for the Sewer, Water, and Storm Drain networks. HDR recommends the City identify personnel to maintain this data source. These maintainers and any users of the Utility Network dataset should be trained in the necessary elements of ArcGIS Pro and Utility Network data model use, maintenance, and editing. Recommended training for City staff is provided in the section below. This training may be self-guided through ESRI Online courses or administered by HDR staff through virtual or in-person sessions.

To leverage the work associated with updating the City's GIS data set, the City should plan to continue maintaining, updating and improving the data to support ongoing decision-making and future capital planning updates. The City should continually update the GIS data as the water distribution infrastructure is improved, replaced, and maintained. This will facilitate its use as the data source for management and analysis activities to support daily capital planning and maintenance decision-making, help to efficiently keep the hydraulic model up to date, facilitate integration with the City's asset management systems, and provide for future integration with other enterprise systems (e.g. utility billing system).

Three potential options are provided to support the City's operational needs for infrastructure management:

1. Option 1 - Desktop Only
   This strategy would augment the CAD Technician's existing capabilities, providing the ability to update and utilize the City's Utility Network in a local file geodatabase, maintain integrated GIS systems, and export pdf production maps.
   Benefits – Limited licensing costs, no need for additional staffing.
   Limitations – Limited sharing capabilities, manual effort to export data and maps, City staff reliant on one person to get the information products they need.
2. Option 2 - Desktop and ArcGIS Online (AGOL)
   This strategy is a hybrid approach between Options 1 and 3. The Desktop GIS file geodatabase would act as the City's authoritative data source for water utilities but would integrate some data from the ArcGIS Online SaaS Portal. This strategy would allow City staff to access interactive web maps and applications in the office and in the field. A standard procedure would have to be established to publish GIS updates, but there would be less burden on GIS staff to export and produce maps, as City staff could rely on web mapping within the ArcGIS Online system as needed.
   Benefits – Additional outreach and specific applications for City staff. Potential for direct

integration opportunities.
Limitations – Licensing costs for ArcGIS Online, data sync process would still be needed for data updates between local file geodatabase and AGOL data displayed.

3. Option 3 - Desktop and ArcGIS Enterprise
This strategy represents the most robust option and is the most common strategy for utilities and medium sized local governments using ArcGIS Enterprise. This approach provides the greatest benefit for managing and maintaining data without the need to export data or maps but also requires more licensing and potentially more staffing. Users can access data and applications like option 2 but the GIS staff will not need to develop a sync procedure for web maps and applications. An enterprise database has many more capabilities than Desktop or ArcGIS Online, but these benefits need to be weighed against the overhead cost of having dedicated staffing and resources.
Benefits – synced desktop and web data, editing versioning, and integration capabilities.
Limitations – More overhead costs and staffing, additional licensing.

The GIS was populated using FME automation to extract spatial data from the provided CAD sources, primarily ACAD_Utility_September2022.dwg. The data was extracted from the identified CAD layers and parsed into the respective Utility Networks, with the primary goal of creating a data source for hydraulic modeling. The sources used for automated extraction were the layers with the following layer name prefixes:

- “Sewer-“
- “Water-“
- “Storm Drain-“

Network connectivity was established using the same automation processes followed by a manual review and editing. The primary goal of this process was to create a data source for the hydraulic modeling that supports development of the Master Plan. Consequently, not all of the detail of the original CAD sources were captured.

For example, the import processes captured not only feature geometry but also attribute information such as pipe material and diameter from CAD annotation based on proximity to those features. In some cases, the closest CAD annotation to a feature applied to a different feature. These types of inconsistencies were largely identified and corrected during hydraulic modeling, but some minor discrepancies like these may still exist.

Also, not all layers from the source CAD file were imported into (or even applicable to) the Water, Wastewater or Stormwater GIS. For example, the CAD source included many layers from historical city projects, and features in those layers may not have been imported during the automation process. Notably, the layer names prefixed with “Utility-“ contained unstructured information from many projects, but because of their unstructured format, were not amenable to automated conversion. These layers were used as reference to clean up and establish network connectivity, however there may be additional information in those layers that could be included in the GIS.

There is also a large amount of unstructured annotation contained in the CAD file that was not possible to import into GIS using automated processes.

We recommend the City continue to update and edit the GIS. A systematic review of the GIS features and comparison with the CAD drawings would allow the capture of additional information from the CAD sources for display and analysis in the GIS.

We recommend the City maintain and utilize the GIS data as the primary source for water asset information going forward. This will facilitate its use as the data source for management and analysis activities such as updates to the hydraulic model, integration with the City's asset management systems, and integration with utility billing systems.

2.5 Recommended Next Steps

The recommended next steps for maintenance of the GIS are:

- Select a GIS use strategy as outlined above.
- Training – Depending on the selected use strategy, training will be required for the CAD/GIS Technician, system users, and system administrators. No matter which strategy is selected, training should include instruction on general ArcGIS Pro use and maintenance, including editing and production workflows as well as specific processes to update the water network.
- Computerized maintenance management system (CMMS) Integration – We recommend integration between the GIS and the City's CMMS for water distribution assets. The City should establish workflows that provide repeatable standardized GIS/CMMS integration processes. Additional discussion is provided in CHAPTER 9.

CHAPTER 3 CURRENT & PROJECTED WATER DEMAND

3.1 Existing Land Use

The City occupies approximately 1,770 acres, divided into 17 land use categories as shown in Figure 2. There are some areas within the City's sphere of influence that do not have a City designated land use category. These areas constitute the City's near-term annexation areas except for the thin strip shaped area south of Pudding Creek Road. These annexation areas have been taken into consideration in the projection of the City's near-term water demands. For the water demand analysis, the 17 land use categories were reduced to a total of nine categories (by combining coastal and inland) to improve visualization of the land use data.

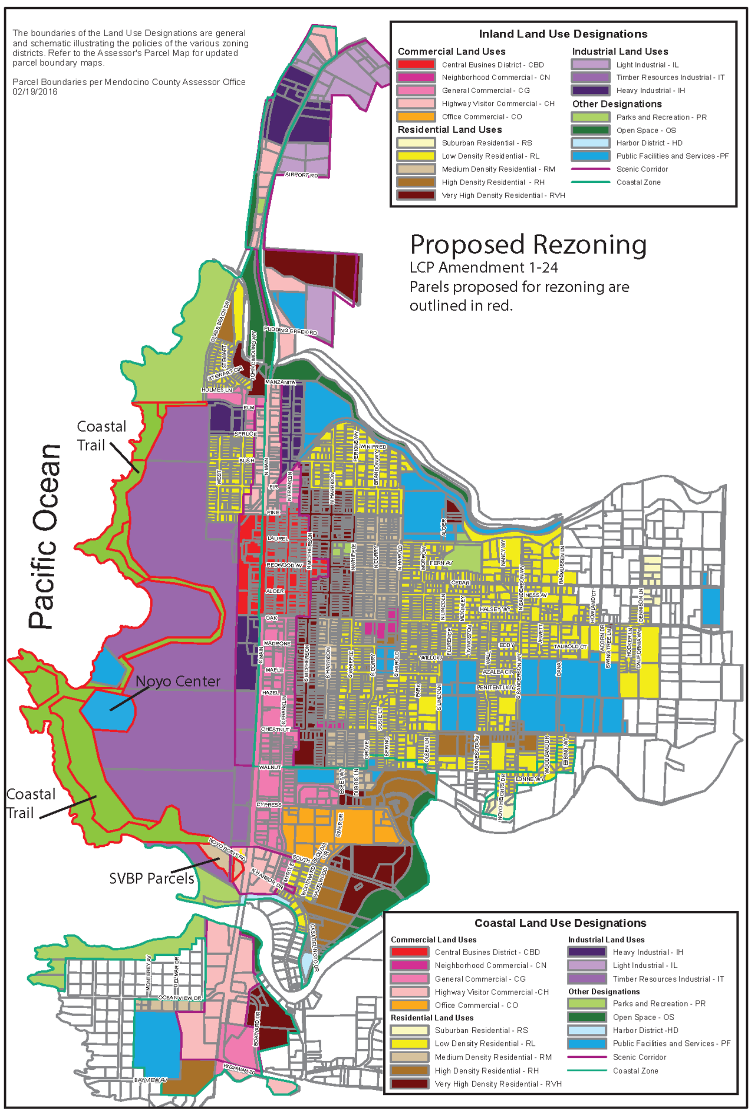


Figure 2 – City's Existing Land Use Designations

Figure 3 shows the distribution of the nine aggregated land use categories based on percentage of total City area. The largest percent area in the City is occupied by the Georgia Pacific (GP) Mill Site (24% by area) followed by Low Density Residential (22% by area). It is worth noting that the GP Mill site spans an appreciable area in comparison to the residential and non-residential land uses (Figure 4). The City is working with the property owner who intends to develop the area at the GP Mill Site in the future.

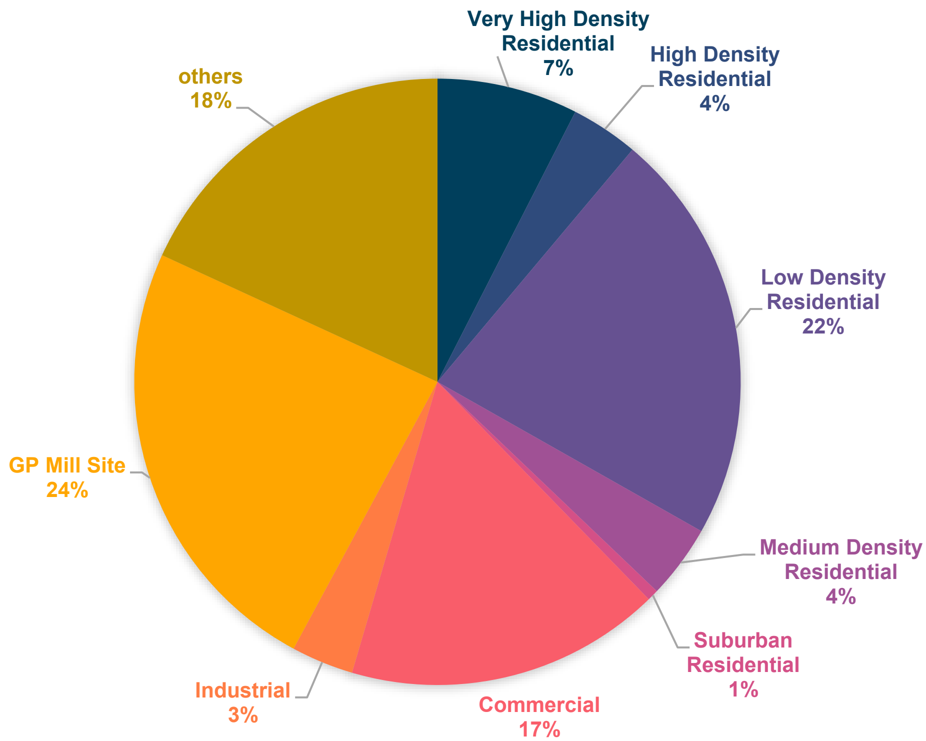


Figure 3 – Existing Land Use Distribution

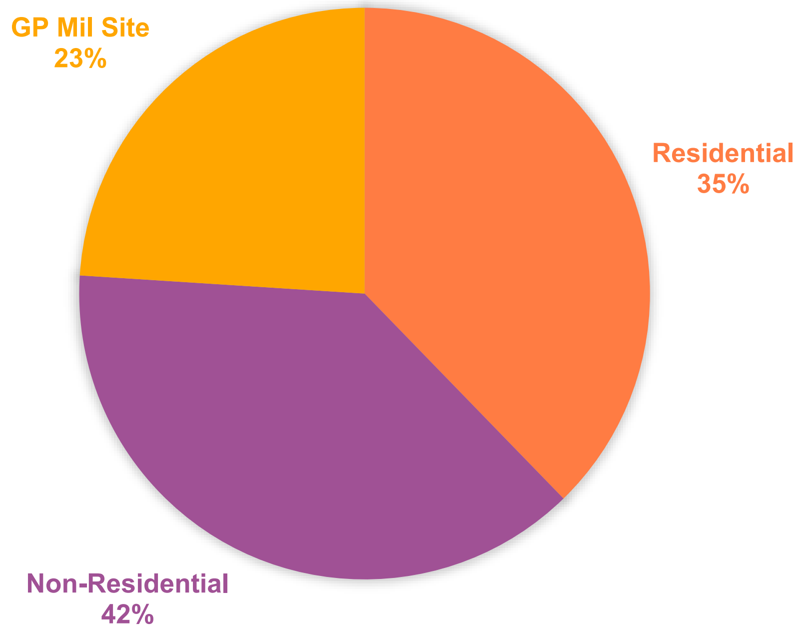


Figure 4 – City's Existing Residential, Non-Residential, and GP Mill Site Land Use Distribution Consolidated

*Note that the land use category, "Other", is excluded

3.2 Historical Demands

To quantify historical water demands, metered water usage data was obtained from the City spanning from July 2018 to May 2021. The information provided included WTP production, water user location, account number, serial number, meter manufacturer, model number, and meter size. Figure 5 below shows the total WTP monthly production, metered water demands from July 2018 to May 2021 and the corresponding monthly water losses.

The City maintained an average monthly water production of approximately 22 million gallons (MG). The peak monthly water production occurred in July 2019, reaching approximately 31 MG, while the lowest production level was recorded in February 2021, totaling approximately 17 MG. The City averaged approximately 23% water loss for the given time frame, with the highest water losses occurring during November 2019. The water losses for the City are above the national target for water losses (about 9-10%). However, average water losses for the City in 2021 (18%) indicate a declining trend in water losses. This declining trend may reflect the successful strategies that the City has taken to mitigate water losses. Potential sources for water losses can be water theft, water leaks, unmetered construction water consumption, or degradation in water meter accuracy.

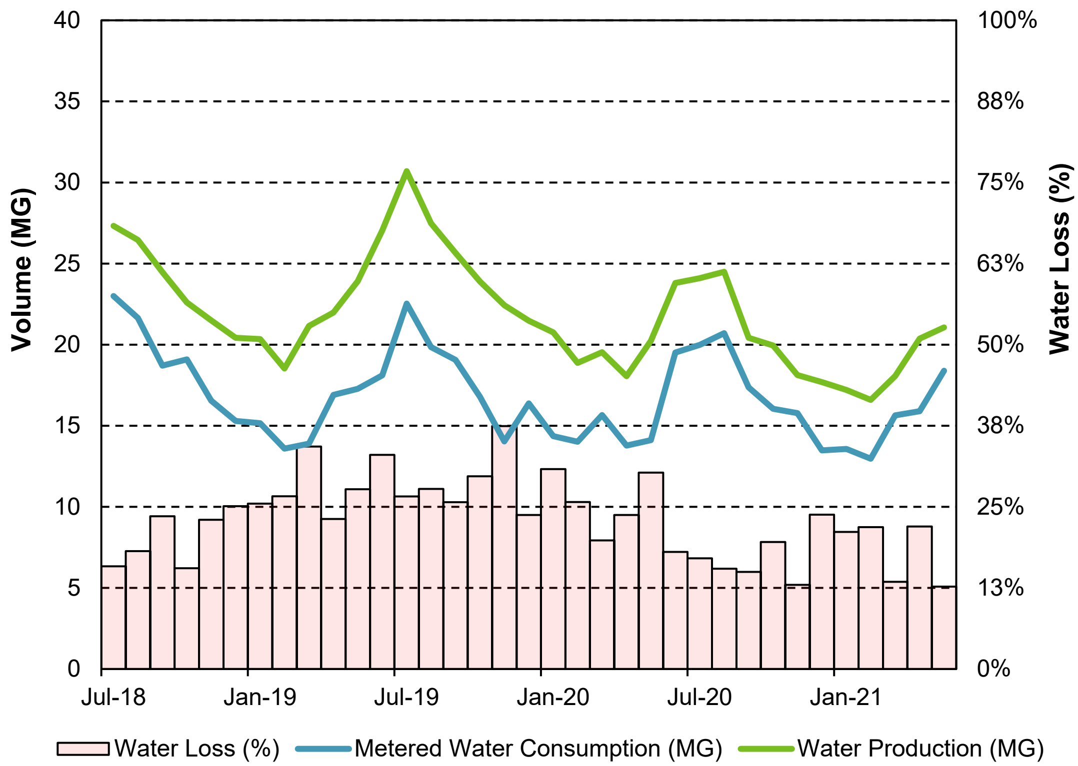


Figure 5 – City's Monthly Production and Metered Water Demands from July 2018 to May 2021

Percent distribution of metered water use by land use category is shown in Figure 6. The largest metered water use category is Low-Density Residential with an average daily demand (ADD) of 41% (0.25 mgd) of the total ADD, followed by Commercial land use with an ADD of 20% (0.12 mgd) of the total ADD. Figure 7 shows the consolidated ADD into the residential and non-residential user types. Residential ADD is 70% (about 0.43 mgd) of the total metered water demands, and non-residential ADD is 30% (0.16 mgd) of the total metered water demand.

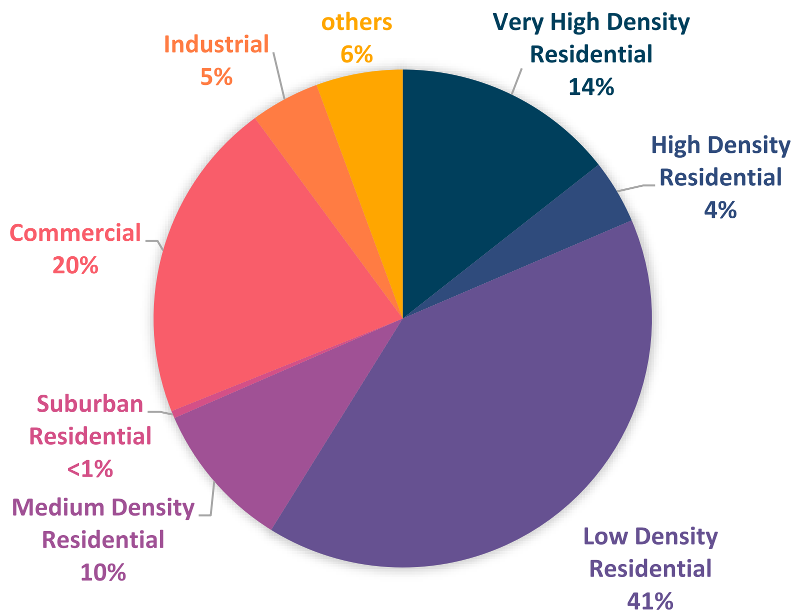


Figure 6 – Historical Average Water Use by Customer Type

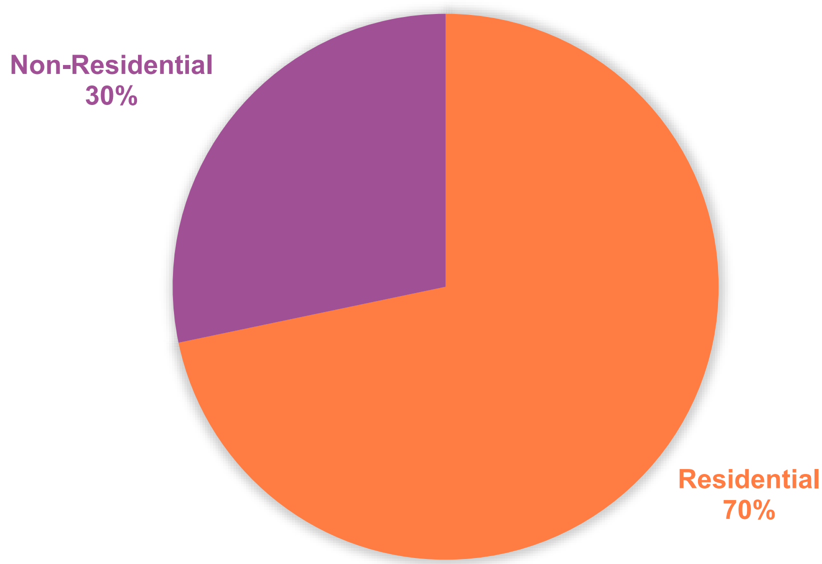


Figure 7 - Historical Average Consolidated Residential and Non-Residential Water Use

The City provided georeferenced meter points in the form of GIS maps for the year 2017. Since the metered water consumption considered in this analysis is limited to July 2018 to May 2021, the May 2021 metered water consumption data was correlated with the 2017 georeferenced meter points to create a master meters list that is used for calculating water-use duty factors. While there was some loss of meter points and the associated water consumption data during the data correlation process due to changes in the parcel database, the loss of these data points does not materially affect the development of the City's water use duty factors.

This can be better visualized in Figure 8 below, which shows the water production data from the City's WTP and the metered water production for the master meter points list resulting from the combination of georeferenced meter points data from 2017 and meter points list from May 2021. Most data loss occurred from July 2018 to December 2019. Therefore, only metered water consumption from January 2020 to May 2021 was considered for further analysis.

Another observation from Figure 8 is that there is an offset between the metered water consumption data and water production data as visible from the mis-aligned peak in July 2020. Potential reasons behind this offset can be delayed measurement of metered water consumption or errors in measuring metered water consumption.

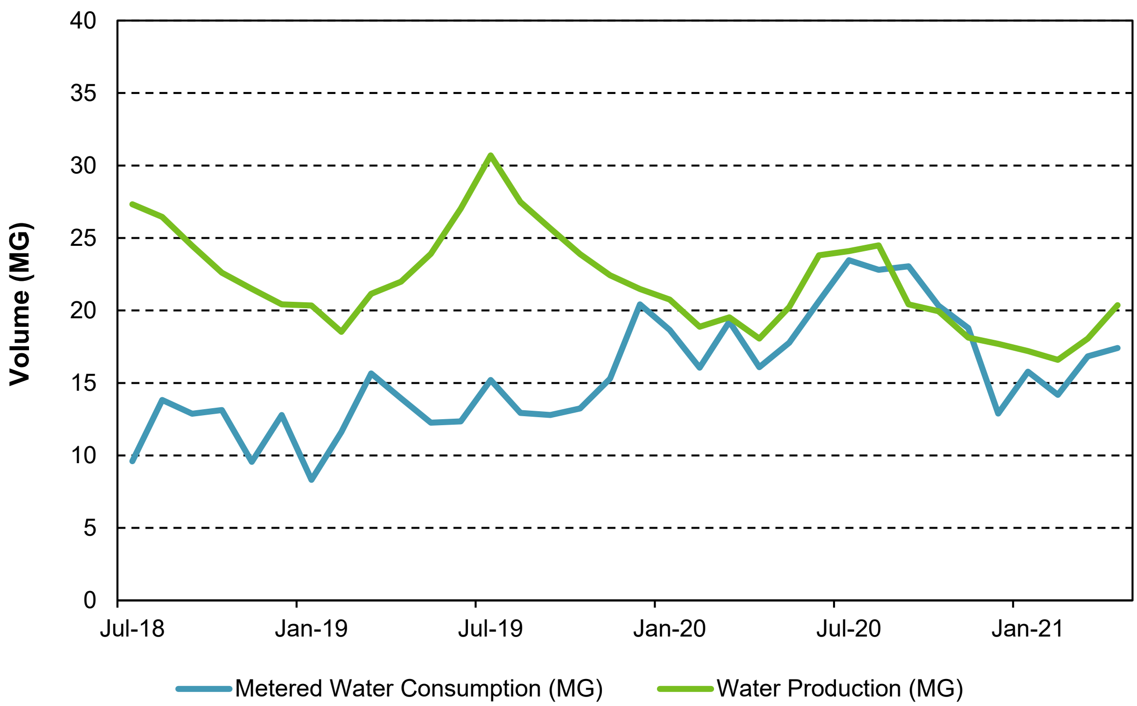


Figure 8 – Water Production Versus Metered Water Consumption Comparison

(note: the metered water data is based on the master service line list)

Table 3 below summarizes the metered water consumption based on various land use types for the City. The City averaged about 0.59 mgd of metered water usage from January 2020 to May 2021.

Table 3 – Metered Water Consumption Data Based on Land Use Types

Land Use Type	2020 (gpd)	2021 (gpd)	January 2020 – May 2021 Average (gpd)
Very High Density Residential	83,700	93,600	88,700
High Density Residential	28,000	26,900	27,500
Medium Density Residential	237,200	261,300	249,200
Low Density Residential	59,000	62,000	61,000
Suburban Residential	3,120	3,110	3,110
Central Busines District	45,900	54,800	50,300
General Commercial	35,900	43,200	39,600
Neighborhood Commercial	15,910	23,890	19,900
Office Commercial	3,700	4,190	3,940
Highway Visitor Commercial	100	400	300
Heavy Industrial	2,320	2,140	2,230
Light Industrial	10,300	11,800	11,000
Harbor District	0	0	0
Open Space	3,130	4,800	3,960
Parks and Recreation	6,250	4,330	5,290
Public Facilities and Services	200	220	210
Timber Resources Industrial	17,372	26,742	22,057
Total Residential	411,000	447,000	429,000
Total Non-Residential	141,100	176,500	158,800
Total	**552,000**	**624,000**	**588,000**

3.3 Water Duty Factors

Water duty factors are a representation of water use per land use category and can be calculated either in terms of gpd per unit area or gpd per service line. Duty factors are used in conjunction with future land use projections to develop future water demands. Existing land use categories and monthly metered water demands from January 2020 to May 2021 were used to calculate the water duty factors.

Table 4 below shows water duty factors that are calculated based on historical data. The calculated duty factors are used for demand projections. As shown in Table 4, most of the calculated duty factors were recommended for use in the projected water demand analysis. However, two calculated duty factors, High-Density and Medium-Density Residential land use, did not fall within the expected range. Based on typical land-use water consumption relationships, these duty factors typically fall between Very High Density Residential and Low Density Residential. Therefore, the high and medium- density duty factors were adjusted to align with the land use based duty factor trends. There are several possible explanations for the inconsistencies in the calculated duty factors. One is that the land use designations may not accurately represent the current conditions. This is a common land use inconsistency as city planning agencies are not equipped to update and field verify new land use designations triggered by changes in occupancy. Additionally, there is also a possibility of inaccuracies associated with the geocoded assignment of water meters to the correct parcels.

Table 4 – Water Duty Factors for Different Land Use Types

Customer Type	Residential/ non-residential	Calculated Duty Factor (gpd/ service line)	Calculated Duty Factor (gpd/ acre)	Recommended Duty Factor (gpd/ service line)	Duty Factor (gpd/ acre)
Very High Density Residential	Residential	277	684	277	684
High Density Residential	Residential	196	442	257	668
Medium Density Residential	Residential	236	896	236	660
Low Density Residential	Residential	226	655	226	655
Suburban Residential	Residential	115	302	115	302
Central Business District	Non-Residential	305	991	305	991
General Commercial	Non-Residential	283	422	283	422
Neighborhood Commercial	Non-Residential	186	336	186	336
Office Commercial	Non-Residential	408	316	408	316
Highway Visitor Commercial	Non-Residential	227	212	227	212
Heavy Industrial	Non-Residential	158	69	158	69
Light Industrial	Non-Residential	227	212	227	212
Harbor District	Non-Residential	995	4,672	995	4,672
Open Space	Non-Residential	0	0	0	0
Parks and Recreation	Non-Residential	264	44	264	44
Public Facilities and Services	Non-Residential	189	32	189	32
Timber Resources Industrial	Non-Residential	71	0.5	71	1
Average Residential		210	596	210	593

Customer Type	Residential/ non-residential	Calculated Duty Factor (gpd/ service line)	Calculated Duty Factor (gpd/ acre)	Recommended Duty Factor (gpd/ service line)	Duty Factor (gpd/ acre)
Average Non-Residential		276	609	316	607
Average		257	605	260	604

3.4 Future Land Use

Figure 9 shows the anticipated buildout condition for the City as depicted in the 2013 Inland Land Use, Development, and General Plan. This analysis includes projected demands for the future build out to the entire City sphere of influence, including areas not classified in the current land use categories shown in Figure 2. Most of these areas cover the rural residential areas located in the west and south of the City's potable water service area. Other areas of potential growth include the Harbor District area in the south along the Noyo River.

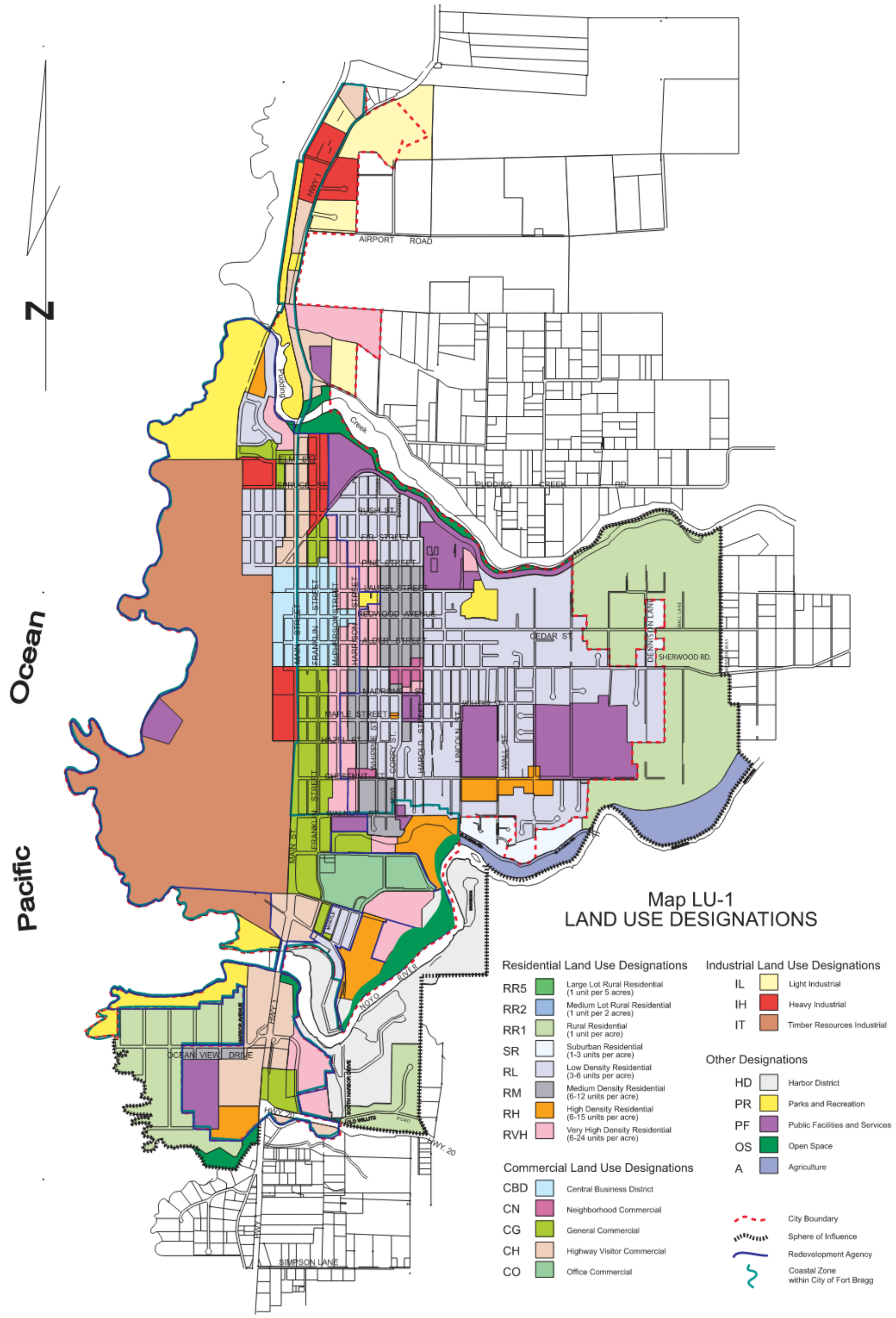


Figure 9 – City's Buildout Land Use Categories

3.5 Potential Future Development Plans

This section summarizes known potential future development plans used to project future water distribution system capacity needs.

3.5.1 Georgia Pacific Mill Site

The City is anticipating development at the GP Mill site, which covers about 300 acres (about 17% of the total existing service area). This area is located along the coast towards the western extents of the City. The City aims for a level and intensity of development on the GP Mill Site for commercial, industrial, and residential purposes that align with the existing development of the City. The GP Mill Site was originally slated for an area of about 400 acres. However, the City purchased 100 acres of area for coastal trails, 95 acres of which were purchased in 2010 and the remaining 5 acres in 2015.

The City's proposed development of the Mill Site is shown in Figure 10. This land use is derived from Proposed Rezoning, LCP Amendment 1-24, that includes the Coastal Trail. and includes the planned Noyo Center development south of the water treatment plant.

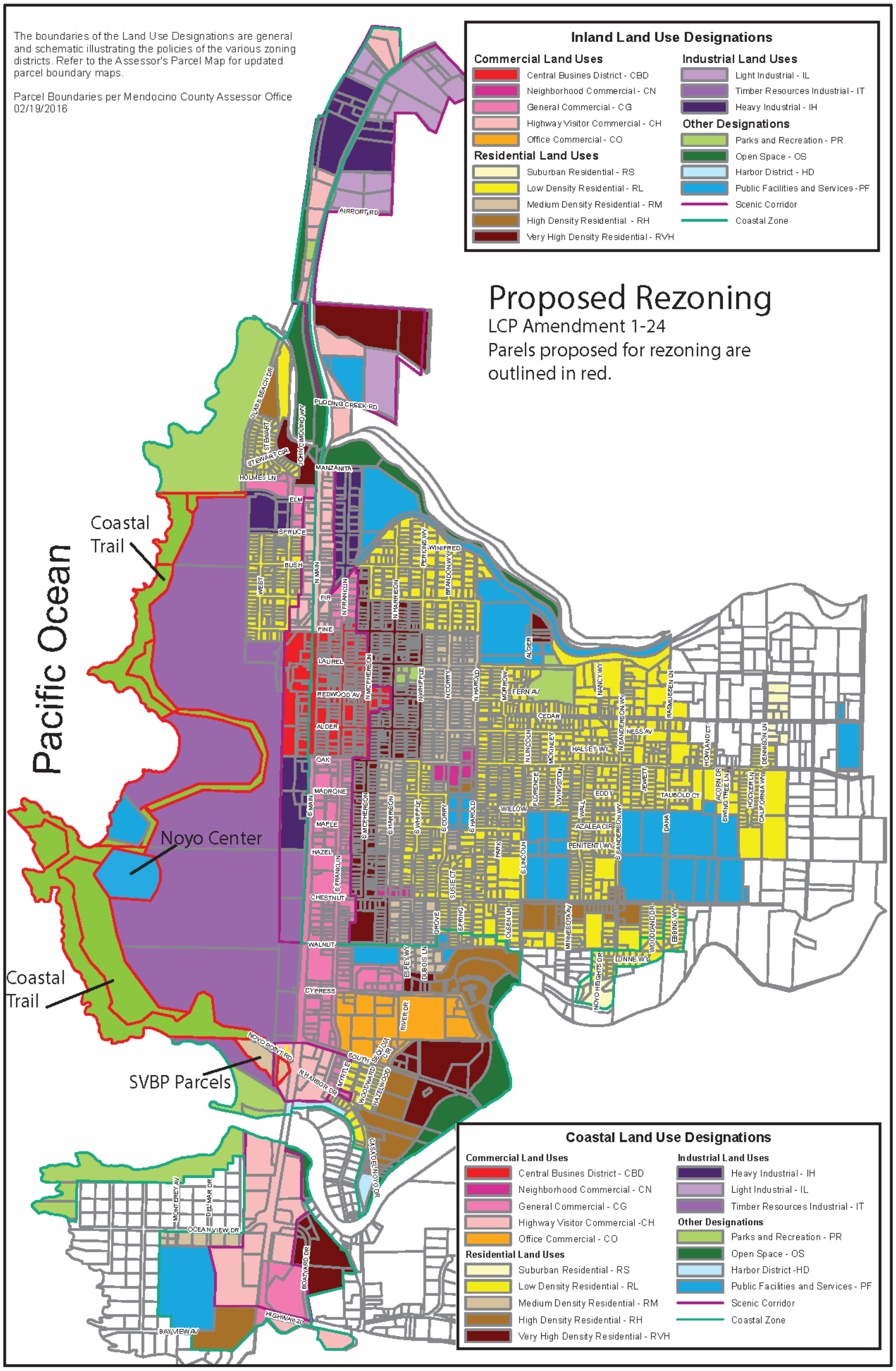


Figure 10 – GP Mill Site included in Proposed Rezoning, LCP Amendment 1-24

3.5.2 Future Annexation Areas

The City has a total of 8 annexation areas that are shown in Figure 11. Water demand for these annexation areas has been projected assuming that these areas are developed following the land use categories shown in Figure 9.

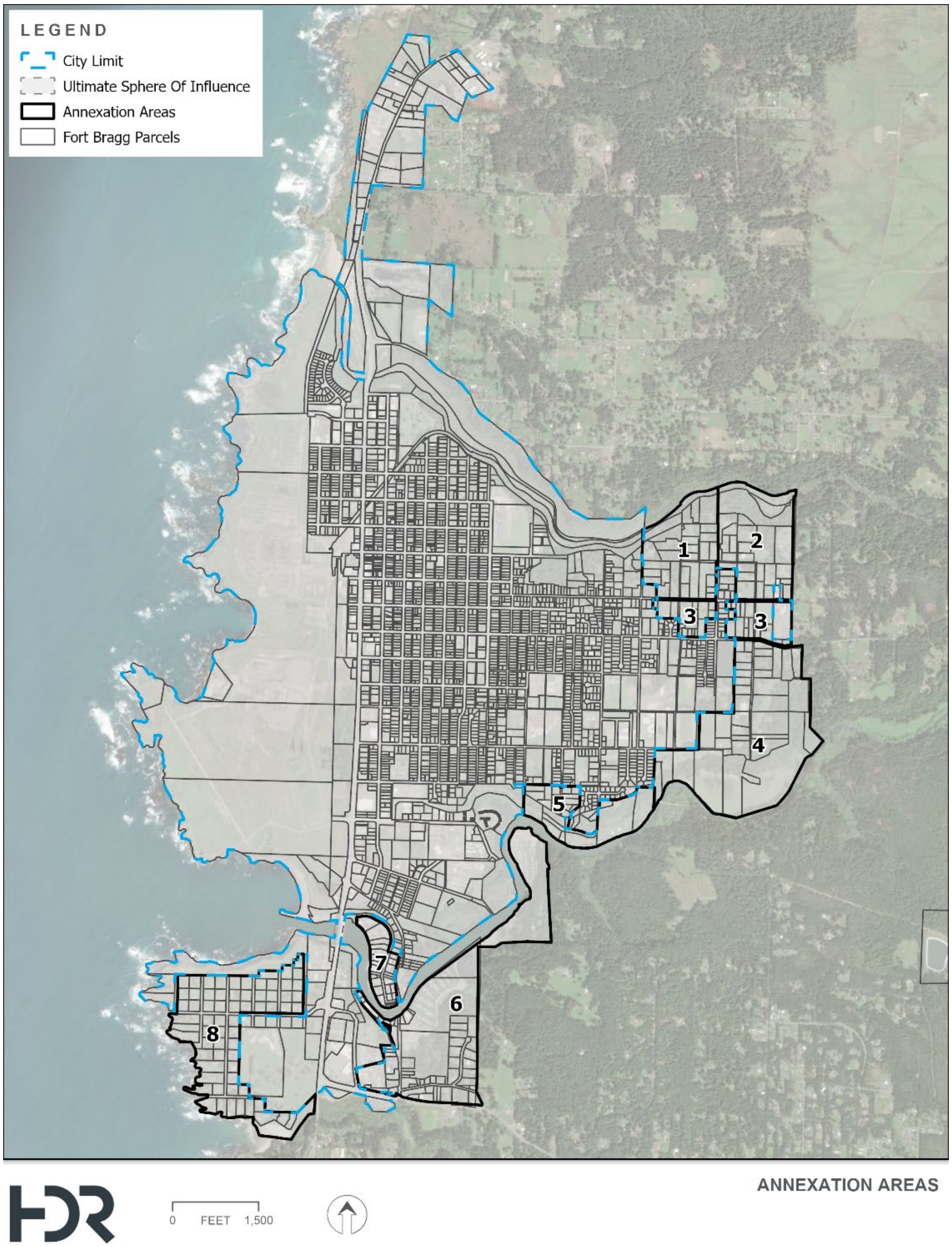


Figure 11 – Annexation Areas

3.6 Demand Projections

To determine future capacity needs for the water distribution system, two scenarios were developed for analysis.

- Near-Term Development – Projected growth over the next 10 years that incorporates undeveloped lots and development plans specified by the City. Based on the growth rate of .5% per year, Mendocino College has been incorporated into the Near-Term Development. The remaining parcels inside the City's service area specified by the City have been incorporated into the Build-Out Scenario.
- Build Out – The Build-Out scenario expands on the near-term development scenario and includes the development of the GP Mill Site, five additional undeveloped lots within the City, APN: 01821029, APN: 01809002, APN: 01809016, APN: 01811303, and APN: 01811301 (See Figure 12), and the future annexation areas.

The demand projections for these scenarios are discussed below.

3.6.1 Near-Term Demand Projections

The City commissioned an Impact Fee Nexus Study in 2023, conducted by Lechowicz + Tseng Municipal Consultants. The study projects a future water demand of 1.14 mgd over the next 30 years. It should be noted that this study assumes a 14.4% of population growth within the next 30 years. In comparison, the current study by HDR assumes that the annexation areas grow at a rate of 0.5% (in terms of area) for the next 10 years. Based upon input from City Staff, near-term developments include two undeveloped lots to the south near the Mendocino College Coast Center, and four near-term specific development plans specified by the City. These developments are shown in Figure 12.

The undeveloped lots (APN: 01845036, APN: 01845041) were specified by the City as being developed in the near term. Demands for these lots have been projected assuming that these areas get developed following the land use categories shown in Figure 9. The four specific development plans are listed below:

1. A 69-unit housing project near the intersection of South Street and River Drive. This project was completed in the summer of 2022. However, it has been included in the near-term projections to capture its water demands because it was not operational during the metering activity.
2. An 83 Unit Multi-Family project with 1,000 SF of retail space and 2,450 SF of visitor serving accommodations at 1151 S. Main Street.
3. Grocery Outlet: This property is located near the intersection of South Franklin Street and South Street. It is a 16,157 square-foot, one-story, retail store with a 55-space parking lot.
4. Avalon Hotel: A 65-room inn contained within three separate, three-story buildings for a total area of 43,469 square feet. It consists of a restaurant (660 square feet) with 63 seats and a bar (818 square feet) with 40 seats located in one of the three buildings. Additionally, there is a 3,064 square-foot event center proposed as a separate single-story structure. The total lot area for Avalon Hotel is 3.65 acres.

Near-term water demand projections for the City are provided in Table 5. The near-term developments add roughly 0.021 mgd of ADD to the City's existing water demands (excluding water losses).

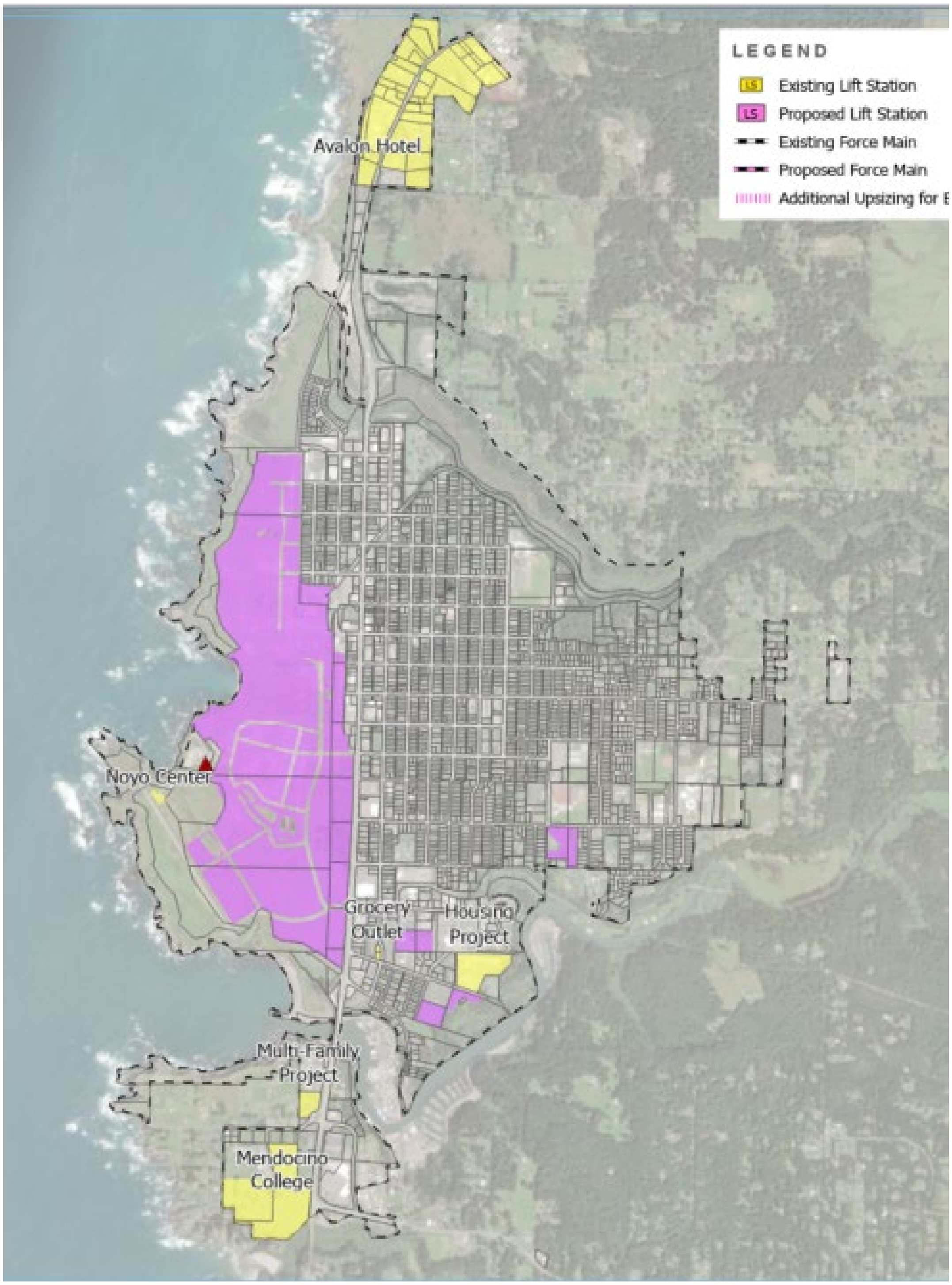


Figure 12 – Future Development Lots Within the City's Existing Service Area

Table 5 – Projected Water Demands for Near-Term Development Plans

Description	Land Use Classification	Total Area (acre)	Duty Factor (gpd/acre)	Total ADD (gpd)	Total Water Loss (gpd) (1)
69-unit housing near intersection of South Street and River Drive	Very High Density Residential	6.5 (2)	676	4,400	800
83 Unit Multi-Family project with 1,000 SF of retail space and 2,450 SF of visitor serving accommodations at 1151 S. Main Street	Mixed Use	0.34	676	230	50
Grocery Outlet	General Commercial	0.37	422	160	30
Avalon Hotel (3)	Highway Visitor Commercial	3.65	196	7,020	1,270
Undeveloped City Lots	High Density Residential	11.3	668	7,550	1,360
	Highway Visitor Commercial	10.1	196	1,980	360
	Public Facilities and Services	8.0	32	260	50
Grand Total		**40.3**		**21,580**	**3,890**

(1) 2021 average City water loss (18%)
(2) Water demand for 69-unit housing project calculated based on an estimated area of 6.5-acres.
(3) The Avalon Hotel is expected to have a total of 65 rooms. Water demand for the Avalon Hotel projected 80 gpcd for the hotel guests and 90% return to the sewer. It is also assumed that the hotel has an average occupancy of 2 guests/unit and is 75% occupied on average.

3.6.2 Buildout

This section describes the water demand projections for buildout which includes GP Mill Site, , five additional undeveloped lots within the City, APN: 01821029, APN: 01809002, APN: 01809016, APN: 01811303, and APN: 01811301 (See Figure 12), and the future annexation areas., Buildout development lots are shown in Figure 13. As shown in the following tables, the ADD for the City is expected to grow by 0.744 mgd by buildout (excluding water losses).

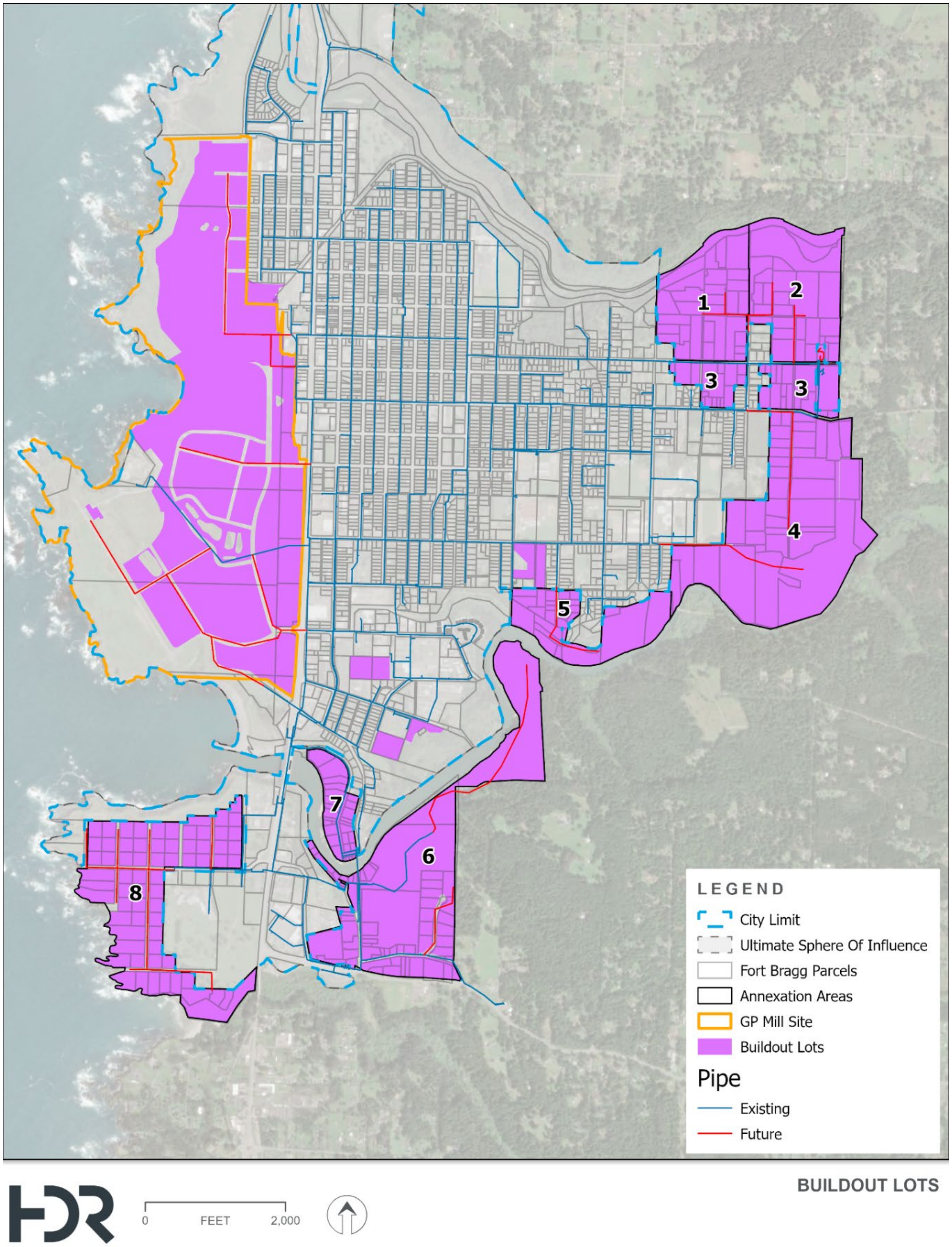


Figure 13 – Buildout Development Lots

3.6.2.1 GP Mill Site

Projected demands for the GP Mill Site per land use type are listed in Table 6. Duty factors were applied to each specified land use in the development. The remaining area within the GP Mill Site will remain undeveloped at buildout and thus have no water demand assigned. The GP Mill Site development is expected to add a total of 0.0627 mgd at buildout (excluding water losses).

Table 6 – Projected Water Demands for GP Mill Site at Buildout

Land Use Type	Total Area (acre)	Duty Factor (gpd/acre)	Total ADD (gpd)	Total Water Loss (gpd) (1)
Central Business District	2.7	991	2,700	500
General Commercial	33.2	422	14,100	2,600
Heavy Industrial	21.0	69	1,500	300
High Density Residential	39.3	668	26,300	4,800
Highway Visitor Commercial	29.6	196	5,800	1,100
Light Industrial	36.2	196	7,200	1,300
Open Space	32.7	77	2,600	500
Parks and Recreation	65.5	44	2,900	600
Grand Total	260.1		62,700	11,300

(1) 2021 average City water loss (18%)

3.6.2.2 Undeveloped city lots

The City specified a total of five undeveloped lots that will be developed at buildout. These lots are: APN: 01821029, APN: 01809002, APN: 01809016, APN: 01811303, and APN: 01811301. The City provided a list of undeveloped parcels that were likely to develop in the near term and acreage was selected to correspond to the recommended .5% per year growth rate. This included 5 lots in the Harbor Area near the Mendocino College Coast Center. Demands for these lots have been projected assuming that these areas will be developed following the land use categories shown in Figure 9. Projected water demands are listed in Table 7. The development of these specified lots is expected to add a total of 140 gpd at buildout (excluding water losses).

Table 7 – Projected Water Demands for Undeveloped City Lots at Buildout

Land Use Type	Total Area (acre)	Total ADD (gpd)	Total Water Loss (gpd) (1)
General Commercial	4.3	1,810	340
High Density Residential	6.1	4,090	750
Low Density Residential	1.9	1,230	230
Very High Density Residential	1.7	1,170	220
Grand Total	14.0	8,300	1,540

(1) 2021 average City water loss (18%)

3.6.2.3 Annexation Areas

Annexation areas 1 through 8 are expected to be fully developed at buildout. Demands for these lots have been projected assuming that these areas are developed following the land use categories in the City's General Plan and shown in Figure 9. Existing water use data did not provide duty factors for agricultural and rural residential land use types. These land use types were assigned to have the same duty factor as low-density residential land use. Project water demands are listed in Table 8. The development of the annexation areas is expected to add a total of 0.681 mgd at buildout (excluding water losses).

Table 8 – Projected Water Demands for Annexation Areas at Buildout

Land Use Type	Total Area (acre)	Total ADD (gpd)	Total Water Loss (gpd) [1]
Harbor District	93.6	437,720	79,030
Open Space	5.8	0	0
Low Density Residential	357.4	235,310	43,380
Suburban Residential	18.6	5,720	1,130
Very High Density Residential	5.1	3,440	630
Grand Total	480.5	682,190	124,170

(1) 2021 average City water loss (18%)

3.6.3 Water Demand Projections Summary

A summary of water demand projections for the existing system, near-term developments, and buildout based on various land use categories is shown in Table 9. The ADD is expected to increase by 0.766 mgd as compared to the existing water demands by the end of the buildout planning horizon, not accounting for water losses.

Table 9 – Projected Water Demands Summary for Existing, Near-Term and Buildout Based on Various Land Use Categories

Land Use Type	Existing Average Metered Consumption (January 2020 – May 2021 Average Period) gpd	Existing + Near Term Water Projection gpd	Existing + Near Term + Buildout Water Projection gpd
Very High Density Residential	88,200	92,600	97,210
High Density Residential	27,690	35,470	65,850
Medium Density Residential	61,120	61,120	61,120
Low Density Residential	250,710	250,710	487,250
Suburban Residential	3,140	3,140	8,860
Central Business District	50,650	50,650	53,300
General Commercial	39,880	40,040	55,880

Land Use Type	Existing Average Metered Consumption (January 2020 – May 2021 Average Period) gpd	Existing + Near Term Water Projection gpd	Existing + Near Term + Buildout Water Projection gpd
Neighborhood Commercial	2,010	2,010	2,010
Office Commercial	10,110	10,110	10,110
Highway Visitor Commercial	20,540	29,540	35,350
Heavy Industrial	3,970	3,970	5,430
Light Industrial	310	310	7,430
Harbor District	20,040	20,040	457,760
Open Space	0	0	2,520
Parks and Recreation	3,930	3,930	6,840
Public Facilities and Services	5,330	5,590	5,590
GP Mill Site (1)	230	230 (1)	230 (1)
Total (2)	588,000	610,000	1,364,000

(1) Water demand projections for the GP Mill site distributed to their respective land use categories for the buildout.

(2) Water demand projections shown here do not account for water losses through the water distribution network.

Table 10 below summarizes the existing, near-term and buildout water demand projections for the City based on ADD and maximum daily demand (MDD).

Table 10 – ADD and MDD Water Demand Projections for Existing, Near-Term, and Buildout

Description	Residential ADD (mgd)	Non-residential ADD (mgd)	Water Loss (mgd) (2)	Total ADD (mgd)	Total MDD (mgd) (3)
Existing Usage (1)	0.428	0.156	0.11	0.58	1.01
Existing + Near Term Usage	0.440	0.165	0.11	0.61	1.05
Existing + Near Term + Buildout Usage	0.717	0.641	0.24	1.36	2.35

(1) GP Mill site area not included in the existing and near-term projections since it will only have water demand during buildout.

(2) Water loss calculated assuming that water loss remains the same as 2021 average (i.e., 18%).

(3) MDD water demand projection calculated based on the selected MDD: ADD peaking factor of 1.73.

3.7 Peaking Factors

2013 – 2022 daily water production data from the water treatment plant was used to calculate the peaking factors, as shown in Table 11. Average peaking factors from 2013 to 2022 were selected for this analysis.

Table 11 – Maximum Day and Minimum Day Peaking Factors with respect to ADD for 2013 - 2022

Year	Average day water production	Maximum day water production	Minimum day water production	Maximum day peaking factor	Minimum day peaking factor
	mgd	mgd	mgd		
2013	0.78	1.23	0.40	1.57	0.52
2014	0.69	1.09	0.39	1.58	0.56
2015	0.68	1.15	0.35	1.71	0.51
2016	0.61	0.96	0.37	1.58	0.61
2017	0.64	1.03	0.28	1.59	0.43
2018	0.72	1.44	0.40	2.01	0.56
2019	0.78	1.55	0.50	1.99	0.64
2020	0.67	1.43	0.23	2.11	0.35
2021	0.61	0.96	0.30	1.57	0.49
2022	0.58	0.89	0.32	1.55	0.56
Average	**0.68**	**1.17**	**0.35**	**1.73**	**0.52**
Max	**0.78**	**1.55**	**0.50**	**2.11**	**0.64**
Min	**0.58**	**0.89**	**0.23**	**1.55**	**0.35**

The City also provided hourly water production data for the day corresponding to the maximum water production (i.e., July 1) in the year 2022. This data and the associated hourly peaking factor is shown in Table 12. A summary of the selected peaking factors is shown in Table 13.

Table 12 – Hourly Water Production Data for the Maximum Day in the Year 2022

Hour	Filtered Effluent Flows
	gpm
00:00	137
01:00	136
02:00	135
03:00	134
04:00	133
05:00	132
06:00	132
07:00	562
08:00	1,012
09:00	1,011

Hour	Filtered Effluent Flows
	gpm
10:00	738
11:00	867
12:00	1,005
13:00	1,015
14:00	1,009
15:00	655
16:00	1,002
17:00	838
18:00	1,002
19:00	1,005
20:00	679
21:00	1,001
22:00	1,007
23:00	789
Maximum Hourly Flow	**1,015**
Average Daily Flow for the year2022	**403**
Maximum Hour Peaking Factor	**2.52**

Table 13 – Selected Peaking Factors with respect to ADD

Description	Maximum Day	Minimum Day	Maximum Hour
Selected Peaking Factor	1.73	0.52	2.52

CHAPTER 4 HYDRAULIC MODEL DEVELOPMENT

4.1 Software Selection

The City's existing hydraulic model is in WaterGEMS format, from Bentley Systems. The attached Software Selection Technical Memorandum (Appendix D) evaluated commercially available water hydraulic modeling software. The recommendation from that tech memo (TM) was to use InfoWater Pro, from Autodesk as the hydraulic modeling software for this Master Plan.

4.2 GIS Integration

A water system GIS database was developed by converting the City's existing CAD utility map (ACAD_Utility_September2022.dwg) into an ESRI geodatabase with Utility Network functionality (see CHAPTER 2). The water system facilities contained in the GIS data are listed in Table 14.

Table 14 – GIS Water System Facilities provided by City

Water Lines	Water Mains Service Lines
Water Junctions	Fittings
Water Devices	Pump Fire Hydrants Valves (System/Service/Flow/Pressure) Storage (Reservoir/Tanks) Supply (Well/Treatment Plants)
Water Assemblies	Backflow Assemblies

Using InfoWater Pro's GIS Gateway, the GIS data was imported into the hydraulic model. Model input data for nonlinear facilities (i.e. pump stations and tanks) was obtained from the City and input into the hydraulic model. The hydraulic model provides an additional level of Quality Control and Quality Assurance (QA/QC) on the GIS data. Additional errors identified included network connectivity errors, such as "floating" system valves and pipeline diameter inconsistencies. These errors were rectified in the GIS, and the model was updated accordingly to reflect the updated GIS database.

The City provided a list of normally closed valves to HDR and pressure zone isolation was validated in the hydraulic model.

The final existing water distribution system model is shown in Figure 14.

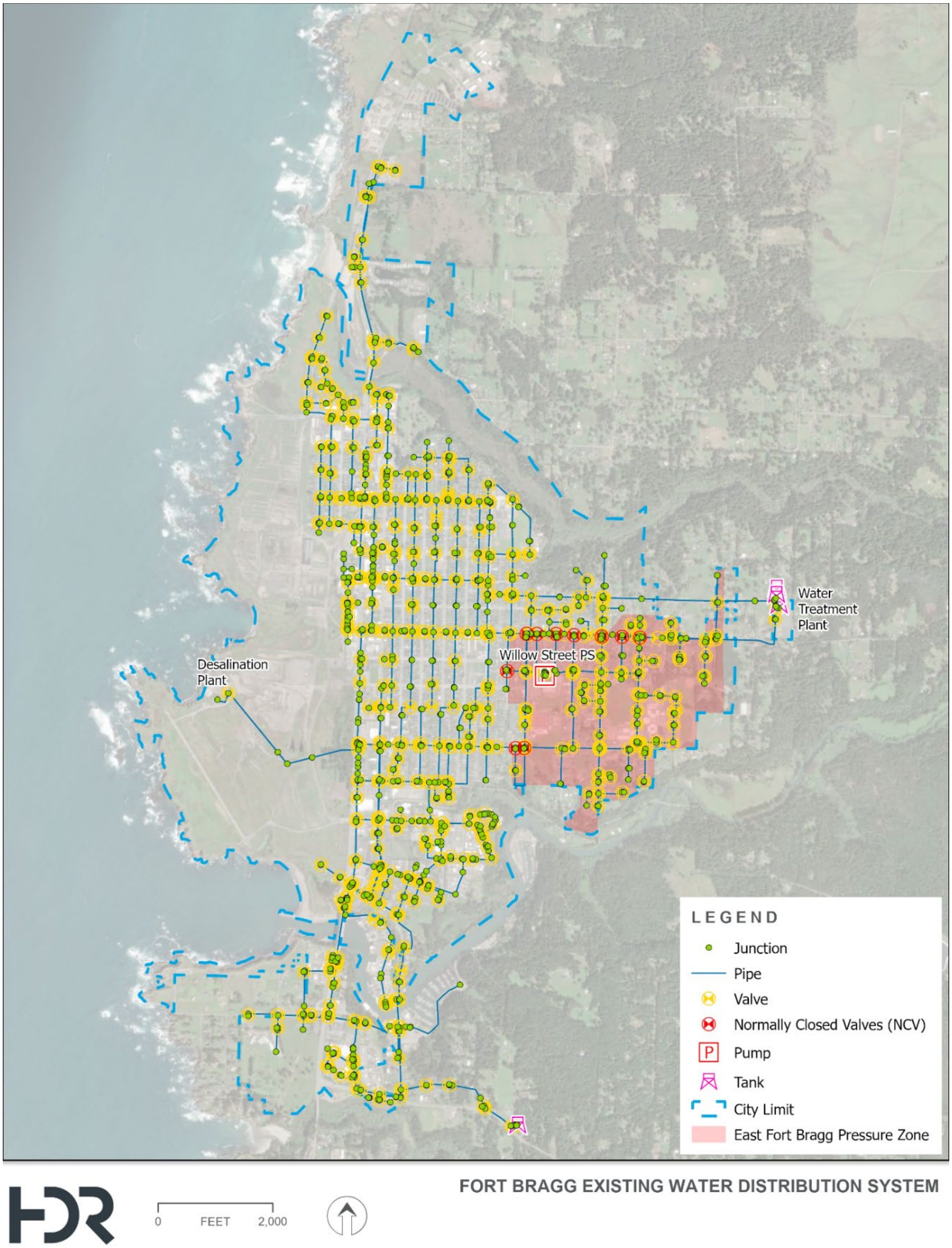


Figure 14 – Fort Bragg Existing Water Distribution System

4.3 Model Input Data

This section describes inputs used in the hydraulic model.

4.3.1 Water Treatment Plant

The Fort Bragg Public Works WTP is located within the City's Corporation Yard at 31301 Cedar Street. The plant was built in 1958 with a process upgrade in 1986 which made the plant capacity 2.2 MGD. The WTP is currently undergoing an upgrade project to improve efficiency. This upgrade project is set to be completed in spring 2026. The plant was modeled as a boundary node reservoir with a pump station to simulate finished water being pumped into the storage tanks at the same rate as City provided Supervisory Control and Data Acquisition (SCADA) information.

4.3.2 Storage Tanks

The existing water distribution system includes four storage tanks: three tanks at the WTP, and one near the Fire Station on Highway 20 (HWY 20). Modeling data and information for these tanks is included in Table 15. Tank elevation, maximum levels, and diameter were specified by the City.

Table 15 – Storage Tank Modeling Data and Information

Tank Name	Model ID	Location	Elevation (ft)	Maximum Level (ft)	Diameter (ft)	Storage Volume (MG)
Tank 1	STRG-6	WTP	183	39	80	1.47
Tank 2	STRG-7	WTP	183	39	80	1.47
Tank 3	STRG-8	WTP	183	39	84	1.62
HWY 20 Tank	STRG-9	HWY 20	183	39	36	0.30

4.3.3 Pump Stations

The Willow St Pump Station is located on Willow Street near the C.V. Starr Community Center and serves the EFBPZ, which is a small, boosted zone generally serving the area north of the Noyo River and Willow Street to Oak Street and East of S. Lincoln Street. Figure 15 shows the pressure zone extents and pump station.

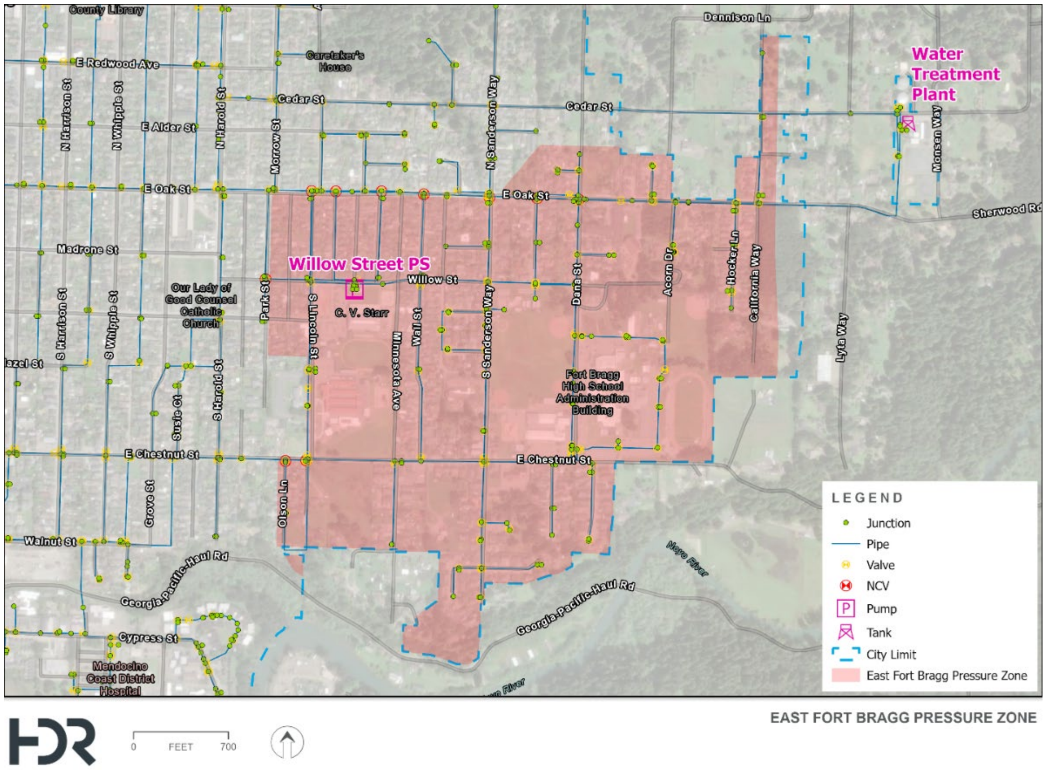


Figure 15 – East Fort Bragg Pressure Zone

4.3.4 Pressure Reducing Valves

There are no pressure reducing valves in the existing water distribution system.

4.3.5 Water Demand Loading

Existing, near-term, and buildout water demands estimated for the City are described in section 3.6: Demand Projections. These demands were processed in the GIS in order to load them into the hydraulic model. They were first assigned to point loads in the GIS and then spatially joined to junctions in the water system to determine total demand at each junction. These junction demands were then loaded into the hydraulic model.

4.3.5.4 Existing

Existing water demands were based on water meter data provided by the City. As such, point loads for existing demands were located at each water meter. These point loads were spatially joined to the existing junctions of the distribution system, and the total demand at each junction was loaded into the existing model scenario.

4.3.5.5 Near-Term

Near-term developments all lie within existing city limits and thus can be served by the existing water distribution system. These demands were loaded into the model in the same way as existing demands. Near-term point loads were spatially joined to the existing junctions of the distribution system, and the total demand at each junction was loaded into the near-term model scenario.

4.3.5.6 Build-Out

Development in the GP Mill Site and annexation areas at buildout lie outside the existing water distribution system. A future hypothetical water system network was developed for the annexation areas and GP Mill Site so that buildout demands for the developments could be loaded into the model. This future system is shown in Figure 37. Point loads were developed for the parcels within the future annexation areas and the GP Mill Site redevelopment, then spatially joined to junctions in the buildout water system. Total demands at each junction were loaded into the buildout model scenario.

4.4 Model Validation

The existing model scenario was validated in both a steady state and extended period simulation (EPS). A steady state validation was performed to compare simulated results to field measurements recorded in the CAD drawing provided by the City. An EPS validation was performed to compare simulated results over a 24-hour period with SCADA data provided by the City.

For this validation, the existing water distribution system was divided into three different zones: the booster station pressure zone, the north distribution pressure zone, and the south distribution pressure zone. Figure 16 shows the zones examined in the steady-state validation.

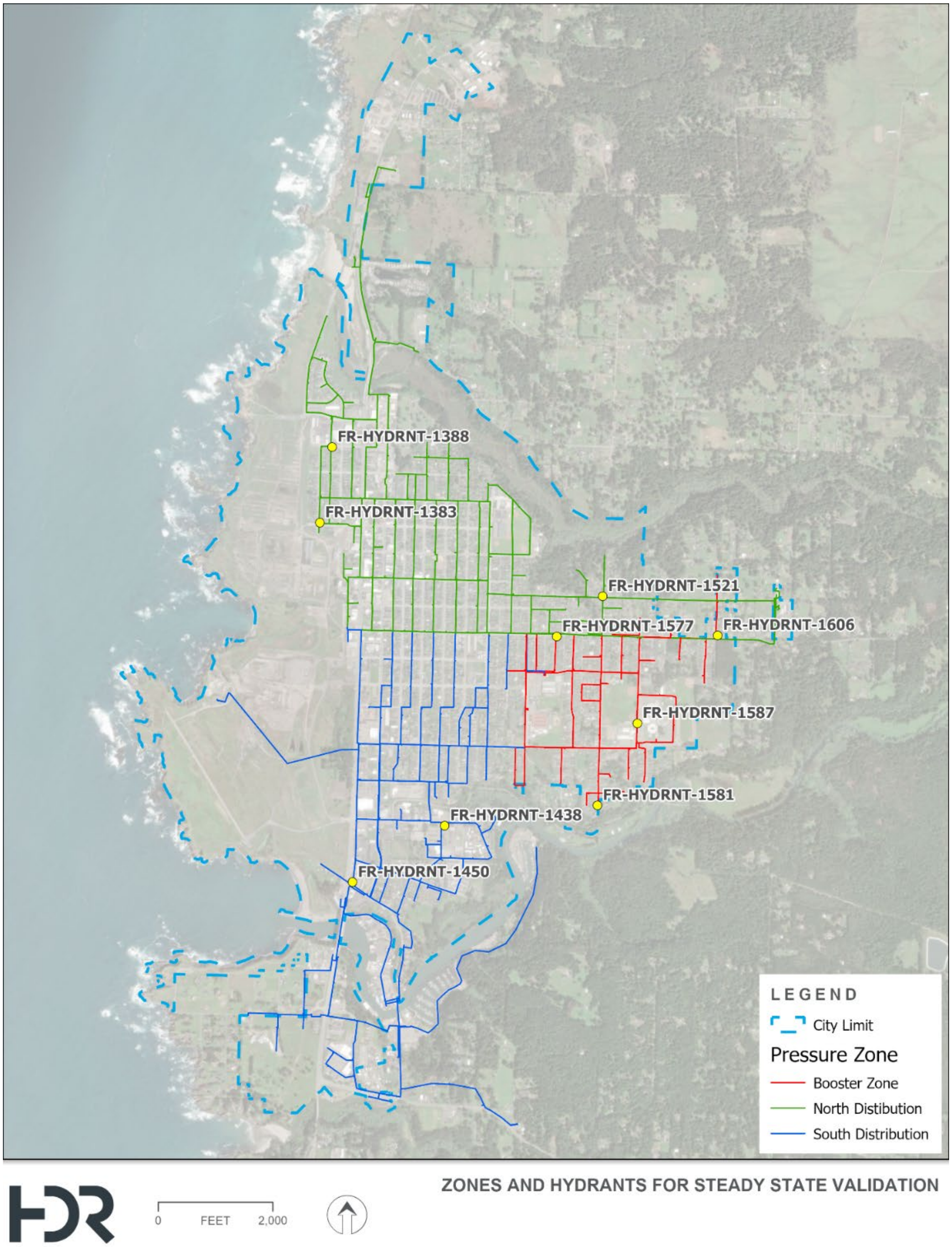


Figure 16 – Zones and Hydrants for Steady State Validation

4.4.1 Steady State Validation

According to America Water Works Association (AWWA) mode validation guidelines, the hydraulic gradient line (HGL) predicted by the model should be within 5 to 10 ft (2.2 to 4.3 psi) of that recorded in the field. HDR model results match static pressures recorded in the field, shown in Table 16. Table 16 also shows the calculated HGL at each hydrant, using elevation acquired from the United States Geological Survey (USGS) National Map GIS database. HGLs predicted by the model are within the range suggested by AWWA.

Residual pressures recorded in the field are likely erroneous and are omitted from Table 16. For accurate values, residual pressure should be recorded from neighboring hydrants.

Table 16 – Steady State Static and Residual Pressure Validation

Hydrant ID	Elevation (FT)	Static Pressure (PSI)		HGL (FT)		HGL Delta
		Field Reading	Model Result	Field Reading	Model Result	
FR-HYDRNT-1521	142.0	38	34.2	229.8	220.9	8.8
FR-HYDRNT-1577	133.9	70	67.4	295.6	289.6	6.0
FR-HYDRNT-1587	158.6	65	61.7	308.7	301.1	7.6
FR-HYDRNT-1581	151.2	68	64.9	308.3	301.1	7.2
FR-HYDRNT-1606	160.4	64	60.9	308.2	301.1	7.1
FR-HYDRNT-1383	75.3	64	62.1	223.1	218.7	4.4
FR-HYDRNT-1388	64.6	65	67.2	214.7	219.9	5.1
FR-HYDRNT-1450	118.8	45	43.7	222.7	219.7	3.0
FR-HYDRNT-1438	111.7	50	46.8	227.2	219.7	7.4

4.4.2 EPS Validation

Two EPS validation scenarios were conducted in the model – one comparing results to SCADA data dated January 2022, and another comparing results to SCADA data dated July, 2022. These dates represent a typical minimum and maximum day, respectively. Diurnal patterns were developed for the booster station zone and the combined distribution zone for each date, for a total of four diurnal patterns. These diurnals were adjusted to match field results. Adjusted diurnals are shown in Figure 17. January EPS validation results for the major pump station and facilities within the model are presented in Figure 18, Figure 19, Figure 20, Figure 21, and Figure 22. July validation results are shown in Figure 23, Figure 24, Figure 25, Figure 26, and Figure 27.

Figure 19 and Figure 24 show a 22.5 PSI pressure difference between model results and field observations, with field observations showing a greater head loss than the model indicates. The previous WaterGEMS model predicted the same HGL on the suction side as the InfoWater Pro model. This indicates that the field measurement is potentially inaccurate, which could be attributed to a bad reading on the suction side of the booster pump station. The other validation parameters fall within generally accepted industry standards for planning level validation.

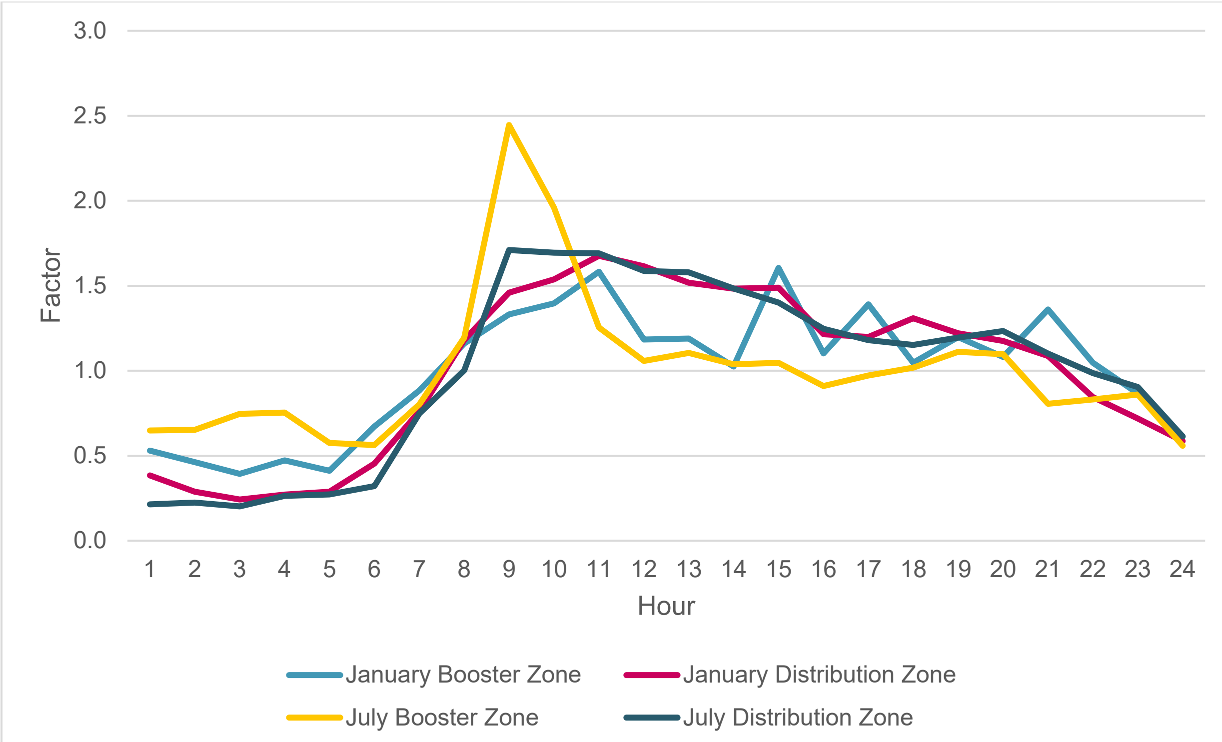


Figure 17 – Adjusted EPS Validation Diurnal Patterns

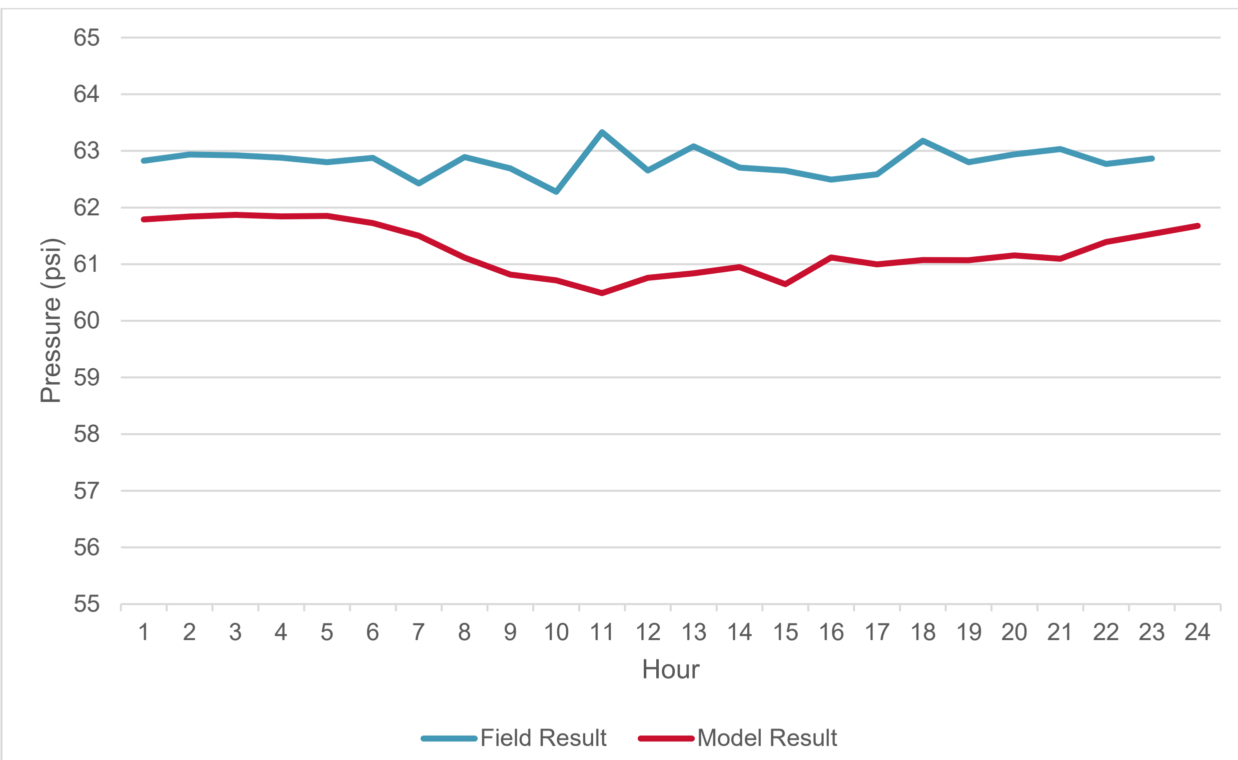


Figure 18 – January Booster Station Discharge Pressure

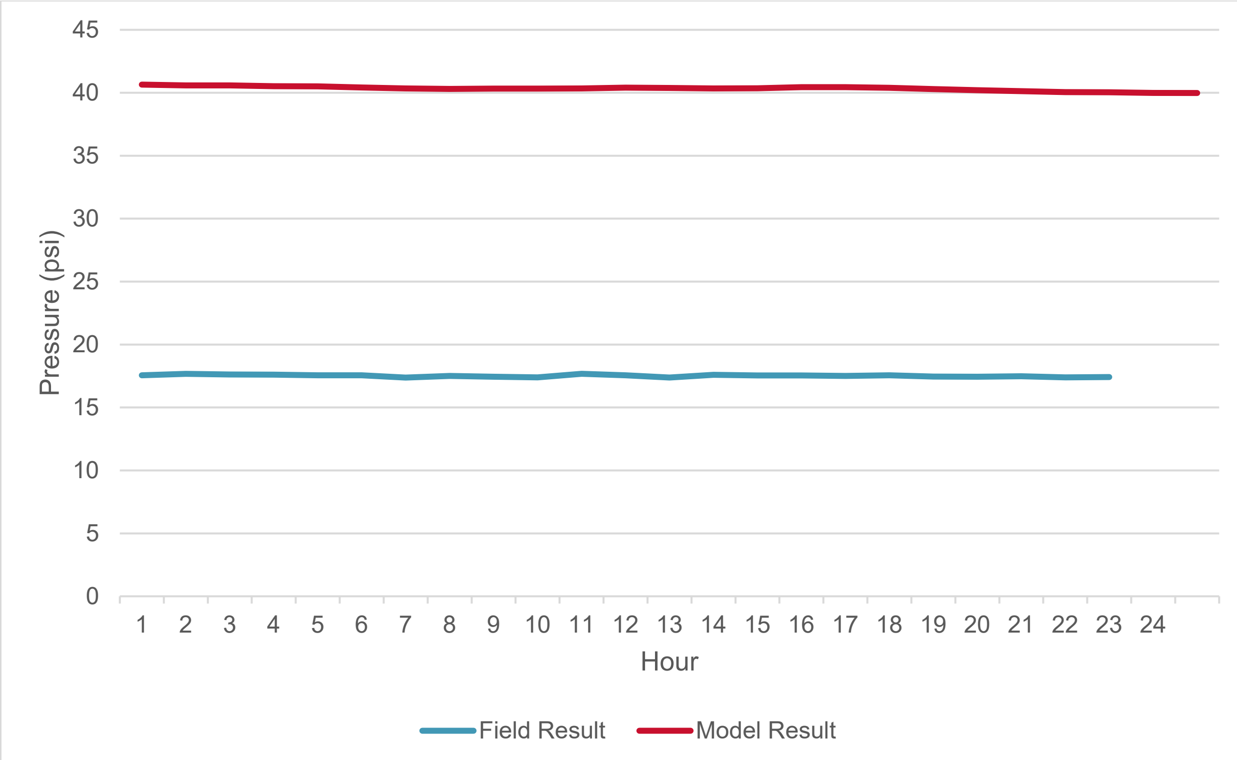


Figure 19 – January Booster Station Suction Pressure

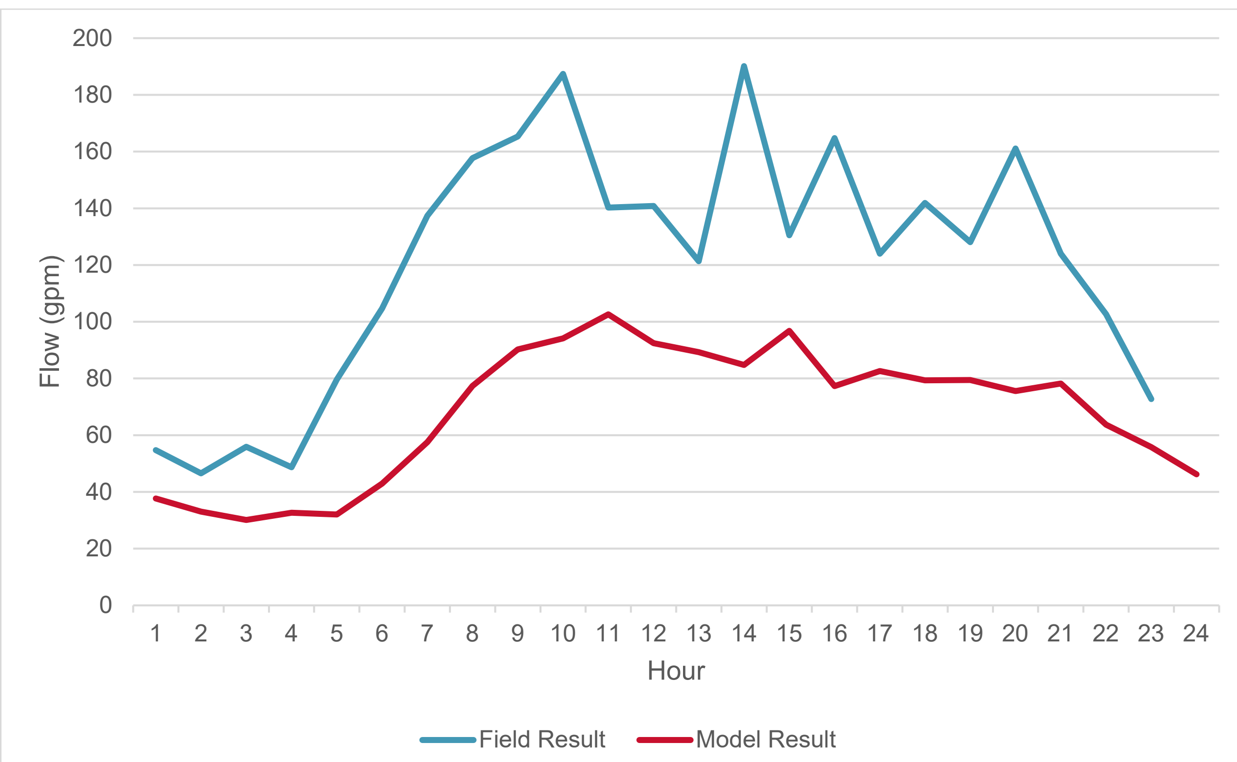


Figure 20 – January Pump Station Flow

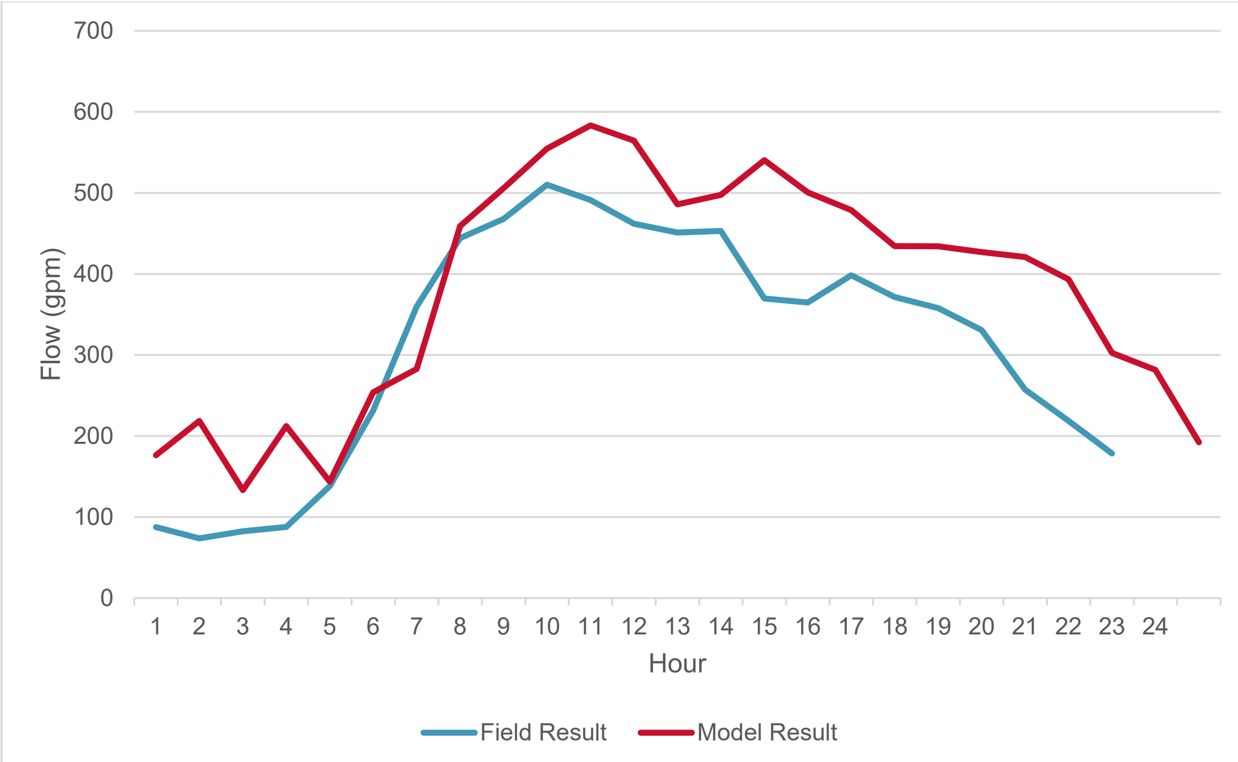


Figure 21 – January Distribution Flow

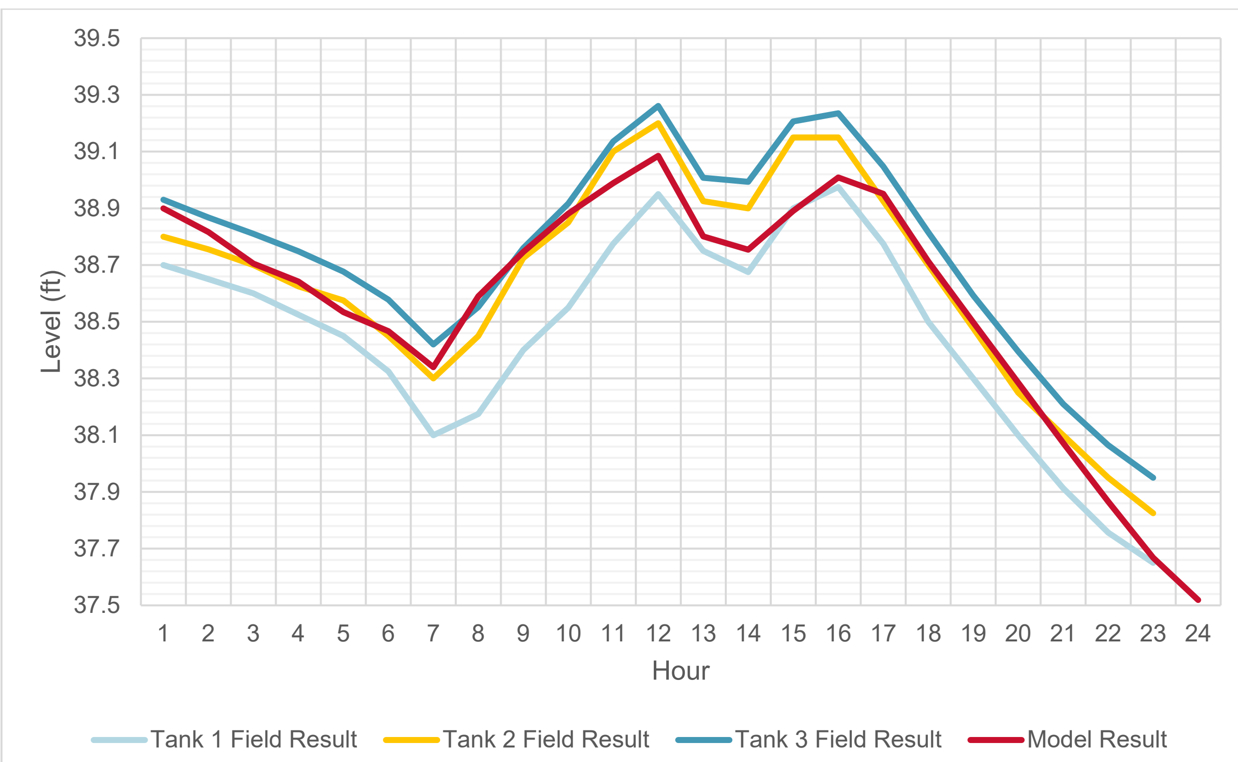


Figure 22 – January WTP Tank Level

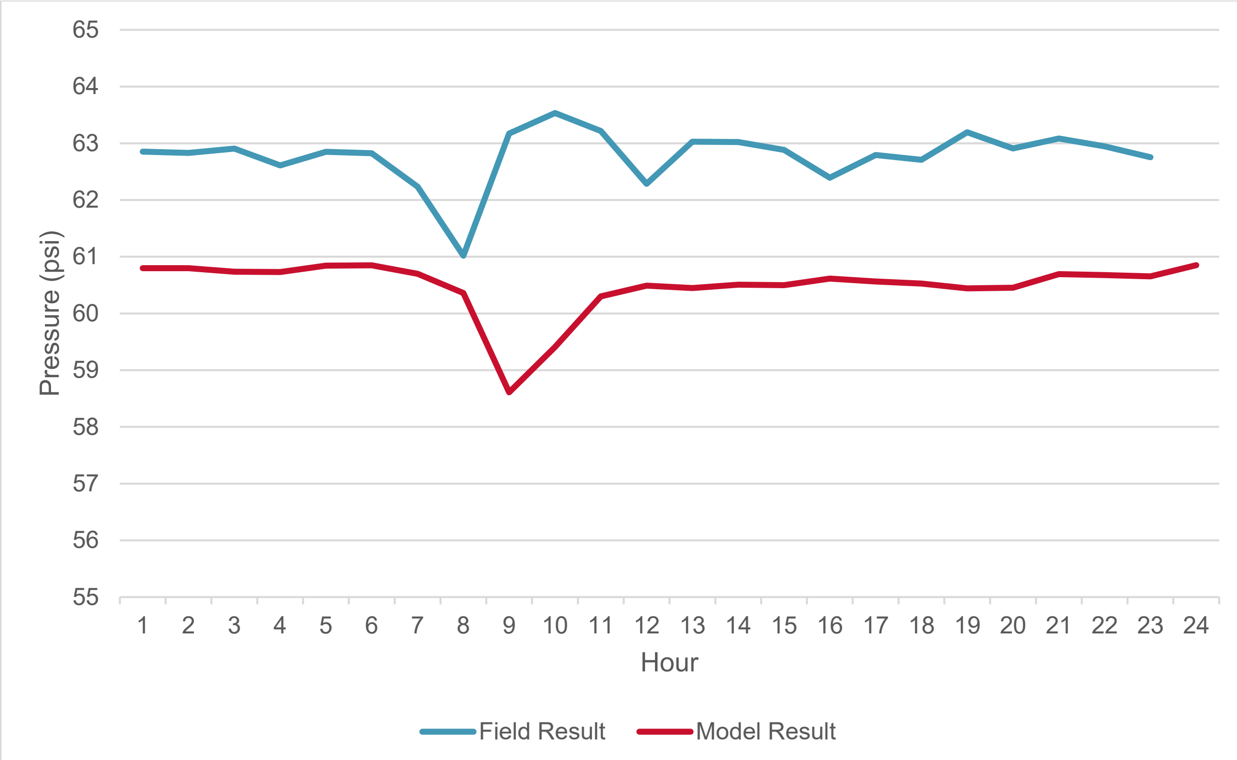


Figure 23 – July Booster Station Discharge Pressure

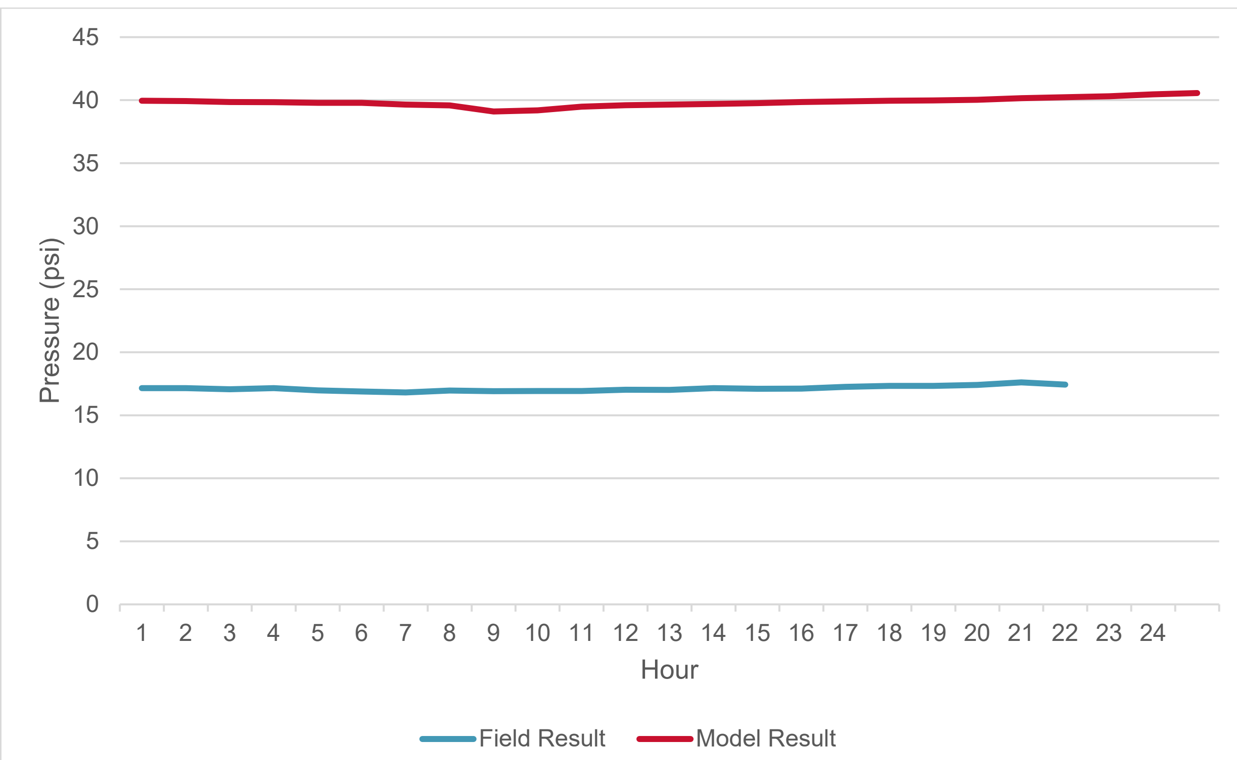


Figure 24 – July Booster Station Suction Pressure

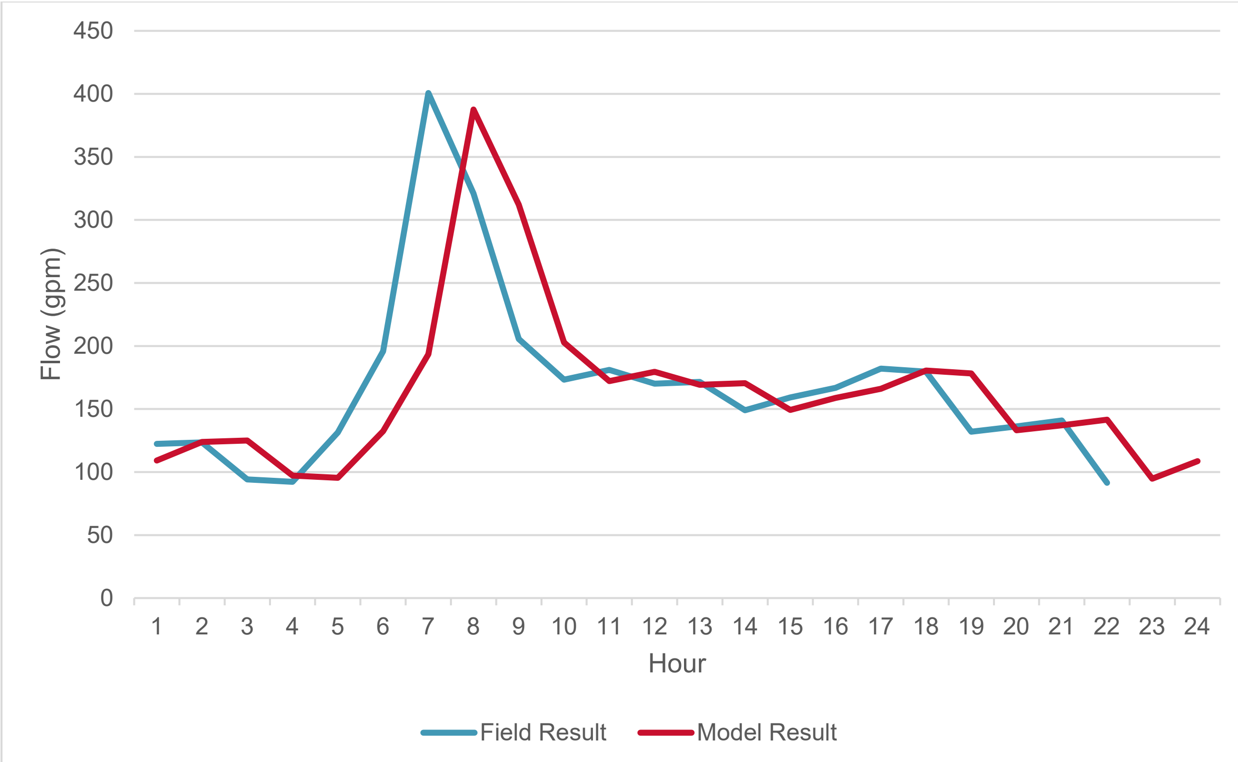


Figure 25 – July Pump Station Flow

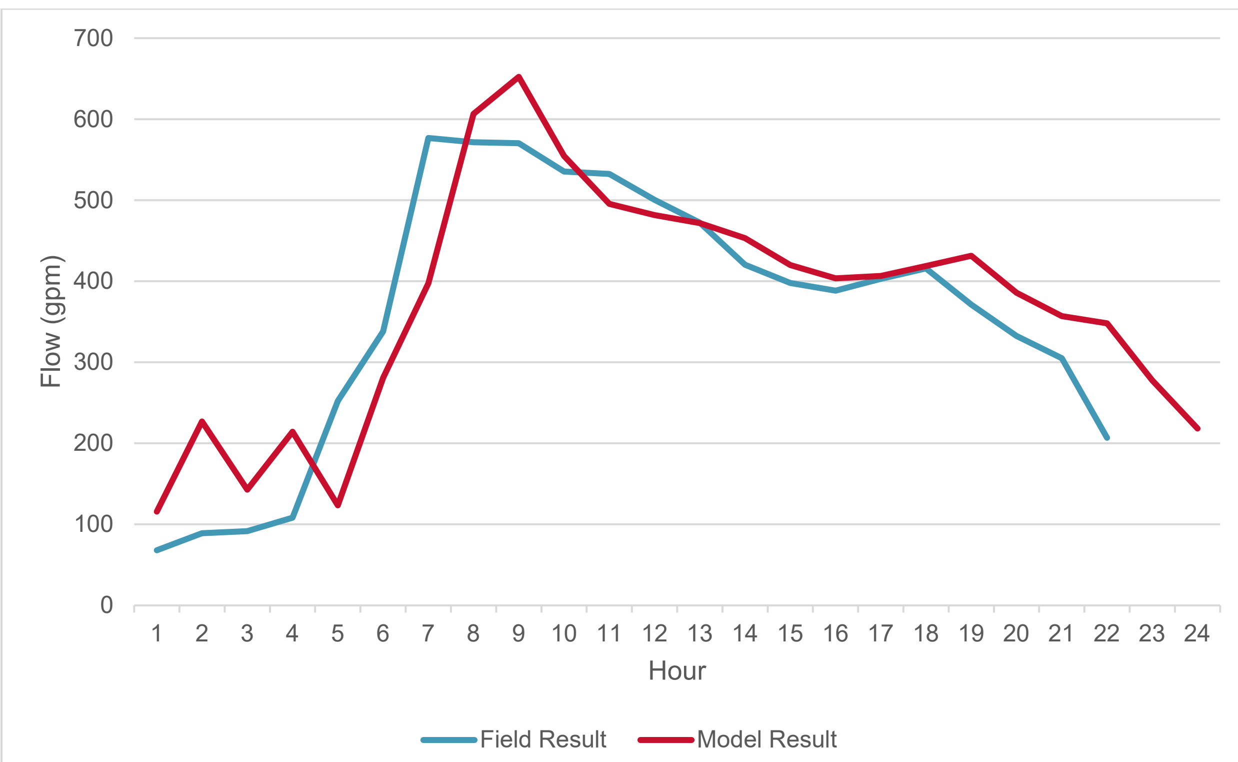


Figure 26 – July Distribution Flow

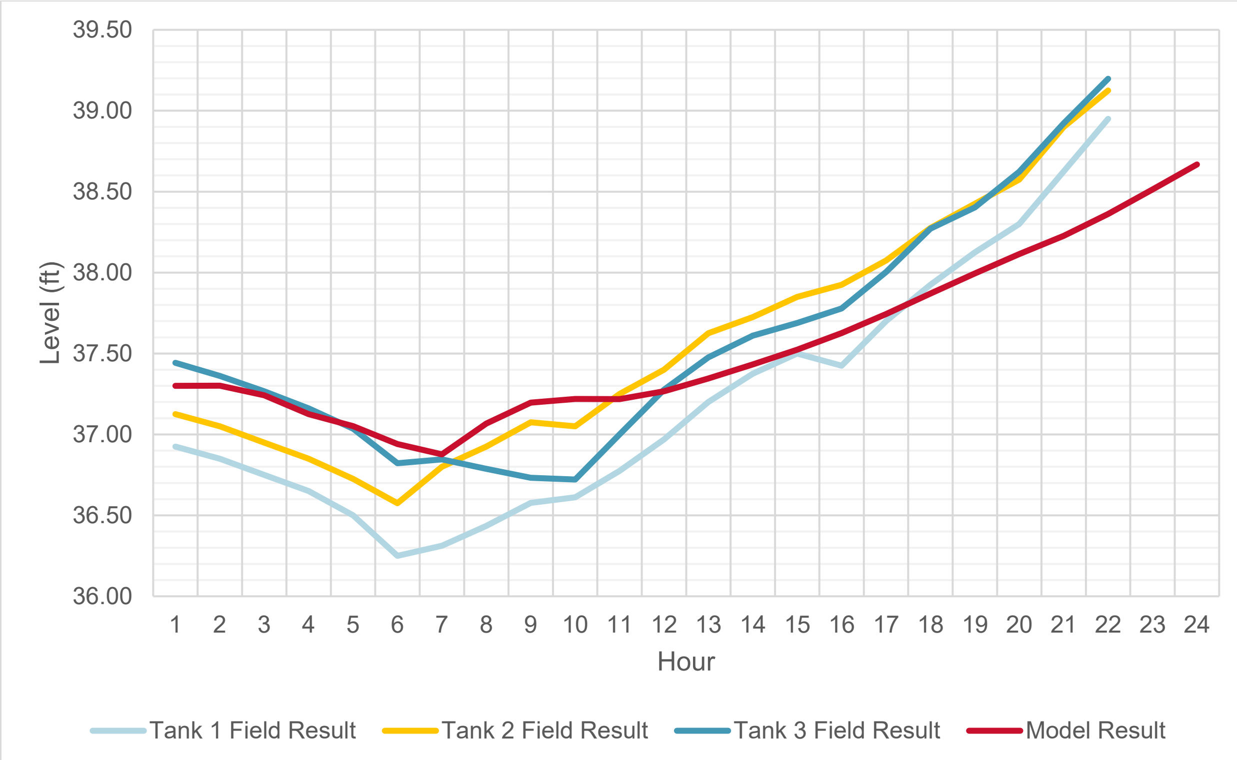


Figure 27 – July WTP Tank Level

4.5 Scenario and Model Use

Several scenarios were developed by applying peaking factors to the average day demand (ADD) sets developed.

- A MDD scenario with a peaking factor of 1.73 was used in fire flow analyses to examine pressures and pipes velocities during fire flow conditions for deficiencies. Capital improvement projects were developed to address these deficiencies.
- A Peak Hour Demand (PHD) scenario with a peaking factor of 2.52 was used to check velocities and pressures at peak hour conditions for deficiencies.
- A Minimum Day Demand (MinDD) scenario with a peaking factor of 0.52 was used to examine water quality during minimum demands.

ADD, MDD, PHD, and MinDD scenarios were developed for the three stages of the water distribution system: existing, near term, and buildout. Improvement scenarios for each stage are developed by addressing the deficiencies identified in each scenario. The City's updated water system model is used to perform the above hydraulic scenarios and develop the resulting water system CIP.

The hydraulic model provided to the City can be used for an operational analysis and capacity analysis tool. Specifically, the steady state runs are typically used to evaluate fire flow availability and the ability to provide service to future development and used to determine capacity needs. The EPS scenarios are typically used to evaluate operational strategies and the impacts of improvement projects to affect system parameters (i.e. flow and pressure) over an extended period of time (typically 24 – 48 hours).

4.5.1 Field Surveying/Potholing

Through the development of the hydraulic model, calibration, and validation, field surveying and potholing were deemed to be unnecessary to improve the quality of the data and disturbance of pipelines were determined to present a high risk of potential damage.

4.5.2 Hydrant Flow Tests

Hydrant flow rates and pressures were provided for the majority of the hydrants on the City's utility CAD map and additional hydrant flow testing was not required.

CHAPTER 5 GEOTECHNICAL, ENVIRONMENTAL, AND CLIMATE RISKS & RESILIENCE

Evaluations of geotechnical and environmental risks, and climate change impacts to the water distribution system were conducted as part of the WDMP. Technical Memorandums were developed for each of these topics and are included as Appendix B and Appendix C, respectively. This section discusses the identified risks and recommendations for mitigation.

While most of the risks discussed in this section are long-term threats and do not require capital improvements over the next ten years, the following risks should be noted for more immediate action:

Seismic – Although the City is not in an active fault zone, it is in a seismically active area. Strong shaking can disrupt the soils and damage pipelines and other infrastructure. The City may incorporate mitigation strategies into their design specifications such as articulating joints for joints on rigid structures and using Earthquake Resistant Ductile Iron Pipe (ERDIP) in highly critical, seismically impacted infrastructure.

Unstable Soils – The City includes many steep slopes and bluffs, which typically contain weak and unstable soil, which could damage or destroy water distribution infrastructure. In addition to project-by-project evaluation of these hazards, the City may wish to periodically evaluate trends in repair or other maintenance activities to indicate soil instability.

Soil Corrosiveness – Soils in the City have been classified as acidic and become more acidic toward the ocean, which can shorten the useful life of buried steel and concrete infrastructure. The City may desire to implement a testing and inspection program to monitor the condition of infrastructure and to better understand the impact. Some testing was completed as part of this master plan and is further discussed in Section 6.8.2 Pipe Condition Assessment.

Wildfire – Fort Bragg is surrounded by areas of dense woodlands, which are designated as moderate to very high wildfire risk zones. Drought and climate change can exacerbate this risk. The most vulnerable water supply infrastructure are the treatment plant and storage tanks. In addition, pipelines can be damaged due to high heat. The City may study and/or update the wildfire vulnerability of their infrastructure to implement appropriate mitigation measures.

Drought – Drought is becoming an increasingly common challenge for the City due to climate change. The City is vulnerable to drought due to its reliance on surface water and the compounding impacts of seasonal saltwater intrusion in the Noyo River. The City is already implementing numerous mitigation measures to address this risk, including the completed desalination system, construction of new reservoirs, testing other desalination technologies, and implementing water conservation measures. These are discussed in more detail below.

Many of these risks are incorporated into the risk model used to evaluate and prioritize water infrastructure projects. The risk model is described in Section 6.9 Risk Assessment.

An assessment of the geotechnical and seismic safety elements related to water distribution facilities is fully documented in the report titled *Geotechnical Evaluation of Seismic Safety Elements Related* *to Water Distribution Facilities*. This report can be found in Appendix B. The following is a summary of the report's findings.

The City is located on a seismically active, uplifted coastal terrace. The uplifted terrace has created a coastal bluff that ranges from 50 feet tall at Soldier Point to 85 feet tall at Pomo Bluffs State Park. Surface elevation slopes gently upward towards the east, rising to approximately 400 feet, where the terrace meets the Coastal Range Mountains. Studies have identified that terrace deposits are acidic (corrosive) and become gradually more acidic closer to the ocean.

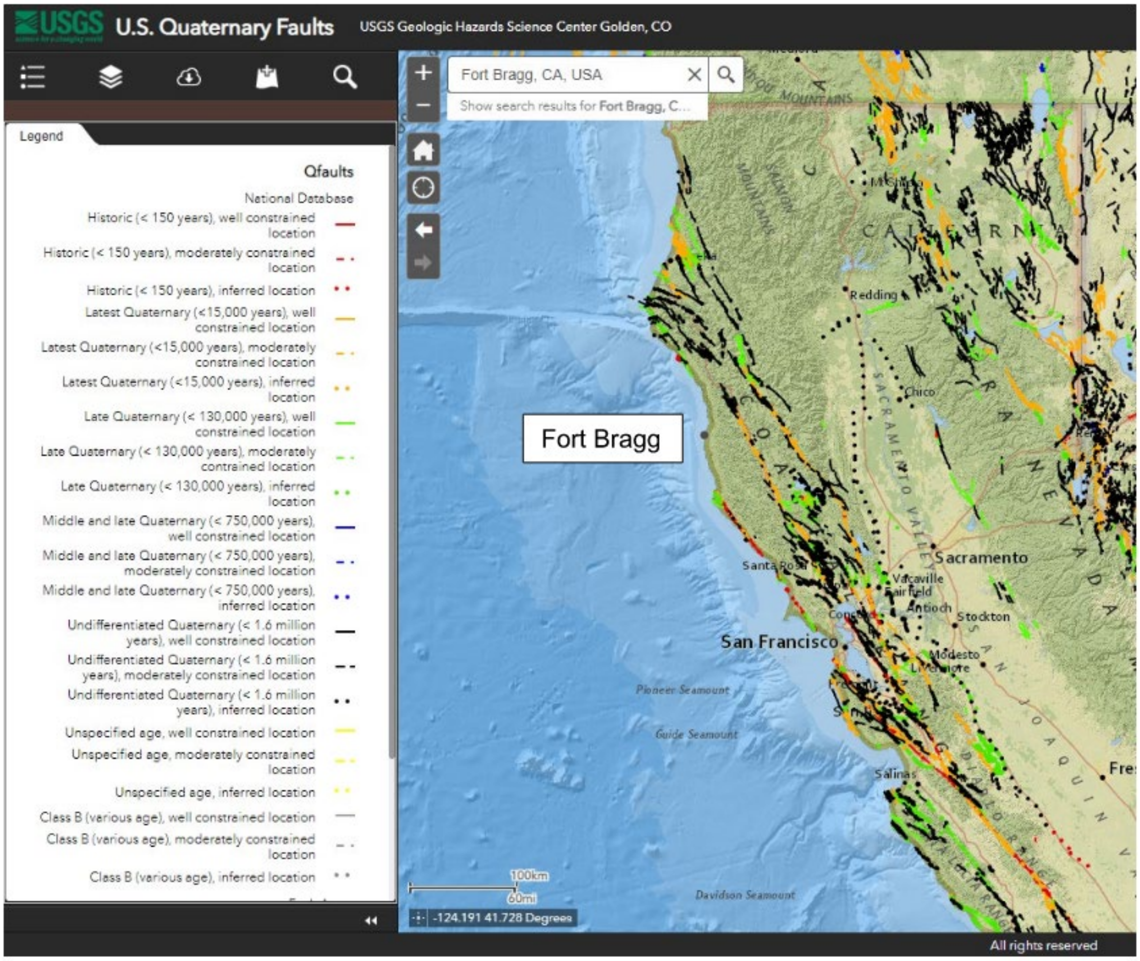
5.1.1 Seismic Hazards

Although the City is in a seismically active area, it is not within an established Earthquake Fault Zone, and the risk of fault surface rupture is low; however, strong ground shaking can impact the soils in the area. Densification of loose to medium-dense terrace deposits may occur in the river and creek channels or along the coastal bluff. The risk of liquefaction is judged to be moderate in the terraces and high in the river and creek channels and can occur in the event of strong ground shaking. Differential movement both vertically and laterally can damage the distribution pipes, especially at connections to structures like bridges.

The nearest fault zone, the Alquist-Priolo Earthquake Fault Zone, is associated with the San Andreas Fault system and is located approximately 6.5 miles West of the City's boundary. The Maacama Fault zone is approximately 21 miles to the east of the City; the Mendocino Fracture Zone is approximately 60 miles to the NorthWest (Figure 28). The potentially active, Pacific Star Fault, is located to the NorthEast between the towns of Fort Bragg and Westport. All faults may cause earth shaking activity. The Pacific Star and Pudding Creek Faults were identified in 2006 and are reported as connecting to the San Andreas fault paralleling the Pacific Coast though they are not located within a special fault study zone.

The fault offset hazard in the City is very low. There are no Alquist Priolo Hazards Zones identified within or near the City (www.conservation.ca.gov). The City will be subject to strong ground shaking that could induce densification of loose to medium dense terrace deposits and slope movement within the steeply incised river and creek channels and along the coastal bluff. Loose, saturated cohesionless soils are susceptible to liquefaction, including sediments that have accumulated within and at the mouth of the coastal, river, and creek channels and potentially in eolian (windblown) derived terrace deposits that become saturated due to groundwater. The State of California Office of Emergency Services online MyHazard maps (myhazards.caloes.gov) does not identify Fort Bragg as having a mapped liquefaction zone; however, the risk of liquefaction is judged to be moderate in the terraces and high in the river and creek channels and could occur in the event of strong ground shaking.

The 1977 5.2 magnitude earthquake near Willits is the largest magnitude earthquake in the vicinity of the City, originating approximately 28 miles east of Fort Bragg. The City reported severe losses after the 1906 earthquake due to structural damage and fire. A 7.0 magnitude earthquake offshore Cape Mendocino occurred on December 12, 2024, approximately 90 miles NorthWest of Fort Bragg, with little damage reported in the City as a result. Strong ground shaking is likely for a large earthquake event along the North California Coast region on the Maacama fault zone east of the city, the San Andreas Fault west of the City, and the Mendocino Fracture Zone/Cascadia Thrust Zone off the Pacific Coast near Eureka, California. USGS estimates that there is a 64.92% chance of an earthquake with a magnitude greater than 5 to occur in the next 50 years.



Source: *USGS.maps.arcgis.com/apps*

Figure 28 - Quaternary Fault Map

Mitigation strategies may include the use of articulating joints for entering rigid structures and the use of Earthquake Resistant Ductile Iron Pipe (ERDIP). ERDIP is often limited to sites deemed critical to the function of the water system in the event of a major earthquake

The American Lifeline Alliance is a public/private alliance between the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. In 2005, they published Seismic Guidelines for Water Pipelines that provide extensive guidance for the design of water pipeline design in the seismic environment. Unstable Soil

The presence of unstable soils on steep slopes, bluff retreat, and the presence of weak and/or unstable soils present a hazard to the water distribution system. Geographic trends of pipe breaks or leaks may indicate areas underlain by weaker soils. Figure 29 presents a ranking of the potential deep-seated landslide occurrence-based on rock strength and slope inclination from CGS Map Sheet 58. The darker color red indicates the higher potential risk. Rock strength in Mendocino County is generally ranked as moderate; therefore; the instability is a function of slope inclination ranging from 3 degrees to over 40 degrees, with rocks inclined 15 to 20 degrees or greater having the highest susceptibility (approximately equivalent to 27 percent grade or higher). Therefore, the susceptibility of landslides impacting the City water supply and distribution system or evacuation routes directly or from debris flows should be evaluated on a case-by-case basis. It should be noted that climate change may increase the risk of slope instability.

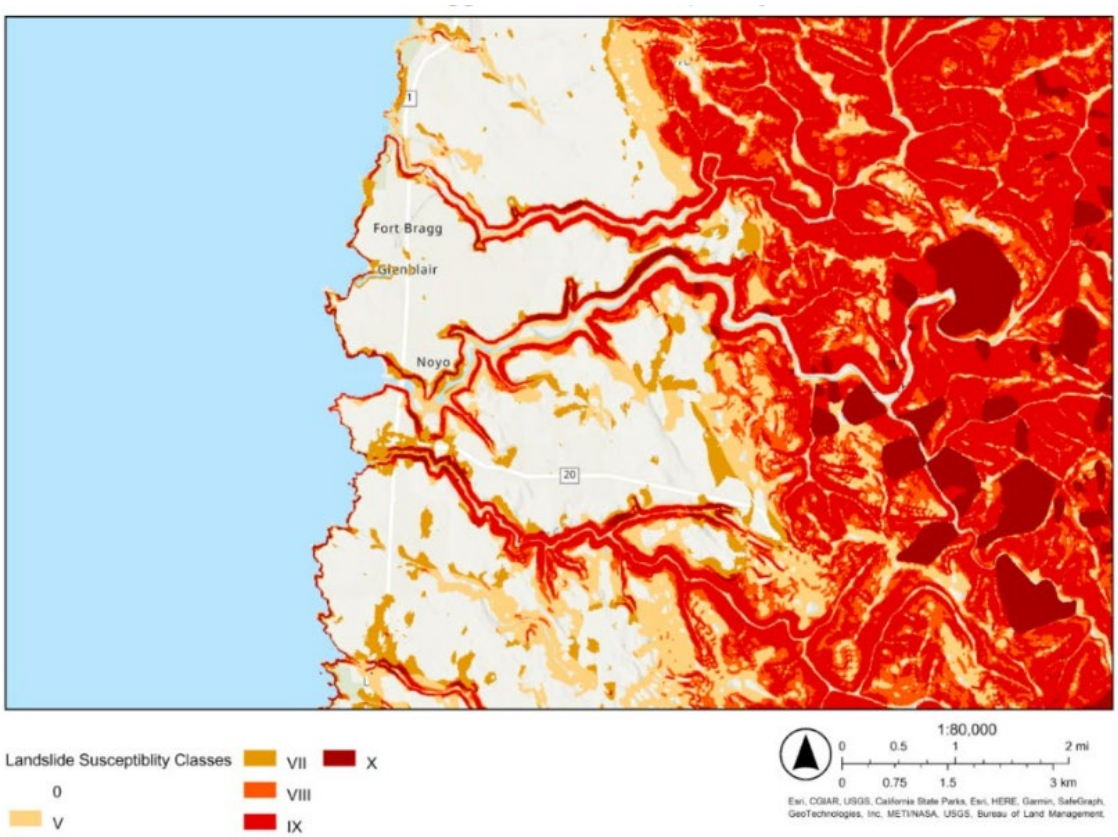
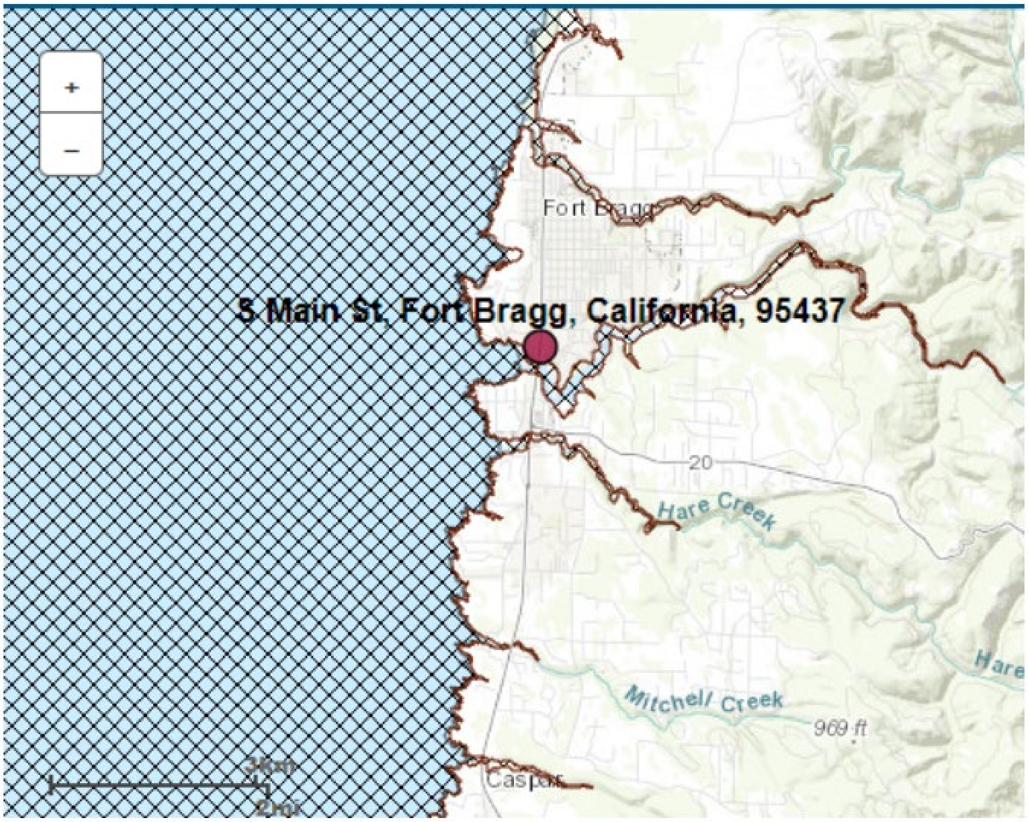


Figure 29 - Fort Bragg Landslide Susceptibility

5.1.2 Tsunamis

Tsunamis could impact coastal areas like Noyo Harbor and upstream areas of Noyo River, Pudding Creek, and Hare Creek. Sea level rise may raise river levels in the Noyo River and Hare Creek to above the 100-year flood level. In combination with sea level rise, a tsunami event could impact all three rivers/creeks and cause additional saltwater intrusion at the existing Noyo River raw water intake.

Tsunamis would impact the coastal areas, the Noyo Harbor and upstream areas of Noyo River Pudding Creek and Hare Creek (Figure 30).The Pacific Institute presents the effect of 55 inches of sea level rise on their Sea Level Rise Map of the Fort Bragg Quadrangle referenced above. The map shows that sea level rise will exceed the 100-year flood level within the Noyo River and Pudding Creek. The occurrence of tsunami(s) combined with sea level rise would impact the areas shown effected by sea level rise within the limits of Pudding Creek, Hare Creek, and the Noyo River including impacting existing raw water intakes along the Noyo River with salt water. The intakes have been impacted in the past with saltwater intrusion from high tides, and beginning in 2021 the City began using a desalination system to treat high salinity raw water from the Noyo River (Water Boards Media Release October 12, 2021).



Source: cal OES MyHazard

Figure 30 - Tsunami Hazard Area - Shaded

5.1.3 Soil Corrosiveness

Soil reports, identified Fort Bragg's surface soil as acidic, gradually becoming more acidic towards the ocean. Terrace deposit soils should be considered corrosive to steel and slightly corrosive to concrete. Specific testing and visual inspection of buried structures is recommended to provide a better understanding of corrosive activity to inform the City's water system management.

5.2 Environmental Risk

Environmental risks related to water distribution facilities are detailed in the report titled *Geotechnical Evaluation of Seismic Safety Elements Related to Water Distribution Facilities,* prepared by HDR Engineering, Inc. and dated December 12, 2023. This report can be found in Appendix B. A summary of these risks is provided below.

5.2.1 Flooding

Flooding hazard is typically determined for a 100-year flood level using maps developed by the Federal Emergency Management Agency. The most recent FEMA flood maps for the Fort Bragg area were published in 2024 and show larger 100-year flood hazards than what is shown in the City's 2008 Coastal General Plan. Because the distribution system is largely pressurized. Impact from flooding is primarily related to additional stresses from groundwater fluctuation.

5.2.2 Fire

The City's fire hydrant system is critical infrastructure for public safety. Significant fires have occurred in Northern California in the last few years and the ability to protect the City from structure fires and wildfire is important. The fire hydrant system is also critical after a large seismic event.

In 2025, the city adopted Ordinance XXXX-2025 to approve a map as recommended by the California Department of Forestry and Fire Protection, which delineates fire severity zones and local responsibility areas. The City is outside the jurisdiction of CALFIRE and the City itself is zoned as a local responsibility area.

5.2.3 Extreme Weather Events

In February 2023, the United States Department of Agriculture (USDA) declared Mendocino County a Disaster Area due to severe winter storms and flooding. Atmospheric rivers are defined by the National Oceanic and Atmospheric Administration (NOAA) as narrow atmospheric regions transporting water vapor out of the tropics. Atmospheric rivers can vary greatly in size and strength, the average atmospheric river carries an amount of water vapor roughly equal to the average flow of water at the mouth of the Mississippi River. An exceptionally strong atmospheric river can transport up to 15 times that amount. (To compare the amount of water transported by an atmospheric river and that have an equivalent flow as at the mouth of the Mississippi River. Atmospheric river events can have 15 times that amount. The Pineapple Express is a strong atmospheric river which brings moisture from the tropics near Hawaii to the west coast.

Rain events can induce slope instability and rapid slope movement and debris flows. One such event happened to the community of Rio Nido along the Russian River in 1998 and have also been linked to coastal landslides in 1962.

The Mendocino County Office of Emergency Services joint powers organization that includes the County of Mendocino and the incorporated cities within the county, serves as the coordinating agency for mutual aid services provided by fire departments, law enforcement agencies, and emergency medical service providers throughout the county. In addition, MESA reviews and makes recommendations regarding emergency operation plans for public and private institutions where pre-planning for emergency procedures is advisable. Coordination of emergency services and planning guidelines is provided for situations including flood, wildland fires, structure fires, explosions, hazardous material spills, severe weather, and earthquakes. Chemically Impacted Sites

A review of the DTSC GeoTracker website showed the locations of numerous identified chemically impacted sites that range from small underground storage tanks to large facility clean-up activities. Many of the sites are identified as having closed files, meaning that the sites have been remediated to meet cleanup goals set forward by regulatory agencies. It should be noted that there may be residual chemically impacted soils at these sites that did not require removal but, should they be excavated, may require special testing and handling to determine material reuse or disposal. The GeoTracker site and associated data should be checked as part future system upgrade or rehabilitation projects to be aware of potential impacted sites.

5.3 Climate Change Impact

A detailed discussion of climate change impact on the water distribution system is provided in a report titled *Climate Risk and Vulnerability Assessment, prepared* by HDR Engineering, Inc. and dated May 27, 2025. This report can be found in Appendix C.

Primary climate change impacts the water distribution system include:

- Hotter temperatures add demand and stress to the Water System, and exacerbate wildfire threat to infrastructure.
- Increasingly exaggerated variability in precipitation, including flooding and drought conditions, require varied and more adaptable water management (discussed further in Section 5.4: Environmental Practices).
- Sea Level Rise in addition to extreme precipitation events and drought, will increase the risk of landslides and erosion.

Additional at-risk infrastructure includes:

- **Transportation:** Bridges are at risk of flooding.
- **Energy Systems:** Transmission lines exposed to wildfire and could impact operations of water pump(s) for the water distribution syste.
- **Water Treatment:** The Water Treatment Plant is at the edge of wildfire susceptibility.
- **Critical Infrastructure:** Fort Bragg Fire Station #2 is vulnerable to wildfire.

Water distribution assets that may benefit the most from implementing resilience strategies include:

- **Mains:** Landslides along creek banks.
- **Storage Tanks:** Vulnerable to wildfire.

5.4 Environmental Practices

Environmental Practices are actions that the City is either currently undertaking or actions that the City may consider when seeking to minimize their infrastructure's impact to the environment. This section focuses on three key environmental practice topics: water efficiency, conservation, and local watershed protection.

5.4.1 Water Efficiency

The City has multiple ongoing water efficiency efforts. The projects summarized below include the Raw Water Line Replacement Project (Dewberry 2022), the Oneka Seawater Desalination Buoy Pilot Study (City of Fort Bragg 2025a), and the Reservoir Project (City of Fort Bragg 2025b).

The **Raw Water Line Replacement Project** (Dewberry 2022) is undertaking a critical infrastructure upgrade to improve the reliability and efficiency of an approximately two-mile section of its aging raw water delivery pipeline. With the existing pipeline nearing the end of its operational lifespan and experiencing frequent failures, replacement is essential to ensure a stable and resilient water supply for the community. To identify the most efficient and environmentally responsible route, the project team—including engineers, biologists, and environmental and geotechnical experts—assessed multiple project alternative options. These alternatives were evaluated based on engineering feasibility, environmental considerations, land use compatibility, cost, and other relevant factors. While the construction activities will occur near aquatic habitats, assessments indicate that potential impacts to sensitive fish species such as steelhead and coho salmon will be minimal and can be effectively mitigated.

The **Oneka Seawater Desalination Buoy Pilot Study** (City of Fort Bragg 2025a) is designed to enhance the resilience and efficiency of the water supply system for Fort Bragg, in response to increasing water reliability concerns. Through grant money awarded by California Department of Water Resources, the City is piloting a new innovative wave-powered desalination system developed by Oneka Technologies. This system uses only ocean wave energy to convert seawater into potable water via reverse osmosis, offering a sustainable and energy-independent solution. A single “Iceberg” unit, capable of producing approximately 13,200 gallons of freshwater per day, will be tested for 12 months about 0.5 miles offshore. The pilot study will monitor system performance, energy efficiency, and potential environmental effects to inform a future utility-scale deployment aimed at securing a reliable, low-impact water source. The Iceberg unit’s offshore location was selected to avoid ecologically sensitive areas, using existing disturbed zones near the wastewater treatment plant’s outfall for pipeline routing. Designed with environmental safeguards, the unit features a fine mesh intake screen, low intake velocity, and passive brine discharge, reducing risks to marine life and avoiding sediment disruption. Environmental monitoring during the study will assess impacts on water quality and marine habitats, with results informing regulatory permitting and the potential expansion of this zero-emission, wave-powered desalination approach in Fort Bragg’s long-term water strategy.

The City is planning the development of the **Reservoir Project** (City of Fort Bragg 2025b) which includes three new 45-acre-foot water storage reservoirs. This project is intended to improve long-term water supply reliability and enhance drought resilience. These reservoirs will be located on a forested, City-owned property encompassing 582 acres adjacent to the existing Summers Lane Reservoir. Designed to capture and store water during periods of high flow—either by gravity from Waterfall Gulch or pumped from the Noyo River—the reservoirs will provide a dependable water source during dry months. This seasonal storage strategy helps maintain streamflow levels in summer, reducing pressure on aquatic ecosystems and protecting sensitive fish species. Water from the reservoirs will primarily be delivered to the City’s treatment plant via gravity, improving energy efficiency. The project will include supporting infrastructure such as a caretaker’s residence, a storage facility, parking, and pit toilets, all sited in previously disturbed areas to limit environmental disruption. The reservoir designs will be modeled after the existing Summers Lane facility, with depths reaching up to 18 feet and stable side slopes. Importantly, the dam and storage parameters are expected to remain below thresholds that would trigger oversight from the California Division of Safety of Dams. The site includes both redwood forest and rare Mendocino Cypress Woodland habitat, prompting the completion of preliminary biological assessments to inform reservoir placement and avoid impacts on sensitive natural resources. As part of the project’s development, an Environmental Impact Report (EIR) will be prepared in compliance with California Environmental Quality Act (CEQA), and close coordination between engineering and environmental consultants will be required. Environmental mitigation strategies will be implemented as needed. The City plans to preserve the remaining forested land as a future community forest, supporting both conservation and public access goals.

In addition to the City's projects, new development and retrofitted landscape water efficiency standards are regulated by the Model Water Efficient Landscape Ordinance (MWELO). These ordinances aim to enhance water efficiency while also improving environmental conditions in urban areas. Landscapes should be recognized not only for their aesthetic value but also for their role in restoring habitat lost to development. Proper landscaping offers a variety of ecological benefits, including habitat restoration, climate change mitigation, energy and materials conservation, and improvements to public health and quality of life, all of which contribute to a more sustainable and resilient environment.

5.4.2 Conservation

This section describes species that have been identified as important for conservation and then describes some of the projects the City has been involved with to support conservation efforts for these species.

Several species within the region have been identified as priorities for conservation efforts by the California Natural Diversity Database (CNDDB) (2024), U.S. Fish and Wildlife Service (USFWS) (2025), and National Marine Fisheries Service (NMFS) (2025). A search of the region using the CNDDB Quickview Tool identified several species of special concern by the California Department of Fish and Wildlife (CDFW) (CNDDB 2025). CNDDB (2025) shows that Central California Coast Coho salmon (Oncorhynchus kisutch) is state listed as endangered. Species of special concern include Northern California distinct population segment (DPS) winter-run steelhead (Oncorhynchus mykiss), California Coastal Chinook salmon (Oncorhynchus tshawytscha), tidewater goby (Eucyclogobius newberryi), and Pacific Lamprey (Entosphenus tridentatus) (CNDDB 2025). Additionally, an Information for Planning and Consultation (IPaC) search (USFWS 2025) of the region, which does not include Endangered Species Act (ESA) listed fishes under NMFS jurisdiction, shows the tidewater goby listed as a federally endangered species with critical habitat located in the lower portion of Pudding Creek and in the lower portion of Virgin Creek. Additionally, the northwestern pond turtle (Actinemys marmorata) is proposed for official listing as threatened, however, there is no critical habitat. Although there is no additional critical habitat listed, the following list of ESA-listed non-aquatic species were generated by an IPaC search of the region (USFWS 2025):

- Birds
  - Endangered Hawaiian Petrel (*Pterodroma sandwichensis)*
  - Endangered Short-tailed Albatross *(Phoebastria albatrus)*
  - Threatened Marbled Murrelet *(Brachyramphus marmoratus)*
  - Threatened Northern Spotted Owl *(Strix occidentalis caurina)*
  - Threatened Western Snowy Plover *(Charadrius nivosus nivosus)*
  - Threatened Yellow-billed Cuckoo (Coccyzus americanus)
- Insects
  - Endangered Behren's Silverspot Butterfly (*Speyeria zerene behrensii)*
  - Endangered Lotis Blue Butterfly (*Lycaeides argyrognomon lotis*)
  - Proposed Threatened Monarch Butterfly (*Danaus Plexippus*)

- Flowering Plants
    - Endangered Burke's Goldfields *(Lasthenia burkei)*
    - Endangered Contra Costa Goldfields *(Lasthenia conjugens)*
    - Endangered Howell's Spineflower *(Chorizanthe howellii)*
    - Endangered Menzies' Wallflower *(Erysimum menziesii)*
    - Endangered Monterey Clover *(Trifolium trichocalyx)*
    - Endangered Showy Indian Clover *(Trifolium amoenum)*

The NMFS Species and Habitat App (NMFS 2025), shows the Central California Coast Coho salmon evolutionarily significant unit (ESU) is endangered and have critical habitat in Pudding Creek and Noyo River. The California Coastal Chinook salmon ESU is threatened and has critical habitat in Noyo River. Finally, the Northern California steelhead DPS is threatened and has critical habitat in Pudding Creek and Noyo River. NMFS (2025) also shows essential fish habitat for Chinook and coho salmon, as listed under the Magnuson-Stevens Act, in the region. All of these species are relevant when considering water use and water development projects as part of the Plan.

The City has been involved in multiple conservation efforts. City staff assisted in developing the Noyo River Watershed Enhancement Plan (CSCC 2007). The primary purpose of this plan was to identify and describe strategic management and restoration activities with a focus on vegetation, wildlife, and salmonids. CSCC (2007) describes the following conservation projects with the City as a contributor:

- South Fork Noyo River Sub-basin Road Related Sediment Reduction Project
- Comprehensive Road Assessment in the South Fork Noyo River Sub-basin
- Road Reshaping and Decommissioning in the South Fork Noyo River Sub-basin
- Kass Creek/Little North Fork Noyo Large Woody Debris Coho Habitat Enhancement
- Kass Creek/Little North Fork Noyo River Road Assessment
- Little North Fork Noyo/Kass Creek Road Implementation
- Sherwood Road Sediment Reduction Project
- Upper Noyo/North Fork Noyo Sub-basin Road Assessment
- Upper Noyo/North Fork Noyo Sub-basin Road Implementation Project
- Otis Johnson Wilderness Park Restoration
- Noyo Watershed Alliance Organizational Support
- Coastal Salmonid Monitoring Program (Pudding Creek)

Note that many of these projects focus on sediment management as it relates to road networks within the Noyo River watershed and other nearby areas which are expected to benefit conditions for listed salmonids described above.

5.4.3 Local Watershed Protection

The City receives its water from three main sources including the Noyo River and Newman Gulch which connects to the Noyo River. The third source is Waterfall Gulch which flows into Hare Creek south of Fort Bragg. Regional Water Board (2005) provides a summary of the Noyo River watershed and activities to assess and improve conditions for anadromous salmonids. Some of the topics reviewed include water quality and excessive sediment loading associated with logging, overgrazing, and road building. These impacts affect both anadromous fish populations and drinking water supply and efficiency.

As part of the CDFW Fisheries Restoration Grant Program, a fish passage barrier was removed from Newman Gulch in 2013 and post-treatment monitoring conducted in 2016 (CDFW 2016). This project aimed to improve fish passage in Newman Gulch by replacing a small, inadequate culvert with a roughened stream channel and a 45-foot prefabricated steel bridge. The new design was specifically intended to allow uninterrupted movement for Chinook salmon, coho salmon, and steelhead trout throughout all stages of their life cycles, granting access to approximately a quarter mile of upstream habitat for spawning and juvenile development. Both coho salmon and steelhead have been observed in Newman Gulch since the barrier was removed (CDFW 2016). The City plans to continue protecting local watersheds in this way as future projects are implemented, supporting both conservation and public access goals.

CHAPTER 6 WATER SYSTEM CAPITAL IMPROVEMENT PROGRAM

6.1 Introduction

This chapter provides a list of recommended improvements within the City's water distribution system and summarizes the capital improvements and their associated planning level costs. The resulting CIP provides the proposed prioritization, timing, and sizing of the recommended improvements. As with any infrastructure planning assessment, the actual timing and sizing will be dictated by the realized impact of growth and the year-to-year increase in water demand in the water service area and future annexation areas. This chapter documents the following components of the capital planning process:

- Planning Criteria to identify deficiencies and size recommended improvements
- Existing System capacity analysis
- Future system capacity analysis
- Risk analysis used for capital project prioritization
- Recommended system improvements
- Descriptions, locations, and sizes of supply, pumping, storage, and major transmission/distribution system improvements
- Prioritized implementation schedule based on water demand projections, hydraulic modeling, and system performance analysis over the planning years
- Planning level opinions of probable cost (OPC) of improvements through the planning period, including documentation of the cost basis for each type of project
- Phased capital improvements plan

6.2 Ten-Year Capital Plan Overview

Table 17 below shows the 10-year capital improvement plan for the water distribution system. This table and a map illustrating all CIP project Physical locations can be found in Appendix F.

Project priority was assigned first by anticipated timeframe, then by maximum proximal risk score and included projects that address priority capacity, fire flow, operational, asset renewal, and other recommended improvements needed to meet anticipated future demands, facilitate system operations, and keep the current system performing at expected levels of service.

Table 17 – Ten-Year Capital Improvement Plan

Priority Ranking	CIP ID	Project Name	Project Description	Total Pipe Footage (FT)	Project Driver	Escalated Project Cost[a]
1	PS-1	Pump Station Upsize	Upsize Willow Street Pump Station capacity to 2,000 GPM.	-	Capacity or Fire Flow Deficiency	$8,141,000
2	V-1	Oak Street Valves	Addition of two isolation valves to 14-inch water main on Oak Street.	930	Operational Improvements	$93,000
3	P-1	Cedar Street Water Line Replacement	Replacement of Cedar Street water main. Increase 53 FT of 6-inch pipe diameter to 16-inch. Increase 4,195 FT of 8-inch pipe diameter to 16-inch.	4,248	Capacity or Fire Flow Deficiency	$3,357,000
4	T-1	Tank 1 Upgrade	Replacement of Tank 1 at WTP.	-	Asset Renewal	$8,955,000
5	P-2	North Fort Bragg Water Main Extension	North Fort Bragg Water Main Extension. Place new 2,144 FT of 10-inch main.	2,144	Capacity or Fire Flow Deficiency	$1,384,000
6	PL-1	System Renewal- Pipe Replacement	Provision for additional projects to meet 1% annual system renewal goal, based on condition.	5,000	Asset Renewal	$2,830,000
7	O-1	Opportunistic Pipe Sampling	Collect and test condition of 3-5 AC pipe samples per year.	-	Other	$69,000
8	O-2	CIP Update	Update capital project list every 5 years.	-	Other	$110,000
9	O-3	CMMS Needs Analysis	Evaluate Computer Maintenance Management Software (CMMS) Needs.	-	Other	$39,000
Next 5 Year Sub-Total						**$24,978,000**
10	P-7	East Laurel Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch	539	Capacity or Fire Flow Deficiency	$354,000
11	P-3	Noyo Center Water Line	Upsize 1,500 FT of existing 4-inch main to 12-inch. Place new 2,500 FT of 12-inch main. Project pending start of Noyo Center Development.	4,018	Capacity or Fire Flow Deficiency	$2,985,000
12	P-6	North Main Street Water Main Replacement	Increase 32 FT of 6-inch pipe diameter to 8-inch. Increase 867 FT of 6-inch pipe diameter to 10-inch. Increase 220 FT of 6-inch pipe diameter to 12-inch. Increase 3,665 FT of 10-inch pipe diameter to 12-inch. Increase 645 FT of 8-inch pipe diameter to 10-inch.	5,429	Capacity or Fire Flow Deficiency	$4,016,000

Priority Ranking	CIP ID	Project Name	Project Description	Total Pipe Footage (FT)	Project Driver	Escalated Project Cost[a]
13	P-14	East Alder Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch	717	Capacity or Fire Flow Deficiency	$470,000
14	P-10	Chief Celeri Dr Water Main Replacement	Increase 6-inch pipe diameter to 10-inch	1,362	Capacity or Fire Flow Deficiency	$951,000
15	P-4	Noyo Point Road Water Main Replacement	Increase 6-inch pipe diameter to 10-inch	651	Capacity or Fire Flow Deficiency	$455,000
16	P-8	Maple Street Water Main Loop	Install new 8-inch pipe	313	Capacity or Fire Flow Deficiency	$206,000
17	P-5	East Elm Street Water Main Loop	Install New 12-inch Pipe	194	Capacity or Fire Flow Deficiency	$145,000
18	P-9	East Chestnut Street Water Main Replacement	Increase 6-inch pipe diameter to 10-inch	472	Capacity or Fire Flow Deficiency	$330,000
19	P-11	Spruce Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch	1,330	Capacity or Fire Flow Deficiency	$873,000
20	PL-2	System Renewal- Pipe Replacement	Provision for additional projects to meet 1% annual system renewal goal, based on condition.	5,000	Asset Renewal	$3,280,000
21	O-4	Opportunistic Pipe Sampling	Collect and test condition of 3-5 AC pipe samples per year.	-	Other	$80,000
22	O-5	CMMS Acquisition & Implementation	Acquire and implement new CMMS. Only if recommended in O-3 CMMS Needs Assessment.	-	Other	$191,000
23	O-6	CIP Update	Update capital project list every 5 years	-	Other	$127,000
					5-10 Year Sub-Total	**$14,463,000**
					Total	**$39,441,000**

a Costs escalated for inflation (see Unit Costs)

Projects categories are described as follows:

- **Capacity & Fire flow Deficiency -** capital projects identified by evaluating current water demands, near-term water demand projections, and expected demands at buildout over the next 10 years (development of the GP Mills site). Currently, the eight annexation areas are not expected to be developed within the next 10 years.
- **Operational improvements** are recommended to maintain or increase the City's ability to efficiently manage the system. These projects are designed to enable the City to perform regular maintenance and repairs on the system while minimizing the impact on customers and the community.
- **Asset renewal** projects include infrastructure replacement and rehabilitation of existing infrastructure to keep the current system operating as expected. These projects are focused on aging infrastructure and infrastructure that is in poor condition. An annual pipeline replacement rate of 1% has been established (see section 6.8.1 Renewal Strategy) to plan for the incremental renewal of the entire system in the next 100 years (which is consistent with current industry standards). For the ten-year CIP, some portion of the 1% annual replacement rate has been accounted for through Capacity and Fire flow projects. Therefore, specific annual allocations have been reduced from the 1% target. This allocation has remained separate to account for unanticipated replacement needs due to condition or pipe failure.
- **Other** capital projects include planned condition assessment efforts, and other studies to continue to evaluate environmental, geotechnical, and climate change risks and resilience opportunities. Condition assessments will be used to plan and prioritize upcoming capital projects (such as pipeline replacements) and the environmental studies will help the City anticipate changes in environmental factors and adjust capital plans to address these changes in the future.

6.3 Preliminary Engineering Reports

Preliminary engineering reports are provided in Appendix F and have been developed for five of the highest priority projects described in the ten-year capital plan (P-1: Cedar Street Line Replacement, P-2: Noyo Center Water Line, T-1: Tank 1 Replacement, and V-1: Oak Street Valves, PS-1: Pump Station Upsize). These reports were designed to contain detail to support the environmental and funding process and include schedule, cost, mapping, project descriptions and design triggers.

6.4 Planning Criteria

Planning criteria are performance metrics and standards required to meet levels of service expected by customers, stakeholders, and regulators. Three scenarios, Existing, Near-Term (anticipated growth and improvements in the next decade), and Build-Out (long-range condition assuming full development) were modeled and compared against the performance criteria outlined in this section to identify needs and define necessary capital projects.

6.4.1 Distribution System

Distribution system criteria address system pressure and pipeline requirements. These criteria are established to ensure that the proposed distribution system will provide adequate, but not excessive, water pressure and the conveyance system can accommodate peak demands without excessive wear or energy usage. These criteria are not recommended to limit, for example, pipeline velocities during intermittent activity such as flushing.

6.4.1.7 Water Service Pressure Requirements

The water service pressure requirements recommended for this hydraulic analysis are as follows:

- Maximum desired pressure: 120 psi
- Maximum allowable pressure: 150 psi
- Minimum allowable pressure at peak flow: 40 psi
- Minimum allowable pressure with MDD plus fire flow: 20 psi

To help provide standardization throughout the City, provide adequate fire flows and avoid excessive velocity and head loss within the distribution system, the following pipeline design criteria are also recommended:

- Minimum pipe size for new construction: 8 inch
- Maximum allowable velocity at peak flow: 7 feet per second (fps)
- Maximum allowable velocity during fire flow conditions: 15 fps
- Maximum desirable head loss at peak flow: 5 feet per 1000 feet
- Maximum allowable head loss at peak flow: 10 feet per 1000 feet

6.4.1.8 Fire Flow Requirements

Fire flow requirements for different land use types were provided by the City. Table 18 lists fire flow requirements used in the capacity analysis

Table 18 – Fire Flow Requirements

Land Use	Minimum Flow Required (gpm)	Minimum Desired Pressure (psi)	Minimum Duration (hrs)	Required Fire Storage Volume (MG)
Residential	1,000	20	2	0.12
Commercial	2,000	20	3	0.36
Industrial	3,000	20	4	0.72

6.4.2 Pump Station Criteria

Pump Stations should be sized to handle MDD in pressure zones with storage. The in-zone storage will handle the fluctuations between MDD and PHD in addition to providing the recommended fire flow volume.

For pressure zones with no in-zone storage, the pump stations should be sized to handle PHD plus fire flow demands, in the event that fire flow demand is required during the peak hour condition.

All pump stations should be sized to handle the required flow with the largest pump on standby (i.e., firm capacity). If a pump station contains a dedicated fire pump, the fire pump can be included in calculating the firm capacity of the pump station.

The existing distribution system has one pump station, the Willow Street Booster Pump Station, serving the EFBPZ. The rest of the city is supplied by the WTP via gravity flow.

6.4.3 Storage Criteria

Treated water storage should be sized to provide the following storage components within each pressure zone:

- Operational Storage – The storage to moderate fluctuations during normal operations between supply and demand. Typically supply provides MDD with storage providing the difference between MDD and PHD.
- Fire Flow Storage – The storage volume required to provide fire protection in each pressure zone (See Table 18 – Fire Flow Requirements)
- Emergency Storage – The storage required to provide supply during emergencies within the City, when water supply is reduced or turned off.

6.4.3.9 Operational Storage

Under normal operating conditions, operational storage balances the difference between water supply (typically MDD) and daily variations in demand. Water is supplied to the City via the WTP. Operational storage is pressure zone dependent and based on the ADD per pressure zone

It is recommended that the City's operational storage be sized to balance the difference between PHD and MDD supplied by the WTP. As discussed previously, the typical peak hour period is a 3-hour period occurring between the hours of 4 a.m. and 7 a.m. Assuming 3 peak hours of demand, the difference between peak hour and maximum day is:

$$Operational\ Storage = \left(\frac{3}{24}hours\right) * (PHD - MDD)$$

$$= 0.125 * (2.52 - 1.73) * ADD$$

$$= 0.099 * ADD$$

6.4.3.10 Fireflow Storage

Fire flow storage is pressure zone specific and is based on the largest fire flow required, based on land use, for each pressure zone. Since there is no storage in the booster station zone, the distribution zone needs to be able to handle fire flow in both zones. The distribution zone has industrial parcels with a 3,000 gpm for 4-hour requirement (i.e., 720,000 gallons).

$$Fire\ Flow\ Storage = 0.72\ MG$$

6.4.3.11 Emergency Storage

Emergency storage, similar to operational storage, is pressure zone dependent and based on the ADD per pressure zone. Typically, water municipalities can respond to and mitigate outages within 1 day, which suggests that 1 average day be reserved for emergency storage. Since the City has a water treatment source and is not dependent on imported water or supply from a neighboring utility, it is important to balance the required level of emergency storage with the potential for adverse water quality issues stemming from excess storage. Therefore, 1 * ADD is recommended for the emergency storage component.

$$Emergency\ Storage = 1 * ADD$$

6.4.3.12 Recommended Storage Criteria

System-wide total treated water storage requirements for existing, near term, and buildout are summarized in Table 19. The City currently has 4.95 MG of treated water storage, and thus no additional treated water storage is required.

Table 19 – Storage Requirement for Existing, Near Term, and Buildout Scenarios

	Existing	Near Term	Buildout
Total ADD (gpm)	482	500	1,109
Total ADD (MG)	0.69	0.72	1.60
Operational Storage (MG)	0.07	0.07	0.16
Fire Flow Storage (MG)	0.72	0.72	0.72
Emergency Storage (MG)	0.69	0.72	1.60
Total Storage Required (MG)	1.48	1.51	2.48
Total Storage Available (MG)	4.95	4.95	4.95
Additional Storage Needed (MG)	None	None	None

6.5 Existing System Capacity Analysis

Existing conditions represent current system performance based on available data and known infrastructure. This scenario identifies immediate deficiencies or constraints that require capital improvements. These improvements include increasing the current capacity of the fire pump at the Willow St. Pump Station from 1,000 GPM to 2,000 GPM, and a series of projects either specified by the City or developed by HDR to address fire flow capacity deficiencies. Fire flow deficiencies were examined in the distribution pressure zone in MDD conditions, and in the booster station pressure zone in PHD conditions. This is because the booster station zone has no storage to provide for the difference in demand between max day and peak hour, the pumps at the booster station must be able to provide fire flow plus the maximum demand required, which could occur at MDD.

CIP projects for the existing system are described in Table 20 and shown in Figure 31. The City specified four CIP projects for the existing system. These projects are shown in Figure 32, Figure 33, Figure 34, and Figure 35. Improvements identified by the hydraulic model were given a lower priority than those specified by the city. Improvements to existing pipes (i.e. upsizing) were prioritized over the addition of new pipes. Lower priority projects were ranked by total risk followed by the enhanced level of fire flow improvements addressed by the project.

Table 20 – CIP Projects For Existing System

CIP Scenario	CIP ID	Project Name	Project Description	Total Pipe Footage (FT)	Time Frame
Existing	PS-1	Pump Station Upsize	Upsize Willow Street Pump Station capacity to 2,000 GPM	-	<5 years
Existing	P-1	Cedar Street Water Line Replacement	Replacement of Cedar Street water main. Increase 53 FT of 6-inch pipe diameter to 16-inch. Increase 4,195 FT of 8-inch pipe diameter to 16-inch.	4,248	< 5 years
Existing	P-2	North Fort Bragg Water Main Extension	North Fort Bragg Water Main Extension. Place new 2,144 FT of 10-inch main.	2,144	< 5 years
Existing	P-4	Noyo Point Road Water Main Replacement	Increase 6-inch pipe diameter to 10-inch	651	5 - 10 years
Existing	P-5	East Elm Street Water Main Loop	Install New 12-inch Pipe	194	5 - 10 years
Existing	P-6	North Main Street Water Main Replacement	Increase 32 FT of 6-inch pipe diameter to 8-inch. Increase 867 FT of 6-inch pipe diameter to 10-inch. Increase 220 FT of 6-inch pipe diameter to 12-inch. Increase 3,665 FT of 10-inch pipe diameter to 12-inch. Increase 645 FT of 8-inch pipe diameter to 10-inch.	5,429	5 - 10 years
Existing	P-7	East Laurel Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch	539	5 - 10 years
Existing	P-8	Maple Street Water Main Loop	Install new 8-inch pipe	313	5 - 10 years
Existing	P-9	East Chestnut Street Water Main Replacement	Increase 6-inch pipe diameter to 10-inch	472	5 - 10 years
Existing	P-10	Chief Celeri Dr Water Main Replacement	Increase 6-inch pipe diameter to 10-inch	1,362	5 - 10 years
Existing	P-11	Spruce Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch	1,330	5 - 10 years

CIP Scenario	CIP ID	Project Name	Project Description	Total Pipe Footage (FT)	Time Frame
Existing	P-13	East Alder Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch	717	5 - 10 years
Existing	T-1	Tank 1 Replacement	Replacement of Tank 1 at treatment plant	-	< 5 years
Existing	V-1	Oak Street Valves	Addition of two 10-inch isolation valves and one 18-inch isolation valve to water main on Oak Street.	930	< 5 years

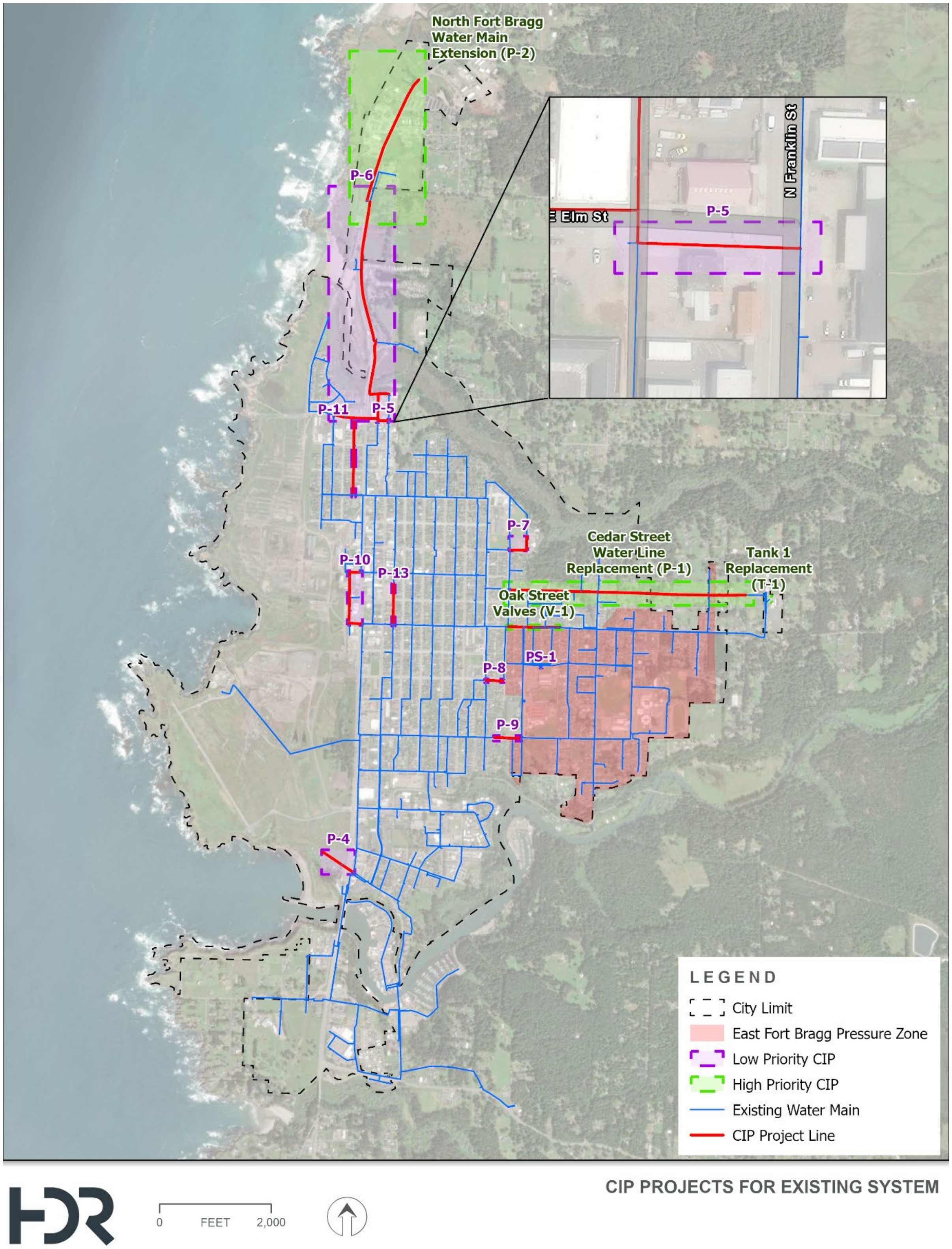


Figure 31 – CIP Projects for Existing System

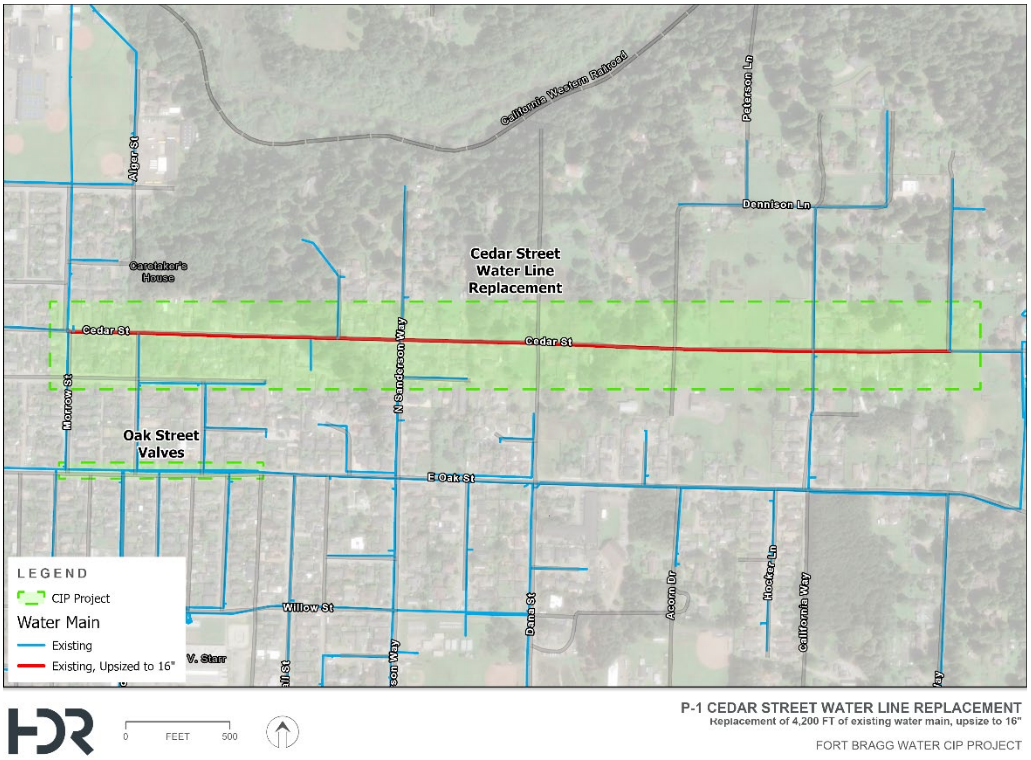


Figure 32 – CIP Project P-1: Cedar Street Water Line Replacement

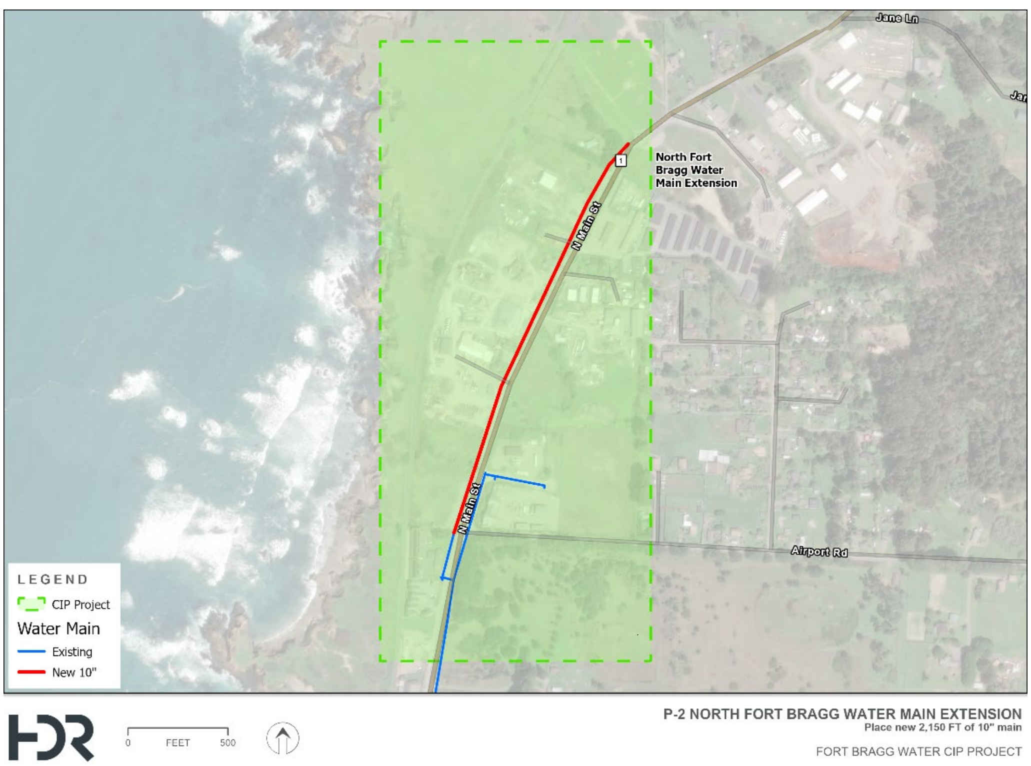


Figure 33 – CIP Project P-2: North Fort Bragg Water Main Extension

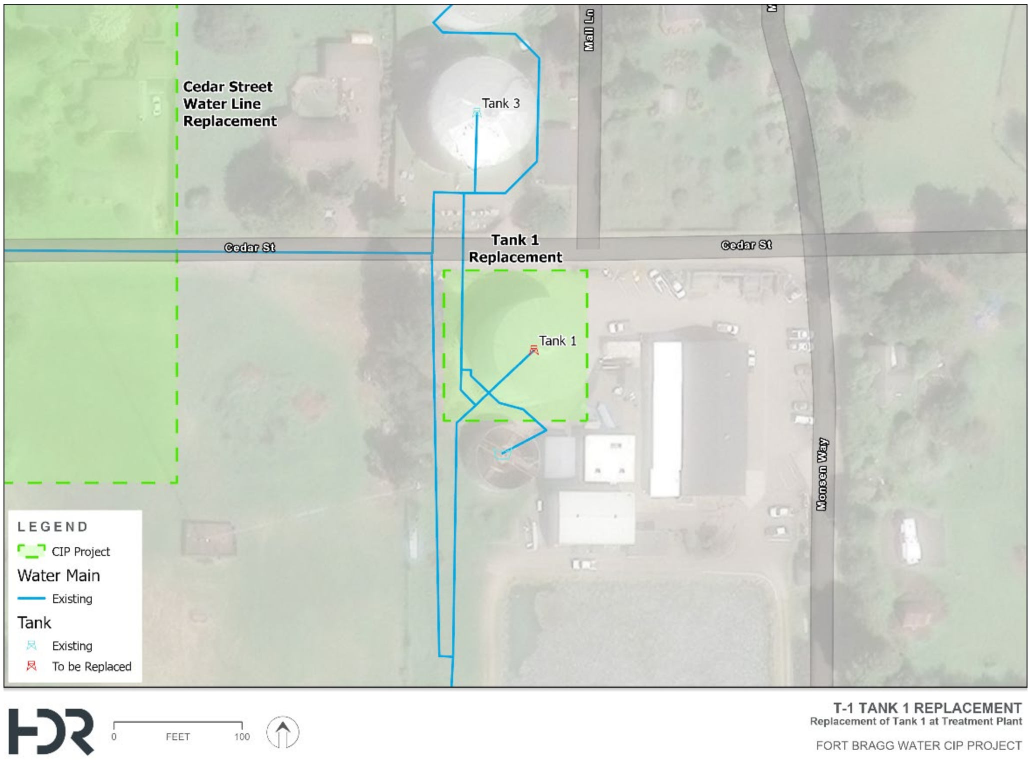


Figure 34 – CIP Project T-1: Tank 1 Replacement

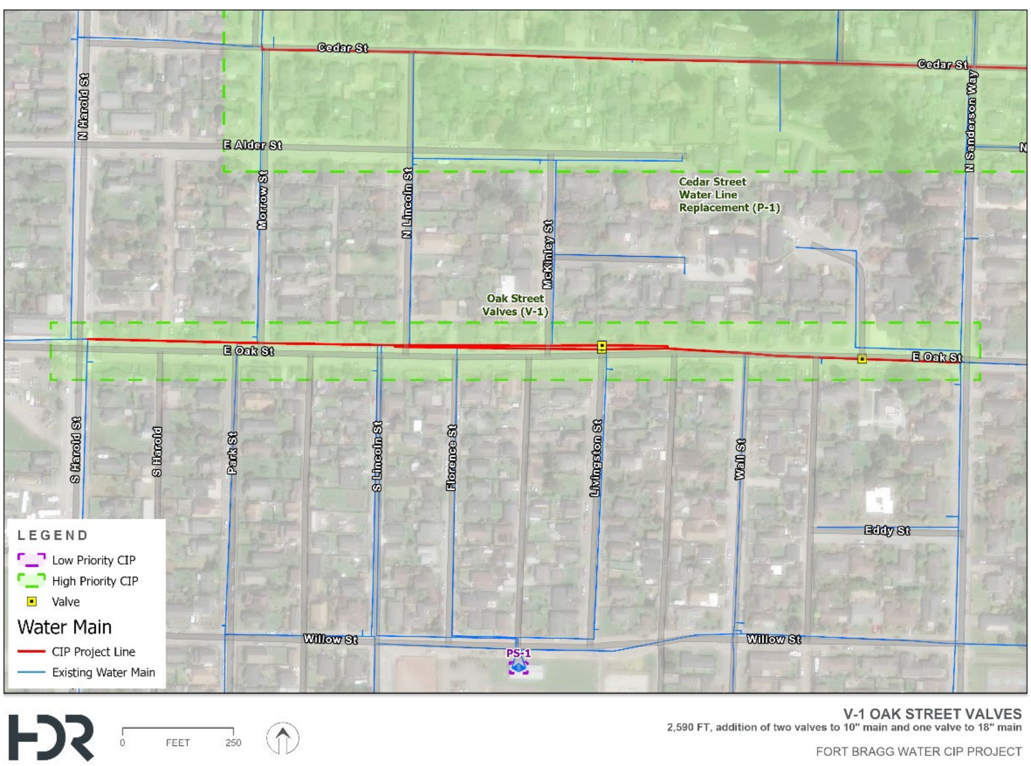


Figure 35 – CIP Project V-1: Oak Street Valves

6.6 Near-Term System Capacity Analysis

Near-Term Conditions reflect system demands and improvements expected in the short-term planning horizon (e.g. 5-10 years). It incorporates committed developments and known growth. The addition of near-term demands to the system does not trigger additional fire flow related system improvements. However, the City identified one CIP project, the Noyo Center Water Line, to be developed in the near-term to serve the proposed Noyo Center, shown in Figure 36. This project would be pending the start of Noyo Center Development. It is anticipated that a fair share of the cost of this project will be borne by the developer.

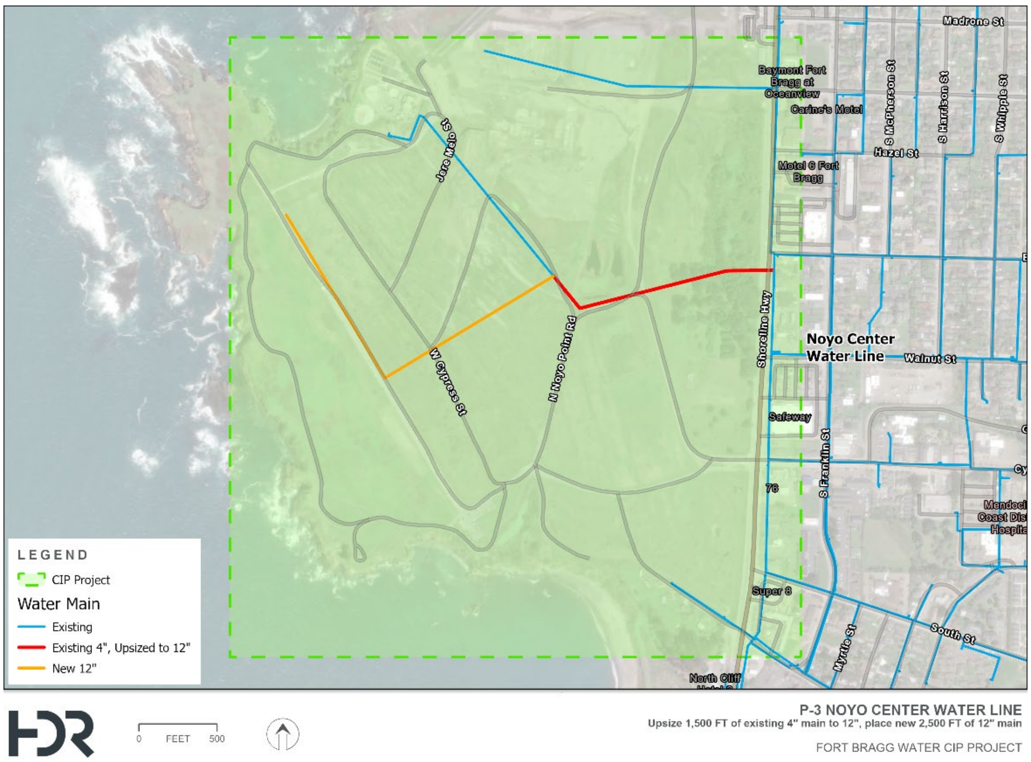


Figure 36 – CIP Project P-3: Noyo Center Water Line

6.7 Build-Out System Capacity Analysis

Build-Out conditions reflect long-range planning needs, incorporating the development of the GP Mill Site and the future annexation areas (Figure 37). It should be noted that annexation is not likely to occur within the next 20 years. Annexation Area 6 is unlikely to be developed in a way that would impact sewer and water because it's in a low-lying, heavily forested area. If Annexation Area 6 does develop, it would need to be evaluated at that time. System improvements would be required to address these additional demands and provide the level of service established in the Planning Criteria.

Figure 37, Figure 35, and Figure 36 and Table below show the improvements to the system (P-12 and P-14) required to meet buildout demands and associated planning and design criteria. These improvements are not included in Table 17 – Ten-Year Capital Improvement Plan as the additional demand would be introduced beyond the planning horizon.

Table 21 – CIP Projects For Buildout System

Priority Ranking	CIP ID	Project Name	Total Pipe Footage (FT)	Time Frame (years)	Risk Score	Category	Project Description
24	P-12	Dana Street Water Line Replacement	1200	> 10	-	Capacity or Fire Flow Deficiency	Increase 6-inch diameter to 10-inch
25	P-14	South Harbor Drive Water Line Extension	580	> 10	-	Capacity or Fire Flow Deficiency	Install New 12-inch Pipe

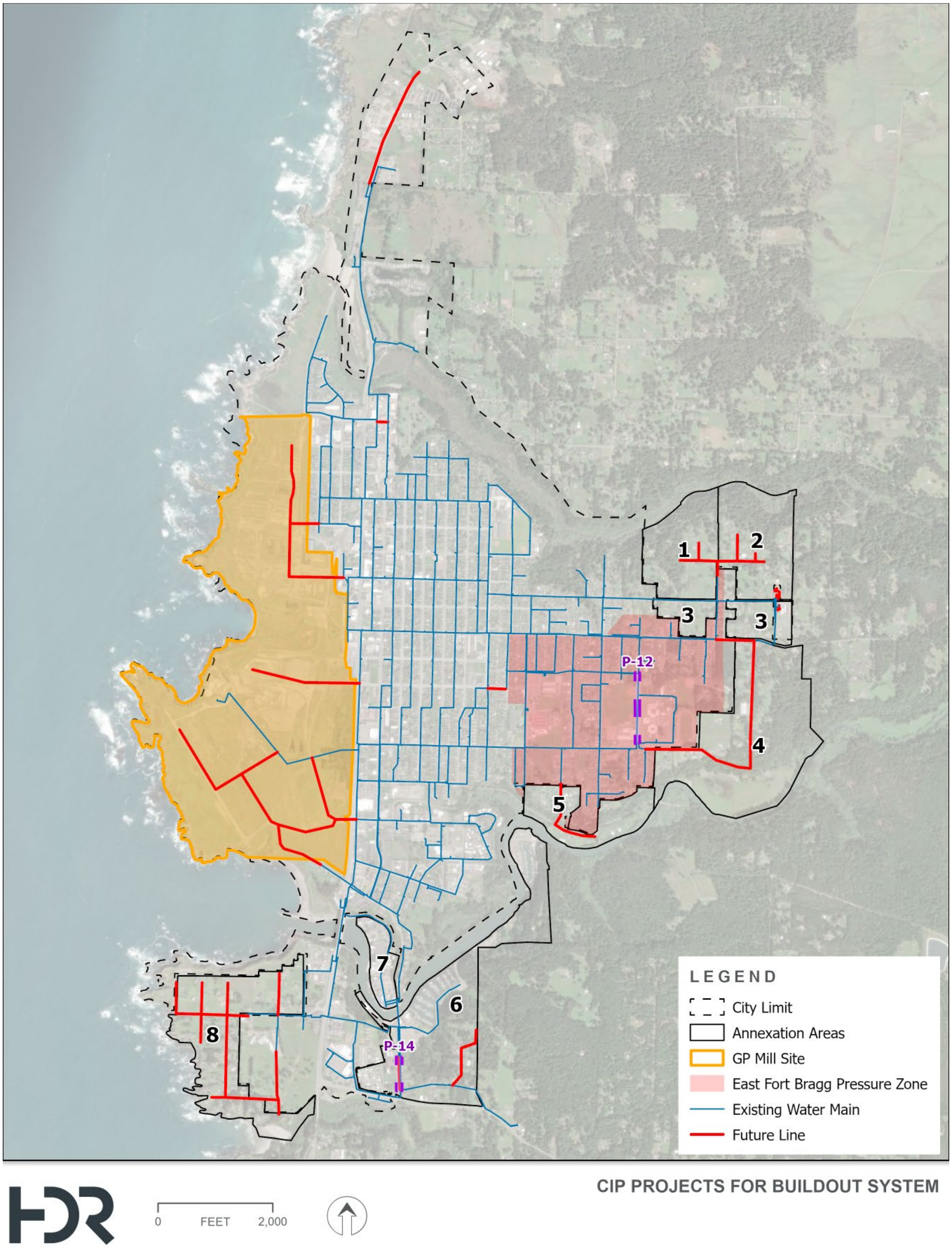


Figure 37 – CIP Projects for Buildout System

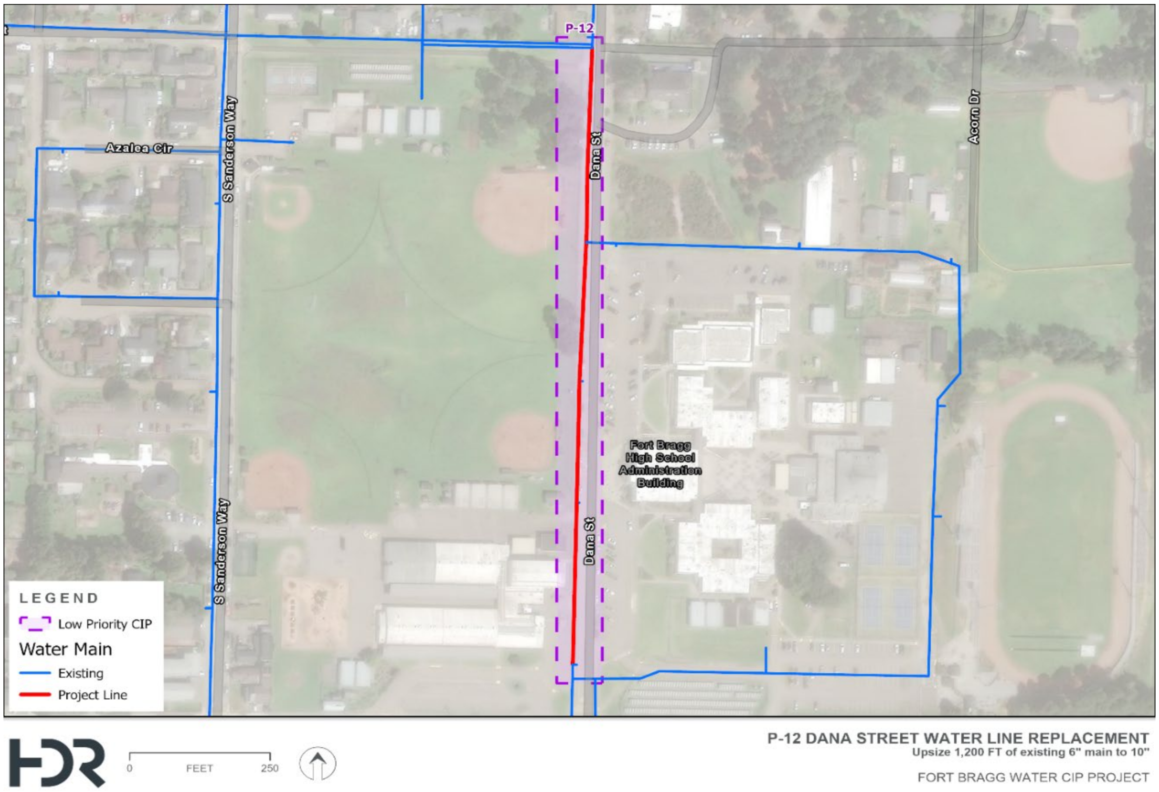


Figure 38 – P-12 for Buildout System

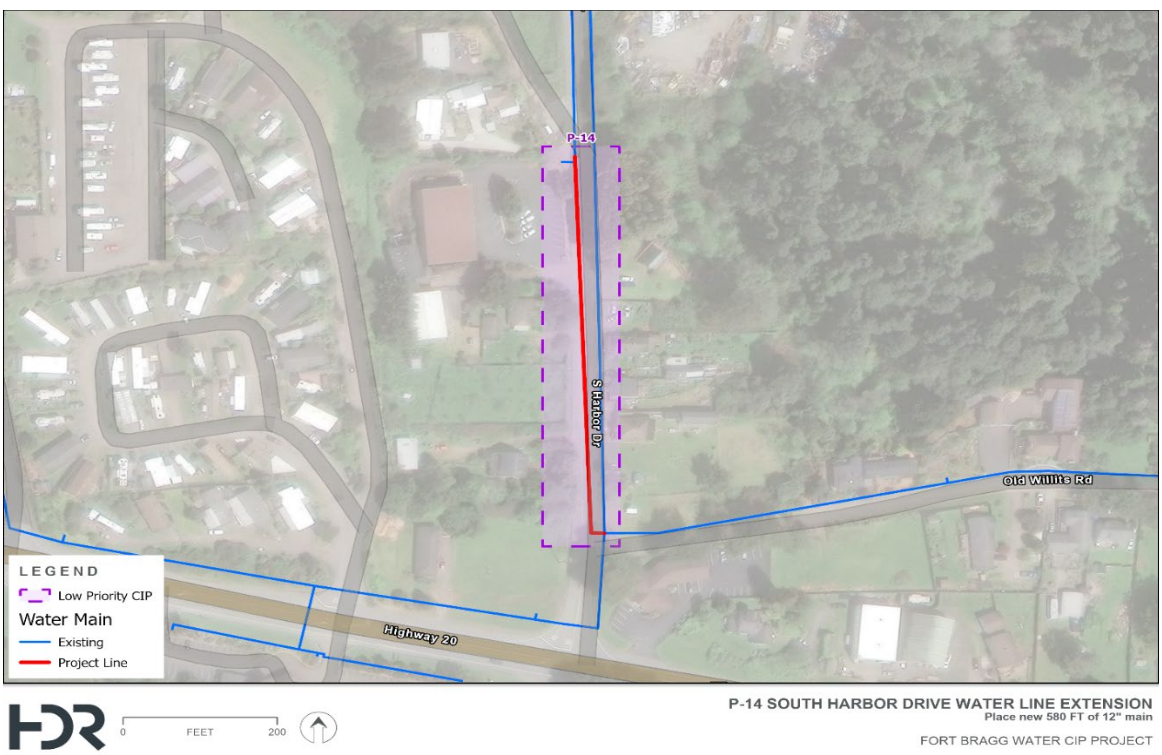


Figure 39 – P-14 for Buildout System

6.8 System Renewal

In addition to the current and future capacity analysis, another key component informing required capital improvement is the need for the proactive renewal of aging infrastructure. All infrastructure ages and deteriorates over time and requires rehabilitation or replacement for the City to continue to provide a consistent level of service to its customers. In general, the water distribution system is in good shape and aside from one tank project, no individual pipelines have been identified for immediate replacement based on condition. However, most of the system is reaching or has exceeded its expected useful life and will eventually require replacement or rehabilitation.

This section develops and presents a pipeline replacement program strategy for the City. The intent of the program is to leverage pipeline condition and risk scoring information to minimize system interruptions over time and implement the program affordably while meeting industry performance standards.

6.8.1 Renewal Strategy

An annual pipe replacement rate of 1% is recommended based on a benchmark comparison of the City's break data with break rates from other utilities. This rate of renewal, replacing approximately half a mile of pipe each year, results in full system replacement approximately every 100 years.

A break rate is defined as the average annual number of breaks per 100 miles of pipe, whereas a replacement rate represents the percentage of the entire pipe system replaced each year. The break rate for Fort Bragg was calculated using the formula below, and is expressed as breaks per year per 100 miles of pipe:

Break Rate = (Breaks Across Range / Year Range) / (Miles of Pipe / 100)

From the available break history data, Fort Bragg has experienced 13 breaks over the last 14 years. For a 41-mile system, this equates to 2.3 breaks per year per 100 miles. Figure 40 shows how this break rate falls in the low range of benchmarked utilities (dashed line).

While the City's current break rate is low, this rate should be anticipated to increase as the system continues to age. The American Water Works Association (AWWA) reports the average estimated service life for AC pipes is 75 to 105 years and 70 years for PVC pipe. City records indicate that approximately 20% of the system is 65 years old or older. 60% of the system is approximately 45 years old, and 22% of the system is 20 years old or newer. This means that by AWWA standards, 20% of the system is either at or expected to reach its anticipated expected useful life within the next 10 years. By establishing an annual recommended replacement rate, Fort Bragg can shift their investment strategy from reactive to proactive, which will limit unexpected impacts to critical customers and allow the City to progressively invest in system renewal, keeping investments and capital effort sustainable over time.

Figure 40 below illustrates the benchmark analysis comparing a 1% and 0.5% annual replacement rate against 26 benchmarked water utilities. The upper left side of this chart represents a higher level of service focus (i.e. a more proactive approach) and the lower right side represents a strategy that is near-term cost-focused (i.e. a more reactive approach). This benchmark assessment evaluated a 0.5% and 1% replacement rate for the City as shown by the two orange dots plotted at the City's calculated break rate of 2.3 breaks per year per 100 miles of pipe. While the City may benefit from a replacement strategy of 0.5% per year, which could offer a more cost-effective approach while still aligning with a higher level of service, at this rate, the entire system would only be replaced every 200 years, in contrast to a 100-year renewal cycle achieved with a 1% annual replacement rate.

The 1% rate equates to replacing approximately 0.5 miles of pipeline per year. The more aggressive, 1% rate is recommended for the 10-year planning period as a portion of the system is either approaching or past its expected useful life. This rate may serve as a planning benchmark for the City’s annual capital improvement budget and could be grouped in the form of larger projects on a multi-year cycle, such as every three to five years.

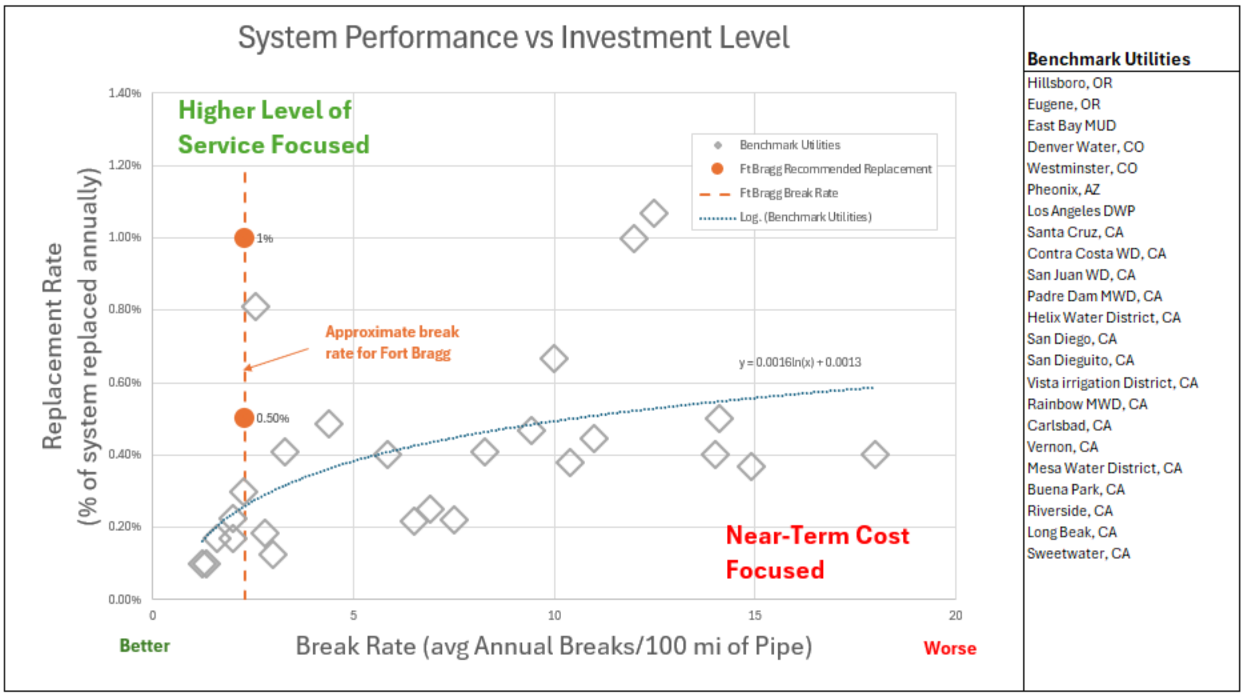


Figure 40 - System Performance vs Investment Level

This rate may be used for capital planning purposes, but it does not indicate which pipes should be prioritized for replacement. The City may consider several factors when deciding which pipes to replace and the replacement schedule. Factors to consider are:

- Water distribution pipe risk score
- Pipes shown to be in poor condition through opportunistic laboratory testing
- Upsizing recommendations based on hydraulic modeling
- New valve installation recommendations
- Other civil projects where water mains will need to be excavated or exposed

6.8.2 Pipe Condition Assessment

While a comprehensive condition assessment of the distribution pipelines was not a component of this Master Plan, some opportunistic testing of asbestos cement pipe was completed on pipe samples that were recently removed from the system during routine maintenance activities. The testing indicates the level of corrosion of the concrete in the pipe wall.

The purpose of this effort was to demonstrate the effectiveness of developing a cost-effective, on-going pipe sampling program to test pipe condition whenever the pipe is exposed for maintenance or service purposes. A line item for continual pipe testing is provided in the current capital plan.

Testing results ($T_{remaining}$), where T=pipe wall thickness are categorized based on the following condition categories.

- Very Poor (<55)
- Poor (55-70%)
- Moderate (70-76%)
- Good (76-83%)

The results for the three opportunistic test samples are listed in Table 22 below.

Table 22 – Summary of AC Pipe Testing Results

Sample ID	Sample Date	Diameter (in)	Approx. RUL (%)	Pressure (psi)	$T_{remaining}$	Condition
AC-1	8/1/2024	6	45	~57	55%	Poor (55-70%)
AC-2	1/11/2024	6	45	~25	63%	Poor (55-70%)
AC-3	4/25/2024	8	>50	~24	64%	Poor (55-70%)

Appendix G describes the testing process and provides greater detail on how to interpret these results. Pipes categorized as being in ‘poor’ condition like the samples above are not necessarily more likely to break when operating under standard conditions. However, should these pipes experience pressure surges, these pipes are more likely to break and may be more difficult to repair.

6.9 Risk Assessment

Risk assessment was used to prioritize capital improvement decisions in this Master Plan. A risk model was developed to assign a relative risk score to each water main, based on:

- **Likelihood of Failure (LoF)** How likely a pipe is to fail, based on factors like pipe age, break history, and seismic/geologic risk.
- **Consequence of Failure (CoF)** The impact of a pipe’s failure, particularly for critical customers, high demand areas, or hard-to-access locations.

The risk model provides each pipe a numerical risk score, quantifying the risk factors relative to the other pipes in the system. The factors used for LoF and CoF represent indirect evidence of the reliability and criticality of each pipe, however none of these factors provide direct evidence of pipe condition. Therefore, the risk model should be used to prioritize assessment and rehabilitation work but should not be relied upon as direct evidence that a rehabilitation action is needed. Additional assessment will be needed to determine the true condition of any given asset.

Examples of how the risk model can be used are:

- **Prioritizing existing capital projects** – When two or more projects are proposed (e.g. valve installation, pipeline expansion or enlargement) the risk model can be used to break a tie when other considerations are equal. If all other considerations are equal and one or more projects must be delayed, the pipe segment with the lowest risk score can be differed because the risks are comparatively lower.
- **Prioritizing condition assessment** – One of the programs initiated during this master plan is the testing of asbestos cement pipeline walls to determine the residual calcium remaining. This is a good indicator of pipeline condition. The risk model can be used to determine where to sample next. This enables the City to focus on the higher risk pipes and mitigate issues that indicate a high consequence of failure.
- **Prioritizing maintenance** – Maintenance staff frequently prioritize between multiple demands on their time. Using the risk model to determine what maintenance activities should be done first enables the City to make risk-based maintenance decisions.

The risk model can also be continually improved as the City collects more data, learns more about the system and implements system changes. Periodically the model should be evaluated against additional information to determine if it should be updated. If there are additional pipeline breaks, it would be useful to look at the risk model to see if the risk results are consistent with the conditions that caused the break. If additional asbestos testing is completed, it can be compared with the model results. As new infrastructure is added or replaced, the model can be updated to accurately reflect current conditions.

6.10 Unit Costs

This section discusses the unit costs used to develop the opinions of probable cost (OPC) for each of the recommended improvements described in the following sections. Unit costs and OPCs are based on information known at this time (e.g., system needs, projected growth rates, development patterns). Costs are order of magnitude, planning level costs and consist of construction costs; engineering, legal, and administrative costs; and expenditures for land acquisition. The OPCs are intended to assist in budgeting for the implementation of the CIP.

It should be noted that OPCs for projects vary depending on the phase of the project when they are developed, which determines the level of detail and the expected accuracy of the estimate. The Association for the Advancement of Cost Engineering International (AACE International) Recommended Practices, specifically Document No. 18R-97, outline typical cost estimate accuracy based on the overall status of the project. The cost estimates for the improvements discussed herein should be considered Study (Estimate Classification 4) level estimates with an expected accuracy of +50 to -30 percent. OPCs should be verified and updated during the pre-design phase of each project.

Project costs in the ten-year capital plan overview have been adjusted for inflation using Engineering News-Record's (ENR) Construction Cost Index (CCI). The ENR CCI is computed from prices of construction material and labor and is based on a value of 100 in the year 1913 and escalated each year. Cost data in this report are based on the 2024 ENR CCI (20-city average) of 11,455. Future CCI was projected using the formula for compound growth (see formula below) and assuming an annual escalation rate of 3%.

$$Future\ ENR\ CCI = Base\ CCI * (1 + r)^n$$

$$Base\ CCI\ (2024) = 11{,}455$$

$$r = Anual\ Escaltion\ Rate$$

$$n = number\ of\ years\ in\ the\ future$$

Project cost data presented in this report was adjusted using the ratio of the future CCI to the base (2024) CCI (see formula below). Projects were adjusted for the mid-point of their respective timeframes. For example, projects identified for the next 5 years were adjusted for 2027 dollars and projects identified for the five-to-ten-year range were adjusted for 2032 dollars.

$$Adjusted\ Project\ Cost = 2025\ Project\ Cost * \frac{Future\ ENR\ CCI}{Base\ CCI}$$

Construction costs are intended to cover the material, equipment, labor, and services necessary to build the proposed project. Prices used in this study were obtained from budgetary prices provided by vendors, as well as a review of construction costs from projects in the region, similar recent master plans in the region, cost estimating guides, and other pertinent sources of construction cost information.

Facility costs (e.g., pump station improvements) include allowances for site work, soil conditions, site piping, mechanical/HVAC, electrical, and instrumentation and control. Linear project costs (e.g., pipeline costs) include allowances for fittings and for incidental items such as dewatering, erosion control, traffic control, utility coordination and mitigation, and concrete removal and replacement.

Engineering, legal, and administrative services may include items such as preliminary investigations and reports, site and route surveys, geotechnical and foundation explorations, preparation of design drawings and specifications, engineering services during construction, construction observation, sampling and testing, start-up services, legal fees, financing fees, and administrative costs. The costs presented in this report include a 29 percent allowance, based on input from the City for design (12%), permitting (2%), and construction management (15%), and a 20% contingency.

6.10.1 Pipeline Unit Costs

Water pipeline unit costs include material costs, asphalt demolition, pipe demolition, and trench repair, in addition to the allowances and contingencies discussed above. Pipeline unit costs assume a material of C900 PVC pipe. Pipeline unit costs are provided in Table 23.

Table 23 - Pipeline Unit costs

Diameter	Construction	Design (12%)	Permitting (2%)	CM (15%)	Contingency (20%)	Total/LF
4"	$288.62	$34.63	$5.77	$43.29	$57.72	$430.04
6"	$314.17	$37.70	$6.28	$47.13	$62.83	$468.11
8"	$347.49	$41.70	$6.95	$52.12	$69.50	$517.76
10"	$369.60	$44.35	$7.39	$55.44	$73.92	$550.70
12"	$395.27	$47.43	$7.91	$59.29	$79.05	$588.95
14"	$420.56	$50.47	$8.41	$63.08	$84.11	$626.63
16"	$442.03	$53.04	$8.84	$66.30	$88.41	$658.62
18"	$481.20	$57.74	$9.62	$72.18	$96.24	$716.99
20"	$525.94	$63.11	$10.52	$78.89	$105.19	$783.65
24"	$616.40	$73.97	$12.33	$92.46	$123.28	$918.44
30"	$924.40	$110.93	$18.49	$138.66	$184.88	$1,377.36
36"	$1,063.08	$127.57	$21.26	$159.46	$212.62	$1,583.99
42"	$1,368.70	$164.24	$27.37	$205.31	$273.74	$2,039.36
48"	$1,534.56	$184.15	$30.69	$230.18	$306.91	$2,286.49

6.10.2 Valve Unit Costs

Valve unit costs include material costs, asphalt demolition, pipe demolition, and trench repair, in addition to the allowances and contingencies discussed above. Pipeline unit costs assume a material of C900 PVC pipe. Valve unit costs are provided in Table 24.

Table 24 - Valve Unit Costs

Description	Construction	Design (12%)	Permitting (2%)	CM (15%)	Contingency (30%)	Total/LF
8" Gate Valve	$9,049.85	$1,085.98	$181.00	$1,357.48	$1,809.97	$13,484.28
10" Gate Valve	$9,382.85	$1,125.94	$187.66	$1,407.43	$1,876.57	$13,980.45
12" Gate Valve	$11,049.85	$1,325.98	$221.00	$1,657.48	$2,209.97	$16,464.28

6.10.3 Tank Unit Costs

Tank unit costs are based upon recent bids received on similar tank projects. Tank unit costs assume a construction cost of $3.67 per gallon of storage and include the allowances and contingencies discussed above.

6.11 Other Capital Projects

This capital plan includes non-construction related projects that enable the City to continue to improve and refine capital planning and maintenance moving forward. These capital program-related projects are necessary for the City to respond to changing conditions, priorities, and requirements to meet customer, regulatory, and stakeholder needs over time. This section describes these projects that are included in Table 17 – Ten-Year Capital Improvement Plan (Projects O-1 through O-6).

6.11.1 Capital Plan Updates

It is recommended that the City update its 10-year capital plan at least every five years to adapt to changing conditions and update the need, timing, priority, and funding of identified CIP projects. This project provides budget for those updates. Key activities to be performed include updating the development of current and projected water demands, verification of hydraulic model accuracy, updating the risk model, and revising/extending the ten-year capital plan as appropriate.

6.11.2 Sampling of Asbestos Pipe

As discussed above, under System Renewal, the City should consider an annual budget for continual testing of asbestos cement pipe to assess the condition of the buried pipelines. The sampling will be opportunistic, meaning that a sample for testing will be obtained when the pipe needs to be exposed for maintenance or service. This cost-effective strategy will enable the City to identify corroded pipes and prioritize them for replacement before failure.

6.11.3 CMMS Needs Analysis

This section provides an overview of asset management and how it may be applied to enhance the City’s maintenance and capital planning process for the water distribution system. Part of this assessment includes a discussion of the current use of the computerized maintenance management system (CMMS) and opportunities for improvement. One of the observations from this analysis is that the CMMS is underutilized at the City and that it is not properly configured to meet the maintenance management needs for maintaining the water distribution and wastewater collection system. It is recommended that the City perform a needs analysis to identify what the CMMS needs to be able to do to most effectively support infrastructure maintenance. This will enable the City to evaluate the capabilities and deficiencies in the current CMMS system and develop a plan for improvement or replacement.

6.11.4 CMMS Acquisition and Implementation

Should the City decide to replace the current CMMS (see the CMMS Needs Analysis discussion above) this project provides the budget to select and implement a new system. Activities anticipated include development of system requirements and a request for proposal to solicit potential solutions, an evaluation process to select a viable system, and a budget for a standard, high-level implementation process for system setup and configuration, system validation, and user training.

CHAPTER 7 FUNDING OPPORTUNITIES

This section discusses the various funding opportunities and strategies that are available to the City and how they might be applied to the projects presented in the ten-year capital plan.

7.1 Overview

This section provides a summary of some of the grants and funding options from state and federal sources that may be considered for funding projects listed in section 6.2, Ten-Year Capital Plan Overview, above. No opinions or recommendations on debt or financing structures are provided as these decisions need to be made in the context of the City's financial situation, long-term financial plans, project costs, and funding available during the respective application period(s).

Significant recent changes have occurred in water infrastructure programs based on the new funding priorities of the Trump Administration. Since the passage of the Infrastructure Investment and Jobs Act (IIJA), the federal government has prioritized funding allocations for projects focused on resiliency, climate change, sustainability and green infrastructure. New federal priorities have transitioned to expanding and improving U.S. energy infrastructure. While there is still water infrastructure related funding available through IIJA, strategically aligning projects to specific programs and new federal priorities is an important next step to improve the likelihood of project funding and reduce the time and costs of applying to multiple programs.

In general, most funding programs cover construction costs as well as development phase activities, including preliminary engineering work and environmental document preparation, acquisition of property, legal work, and engineering design including permit fees. Costs incurred prior to a funding award may be covered, depending on the program-specific restrictions. Federal funding programs will have additional requirements—such as Davis-Bacon prevailing wages, Build America, Buy America Act or American Iron and Steel provisions, adherence to federal procurement (including Brooks Act), environmental review, etc.—as part of assistance agreements.

Timing wise, it is important to consider applying to these programs as early as practical since engineering and environmental review documents must be prepared and reviewed prior to commencing with construction. Preparing applications early leaves time for drafts to be reviewed by agency partners and proper permit acquisition prior to deadline requirements. Since each funding program has specific requirements surrounding permits and project timelines, the individual program's process, timeline, and requirements should be reviewed within the context of the City's overall goals, financial situation, project timelines, and debt policies. The following programs have been identified as potential funding sources for projects listed in the Master Plan and are summarized herein:

Water Infrastructure Finance and Innovation Act (WIFIA)

- Community Development Block Grants (CDBG)
- U.S. Department of Agriculture Water and Waste Disposal Loans and Grants
- Economic Development Administration (EDA) Grants

- Congressional Earmarks
- State Revolving Funds (SRF)

7.2 Water Infrastructure Finance and Innovation Act (WIFIA)

WIFIA is a long-term, supplemental loan program administered by the Environmental Protection Agency (EPA). This program is intended to move projects forward that need additional funding beyond the capacity of other funding programs (e.g., SRFs). WIFIA can provide direct loans and loan guarantees to eligible borrowers for water infrastructure projects. WIFIA can only fund 49 percent of project costs; other funding sources must be obtained for the other 51 percent. If other funding sources include other federal programs, the total federal involvement is limited to 80 percent. Most water-related infrastructure projects are eligible under WIFIA. All SRF eligible projects eligible under WIFIA. In addition to general costs associated with a project, WIFIA loans can also include debt issuance reserve funds and debt issuance costs.

Highlights of WIFIA:

- $7.5 billion in available funding until fully expended
- Funding available for 49% of project
- No more than 80% from federal sources
- $5 million project minimum for communities of 25,000 or less
- Interest based on U.S. Treasury securities
- Maturity up to 35 years
- Debt payments can be sculpted
- Defer payments up to 5 years after substantial completion
- If invited to apply after submittal of letter of interest, application fee is $100,000 (large communities) or $25,000 (small communities)
- Credit assurance review fee is typically $100,000–300,000 (application fee is credited)
- Service fees do apply for the life of the loan (+/- $8,000–26,000 per year)

WIFIA is typically used for larger projects with a minimum project size of $20 million. Similar projects 6in a capital improvement plan (CIP) can be combined to form one larger project to meet the minimum project size or to simplify the overall process by having one loan instead of multiple loans if the projects will be constructed over a limited timeframe (i.e., EPA suggests a 5-year period).

The interest rate on WIFIA loans is based on U.S. Treasury securities and may be lower than bonds (depending on maturity, ratings, and market). One advantage of WIFIA financing is the ability to defer repayment of principal and interest for 5 years after substantial completion of the project. Another potential advantage of WIFIA financing is the ability to negotiate the repayment terms. For example, U.S. Treasury rates at longer debt maturities may be much lower than other market debt instruments at the same maturity when compared to shorter term debt where the spread may be less. At shorter maturities, the spread between private market rates and U.S. Treasury rates may not be enough to provide a significant benefit. By issuing debt at a shorter maturity in the private market (for the 51 percent of costs that WIFIA will not cover) and then pushing WIFIA debt to a longer maturity (e.g., 30–35 years), sculpting repayments may provide a potential interest saving versus issuing both sources of debt at equal, longer maturities. However, bond markets and the U.S. Treasury securities market can vary significantly, and somewhat independently, year to year. WIFIA debt can be prepaid without penalty.

EPA accepts Letters of Interest (LOI) on a rolling basis from the date listed in the Notice of Funding Availability (NOFA). Prospective borrowers can submit a LOI for review by EPA on a rolling basis from the date listed in the NOFA until the earlier of (1) the commitment of all available funding made available for that round or (2) publication of a subsequent notice cancelling or overriding the current NOFA. A rolling selection process allows EPA to provide year-round access to WIFIA funding and quicker selection decisions to prospective borrowers. The LOI is essentially a pre-application that EPA reviews and prioritizes against other LOIs. If the project is prioritized within the funding range, EPA will invite the prospective borrower to make a formal application (the application $100,000 fee is then due). Prospective borrowers must submit a formal application within a year of the invitation to apply.

For example, if the City combined all the proposed near term improvement projects including the Cedar St. line replacement, Oak St. valves, Noyo water liner, and tank replacement into a single fundable water transmission project, the consolidated projects may be eligible for WIFIA funding under a single loan. The advantage of having all projects under a single loan would be securing funding for all the near-term projects. However, including all projects under a WIFIA loan would require every near-term project to be federally compliant with regulations including the National Environmental Policy Act (NEPA) and the Build America, By America Act (BABA). Adherence to federal environmental and sourcing requirements could increase the cost of projects, especially if it is difficult to source materials domestically based on BABA requirements. BABA compliance can increase the timing required for project planning and approval. WIFIA funding should primarily be used for projects with flexible implementation and construction timelines when possible.

7.3 U.S. Department of Housing and Urban Development Community Development Block Grants

The U.S. Department of Housing and Urban Development (HUD) provides annual funding to states, cities, and counties to stimulate the development of urban communities. In California, annual funding allocations are administered by the California Department of Housing and Community Development. Based on Federal and State requirements, eligible projects must benefit low- and moderate-income persons, aid in the prevention of extreme poverty areas, or meet an urgent need. Eligible non-entitlement applicants in California include cities with populations below 50,000 or counties with a population of less than 200,000. One of the eligible activities under the program are public improvements including water and wastewater system updates. For public facilities projects to be eligible, the improvement must directly benefit a disadvantaged community.

Based on recent U.S. census data, Fort Bragg has a median household income that is below the state average and a higher population of person in poverty when compared to the state average. Based on these statistics, valve and water line replacement projects may qualify for HUD funding if Fort Bragg can present a compelling case that improvements are needed to serve portions of the City with moderate income levels. Portions of the Noyo Center water line project may be eligible if it serves future developments that will address local housing needs. Fort Bragg should consider reaching out to the California Department of Housing and Community Development to discuss proposed water conveyance projects and how they align with the department's future funding priorities.

7.4 Economic Development Administration Public Works and Economic Adjustment Assistance Programs

The Economic Development Administration (EDA) awards grants for projects that advance economic development. Special consideration is given to projects that incorporate EDA priorities, including workforce development. Eligible projects include acquisition and improvement of land for public works use, water and sewer improvement projects, and other construction and pre-construction improvements that assist with community economic development. For the current funding cycle, EDA was appropriated $121.5 million for the public works program. Historically, the average grant award has been $1.4 million, but EDA expects awards in the current cycle to range between $600,000–5,000,000. The program has cost-match requirements, that vary depending on the community's relative needs.

The Noyo water line project may qualify for EDA grant funding if the City can show that the project will serve new developments and industries needed for local economic development. EDA's primary mission is to fund projects in communities that are experiencing economic stress due to loss of industry. Fort Bragg projects align with EDA priorities because the City's economy was built on timber and logging. With the recent reduction in lumber milling, the City could make a compelling case that it would benefit from funding due to economic challenges from loss of industry.

7.5 U.S. Department of Agriculture Water and Waste Disposal Loans and Grant Program

The United States Department of Agriculture (USDA) allocates funding for clean drinking water, sanitary sewer disposal, and stormwater drainage for households in eligible rural areas through Water and Waste Disposal Grants. Most state and local governmental agencies are eligible for funding. Eligible service areas include rural areas with populations of 10,000 or less and tribal lands in rural areas. Funding is available in the form of long-term, low-interest loans with up to a 40-year payback period. It should be noted that interest may be set at market rates for counties with a high median household income (MHI). A cost-benefit analysis should be used to evaluate if a USDA loan would be worth applying for when compared to water revenue bonds. To qualify, Fort Bragg must propose projects that expand services to very small, rural parts of the town. Eligible activities include legal and engineering fees, acquisitions, start-up operations and maintenance, interest incurred during construction, and the purchase of facilities to expand service. Potentially applicable interest rates are shown in Table 25.

Table 25 – Interest Rates Effective April 1, 2025

Financial Status	Interest Rate
Poverty	2.500%
Intermediate	3.375%
Market	4.250%

Fort Bragg qualifies as a small and rural community based on the USDA's eligibility criteria of providing loans to populations of 10,000 or less. For large projects including the tank replacement at the water treatment plant, the low interest rates offered by the USDA may offer some cost savings over the lifetime of the project when compared to market interest rates. USDA loan funding should primarily be used to fund larger projects that cannot be funded primarily through rate revenues and reserves.

7.6 Congressional Earmarks

Earmarks are direct congressional funding for a specific local project. Earmarks are administered through federal agencies and projects must qualify based on established program requirements. Earmarks are not merit based and circumvent the traditional grant application process. Earmarked projects are selected for funding and then follow an application process to ensure projects meet agency/program guidelines. Accessing earmark funding requires direct support from a congressional representative. To receive earmark funding, the utility needs to have a strong connection to a congressional representative and have direct meetings to present the value of the project to the state/county/community.

Future SRF funding may be reduced significantly due to allocations of funding to earmarks. In the 2024 House Appropriations Bill for SRF funding, the Appropriations Subcommittee approved an appropriations bill that allocated 46% of drinking water state revolving funds (DWSRF) funding as congressional earmarks. The amount of funding distributed to each state is determined through a formula after all earmarked funding has been removed. Annual funding allocations through the SRF program in FY2025 were significantly lower compared to previous years. In FY2026, congress elected not to earmark SRF funding and the entirety of the SRF allocations will be allotted to the states. However, the trend of earmarking funds from the SRF programs may continue in the future. If Fort Bragg has a high priority project, it could consider reaching out to a congressional representative about earmark funding for the project. Earmarked funding could result in significant saving for the City if awarded.

7.7 State Revolving Funds

SRF programs are low-interest, revolving loan programs administered by the state with EPA oversight. There are two SRF programs: the Clean Water SRF and the Drinking Water SRF (DWSRF). The DWSRF distributes funding annually for drinking water utility projects and infrastructure improvements. Examples of eligible projects include treatment facility upgrades, rehabilitation of wells or development of sources to replace contaminated sources, and transmission and distribution improvements. SRF requirements in many states, including California, are a mixture of federal and state-level requirements based on state law or state management preferences.

For example, federal statutes limit additional subsidization to disadvantaged communities (DACs), but the state SRF will have discretion on how a disadvantaged community is defined for their state program. The California DWSRF program is administered by the California Water Board and operates as a direct local loan program. Based on federal regulations, states must set interest rates for loans below market rates. The California Water Board set interest rates at 1.9% for 2025. Loan repayment periods are typically less than 30 years but a maximum term of 40 years. The DWSRF interest rates for specific funding allocations in federal fiscal year (FFY) 2024/2025 are provided in Table 26.

Table 26 – DWSRF Interest Rates

Loan	Community Type	Interest Rate	Loan Forgiveness
Planning	<3,300 connections or <10,000 persons <80% of state MHI	N/A	Up to 100%
Forgivable Loans	Small DAC	N/A	Up to 100%
Repayable Construction	Small SDAC with Water Rates >=1.5% MHI	0.00% Interest	Up to 100%
Expanded Repayable Construction	Small DAC or Expanded Small DAC/SDAC	½ General Obligation Bond Rate	N/A

Base Program Principal Forgiveness Principal forgiveness (equivalent to a grant and referred to as a grant in some cases by the SRF program) is available in the base program to help small and disadvantaged communities fund water infrastructure projects. These are applied to applicants that intend to obtain an SRF subsidized loan.

Entities meeting the criteria for financial hardship consideration may be eligible for reduced interest rates and loan principal forgiveness. Principal forgiveness eligibility is predominantly based on the medium household income (MHI) of the community a water system serves. The size of the population served also contributes to the interest rates or loan forgiveness awarded for a project. The types of projects eligible for forgiveness either address a public health order or a drinking water emerging contaminant. Some forgiveness is also available for projects eligible for Green Project Reserve funding (GPR) with a sustainability factor. GPR funding is reserved for projects that utilize green infrastructure, create energy saving, or have some environmental benefits. The DWSRF DAC criteria and principal forgiveness criteria is provided on Table 27 and Table 28, respectively.

Table 27 – DWSRF Disadvantaged Community Citeria

Disadvantaged Community Definitions	
Disadvantaged Community= MHI 80% or Less of State Annual MHI	
Disadvantaged Community (DAC)	MHI <80% statewide MHI
Small Community	<3,300 connections or <10,000 people
Expanded Small Community	3,3000-6,600 connections or 10,000 – 20,000 people
Medium DAC	20,000 – 100,000 people and a MHI< 80% state MHI

Table 28 – DWSRF Principal Forgiveness Criteria

Construction Grants and Principal Forgiveness			
Type of Community	Residential Water Rates as a % of MHI	% of Total Eligible Project Cost	Max Amount Per Connection
Small DAC/SDAC; Eligible NTNC That Serves a Small DAC/SDAC; Expanded Small DAC/SDAC; or Small Non-DAC with MHI < 150% of Statewide MHI	N/A	Up to 100%	$80,000
Medium DAC	>=1.5%	Up to 50%	$40,000

After an initial review, Fort Bragg may meet the disadvantaged community requirements. The 2022 census lists Fort Bragg's MHI as $47,662 which is 52% of the state MHI of $91,551. The City's population in 2022 was 6,919 which is also below the small community definition of having a population of 10,000 or less. Depending on the project Fort Bragg may be eligible for principal forgiveness/grant funding through the state SRF program. It is recommended to City confirm its eligibility with a State Water Board representative. The DWSRF application and funding schedule is provided in Table 29.

Table 29 – DWSRF Schedule

Historical Schedule of Annual Water Board SRF Milestones	
Submit Capitalization Grant Applications to the U.S. EPA	June
Draft Intended Use Plan (IUP) and Draft Supplemental IUPs Posted for Public Comment	June
Board Workshop	July
Deadline for Public Comments on Draft IUP and Draft Supplemental IUPs	Late July
State water Board Considers IUP and Supplemental IUP at Regularly Scheduled Meetings	August
Receive Capitalization Grant Agreements from the U.S. EPA	October

All the near-term CIP projects would likely qualify for SRF funding. The City should prioritize applying for SRF funding with projects that have the greatest societal benefit. Projects that serve disadvantaged portions of the community and improve public safety will score highest on the SRF scoring criteria. Additionally, the City should apply for projects where other alternative funding sources are not available. The Noyo Center water line may be partially funded through developer agreements. Therefore, projects like the Cedar St. water line replacement, Oak St. valves and the tank replacement should be prioritized when applying for SRF funding.

The SRF process should be started early in the project schedule, particularly if bond supported loans are needed. In California, application packages including environmental reviews should be completed in the spring to be eligible for the upcoming fiscal year. If projects are selected and placed on the state's intended use plan, it may take a year or more for contracts to be approved and for the project to receive funding. If the City intends to use SRF funding for any proposed projects, it is suggested that conversations with Water Board officials begin approximately a year and a half before project funding is needed. It should also be noted that eligibility for SRF funding is contingent on completion and approval of environmental reviews before the start of any construction activities.

7.8 Funding Recommendations

As outlined in the Fort Bragg Master Plan, some of the City's water infrastructure including the Cedar St. water line and Noyo Center Water line need to be upsized to properly serve portions of the City and provide adequate fire flow. Other treatment facility components including a storage tank are aging and in need of replacement. Installing and improving the City's water conveyance infrastructure would be a significant undertaking and the City should develop an initial funding plan to evaluate how it could pay for new and improved water infrastructure. Table 26 outlines the funding mechanisms described in this section and what near term CIP projects may be eligible based on eligibility requirements. One or several of these programs and strategies could be utilized when considering how to fund long-term CIP projects. Additionally, Table 27 describes the current available funding levels and type of funding mechanisms for each program that has been identified as a potential funding mechanism for Fort Bragg. It is important to note that funding levels and eligibility requirements are prone to yearly changes. The tables below provide initial funding guidance, but updated funding availability and program requirements should be reviewed before developing an application.

Long-term, water rate increases may be needed to recover revenue for projects that do not closely align with grant priorities. For other projects that serve new development areas like the Noyo water Line, developer agreements should be leveraged when possible. This will allow the City to focus its attention on applying for other improvement projects like water line replacements and tank upgrades. It is best practice to conduct a rate study every five years to project revenue requirements based on anticipated increases in operations and maintenance (O&M) costs. For larger system improvement and expansion projects beyond localized sewer main extensions, long-term debt like SRFs, WIFIA, and Water Revenue Bonds will likely provide more support than many of the grant programs that are more prone to year-to-year budget decisions. For treatment capacity expansions and infrastructure modernization projects over $20 million, WIFIA loans could be considered. All the near-term CIP projects including the Cedar St. Water Line Replacement, Oak St. valves, Noyo water line, and tank replacement could also be combined into a single application for WIFIA as a larger water transmission improvement project. Although current WIFIA interest rates are not as competitive as they were previously, the ability to defer principal payments and sculpting repayments is worth consideration. Programs like WIFIA will only fund new infrastructure projects, long-term maintenance and repairs should predominantly be funded using water rate revenue when possible. Mid-sized projects like the Cedar St. water line and Oak St. valves could be funded through a combination of rate increases, and SRF funding.

The loan process should be started early whenever possible, and efforts in capital improvement planning can aid this process. When planning for future land use changes, capital improvement planning with funding programs in mind is important in securing funding and allowing for a quick response when additional funding opportunities arise. When developing a funding strategy, it is helpful to develop a long-term plan which includes project milestones and how they line up with funding application deadlines. Developing a long-term funding plan would allow the City to apply for program funding early, providing adequate time for necessary environmental and compliance reviews that can create project delays and delay funding awards.

As described in the grants section, some grant funding is available that may cover the cost of system expansions that service low income and disadvantage communities. Based on U.S. Census and SRF criteria, Fort Bragg qualifies as a low-income disadvantaged community. The City's disadvantaged status can be leveraged when applying to programs like HUD Community Development Grants and the EDA Public Works and Economic Adjustment Assistance Program. When applying for grants, projects that improve transmission or serve disadvantaged parts of the City should be prioritized. For EDA funding, the Noyo Center water line may be eligible if the City can show that it will serve new developments that are needed for local economic development.

New Federal funding priorities have made grant funding levels more uncertain. Some annual funding programs have temporarily paused or halted funding allocations all together. With uncertainty regarding the future of some federal grant programs, the City should not rely on grants as the primary mechanism of project funding but monitor funding notices and maintain communication with funding agencies to learn about updates to grant funding availability as soon possible to maximize the potential for these outside funding sources. Project planning, initial environmental reviews, and early engineering designs should be developed as soon as possible. Starting to plan early will assist with the development of grant applications that will have limited application windows when notices of funding availability are posted. A correlation of the City's water system CIP and potential funding source eligibility is provided in Table 30. A summary of the criteria associated with the potentially applicable funding sources is provided in Table 31.

Table 30 – Potential Funding and Project Eligibility Matrix

CIP ID	Project Name	WIFIA	HUD CDBG	EDA Public Works	USDA Loans and Grants	EPA SRF
P-1	Cedar Street Line Replacement	X		X		X
V-1	Oak Street Valves	X		X		X
P-2	North Fort Bragg Water Main Extension	X		X		X
T-1	Tank 1 Replacement	X		X		X

Table 31 – Available Funding Summary

Source	Funding Type	Available $[a]	Notes
WIFIA	Long-Term Loan	49% of eligible projects over $20M and $5M for small communities	• Interest rate based on U.S. Treasury Securities • Maturity up to 35 years • Sculpted debt • Letters of Interest on a rolling basis
DWSRF	Loan/Some Grant Funding Available	$391M	• Low interest for 20-year maturity • Available $ = CA FY25 funding allocation • Amount of funding likely to decline after 2026 • Broad eligibility

Source	Funding Type	Available $[a]	Notes
HUD Community Development Block Grants	Grant	2025 Allocation not announced	• Funds allocated to state, city, and county • Project must resolve a problem that will help revitalize the community • Short project completion window, 24 months
EDA Public Works and Economic Adjustment	Grant	$30 million	• Must promote economic development in disadvantaged areas • Percent match requirements depending on disadvantaged status
USDA Water and Wastewater Loans and Grants	Predominately loans and some grants	Varies based on annual funding allocations	• Projects must serve rural communities (population less than 10,000) • Interest rates vary based on communities disadvantaged status • Up to 40-year payback period

[a]Available funds provided in 2025 dollars

CHAPTER 8 CEQA COMPLIANCE

The California Environmental Quality Act (CEQA) was passed in 1970 and as defined in CEQA Guideline 15002 General Concepts subsection a, is intended to:

1. Inform governmental decision makers and the public about potential, significant environmental effects of proposed activities.
2. Identify the ways that environmental damage can be avoided or significantly reduced.
3. Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible.
4. Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

CEQA governs public actions and does not apply to private actions unless the action involves governmental participation, funding, or approval (CEQA Guidelines 15002 (c)). Such actions are referred to as "Projects", and the definition of a Project has been refined by court decisions. Complying with CEQA involves evaluating potential impacts from the proposed Project on the natural and human environment. These impacts cover a broad range of more than twenty resources, including but not limited to air quality, biological resources, transportation, recreation, and wildfire threat.

As a planning process, CEQA should be started at the earliest feasible time in Project development, but late enough so that they provide meaningful information in the environmental analysis (CEQA Guidelines 15004).

8.1 Levels of Documentation under CEQA

The level of review a project is subject to under CEQA varies based on the expected impacts from that project. Once established as a project that is subject to CEQA review, there are three general levels of review under which a project may be considered: Exemption, Initial Study (IS), and Environmental Impact Report (EIR). These review levels are briefly discussed below, with a focus on opportunities they present for streamlining the review process and their vulnerabilities to legal challenges.

8.1.1 Exemptions

Two types of exemption exist under CEQA. Statutory Exemptions are exempt by law. Categorical Exemptions are classes of projects that have been found to have less than significant environmental impacts. Statutory Exemptions are listed in Article 18 of the CEQA Guidelines (Sections 15260 to 15285), and Categorical Exemptions are detailed in Article 19 (Sections 15300 to 15333). The degree of exemption varies between completely exempt, exempt from part of CEQA's requirements, or exempt just to the timing of CEQA compliance.

Categorizing a project as exempt from CEQA can simplify regulatory requirements, however there are significant limits to how exemptions may be employed. There are many conditions that provide exceptions to exemptions, for example the presence of a scenic highway, or of critical habitat for a species of special concern could override the applicability of categorical exemptions under classes 3, 4, 5, 6, and 11.

Further, the empowering statute for CEQA, California Public Resources Code Division 13, Section 21159.27, includes a prohibition against 'piecemealing'. Piecemealing is first defined in Bozung v. Local Agency Formation Com. (1975) which states:

- Environmental considerations do not become submerged by chopping a large project into many little ones – each with a minimal potential impact on the environment – which cumulatively may have disastrous consequences.

Laurel Heights Improvement Assn. v., Regents of University of California (1988) refined this discussion by providing the following test:

- We hold that an EIR must include an analysis of the environmental effects of future expansion or other action if: 1) it is a reasonably foreseeable consequence of the initial project; and 2) the future expansion or action will be significant in that it will likely change the scope or nature of the initial project or its environmental effects.

To summarize, the analysis of a project that is contingent upon another project being completed is not adequate without the inclusion of analysis of that project. Use of multiple exemptions to reduce paperwork within a project may seem appealing, however such use can create a significant effect on the environment and make the projects vulnerable to legal challenges.

Many other cases have tested this level of review; however, Laurel Heights remains the benchmark for evaluation of whether a project is part of a larger endeavor that has been piecemealed. The piecemealing question and test is an important consideration when evaluating the use of exemptions for implementation of a large, long-term program.

8.1.2 Initial Study

Projects that are not Statutorily or Categorically exempt from CEQA, often start with an environmental review through the preparation of an Initial Study (IS). If the IS identifies no significant impacts, the project may adopt a Negative Declaration and proceed with implementation. If the IS identifies significant impacts, but the impacts can be reduced to a less than significant level through mitigation then the project may adopt a Mitigated Negative Declaration (MND) and proceed. Projects with significant impacts that cannot be mitigated to less than significant levels must be evaluated in an Environmental Impact Report (EIR).

8.1.3 Environmental Impact Reports

An EIR is recognized as the 'gold standard' of CEQA documentation and analysis within an EIR requires substantial evidence. EIRs must evaluate the impacts of a proposed Project, alternatives to the proposed Project that can feasibly accomplish the Project's objectives and may reduce environmental impacts, and mitigation measures that may be used to reduce Project impacts to a less than significant level. EIRs include a period of public review, during which public agencies and individuals may provide comments on the adequacy and accuracy of the document.

Ideally, an EIR will identify an environmentally superior alternative that is feasible and accomplishes the Project's goals while causing no significant and unavoidable impacts. However, often an EIR identifies and evaluates an alternative that is feasible, meets the Project's objectives, avoids and minimizes some impacts but still results in some significant impacts. In this instance, the lead agency may still certify the EIR and pursue their preferred alternative through the publication of a Statement of Overriding Considerations (SOC) as part of their decision making.

There are several types of EIR, intended to provide an opportunity to streamline the process and facilitate environmental review and CEQA compliance. These include a Project EIR, Staged EIR, Program EIR, and Master EIR. This section will not address Staged EIRs as they are less appropriate for city-wide, or district wide projects.

8.1.3.13 Project EIR

The Project EIR is the most common of EIR types. These evaluate the impacts of a specific Project and focus on changes in the environment that would result from the Project. Such analysis must include all elements of the Project including planning, construction, and operation (CEQA Guidelines 15161).

8.1.3.14 Program EIR

A Program EIR is defined in CEQA Guidelines 15168:

> (a) General. A program EIR is an EIR which may be prepared on a series of actions that can be characterized as one large project and are related either:
>
> 1) Geographically,
> 2) As logical parts in the chain of contemplated actions,
> 3) In connection with issuance of rules, regulations, plans, or other general criteria to govern the conduct of a continuing program, or
> 4) As individual activities carried out under the same authorizing statutory or regulatory authority and having generally similar environmental effects which can be mitigated in similar ways.

A Program EIR has multiple advantages in streamlining complicated projects and subsequent review, as the document can be relied upon for related projects. This reduces repetitive analysis, broadens consideration of cumulative impacts, considers a wider range of alternatives before the lead agency has committed to a specific course, and can reduce paperwork. A program EIR also allows other activities to be performed under its auspices, assuming no substantial changes have occurred to the project, the circumstances under which it is undertaken, or new information is discovered (CEQA Guidelines 15168(c)). A project that is not specifically included in the scope of a Program EIR will not be evaluated under PRC 2166's deferential standard of review but may be included under the fair argument standard. This has been successfully defended in court (Friends of the College of San Mateo v. San Mateo County (2016)) and provides a less rigorous standard of review than a new EIR.

8.1.3.15 Master EIR

A Master EIR evaluates the cumulative, growth inducing, and irreversible significant impacts on the environment of subsequent projects. It is intended to streamline review of subsequent projects for the classes laid out in CEQA Guidelines section 15175. The following list omits those sections that would not be relevant to utilities redevelopment or rehabilitation within Fort Bragg:

1. A general plan, or component update, element, amendment, or specific plan
2. Public or private projects that will be carried out or approved pursuant to, or in furtherance or, a redevelopment plan
3. A project that consists of smaller individual projects which will be carried out in phases
4. A rule or regulation which will be implemented by later projects
5. Projects that will be carried out or approved pursuant to a development agreement

Of particular note in regards to the preparation of a Master EIR for use in streamlining a Capital Improvement Program, CEQA Guideline 15176 (b)(4) states that a Master EIR shall include a description of anticipated subsequent projects within the scope of the Master EIR including a capital improvement program that governs the submission and approval of subsequent projects, or an explanation as to why practical planning considerations render it impractical to identify any such program or scheduling or other device at the time of preparing the Master EIR.

Tiering under CEQA

Tiering is defined under CEQA Guidelines Section 15152 (a)

- “Tiering” refers to using the analysis of general matters contained in a broader EIR (such as one prepared for a general plan or policy statement) with later EIRs and negative declarations on narrower projects; incorporating by reference the general discussions from the broader EIR; and concentrating the later EIR or negative declaration solely on the issues specific to the later project.

As such, Tiering can be applied to streamline environmental review in projects that follow from and are largely covered by a precedent environmental document, including a Master EIR; however, when Tiering a CEQA document from another one, if the precedent document includes an SOC, any document Tiering off of it will need to adopt another SOC, as established by Communities for a Better Environment v. California Resources Agency (2002). Establishing the intent and coverage of a Master EIR is important in calibrating the document’s scope, and when done effectively they simplify CEQA compliance, reduce paperwork, and manage many of the sorts of constituent projects that may be otherwise exempt or ministerial, without opening them to a meaningful piecemealing challenge.

8.2 Level of Effort for Environmental Compliance: Fort Bragg’s Water Enterprise CIP

8.2.1 Expected Notice of Exemptions (NOEs) for City CEQA Compliance

Some projects and improvements in the WDMP may be covered by a Categorical or Statutory exemption and be exempt from evaluation under CEQA. Statutory exemptions were recently expanded by Senate Bill 131, passed on June 30 of 2025. Exemptions expected to be useful in the CIP complying with CEQA are listed below.

Statutory Exemptions

- CEQA Statutes Section 21080.47 includes exemptions from CEQA for certain community water systems. As noted above, these exemptions were expanded due to Senate Bill 131. Despite these expansions there are still some additional requirements that will need to be observed to make use of this exemption. The project must meet the following conditions:
  - Does not affect wetlands as defined in the United States Fish and Wildlife Service Manual 660 FW 2 (June 21, 1993), or an environmentally sensitive habitat area within the coastal zone, as defined in Section 30107.5.
  - Unusual circumstances do not exist that would cause a significant effect on the environment.
  - Is not located on a hazardous waste site that is included on any list compiled pursuant to Section 65962.5 of the Government Code.
  - Does not have the potential to cause a substantial adverse change in the significance of a historical resource.
  - The construction impacts are fully mitigated consistent with applicable law.
  - The cumulative impact of successive reasonably anticipated projects of the same type as the project, in the same place, over time, is not significant.

None of these exceptions are expected to apply to projects within the City of Fort Bragg and covered by the Inland General Plan. If any of these exceptions are found to be applicable to a specific project proposed by the CIP, that project would require further evaluation to confirm applicability and before it could be implemented.

- CEQA Statutes Section 21080.21: Public Right-of-Way Projects less than One Mile in length.

Categorical Exemptions

- Class 2 Replacement or Reconstruction (c) On-site replacement of utility systems and/or facilities involving negligible or no expansion of capacity.

Categorical Exemptions do not apply to all projects. Projects that would normally be exempt from CEQA under one of these classes are excepted if:

- The project is located in a particularly environmentally sensitive area, where a normally insignificant impact may be substantial.
- Multiple projects of the same type in the same place would cause a significant cumulative impact over time.
- The project would result in a significant effect, due to unusual circumstances.
- The project may result in damage to scenic resources.
- The project would be located on a list of hazardous waste sites compiled under Section 65962.5 of the Government Code.
- The project would cause a substantial adverse change to a historical resource.

8.2.2 Environmentally Clearing Individual Projects

This section evaluates CEQA clearance on a project-by-project basis. The updates to CEQA Statutes Section 21080.47 from SB 131 expand the exemptions available to streamline CEQA compliance for projects within the City of Fort Bragg that are in existing public rights-of-way and also in areas covered by the Inland General Plan.

CIP Projects that qualify for CEQA exemption under CEQA Statutes Section 21080.47

The following definitions from the revised CEQA Statutes Section 21080.47 establish the foundation for compliance with CEQA.

- Small Community Water System – A Community Water System is defined in the PRC as a public water system that serves at least 15 service connections used by yearlong residents, or that regularly serves at least 25 yearlong residents within the area served by that system. It qualifies as a "small" system if that system serves no more than 3,300 service connections, or a yearlong population of no more than 10,000 persons.
  - According to 2023 American Community Survey Data (U.S. Census Bureau 2023), the City of Fort Bragg has a population of 7,001. As such, it falls between 25 yearlong residents and serves no more than 10,000 yearlong persons, thereby qualifying as a Small Community Water System.
- Disadvantaged Community - a community with an annual median household income that is less than 80 percent of the statewide annual median household income.
  - According to 2023 American Community Survey Data (U.S. Census Bureau 2023), the City of Fort Bragg has a median household income of $53,580. Median household income for the state of California in the same survey is $96,334. This puts the City of Fort Bragg's median household income at 56 percent of that of California, less than the 80 percent threshold that qualifies as disadvantaged.
- These points together demonstrate that, by definitions set forth in CEQA Statutes Section 21080.47, the City of Fort Bragg's water system qualifies as a "small, disadvantaged community water system".
- Project - under CEQA Statutes Section 21080.47 certain specific infrastructure elements are defined as a project. The most salient to the City of Fort Bragg's CIP are listed below:
  - Drinking Water Storage Tanks with a capacity of up to 250,000 gallons,
  - Booster pumps and hydropneumatics tanks,
  - Pipelines of less than three miles in length in a road right-of-way,
  - Water service lines,
  - Minor drinking water system appurtenances, including, but not limited to, system and service meters, fire hydrants, water quality sampling stations, valves, air releases and vacuum break valves, emergency generators, backflow prevention devices, and appurtenance enclosures.
- Note that CEQA Statutes Section 21080.47 specifically excludes "Facilities that are constructed primarily to serve irrigation or future growth".

As Fort Bragg's system fits the statutory definition of a small, disadvantaged community water system and many projects included in the CIP are pipelines within existing road right-of-way, or otherwise included in the statutory definition of "project" outlined above, these projects are presumed exempt from CEQA, absent any of the exceptional circumstances outlined under Statutory Exemptions in Section 8.2.1. These projects include: The Willow Street Pump Station Upsize Project (PS-1), Oak Street Valves Project (V-1), Cedar Street Water Line Replacement Project (P-1), System Renewal-Pipe Replacement Project (PL-1), East Laurel Street Water Main Replacement Project (P-2), North Main Street Water Main Replacement Project (P-6), East Alder Street Water Main Replacement Project (P-13), Chief Celery Dr Water Main Replacement Project (P-10), Noyo Point Road Water Main Replacement Project (P-4), Maple Street Water Main Loop Project (P-8), East Elm Street Water Main Loop Project (P-5), East Chestnut Street Water Main Replacement Project (P-9), Spruce Street Water Main Replacement Project (P-11), and System Renewal-Pipe Replacement Project (PL-2).

Should any circumstance listed as an exception to 21080.47 listed in section 8.2.1 arise during project planning or implementation, additional evaluation may be required. Otherwise, to demonstrate and record Project compliance with a Statutory Exemption under CEQA, the City would need to file a Notice of Exemption with the State Clearinghouse and Mendocino County.

CIP Projects not covered by CEQA Statutes Section 21080.47:

The CIP Projects that do not meet the CEQA Statutes Section 21080.47 Exemption conditions include the Tank 1 Upgrade Project at the treatment plant, the North Fort Bragg Water Main Extension Project, and the Noyo Center Water Line Project. These three Projects are discussed below.

The North Fort Bragg Water Main Extension Project (P-3) would install 2,144 feet of new water main, to serve future growth. The proposed alignment is within the right-of-way of Highway 1. As such, the North Fort Bragg Water Main Extension falls under the exemption in CEQA Statutes Section 21080.21, "…any project of less than one mile in length within a public street or highway or any other public right-of-way for the installation of a new pipeline…". Therefore, implementation of P-3 would be exempt from CEQA. To demonstrate and record Project compliance with this Statutory Exemption under CEQA, the City would need to file a Notice of Exemption with the State Clearinghouse and Mendocino County.

The Tank 1 Upgrade Project (T-1) at the treatment plant exceeds 250,000 gallons of capacity and therefore would not be exempt under CEQA Statutes Section 21080.47 or any other Statutory Exemption. The Project is, however, Categorically Exempt under a Class 2 exemption for replacement of a facility on-site with no expansion in capacity. To demonstrate and record Project compliance with this Categorical Exemption under CEQA, the City would need to file a Notice of Exemption with the State Clearinghouse and Mendocino County.

The Noyo Center Water Line (P-2) is located in the Coastal Zone and would require additional investigation before it could be properly evaluated under CEQA Statutes Section 21080.47, furthermore this project is intended to serve future growth, and as such is specifically excluded from that exemption. The Noyo Center Water Line does not exist within a public right-of-way and therefore is not exempt under CEQA Statutes Section 21080.21. An Initial Study or EIR would likely need to be prepared before the Noyo Center Water Line could be implemented.

8.2.3 Program Environmental Impact Report(s)

There are multiple ways that the City could scope the development of one or more Program EIRs. A Program EIR could potentially address all WDMP projects. A Program EIR could be focused to present mitigation as necessary to reduce impacts during construction within the right-of-way and to lessen or avoid impacts to Air Quality, Noise, Utilities, Public Services, Transportation and other resources. In the event of multiple Program EIRs being prepared it would be possible to focus them more tightly by expansion area, for example, the Noyo Water Line and the North Fort Bragg Water Main Extension Project could be combined. Once more information is available for the proposed projects, the determination if a Program EIR would be the appropriate level of documentation could be answered. The preparation of a Program EIR that could present general mitigation for projects that share certain characteristics (such as those that could be implemented entirely within existing right-of-way) would significantly streamline future environmental review.

Developing a Program EIR capable of encompassing all projects in the CIP may be difficult, and considering the expansion of exemptions represented by SB 131 may not be necessary or required. The only project the CIP includes that is not expected to be exempt from CEQA is the Noyo Water Line Project. If a plan to redevelop the area surrounding the Noyo Water Line Project is to be developed, a Program EIR to support that the entirety of that project may be beneficial.

8.2.4 Master Environmental Impact Report

The development of a Master EIR for the City's Capital Improvement Program would include a discussion of environmental and regulatory constraints. Incorporation of this discussion into the compliance effort for any project that fits within the parameters of the Master EIR would significantly reduce, and potentially eliminate, environmental analysis for subsequent projects. As a Master EIR is intended as a document to tier from, rather than incorporate the majority of a program, fewer project specifics are required than with projects covered under a Program EIR. This reduces repetition and revision of project elements in the event that a project description changes.

Due to this general flexibility a Master EIR could be used to tier to other projects that may not be considered at the time the Master EIR is prepared. A sufficiently broad Master EIR could, for example, be used to partially analyze projects forwarded by the Wastewater and Broadband enterprises of the City's CIP. A project that doesn't fall under the scope of a Master EIR would require additional analysis, however, the work done in the Master EIR could still be applied to reduce future necessary analysis.

The versatility of a Master EIR could also be extended to operate anywhere within the project area, whether the project site in question would be covered under the Inland General Plan or the Coastal General Plan. The inclusion of a section that discusses the additional regulatory elements of the Coastal General Plan would further simplify analysis of subsequent projects and may minimize the level of environmental review and compliance for each covered project.

CHAPTER 9 ASSET MANAGEMENT

This section provides an evaluation of the City's current asset management practices and provides prioritized future recommendations for improving asset management practices to track, evaluate, and replace aging infrastructure. It will define and discuss asset management strategies, provide an overview of current asset management practices in the City to support water distribution infrastructure, and will provide recommendations for improvement.

9.1 What is Asset Management?

Asset management is a framework that enables an organization to effectively manage their assets across the asset life cycles (acquisition, operation, disposal) in a sustainable and consistent way to get the most value from the asset while meeting the organization's objectives and performance expectations. Asset management provides methods to make data-driven decisions which increases transparency to customers and stakeholders, provides consistency in decision-making, and presents a common language and strategy that facilitates communication and buy-in among management and staff.

Asset management is based on measurable asset data that describes:

- What assets do the organization own?
- Where are they located?
- What is their condition?
- How are they performing?
- What needs to be done to keep them performing?
- What has been done in the past?

Decisions made using asset management include both maintenance actions and capital improvements to the organization's infrastructure. The decisions need to align with the overall organization mission, values, and performance measures. This alignment includes:

- Developing a common understanding of how asset management contributes to business.
- Creating processes that address overall organizational needs with the realities of day-to-day management and operation of the infrastructure.
- Provides structure for consistent decision-making and values at all levels of the organization.
- Implements process that collect, analyze and manage relevant data and technology systems.
- Provides a strong focus on risk management.

A typical asset management framework is illustrated in Figure 41. The pyramid shows several important asset management relationships and how they build on each other as they move up the pyramid. The foundation of this framework is asset data. Asset data is generated organizationally by field staff and analysts and provides an on-going means to measure the condition and performance of the infrastructure. These data are first used for tactical, day-to-day decisions. At high levels in the pyramid, the data is analyzed for more strategic decisions which are typically made by management and executives. The highest levels in the pyramid create alignment with the organization's mission, goals, and performance expectations.

With organizations that have thousands of assets, limited resources, and competing needs, it is imperative that risk is factored into decisions. A risk framework can be established that enables the organization to determine where the biggest risk is to their expected levels of service, and what investments will provide the biggest return on risk reduction.

Figure 41 - Asset Management Pyramid

9.2 Why is it Important for the City?

There is ample evidence that implementing an asset management program provides several benefits, including improving service levels, reducing costs, and increasing staff motivation. An Asset Management Program will move the City towards a more proactive maintenance management process and establish best practices for developing capital and operating budgets

International Organization for Standardization (ISO) 55000 states that "Organizations have achieved improvements in service level and system reliability between 5-25% and sustained total cost reductions of between 20-40%, along with better employee motivation and productivity, greater customer satisfaction and increased confidence from regulators and other external stakeholders."

Recent surveys by the American Water Works Association show that over one third of surveyed water utilities are using a robust asset management program to prioritize their capital and operational/maintenance investments. 62% of the surveyed agencies use asset management plans to manage infrastructure maintenance instead of reactively responding to wastewater pipeline and equipment failures (American Water Works Association, “AWWA Utility Benchmarking: Performance Management for Water and Wastewater,” 2019).

Specifically, asset management strategy provides many benefits including:

- Maximizing investment in City infrastructure by optimizing the useful life of each asset.
- Providing a data-driven, transparent, and repeatable capital improvement process.
- Improves alignment of resources to maintain or improve utility performance.
- Provides for risk-based decision-making.
- Offers a framework and vocabulary that improves transparency, communication, and decision-making throughout the organization.

Asset management is not a “one size fits all” proposition. A comprehensive asset management program will apply can impact the whole agency, aligning how it is organized, developing policies, processes, and procedures around asset maintenance and capital planning. Others selectively apply specific asset management techniques and tools to certain aspects of their operations. The City does not currently have a comprehensive asset management program, however, they do apply some asset management strategies to maintenance and capital planning. Additional practices and recommendations are discussed below that will complement the City ‘s current practices and facilitate decision-making.

9.3 Asset Management Practices at the City

This section describes the current work practices in place for performing asset maintenance and for capital planning.

9.3.1 Maintenance

Work practices for performing maintenance can be divided into several parts: These are typically planning and scheduling, work assignment, and work completion. The maintenance management work process is the same for both the water distribution system and the wastewater collection system. Both are handled by the same field staff and Maintenance Lead. There are several ways that maintenance work is identified and initiated. Some of the most common ways are:

- Unscheduled work, such as leaks and repairs, are reported to the Maintenance Lead.
- New water connections are provided by City Hall to the Maintenance Lead via a paper work order. The Maintenance Lead assigns the work to appropriate staff and attaches the paper work order to an electronic work order in Asset Essentials.
- Programmatic maintenance, such as flushing or valve turning, is done on a regular basis. These are scheduled by the Operations Manager and tracked in a spreadsheet.
- Collection system cleaning is done on a regular basis. These are scheduled by the Operations Manager and tracked in a spreadsheet.

Work planning and scheduling are managed through a whiteboard. All maintenance work is listed on the whiteboard until it is completed.

Work assignments are allocated by the Maintenance Lead daily. Regular coordination meetings are held early morning to provide assignments, coordinate, and discuss the necessary work.

Once work has been assigned, it is the responsibility of the field staff to prioritize and complete their assignments. As work is completed, the field staff will take relevant notes and pictures to capture what work was performed but these are not recorded permanently except for the programmatic maintenance and the collection system cleaning. Critical details related to new service connections are recorded and passed on to City Hall. Field staff will brief the Maintenance Lead on work completed at the end of each day, who will update his maintenance notes accordingly, and may plan for future work, if necessary. All tasks tracked in Asset Essentials are closed and marked completed in the CMMS system. Coordination of maintenance work throughout the year is managed verbally between the Operations Manager and the Maintenance Lead.

9.3.2 Capital Planning

Capital planning for the City is done on an annual basis. Most of the capital planning has focused on the water and wastewater treatment systems or other civil infrastructure and not on the water distribution or wastewater collection systems due to more urgent needs in the last several years.

When capital projects are identified for the distribution or collection systems it is usually triggered by an urgent issue, new regulation or litigation, or a new opportunity related to work being performed by other agencies. New potential projects can be identified by the Lead Operator or Operations Manager.

When a new project is identified, it is entered into the budget spreadsheet. The project will then be assigned to a staff member to research. The staff member responsible will update the description, justification, estimated cost, and general schedule for the project. All new projects are assigned to staff members for development of project plans based on new and existing priorities.

Once the project budget spreadsheet has been updated, the projects will be reviewed by the Operations Manager, Assistant Director of Engineering Division, Public Works Director, and City Manager. Projects are prioritized and scheduled based on several factors including factors impacting project construction, potential for grant funding, customer/stakeholder impacts, and/or City Council concerns.

The proposed capital plan is submitted to the City Council for review and approval at the June budget session. The City Council then reviews the plan and approves it if no changes are identified.

As mentioned above, most capital planning work for water or wastewater infrastructure has been focused on treatment facilities where the most urgent needs have been identified. There are not very many issues with the current water distribution or collection system infrastructure, but the City anticipates that more focus and resources will be needed in the near term as the systems continue to age. The current efforts to develop a master plan and ten-year capital plan for both the water distribution and wastewater collection systems will help the City identify and prioritize these needs before they become emergencies. Projects that are defined from these efforts will be used for the basis of annual capital planning in the coming years. The capital planning effort is based on current asset information and includes hydraulic modeling, condition assessment, and development of a risk model to facilitate prioritization. The master plans will provide defensible justification, supporting data, a transparent process, and assess impacts if the projects are not completed. This will provide the City with a balanced view to compare these projects with more highly visible civil projects for budget approval.

9.4 Asset Management Improvement Recommendations

There are several actions that the City can take to incorporate asset management best practices into the maintenance and capital planning process. This section provides recommendations to help the City align its water system maintenance and capital planning work processes with asset management best practices. The recommendations include a suggested priority to indicate which ones will provide the highest value in achieving this goal. Priorities are categorized as follows:

- High – Recommendation should be started as soon as possible and should be completed in the next two to three years.
- Medium – Recommendation should be completed in the next five years.
- Low – Recommendation should be completed within the next five to ten years.

These recommendations reflect best practices and standards for asset management implementation that other agencies have applied successfully to improve utility performance. They have been selected and presented here because they would enable the City to increase asset management knowledge and maturity based on current work practices in place. Implementing these recommendations would help the City achieve the benefits described above. Some of the recommendations work best if implemented together, and some can be implemented successfully individually. The City should consider each of the recommendations and determine whether or not implementation will be cost-effective and provide sufficient value.

9.4.1 Maintenance Recommendations

- [High] Establish an asset data management specification that describes the critical information needed for maintenance management, including data requirements, staff roles and responsibilities, and standard work processes. Note that this recommendation is provided in the current ten-year plan.
- [High] Identify critical assets in the asset inventory to assist in prioritization.
- [Medium] Maintain a central asset inventory and repository of maintenance activities, history, and plans (e.g. a CMMS). This will facilitate maintenance planning, assist with troubleshooting and decision-making, and provide more insight into maintenance needs for more cost-effective maintenance.
- [Medium] Capture labor and materials as appropriate on work orders, service requests, and inspections. Typically, the most valuable information that a CMMS provides is data about repair history, the effort involved, and parts used. This enables O&M management to make more informed maintenance decisions, determine if O&M needs are being appropriately addressed, and assess maintenance performance. Information on the amount of labor and materials needed to complete maintenance work is essential.
- [Medium] Maintain an easily accessible maintenance history that can be accessed by maintenance staff for maintenance planning and troubleshooting.

- [Medium] Build data quality control process into all workflows. It is not uncommon to introduce errors or data gaps when making updates to data. To address this, it is important that all data updates undergo a quality review process to catch errors or omissions. By building quality control work practices into data management, errors will be quickly identified and corrected, which will promote high confidence and reliability among data users.
- [Low] Document job plans, tasks, and procedures in an electronic format to preserve institutional knowledge about maintenance needs and to provide maintenance consistency.
- [Low] Implement the use of mobile technology to capture work in the field and access key information from GIS/CMMS. Most CMMSs provide useful tools to support capturing inspection and work order information electronically on tablets or cell phones while in the field. Many systems today are able to work "offline" in areas where cell coverage is unreliable.

9.4.2 Capital Planning Recommendations

- [High] Internalize the tools and processes developed for this Master Plan so that the City can continue to use it for capital planning. Establish procedures to regularly update asset data over time so that the capital priorities continue to align with the City's changing needs over time. Key elements are the hydraulic model, GIS, and asset risk model. Details on these technological elements are provided below.
- [High] Continue to perform opportunistic asbestos testing of pipe samples to measure remaining wall thickness of the asbestos pipe. Energy Dispersive X-Ray Spectroscopy (EDS) uses mass spectroscopy to measure remaining carbon through a cross section of pipe. This provides direct evidence of pipe condition and can be used to prioritize pipe replacement. The use of EDS testing for the City is discussed in section 6.8.2: Pipe Condition Assessment and a line item for continual opportunistic testing is provided in the ten-year CIP (see section 6.11.2: Sampling of Asbestos Pipe)
- [Low] Periodically update the pipeline risk model as more information is collected about the system. Evaluate the asbestos sampling results and compare them to the risk model results to add or replace risk model factors.
- [Low] Establish a regular cycle for master planning and 10-year CIP development.

9.4.3 Technology Recommendations

Recommendations for each of the technological components are provided below.

9.4.3.16 CMMS Recommendations

- [High] Develop a requirements analysis to document CMMS needs for water distribution as well as other divisions within the City. This will define the minimum requirements that the CMMS system needs to fulfill. These requirements can be used to either improve the existing CMMS for more consistent and comprehensive use or to help determine if a new system is needed. This recommendation is included in the ten-year capital plan.
- [High] Specific functionality that should be implemented based on initial discussions with the City includes;

  - Integration of GIS features into the CMMS to facilitate use by Water Distribution.
  - Develop or modify work order templates that support the water system maintenance activities.
  - Identify and develop standard reports that will support maintenance and capital planning.
  - Develop the capability to attach the appropriate water distribution assets to work orders to facilitate evaluation of maintenance history.
- [High] Assign a staff member to be the CMMS system owner. They will be responsible for working with the Operations Manager to keep the system updated, support planning and scheduling of maintenance work, help users with access and functionality, develop standard reports, and perform specific as-needed data analysis. They will also keep the asset inventory up to date as infrastructure components are replaced.
- [Medium] All maintenance work should be recorded and maintained in the CMMS. The CMMS should be the system of record for all maintenance work. Consolidating all maintenance data and documentation into one system makes it easier to maintain, minimizes errors and discrepancies, and increases staff confidence in the accuracy and usefulness of the system. Data may be extracted and shared with other systems or further processed with other tools, but the CMMS should be the authoritative data source for maintenance data.
- [Low] Develop standard reports to be used across the department. A key strategy for successful CMMS implementation and return on investment is to maximize the use of the data and information collected. The most common and obvious uses for the data are for the O&M staff to use it for identifying maintenance requirements and maintenance history for troubleshooting, and for O&M management to use it for planning, understanding maintenance trends, and for daily decision-making. However, there are many other uses for the data as well. For example, Engineering can use trends in unscheduled maintenance and repair to prioritize capital planning, and Department management can use key performance indicators (such as percent of system flushed) to gauge how well the Department is meeting expected service levels.

9.4.3.17 GIS Recommendations

- [High] Select a GIS implementation strategy as outlined in CHAPTER 2: System Mapping.
- [High] Assign a system owner to manage the water distribution GIS data. The City will realize the most benefit from its investment in GIS if it is regularly used for planning and decision-making. This requires accurate and up-to-date asset data and the ability to keep the GIS linked with the CMMS for current maintenance history. Without a focused effort on data maintenance, users will lose confidence in the data in the GIS, making it unreliable and requiring more effort to validate the work products and results.
- [High] Establish a GIS update process. As the City completes maintenance and replacement of water mains and other maintenance or capital projects, it is essential that the information get updated in GIS in a timely manner. This will potentially impact other maintenance and inspection activities.
- [Medium] Integrate the GIS with the City’s selected CMMS. The GIS can function as the system-of-record for the City’s linear assets (i.e., assets outside of the treatment plants).

These assets should be imported into the CMMS and a procedure established to keep them synchronized. This will allow maintenance and capital planning activities to be linked to linear assets as well as vertical (plant) assets, providing the foundational element for asset management.

- [Low] Consider leveraging the new Utility Network to develop a valve isolation function to identify valves to close and customers affected when pipes need to be isolated for repairs. A valve isolation application is available from ESRI for water system utility networks and can be configured to identify the valves to be turned to isolate a pipe for repair. It may also identify customers who will be affected.

9.4.3.18 Hydraulic Model Recommendations

- [Medium] The hydraulic model is linked to the GIS database through InfoWater Pro's GIS Gateway. The model should be updated at routine intervals, as required. It is recommended that the model be updated at least every 5 years to coincide with Master Plan update intervals or updated after a significant capacity improvement is constructed. This recommendation is included in the ten-year capital plan under Capital Plan Updates. See section 6.11.1: Capital Plan Updates for additional discussion.

CHAPTER 10 CONCLUSION & SUMMARY OF RECOMMENDATIONS

Similar to many communities throughout the country, the City of Fort Bragg's water distribution system faces the challenge of dealing with aging infrastructure to maintain system reliability. Approximately 90% of the system is constructed from asbestos cement (AC) and polyvinyl chloride (PVC) pipe materials, with estimated useful lives of 75 to 70 years, respectively, depending on environmental conditions. Since the oldest segments installed in the 1960s are now over 65 years old, the City is faced with the challenge of implementing a proactive pipeline replacement program.

Currently, the City has not experienced many water distribution system issues. However, the City anticipates that more focus and resources will be needed in the near term to maintain the system as it continues to age. This 2025 update to the Water Distribution Master Plan will help the City identify and prioritize these needs in an effort to improve system reliability to minimize emergency conditions. This plan provides a transparent, data-driven, and repeatable capital planning process that identifies and prioritizes improvements and other planning actions for the water distribution system.

The system is generally well-sized for current needs based on hydraulic modeling analysis. Several areas of the City have been identified that could benefit from capacity or fire flow improvements. These are included in the Capital Improvement Plan (CIP), prioritized first by City-designated importance and then by the risk assessment score developed in this Master Plan.

Key capacity enhancements and fireflow improvement projects include:

- PS-1: Upgrading the fire pump at the Willow Street Pump Station from 1,000 GPM to 2,000 GPM.
- P-1 through P-13: Distribution improvements to address capacity and fire flow needs.

The proposed Noyo Center development is the only known near-term project expected to increase system demands beyond the existing system capacity. The anticipated capacity improvement (P-3) has been included in the 10-year CIP, pending the start of the Center's development.

Project V-1 (Oak Street Valves) was identified to provide recommended additional redundancy and operational improvement for the existing system. In addition, Tank 1 (T-1) was assessed to be in poor structural condition and is recommended for replacement as a high-priority project. While the current storage capacity is adequate for existing and near-term demand scenarios, the Tank 1 improvements will provide additional value to both current and future customers.

In the area of water supply resiliency, increasing occurrences of drought, as well as high-salinity and sea-level rise at surface water intakes and declining spring water availability highlight the need for continued evaluation of alternative supply sources. While desalination pilot projects are underway, further assessment is beyond the scope of this Master Plan but should continue to be studied. Future intake location changes or source development should consider California Department of Fish and Wildlife regulations.

Given the system's age, this Master Plan recommends a pipe sampling plan and an allocation for an annual replacement target. Three asbestos cement pipe samples from recently replaced distribution mains were analyzed for remaining wall thickness as part of this master plan study. All three samples were classified as being in "poor" condition. While “poor” condition does not necessarily indicate imminent failure, it does suggest increased vulnerability during high-pressure or surge events and may make pipe repair in the event of a break more difficult, often leading to prolonged outages if the potentially fragile neighboring pipes fail to support the required repairs.

While there are very few leaks identified in the system, much of the system’s pipeline network is old and has reached or exceeded its expected useful life. The City should consider investing in an on-going pipe replacement program (PL-1) to manage future break rates and affordably renew its aging infrastructure.

Based on benchmarking several California utilities, a 1% annual replacement rate is recommended and has been included in the CIP. The City may implement this recommendation annually or develop replacement projects at longer intervals but should make continual progress on pipeline replacement to avoid larger (and costlier) emergency repairs that impact larger areas of the City. Specific pipe segments beyond the targeted capacity-related replacements have not been identified due to limited data on actual pipe condition. As such, pipes selected for replacement should be fully investigated to verify that they are good candidates for replacement prior to starting the work. Additional pipe sampling and condition assessment will facilitate this process, and the pipe risk model developed for this Master Plan may be used to prioritize sampling. These considerations have all been incorporated into the CIP.

Additional asset management recommendations include:

- Updating the CIP every five years to reflect new data, priorities, and condition assessments (O-2 & O-6).
- Evaluating and improving the City's Computerized Maintenance Management System (CMMS) to enhance maintenance tracking and planning (O-3 & O-5).

Following City Council review, this Master Plan and CIP will be incorporated into the City’s annual budgeting process. To support project implementation, project sheets have been developed, and project funding eligibility has been assessed for four of the highest priority projects (P-1: Cedar Street Line Replacement, P-2 North Fort Bragg Water Main Extension, T-1: Tank 1 Replacement, and V-1: Oak Street Valves). Environmental review requirements are outlined in the CEQA section of this report.

CHAPTER 11 REFERENCES

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Appendix A. CAD to GIS Conversion

Appendix A – CAD to GIS Conversion

Data Conversion Workflow Process & Database Schema Design

Introduction

The City of Fort Bragg (City) manages and maintains a water distribution system, sewer collection system, and stormwater collection system. To modernize and add analytical capabilities, HDR converted the existing Fort Bragg Systems of record, which are stored in both CAD and GIS formats, into one standardized GIS Utility Network dataset. The standardized data set will serve as the system of record for Fort Bragg Utilities being used as the source for hydraulic models, incorporate into asset management, and provide a common reverence for City staff in the office and in the field.

GIS Conversion Approach

To begin, HDR created a staging file Geodatabase that includes a prebuilt data schema for Water, Sewer and Storm Utilities using the industry standard GIS. The conversion process involved identifying the aspects of both CAD and GIS that we want to convert to the standardized model. Fort Bragg has been updating the CAD file more frequently and the CAD file was identified as the best spatial source, so the **CAD geometry is being used for the locational data**. There were some attributes such as feature ID's that are important to maintain for specific features (Hydrants) and in those cases their additional fields have also been added. To perform the conversion and add in some additional geometry improvement processes HDR used FME software. Geometry processes were included to enable use in the hydraulic model and to enable accurate tracing in the utility network these processes included:

- Added surface elevations to z values and in the attribute tables for point features
- Snap valves to mainlines
- Splitting mainlines at valve locations
- Adding tap fitting locations on mainlines (complex edges) and associating to Meter points
- Joining attributes from GIS features
- Correctly tagging asset categories such as hydrant service lines and valves

The migrated data has been added to a Utilities GIS ArcGIS Pro Project (.aprx) file that is incorporated with the Esri Solutions Utility Network map templates. 2D and 3D map templates have been configured with saved configured traces configured including:

- Subnetwork trace (system)
- Subnetwork Controller
- Downstream
- Upstream
- Isolation
- Shortest Path

The Utility Network APRX also includes saved diagram and map export templates.

Similar methodology was used for Sewer and Stormwater systems. Sample images of the migrated data in the Utility Network are provided below.

We have included the Utility Network Schema in electronic (.xls) format as an electronic attachment to this repot.

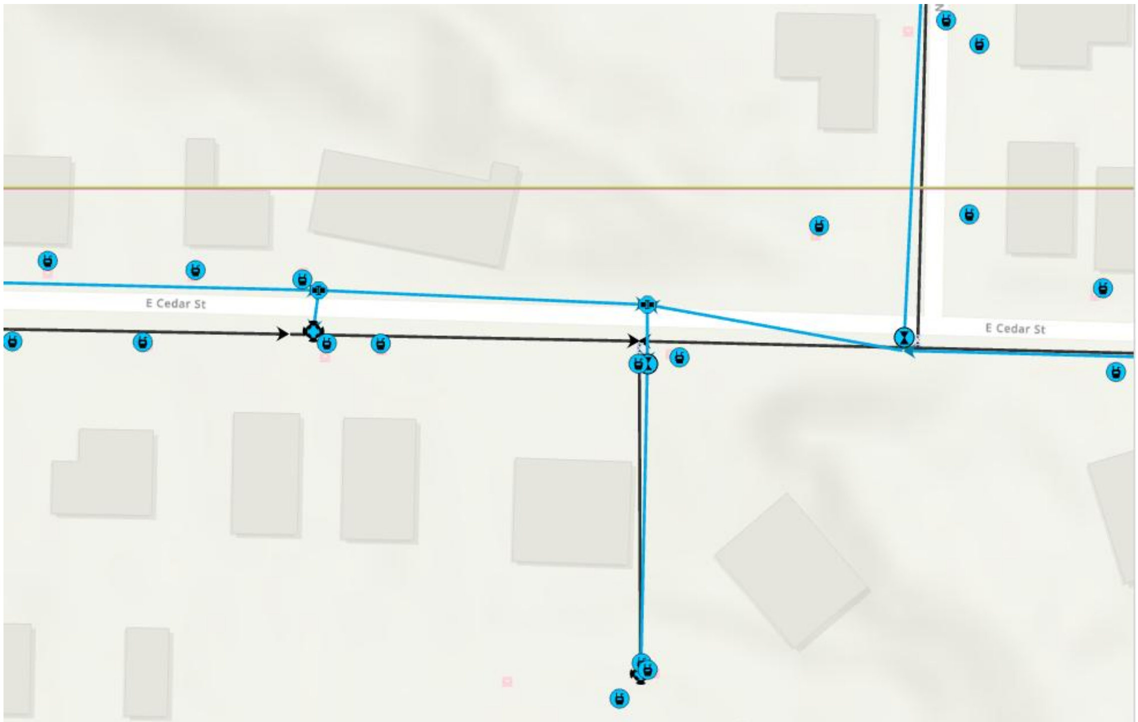

Image 1: Initial CAD (black) and GIS (blue) Geometry

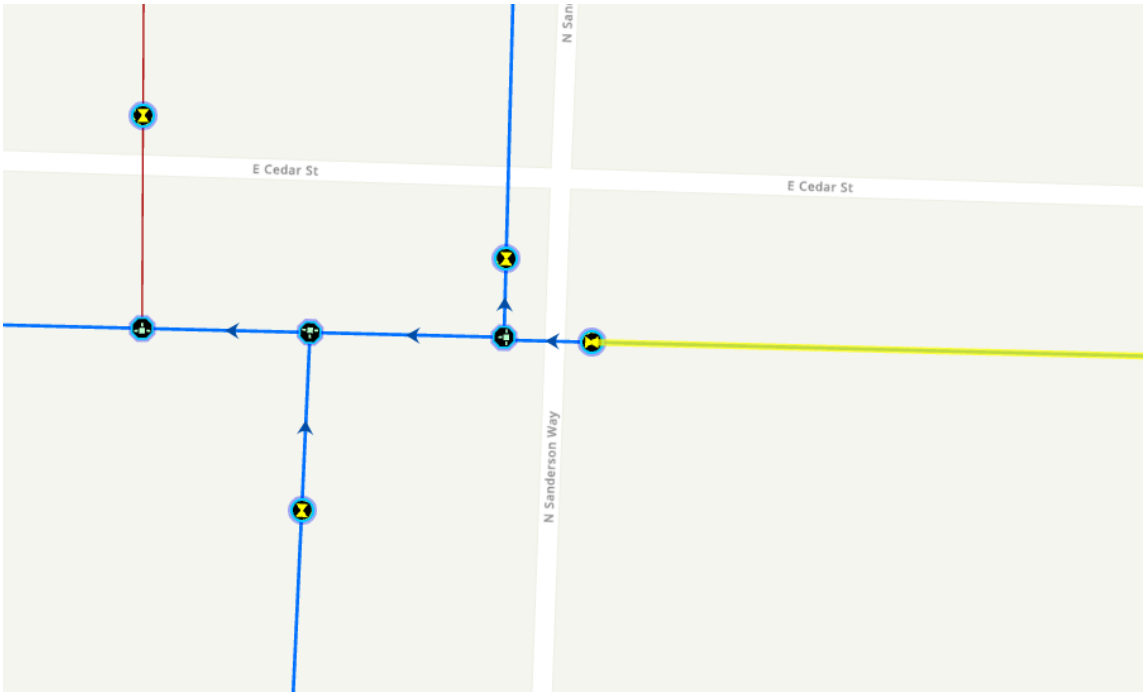

Image 2: Migrated Data Mainline Splits at Valve Locations

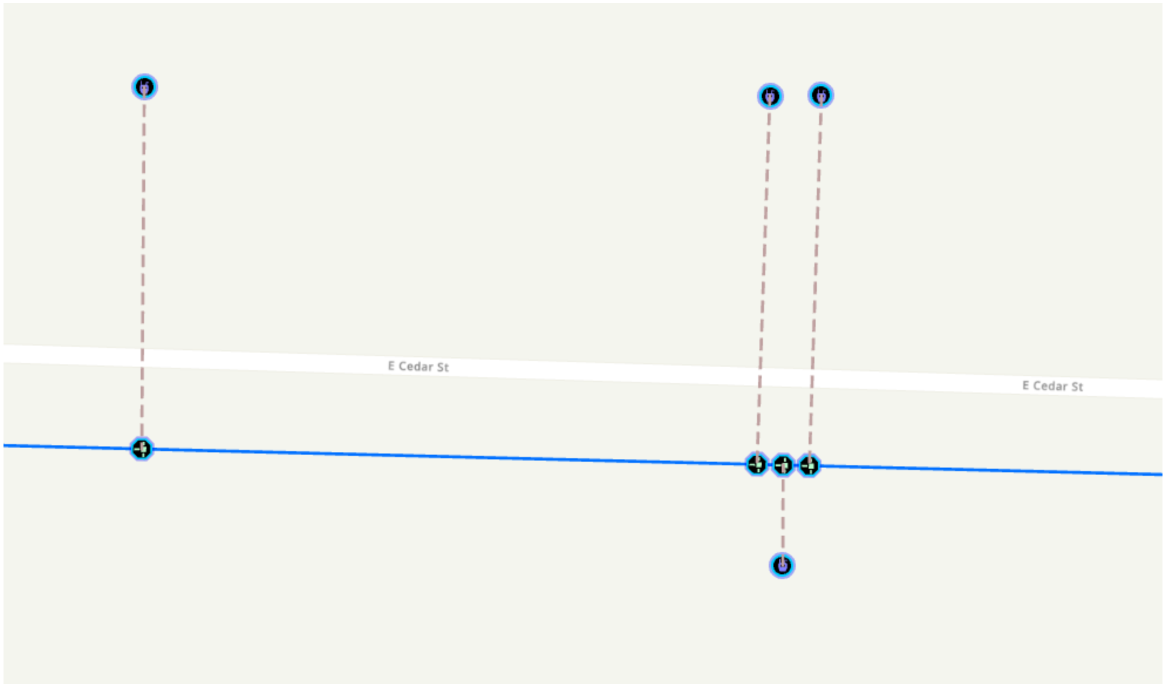

Image 3: Added Taps and Association Lines to Meter Points

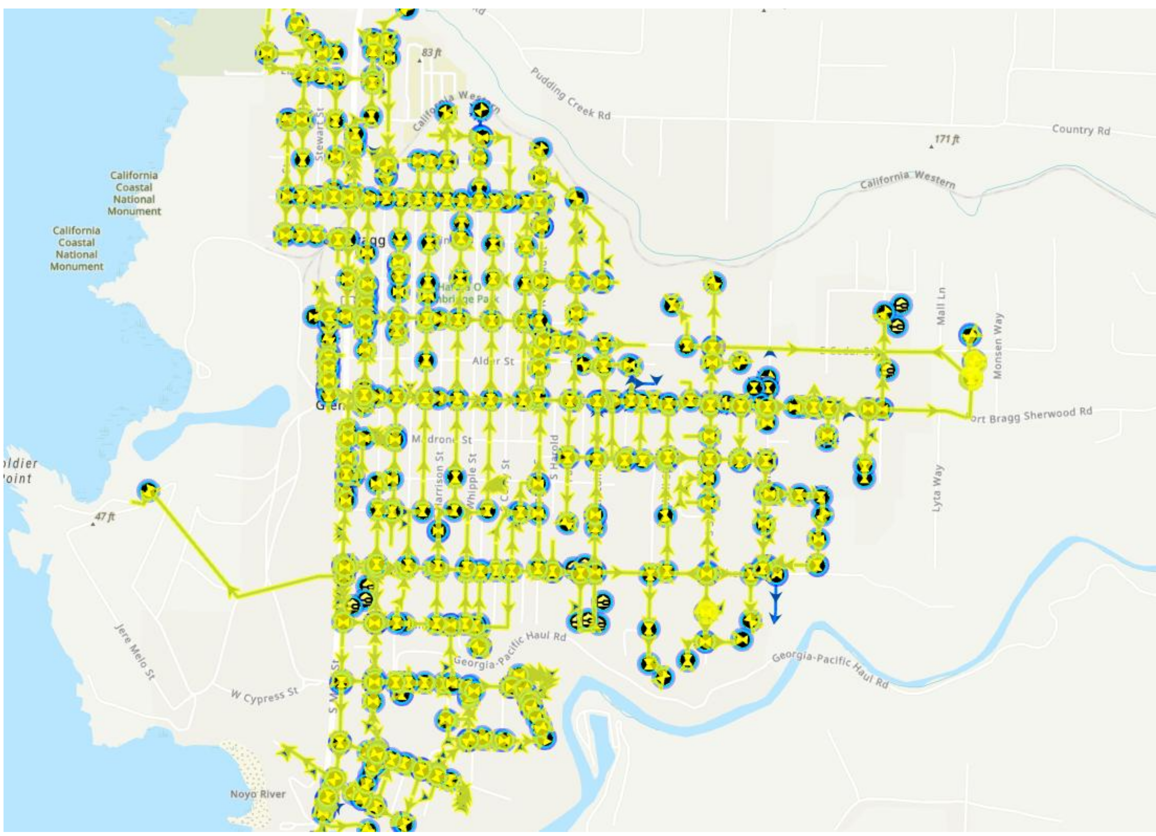

Image 4: Subnetwork Trace

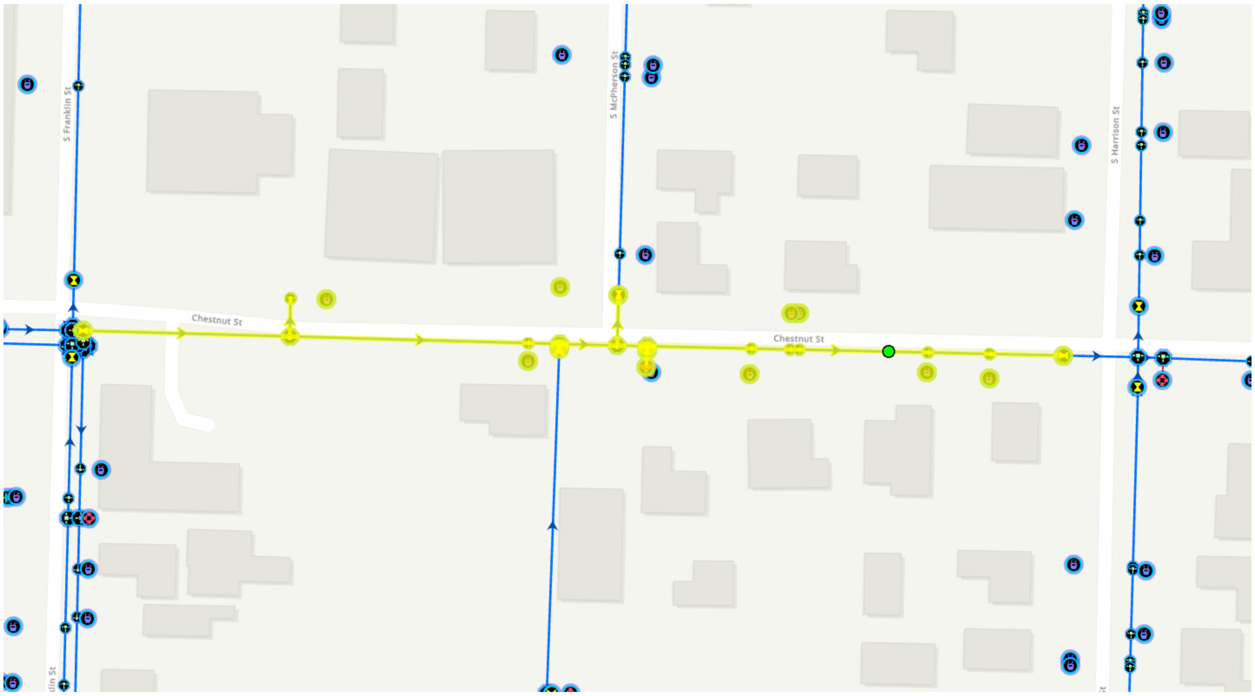

Image 5: Water Isolation Trace

GIS Database Schema

HDR has used the standard Utility Network Data Models for conversion from CAD to GIS. FME was used to convert the CAD linework into GIS features as well as convert annotation into feature attributes. The attribution included diameters, materials, and Asset ID's. HDR also included ownership information for assets that are managed and maintained vs other features that are managed by external parties such as Caltrans for Stormwater. Below is a list of current data layers (feature classes) used in GIS.

Water

Water Device – Used for most water point assets that are not lines or fittings and includes the following data groupings.

- Pump
- Hydrant
- System Valve
- Service Valve
- Flow Valve
- Pressure Valve
- Station
- Blowoff
- Storage
- Supply (Treatment Plant, Network Source)
- Service Meter

Water Junction – Used for fittings

- Misc Types (Tee, Tap, Elbow, etc.)

Water Line – Includes Mains and Service lines.

- Water Main – (Transmission, Distribution)
- Service – Includes Asset Types for (Residential, Commercial, etc.)

Water Network (Subnet line) – UN generated aggregation created using Update Subnetwork tool

Sewer

Sewer Device – Used for most sewer point assets that are not lines or fittings and includes the following data groupings.

- Cleanout
- Controllable Valve
- Service Valve

- Backflow Preventer
- Manhole
- Treatment (Network Source)
- Service Connection

Sewer Junction – Used for fittings

- Misc Types (Tee, Tap, Elbow, etc.)

Sewer Line – Includes Mains and Service lines.

- Gravity Main – (Collector, Interceptor)
- Force Main
- Lateral – Includes Asset Types for (Residential, Commercial, etc.)

Sewer Network (Subnet line) – UN generated aggregation created using Update Subnetwork tool.

Stormwater

Stormwater Device – Used for most sewer point assets that are not lines or fittings and includes the following data groupings.

- Catch Basin
- Outlet (Network sources)
- Manhole

Stormwater Junction – Used for End walls.

Stormwater Line

- Pipe (Gravity, Force, Perforated)
- Culvert
- Open Channel – used for natural channels and ditches that participate in the overall stormwater network

Stormwater Network (Subnet line) – UN generated aggregation created using Update Subnetwork tool.

Basins – Basins polygons for the Stormwater network has been digitized and included.

Structures

The water data also includes structure layers for assets that support the individual domain networks.

Structure Junction – Vaults

Structure Lines – Casings

Structure Area – Boundaries for assets such as pump stations and treatment plants.

Detailed Database Schema Definition

A detailed database schema definition is included as an attached Microsoft Excel Spreadhseet, UN_Schema_All_Domains.xls. This includes detailed definitions of the following Utility Network geodatabase elements:

- A tab for each feature class
- All attribute field names and aliases
- Attribute field data types
- Attribute field domains (where applicable)
- Default attribute values

Name
OBJECTID
SHAPE
ASSETGROUP
ASSETTYPE
ASSOCIATIONSTATUS
ISSUBNETWORKCONTROLLER
ISCONNECTED
SUBNETWORKCONTROLLERNAME
TIERNAME
TIERRANK
TERMINALCONFIGURATION
GLOBALID
SystemSubnetworkName
SUPPORTEDSUBNETWORKNAME
SUPPORTINGSUBNETWORKNAME
IsolationSubnetworkName
diameter
secondarydiameter
pressure
designtype
normalstatus
presentstatus
additionaldetails
designinfo
operable
name
installdate
assetid
accountid
ownedby
maintby
additionaldevice
notes
symbolrotation
lastmaint
lifecyclestatus
inservicedate
retireddate
spatialsource
spatialconfidence
manufacturer
operator
actualInsideDiameter

Alias	Type
Object ID	OID
Shape	Geometry
Asset group	Integer
Asset type	SmallInteger
Association status	SmallInteger
Is subnetwork controller	SmallInteger
Is connected	SmallInteger
Subnetwork controller name	String
Tier name	Integer
Tier rank	Integer
Terminal path	String
Global ID	GlobalID
System Subnetwork Name	String
Supported subnetwork name	String
Supporting subnetwork name	String
Isolation Subnetwork Name	String
diameter: Diameter, Diameter 1, Height, Inlet Diameter, Pipe Diameter, Weight	Double
secondarydiameter: Diameter 2, Nozzle Diameter, Outlet Diameter, Width	Double
pressure: Amperage, Pressure, Rated Pressure, Volume	Double
designtype: Anode Count, Design Type, Manufacturer, Pump Type, Test Wire Count, Valve Ty	SmallInteger
Normal Status	SmallInteger
Present Status	SmallInteger
additionaldetails: Clockwise to Close, Cooling Method, Critical, Material	SmallInteger
designinfo: Anode Depth, Rated Flow, Turns to Close, Voltage	Double
Operable	SmallInteger
Name	String
Install Date	Date
Asset ID	String
Account ID	String
Owned By	SmallInteger
Maintained By	SmallInteger
additionaldevice: Additional Device, Has Bypass, Internal Meter, Metered	SmallInteger
Notes	String
Symbol Rotation	SmallInteger
Last Maintenance	Date
Lifecycle Status	SmallInteger
In-Service Date	Date
Retired Date	Date
Spatial Source	SmallInteger
Spatial Confidence	SmallInteger
Manufacturer	SmallInteger
Postindicator Valve	SmallInteger
actualInsideDiameter	String

Length	Domain	Default	Nullable	Editable
				TRUE
		0		TRUE
		0		TRUE
		0		
		0		
		2		
2000		Unknown		
		0		
		0		
128		Default		TRUE
2000		Unknown		
2000		Unknown		
2000		Unknown		
2000		Unknown		
			TRUE	TRUE
			TRUE	TRUE
			TRUE	TRUE
			TRUE	TRUE
	Pipeline_Valve_Status		TRUE	TRUE
	Pipeline_Valve_Status		TRUE	TRUE
			TRUE	TRUE
			TRUE	TRUE
	Boolean	1		TRUE
64			TRUE	TRUE
			TRUE	TRUE
64			TRUE	TRUE
50			TRUE	TRUE
	Asset_Owner	1	TRUE	TRUE
	Asset_Manager	1	TRUE	TRUE
			TRUE	TRUE
2000			TRUE	TRUE
	Symbol_Rotation		TRUE	TRUE
			TRUE	TRUE
	Lifecycle_Combined	0		TRUE
			TRUE	TRUE
			TRUE	TRUE
	Spatial_Source		TRUE	TRUE
	Spatial_Confidence		TRUE	TRUE
			TRUE	TRUE
			TRUE	TRUE
8			TRUE	TRUE

Appendix B. Geotechnical Evaluation of Seismic Safety Elements Related to Water Distribution Facilities

Geotechnical Evaluation of City of Fort Bragg Seismic Safety Elements Related to Water Distribution Facilities

Fort Bragg Distribution System Master Plan

City of Fort Bragg

April 1, 2025

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1 Executive Summary

1.1 Scope

HDR has been retained by the City of Fort Bragg (City) to develop a water distribution system master plan. The purpose of this memorandum is to:

- Provide input on the geotechnical section of the Seismic Safety Components of the General Plan as they relate to the water distribution system,
- Develop a high-level summary description of geotechnical and geologic conditions within the City's area of influence, and

Provide discussion regarding critical elements of the analysis of six geotechnical studies for City and private development projects, provided from the City representing subsurface conditions in different areas across the City, and geotechnical data available online related to the former Georgia-Pacific Lumber Company site closure. The study did not include an exhaustive investigation of applicable geotechnical reports that may be contained in City records and does not provide a site-specific seismic hazard analysis. This Executive Summary should not be referenced alone as it is a summary and does not contain specific discussions and details provided in the body of the report.

The data and discussion presented in this memorandum are organized as follows:

- Topography and Geology
- Emergency Access
- Water Supply and Distribution System
- Geotechnical Condition Assessment
- Geologic and Non-Geologic Hazards
- Areas of Concern for Rehabilitation of Water Distribution Facilities
- Limitations

HDR's review of the subsurface conditions as described in the provided reports is briefly summarized in Attachment A. Although some portions of this memorandum may include discussions on climate change, a separate report is being prepared by HDR addressing climate change implications.

Although the memorandum was prepared specifically as part of the water distribution master planning effort, it is applicable to other City agencies responsible for infrastructure such as the stormwater and sewer system.

1.2 Topography and Geology

The City is located on an uplifted terrace along the California Pacific North Coast. The uplifted terrace has created a coastal bluff that is approximately 50 feet tall at Soldier Point near the existing City's Wastewater Treatment Plant and 85 feet tall at Pomo Bluffs State Park. Site grades slope gently upward towards the east to approximately El. 400 feet where the terrace meets the western edge of the Coastal Range Mountains. A high-level discussion of the City topography and mapped geology is provided in the memorandum based on review of available published information. Review of other geotechnical studies contained in the City files could be a benefit to better understand subsurface conditions that could impact the water distribution (or other) system. Former creek channels may be present beneath the City that became obscured as the terraces were uplifted.

1.3 Emergency Access

Subsurface conditions and the response to strong seismic shaking or a large storm event can impact City features such as vehicle access. The main vehicle access (and emergency evacuation/access routes) into and out of the City is Highway 1, which includes bridges that cross Hare Creek, Noyo River, and Pudding Creek (from south to north). If these bridges were damaged during a seismic event or a large storm event, such as an intense storm washing out the bridge approaches or a tsunami damaging the bridge foundations, access would be limited. Highway 1 provides the main emergency access in and out of the City over bridges maintained by California Department of Transportation (Caltrans). Caltrans reports that the Noyo and Pudding Creek bridges have undergone seismic structure upgrades and plans to perform Hare Creek Bridge seismic structure upgrades in the future. In addition, the 2020 Medocino County Hazard Mitigation (MCHMP) plan identifies slope failure and wildfire risk as having highly likely and critical impact on the city of Fort Bragg while earthquake would be an extreme risk though it is a less likely hazard (see figure 2-2, City of Fort Bragg Risk Assessment, MCHMP Vol 2 2020), both briefly discussed in subsequent sections of this report.

1.4 Risks to Water Supply and Distribution

The City water supply system, described in the memorandum, consists of water collection points, treatment facilities and storage structures, and distribution system interconnected by pipelines. The water main line system connects the storage system to the end user and these pipelines likely have additional structural connections to a network of smaller diameter pipes forming the distribution system. Each part of the system is subject to geologic hazards including strong seismic shaking, seismic-induced differential movement at connections, seismically induced ground settlement and, potentially, ground failure. Also, soil chemistry can cause corrosion to steel and concrete materials. Each needs to be evaluated based on site-specific conditions and in accordance with the appropriate design code.

Distribution piping itself can be at risk due to many geotechnical causes, such as:

- Corrosive soils that weaken the pipe itself
- Differential settlement or pipe lengthening due to land sliding, bluff retreat, soil densification, or liquefaction resulting in large magnitude settlements or lateral spreading, static settlement due to change of overburden or imposed loads, or hydro-compression due to changes in saturation
- Differential movement during earthquake, such as at service or distribution connections like large maintenance holes or bridge crossings

Also, the City fire hydrant system must be operational for small and large seismic events and wildfires.

1.5 Geologic Hazards

1.5.1 Seismicity

The City of Fort Bragg is in an area that is known for seismic activity; however, the City is not within a currently established State of California Earthquake Fault Zone for surface fault rupture hazards and there are no known active fault traces in the immediate project vicinity. The following active faults are located within 60 miles of the City

- North San Andreas Faults System – 6.5 miles west
- Maacama Fault Zone – 21 miles east
- Mendocino Fault Zone – 60 miles north

The Pacific Star Fault is a recently identified potentially active fault located northeast of the City as is the Pudding Creek Fault. They are reported as being connected to the San Andreas Fault but have not been located in the State of California Special Studies Zone. USGS estimates that there is a 64.92% chance of an earthquake with a magnitude greater than 5 to occur in the next 50 years.

1.5.2 Fault Offset, Strong Ground Motion, Liquefaction and Tsunami Impacts

The fault offset hazard in the City of Fort Bragg is very low. There are no Alquist Priolo Hazards Zones identified within or near the City (www.conservation.ca.gov). The City will be subject to strong ground shaking that could induce densification of loose to medium dense terrace deposits, and slope movement within the steeply incised river and creek channels and along the coastal bluff. Loose, saturated, cohesionless soils are susceptible to liquefaction, including sediments that have accumulated within and at the mouth of the coastal, river, and creek channels and potentially in eolian (windblown) derived terrace deposits that become saturated due to groundwater.

The State of California Office of Emergency Services online MyHazard maps (myhazards.caloes.ca.gov) does not identify Fort Bragg as having a mapped liquefaction zone; however, the risk of liquefaction is judged to be moderate in the terraces and high in the river and creek channels and could occur in the event of strong ground shaking.

Tsunamis would impact the coastal areas, the Noyo Harbor, and upstream areas of Noyo River, Pudding Creek, and Hare Creek. The Pacific Institute has prepared a graphic showing the effects of a 55-inch sea level rise and the effect combined with a tsunami. Sea level rise would raise river levels in Noyo River and Hare Creek to above the 100-year flood level. Sea level rise combined with a tsunami would impact all three river/creeks and cause saltwater intrusion to the existing raw water intake on the Noyo River. Recent high tides have also caused saltwater intrusion and impacted the raw water intake.

1.5.3 Non-seismic Hazards

Non-seismic hazards include presence of unstable soils on steep slopes, continued bluff retreat, and presence of weak and/or unstable soils.

- The presences and mitigation, if required, would be determined on a project-specific investigation/basis. It would be beneficial to document the past performance of the water distribution system (Geographical information System [GIS], mapping, and tabular format), including areas of past pipe repairs/leak/breaks and areas of known surface (street pavement and hardscape) distress to identify areas that may be underlain by weaker soils.

A more detailed description of the regional geology and the near-surface geology and surface conditions is included in the body of this document. Of particular importance is that groundwater conditions documented in the reference reports represent conditions observed at the time of investigation and are generally poorly understood. Groundwater (at depth) and near-surface perched groundwater are two different groundwater occurrences and both have been reported. Additional groundwater investigations would be required to better understand the current temporal variations in groundwater at a specific site within the City's area of influence. The assumptions related to groundwater levels have a significant impact on the occurrence of liquefaction induced by strong ground shaking and the values reported in the different documents should not be relied on for future projects.

The Georgia-Pacific Site cleanup documentation provides detailed maps showing groundwater conditions west of Highway 1 in the central portion of the City Coastal Area. The City of Fort Bragg has recently began to track shallow groundwater condition for the stormwater and water projects in the city.

1.6 Other Geologic Related Concerns

1.6.1 Mineral Resources

The Fort Bragg General Plan does not identify any locally important mineral resource recovery sites or sites being utilized for Surface Mining and Reclamation Act (SMARA) activities.

1.6.2 Corrosion

Limited studies have identified that the terrace deposits are acidic and have cation exchange capacity, being more acidic closer to the ocean.

The terrace deposit soils should be considered corrosive to steel and slightly corrosive to concrete unless specific testing is performed or the performance of buried structures can be determined from visual inspection. A testing standard should be developed for all corrosion testing so that a "Zone" database can be developed by the City to aid in their management of the water system.

1.6.3 Erosion

Removal of vegetation and redirection of surface water could induce erosion on any area of the City. Care must be taken to restore disturbance to reduce the risk of developing areas of concentrated surface water flow that could induce erosion. Care must be taken to install trench dams along lengthy pipelines and in elevation transitions so that the pipeline trench does not act as collection, drawing and redirecting concentrated seepage to the trench outlet causing ground saturation and potential slope failure and erosion.

1.7 Non-Geologic Hazards

1.7.1 Flooding

Flooding hazard is typically determined for a 100-year flood level for insurance purposes using maps developed by the Federal Emergency Management Agency (FEMA). The FEMA updated flood maps for the Fort Bragg area are dated as being published in 2017 and show larger 100-year flood hazard than shown in the Coastal General Plan Map. The Inland Zone General Plan includes Map SF-3 Tsunami Inundation Map and Map SF-4 100-year Sea Level Rise Inundation Area, which is the Pacific Institute map previously referred to as an additional source document for this memorandum. The most recent FEMA Flood Mapping and the Pacific Institute mapping of sea level rise are recommended as references for assessing flooding impacts.

1.7.2 Fire

The City's fire hydrant system is critical infrastructure for public safety. Significant fires have occurred in Northern California in the last few years and the ability to protect the City from structure fires and wildfire is important. The fire hydrant system is also critical after a large seismic event.

In 2022, California Department of Forestry and Fire Protection (CALFIRE) published maps depicting Fire Hazard Severity Zones for Mendocino County as part of the Fire and Resource Assessment Program. The City is outside the jurisdiction of CALFIRE and the City itself is zoned as a local responsibility area (LRA). The Fire Hazard Zone Severity Viewer is no longer available online . The MCHMP does include earlier viersions of these maps that show the area south and east of the Noyo River zoned as Very High risk and the area north and east of the City as Moderate risk. High risk zones are located east of the City on the north side of the Noyo River and east of the north Coastal Area. The south Coastal Area is located in a Moderate risk zone west of Highway 1 and in the lower elevations east of Highway 1.

1.7.3 Extreme Weather Events

In February 2023, the United States Department of Agriculture USDA) declared Mendocino County a Disaster Area due to severe winter storms and flooding. The occurrence of heavy storms and storm events characterized as Atmospheric Rivers, defined by National Oceanic and Atmospheric Administration (NOAA) as long narrow regions in the atmosphere that transport most of the water vapor out of the tropics that have an equivalent flow at the mouth of the Mississippi River and exceptionally strong events can have 15 times that amount. The Pineapple Express is a strong atmospheric river bringing moisture from the tropics near Hawaii to the west coast. The rain events can induce slope instability and rapid slope movement and debris flows.

The ranking of deep-seated landslide susceptibility is presented on California Geological Survey (CGS) Sheet 58 that show the areas to the east and along the incised channel banks having the highest potential for slope instability and deep-seated sliding. The susceptibility of landslides impacting the City water supply and distribution system or evacuation routes directly or from debris flows should be evaluated on a case-by-case basis. It should be noted that climate change may increase the risk of slope instability.

1.7.4 Chemically Impacted Sites

A review of the DTSC GeoTracker website showed the locations of numerous identified chemically impacted sites that range from small underground storage tanks to large facility clean-up activity. Many of the sites are identified as having closed files, meaning that the sites have been remediated to meet cleanup goals set forward by regulatory agencies. It should be noted that there may be residual chemically impacted soils at these sites that did not require removal but, should they be excavated, may require special testing and handling to determine material reuse or disposal. The GeoTracker site and associated data should be checked as part future system upgrade or rehabilitation projects to be aware of potential impacted sites.

1.8 Areas of Concern for Rehabilitation of Water Distribution Facilities

The following geotechnical factors should be considered when addressing water distribution design or rehabilitation.

- Densification and Liquefaction
- Corrosivity
- Seismic Response
- Bluff Erosion

1.9 Recommended Future Actions

To better understand geologic risk to specific portions of the water distribution system, a more detailed understanding is needed at the location of critical components of the system. Specifically, the following should be determined:

- The peak ground acceleration based on current code requirements, typically expressed as the design earthquake return period. Depending on the age of the facility, the current design code may be different than what was used at the time the component was designed and constructed.
- The thickness of fill and/or terrace deposits at the site, the depth to bedrock and an understanding of the groundwater depth and seasonal fluctuation. Past geotechnical investigations associated with the original design of the component/facility, or a report prepared for an adjacent property combined with review of the as-built grading plans would typically provide data regarding the site soil stratigraphy and depth to bedrock. Understanding groundwater conditions below the site would likely require additional study, discussed below. This information is required as input into a seismic vulnerability assessment for understanding the potential for seismic densification or vertical or lateral deformation because of liquefaction, if potentially liquefiable soils are present at the specific site.
- Mapping of areas of slope instability along pipeline corridors and within 300 feet of a component or facility at a local scale will provide the input to assess the current hazards slope instability pose to the facility as well as allow comparison for changes in the risk, specifically after major storms/flood events or a large seismic event. Each specific area of concern should be mapped at a scale of 1 inch = 50 feet and fixed reference points set, such as rebar hubs setback (above) the area of instability in readily accessible areas that can be

used to easily identify changes visually and hand measurement. Each location will need to be assessed on a case-by-case basis to establish the limits of mapping and location and number of reference points. Use of fixed features such as a fence, fire hydrant, or street curb may not be sufficient as they can be modified or damaged over time.

The depth to bedrock could be evaluated by performing limited geophysical surveys (seismic refraction) that is a non-invasive and lower cost method of field investigation. The geophysical surveys, in combination with other geotechnical or environmental investigation reports that the City has, could provide the level of detail required without the expense of drilling soil borings. Understanding the depth of groundwater and fluctuation over time could require installation of a strategically placed monitoring well or wells to understand the source and direction of groundwater flow and the effects of rainwater and irrigation infiltration. An initial widely spaced grid of wells could be established and monitored semi-annually to quarterly to develop an understanding of groundwater behavior. The wells could be supplemented if an areas data seems erratic of if additional detail is desired.

Planning for such a study should be proceeded by a desktop study reviewing available data contained in City files and interviewing local civil/geotechnical and geological consultants familiar with area soil and geologic conditions that may bring specific knowledge from past experience within the City limits. All the groundwater, soil, and bedrock depth and slope instability data can then be collected in a geographic information system (GIS) and reviewed to determine where more detailed study would be warranted. The information would need to be reviewed and updated to provide a living document that can be used by all City departments for planning and risk assessment.

2 Introduction

HDR has been retained by the City of Fort Bragg (City) to develop a water distribution system master plan. The purpose of this evaluation is to:

- Provide input on the geotechnical section of the Seismic Safety Components of the general plan as it relates to the water distribution system,
- Develop a high-level summary description of geotechnical and geologic conditions within the City's area of influence, and
- Provide discussion regarding critical elements of the water supply system that should be considered as part of master planning and future distribution system maintenance/rehabilitation efforts.

This study is limited to review of the City's existing general plans for the Inland and Coastal Zones, review of available published geotechnical and geologic information, review of six geotechnical studies for City and private development projects provided from the City representing subsurface conditions in different areas across the City, and geotechnical related data available online related to the former Georgia-Pacific Lumber Company site closure. This is not an extensive review of all potentially available geotechnical reports or related documents that may be contained in the City's records or from local consultants, which is beyond the scope of this study. This evaluation also does not provide specific geotechnical hazards assessments for the specific components of the water distribution system. The scope of site-specific hazards assessments would need to be developed after a detailed review of each specific component which has not been performed for this evaluation.

3 Approach

The data and discussion presented in this evaluation are organized as follows:

- Topography and Geology
- Emergency Access
- Water Supply and Distribution System
- Geotechnical Conditions Assessment
    - Geologic and Non-Geologic Hazards
- Areas of Concern for Rehabilitation of Water Distribution Facilities
- Recommended Future Actions
- Limitations

HDR's review of the subsurface conditions as described in the provided reports is briefly summarized in Attachment A. Although some portions of this evaluation may include discussions on climate change, a separate report is being prepared by HDR addressing climate change implications.

4 Background

The City is located along the coast of Mendocino County. The City is approximately 2.92 square miles in size and includes five island areas (non-contiguous land) totaling 0.15 square miles in size and comprised of city-owned property that was annexed on April 7, 1997.

While Fort Bragg is a small community, it is the largest city on the coast between San Francisco and Eureka and is a popular tourist and recreational destination. Commercial land uses in the City are located along the California State Route 1 (Highway 1) and Franklin Street corridors. The Central Business District, located between Oak Street and Pine Street, is the historic, civic, and cultural core of the community. Industrial lands are located on the Georgia-Pacific Mill property located west of Highway 1 on North Franklin Street, immediately north of the Central Business District, and on Highway 1 north of Pudding Creek. Residential neighborhoods are located east of the commercial core and in the west Fort Bragg area.

For planning purposes, the City is divided into the Coastal Zone as described in Coastal Act Section 30150 (July 2008 Land Use Element Fort Bragg Coast General Plan) and the Inland Zone for areas within the City influence but outside of the Coastal Zone (bounded by the City limits on the north and east, and the coastal zone to the south [Walnut Street] and west [Highway 1]). These zones are shown on Map LU-1, Land Use Designations and LU-2 City Boundary and Sphere of Influence, both contained in the updated 2012 Inland General Plan. The Coastal zone includes a specific plan area in the Timber Resources Industrial Land Use Designation (former Georgia-Pacific Properties) between Walnut Street to the South and Elm Street to the North and Highway 1 on the east.

Figure 1 presents a graphic showing the existing City water distribution system that consists of a network of pipes within the central portion of the City, primarily in the Inland Zone with supply provided to the south of the Noyo River in the Pomo Bluffs area north of Hare Creek, and to the north across Pudding Creek to the Fort Bragg Airport area. The coastal area west of Highway 1 and the main part of the City was previously occupied by the now closed Georgia-Pacific Mill with limited connection to the water distribution system.

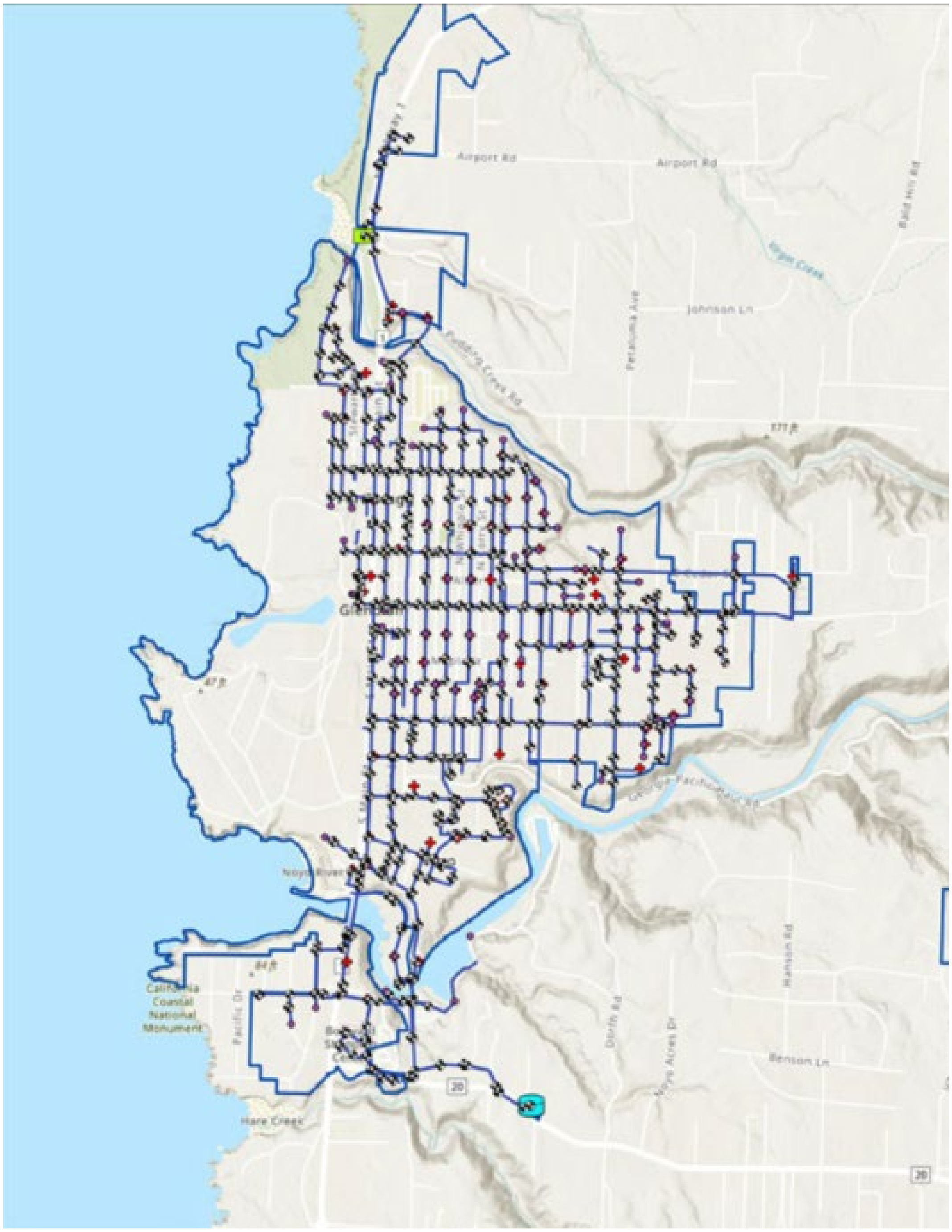

Figure 1 – City of Fort Bragg Water Distribution System Schematic (no scale)

5 Topography and Geology

The City is located on an uplifted terrace along the California Pacific North Coast. The uplifted terrace has created a coastal bluff that is approximately 50 feet tall at Soldier Point near the existing City's wastewater treatment plant and 85 feet tall at Pomo Bluffs State Park. Site grades slope gently upwards towards the east to approximately El. 400 feet where the terrace meets the western edge of the Coastal Range Mountains. A topographic terrain map of the region is provided below.

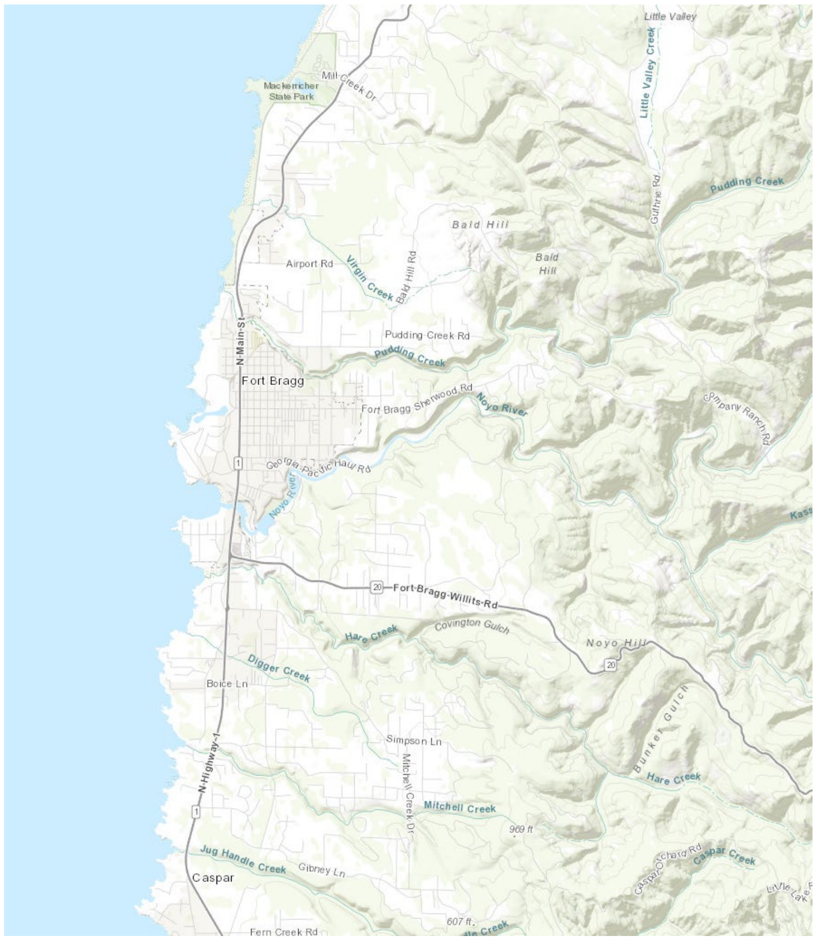

Figure 2 – Area Topography
Source: www.topozone.com

The elevations used in this study are relative to the 1929 National Geodetic Vertical Datum (NGVD 1929) which is sufficient for the general purposes of this discussion. Coastal Area elevations range on the east boundary from El. 78 feet (Main Street at Pine Street) to El 82 feet (Simpson Lane at Highway 1). Inland areas rise in elevation to about El. 200 feet (Marsben Lane at Sherwood Road). The terrace is incised by the Noyo River, Pudding Creek, and Hare Creek. Pudding Creek and the Noyo River have incised at least 160 feet into the terrace where the California Western Railroad once crossed these creeks and enters a now collapsed tunnel beneath Sherwood Road. United States Geologic Survey Benchmark at Noyo Harbor is listed as El. 11.73 feet. The mouth of Pudding Creek and Hare Creek are at or slightly above sea level where beaches have formed (El. 0 feet).

Noyo Harbor has been dredged to provide access to the Noyo Basin Marina. The most recent nautical charts should be reviewed to determine the depth of the dredged channel.

There is limited published geologic mapping of the City vicinity. The most detailed mapping was prepared as part of the Noyo River Watershed program in 2025 that includes preliminary mapping performed by Durham for the Department of Forestry in 1979. A portion of the Durham 1979 map and maps from the Noyo Watershed mapping are presented in Figure 3, Figure 4, and Figure 5. These figures are provided for illustrative purposes and are not presented to scale. The actual maps should be referenced for more specific information.

The primary units mapped by Durham are quaternary aged Terrace Deposits (Qtm) and tertiary aged Franciscan bedrock. These units are further differentiated and described by Manson as Pleistocene aged Marine Terrace Deposits Undifferentiated (Qmts) and tertiary - cretaceous aged Coastal Belt Franciscan (TKfs). Manson also maps an additional unit Older Dunes (Qods), briefly described as follows and shown in Figure 4.

5.1 Mapped Units

- Older Dunes (Qods) – Well-sorted, semi-consolidated, fine- to medium grained overlying various marine terrace deposits (Qtmts)
- Marine Terrace Deposits Undifferentiated (Qmts) Deposits generally consist of well sorted sand with minor gravel and have courser textures near major drainages, may include some dune sand.
- Coastal Belt Franciscan (TKfs) – Broken formation consisting of light colors, well-cemented to deeply weathered and sheared, clastic sedimentary rock (sandstone, conglomerate, shale).

Durham mapped a number of active landslides along the incised slopes of Pudding Creek, Hare Creek, and the Noyo River identified with the letter “A” and an arrow showing the direction of movement. Mapping by Mason et. al for the Noyo River (Figure 5) also includes shading depicting the relative risk of landslide in areas that were also mapped by Durham and show a correlation between the risk of landslide and slope inclination. Review of current Map SF-1 Geologic Hazards contained in both the Coastal and Inland General Plans include identification of landslide hazards in the City’s sphere of influence and references mapping by the State of California dated 1983.

These figures are in general agreement with the Manson landslide mapping. As the data for the General Plan maps is approximately 40 years old, a site reconnaissance by a registered engineering geologist should be considered to update the general plan Map SF-1. The State of California has prepared a map of deep landslide susceptibility originally published in 2011 as California Geologic Service Map Sheet 58 (CGS 2011). This map ranks landslide susceptibility to underlying bedrock strength and slope inclination. This map does not present the location of mapped/identified landslide and is discussed in more detail in the Geologic Hazard Section.

Mapped instability identified in Figure 5 are areas of surficial instability in the immediate City limits as points and the actual mapping of large deep-seated sliding are shown a distance approximately 2.5 miles east of the Noyo River Bridge along the Noyo river south Bank. Deep-seated landslides are more abundant within the State of California Jackson Demonstration Forest located to the east and southeast of the City with the closest slides located about 3.5 miles east of the Noyo River Bridge.

Additional insight into the surficial geology is provided from the review of mapped conditions within the City north of the Noyo River as depicted by the NCRS Soil Survey and review of the geotechnical report performed for the Aquatic Center near the intersection of Maple Street and South Lincoln Street. The 2003 geotechnical study (see Table 1) did not include a location plan for their borings; however, NCRS Soil Survey reports the material to the east of this site as fluvial marine derived deposits.

The 2003 SHN report identified the presence of soft soils and a layer of peat at a depth of 15.5 to 22 feet in Boring B-3. Boring B-2 found a gravel strata at a deeper depth. The study found the site contained fill to a depth of 4.5 feet along the north side of the site, underlain by dense sandy deposits to a depth of 18.5 feet. Boring B-3 depicts slightly different conditions suggesting that the terrace deposits mantled the bedrock and state that "the data indicates potentially variable or erratic soil conditions."

However, an alternate interpretation may be that the boring data suggests that the Noyo River or Pudding Creek may once have crossed the site and later shifted as the underlying bedrock was tectonically uplifted. The former drainage may have connected to the Soldier Bay cove at the coast, located to the west of Fort Bragg – Sherwood Road (Sherwood Road) shown in Figure 6. Studies performed for the restoration of the former mill pond document that Alder and Maple Creeks do cross the City and discharge into Soldier Bay that was dammed to form the mill pond (Arcadis 2011). The creeks were later placed in culverts and buried. The drainage could indicate more variable subsurface conditions and effect groundwater conditions beneath the main portion of the City (see https://www.fortbragghistory.org/?page_id=1071 for the 1873 map). The location of the postulated drainage roughly corresponds to the west end of the Noyo Anticline (geologic ridge formed by tectonic movement) shown on the geologic map in Figure 3. The anticline is an extension of the anticline mapped on the adjacent geologic map, the Geologic Map of the Comptche Quadrangle prepared by the State of California Department of Forestry also by Durham, 1979. If present, the drainage feature may follow a less resistant bedrock zone along the north side of the mapped anticline.

Figure 3 – Excerpt Geologic Mapping by Durham, 1979

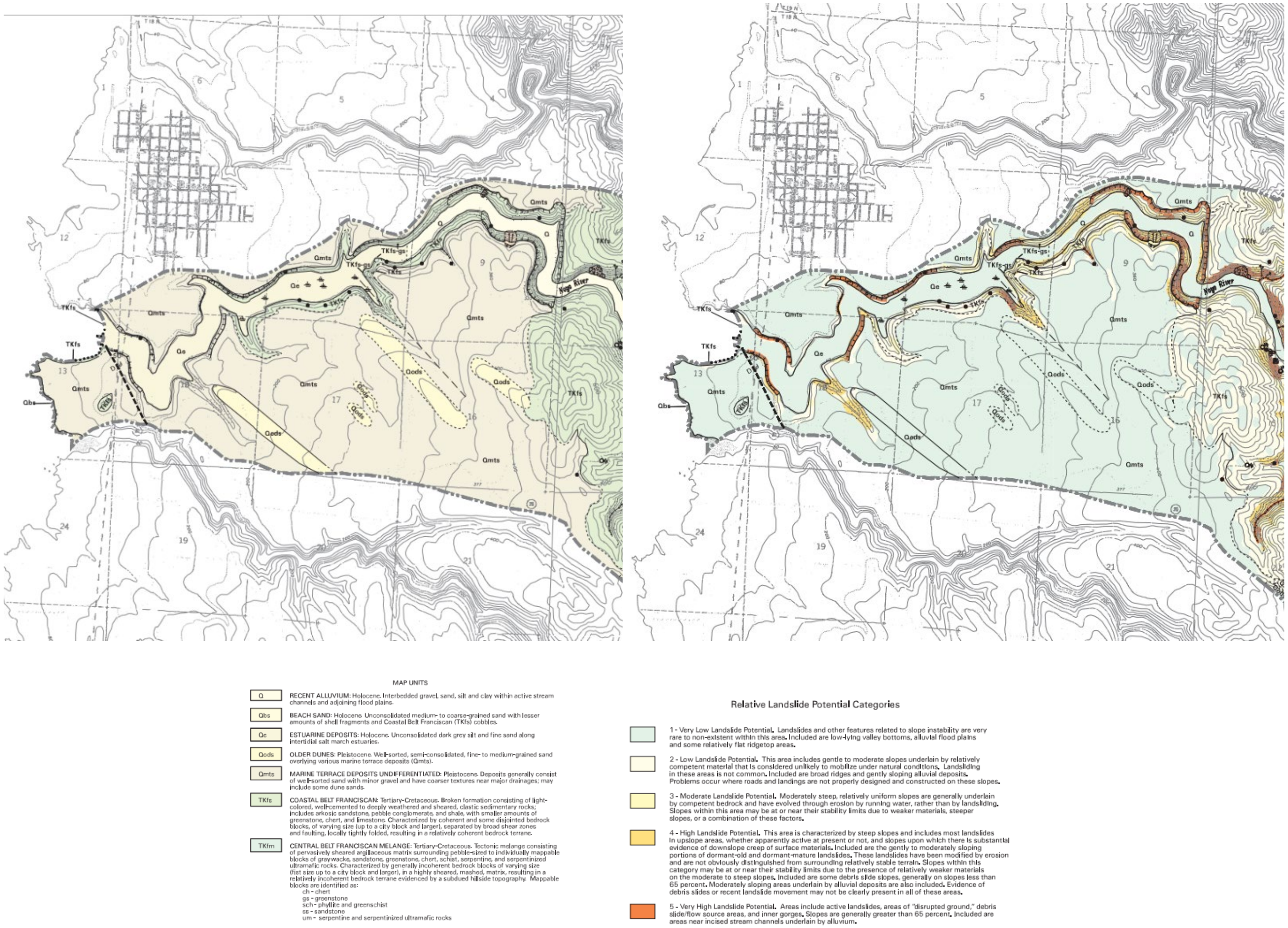

Figure 4 and Figure 5 – Excerpt from Noyo Watershed Mapping Relative Landslide Potential with Geology and Geomorphic Features (Manson et Al. 2001)

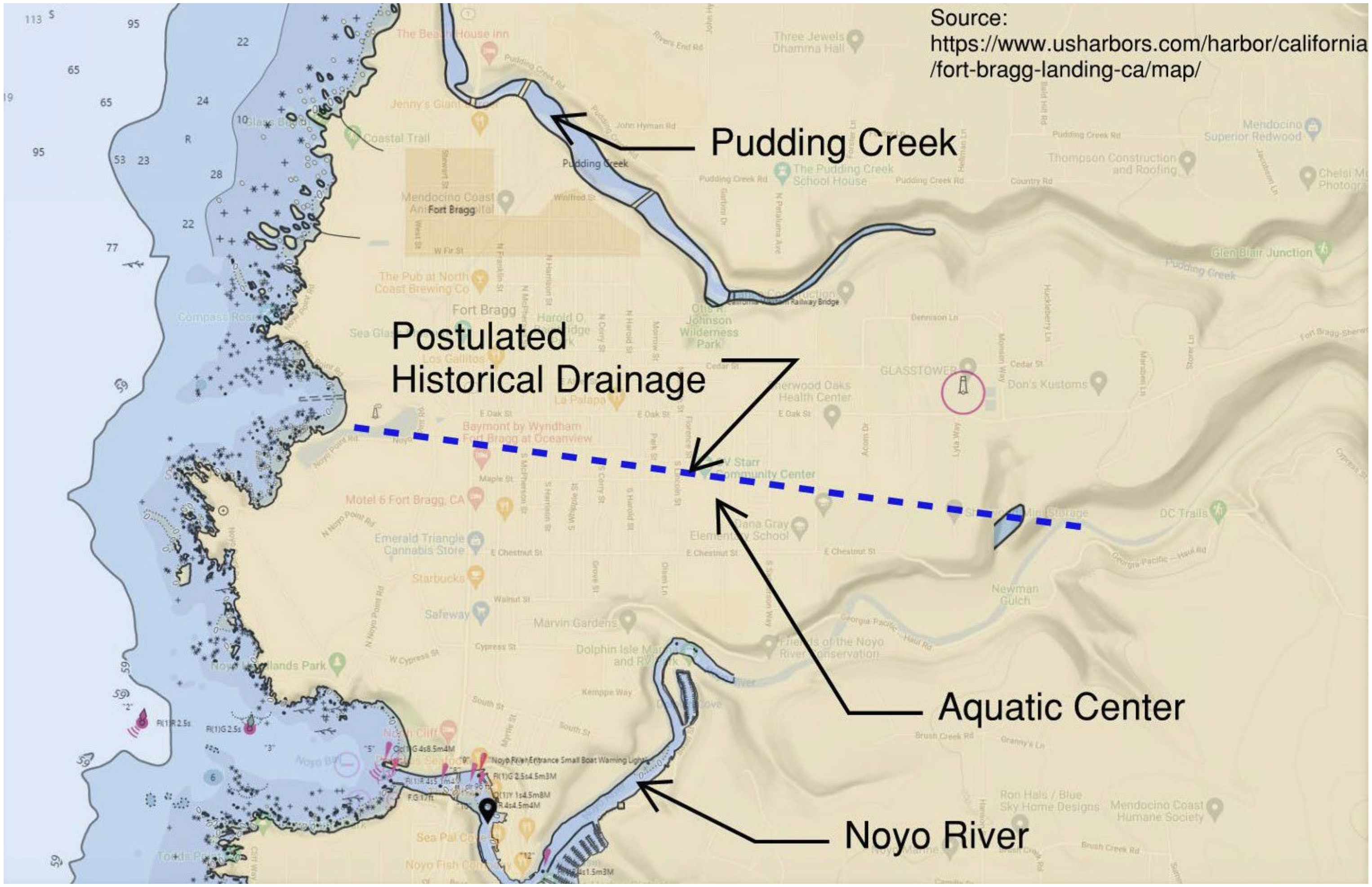

Figure 6 – Postulates Path of Historical Drained Beneath the City (No Scale)

6 Emergency Access

Subsurface conditions can impact City features such as vehicle access. The main vehicle access (and emergency evacuation/access routes) into and out of the City is Highway 1, which includes bridges that cross Hare Creek, Noyo River and Pudding Creek (from north to south). If these bridges were damaged during a seismic event or a large storm event, such as an intense storm washing out the bridge approaches or a tsunami damaging the bridge foundations, access would be limited.

The conditions of the logging roads that would be traveled to reach these points have not been evaluated as part of this study and do cross areas with high landslide susceptibility. Pedestrian access to the north from central Fort Bragg could be provided over the train trestle that crosses Pudding Creek west of the Highway 1 Bridge. The bridges are under the jurisdiction of the California Department of Transportation (Caltrans). The Noyo River Bridge replacement was completed in 2005. The previous bridge was replaced due to the seismic vulnerability. Pudding Creek Bridge was seismically retrofitted in 1998 and is currently being widened by Caltrans (2023). The Hare Creek Bridge is to be widened and retrofitted by Caltrans in the future.

It should be noted that Caltrans has its own design standards for bridges that is different than other codes such as the California Amendments to the International building Code (IBC) that govern design of occupied structures and American Water Works Association (AWWA) that govern design of water treatment, storage, and distribution systems.

7 Water Supply and Distribution

The following description of the water supply and distribution system is taken from Section 3 Public Facility Element included in the Inland General Plan.

> *The City's current water supply system consists of the Newman Reservoir, the Simpson (Waterfall Gulch) diversion, and a direct diversion in the Noyo River (which includes a wet well in the Noyo River, a pump station at the Noyo River, and various conveyances to the water treatment plant.*
>
> *The City currently obtains about 50 percent of its water from the Noyo River. Under its existing temporary license, the City is entitled to draw up to 1,500 acre feet of water per year from the Noyo River so long as withdrawals do not exceed 3.0 cubic feet per second and specified amounts are maintained in the river to meet the needs of the fish population. The City's Water Permit limits how much water can be pumped from the Noyo River during drought conditions. These limits were established by the State Department of Health Services because it concluded that the City must ensure sufficient flows within the river necessary to support the fish population. To comply with these Permit conditions, the City requires that new development implement measures that limit new water demand. Additionally, the City is developing new water storage facilities to ensure adequate water during severe drought years and to meet the needs of future development in both the Inland Area and the Coastal Zone.*

Since the Inland General Plan was last updated, the City constructed a new 45-acre-foot lined water storage reservoir and then purchased 580 acres of land south and east of the city limits on Summer Lane for future reservoirs. The City is also in the process of designing and replacing raw water pipelines connecting to the water treatment facility on Cedar Street that includes two older above-grade welded steel storage reservoirs (tanks) and one above-grade welded steel reservoir. The city also has a tall above grade welded steel reservoir at the corner of Highway 20 and Babcock Lane.

As the treated water steel reservoirs will be subject to strong ground shaking during an earthquake the design and maintenance of the reservoirs are governed by AWWA D-100 for welded steel tanks and D103 for bolted steel tanks, including requirements for having retrained foundations. Steel structures require inspection and maintenance and may require seismic upgrades as design codes evolve. Geotechnical reports related to these tanks have not been provided for review and comments regarding the design of the reservoirs is beyond the scope of this report.

Pipeline connections to these reservoirs present a seismic vulnerability as the structure and the pipe connection movement can cause localized stresses and cause failures. Flexible/articulating connections are usually provided to connect the reservoir to pumping to accommodate differential movement.

Distribution piping itself can be at risk due to many geotechnical causes, such as:

- Corrosive soils that weaken the pipe itself
- Differential settlement or pipe lengthening due to land sliding, bluff retreat, soil densification, or liquefaction resulting in large magnitude settlements or lateral spreading, static settlement due to change of overburden or imposed loads, or hydro-compression due to changes in saturation
- Differential movement during earthquake such as at service or distribution connections such as large manhole or bridge crossings

The fire hydrant network is also critical infrastructure for the City. The hydrant system needs to remain operational for small and large events such as wildfire and after a large seismic event.

The following sections discuss the different geotechnical conditions that are present within the City of Fort Bragg and its areas of influence.

8 Geotechnical Conditions Assessments

The City of Fort Bragg provided eight geotechnical reports from their files to provide a background of near surface soils conditions listed in Table 1 below and the location of the investigations are shown on Figure 7. Geotechnical information provided in these reports and in other information reviewed include the following topics, to some degree:

- Review of existing data
- Geologic setting
- Site conditions
- Site geology
- Subsurface conditions

- Groundwater
- Soil corrosivity
- Geologic hazard including:
  - Seismicity and strong ground motion
  - Soil liquefaction
  - Expansive soils
  - Bluff retreat

General geotechnical subsurface conditions within the coastal and inland areas of Fort Bragg are discussed in the following sections referencing the eight reports provided for review. Each report is identified in the specific area it is located. All the reports include a very limited review of existing data and typically limited review of available published geology and other historical investigations that were performed at the site being investigated.

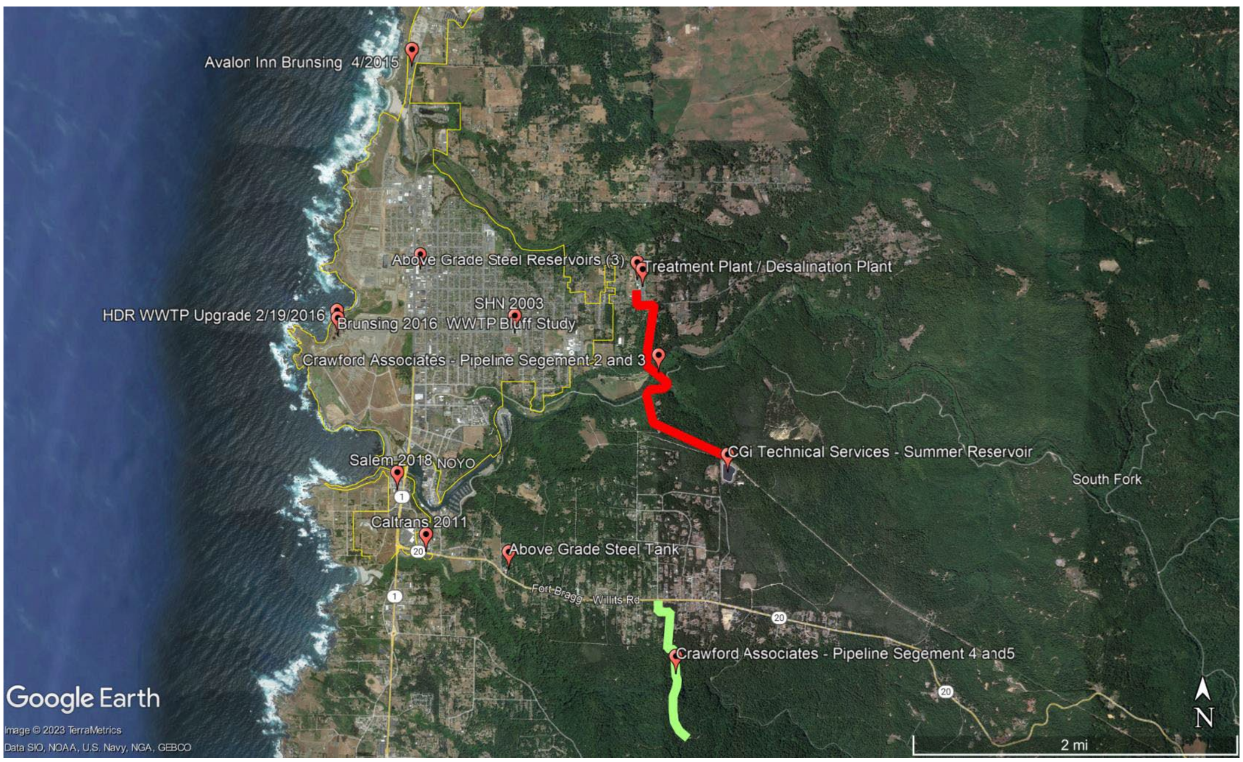

Figure 7 – Location Map – Reference Geotechnical Investigations

Other sources of data that were reviewed for this evaluation and may be of interest are cited below to provide additional insight in the geotechnical conditions and geologic hazards within the City's area of influence.

- California Department of Conservation, Mendocino County Tsunami Hazard Areas https://www.conservation.ca.gov/cgs/tsunami/maps/mendocino
- California Department of Conservation - Alquist-Priolo Earthquake Fault Zones (ca.gov)
- California Geological Survey (CGS) 2011, Sheet 58, Deep Seated Landslide Susceptibility
- California Office of Emergency Services online MyHazard Maps myhazards.caloes.gov

- Geotracker - Environmental Clean-up Areas within and in the Vicinity of Fort Bragg https://geotracker.waterboards.ca.gov/map/?CMD=runreport&myaddress=Fort+Bragg+Ca
- Coastal Conservancy – Projects and Land Acquisitions the Coastal Conservancy is s supporting along the coastline in Fort Bragg - http://websites.greeninfo.org/mapcollaborator/sccpv/prod/#
- Mendocino County Hazard Management Plan (2020) https://mitigatehazards.com/mendocino-county/final-mjhmp/
- Office of the State Fire Marshal – Fire Hazard Severity Zones Pacific Institute – California Flood Risk: Sea Level Rise, For Bragg Quadrangle https://pacinst.org/reports/sea_level_rise/hazmaps/Fort_Bragg.pdf (Link not active in 2025)
- TRC, 2004, Phase II Environmental Site Report, Georgia-Pacific California Wood Product Manufacturing Division, 90 Fort Bragg Avenue, Fort Bragg, California, May (EnviroStor.ca.gov))
- United Stated Department of Agriculture Web Soil Survey https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
- United States Geological Survey Quaternary fault map - USGS.maps.arcgis.com/apps

8.1 Geologic Hazards

8.1.1 Seismicity

The City of Fort Bragg is located in an area that is known for seismic activity; however, the City is not within a currently established State of California Earthquake Fault Zone for surface fault rupture hazards and there are no known active fault traces in the immediate project vicinity. The nearest Alquist-Priolo Earthquake Fault Zone to the project site is associated with the North San Andreas Fault system and located approximately 6.5 miles west of the site, which is the most likely source of earth shaking. The Maacama Fault zone is approximately 21 miles to the east of the City; the Mendocino Fracture Zone is approximately 60 miles to the northwest (Figure 8). The recently identified, potentially active, Pacific Star Fault is located to the northeast between the towns of Fort Bragg and Westport. All the faults could potentially cause earth shaking activity. Potential hazards associated with earthquakes includes rupture of the ground surface by displacement along faults, shaking of the ground caused by the passage of seismic waves through the earth, ground failure induced by shaking, such as landslides, liquefaction and subsidence of unstable ground, and tsunamis. The Pacific Star and Pudding Creek Faults were identified in 2006 and are reported as connecting to the San Andreas fault paralleling the Pacific Coast though they are not located within a special fault study zone.

The 1977 5.2 magnitude earthquake near Willits is the largest magnitude earthquake in the vicinity of the City, approximately 28 miles east of the City. Fort Bragg reported severe losses after the 1906 earthquake due to structure damage and fire. A 7.0 magnitude earthquake offshore Cape Mendocino occurred on December 12, 2024, approximately 90 miles northwest of Fort Bragg, with little damage report in the City as a result. Strong ground shaking is likely for a large earthquake event along the North California Coast region on the Maacama fault zone east of the city, the San Andreas Fault west of the City, and the Mendocino Fracture Zone/Cascadia Thrust Zone off the Pacific Coast near Eureka, California. USGS estimates that there is a 64.92% chance of an earthquake with a magnitude greater than 5 to occur in the next 50 years.

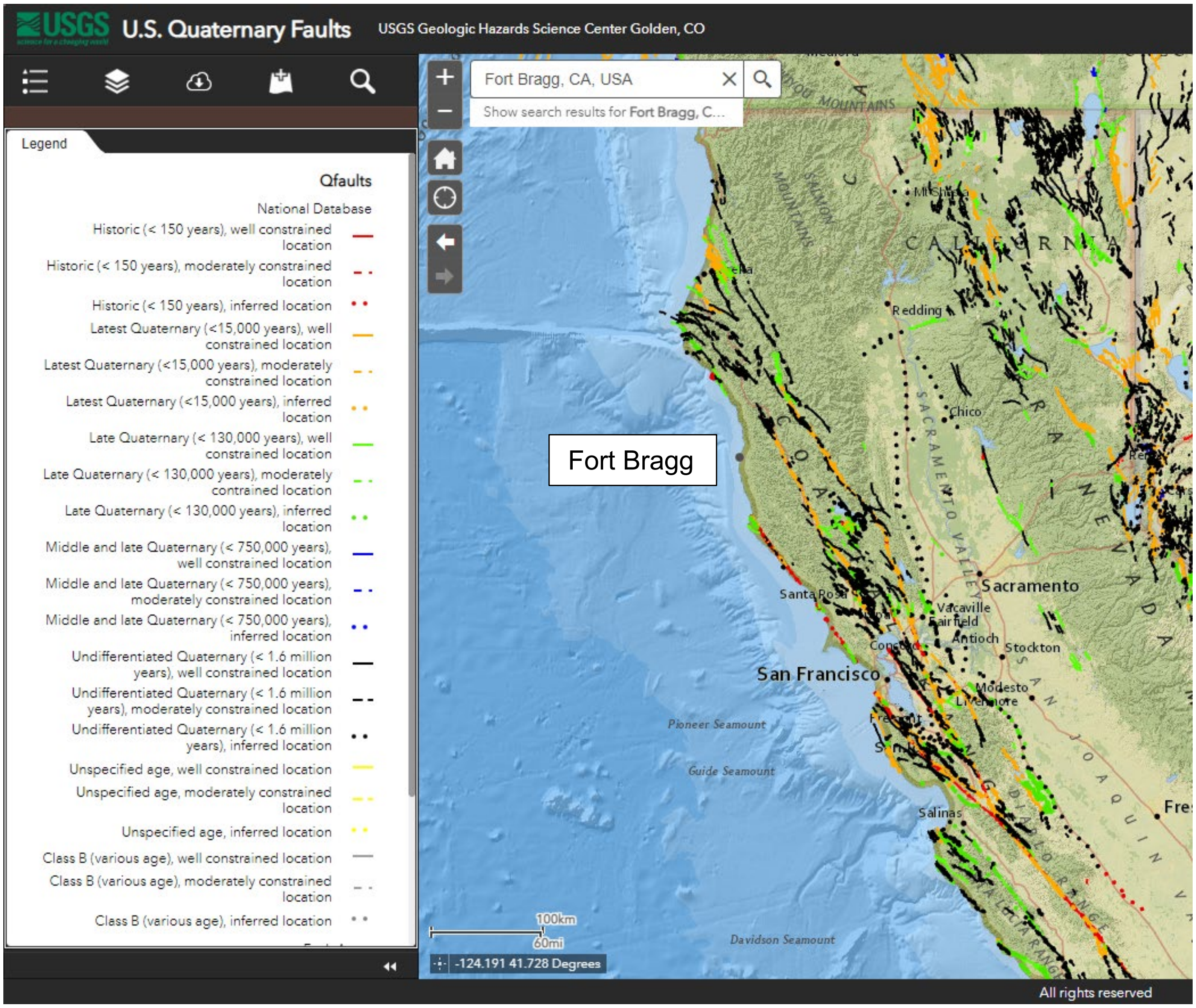

Figure 8 – Quaternary Fault Map (Source USGS.maps.arcgis.com/apps)

8.1.2 Fault Offset, Strong Ground Shaking, Liquefaction and Tsunami Impacts

The fault offset hazard in the City is very low. There are no Alquist Priolo Hazards Zones identified within or near the City (www.conservation.ca.gov). The City will be subject to strong ground shaking that could induce densification of loose to medium dense terrace deposits and slope movement within the steeply incised river and creek channels and along the coastal bluff. Loose, saturated cohesionless soils are susceptible to liquefaction, including sediments that have accumulated within and at the mouth of the coastal, river, and creek channels and potentially in eolian (windblown) derived terrace deposits that become saturated due to groundwater.

The State of California Office of Emergency Services online MyHazard maps (myhazards.caloes.gov) does not identify Fort Bragg as having a mapped liquefaction zone; however, the risk of liquefaction is judged to be moderate in the terraces and high in the river and creek channels and could occur in the event of strong ground shaking.

Tsunamis would impact the coastal areas, the Noyo Harbor and upstream areas of Noyo River Pudding Creek and Hare Creek (Figure 9). The Pacific Institute presents the effect of 55 inches of sea level rise on their Sea Level Rise Map of the Fort Bragg Quadrangle referenced above. The map shows that sea level rise will exceed the 100-year flood level within the Noyo River and Pudding Creek. The occurrence of tsunami(s) combined with sea level rise would impact the areas shown effected by sea level rise within the limits of Pudding Creek, Hare Creek, and the Noyo River including impacting existing raw water intakes along the Noyo River with salt water. The intakes have been impacted in the past with saltwater intrusion from high tides, and beginning in 2021 the City began using a desalination system to treat high salinity raw water from the Noyo River (Water Boards Media Release October 12, 2021).

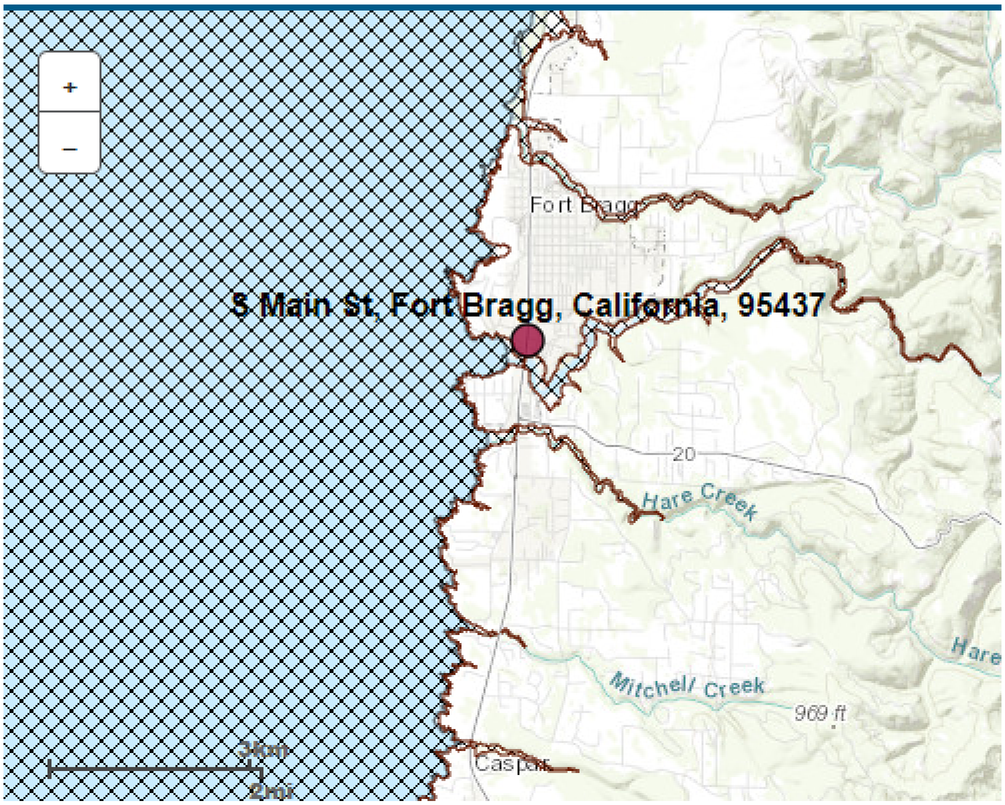

Figure 9 – Tsunami Hazard Area - Shaded (source Cal OES MyHazard)

Table 1 – Geotechnical Reference Provided by City of Fort Bragg by Area

Date	Area	Author	Address	Rock Depth	Bluff Erosion Estimated	Dynamic Densification	Liquefaction	Lateral Spreading	Tsunami Risk
2022	Inland	Crawford	Segment 2	NE	NA	Low	Low	ND	ND
	Inland *		Segment 3	NE	NA	low	Low	ND	ND
	Inland *		Segment 4	NE	NA	Low	Low	ND	ND
	Inland *		Segment 5	NE	NA	Low	Low	ND	ND
2018	South Coastal	Salem	1151 South Main Street	>20 ft	NA	Yes	Low	Low	Low
2016	Central Coastal	HDR	101 Cypress Street	11.5 to 18	No	Yes	No	No	NA
2016	Central Coastal	Brunsing	101 Cypress Street	ND	Yes (14.75 ft/75 years)	NA	NA	NA	NA
2015	North Coastal	Brunsing	1201 North Main Street	10 to16 ft	Yes (31.25 ft /75 yrs)	Yes	Yes (0.4g shallow GW)	Yes	Low
2011	South Coastal	Caltrans	Highway 1 (ADA Project)	10 to 11 ft	NA	ND	ND	ND	ND
2007	Inland (outside City Limits)	Curry Group	Summers Lane	NE	NA	Yes	Yes (0.65g and GW at ground surface)	Yes	NA
2003	Inland	SHN	Green Memorial Field/Starr State Park	11.5 to 38.5 ft	NA	Low	Low	ND	ND

Note: * - Outside of City Limits
ND – Not Determined
NA – Not Analyzed
NE – Not Encountered
Low, No, Yes – Individual Report Author's Opinion

8.1.3 Non-Seismic Hazard

Non-seismic geologic hazards include the presence of unstable soils on steep slopes and expansive soils which, in the presence of moisture, will swell and shrink when returning to a dry condition, and compressible soils. Map SF-1: Geologic Hazards identifies areas of potential landslides and is discussed in more detail in the Section of Topography and Geology earlier in this evaluation.

Bluff retreat (erosion) is estimated for two locations in the provided reports, and is discussed in more detail in the following sections. The Pacific Institute has provided graphical estimates of bluff retreat by the year 2100 on their Sea Level Rise Map of the Fort Bragg Quadrangle referenced above. It is unlikely that bluff retreat will impact the City's water distribution system unless there are existing distribution pipelines or connections within that zone.

The presence of loose and/or weak compressible soils has been noted in the reference geotechnical reports. The presence and mitigation, if required, would be determined on a project-specific investigation/basis. It would be beneficial to document the past performance of the water distribution system (Geographic Information System [GIS], mapping and tabular format) including areas of past pipe repairs/leak/breaks and areas of known surface (street pavement and hardscape) distress to identify areas that may be underlain by weaker soils.

8.1.4 Regional Geology

The bedrock of this part of the Mendocino coast is comprised of well-consolidated sedimentary rocks of the Cretaceous-Tertiary Period coastal belt Franciscan Complex, such as sandstone and shale. The bluff-top property occupies a near-level marine terrace underlain by the Franciscan Complex bedrock. The terrace was formed during the Pleistocene Epoch, when periods of glaciation caused sea level fluctuations, which created a series of steps, or terraces, cut into the coastal bedrock by wave erosion. Shallow marine sediments (Pleistocene terrace deposits) were deposited on the wave-cut, bedrock platforms while they were submerged beneath the ocean during interglacial sea-level high stands. Some of these marine deposits have been locally eroded as the terraces began to emerge from the ocean due to uplift associated with the San Andreas Fault Zone during the middle and late Pleistocene. Present sea levels are believed to have been achieved about 5,000 to 7,000 years ago.

8.1.5 Near-Surface Geology and Surface Condition

The following descriptions of site near-surface geotechnical conditions are excerpted from the geotechnical reports provided by the City separated by zone, Coastal (North, Central and South) and Inland zones, and by report author to provide a basis to understand the variability of subsurface geotechnical and groundwater conditions of the terrace deposits that mantle the bedrock within the city. It should be noted that the geotechnical reports have been developed to different standards based on their age and their primary purpose. However, the reports provide insight into the variable subsurface conditions across the city, particularly the thickness of fill materials and terrace deposits.

The identification of Zones is based on the City of Fort Bragg Inland and Coast General Plans (City of Fort Bragg 2012 and 2008) The Inland Zone is identified as a generally a westward project extending from the intersection of Walnut Street and Highway 1, projecting east to the top of the Noyo River north bank and to the north from the intersection of Walnut Street and Highway 1, following Highway 1 north to beyond Virgin Creek, as shown on Map LU-1, Land Use Designation. The Coastal Zone is all areas west and south of the Inland Zone, including the intersection of Highway 1 and Highway 20, for areas within the City boundary and sphere of influence as shown on Figure LU-1 Land Use Designations. The Noyo River has been included in the Coastal Zone. For this document, Pudding Creek and the Noyo River have been selected to divide the Coastal Zone into the North, Central and Southern zones. Therefore, historical investigations that extend or are located south of the Noyo River north top of bank are included in the southern Coastal Zone.

A summary of the conditions reported at each of the eight reports are provided in attachment A. Included is a comparison to the data available from the NCRS Soil Survey data regarding the composition of new surface soil composition. The NCRS Soil Survey Data is provided in an online map of soil conditions for depths on the order of 6 feet. A map of the units overlain on an aerial map for the City and surrounding area is provided as Attachment B as well as tabular list data of typical engineering and chemical properties contained in the NCRS database organized by soil unit number. The tabulated values are developed focused on agricultural uses but can provide insight into the soil texture and chemical nature of the soil. This data can be used for a preliminary high-level assessment of near surface site conditions in areas within a specific zone but not explicitly investigated. More detailed investigations may be warranted depending on the project under consideration.

It is particularly important to note that groundwater conditions documented in the reference reports represent conditions observed at the time of investigation and are generally poorly understood. Groundwater (at depth) and near surface perched groundwater are two different groundwater occurrences and both have been reported. Additional groundwater investigations would be required to better understand the current temporal variations in groundwater at a specific site with the City's area of influence. The assumptions related to groundwater levels have a significant impact on the occurrence of liquefaction induced by strong ground shaking and the values reported in the different documents should not be relied on for future project.

Documents related to the environmental cleanup of the Georgia-Pacific site (Central Coastal Zone) are available through the California Department of Toxic Substances (DTSC) using the Envirostor system (https://www.envirostor.dtsc.ca.gov). Groundwater in the central portion of the Coastal Zone is depicted in a series of monitoring reports that show a groundwater depression in the vicinity of Soldier Bay. The 2004 Phase 1 study described this area as a natural low spot and groundwater at the eastern edge of the zone was measured at El. 65 feet.

Fill – All Reports

Variable thickness of fill is present throughout the City due to historical grading and development. Fill is likely locally derived and can be highly variable. Fill material may contain significant organics (such as topsoil) and can have little to no compaction efforts. Suitability for reuse of fill will need to be determined on a case-by-case basis.

Marine Terrace Deposit – Coastal (five report sources)

The Coastal Zone generally consists of sand with variable amounts of gravel, silt and in some instance s clay. It is listed as being eolian (windblown) origin by NCRS, is under consolidated and can be susceptible to liquefaction due to strong ground shaking depending on the level of groundwater. Where estimated, the liquefaction hazard is generally low and liquefaction induced settlement has been calculated based on conservative (elevated) groundwater levels. The liquefiable soils are also susceptible to lateral spreading.

The depth of bedrock is variable. Bedrock was not encountered in the southern coastal zone. In the Coastal Central Zone, depth to bedrock varies from to within 2 feet of the ground surface to a depth of 9.5 feet at the City WWTP and 20 to 30 feet at the Georgia-Pacific facility in the topographic low point at Soldier Point. In the Coastal Northern Zone the depth of bedrock varied from 7 to 15 feet.

The depth to groundwater has been reported to occur at a depth of 7 to 8 feet in Georgia-Pacific monitoring wells. Groundwater encountered at the time of drilling in the north and south area was reported between 2 and 7 feet and are expected to vary seasonally.

Marine Terrace Deposits – Inland (two report sources)

The Inland Zone is likely comprised of both eolian and fluvial terrace deposits depending on the distance east from Highway 1. The terrace deposits transition to fluvial derived deposits that have higher clay and silt contents up to materials being classified as clay. These have been identified at the Aquatic Center and along the raw water pipeline alignment. The transition between the two types of terrace deposits are not defined but, for a first estimate, may be located along the El. 160-foot contour.

A potential buried drainage (bedrock depression) may be located beneath the Aquatic Center and may extend to the west towards the bay north of Soldier Point. The buried drainage would have thicker terrace deposits than the adjacent areas that could increase the risk of differential settlements due to seismic densification liquefaction. Bedrock was only encountered by the 2003 Aquatic Center investigation at depths of 5 to 10 feet but was below a depth of 22 feet at one location. A compressible peat layer was found at depths of 22 feet.

Shallow groundwater was encountered during the 2003 investigation.

Colluvium – Incised River and Creeks Slopes

Colluvium is mapped as being along slopes that have moderate to high risk for landslides. The thickness of the colluvium is not defined but is estimated in one report as being on the order of 5 feet.

Alluvium and Beach Deposits

Alluvium and beach deposits have accumulated along the river and creek channels. The Noyo River is maintained by the United Stated Corps of Engineers that periodically dredge the channel. Beach deposits are located at the mouth of Hare and Pudding creeks. Alluvium derived from erosion of adjacent areas has accumulated in the stream bottoms and likely varies from sand bars to siltation within the channel that are likely saturated and loose (granular deposits) and soft and weak (cohesive deposits). Targeted geotechnical studies would need to be performed to assess the conditions that existing for projects that are located across these deposits.

8.2 Other Geologic Related Concerns

8.2.1 Mineral Resources

According to a 2019 Initial Study and Mitigated Negative Declaration, the City does not have any identified locally important mineral resources recovery sites delineated in the general plan, specific plan, or other land use. The City has also not been utilized for Surface Mining and Reclamation Act (SMARA) activities, as noted in the City of Fort Bragg General Plan Amendment 1-19 (GPA 1-19), Inland General Plan Amendment – Housing Element Update (2019).

8.2.2 Corrosivity (Chemical Analysis)

As stated in the previous sections, the near-surface soil blanketing the site is acidic and has a low cation exchange capacity being more acidic closer to the ocean. Corrosivity analyses were only available from two of the eight studies reviewed, reported as follows.

South Coastal Zone (Salem 2018)

Soluble Sulfate - 100 mg/kg

Soluble Chloride - 36 to 37 mg/kg

pH – 7.1

The water-soluble chloride concentration detected in saturation extract from the soil samples was 37 mg/kg.

The reports states that this level of chloride concentration is considered slightly corrosive.

Inland – (Crawford 2022)

Pipeline Segment 4 – two samples depths 2.0 to 3.0 feet.

Minimum Resistivity (Ohm-CM) - 4,290 and 10,990

Sulfate Content (ppm) - 3.1 and 15.1

pH - 3.99 and 4.26

The report states that in accordance with Caltrans Standards, the soil tests indicate corrosive to structural steel materials and non-corrosive to structural concrete materials. The Crawford results correlate with NCRS data for pH.

The terrace deposits soils should be considered corrosive to steel and slightly corrosive to concrete unless specific testing is performed or the performance of buried structures can be determined from visual inspection. A testing standard should be developed for all corrosion testing so that a “Zone” database can be developed by the city to aid in their management of the water system.

8.2.3 Erosion

For the steeper slopes, Crawford (2022) stated the following for the proposed pipelines:

> *The proposed pipeline alignment meanders through steep slopes with a few areas mapped as inner gorge which are prone to landslides, erosion, and creeping. Based on our review of the project plans, the slopes are shown to range from 1H:1V to 4H:1V along the pipeline alignment. Observations along the proposed alignment showed the existing slopes are performing adequately and consist of heavily established vegetation. Following the completion of construction, overly steepened areas (such as between Station 125+00 through 126+60 and Station 130+00 through 132+00) where vegetation is being removed will be susceptible to erosion and may require periodic maintenance while the vegetation is reestablished.*

Removal of vegetation and redirection of surface water could induce erosion on any area of the City. Care must be taken to restore disturbance to reduce the risk of developing areas of concentrated surface water flow that could induce erosion. Care must be also taken to install trench dams along long lengths of pipeline in and in areas of elevation transitions so that the pipeline trench does not act as collection drawings redirecting and concentrated seepage to the trench outlet, which could lead to ground saturation and potential slope failure and erosion.

8.2.4 Non-Geotechnical Hazards

8.2.4.1 Flooding

Flooding Hazard is typically determined for a 100-year flood level for insurance purposes using maps developed by the Federal Emergency Management Agency (FEMA). As described in the Inland General Plan:

> *"FEMA … requires the City to establish development standards for construction in the 100-year floodplain. Typically the standards developed by a city or county can range from limits on the intensity of development to requirements to raise the "habitable floor" of the structure to at least one foot above the 100-year flood peak elevation. Most of the City, over 99% of the land area, is situated above both the 100-year and the 500-year floodplains. The only areas in the Inland Area located within the 100-year flood plain are along the Noyo River and Pudding Creek. The presence of riparian habitat and excessive slopes in this area prohibits development within the 100-year flood plain."*

And,

> *"Portions of the City have areas subject to potential flooding during severe storms. Because of the generally flat terrain in the Fort Bragg area, a 100-year storm could exceed the ability of the City's infrastructure to move runoff water from the City to outfalls into natural drainages and the ocean. This drainage overload may result in standing water in low areas. High tides and severe storms may also cause flooding in low-lying areas near creeks and drainages."*

The Coastal Zone Map SF-2 references flood mapping dated 1992 while the Inland Zone map references mapping stated in 2011. The FEMA updated flood maps for Fort Bragg area are dated as being published in 2017 that show larger 100-year flood hazard than shown in the Coastal General Plan Map. The Inland Zone General Plan includes Map SF-3 Tsunami Inundation Map and Map SF-4 100-year Sea Level Rise Inundation Area, which is the Pacific Institute map previously referred as an additional source document for this evaluation. The most recent FEMA flood mapping and the Pacific Institute mapping of sea level rise is recommended as references for assessing flooding impacts.

8.2.5 Fire Hazard

The City's fire hydrant system is critical infrastructure for public safety. Significant fires have occurred in Northern California in the last few years and the ability to protect the City from structure fires and wildfire is important. The fire hydrant system is also critical after a large seismic event.

In 2022, the California Department of Forestry and Fire Protection (CAL FIRE) published large-scale maps depicting Fire Hazard Severity Zones for Mendocino County as part of the Fire and Resource Assessment Program (https://osfm.fire.ca.gov/media/loqhpr10/fhsz_county_sra_e_2022_mendocino_ada.pdf).

Zones north and south of the City are zoned as having a high severity and the east is zoned as moderate severity. The City is outside the jurisdiction of CAL FIRE and the City itself is zoned as a local responsibility area (LRA). The Fire Hazard Zone Severity Viewer is located at https://egis.fire.ca.gov/FHSZ/. The viewer shows the area south and east of the Noyo River zoned as very high and the area north and east of the City as moderate. High risk zones are located east of the City on the north back of the Noyo River and east of the north Coastal Area. The south Coastal area is located in a moderate risk zone west of Highway 1 and in the lower elevations east of Highway 1.

8.2.6 Extreme Weather Events

In February 2023, the United States Department of Agriculture (USDA) declared Mendocino County a Disaster Area due to severe winter storms and flooding. The occurrence of heavy storms and storm events, characterized as atmospheric rivers, are defined by National Oceanic and Atmospheric Administration (NOAA) as long narrow regions in the atmosphere that transport most of the water vapor out of the tropics that have an equivalent flow at the mouth of the Mississippi River and exceptionally strong events can have 15 times that amount. The Pineapple Express is a strong atmospheric river bringing moisture from the tropics near Hawaii to the west coast. The rain events can induce slope instability and rapid slope movement and debris flows. One such event happened to the community of Rio Nido along the Russian River in 1998 and have also been attributed to coastal landslides in 1962.

Figure 10 presents a ranking of the potential deep-seated landslide occurrence-based on rock strength and slope inclination from CGS Map Sheet 58. The darker the color red indicates the higher potential risk. Rock strength in Mendocino County is generally ranked as moderate; therefore; the instability is a function of slope inclination ranging from 3 degrees to over 40 degrees, with rocks inclined 15 to 20 degrees or greater having the highest susceptibility (approximately equivalent to a 27 percent grade or higher). Therefore, the susceptibility of landslides impacting the City water supply and distribution system or evacuation routes directly or from debris flows should be evaluated on a case-by-case basis. It should be noted that climate change may increase the risk of slope instability.

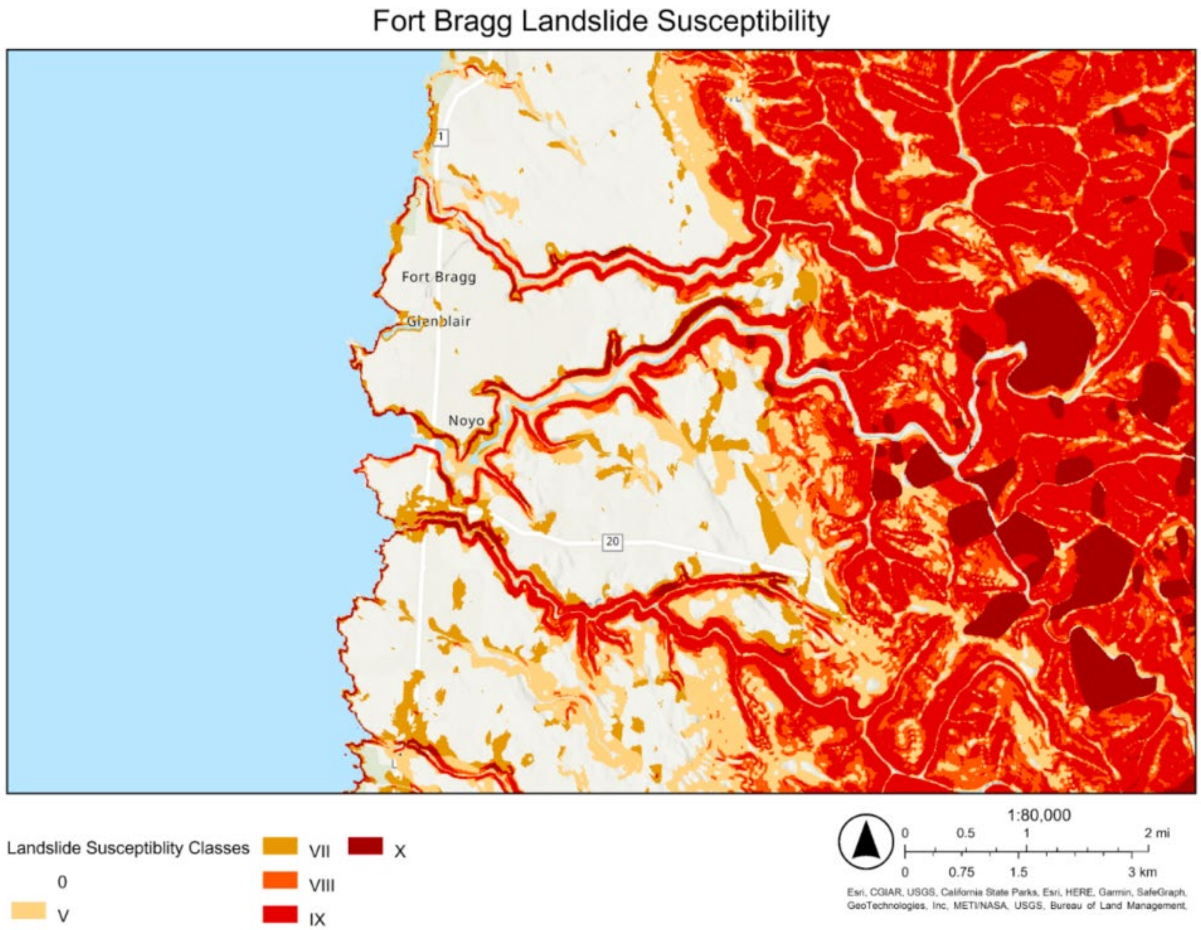

Figure 10 - Relative Slope Instability in the Fort Bragg Area (After CGS Map 58, 2011)

8.2.7 Chemically Impacted Sites

A review of the DTSC GeoTracker website provides the locations of numerous identified chemically impacted sites that range from small underground storage tanks to large facility clean-up activity. Many of the sites are identified as having closed files, meaning that the sites have been remediated to meet cleanup goals s set forward by regulatory agencies. It should be noted that there may be residual chemically impacted soils at these sites that did not require removal but, should they be excavated, may require special testing and handling to determine material reuse or disposal. The GeoTracker site and associated data should be checked as part of a future system upgrade or rehabilitation projects to be aware of potential impacted sites.

9 Areas of Concern for Rehabilitation of Water Distribution Facilities

The following geotechnical factors should be considered when addressing water distribution design or rehabilitation.

9.1 Densification and Liquefaction

The City will experience strong ground shaking that could induce seismically densification and/or liquefaction in saturated, loose granular soil. Liquefaction can also induce lateral spreading. Differential movement both vertically and laterally can damage water distribution facilities such as when connected to structures founded on rock or connected to bridges. The magnitude of movement will dictate the appropriate measures to include in a repair or rehabilitation of the system including use of articulating joints for entering rigid structures and the use Earthquake Resistant Ductile Iron Pipe (ERDIP) if the anticipated movements are significant and would damage standard pipe systems, such as those being implemented by the Los Angeles Department of Water and Power (LADWP) to provide greater resilience to their distribution system. ERDIP allows for the pipeline to extend, accommodating seismic deformations limiting failures for pipelines failing at joint. The amount of movement that can be accommodated is a function of the length of ERDIP installed. LADWP limits use of ERDIP to sites that are deemed critical to the function of the entire water system in the event of a major earthquake and are typically located in areas that are calculated to have widespread lateral spreading and large fault offset. For more information, see https://www.hdrinc.com/sites/default/files/2017-05/hdr-seismic-considerations-for-water-distribution.pdf (link not active in 2025). and

https://scag.ca.gov/sites/main/files/file-attachments/srpwebinar_orourkepresentation.pdf?1603219825)

The American Lifeline Alliance is a public/private alliance between FEMA and the National Institute of Building Sciences. In 2005, they published Seismic Guidelines for Water Pipelines that provides extensive guidance for the design of water pipelines in the seismic environment. (https://www.americanlifelinesalliance.com/pdf/SeismicGuidelines_WaterPipelines_Comm.pdf.

There are also numerous articles published in AWWA and ASCE conference proceedings, including work by O'Rourke. In the 1970s, asbestos concrete pipe (ACP) was used for water distribution systems. As these pipes age the pipes can become brittle and fail catastrophically with no warning. ACP also poses an environmental hazard. Therefore, the pipelines can be lined with a drinking water compatible resin cured-in-place pipe (CIPP) line technology that, when the resin hardens, forms a new ductile and deformation resistant pipe within the ACP. CIPP can also be applied to ductile iron pipes.

Seismic shaking itself can induce differential movement between structures and pipeline causing damage to connections, such as connections to vaults, steel reservoirs, or bridge crossings. Large, out-of-phase movement can cause damage to connections to structures. To improve resiliency flexible connections should be provided. The City will likely be subject to strong ground shaking due to earthquakes occurring on nearby faults. Existing and new connections should be evaluated by the appropriate design standards.

9.2 Corrosivity

Based on the limited amount of the data, the soils in and around Fort Bragg should be considered corrosive to iron and mildly corrosive to concrete. Site Specific testing should be performed and compiled to confirm the corrosivity of the soils. Testing should include:

- As-received and saturated electrical resistivity per ASTM G-187 and pH per ASTM G-51; and
- Chemical analysis for Major anions and cations per ASTM 6919, ASTM 4327 and AWWA 4110B

9.3 Groundwater

Groundwater levels are reported as varying seasonally, rising to near the ground surface in some instances. Long reaches of pipelines can interconnect areas of high groundwater and transmit water to other areas along the trench bedding or pipe zone material. This can be exacerbated by pipelines that run from higher elevations to lower elevations in the city. Trench dams should be included wherever expected or known groundwater is encountered during construction and spaced at the midpoint of each line segment, and where future construction access will be required. Trench dams consist of low permeability material (soil or Controlled Low Density Fill, manufactured materials that are slipped over the pipe at the time of installation).

9.4 Seismic Response

In addition to dynamic densification and liquefaction effects, pipe connections to structures, such as vaults, steel reservoirs or bridge crossing may experience differential movements based on the response of the ground compared to the response (shaking) of the structure. Out-of-phase movement can cause damage to connections to structures. To improve resiliency flexible connections should be provided. The City will likely be subject to strong ground shaking due to earthquakes occurring on nearby faults. Existing and new connection should be evaluated by the appropriate design standards.

9.5 Bluff Erosion

The bluffs along the coastline are actively eroding, which is referred to as bluff retreat or bluff erosion. Estimates of bluff erosion have been provided in two referenced geotechnical reports (Table 1) and from the Pacific Institute. Placement of distribution systems within the limits of future bluff retreat is not recommended.

10 Recommended Future Actions

To better understand specific geologic risk to specific portions of the water distribution system, a more detailed understanding is needed at the location of critical components of the system. Specifically, the following should be determined:

- **The peak ground acceleration based on current code requirements, typically expressed as the design earthquake return period**. Depending on the age of the facility the current design, the code may be different from what was used at the time the component was designed and constructed.
- **The thickness of fill and/or terrace deposits at the site, the depth to bedrock and an understanding of the groundwater depth and seasonal fluctuation**. Past geotechnical investigations associated with the original design of the component/facility or a report prepared for an adjacent property combined with review of the as-built grading plans would

typically provide data regarding the site soil stratigraphy and depth to bedrock. Understanding groundwater conditions below the site would likely require additional study, as discussed below. This information is required as input into a seismic vulnerability assessment for understanding the potential for seismic densification or vertical or lateral deformation as a result of liquefaction, if potentially liquefiable soils are present at the specific site.

- **Mapping of areas of slope instability along pipeline corridors and within 300 feet of a component or facility at a local scale** will provide the input to assess the current hazard that slope instability poses to the facility as well as allow comparison for changes in the risk, specifically after major storms/flood events or a large seismic event. Each specific area of concern should be mapped at a scale of 1”=50 feet and fixed reference points set, such as rebar hubs setback (above) the area of instability in readily accessible areas that can be used to easily identify changes visually and hand measurement. Each location will need to be assessed on a case-by-case basis to establish the limits of mapping and location and number of reference points. Use of fixed features such as a fence, fire hydrant, or street curb may not be sufficient as they can be modified or damaged over time.

The depth to bedrock could be evaluated by performing limited geophysical surveys (Seismic Refraction) that is a non-invasive and lower cost method of field investigation. The geophysical surveys in combination with other geotechnical or environmental investigation reports available from the City could provide the level of detail required without the expense of drilling soil borings.

Understanding the depth of groundwater and fluctuation over time could require installation of strategically placed monitoring well(s) to understand the source and direction of groundwater flow and the effects of rainwater and irrigation infiltration. An initial widely spaced grid of wells could be established and monitored semi-annually to quarterly to develop an understanding of groundwater behavior. The wells could be supplemented if an area’s data seems erratic or if addition detail is desired.

Planning for such a study should be preceded by a desktop study reviewing available data contained in City files and interviewing local civil/geotechnical and geological consultants familiar with the Fort Bragg’s soil and geologic conditions that may offer specific knowledge from past experience within the City. All the groundwater, soil, and bedrock depth and slope instability data can then be collected through GIS and reviewed to determine where more detailed study would be warranted. The information would need to be reviewed and updated to provide a living document that can be used by all departments of the City for planning and risk assessment. HDR understands that they City is documenting the presence of shallow groundwater as part of ongoing maintenance work (unpublished).

11 Limitations

This report was developed by HDR for the client's sole and exclusive use on this project for the purposes described in this report and within the scope of work, and in accordance with contract conditions. This report is not for the benefit of any third party and may not be distributed to, disclosed in any form to, used by, or relied upon by any third party without prior written consent of HDR. Consent may be withheld by HDR at its sole discretion. Use of this work product by others is at their own risk and the user assumes all liability for its use. This report must be read as a whole; individual sections should not be considered or interpreted on a stand-alone basis. The content included in this report is correct to the best of HDR's knowledge and has been developed in accordance with the standard of care that is customarily followed by a practitioner in this industry reviewing and reporting existing data. The scope of this project did not include collection and analysis of data and for calculations or modeling in support of this report.

The information provided in this report was developed or provided by others. Except as specifically identified in this report, HDR has not performed independent validation or verification of exploration data, modeling data, or other analysis data provided by others. HDR has used qualified and diligent staff to prepare this report and has assumed that third-party or client data are accurate, complete, reliable, and current. Depth to groundwater levels recorded on boring logs in these studies is subject to many variables and may not be indicative of long-term equilibrium conditions. These variables include water introduced during drilling operations, surface infiltration, puncture of perched horizons, build-up of mud against the walls of the boring (which can reduce infiltration), and inadequate time for equilibration of groundwater pressure.

HDR has not performed a site-specific seismic evaluation of ground shaking intensity or duration. Recommendations in this report are based on published mapping prepared by others and standard practices for the area.

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Attachment A – Summary of Geotechnical Conditions Depicted by City-Provided Geotechnical Reports

The thickness of soil layers described below will likely vary across the project site. Borings indicate the depth across the site, but these elevations (or depths) may be somewhat higher/lower/greater between the borings.

The reports state that the materials encountered in exploratory borings were continuously logged in the field by an engineering geologist/geological engineer. The unconsolidated materials (soil) were visually classified using the Unified Soils Classification System (USCS), according to ASTM D-2487. However, the quality of the observations, visual logging, and quantity supporting laboratory testing vary between the reports. HDR has not performed independent validation or verification of exploration data, modeling data, or other analysis data provided by others. HDR has used qualified and diligent staff to prepare this report and has assumed that third-party or client data are accurate, complete, reliable, and current.

The reports reviewed are:

- Brunsing and Associates (2015), Geotechnical Investigation, The Avalon Inn, 1201 North Main Street, Fort Bragg, December 4
- Brunsing and Associates (2016), Engineering Geologic and Geotechnical Reconnaissance, Blufftop Biological Treatment Facility, Fort Bragg Wastewater treatment Plan, 101 Cypress Street, Fort Bragg, California, September 12
- Caltrans (2011), Memorandum, Geotechnical Design Report, Fort Bragg ADA project October 31
- Crawford and Associates (2022), Final Geotechnical Report, City of Fort Bragg Raw Water Pipeline Replacement, Segment 2 – 5, Fort Bragg, California, March
- Curry Group (CGI, INC) (2007), Geotechnical Study, 45-acre-foot Line Reservoir, Fort Bragg California, January 9
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- Salem Engineering Group, Inc. (2018), Geotechnical Engineering Investigation, Proposed AutoZone Retail Store, 1151 South Main Street, Fort Bragg, California, March 6
- SHN Consulting Engineers & Associates (2003) Revised Geotechnical Report, Proposed Recreation Building Green Memorial Field, Fort Bragg, California, August

The identification of Zones is based on the City of Fort Bragg Inland and Coast General Plans (City of Fort Bragg 2012 and 2008) The Inland Zone is identified as a generally a westward project extending from the intersection of Walnut Street and Highway 1, projecting east to the top of the Noyo River north bank and to the north from the intersection of Walnut Street and Highway 1, following Highway 1 north to beyond Virgin Creek, as shown on Map LU-1, Land Use Designation. The Coastal Zone is all areas west and south of the Inland Zone, including the intersection of Highway 1 and Highway 20, for areas within the City boundary and sphere of influence as shown on Figure LU-1 Land Use Designations. The Noyo River has been included in the Coastal Zone. For this document, Pudding Creek and the Noyo River have been selected to divide the Coastal Zone into the North, Central and Southern zones. Therefore, historical investigations that extend or are located south of the Noyo River north top of bank are included in the southern Coastal Zone.

North Coastal Zone

Brunsing 2015

The report by Brunsing (2015) is located in the North Coastal Area along the west side of Highway 1 just south of the intersection of Airport Road. The report states:

- Surface soils depicted by the exploratory borings generally consist of about one to 2.5 feet of brown silty sand topsoil that is very loose to medium dense and porous.
- Beneath the topsoil, the site is typically mantled by poorly-consolidated marine terrace deposits.
- The terrace deposits consist of beach or shallow marine sediments that are typically comprised of sands with some silt, gravel, and clay, along with incorporated rock fragments eroded from the underlying bedrock platform.
- The terrace materials were deposited in lenses that are generally flat, with local undulations caused by the variable-energy nature of the depositional environment and are mostly comprised of loose to medium dense, saturated sands. Clayey or silty sands were observed in some of the borings, generally just under the topsoil, but most of the terrace deposits encountered are relatively devoid of fines (silt- and clay-sized particles).
- The terrace deposits generally extend to between 7.5 and 15 feet below the ground surface (bgs), and appear to generally thicken toward the east.
- The terrace deposits we observed within the bluff face west of the property, up to about 10 feet thick, consisting of reddish brown silty sands interbedded with silty sandy gravels.
- Bedrock was encountered at depths ranging from approximately 7.5 to 15 feet. The encountered bedrock generally consists of dark gray sandstone that is moderately to intensely fractured, moderately hard to very hard, and deeply- to little-weathered.
- Practical drilling refusal was generally encountered after about one to three feet of penetration into the bedrock.

Unstabilized ground water levels were observed at the time the exploration was performed between about 2.5 and 7 feet below the ground surface. The report state states that shallow ground water can temporarily occur during, and immediately following wet weather periods.

The US Department of Agriculture provides maps of soil conditions depths on the order of 6 feet. A map of the units for the City and surrounding and typical engineering and chemical properties are provided in Attachment A. The units for this are (117, 161, and 214) are consistent with the Brunsing report's description of near surface conditions.

The results of tests evaluating the corrosion protection of the soil on steel and concrete were not performed by the Author of the report. According to the available soil survey data the marine terrace deposits are acidic (pH range of 2 to 5.5) and have a low cation exchange capacity. Discussion of corrosivity testing results presented in other geotechnical report is discussed in the section entitled Other Geologic Related Concerns.

Central Coastal Zone

HDR 2016

HDR performed a focused geotechnical investigation of the City's Waste Water Treatment Plant (WWTP) Expansion in 2016. The plant is located on Noyo Point Road to the south west of the former Georgia-Pacific Lumber southern processing mill site, on the southside of the site. Other geotechnical investigation have been performed in the historical past related to the WWTP and are included within this report. This document reports near surface geotechnical conditions consisted of:

- Pleistocene age marine terrace deposits that overlie marine sedimentary bedrock consisting of sandstone, shale, and conglomerate.
- Past borings by others and borings for the current study indicate that fill generally overlies bedrock at the WWTP site except shallow bedrock was encountered for two structures.
- Fill was reported as extending to depths of about 8 to 9½ feet, and the report states "generally consists of dark brown to black, loose to medium dense silty sand with varying amounts of gravel.
- Beneath the fill, brown-yellow loose to medium poorly-graded fine sand with silt was encountered.
- The sand deposits are consistent with descriptions of marine terrace deposits mapped by Kilbourne (1983). The sand deposits extend to depths of about 11½ feet (Elevation 38½ feet) in Boring K-2, 13 feet in Boring B-02 (Elevation 35 feet), and 18 feet in Boring B-01 (Elevation 30 feet), where bedrock was encountered suggesting that the depth to bedrock generally increases to the north and west.
- The bedrock encountered generally consists of slightly weathered to decomposed, weak to moderately strong sandstone and interbedded shale and sandstone and extended to the maximum depth explored of about 24 feet.

The units for the northern area just south of Pudding Creek are reported as the same as for the North Coast Area (117, 161, and 214). The unit for the majority of the Central Coast Zone and the Inland Zone of Fort Bragg is Unit 219 – Urban Land with little soil descriptions other that the material source is fluvial marine.

The results of tests evaluating the corrosion protection of the soil on steel and concrete were not performed by the Author of the report. According to the available soil survey data the marine terrace deposits are acidic (pH range of 2 to 5.5) and have a low cation exchange capacity. Discussion of corrosivity testing results presented in other geotechnical report is discussed in the section entitled Other Geologic Related Concerns.

Two boring (B-03 and B-04) were drilled in an area of shallow bedrock with near surface conditions reported as the upper approximately ½-foot to 1.5 foot silty sand fill and underlain by bedrock generally consisting of slightly weathered, moderately strong sandstone that extended to the depth explored of about 15 feet.

The report states that monitoring well data from studies performed in the surrounding area associated with the adjacent Georgia-Pacific operations were available online (Arcadis, 2010). "From a review of these data and what was encountered in the WWTP borings, … "true" groundwater may exist in the bedrock at depths below the bottom elevation of the proposed structures (Elevation 28 feet)."

The report concluded that the reported groundwater in the past WWTP borings is perched water from near surface sources. Fluctuations in the groundwater level could occur due to changes in seasons, variations in rainfall, and other factors.

South Coastal Zone, Salem 2018 and Caltrans 2011

Salem (2018) - West of Highway 1

Salem performed a geotechnical investigation for a commercial development to be located at 1151 South Main Street northwest of the intersection of Highway 1 and Ocean View Street. The document reports:

- The soils encountered in the test borings drilled as part of this investigation generally consisted of silty and clayey sands with gravel underlain by interbedded layers of sandy silty clay, sand with silt, silty sands, and sandy silts to the maximum depth explored of 20.5 feet.
- The upper 5 feet were noted to be loose to medium dense. Below 5 feet the soils were generally described as dense to very dense, however one boring encountered loose soils at 15 feet.
- The borings were checked for the presence of groundwater during and after the drilling operations. Free groundwater was not encountered within the borings excavated for this investigation. However, perched groundwater was encountered in two borings at depths of about 11 feet below ground surface.

Caltrans 2011 - East of Highway 1 on the North Side of Highway 20

Caltrans performed an investigation for a sidewalk/retaining structure at the intersection of Highway 20 and Boatyard Drive. Subsurface Material Consist of Terrace Deposits underlay by decomposed sandstone. Weathering progresses from decomposed to intensely weathered between depths of 10 to 12 feet.

Groundwater was encountered at about 9 feet below ground surface in one boring and not encountered in other borings.

The NCRS units for this area lying north of Hare Creek are Units 106 and 161 and south of Hare Creek 212. These units are windblown terrace deposits (Eolian) consistent with the conditions provided in the two reports. Within Hare creek and the incised drainage, it is Units 131 and 139 alluvial sediments derived from bedrock.

The results of tests evaluating the corrosion protection of the soil on steel and concrete were not performed by the Author of the report. According to the available soil survey data the marine terrace deposits are acidic (pH range of 2 to 5.5) and have a low cation exchange capacity. Discussion of corrosivity testing results presented in other geotechnical report is discussed in the section entitled Other Geologic Related Concerns. The Caltrans report states that corrosion testing of soils was ongoing and would be provided at a later date.

Inland Zone – South (Outside City Limits)

CGI 2007 – Summer Lane Reservoir

The Summer Lane reservoir is located at the north end of Summer Lane north of Highway 20, located is outside of the City Limits and Inland of Southern Coastal Area. The report states the near surface conditions as:

The project site is located on an emergent marine terrace that is locally covered with older dune sands. According to Kilbourne (1983), the Fern Creek marine terrace deposits underlie the majority of the site and are exposed in Newman Gulch that projects north of the project. The Fern Creek marine terrace in the project area is composed predominantly of interbedded silty sand with intermittent sandy silt, clayey sand, and sandy clay. Minor fine to medium, subangular to subrounded gravels were observed in test pits and local cobbles might be encountered within these terrace deposits; however, cobbles were not observed during this study. The Fern Creek terrace is approximately 70 to 90 feet thick and is underlain by the Coastal Belt of the Franciscan Formation bedrock. Older dune sands were mapped by Kilbourne (1983) overlying the terrace deposits in the southwesterly corner of the site. The presence of these dune sands was not observed during this study.

Bedrock was not encountered within explorations made during this study. Regional geotechnical studies have encountered Franciscan Formation sandstone, siltstone, and shale at depths ranging from:

- *12 to 35 feet on the Boddy property located about 3,000 west of the project site (Wahler, 1994b);*
- *25 to 32 feet at a site downstream of the existing Newman Reservoir (Wahler, 1994b);*
- *26 to 55 feet at GP-2 and GP-3, located about 5,000 feet east if the site (Wahler, 1994a and 1994b).*

The report notes that groundwater was encountered at depths of 10 to 18 feet.

Crawford 2022

Crawford investigated near surface soil conditions for construction of a replacement pipeline that included 7 test pits excavated to a depth of 6 to 9 feet and 31 hand augers to depths of 3 to 5 feet. The pipeline segments are located along the eastern edge of the City extending from the water treatment facility located at the intersection of Sherwood Road and Monsen Way, extending about 2,500 lineal feet south to Chestnut Street (Segment 2 discussed in the previous section), then about 5,000 lineal across the Noyo River and then to the southeast to the Summer Lane Reservoir (Segment 3). Two additional segments are located from Benson Lane water storage facility and progress to the south side of Hare Creek (Segment 4) to a hilltop above and to the south of Hare Creek Segment 5. Segments 4 and 5 have a straight-line distance of 4,500 feet. Bedrock was only encountered in one exploration at a depth of 3.5 feet and not encountered in the remainder of the explorations. Refusal was encountered in 16 of the 31 hand augers between 2 to 4.5 feet. No estimates of stiffness or consistency were provided on the log of borings. The report states for Segments 3,4 and 5:

- Segment 3 and 4 – Encountered conditions: silty to clayey sand with interbedded silt and clay. Poorly graded sand was encountered along Dwyer Lane. Auger refusal ranged from 2 to 4 feet.
- Segment 5 – Encountered Conditions clayey sand, sandy silt and sandy lean clay. Auger refusal at a depth 4.0 to 5 feet along the alignment.

Groundwater was not encountered in the explorations. However, the report states that groundwater will likely fluctuate with the river and stream elevations in Hare Creek (Segment 5) and the Noyo River (Segment 3).

The units, as shown on Attachment B – NCRS Soil Survey Map,   for Inland Zone are 122, 174 and 214 for the Segment 3 Noyo Creek crossing to the Summer Lane Reservoir. The soil unit for Segment 4 is primarily unit 122, and until 135 where it crosses hare Creek. Unit 5 is in Unit 157. Unit 122 is derived from salt affected marine terrace deposits with no reported depth to bedrock, Unit 214 are fluvial marine deposits with depth of bedrock in excess for 6 feet and Units 135 and 174 are colluvium derived material with bedrock at a depth of 5 feet or greater.

The units for the Inland Zone (south) is 196 and in the adjacent areas as 108, 122, 148, 149, 195, 199 and 214. These units are all described as marine terrace deposits derived from sandstone with the western units (122, 148, 149) comprised of Eolian Terrace Deposits that would be subsurface conditions similar to the Southern Coastal Area.

The results of tests evaluating the corrosion protection of the soil on steel and concrete were not performed by the Author of the report. According to the available soil survey data the marine terrace deposits are acidic (pH range of 4.5 to 5.5) and have a low cation exchange capacity. Discussion of corrosivity testing results presented in other geotechnical report is discussed in the section entitled Other Geologic Related Concerns.

Inland

SHN 2003

This report was prepared for the design and construction of the aquatic facility located at the intersection of South Lincoln Street and Maple Street. The report states that site soils include compressible upper deposits to depths of at least 6 feet, some minor layers of loose to moderately dense sandy soils below that depth and are variable (erratic), with low density Peat, or silty/clayey layers, extending as deep as 22 feet in some locations. The density of the sand layers below 155 feet was estimated as dense to very dense in one boring. Sand Heaving occurred in other borings resulting in lower density estimates and are not representative. Dense materials were encountered between 5 to 10 feet of the ground surface at the southern 2/3 building area (Location unknown). A compressible clay layer was encountered in three explorations between 11 and 15 feet. It is not clear if the dense sand below 15 feet is completely weathered sandstone.

Groundwater was monitored by what is described as installing a well screen at a depth of 20 feet then sealing the borehole. Groundwater reportedly rose to a depth of 3 feet below the ground surface. Other groundwater investigations are to be performed per the report. Log of borings report water at a depth of 6.5 to 7.5 ft at the time of drilling (October 28, 1998)

Crawford (2022)

As previously stated, Crawford investigated near surface soil conditions for construction of a replacement pipeline that included 7 test pits excavated to a depth of 6 to 9 feet and 31 hand augers to depths of 3 to 5 feet. Crawford performed a near surface geotechnical investigation for 4 segments of pipeline (Segments 2 through 5) that extends from the inland (segment 2) area to the south inlead area (Segments 3, 4 and 5). Segment 2 is located along the eastern edge of the City extending from the water treatment facility located at the intersection of Sherwood Road and Monsen Way, extending about 2,500 lineal feet south to Chestnut Street. Bedrock was only encountered in one exploration at a depth of 3.5 feet and not encountered in the remainder of the explorations. Refusal was encountered in 16 of the 31 hand augers between 2 to 4.5 feet. No estimates of stiffness or consistency were provided on the log of borings. The report states for Segment 2:

- Segment 2 – Encountered conditions: clayey sand to lean clay over slightly weathered sedimentary rock

Groundwater was not encountered in the explorations.

The units for the Inland Zone is 195 for the majority of the city (Urban Land) and 141, 199, 214 along the eastern edge of the city with and 136 and 174 along the north slope of the Noyo River incised channel. Units 199, and 214 are thick fluvial marine in origin derived from sedimentary rock and Unit 141 is comprised of Marine deposits. Units 136 and 174 are colluvial deposits.

The results of tests evaluating the corrosion protection of the soil on steel and concrete were not performed by the Author of the report. According to the available soil survey data the Unit 141 marine terrace deposits are acidic (pH range of 3.5 to 5.5) and have a low cation exchange capacity (5 to 50 meq/100g). Unit 199 upper soils are reported as having similar to Unit 141 while no data is provided for Unit 214. Colluvial units are report as being less acidic (Ph 5.6 to 6.5) and have a slightly higher cation exchange capacity. Discussion of corrosivity testing results presented in other geotechnical report is discussed in the section entitled Other Geologic Related Concerns.

Attachment B – NCRS Soil Survey Map and Select Data

Figure B-1 NCRS Map of Soil Units

NCRS Engineering Properties by Unit (See Figure B-1 for Unit Numbers)

NCRS Chemical Properties by Unit (See Figure B-1 for Unit Numbers)

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Report—Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
106—Biaggi loam, 5 to 15 percent slopes														
Biaggi	80	C	0-23	Loam	ML	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	70-78-85	50-55-60	25-30-35	NP-5-10
			23-27	Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
107—Bigriver loamy sand, 0 to 5 percent slopes														
Bigriver	80	A	0-6	Loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	15-23-30	—	NP
			6-63	Stratified loamy sand to silt loam	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-68-75	25-38-50	15-20-25	NP-3 -5

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
108—Blacklock and Aborigine soils, 0 to 5 percent slopes														
Blacklock	42	D	0-7	Loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	15-23-30	0-7 -14	NP
			7-14	Sandy loam, loamy sand	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	15-28-40	20-23-25	NP-3 -5
			14-61	Cemented	SP-SM, SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-73-85	5-18- 30	0-7 -14	NP
			61-64	Loamy sand, sand, loamy fine sand	SP-SM, SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-73-85	5-18- 30	0-7 -14	NP
Aborigine	38	D	0-6	Sandy loam	SC-SM, SM	A-2-4, A-4	0- 0- 0	0- 0- 0	95-97-100	90-93-100	65-71-80	30-35-43	18-22-25	2-4 -6
			6-13	Loam	CL	A-6	0- 0- 0	0- 0- 0	95-97-100	90-93-100	76-83-93	53-60-71	25-30-35	9-13-17
			13-61	Sandy clay, clay, clay loam	CH, CL	A-7-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	81-85-93	51-57-68	42-52-62	24-32-40

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
117—Cabrillo-Heeser complex, 0 to 5 percent slopes														
Cabrillo	50	B	0-26	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	65-73-80	35-43-50	20-25-30	NP-3 -5
			26-35	Sandy clay loam	SC	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-85-90	35-43-50	30-35-40	10-15-20
			35-50	Sandy clay loam, sandy clay	SC	A-6, A-7	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-85-90	35-43-50	30-38-45	10-15-20
			50-60	Sandy loam, loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-60-70	10-23-35	20-25-30	NP-3 -5
Heeser	30	A	0-34	Sandy loam	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	60-70-80	30-35-40	20-25-30	NP-3 -5
			34-65	Sandy loam, loamy sand, sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	95-98-100	50-65-80	15-25-35	—	NP
122—Caspar sandy loam, 2 to 9 percent slopes														
Caspar	80	B	0-16	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	60-68-75	35-43-50	20-25-30	NP-3 -5
			16-37	Sandy loam, loam, sandy clay loam	SC-SM, SC	A-4, A-6	0- 0- 0	0- 0- 0	85-93-100	75-88-100	50-68-85	35-43-50	25-30-35	5-10-15
			37-48	Sandy clay loam, clay loam, sandy clay	CL, SC	A-6, A-7	0- 0- 0	0- 0- 0	85-93-100	75-88-100	65-78-90	35-48-60	30-38-45	10-15-20
			48-62	Sandy loam, loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-60-70	20-28-35	20-25-30	NP-3 -5

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	**Pct. of map unit**	**Hydrologic group**	**Depth**	**USDA texture**	**Classification**		**Pct Fragments**		**Percentage passing sieve number—**				**Liquid limit**	**Plasticity index**
					Unified	**AASHTO**	**>10 inches**	**3-10 inches**	**4**	**10**	**40**	**200**		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
123—Caspar-Quinliven complex, 30 to 50 percent slopes														
Caspar	50	B	0-16	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	60-68-75	35-43-50	20-25-30	NP-3 -5
			16-37	Sandy loam, loam, sandy clay loam	SC-SM, SC	A-4, A-6	0- 0- 0	0- 0- 0	85-93-100	75-88-100	50-68-85	35-43-50	25-30-35	5-10-15
			37-48	Sandy clay loam, clay loam, sandy clay	CL, SC	A-6, A-7	0- 0- 0	0- 0- 0	85-93-100	75-88-100	65-78-90	35-48-60	30-38-45	10-15-20
			48-62	Sandy loam, loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-60-70	20-28-35	20-25-30	NP-3 -5
Quinliven	35	C	0-4	Sandy loam	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-65-70	30-38-45	20-25-30	NP-3 -5
			4-11	Sandy loam, loam	CL-ML, SC-SM, ML, SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	65-78-90	35-48-60	25-30-35	5-8 -10
			11-18	Loam, sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-88-95	45-60-75	25-33-40	10-15-20
			18-51	Clay, sandy clay	MH, ML	A-7	0- 0- 0	0- 0- 0	100-100-100	100-100-100	85-93-100	50-73-95	40-50-60	10-18-25
			51-60	Sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-90-100	40-60-80	30-35-40	10-15-20
			60-64	Loamy sand, sandy loam	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	20-30-40	20-25-30	NP-3 -5

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
124—Caspar-Quinliven-Ferncreek complex, 9 to 30 percent slopes														
Caspar	37	B	0-16	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	60-68-75	35-43-50	20-25-30	NP-3 -5
			16-37	Sandy loam, loam, sandy clay loam	SC-SM, SC	A-4, A-6	0- 0- 0	0- 0- 0	85-93-100	75-88-100	50-68-85	35-43-50	25-30-35	5-10-15
			37-48	Sandy clay loam, clay loam, sandy clay	CL, SC	A-6, A-7	0- 0- 0	0- 0- 0	85-93-100	75-88-100	65-78-90	35-48-60	30-38-45	10-15-20
			48-62	Sandy loam, loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-60-70	20-28-35	20-25-30	NP-3 -5
Quinliven	33	C	0-4	Sandy loam	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-65-70	30-38-45	20-25-30	NP-3 -5
			4-11	Sandy loam, loam	CL-ML, SC-SM, ML, SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	65-78-90	35-48-60	25-30-35	5-8 -10
			11-18	Loam, sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-88-95	45-60-75	25-33-40	10-15-20
			18-51	Clay, sandy clay	MH, ML	A-7	0- 0- 0	0- 0- 0	100-100-100	100-100-100	85-93-100	50-73-95	40-50-60	10-18-25
			51-60	Sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-90-100	40-60-80	30-35-40	10-15-20
			60-64	Loamy sand, sandy loam	SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	20-30-40	20-25-30	NP-3 -5
Ferncreek	15	D	0-7	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	65-70-75	35-43-50	20-25-30	NP-3 -5
			7-33	Clay, clay loam	MH, ML	A-7	0- 0- 0	0- 0- 0	80-90-100	75-88-100	70-80-90	50-63-75	40-50-60	10-18-25

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
			33-43	Sandy clay loam	SC-SM, SC	A-4, A-6	0- 0- 0	0- 0- 0	80-90-100	75-88-100	65-73-80	35-43-50	25-33-40	5-10-15
			43-61	Sandy loam, sandy clay loam	SC-SM, SC	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-68-75	35-43-50	20-25-30	5-8 -10
131—Cottoneva loam, 0 to 2 percent slopes														
Cottoneva	90	C	0-12	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-90-95	50-63-75	20-25-30	NP-5-10
			12-43	Stratified sandy loam to very fine sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	60-73-85	35-43-50	15-20-25	NP-3 -5
			43-63	Stratified loam to clay loam	CL-ML, CL	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	95-98-100	80-88-95	55-65-75	25-33-40	5-10-15

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	**Pct. of map unit**	**Hydrologic group**	**Depth**	**USDA texture**	**Classification**		**Pct Fragments**		**Percentage passing sieve number—**				**Liquid limit**	**Plasticity index**
					Unified	**AASHTO**	**>10 inches**	**3-10 inches**	**4**	**10**	**40**	**200**		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
135—Dehaven-Hotel complex, 50 to 75 percent slopes														
Dehaven	45	B	0-17	Gravelly loam	GC-GM, SC-SM, GM, SM	A-4	0- 0- 0	0- 0- 0	60-70-80	50-63-75	45-58-70	35-43-50	25-30-35	5-8 -10
			17-34	Very gravelly sandy clay loam, very gravelly clay loam	GC	A-2	0- 0- 0	0-13- 25	30-45-60	25-38-50	25-35-45	15-25-35	25-33-40	10-15-20
			34-52	Extremely gravelly sandy clay loam, extremely gravelly clay loam	GP-GC, GC	A-2	0- 0- 0	0-13- 25	25-28-30	15-20-25	10-18-25	5-13- 20	25-33-40	10-15-20
			52-56	Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
Hotel	35	C	0-8	Very gravelly loam	GC-GM, GM	A-2	0- 0- 0	0- 3- 5	40-48-55	35-43-50	30-38-45	25-30-35	25-30-35	5-8 -10
			8-35	Very gravelly clay loam, very gravelly sandy clay loam, extremely gravelly clay loam	GP-GC, GC	A-2	0- 0- 0	0- 8- 15	20-40-60	15-35-55	10-28-45	5-20- 35	30-35-40	10-15-20
			35-39	Unweathered bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
136—Dehaven-Hotel complex, 75 to 99 percent slopes														
Dehaven	42	B	0-17	Gravelly loam	GC-GM, SC-SM, GM, SM	A-4	0- 0- 0	0- 0- 0	60-70-80	50-63-75	45-58-70	35-43-50	25-30-35	5-8 -10
			17-34	Very gravelly sandy clay loam, very gravelly clay loam	GC	A-2	0- 0- 0	0-13- 25	30-45-60	25-38-50	25-35-45	15-25-35	25-33-40	10-15-20
			34-52	Extremely gravelly sandy clay loam, extremely gravelly clay loam	GP-GC, GC	A-2	0- 0- 0	0-13- 25	25-28-30	15-20-25	10-18-25	5-13- 20	25-33-40	10-15-20
			52-56	Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
Hotel	38	C	0-8	Very gravelly loam	GC-GM, GM	A-2	0- 0- 0	0- 3- 5	40-48-55	35-43-50	30-38-45	25-30-35	25-30-35	5-8 -10
			8-35	Very gravelly clay loam, very gravelly sandy clay loam, extremely gravelly clay loam	GP-GC, GC	A-2	0- 0- 0	0- 8- 15	20-40-60	15-35-55	10-28-45	5-20- 35	30-35-40	10-15-20
			35-39	Unweathered bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
141—Ferncreek sandy loam, 2 to 9 percent slopes														
Ferncreek	80	D	0-7	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	65-70-75	35-43-50	20-25-30	NP-3 -5
			7-33	Clay loam, clay	MH, ML	A-7	0- 0- 0	0- 0- 0	80-90-100	75-88-100	70-80-90	50-63-75	40-50-60	10-18-25
			33-43	Sandy clay loam	SC-SM, SC	A-4, A-6	0- 0- 0	0- 0- 0	80-90-100	75-88-100	65-73-80	35-43-50	25-33-40	5-10-15
			43-61	Sandy clay loam, sandy loam	SC-SM, SC	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-68-75	35-43-50	20-25-30	5-8 -10
148—Gibwell loamy sand, 2 to 9 percent slopes														
Gibwell	75	C	0-12	Loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	15-23-30	—	NP
			12-18	Sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	80-88-95	40-55-70	30-35-40	10-13-15
			18-26	Sandy clay, clay	MH, ML	A-7	0- 0- 0	0- 0- 0	95-98-100	90-95-100	85-90-95	50-65-80	40-50-60	10-18-25
			26-42	Sandy clay loam	SC	A-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	75-83-90	35-43-50	30-35-40	10-13-15
			42-65	Sandy loam, loamy sand, sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	10-20-30	—	NP

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
149—Gibwell loamy sand, 9 to 15 percent slopes														
Gibwell	75	C	0-12	Loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	15-23-30	—	NP
			12-18	Clay loam, sandy clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	80-88-95	40-55-70	30-35-40	10-13-15
			18-26	Sandy clay, clay	MH, ML	A-7	0- 0- 0	0- 0- 0	95-98-100	90-95-100	85-90-95	50-65-80	40-50-60	10-18-25
			26-42	Sandy clay loam	SC	A-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	75-83-90	35-43-50	30-35-40	10-13-15
			42-65	Sandy loam, loamy sand, sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-63-75	10-20-30	—	NP
157—Harecreek sandy loam, 2 to 9 percent slopes														
Harecreek	85	A	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			2-10	Sandy loam	SM	A-2-4, A-4	0- 0- 0	0- 0- 0	95-97-100	85-91-100	62-70-81	30-35-43	20-25-30	—
			10-18	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	95-97-100	85-91-100	62-70-81	30-36-43	20-25-30	—
			18-45	Sandy loam, sandy clay loam	SC-SM, SC, SM	A-2-4, A-4	0- 0- 0	0- 0- 0	95-97-100	85-92-100	68-79-88	34-42-48	25-30-35	5-8 -10
			45-65	Sand, loamy sand, sandy loam	—	—	0- 0- 0	0- 0- 0	95-97-100	86-92-100	66-74-84	9-13- 19	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	**Pct. of map unit**	**Hydrologic group**	**Depth**	**USDA texture**	**Classification**		**Pct Fragments**		**Percentage passing sieve number—**				**Liquid limit**	**Plasticity index**
					Unified	**AASHTO**	**>10 inches**	**3-10 inches**	**4**	**10**	**40**	**200**		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
161—Heeser sandy loam, 2 to 15 percent slopes														
Heeser	85	A	0-34	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-97-100	69-75-82	33-38-46	20-25-30	—
			34-65	Sandy loam, loamy sand, sand	—	—	0- 0- 0	0- 0- 0	100-100-100	96-97-100	69-74-83	29-37-43	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H
173—Irmulco-Tramway complex, 30 to 50 percent slopes														
Irmulco	70	B	0-1	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			1-7	Loam	SC-SM, CL, ML	A-4	0- 0- 0	0- 0- 0	90-95-100	76-86-100	65-80-96	45-57-72	25-30-35	5-8 -10
			7-42	Loam, clay loam, gravelly loam	SC-SM, CL, SC	A-2-4, A-4, A-6	0- 0- 0	0- 0- 0	76-86-100	49-69-100	43-64-98	31-49-78	25-33-40	5-10-15
			42-62	Clay loam, gravelly clay loam	CH, SC	A-2-4, A-6, A-7-6	0- 0- 0	0- 0- 0	76-86-100	48-68-100	41-63-100	30-49-81	30-40-50	10-18-25
			62-72	Bedrock	—	—	—	—	—	—	—	—	—	—
Tramway	16	C	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			2-9	Loam	SC-SM, CL, ML	A-4	0- 0- 0	0- 0- 0	91-95-100	77-87-100	66-77-91	47-56-66	25-30-35	5-8 -10
			9-14	Loam	CL-ML, CL	A-4, A-6	0- 0- 0	0- 0- 0	91-95-100	78-87-100	67-78-93	50-59-71	25-33-40	5-10-15
			14-30	Clay loam, gravelly clay loam	CL, SC	A-2-4, A-6, A-7-6	0- 0- 0	0- 0- 0	76-85-100	48-68-100	40-62-98	31-48-78	30-38-45	10-15-20
			30-43	Bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	**Pct. of map unit**	**Hydrologic group**	**Depth**	**USDA texture**	**Classification**		**Pct Fragments**		**Percentage passing sieve number—**				**Liquid limit**	**Plasticity index**
					Unified	**AASHTO**	**>10 inches**	**3-10 inches**	**4**	**10**	**40**	**200**		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
174—Irmulco-Tramway complex, 50 to 75 percent slopes														
Irmulco	45	B	0-6	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	90-95-100	85-93-100	75-85-95	55-63-70	25-30-35	5-8 -10
			6-61	Loam, clay loam, gravelly loam	CL-ML, GC-GM, CL, GC	A-4, A-6	0- 0- 0	0- 0- 0	65-83-100	60-80-100	50-70-90	40-58-75	25-33-40	5-10-15
			61-65	Weathered bedrock	—	—	—	—	—	—	—	—	—	—
Tramway	35	C	0-7	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	90-95-100	85-93-100	65-80-95	50-63-75	25-30-35	5-8 -10
			7-12	Loam	CL-ML, CL	A-4, A-6	0- 0- 0	0- 0- 0	90-95-100	85-93-100	65-80-95	50-63-75	25-33-40	5-10-15
			12-28	Clay loam, gravelly clay loam	CL, GC, SC	A-6, A-7	0- 0- 0	0- 0- 0	65-83-100	60-80-100	55-75-95	40-60-80	30-38-45	10-15-20
			28-32	Weathered bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
196—Quinliven-Ferncreek complex, 2 to 15 percent slopes														
Quinliven	60	C	0-5	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			5-9	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	72-77-83	34-40-46	20-25-30	—
			9-16	Loam, sandy loam	SC-SM, ML, SC	A-2-4, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	69-77-85	32-40-50	25-30-35	5-8 -10
			16-23	Loam, sandy clay loam, clay loam	CL	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	83-91-96	59-69-76	25-33-40	10-15-20
			23-56	Clay, sandy clay	MH, ML	A-7-5	0- 0- 0	0- 0- 0	100-100-100	100-100-100	84-92-100	67-80-89	40-50-60	10-18-25
			56-65	Sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	79-87-95	42-51-60	30-35-40	10-15-20
			65-75	Loamy sand, sandy loam	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	75-82-89	18-22-33	20-25-30	—
Ferncreek	25	C	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			2-9	Sandy loam	SM	A-2-4, A-4	0- 0- 0	0- 0- 0	85-91-100	67-80-100	49-61-84	24-31-48	20-25-30	—
			9-35	Clay loam, clay	MH, SM	A-7-5	0- 0- 0	0- 0- 0	85-90-100	65-78-100	57-75-100	44-61-91	40-50-60	10-18-25
			35-45	Sandy clay loam	SC-SM, CL, SC	A-2-4, A-4, A-6	0- 0- 0	0- 0- 0	85-90-100	66-79-100	54-69-92	30-39-54	25-33-40	5-10-15
			45-63	Sandy loam, sandy clay loam	SC-SM, SC	A-2-4, A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	71-77-84	34-40-48	20-25-30	5-8 -10

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
199—Shinglemill-Gibney complex, 2 to 9 percent slopes														
Shinglemill	45	C/D	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			2-10	Loam	ML, SM	A-4	0- 0- 0	0- 0- 0	84-88-95	68-78-95	55-69-89	38-49-65	25-30-35	—
			10-17	Sandy clay loam, loam	CL, SC	A-6	0- 0- 0	0- 0- 0	85-90-100	66-79-100	56-71-91	42-54-69	30-35-40	10-13-15
			17-27	Clay, clay loam	MH, ML	A-7-5	0- 0- 0	0- 0- 0	85-90-100	65-78-100	60-74-100	51-62-100	40-53-65	10-18-25
			27-65	Sandy clay, clay	MH, SM	A-2-7, A-7-5	0- 0- 0	0- 0- 0	85-90-100	65-78-100	48-66-91	30-44-63	45-55-65	15-20-25
Gibney	35	C	0-9	Loam	SC-SM, ML, SC	A-4	0- 0- 0	0- 0- 0	83-90-100	62-78-100	51-68-91	36-48-66	25-30-35	5-8 -10
			9-29	Sandy clay loam, clay loam	CL, SC	A-2-4, A-6	0- 0- 0	0- 0- 0	84-90-100	63-79-100	51-68-92	31-42-59	30-35-40	10-15-20
			29-55	Clay	MH, SM	A-7-5	0- 0- 0	0- 0- 0	83-90-100	62-78-100	51-72-100	44-63-91	40-50-60	10-18-25
			55-63	Sandy clay loam, sandy clay	CH, SC	A-2-4, A-6, A-7-6	0- 0- 0	0- 0- 0	84-90-100	63-79-100	49-69-98	30-45-67	30-40-50	10-18-25

Engineering Properties–Mendocino County, Western Part, California															
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
212—Tregoning-Cleone complex, 0 to 5 percent slopes														
Tregoning	60	B/D	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			2-11	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	72-77-81	33-39-45	20-25-30	—
			11-25	Loamy sand, sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	70-76-82	30-38-46	20-25-30	—
			25-64	Sand	—	—	0- 0- 0	0- 0- 0	100-100-100	100-100-100	78-80-83	11-14-16	—	—
Cleone	20	B	0-3	Loamy sand	—	—	0- 0- 0	0- 0- 0	100-100-100	100-100-100	76-80-85	19-23-28	—	—
			3-7	Sandy loam	SM	A-2-4, A-4	0- 0- 0	0- 0- 0	87-92-100	70-83-100	52-63-79	25-31-41	20-25-30	—
			7-13	Gravelly sandy loam, gravelly loamy sand	SC-SM, SC	A-2-4, A-4	0- 0- 0	0- 0- 0	76-81-86	57-70-86	41-54-70	19-27-37	20-25-30	—
			13-40	Sandy loam, loamy sand	SC-SM, SC	A-2-4, A-4	0- 0- 0	0- 0- 0	95-97-100	86-92-100	61-70-82	29-35-44	20-25-30	—
			40-62	Loamy sand, sand	—	—	0- 0- 0	0- 0- 0	100-100-100	100-100-100	77-80-84	19-23-26	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
213—Tregoning-Cleone complex, 5 to 15 percent slopes														
Tregoning	55	B/D	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	—	—	—	—	—	—
			2-11	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	72-77-81	33-39-45	20-25-30	—
			11-25	Loamy sand, sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	70-76-82	30-38-46	20-25-30	—
			25-64	Sand	—	—	0- 0- 0	0- 0- 0	100-100-100	100-100-100	78-80-83	11-14-16	—	—
Cleone	25	B	0-3	Loamy sand	—	—	0- 0- 0	0- 0- 0	100-100-100	100-100-100	76-80-85	19-23-28	—	—
			3-7	Sandy loam	SM	A-2-4, A-4	0- 0- 0	0- 0- 0	87-92-100	70-83-100	52-63-79	25-31-41	20-25-30	—
			7-13	Gravelly sandy loam, gravelly loamy sand	SC-SM, SC	A-2-4, A-4	0- 0- 0	0- 0- 0	76-81-86	57-70-86	41-54-70	19-27-37	20-25-30	—
			13-40	Loamy sand, sandy loam	SC-SM, SC	A-2-4, A-4	0- 0- 0	0- 0- 0	95-97-100	86-92-100	61-70-82	29-35-44	20-25-30	—
			40-62	Loamy sand, sand	—	—	0- 0- 0	0- 0- 0	100-100-100	100-100-100	77-80-84	19-23-26	—	—
221—Vandamme loam, 9 to 30 percent slopes														
Vandamme	85	C	0-9	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	95-98-100	85-90-95	70-78-85	55-63-70	25-30-35	5-8 -10
			9-42	Clay, clay loam	CH, MH	A-7	0- 0- 0	0- 0- 0	95-98-100	85-90-95	80-85-90	75-80-85	50-55-60	20-25-30
			42-46	Bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
222—Vandamme-Caspar complex, 2 to 15 percent slopes														
Vandamme	50	C	0-9	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	60-65-70	35-43-50	20-25-30	NP-3 -5
			9-42	Clay, clay loam	CH, MH	A-7	0- 0- 0	0- 0- 0	95-98-100	85-90-95	80-85-90	75-80-85	50-55-60	20-25-30
			42-46	Weathered bedrock	—	—	—	—	—	—	—	—	—	—
Caspar	35	B	0-16	Sandy loam	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	60-68-75	35-43-50	20-25-30	NP-3 -5
			16-37	Sandy loam, loam, sandy clay loam	SC-SM, SC	A-4, A-6	0- 0- 0	0- 0- 0	85-93-100	75-88-100	50-68-85	35-43-50	25-30-35	5-10-15
			37-48	Sandy clay loam, clay loam, sandy clay	CL, SC	A-6, A-7	0- 0- 0	0- 0- 0	85-93-100	75-88-100	65-78-90	35-48-60	30-38-45	10-15-20
			48-62	Sandy loam, loamy sand	SM	A-2	0- 0- 0	0- 0- 0	100-100-100	100-100-100	50-60-70	20-28-35	20-25-30	NP-3 -5

Engineering Properties–Mendocino County, Western Part, California														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H
224—Vandamme-Irmulco-Tramway complex, 50 to 75 percent slopes														
Vandamme	32	C	0-9	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	95-98-100	85-90-95	70-78-85	55-63-70	25-30-35	5-8 -10
			9-42	Clay, clay loam	CH, MH	A-7	0- 0- 0	0- 0- 0	95-98-100	85-90-95	80-85-90	75-80-85	50-55-60	20-25-30
			42-46	Weathered bedrock	—	—	—	—	—	—	—	—	—	—
Irmulco	28	B	0-6	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	90-95-100	85-93-100	75-85-95	55-63-70	25-30-35	5-8 -10
			6-61	Loam, clay loam, gravelly loam	CL-ML, GC-GM, CL, GC	A-4, A-6	0- 0- 0	0- 0- 0	65-83-100	60-80-100	50-70-90	40-58-75	25-33-40	5-10-15
			61-65	Weathered bedrock	—	—	—	—	—	—	—	—	—	—
Tramway	15	C	0-7	Loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	90-95-100	85-93-100	65-80-95	50-63-75	25-30-35	5-8 -10
			7-12	Loam	CL-ML, CL	A-4, A-6	0- 0- 0	0- 0- 0	90-95-100	85-93-100	65-80-95	50-63-75	25-33-40	5-10-15
			12-28	Clay loam, gravelly clay loam	CL, GC, SC	A-6, A-7	0- 0- 0	0- 0- 0	65-83-100	60-80-100	55-75-95	40-60-80	30-38-45	10-15-20
			28-32	Weathered bedrock	—	—	—	—	—	—	—	—	—	—

Data Source Information

Soil Survey Area: Mendocino County, Western Part, California
Survey Area Data: Version 18, Sep 7, 2022

Virgin Creek
Pudding Creek
Noyo River
Hare Creek
Digger Cr.

Appendix C. Climate Risk And Vulnerability

Climate Risk and Vulnerability Assessment

Fort Bragg Distribution System Master Plan

City of Fort Bragg

May 27, 2025

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Executive Summary

This Climate Risk and Vulnerability Assessment (CRVA) report addresses and quantifies risk associated with the impacts of climate change on the Fort Bragg Water System (Water System).

This step-by-step analysis utilizes historic climate trends to set the baseline for understanding projected future climate trends so that the Water System site risk/vulnerabilities can be correlated to those that are anticipated due to climate change. Once the observed climate trends and projections were collected, the findings were used to identify the building and regional infrastructure vulnerability to projected climate changes as part of this CRVA.

The Water System challenges adapting to more extreme climate events are:

- Increased air temperatures will produce added demand and stress on the Water System and exacerbate the threat of wildfire in the region.
- Increased air temperatures, coupled with an increase in year-over-year variability in precipitation, will make for years in which water management will become increasingly difficult to balance between years of flood and years of drought.
- Sea Level Rise (SLR) and extreme rain events with subsequent periods of drought are most likely to increase the risk of landslides and erosion.
- Wildfire remains a concern for the urban area impacting infrastructure.

The key regional infrastructure elements supporting the Water System that are most at risk are:

- Transportation: Bridges are most at risk of being impacted by Sea Level Rise and Storm Surge or flooding. While the City does not own or maintain any bridges, the two main bridges in town are on Highway 1 and are 85'+ above sea level, making them unlikely to flood. However, they still might be impacted by erosion. It is recommended that the City develop a more comprehensive understanding of the risks associated with sea level rise and work in partnership with Caltrans to assess and implement resilient measures that will not obstruct access to critical water infrastructure.
- Energy Systems: Transmission lines exposed to wildfire could impact operations of water pump(s) for the water distribution system.
- Water: Water treatment plant is at the edge of wildfire susceptibility.
- Critical Infrastructure: The Fort Bragg Fire Station #2 is vulnerable to wildfires, which could hinder its ability to effectively respond and protect water system assets.

Assets of the water distribution systems to be enhanced by resiliency strategies are:

- ***Pump Station***: Pump station inundated by 100-year, and base water surface in 2070.
- ***Mains***: Landslides along creek banks.
- ***Storage Tanks***: Vulnerable to wildfire.
- ***Water Treatment Plant***: The climate assessment was limited to a high-level preliminary review of the area within the study boundaries and did not consider risks to individual assets or infrastructure inside the treatment plant. It is recommended that a detailed climate vulnerability assessment be conducted for the water treatment facility itself.

1.0 Introduction

This CRVA overview provides information for the development of a Climate Action Plan that will identify and better prepare the Fort Bragg Water System for climate change-related hazards.

For this report, resiliency is defined as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. The step-by-step analysis utilizes historic climate trends to set the baseline for understanding projected future climate trends for the Water System (Figure 1) and supporting infrastructure. It is based on best available information providing for a framework that can be updated with new information when available.

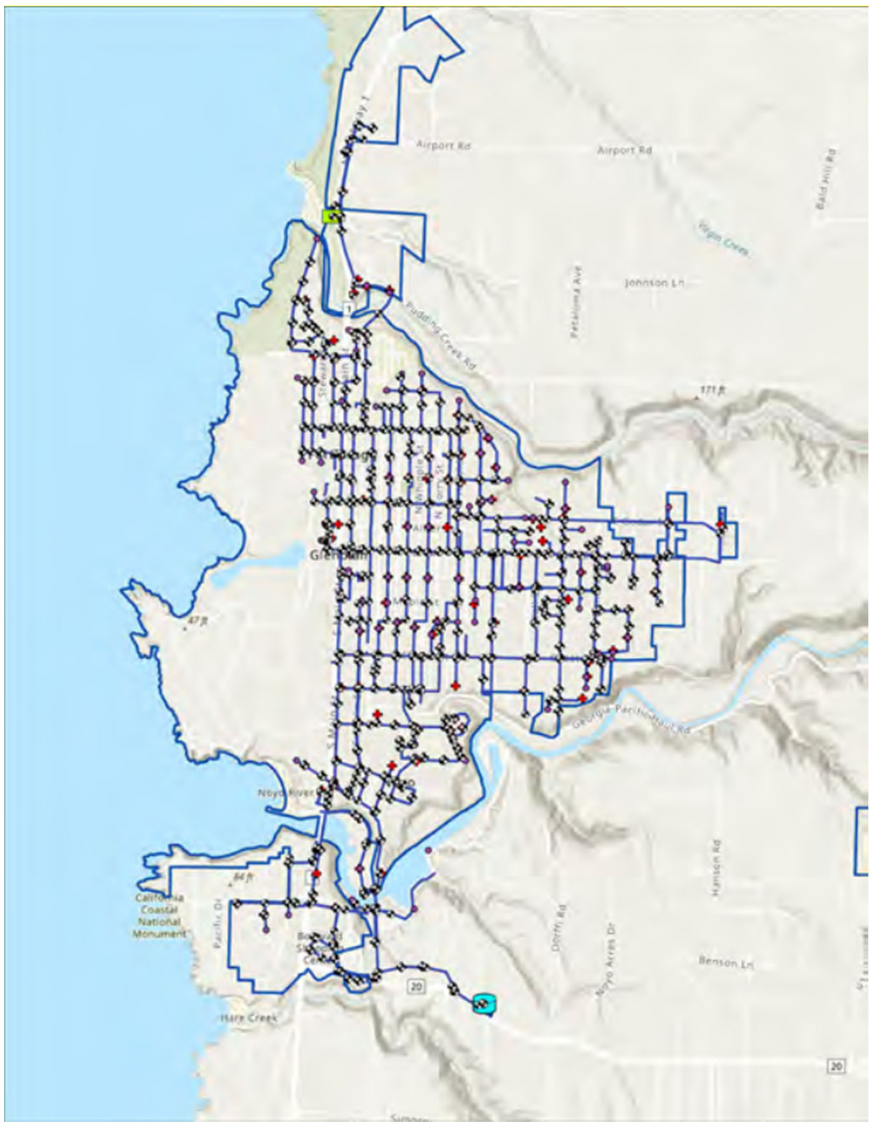

Figure 1 – Project Area, City of Fort Bragg Water System
(Source: HDR GIS based on Fort Bragg database)

2.0 Climate Analysis

2.1 Overview

The project is in the City of Fort Bragg, California. The city is located on the north central coast of California that is strongly influenced by its proximity to the cool waters of the eastern Pacific. It has a population of 6,970 (est. 2021) and an official elevation of 85 feet above sea level. This study analyzed environmental hazards/threats as they exist in the present day and provides guidance on how those hazards/threats to the City's water system are expected to change in the future. The key hazards are listed below:

- Flooding (SLR, Storm Surge, and Riverine).
- Precipitation.
- Landslides / Slope Instability / Erosion.
- Temperature / Extreme Heat.
- Wildfire.
- Groundwater.
- Drought.

Time horizons selected for the project matched the state-adopted timeframe and the life expectancy of the Water System being designed for a 50-year standard. For this study, climate scenarios have been developed for:

- Baseline/ existing conditions (historic record).
- Mid-term: 2050.
- Long-term: 2070.

Projected climate scenarios utilized in this study came from the Coupled Model Intercomparison Project 5 output with GDDP (NASA) downscaling for the Representative Concentration Pathway (RCP) climate emissions scenarios 4.5 and 8.5. RCP 4.5 is a scenario where emissions continue to increase at their current rate until the year 2050, when they begin to decrease through the year 2070, at which point they begin to decline through the remainder of the 21st century. RCP 8.5 is an emissions scenario that sees emissions increase unabated through the end of the 21st century.

2.2 Historic Climate Trends

An analysis of climatic trends provides perspective on the climate projections and evolution of anticipated future climate threats that is discussed in Section 2.3.

2.2.1 Flooding (Coastal, Storm Surge, and Riverine)

Fort Bragg's juxtaposition along the California coast at the mouth of the west-east oriented Noyo River makes it susceptible to a combination of ocean swell, storm surge, wind waves, and astronomical tides, as well as a tsunami originating anywhere within the "Ring of Fire" surrounding the adjacent Pacific Ocean. As can be seen in Figure 2, FEMA base flood elevations (BFEs) along the coast (Zone VE) range from 29 to 36 feet along the bluffs, 19 feet at the beach immediately north of the Noyo River mouth, and 40 feet at the mouth of the Noyo River and adjacent bluff within the bay. These values represent 100-year recurrence interval water levels at current sea level conditions, including wave setup and runup. Wave setup and runup are dependent on the slopes of the terrain, both below the stillwater level and above it along beaches and bluffs. The variability in mapped water levels is based on the differing conditions at individual transects in the FIS study, which are indicated on the map as dashed lines numbered 25 through 31 within the City.

Elevated tides and higher wave heights can occur coincidentally with high river flows on the Noyo River. The FEMA floodplain modeling and Zone designations along the Noyo River are based on mean higher-high water at current climactic conditions and do not include elevated tides or future climate changes. Therefore, when riverine flows are combined with high tides, the water levels along the Noyo River, particularly closer to the mouth of the river, may be higher than indicated by the BFEs.

An analysis of year-over-year coastal water surface elevations shows that the highest annual water surface elevations in the region are the result of thermal expansion of the Pacific Ocean during years of significant El Niño conditions (i.e. 1992, 1997-1998, 2015, and 2023).

Outside the scope of this analysis but worth noting is the threat of a tsunami, although rare, is ever-present in the region of the north-central California coast. Any one of the hundreds of earthquake faults surrounding the Pacific Rim can produce a tsunami that could reach the City of Fort Bragg. The California State Department of Conservation maintains a website devoted to the transfer of knowledge and information regarding Mendocino County Tsunami Hazard Areas.[1] This website provides real-time information about what to do before, during, and after a tsunami event.

[1] https://www.conservation.ca.gov/cgs/tsunami/maps/mendocino

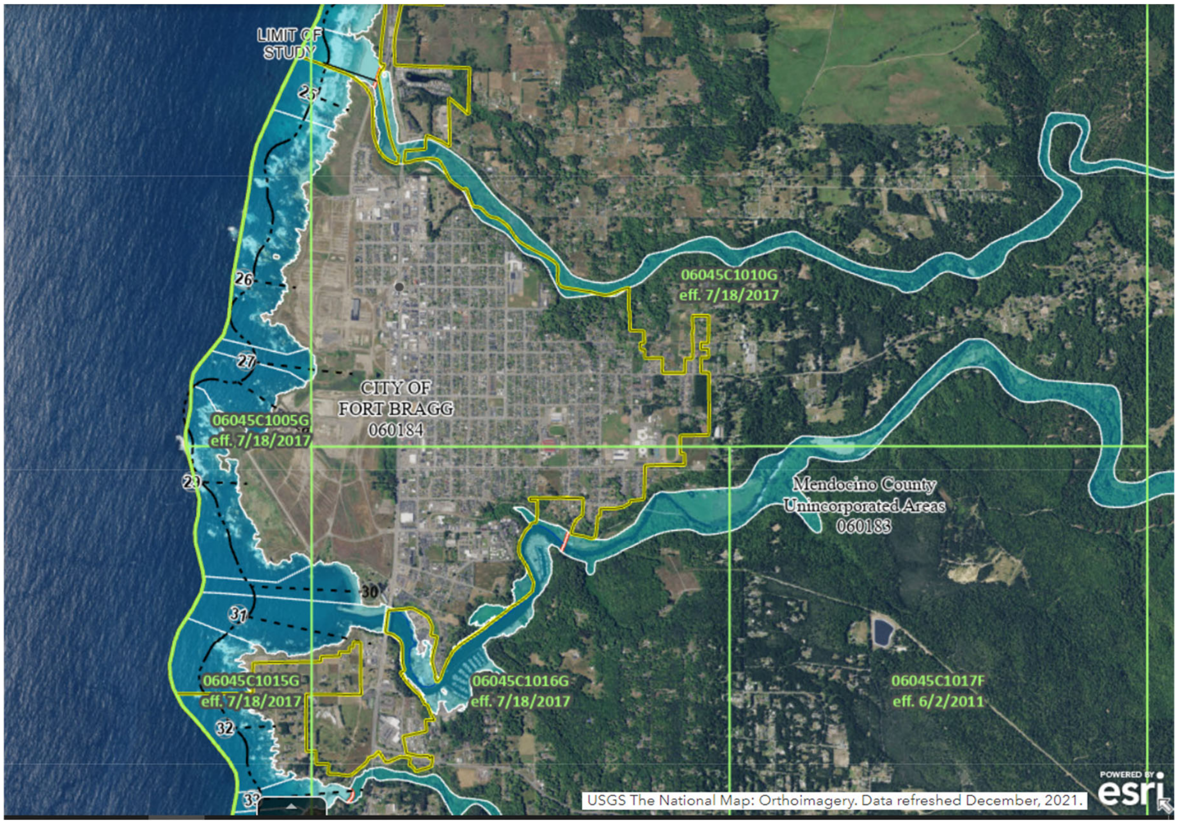

Figure 2 – FEMA 100-Year Event Flood Risk
(Source: FIRM map at https://hazards-fema.maps.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd)

2.2.2 Precipitation

Historic climate trends are critical to setting a relationship between observed changes in the climate and projected changes in the future climate. They represent the “here and now” of climate hazards and how those hazards have changed over time in the observed record. This section investigates current and future extrapolated climate trends, so that those extrapolations can be compared with future climate scenarios for the following environmental parameters.

The National Center for Environmental Information (NCEI) was the primary source of data for historical observations, which were developed from the Fort Bragg 5 N (Station ID: USC00043161) meteorological reporting station located 5 miles north of Fort Bragg (Figure 3). The reporting station is used for a period of record (POR) from 1950 to present day for temperature and precipitation data.

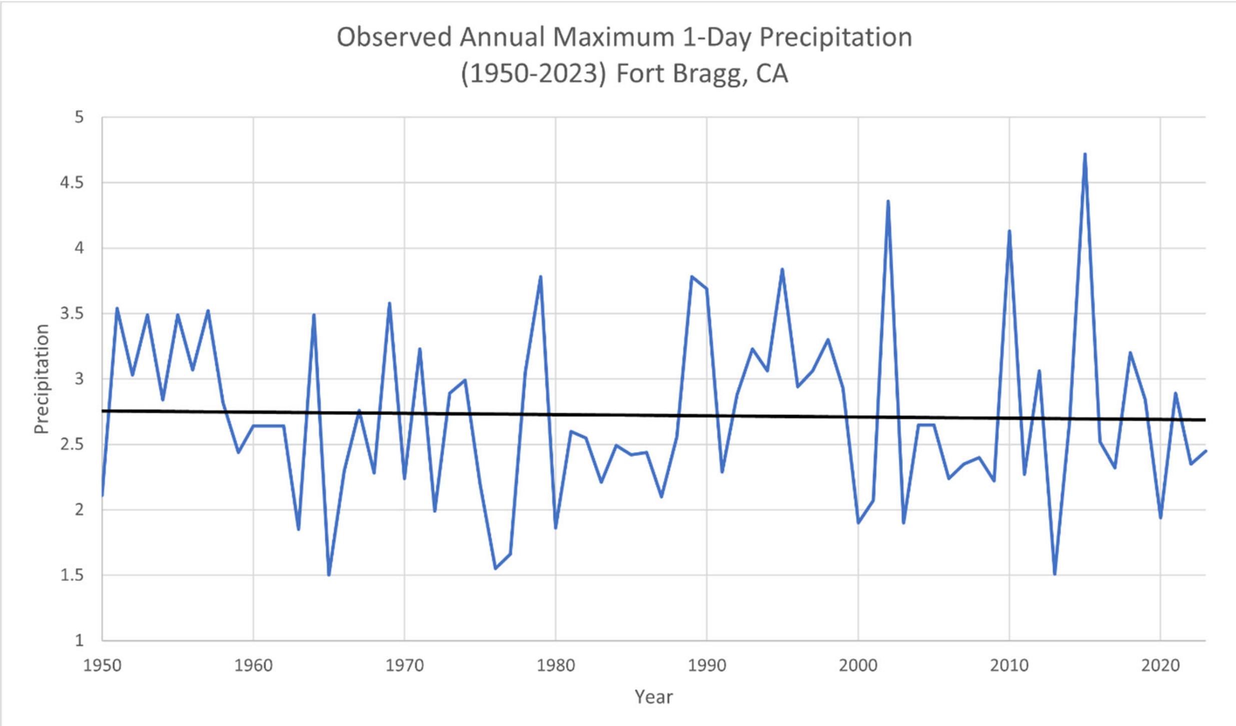

Figure 3 – Observed Annual Maximum 1 Day Precipitation at Fort Bragg 5 N Station (1950-2023)
(Source: NCEI)

The observed maximum single day precipitation in Figure 3 shows a flat trend (neither decreasing nor increasing) from 1950 to present day. However, this trendline does not highlight the increasingly variable nature of single-day precipitation events. Precipitation events across the region and in Fort Bragg are increasing in relative intensity and variability. In other words, while a similar amount of rain may fall each year, that rain will likely be concentrated into heavy rainfall events interspersed with more intense dry periods.

This seasonal variability is also reflected in the Observed Total Annual Precipitation shown in Figure 4. While the trendline of total annual precipitation is also relatively flat, the intensity has increased dramatically in recent years. For example, in Figure 4, it is observed that since the early 1980s, there have been 15 years where the difference in precipitation from one year to the next is greater than 15 inches. Another way of measuring the increasing variability is through the standard deviation of the precipitation, or in other words, how much does the rainfall varies from year to year. In Fort Bragg, the standard deviation of the total annual precipitation from 1950-1986 was 7.68 inches. From 1987-2023 it increased to 11.83 inches. Therefore, it is shown that statistically speaking, the amount of precipitation that falls annually in Fort Bragg is becoming more variable from year to year.

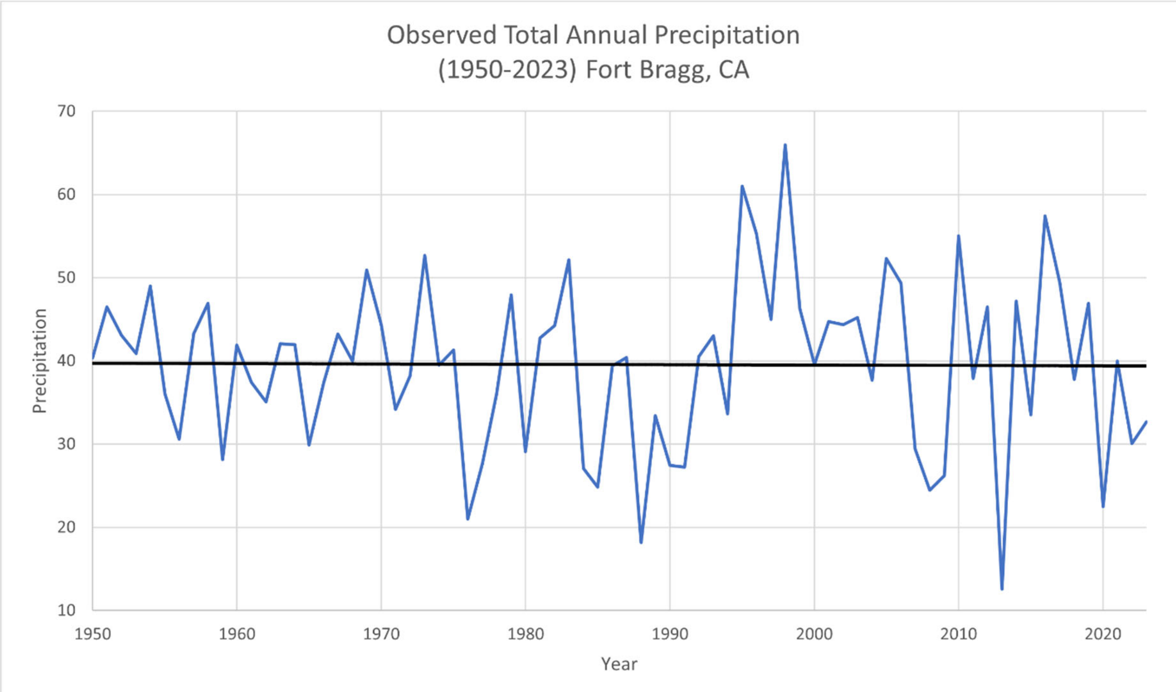

Figure 4 – Observed Total Annual Precipitation at Fort Bragg 5 N Station (1950-2023)
(Source: NCEI)

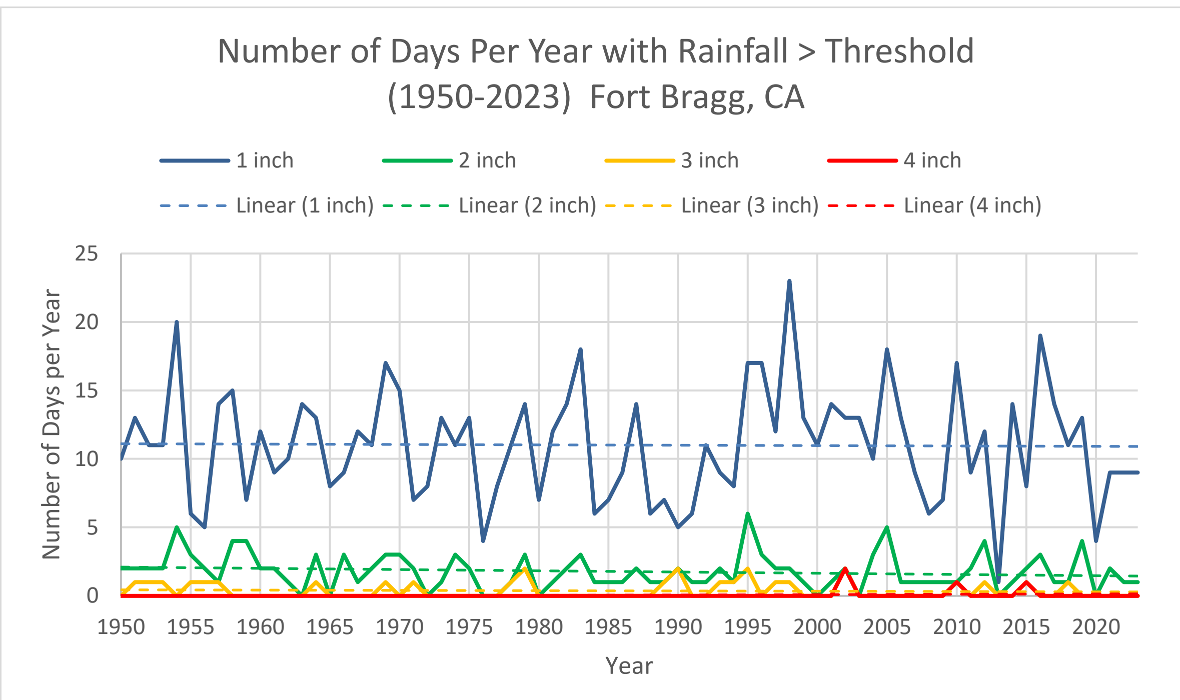

Figure 5 – Observed Number of Days Where Rainfall Exceed 1 Inch (blue), 2 Inches (green), 3 Inches (orange), 4 Inches (red), with Trendlines Plotted in Each Respective Color
(Source: NCEI)

The number of days that experience extreme rainfall events can be associated with increasing variability and relative intensity of rainfall in the region. Figure 5 highlights the number of days each year with 1-4 inches of rainfall on a single day. The associated trendlines are especially helpful in understanding the rate of increase in the heaviest rainfall events with a slight decline in moderate rainfall. While the blue trendline (1-inch rainfall days) remains relatively flat, the green (2-inch) and orange (3-inch) trendlines decrease slightly, which gives rise to the extreme red (4-inch) trendline visible in the bottom right of the figure. This demonstrates that there has already been an increase in the extreme rainfall events in the past 20 years where we see fewer 2- and 3-inch rainfall events per year and instead see occasional 4-inch or greater rainfall days, which have historically over-stressed City water management and breached riverine flood barriers.

It is important to note that as the historic record shows an increase in storms producing greater than 4 inches of daily precipitation, the increased flows because of these storms in Virgin Creek, Pudding Creek, and the Noyo River will increase the likelihood of coincidental coastal flooding.

2.2.3 Coastal Bluff Erosion (Coastal) & Landslides

Bluff erosion is influenced by sea level rise in addition to the mechanisms that impact landslides inland and need to be evaluated concurrently. Figure 6 below documents geologic hazards with risk of erosion and landslides.

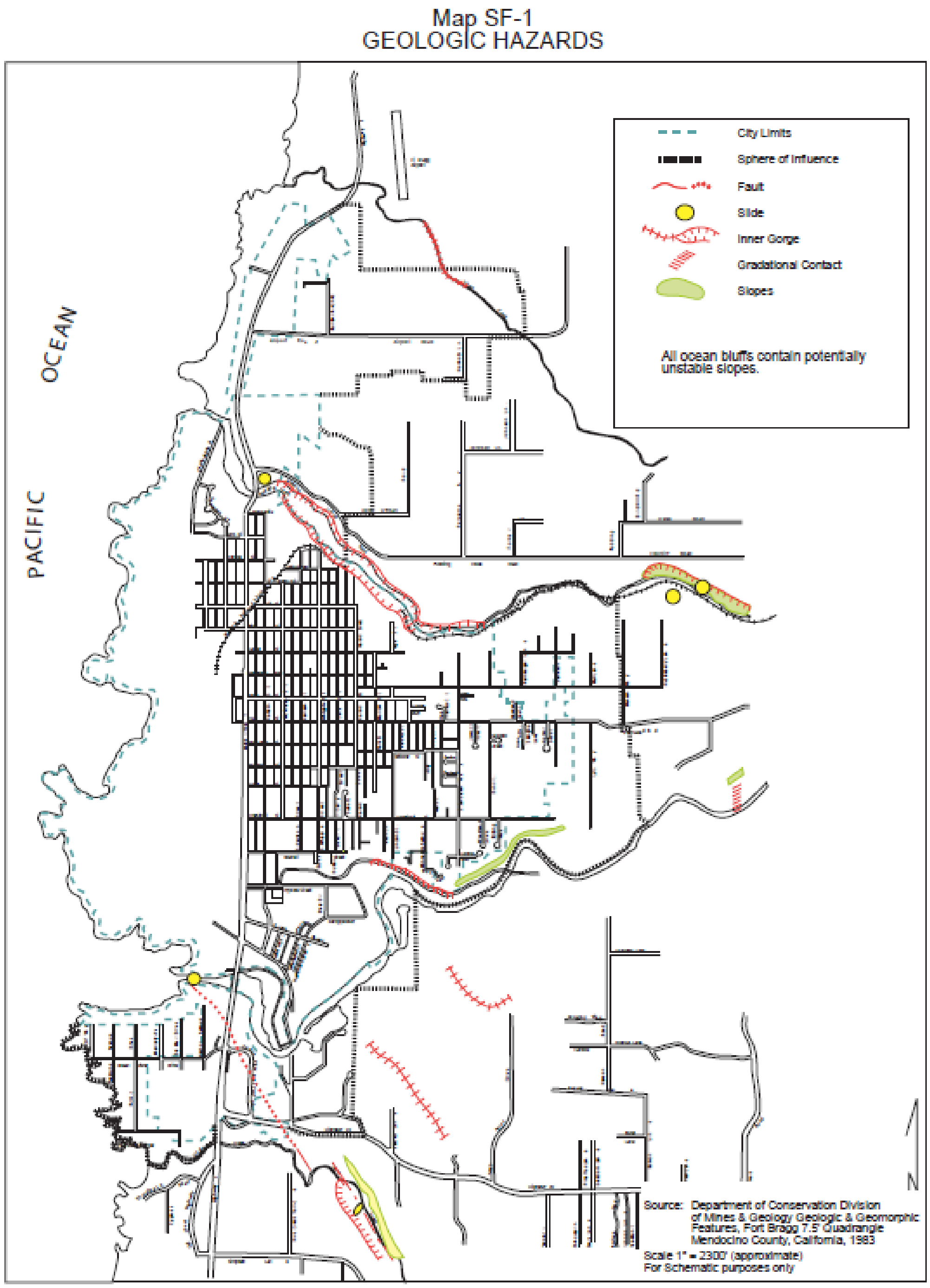

Figure 6 – Geologic Hazards, Fort Bragg
(Source: Department of Conservation Division of Mines& Geology. 1983)

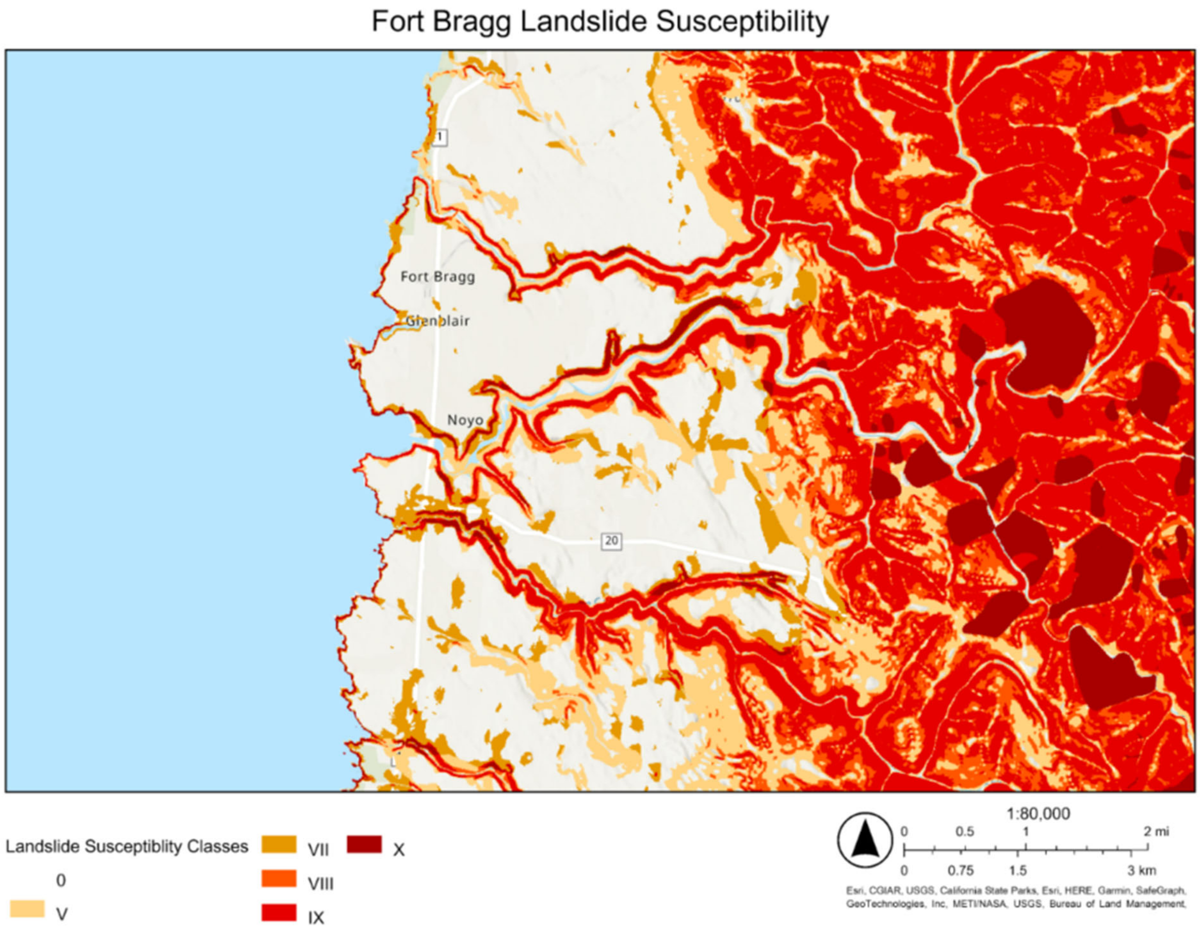

Figure 7 – Relative Slope Instability in the Fort Bragg Area (After CGS Map 58, 2011)

Figure 7 above shows the rankings from “Susceptibility to Deep-Seated Landslides” from beige to red. This is not identified landslides, but an evaluation of the risk of land sliding. Based on this map of the system, the sections near the creeks and rivers appear vulnerable. Most of the area is flat and shows low potential for land sliding. Findings from this high-level analysis will need to be compared and coordinated with the soil/Geotech evaluations part of the risk assessment.

2.2.4 Temperature / Extreme Heat

A similar scenario is seen with the observed temperature in Fort Bragg as has been shown with observed precipitation. The trendline is flat in the observed annual mean maximum temperature for the period from 1950-2023 (Figure 8). However, the variability of the annual mean maximum temperature is plainly seen in the last 30 years. In this case, the standard deviation of the annual mean maximum temperature nearly doubles in variability from the first half of the dataset to the most recent half. From 1950-1986 the standard deviation of temperature was 0.97 °F. From 1987-2023 it increased to 1.63 °F. Therefore, it is shown that statistically speaking, the average hottest days in Fort Bragg each year are becoming more variable.

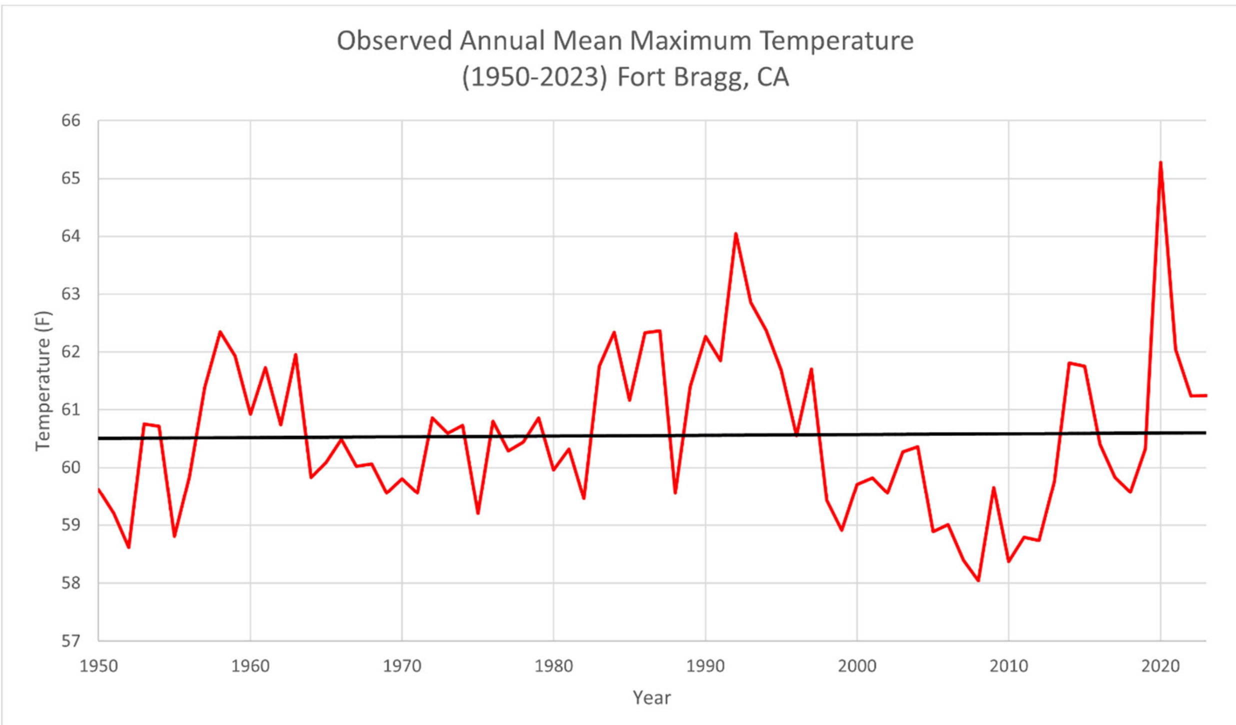

Figure 8 – Observed Annual Mean Maximum Temperature at Fort Bragg 5 N station (1950-2023)
(Source: NCEI)

Interestingly, the observed annual mean minimum temperature (Figure 9) shows a decreasing trend, meaning that on average the coldest days are getting colder in Fort Bragg. In terms of statistical variability, there is a small increase in variability in the second half of the annual mean minimum temperature data, which is consistent with the rest of the temperature and precipitation data and supports the overall trend towards more variable weather patterns depicted in the climate section.

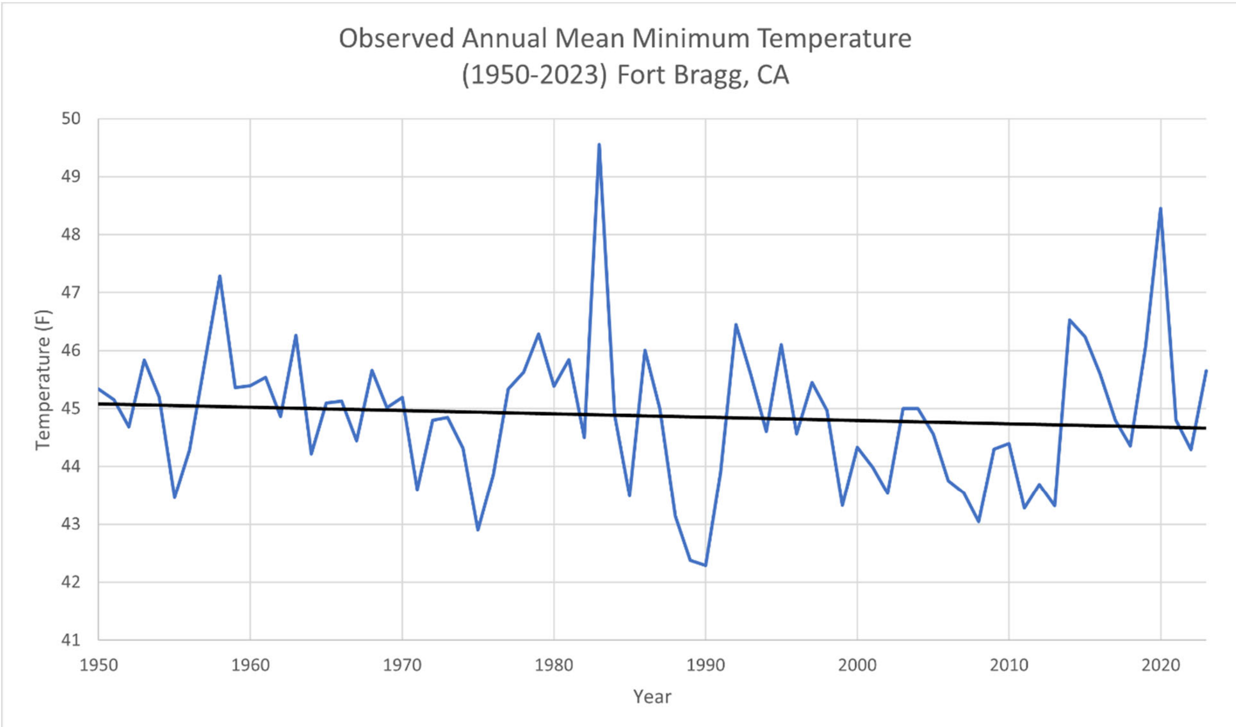

Figure 9 – Observed Annual Mean Minimum Temperature at Fort Bragg 5 N station (1950-2023)
(Source: NCEI)

2.2.5 Wildfire

The California Air Resources Board (CARB) has unequivocally stated that, “Climate change, primarily caused by the burning of fossil fuels, is increasing the frequency and severity of wildfires not only in California but also all over the world. Since 1950, the area burned by California wildfires each year has been increasing, as spring and summer temperatures have warmed, and spring snowmelt has occurred earlier (CARB, 2023).” As seen in the graph of annual precipitation and annual maximum temperatures (Figure 4 and Figure 8), the most recent drought in California (2020-2022) was accompanied by increased air temperatures as well. This combination of lack of precipitation, increased temperatures, and even increasing wind events has resulted in a dramatic increase in the frequency and intensity of wildfire in all of California.

2.2.6 Drought

As previously mentioned in Section 2.1.2, precipitation has historically been highly variable within California. This was particularly true in the last six years, where the water year 2016-2017 produced well above normal precipitation in northern California, while 2020-2022 were years of significantly below normal precipitation. The water year 2022-2023, in turn, produced record snowfall in the Sierras and well-above normal precipitation elsewhere in the state. That year-over-year variability will continue to challenge water managers in the future and will require continued conservation efforts during times of drought.

2.3 Projected/Possible Climate Scenarios

Climate change projections are manifestations of output from global climate models that use future climate scenarios (climate forcing) to quantify future changes in atmospheric parameters. Changes in air temperatures and precipitation, which may result in consequential changes in other hazards such as flooding, ice storms, lightning, and tornadoes, are assessed using climate scenarios.

The emission of Greenhouse Gases (GHG) from human activity is expected to be largely responsible for the magnitude of climate change through the end of this century. To capture an understanding of different climate change outcomes, this study utilized two future emissions (climate) scenarios or Representative Concentration Pathways (RCP) to provide a perspective on future change. RCP 4.5 represents a future wherein GHG emissions continue to increase until the year 2050 and then begin to decrease through the year 2100. In this scenario it takes until the year 2070 before that decrease becomes impactful to the projections. RCP 8.5 represents a future where emissions continue to accelerate through the year 2100. RCP 4.5 is considered the middle-of-the-road case, while RCP 8.5 represents the highest level of future emissions.

The climate projection data utilized in this study comes from the U.S. Climate Resilience Toolkit Climate Explorer (CRTCE, 2023). This resource is supported by data from NOAA's National Centers for Environmental Information (NCEI) and shows results generated by global climate models for the Coupled Model Intercomparison Project Phase 5 (CMIP5). While this is not the most current CMIP (CMIP6), the projected data still gives an accurate idea of the expected climate trends. For any major discrepancies between the projected data shown here and the projections shown by the State of California can be attributed to the use of CMIP5 by the CRTCE. It is expected that integrating CMIP6 data into these projections would produce more intense trends.

2.3.1 Flooding (Sea Level Rise, Storm Surge and Riverine)

Sea level rise is accelerating along the California coast and will continue to rise substantially during the 21st century, threatening coastal communities, natural resources, cultural sites, and infrastructure. *State of California Sea Level Rise Guidance: 2024 Science and Policy Update* (“2024 State Guidance”) was published by the California Ocean Protection Council (OPC) to provide recommendations for evaluating proposed projects against future sea level rise scenarios. The 2024 State Guidance includes relative sea level rise projections for a series of NOAA tide gauges along the California Coast. The closest tide gauge to the project location is the Arena Cove, CA gauge, located 45 miles south of Fort Bragg, which indicates 1.2 ft to 2.8 ft of sea level rise by 2070 and between 2.9 ft and 6.4 ft by 2100 under the Intermediate and high sea level rise projection scenarios, respectively. Though the exact amount of sea level rise for a specific location in a certain year is unclear, we know that water levels are rising, and communities need to be prepared. Coastal wave events and king tides, in combination with current and rising sea levels, will increase flood impacts on land, which will exacerbate the impact on coastal assets. Rising sea levels may also raise groundwater tables, causing increased flooding and leading to impacts that will further damage buried and low-lying infrastructure[2].

Sea level rise projections were selected based on the 2024 State Guidance. For planning purposes, and in alignment with California Coastal Commission guidance[3], the high sea level rise projection scenario was selected to determine conservative SLR projections at the Project location (OPC 2024). Sea level rise values corresponding to the nearest NOAA tide gauge to the Project location, Arena Cove, CA, were used. The high sea level rise projections for late- and end of century at Fort Bragg are as follows:

- 2070: 2.8 feet.
- 2100: 6.4 feet.

To appropriately assess the resiliency of a region or select assets, we typically evaluate sea level rise added to the *100-year water surface elevation*, also characterized as the Base Flood Elevation (BFE) in FEMA mapping. For this preliminary planning-level assessment, we assume that the future 100-year water level is equal to the BFE plus the sea level rise quantity. This is because more detailed bathymetric data than what is currently available is required to develop these calculations for future conditions and map them. This is a high-level estimate, and as projects are identified and moved into the design phase, detailed site-specific calculations should be performed to account for the impacts of sea level rise on wave setup and runup in more detail.

Using these high-level assumptions, for example, at Noyo Bay, the coastal BFE is 19 feet NAVD 88 (see FIRM). By adding sea level rise projections, we could assume the future BFE with sea level rise would be approximately 22.8 feet NAVD 88 by 2050 (19+2.8) and 25.4 feet NAVD 88 by 2100 (19+6.4). This estimation procedure would be limited to coastal Zone VE BFEs. The analysis for the FEMA fluvial zones reflects different considerations, and a more detailed hydraulic study would be needed to properly reflect both coastal impacts from sea level rise and concurrent riverine flows. Such studies are recommended for individual projects as needed for the scale and impact of those projects.

Along the bluff face, we also reviewed the BFEs plus sea level rise as an approximation of the future total water levels including wave effects. Based on this preliminary analysis, the total water elevations in areas along the bluff would not reach the top of the bluff. Waves may overtop the bluff in future sea level conditions. This overtopping could be unsafe for pedestrians and cars, but the infrastructure evaluated for this study is not in these locations, so a more detailed evaluation is beyond the scope of this study.

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[2] https://climateresilience.ca.gov/overview/impacts.html#:~:text=The%20daily%20maximum%20average%20temperature,worsen%20drastically%20throughout%20the%20state.

[3] https://www.coastal.ca.gov/climate/slr/vulnerability-adaptation/infrastructure/#:~:text=The%20goal%20of%20the%20Commission's,managers%2C%20and%20other%20stakeholders%20with

Sea level rise mapping data was pulled from the NOAA Sea Level Rise Viewer (NOAA 2022). The sea level rise values are projected over mean higher-high water (MHHW) elevations, representing sea level rise under daily conditions. This mapping of sea level rise over MHHW is shown below (Figure 10) for reference, because it is the best available mapping currently for the location, although it does not correspond directly to the future BFE scenarios described above.

Sea level rise is anticipated to impact the interactions between the Noyo River and the Pacific Ocean. It is anticipated that sea level rise will cause coastal backwaters to propagate up through the Noyo River which may impact portions of the Fort Bragg's water distribution system that interact with this river including intakes or outfalls. Beyond the Noyo River, sea level rise is not anticipated to have a significant impact on the water distribution system infrastructure.

Determining water levels in detail is beyond the scope of this planning-level study. More detailed hydraulic modeling of the combined riverine and coastal conditions is recommended when developing projects, particularly at the Noyo River. More detailed hydraulic modeling would be required to assess the relative contributions to riverine water levels from sea level rise and riverine flows.

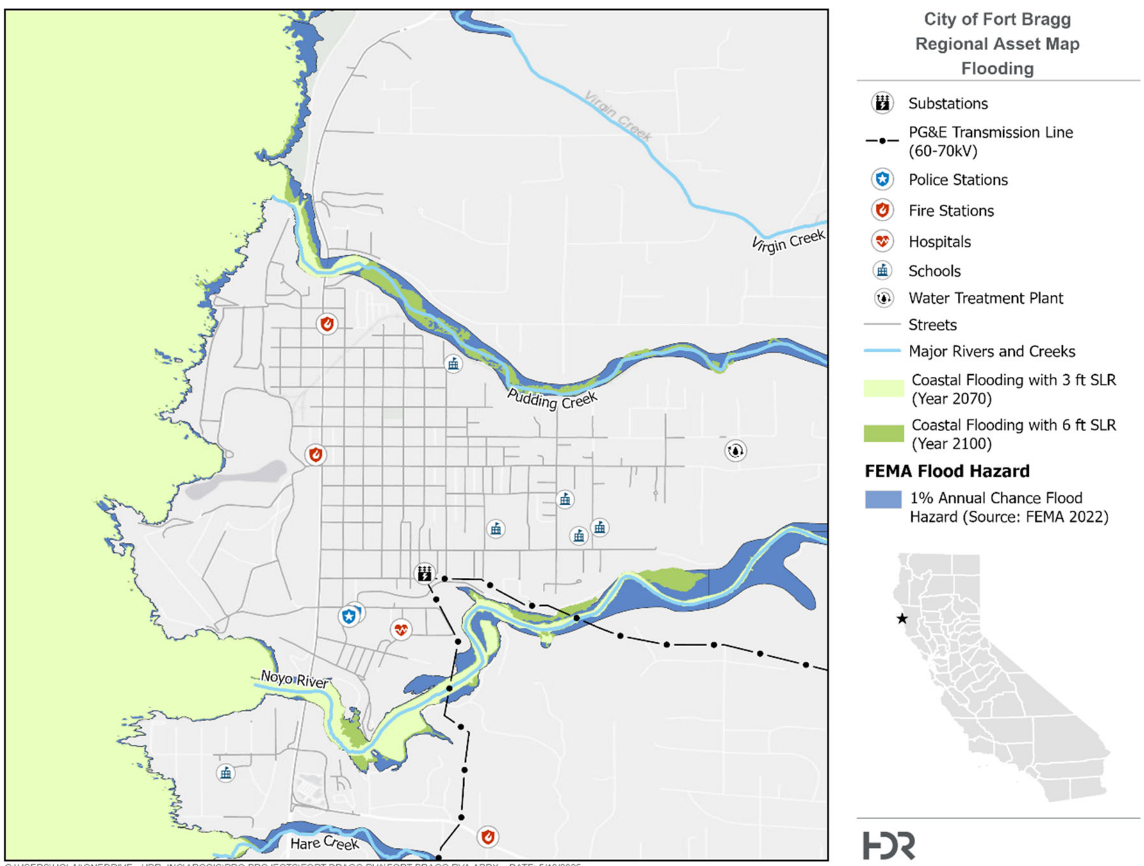

Figure 10 – Flooding Risk Projected: Highest Water Levels Mapped in the Regional Water Level Viewer, Equal to 10 Feet SLR over the MHHW Elevation
(HDR based on NOAA Sea Level Rise Viewer (NOAA 2022). FEMA historic flooding risk)

The coincidental occurrence of heavy rains, high stream flows, SLR, storm surge, and high astronomical tides are expected to increase the threat of coastal inundation in the future. Rainfall runoff occurring simultaneously with high tides will result in inundation areas greater than what is shown. As sea levels rise, this situation is expected to be exacerbated during times of storm, king tide, or both.

2.3.2 Precipitation

California is known for its highly variable precipitation and has the highest variability of year-to-year precipitation in the contiguous United States. California's variable precipitation is also characterized by multi-year wet or dry periods. As a result, future average precipitation is difficult to predict (Figure 11 and Figure 12) but may likely not change substantially when measured by annual precipitation. However, there is high confidence in projections that even if precipitation remains stable or increases, drought severity and the number of dry years will increase, even as more extreme precipitation events may occur. Warming air temperatures will increase moisture loss from soil, which will lead to drier seasonal conditions even if precipitation increases. The snowpack in California's mountains is a key source of surface and groundwater in the state, and rising temperatures will cause a decline in snowpack by more than a third by 2050 and more than half by 2100, even if precipitation levels remain stable[4].

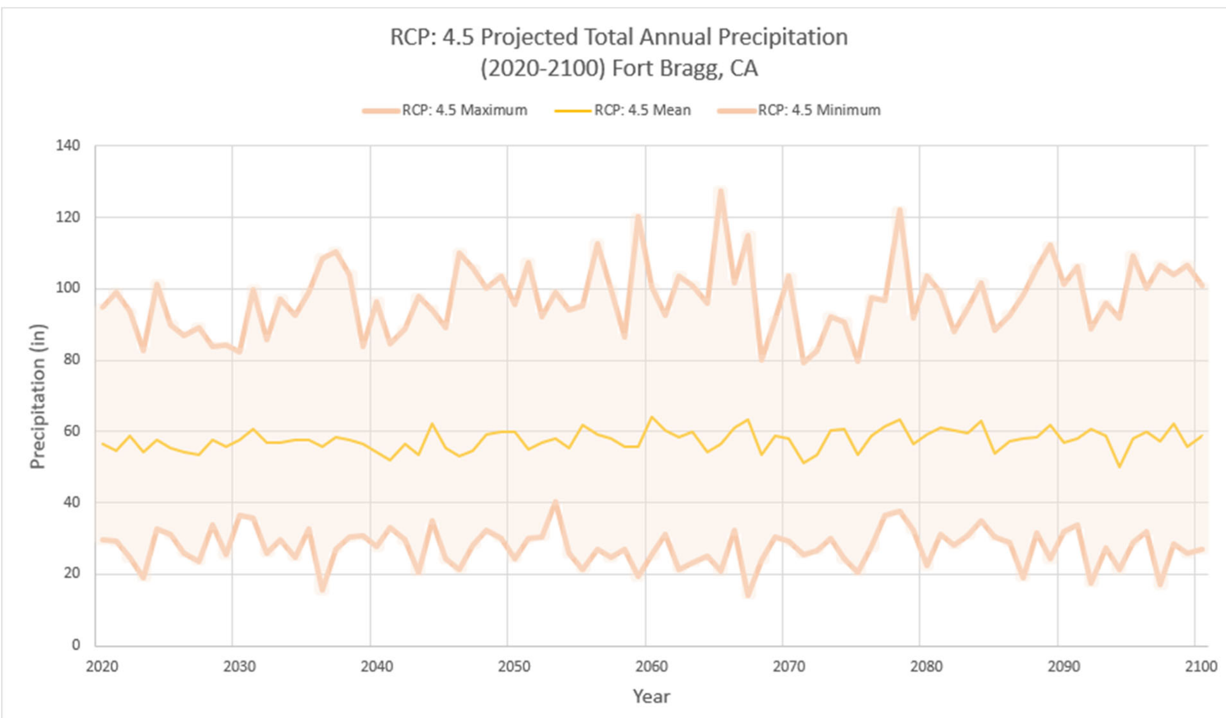

Figure 11 – Projected Total Annual Precipitation for Fort Bragg Based on Climate Scenario RCP 4.5.

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[4]https://climateresilience.ca.gov/overview/impacts.html#:~:text=The%20daily%20maximum%20average%20temperature,worsen%20drastically%20throughout%20the%20state

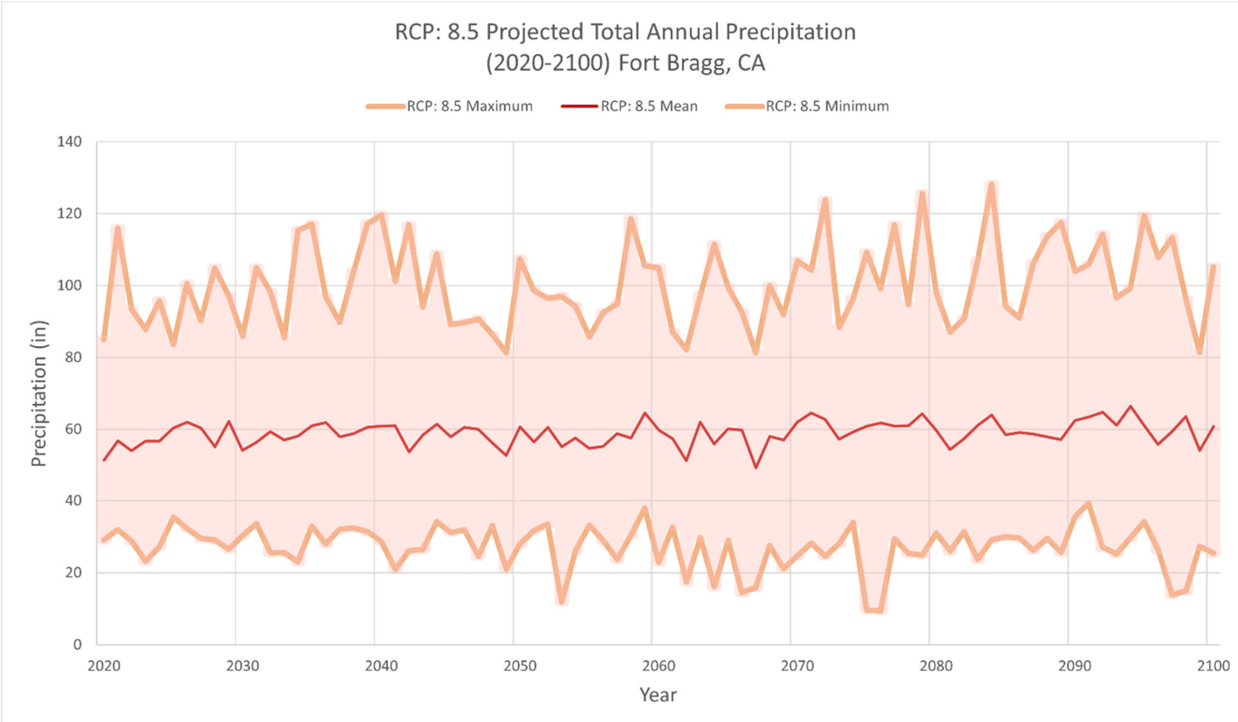

Figure 12 – Projected Total Annual Precipitation for Fort Bragg Based on Climate Scenario RCP 8.5.

Figure 11 shows the projected change in total annual precipitation for Fort Bragg based on climate scenario RCP 4.5. Projected precipitation under this scenario is reflective of the nature of the RCP 4.5 scenario wherein precipitation intensities show some increase through the mid-century but then level off as emissions begin to decrease during the latter portion of the century. Interestingly, Figure 12 also reflects this despite RCP 8.5 having an increase in GHG emissions. The relatively flat profile of both the RCP 4.5 and 8.5 projected total precipitation curves indicates that while precipitation intensity will increase, the total amount of rainfall is projected to remain the same. In other words, a similar amount of rain each year will be segregated out into fewer more powerful storms. This combination is a recipe for flooding events.

In Figure 13 and Figure 14, the projected number of days that will see 1 inch or more of rainfall is shown for RCP 4.5 and 8.5, respectively. This set of projections shows that in either cast (4.5 or 8.5) there is expected to be an increase in the number of days each year where Fort Bragg receives 1 inch or more of rain. While a single inch of rain in a day is not always cause for concern, this highlights the general trend of increasing variability where the amount of rain that falls per year is expected to be stable, but the events in which it falls are expected to be less frequent and more intense, producing periods of drought between heavier rainfall events.

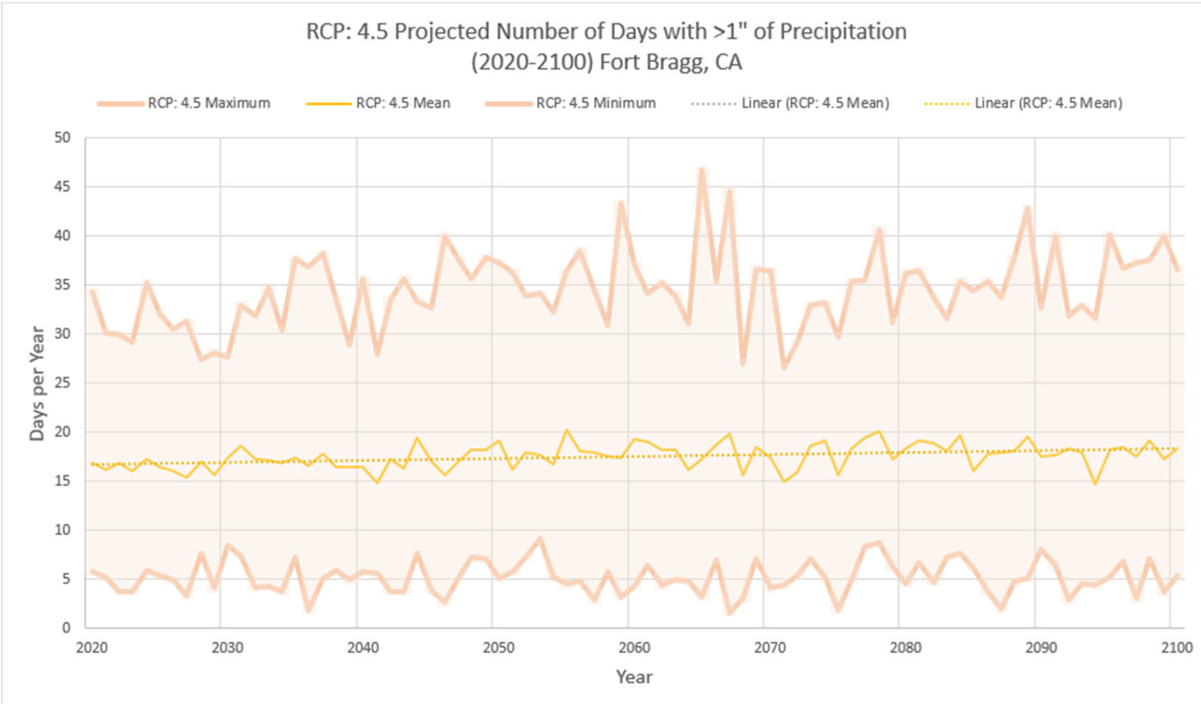

Figure 13 – Projected Number of Days with Greater Than 1 Inch of Precipitation for Fort Bragg Based on Climate Scenario RCP 4.5

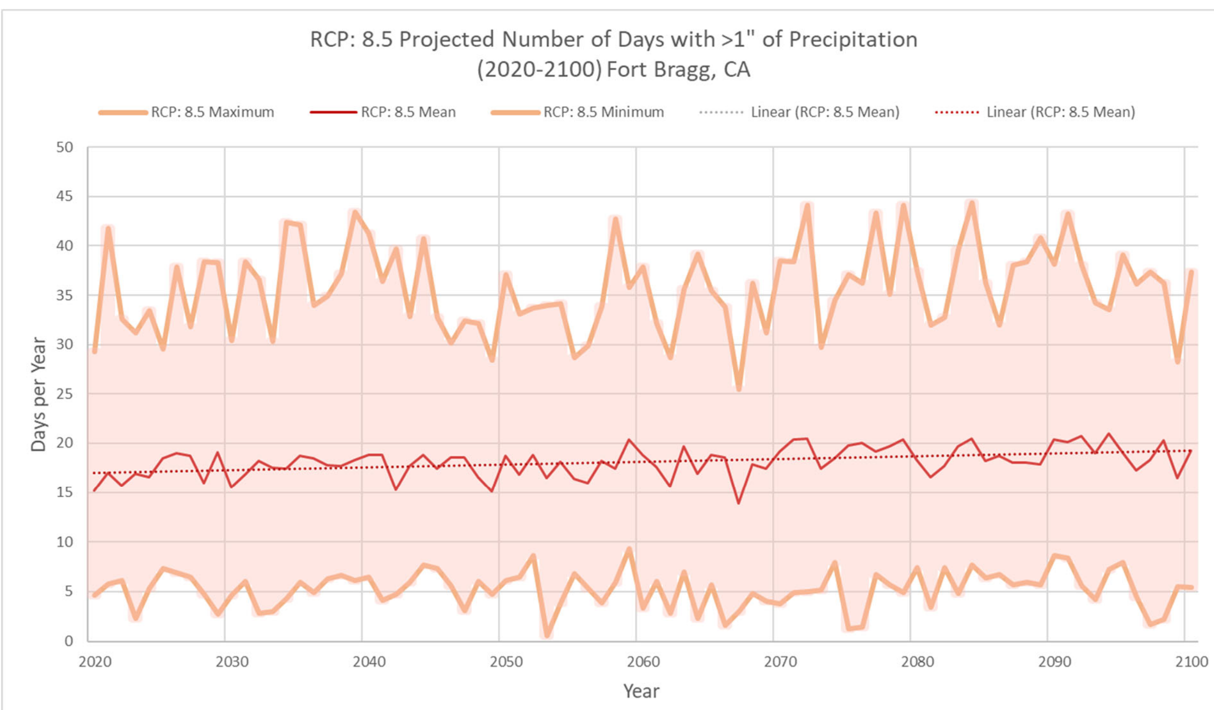

Figure 14 – Projected Number of Days with Greater than 1 Inch of Precipitation for Fort Bragg Based on Climate Scenario RCP 8.5

2.3.3 Coastal Bluff Erosion (Coastal) and Landslides

The noted increase in year-over-year precipitation variability is likely to result in bank destabilization and increase in slope instability during the water years with greater precipitation. It is a double-edged sword of drought years killing off vegetation that might otherwise stabilize a hillside followed by years of heavy precipitation that cause the soils to destabilize and produce landslide. This would be further exacerbated by drought years that produce significant wildfire in the watersheds above the city of Fort Bragg.

Bluff erosion is influenced by SLR in addition to the mechanisms that impact landslides inland. Cliff retreat data was pulled from the Coastal Storm Modeling System Coastal Cliff Retreat dataset (Barnard et al 2022). The data assumes a “let it go” cliff retreat scenario where the model allows cliffs to recede regardless of existing cliff armoring. The boundary drawn (see Figure 15) represents the projected uncertainty band for future cliff top edge. Like the sea level rise water level evaluation, the closest available ranges in that dataset to the projections were used to represent late- and end of century conditions.

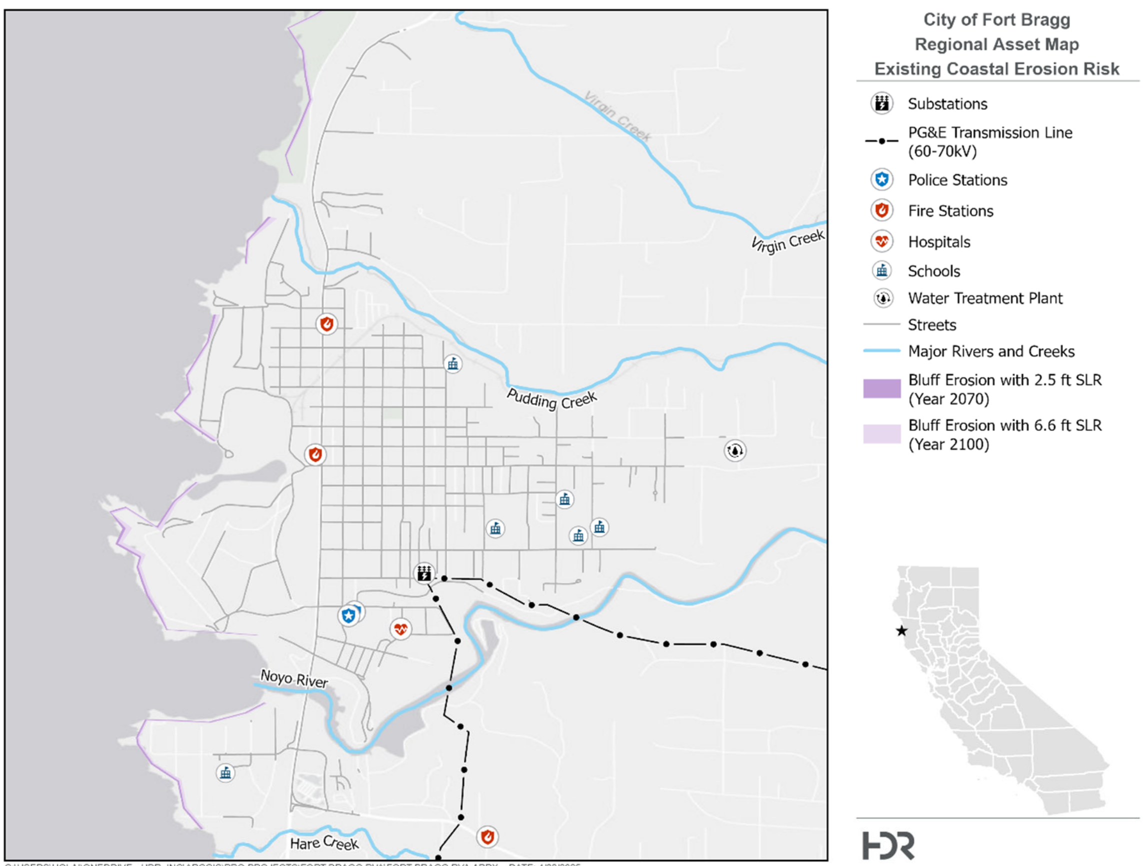

Figure 15 – Existing Coastal Erosion Risk
(Source: Coastal Storm Modelling System (CoSMoS), US geological Survey (USGS), 2022)

2.3.4 Temperature / Extreme Heat

Annual temperature increases experienced over most of California have already exceeded 1°F, with some areas exceeding 2°F. The daily maximum average temperature, an indicator of extreme temperature shifts, is expected to rise 4.4°F–5.8°F by mid-century and 5.6°F–8.8°F by late century. Heat-Health Events (HHEs), which better predict risks to populations vulnerable to heat, will worsen drastically throughout the state. By midcentury, the Central Valley is projected to experience average HHEs that are two weeks longer, and HHEs could occur four to ten times more often in the Northern Sierra region[5].

The projected annual mean maximum temperatures shown below in Figure 16 through Figure 19) are showing similar trends. As discussed previously, the trends here are produced with CMIP5 informed climate models. In the case of both RCP 4.5 and RCP 8.5 the mean maximum temperature is expected to increase annually.

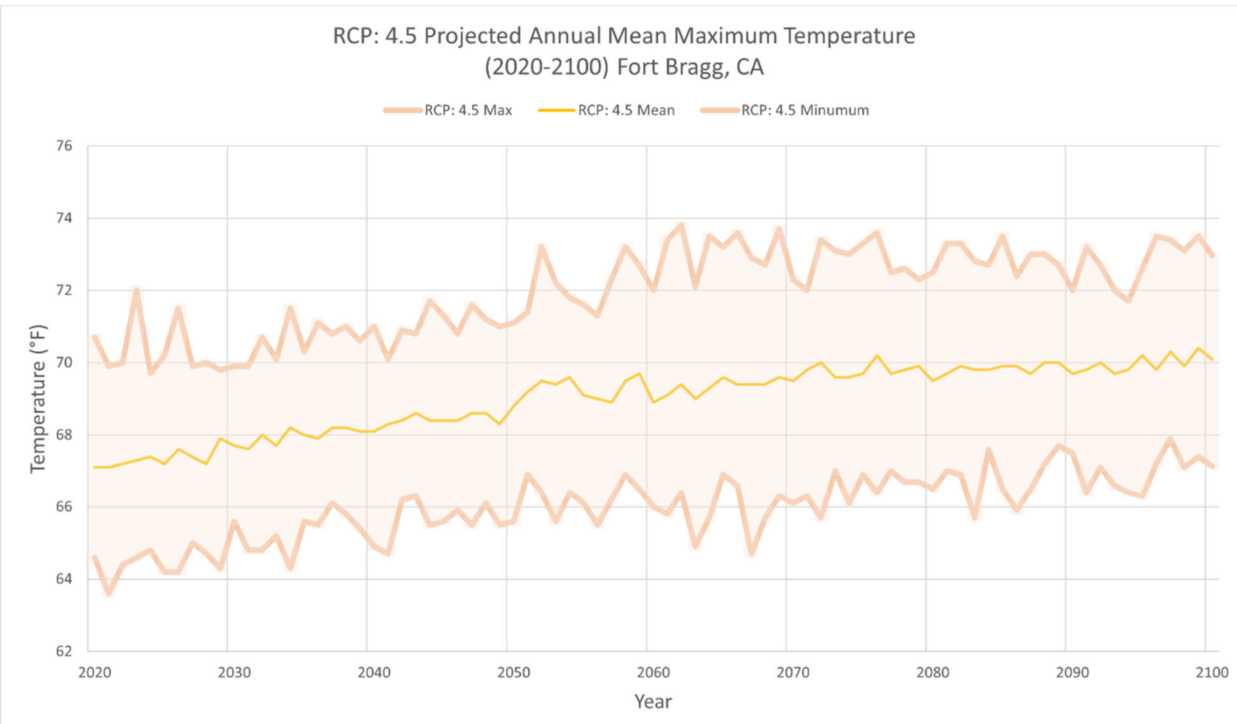

Figure 16 – Projected Annual Mean Maximum Temperatures Expected in Fort Bragg for the Years 2020-2100 Based on the RCP 4.5 Climate Scenario

[5]https://climateresilience.ca.gov/overview/impacts.html#:~:text=The%20daily%20maximum%20average%20temperature,worsen%20drastically%20throughout%20the%20state.)

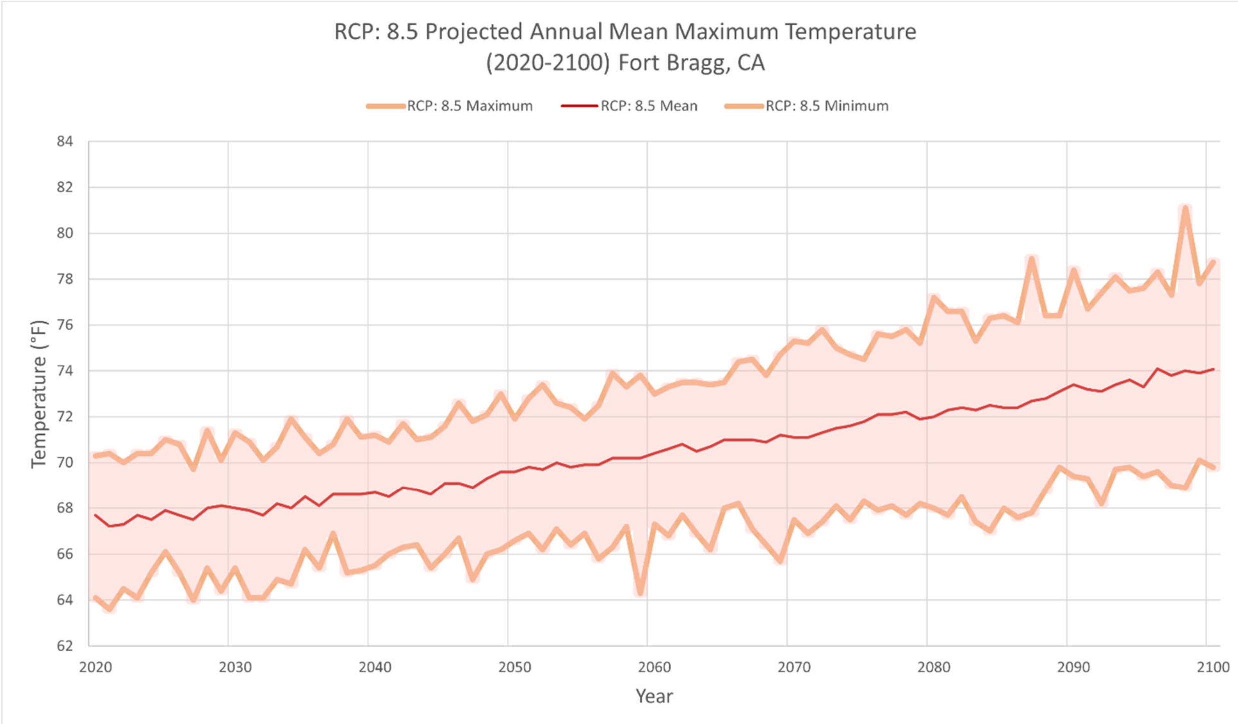

Figure 17 – Projected Annual Mean Maximum Temperatures Expected in Fort Bragg for the Years 2020-2100 Based on the RCP 8.5 Climate Scenario

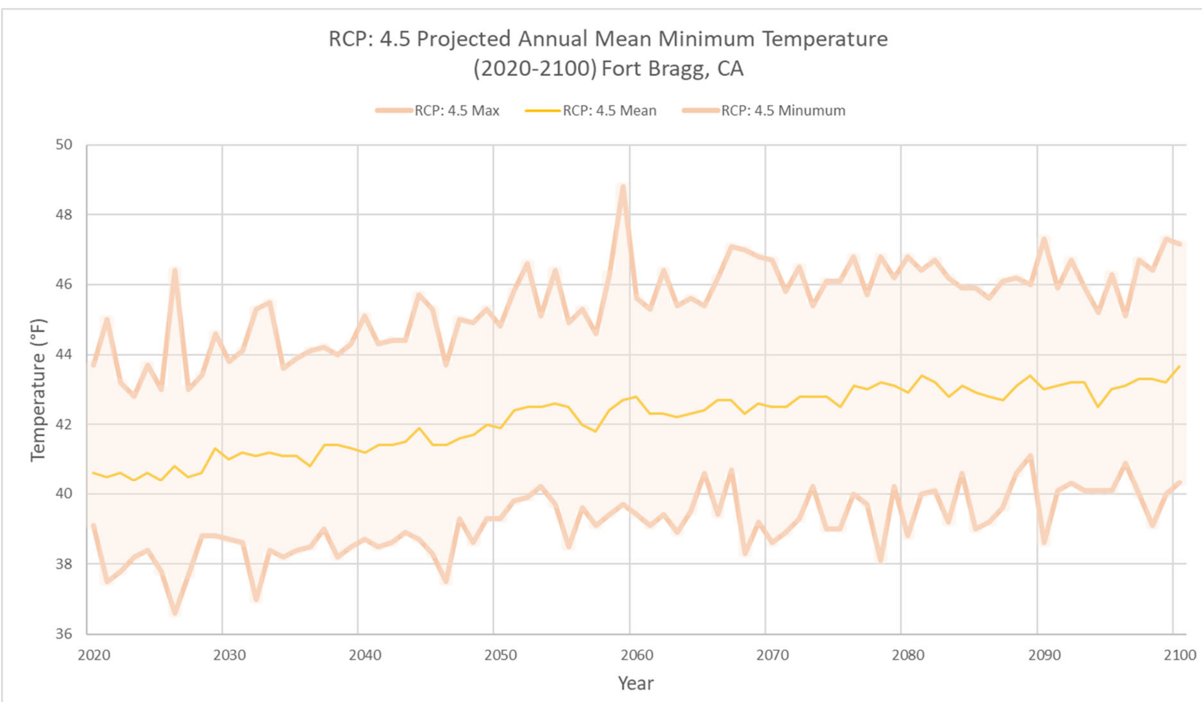

Figure 18 – Projected Annual Mean Maximum Temperatures Expected in Fort Bragg for the Years 2020-2100 Based on the RCP 4.5 Climate Scenario

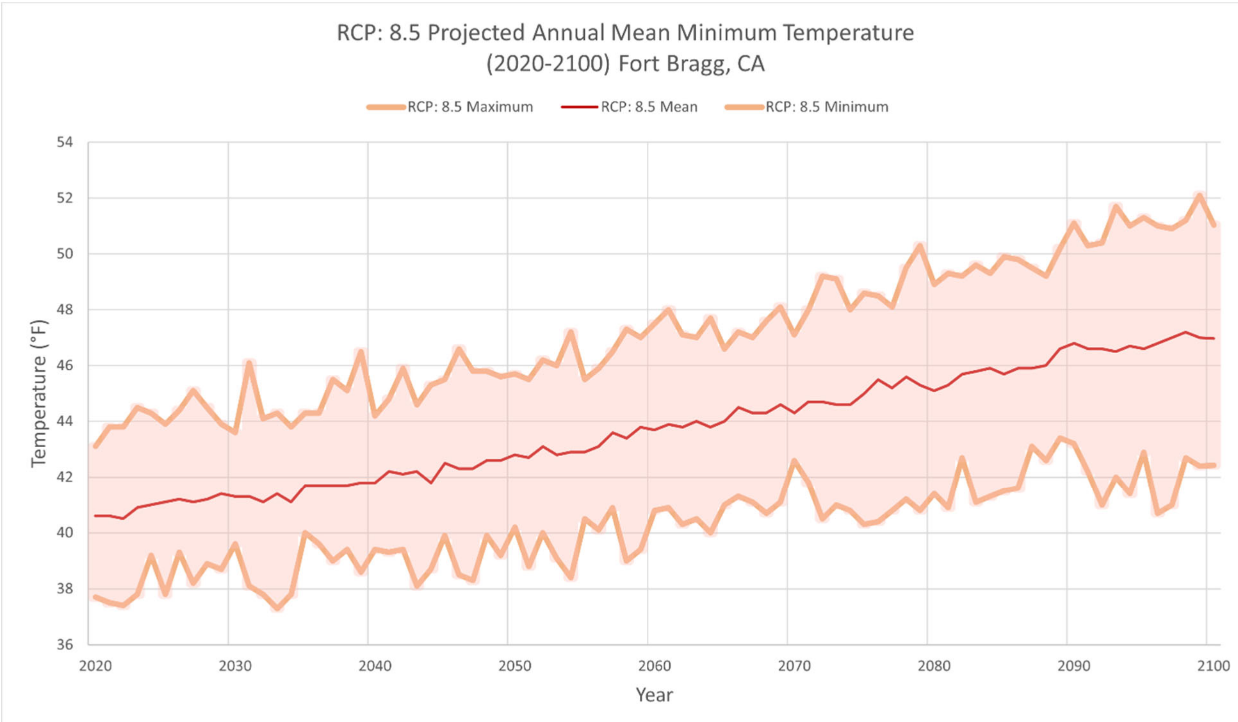

Figure 19 – Projected Annual Mean Minimum Temperatures Expected in Fort Bragg for the Years 2020-2100 Based on the RCP 8.5 Climate Scenario

The annual mean minimum temperature for Fort Bragg, based on data from the POR 1950-2023, shows a slight decreasing trend, which is reflected here in the projected annual mean minimum temperatures (Figure 18 and Figure 19 above) until just before the year 2030 in RCP 4.5 and until 2023 in RCP 8.5. Then an annual increase in the mean minimum temperature is expected.

2.3.5 Wildfire

Wildfires are concentrating in upper watersheds, further compounding crises like drought. The year 2020 was the largest wildfire season recorded in California's modern history, with nearly 10,000 fires that burned over four million acres in total. However, fewer than 40 fires accounted for most of the area burned, pointing to the accelerating severity and frequency of extreme fires. In 2021, California experienced 4 of the 20 largest wildfires in the state's history, with 8,000 wildfires burning over 2.5 million acres. The 2021 fire season also marks the first time that fire crossed the granite crest of the Sierra, California's largest natural fuel break. A model developed for California's Fourth Climate Change Assessment projected up to a 77 percent increase in average area burned and a 50 percent increase in the frequency of fires exceeding 25,000 acres by 2100[6].

[6]https://climateresilience.ca.gov/overview/impacts.html#:~:text=The%20daily%20maximum%20average%20temperature,worsen%20drastically%20throughout%20the%20state.)

Fortunately, Fort Bragg was spared from the recent Mendocino Complex Fire but that does not mean that the threat of wildfire to the region is not being exacerbated by climate change. As noted earlier in this document, the increased year-over-year variability in precipitation and air temperatures is expected to continue to increase the threat of wildfires. The greatest threat will come in years that are hot and dry following a year, much like water year 2022-2023, that has significantly above normal rainfall contributing to brush and ground cover growth. Peak months for the likelihood of wildfires in the region are from August through September during periods of strong offshore winds or during times when thunderstorms can produce dry lightning in the region.

The threat of wildfire is expected to increase. This will require resilient actions on the part of local, regional, and state agencies because the City is dependent on surface water for it's drinking water supply. The intense heat related to wildfires drastically changes the runoff characteristics of a watershed and increases the threat of sedimentation and severe water quality issues. Wildfire heat will also negatively impacs pipe integrity and poses a threat to the City's raw water pipeline infrastructure.

2.3.6 Groundwater

The same conditions that are the result of an increase in year-over-year variability for drought and heavy precipitation (Section 2.1.7) will impact groundwater availability in the region. As identified in other locations in the West (Jensen, M.N., 2016), groundwater supplies may be further stressed by increasing evapotranspiration because of increasing air temperatures.

Increasing sea levels will increase groundwater elevations. The rate at which groundwater will rise depends on the types of soils present at the site and quantifying that rate is beyond the scope of this study. However, it is worth mentioning that most of Fort Bragg is at high elevation and consequently this is probably not a near-term concern.

2.3.7 Drought

As shown in the prior sections, historic year-over-year precipitation variability between years of flood and drought is expected to be exacerbated by climate change in the region. Increasing air temperatures combined with years of below normal precipitation will produce a multiplying effect on water usage through increasing demand, evaporation, evapotranspiration, and, of course, the increased risk of wildfire during drought years.

2.4 Conclusion/Key Findings

The historic climate trends provide a baseline for understanding projected future climate trends. The Water System site risk/vulnerabilities have been correlated to those that are anticipated to change at future time scales due to climate change. The Water System challenges adapting to more extreme climate events are:

- SLR and extreme rain events with subsequent periods of drought are most likely to increase the risk of landslides and erosion.

- Increases in air temperatures, which will produce added demand and stress on the Water System and exacerbate the threat of wildfire in the region.

Acknowledging that the area will be under water stress, the resilience and effectiveness of the water distribution system is consequently becoming more critical. There are often inefficiencies in water distribution and water losses that should not be exacerbated because of increased stress caused by climate impacts (chronic changes in operating conditions as well as acute extreme events) on the distribution infrastructure. The increases in air temperatures coupled with an increase in year-over-year variability in precipitation, will make for years in which water management will become increasingly difficult to balance between years of flood and drought.

The observed climate trends and climate projections will allow for identification of Water Distribution asset vulnerability to projected changes in climate as part of this CRVA.

Although not addressed in this scope, we recommend addressing the following topics at a later stage and/or when new information becomes available:

- A more robust understanding of flooding risk caused by extreme events. Particularly, flooding extends associated with future 100-year storms superimposed on SLR elevations.
- Monitoring impact of high temperature for longer periods of time for the level of operations of the water distribution systems.
- Impact of groundwater changes.
- Impact of sea level rise on groundwater levels and saltwater intrusion into freshwater resources, especially the Noyo River.

3.0 Climate Change Impact Assessment

3.1 Approach

The Climate Risk and Vulnerability Assessment (CRVA) approach is based on the Schematic Basis of Design. The proposed approach for conducting the CRVA is aligned with best practices adapted to match the Fort Bragg unique conditions. Preliminary findings need to be reviewed and adjusted to reflect the client's preference in assessing risk and identifying priorities.

The CRVA is conducted by first assessing possible exposure to identified climate risks, followed by conducting a vulnerability assessment based on the sensitivity of assets or functions and their adaptive capacity to identified climate threats. The third and final step is to conduct a risk assessment based on the consequences of an asset or function failing and the probability of identified climate threats. The steps used for the CRVA (Figure 20) informs the prioritization of asset functions or systems that should be resilient and the development of an implementation plan.

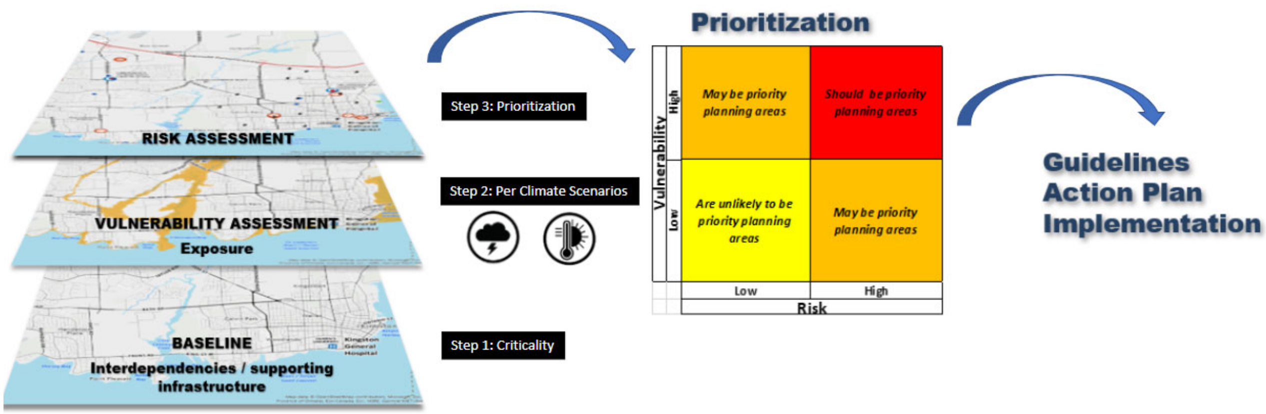

Figure 20 – Illustration of Steps for Developing a Climate Risk and Vulnerability Assessment (CRVA)
(Source: HDR)

Vulnerability is a function of exposure, sensitivity, and adaptive capacity.

- Exposure determines which assets are exposed to climate risks using the best available information. For the purposes of this study, exposure is considered for the primary climate parameters as identified within the scope and resources of climate analysis in Section 2.
- Sensitivity is the degree to which an asset can be affected by a hazard. For this initial assessment, it is assumed that all assets exposed to a hazard are sensitive to it.
- Adaptive Capacity is assessed based on whether assets had technological or operational protections in place and system-wide redundancy to help mitigate or cope with the impacts of exposure.

For this high-level assessment, vulnerability (Figure 21) has been assessed by exposure defining sensitivity.

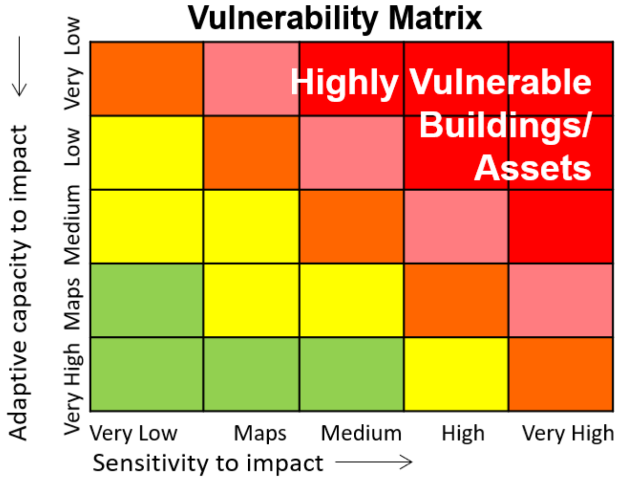

Figure 21 – Vulnerability Matrix
(Source: HDR, Adapted from ICLEI)

Risk is a function of consequences (of an asset failing) and the likelihood/probability it will occur (e.g., observed or projected) as illustrated in Figure 22. Likelihood was scored as either "High" or "Highest" (as informed by the exposure to the identified climate scenarios) while consequence of failure could be scored as "Low," "Medium," or "High" per anticipating possible consequences.

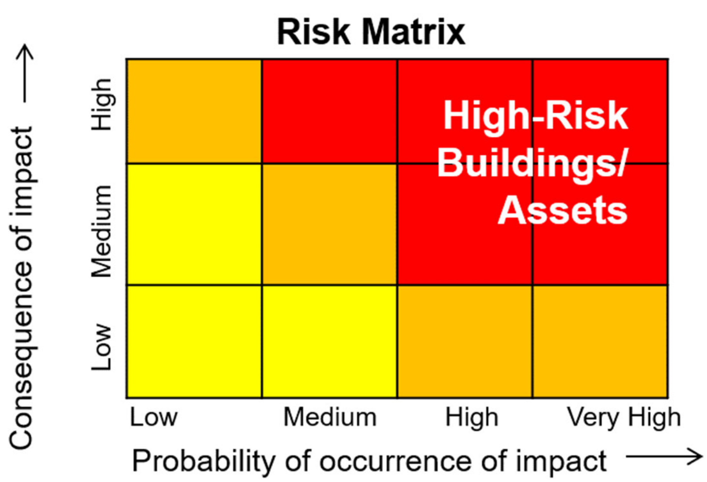

Figure 22 – Risk Matrix
(Source: HDR, Adapted from ICLEI)

Prioritization is the last step in the risk and vulnerability assessment. Prioritization takes in all the information gathered related to vulnerability and risk and allows for a final assessment of infrastructure or assets that may or may not be a priority for focus. The prioritization of critical assets and infrastructure can then lead to better guidelines for climate-related issues and can focus an action plan on assets that are a higher priority, and, therefore, introduce changes to help assets become more resilient.

3.2 Interdependency CRVA

The purpose of the interdependencies CRVA is to identify regional infrastructure, critical for supporting the Water Distribution System operations (Figure 23). It is also intended to highlight vulnerable communities with greater risk in the event of water system failure.

Risks and vulnerabilities were assessed for the following interdependent asset categories:

- ***Transportation systems***: These assets are critical for accessing the Water System to properly repair, maintain, and operate.
- ***Energy and electrical systems***: Energy assets must provide safe and sufficient power delivery to support pump station operations and any leak detection or monitoring.
- ***Interconnected water infrastructure***: Reliable and safe potable water supply is inextricably linked to water intake and treatment facilities.
- ***Telecommunication/IT***: Some Water System assets or procedures may require telecommunication connectivity.
- ***Critical facilities***: Emergency and protection services play an outsized role in stabilizing and restoring community capacities. As such, these critical facilities should be identified and prioritized.
- ***Serviced communities***: End-user demographics have varying degrees of adaptive capacity. Low-Income and Disadvantaged Communities within the service area should be specifically identified.
- ***Natural systems***: The furthest upstream assets are the water resources supplying fresh water to the Water Treatment Plant. Attention should be given to protect and preserve the quantity and quality of these resources. Additionally, natural land cover and urban tree canopies offer myriad ecological benefits, including flood mitigation.

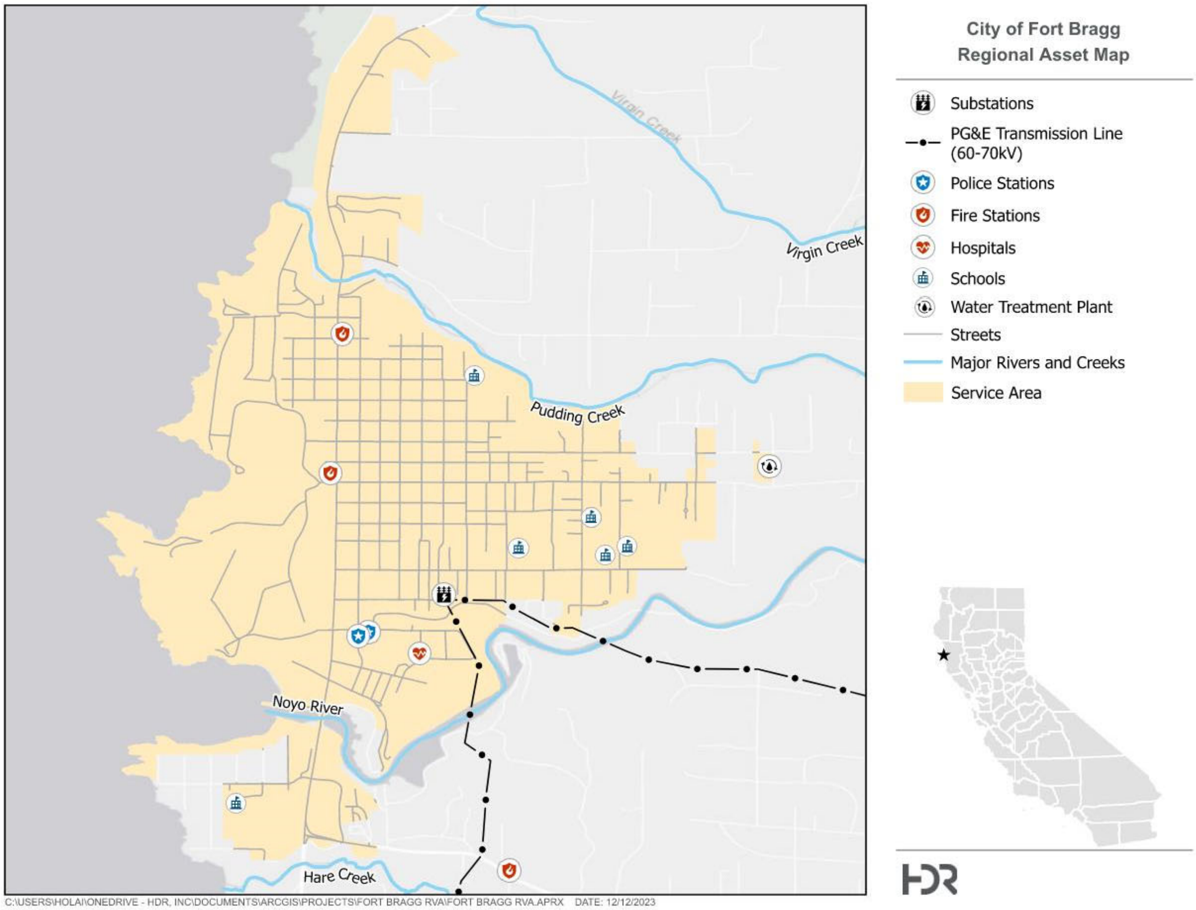

Figure 23 – Critical Assets
(Source: HDR GIS Fort Bragg)

The boundaries for the interdependency CRVA include the area being serviced by the water distribution system of Fort Bragg and extend to the next larger scale of interdependent systems.

Figure 24 illustrates the relationship between identified interdependent assets and flooding/SLR.

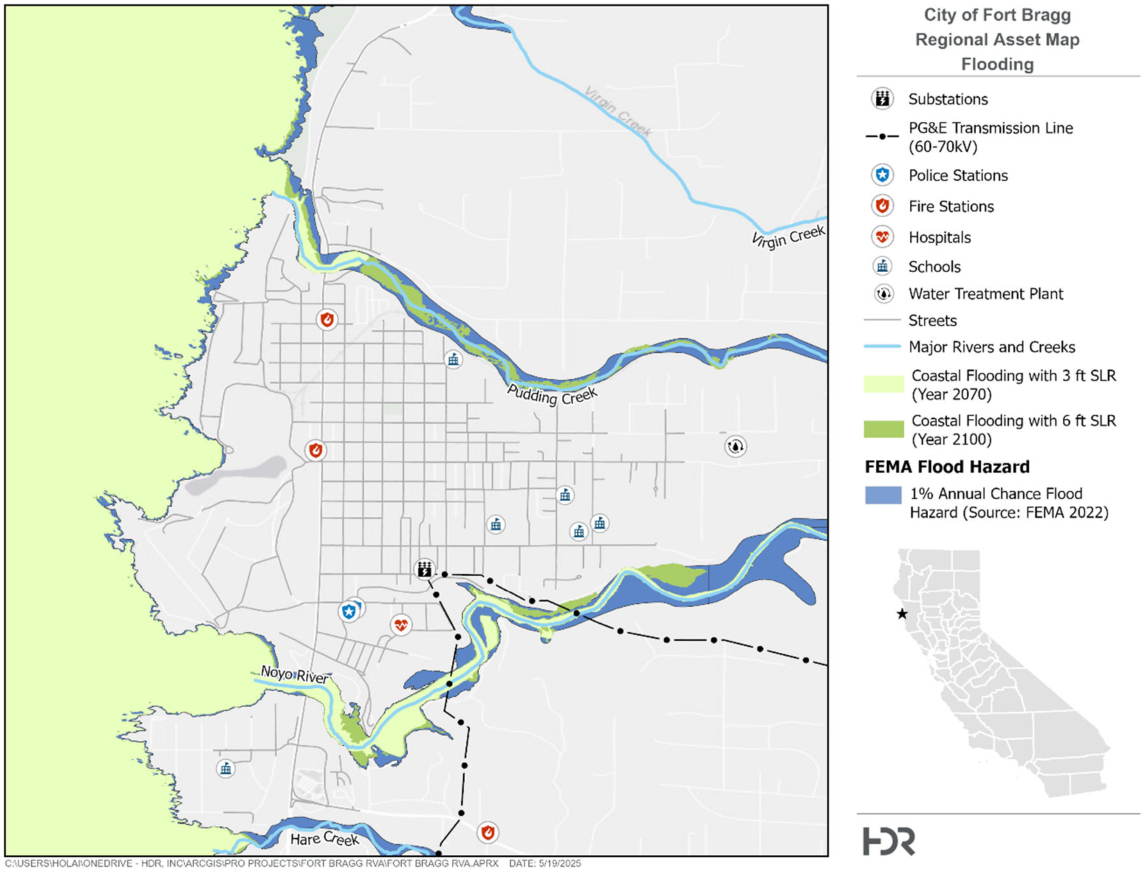

Figure 24 – Regional Asset Map and Flooding Risk
(Source: HDR GIS based on Fort Bragg database; FEMA 2022)

Figure 25 illustrates the relationship between identified interdependent assets and coastal erosion and landslides.

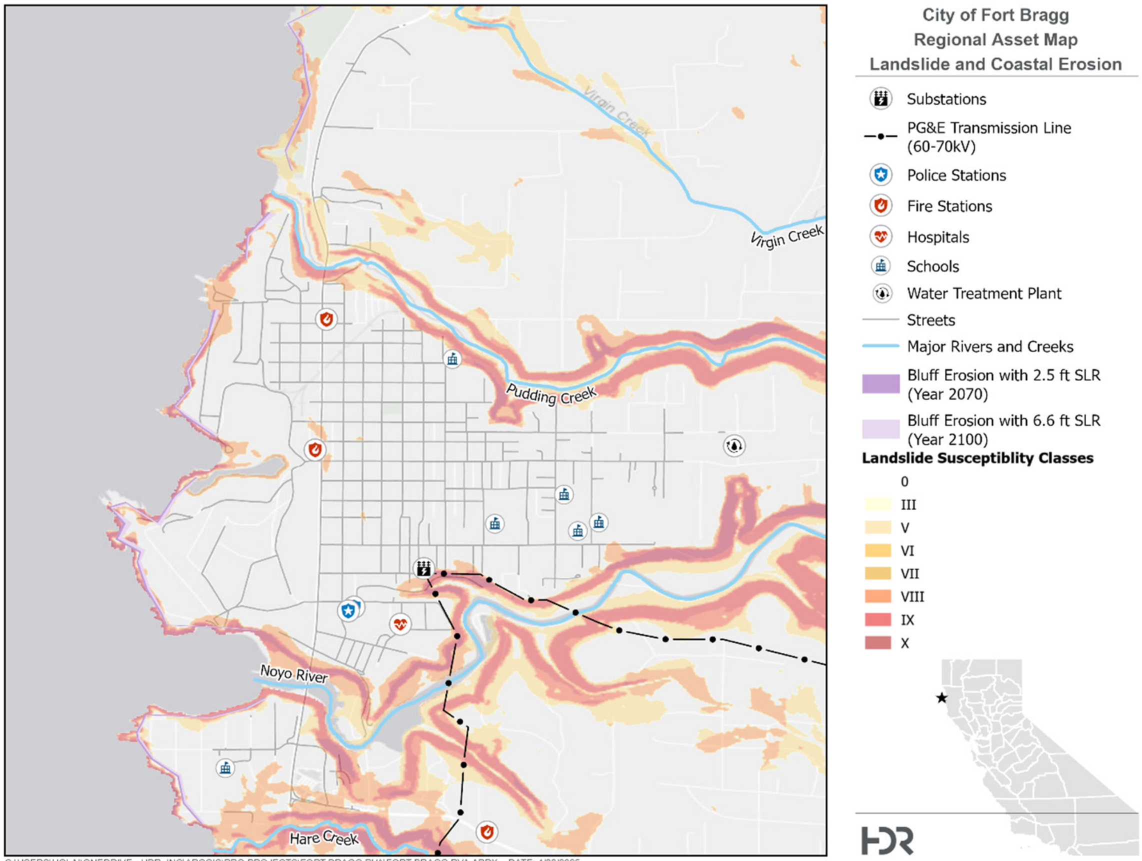

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Figure 25 –Regional Asset Map of Existing Landslide and Coastal Erosion Risk
(After CGS Map 58, 2011)

Figure 26 illustrates the relationship between identified interdependent assets and wildfires.

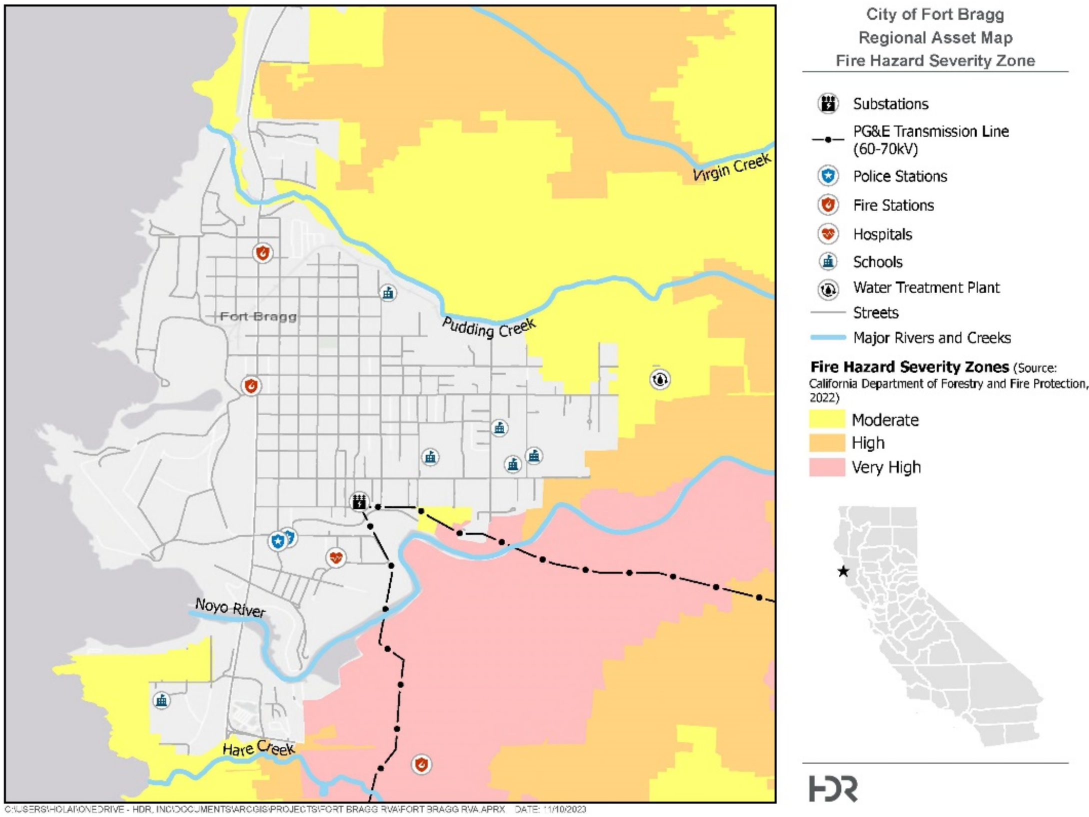

Figure 26 – Regional Asset Map of Existing Wildfire Risk
(Source: HDR GIS based on Fort Bragg database; CA Department of Forestry 2022)

3.2.1 Transportation

The Noyo River Bridge is the single means for automobiles to cross the Noyo Basin and River. Erosion, landslides, and other acute or chronic conditions could result in premature bridge failure. Bridge closure can prevent access to Water System assets for repairs or maintenance. The assets most at risk are those south of Noyo River; resources, staff, and equipment are primarily located on the north side.

3.2.2 Energy and Electrical

Fort Bragg has a single substation transmitting electrical power to all community assets, including the pump station located along S Harbor Drive. Additionally, the on-site sodium hypochlorite generation (OSHG) used for primary disinfection at the Water Treatment Plant requires reliable and continuous electricity. The substation is not at risk, as informed by our current available information. Transmission lines carrying electricity to the substation are at risk of wildfires, as they are predominately wood and traverse through forested corridors. Damaged transmission lines could result in a loss of power for all Water Systems. Distribution lines were not assessed within this scope. However, it is worth noting there is an increased risk of power outages from the substation to the pump station and treatment facility. Per the climate projection assessment, Fort Bragg is likely to experience an increase in maximum daily temperatures. Future extreme heat events could overburden the weakest link in the energy infrastructure, resulting in power outages.

3.2.3 Water Infrastructure

For the purposes of this study, interdependent water infrastructure includes:

- Intake structures off Madsen Lane, Simpson Lane, and Summers Lane: SLR is projected to increase up to 5 feet by 2070. This will likely be accompanied by an increase in saline concentration at the three intake structures, which could result in premature deterioration of intake equipment and materials.
- Summers Lane Reservoir: This asset is not at risk, as informed by our current available information.
- Pump station at Madsen Lane intake: This asset is not at risk, as informed by our current available information.
- Centralized Water Treatment Plant near Monsen Way and Cedar St:
    - This asset was identified as being at risk of wildfire. Dense woodlands extend close to the plant, but there are a few blocks between the Storage Tanks and the dense forest with only a few buildings and urban trees. Fire risk for this facility should be further investigated. The plant's primary treatment method is OSHG. More saline water entering the treatment facility as a product of rising sea levels could prematurely deteriorate equipment.
    - In 2021, an emergency desalination-reverse osmosis treatment system was installed to treat brackish water from the Noyo River. While this temporary treatment process has been effective, more detailed study needs to be performed to consider the impact of brackish water on raw water sources of the Water Treatment Plant.

3.2.4 Telecommunications

No telecommunication assets were identified in connection with the current Water System infrastructure. This will need to be assessed if remote system management is ever implemented.

3.2.5 Critical Infrastructure

For this study, critical infrastructure includes support emergency infrastructure and schools:

- ***Fire station***: There are three fire stations. The two facilities north of Noyo River are not at risk, as informed by our current available information. The facility south of Noyo River (Fort Bragg Fire Station 2) is at risk of wildfire. Because the facility is at the furthest limits of the Water System the water pressure may be low. Additionally, the water main does not appear to be looped, thus reducing capacity for fire protection.

- ***Hospital**:* There is one hospital serving Fort Bragg. This facility is not at risk, as informed by our current available information.
- ***Schools**:* There are six schools served by the Water System – five north of Noyo River, and one south. These facilities are not at risk, as informed by our current available information.

3.2.6 Impacted Communities

The CalEnviroScreen has been used as a placeholder to address socio economic vulnerability for Fort Bragg. It is a is a screening tool used to identify communities disproportionately burdened by multiple sources of pollution and with population characteristics that make them more sensitive to pollution. It indicates the entirety of Fort Bragg is in the >50-60 range, which represents higher vulnerability compared to the much lower 0-10 CalEnviroScreen Score for the surrounding area. Within Fort Bragg, populations east of Main Street and South of Oak St. have a moderately Higher Social Vulnerability Index. Given the available information, we are not able to meaningfully identify EJ Communities to be prioritized.

3.2.7 Natural Systems

Currently, Fort Bragg's Water System is fed by three water sources, all of which utilize surface water: Waterfall Gulch (tributary to Hare Creek), the Noyo River, and the Summers Lane Reservoir. As the sea level rises, these surface waters are expected to become more saline. As noted in Section 2.2.5, drought and flooding conditions are likely to become even more variable. The Noyo River may continue to experience severe drought conditions like that of 2021.

3.2.8 Key Findings

Table 1 highlights which key infrastructure elements are most at risk of being impacted by climate change events and consequently place the water system operations at risk.

Table 1 – Prioritization of Regional Infrastructures

		Vulnerability	
		Lower (Low & Medium)	Higher
Risk	Higher	Noyo River Bridge Increased salinity of surface waters at intake locations	Electric transmission lines
	Lower	Summers Lane Reservoir	Water Treatment Plant Substation and distribution capacity Fort Bragg Fire Station 2

3.3 Water Distribution System CRVA

Most of the Water System is located along the coastal zone and bordered north and south by two rivers. Exposure has been assessed using the existing climate risks and projected climate scenarios developed in Section 2.

3.3.1 Water System Climate Risk and Vulnerability Assessment

The Risk and Vulnerability Assessment is conducted by assets within the geographic boundaries shown on Figure 27. This approach allows for an understanding of risk per water system asset group providing targeted information on how best to develop a range of resiliency strategies by mitigating exposure, decreasing sensitivity, or enhancing adaptive capacity.

Assets reviewed in the CRVA include:

- ***Water Mains:*** Water distribution mains in the distribution system include gravity-fed lines and a pressure zone fed from the Willow Street Pump Station.
- ***Water Pump Stations:*** There is one pump station located on Willow St. between Lincoln St. and Minnesota Ave.
- ***Storage Tanks:*** There are four storage tanks within the service area. Three are located at the Water Plant on the east side of Fort Bragg, where the elevation is highest. The last storage tank is located south of Noyo River, at Fort Bragg Fire Station 2.

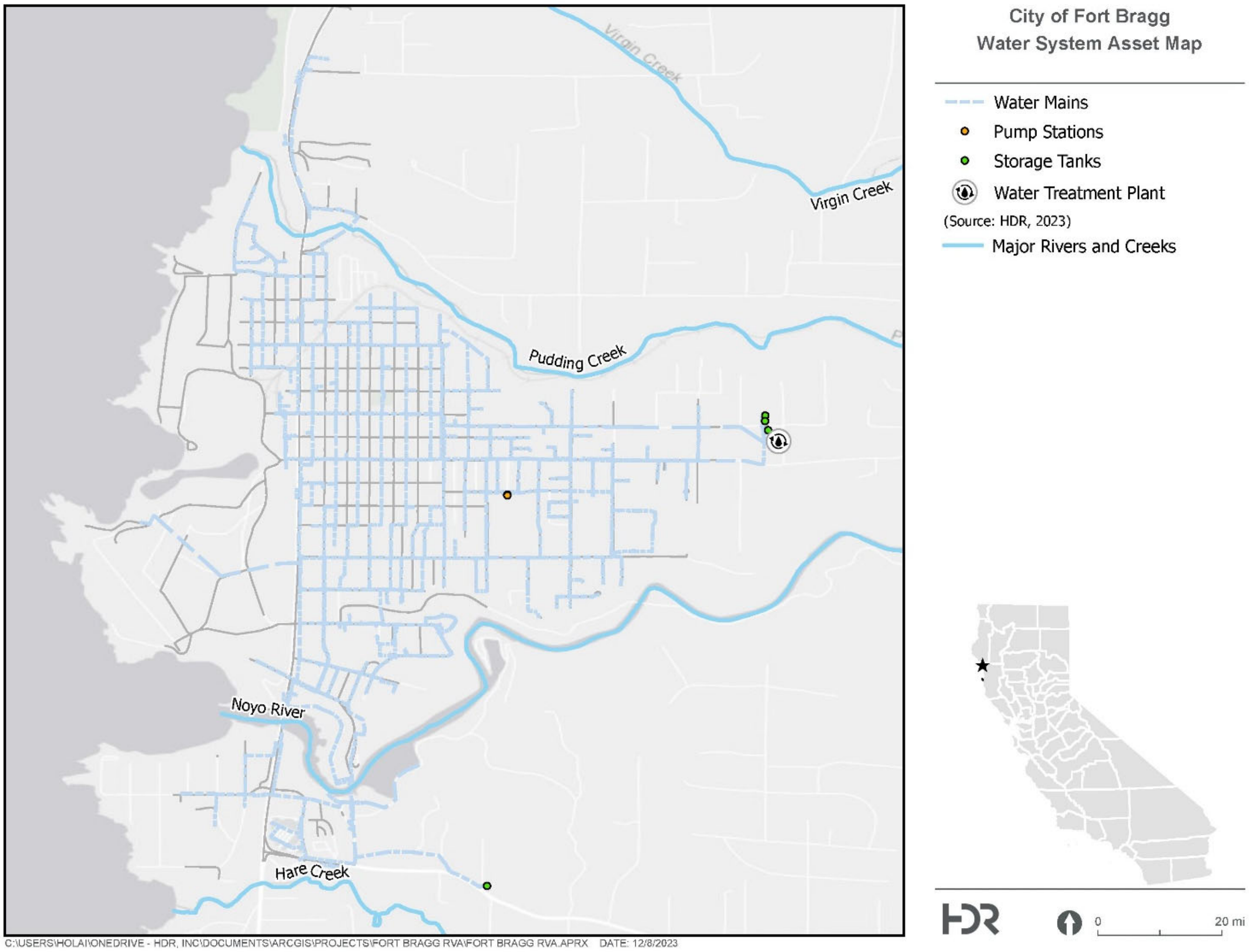

Figure 27 – Water Distribution Assets Map
(Source: HDR GIS based on Fort Bragg database)

3.3.2 Assumptions

The following assets associated with the water distribution system were not assessed within this RVA:

- Valves.
- Hydrants.
- Metered Laterals.
- Other Appurtenances.

While these assets may still be vulnerable to identified climate hazards, it is assumed the risk associated with these assets is less than that of the assets included in the CRVA.

Figure 28 illustrates the relationship between Water System assets and flooding/SRL.

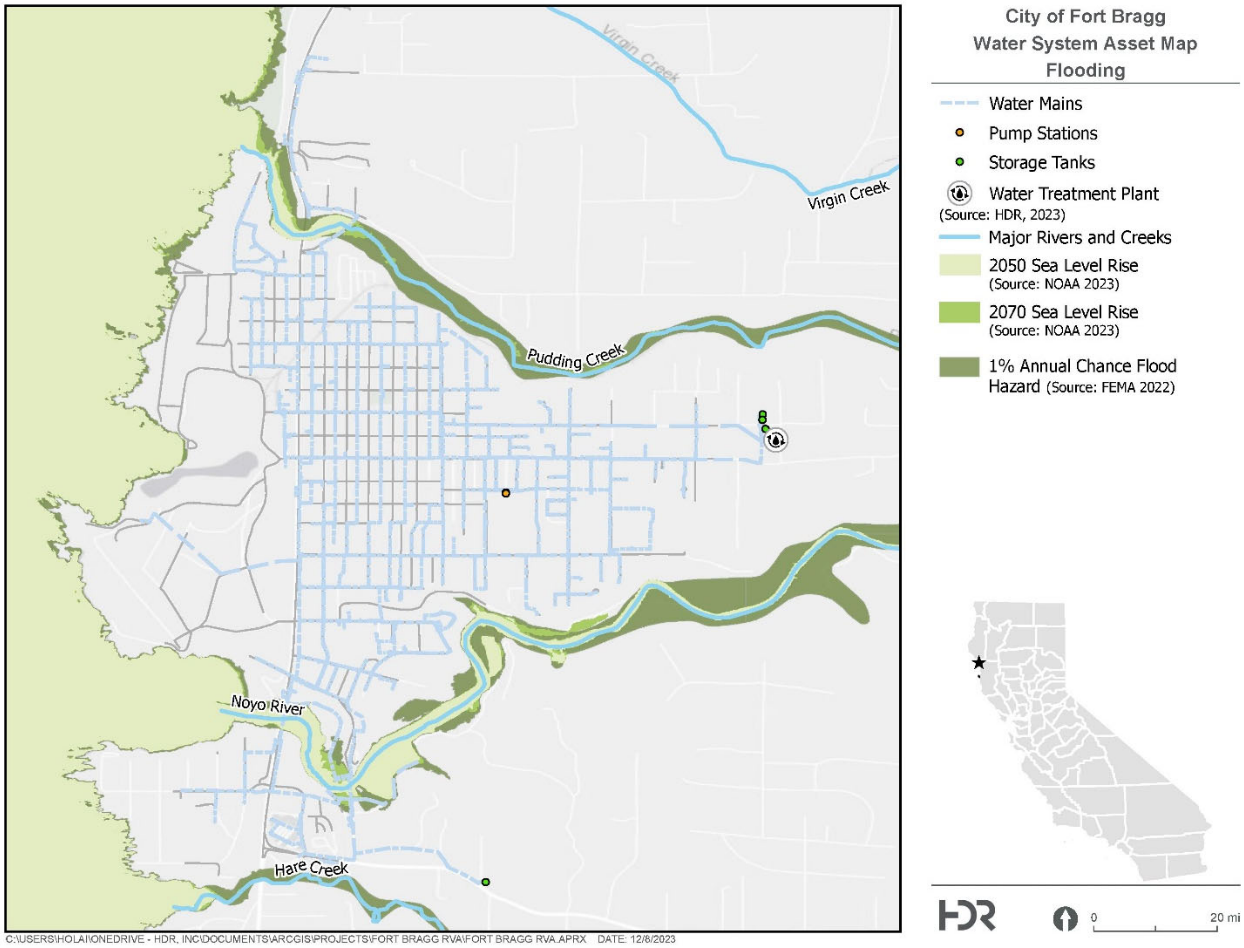

Figure 28 – Water Distribution Assets Map and Flooding Risk
(Source: HDR GIS based on Fort Bragg database; NOAA 2023; FEMA 2022)

Figure 29 below illustrates the relationship between Water System assets and coastal erosion.

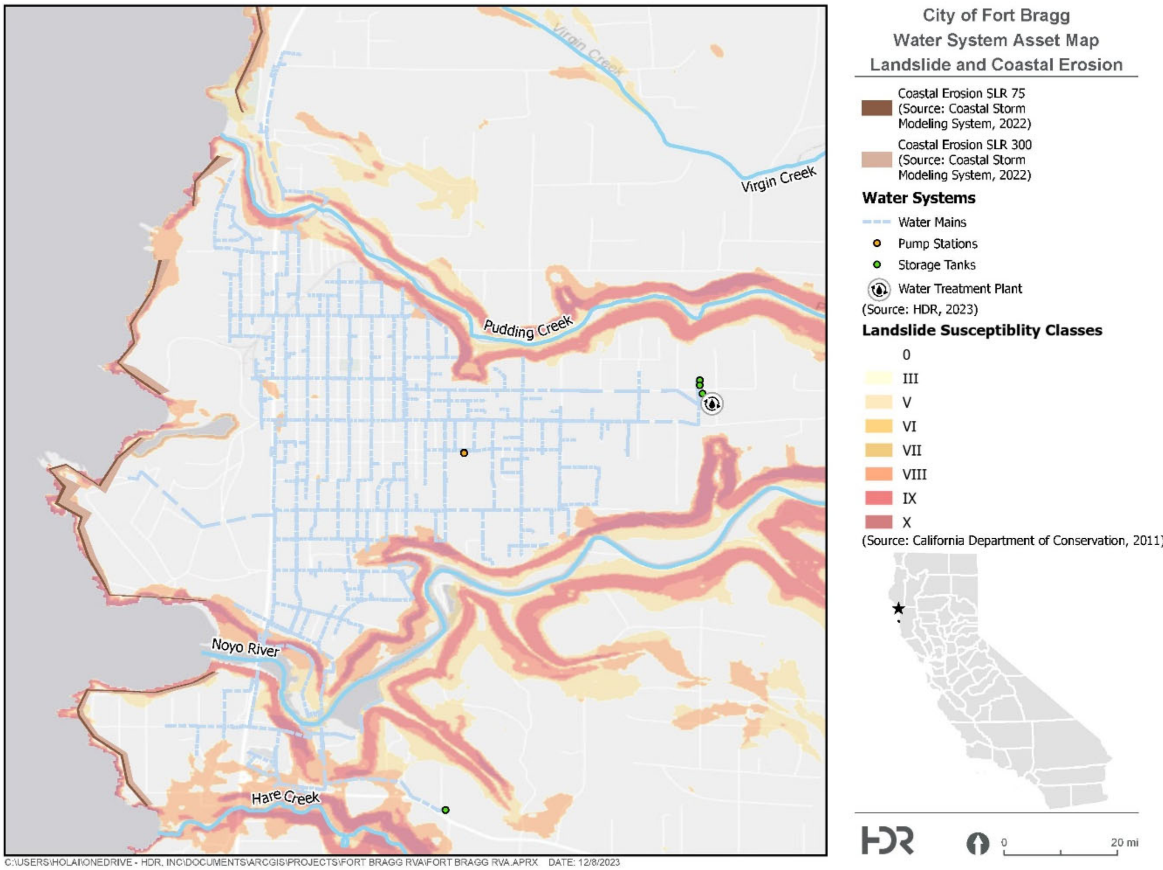

Figure 29 – Water Distribution Assets Map and Erosion and Landslide Risk
(Source: HDR GIS based of Fort Bragg database; CA Department of Conservation 2011; CoSMoS 2022)

Figure 30 illustrates the relationship between Water System assets and wildfires.

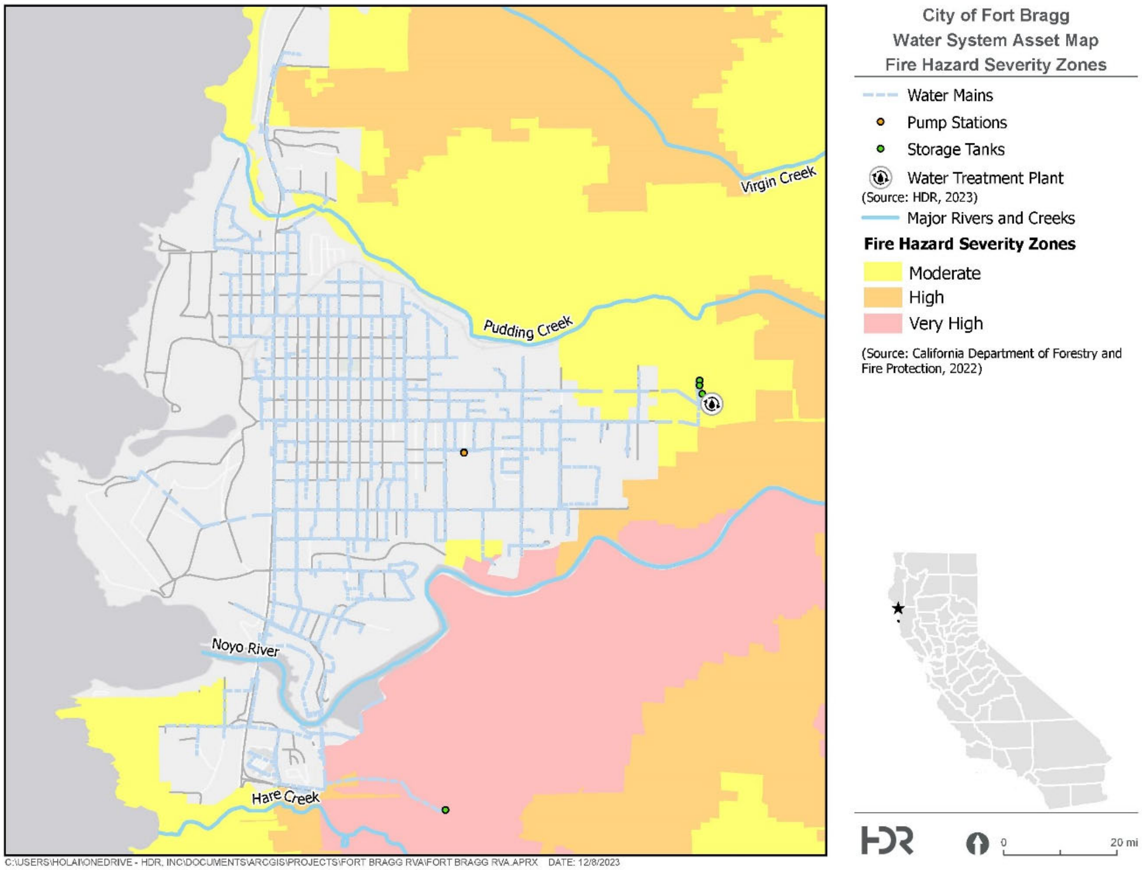

Figure 30 – Water Distribution Assets Map and Fire Risk
(Source: HDR GIS based on Fort Bragg database; CA Department of Forestry 2022)

- ***Water Mains*** – Water mains crossing the Noyo River are vulnerable to bank and channel erosion. The water system does loop, so if one main is taken offline, the other can still provide water south of Noyo River. Several mains, particularly along the Noyo River and Pudding Creek banks, are vulnerable to landslides. Landslides are likely to damage pipes resulting in the need for repairs and disinfection of the water distribution system. Mains within steeper slopes near SR 20 are also susceptible to landslides.
- ***Water Pump Stations: This*** facility is not at risk, as informed by current available information.
- ***Storage Tanks:*** The storage tank located at Fort Bragg Fire Station 2 is at risk of wildfire as it is located well within the Severe Fire Hazard Zone. The three storage facilities located at the Water Treatment Plant were also identified as being at risk of wildfire, but at a lower likelihood. Dense woodlands extend close to the plant, but there are a few neighborhood blocks between the Storage Tanks and the dense forest which contain a few buildings and urban trees. Storage tank material and coatings, as well as

proximity to and height of adjacent fuel, should be further investigated for all storage tanks.

3.3.3 Key findings

The Water System assets most at risk (Table 2) are the water mains across and adjacent to the Noyo River as well as the Pump Station within the Noyo Harbor District.

Table 2 – Assets Prioritization

		Vulnerability	
		Lower (Low & Medium)	Higher
Risk	Higher	Water Mains crossing Noyo River Water Mains adajacent to Noyo River	Storage Tank near Ft. Bragg Fire Station 2
	Lower		Storage Tank near Water Treatment Plant

4.0 Recommendations

This report considers phased adaptation as recommended in the California Sea Level Rise Guidance for Critical Infrastructure[7].

4.1 Regional Recommendations

- ***Transportation***: Bridges are at risk of flooding. It is recommended to have a better understanding of risk by developing further the climate risk for SLR and work in partnership with Caltrans and the community to assess implementable resiliency measures.
- ***Energy Systems***: Transmission lines exposed to wildfire and could impact operations of water pump(s) for the water distribution system.
- ***Water***: The Water Treatment Plant is at the edge of wildfire susceptibility.
- ***Critical Infrastructure***: Fire Station #2 is vulnerable to wildfire, and this could impact response in protecting the Water System assets.

4.2 Water Distribution System Recommendations

- ***Pump Station***: No identified risks within existing location. To be reassessed if location is changed.
- ***Mains***: Landslides along creek banks.
- ***Storage Tanks***: Vulnerable to wildfire

4.3 Next Steps / Further Studies

- Evaluation of land subsidence, particularly as it relates to decreasing soil moisture as a product of droughts.
- Wildfire assessment for Water Treatment Plant and Fire Station #2.
- Forecast salinity study at intake points at the Noyo River, Waterfall Gulch, and Newman Gulch.

While the scope of this project is focused on the Water Distribution System, we would like to highlight that the project is part of an interconnected and interdependent system of infrastructure, economics, community, ecology, and hydrology that must perform and adapt to sustainably serve Fort Bragg. Some systems are more critical than others and some systems have adaptive capacity in the sense that they, and the residents they serve, could be relocated.

[7] https://documents.coastal.ca.gov/assets/slr/SLR%20Guidance_Critical%20Infrastructure_12.6.2021.pdf

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Appendix D. Software Selection Technical Memorandum

Hydraulic Model Software Selection Technical Memorandum

Ft. Bragg Distribution System Master Plan

City of Fort Bragg

July 26, 2023

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1.0 Introduction

HDR is in the process of developing a Water System Master Plan for the City of Fort Bragg (City), which includes the development of a water system hydraulic model.

The City currently uses WaterCAD/WaterGEMS (developed by Bentley) as their water system modeling software. The model was developed by and is maintained by KASL Engineering. The City does not currently own a WaterCAD software license. It should be noted that WaterGEMS is a superset of WaterCAD and contains all of the features of WaterCAD in addition to other modeling features and the ability to run in the ESRI GIS environment. For the purposes of this Technical Memorandum (TM), WaterGEMS will be used to indicate either software platform.

HDR conducted a review of the City's existing WaterGEMS model and has the following observations:

- The model does not match the City's existing GIS or CAD data
- The model only contains steady state scenarios, limiting the ability to perform operational analysis and water quality simulations.
- The Water Treatment Plant is modeled as a "boundary node" reservoir, meaning it will provide an infinite amount of supply to the distribution system. This was common modeling practice historically, however, advancements in modeling algorithms and run times allow us to model treatment plants with storage tanks and pump stations similar to how these facilities actually operate in the field.

HDR is in the process of developing a GIS database of the water system through conversion of the City's existing CAD water system map. The new GIS database will include ESRI's new Utility Network and will have full network functionality. In addition, the new GIS database will contain the most up to date and spatially accurate data set. It will be more efficient to develop a new model based on the updated GIS data than to try to update the existing model. For this reason, HDR is recommending a new model build as part of the master plan project. As this will be a new model build, as opposed to a model update, this presents the City with an opportunity to evaluate commercially available water modeling software for use on this project.

The purpose of this TM will be to develop evaluation criteria and provide a recommended modeling software for the project and the City's use in the future.

1.1 Methodology

HDR has formulated evaluation criteria for determining hydraulic modeling software suitability. Our criteria focuses on functionality that best satisfies the needs of the City for the Water System Master Plan, as well as future analysis and studies. This recommendation will be based on the following:

- Ease of use (i.e. user-friendly)
- Technical accuracy
- Primary use of the model

- Cost of the software
- Ease of future modeling updates
- GIS compatibility
- Results/report generation
- Availability and quality of technical support

2.0 Discussion of Alternatives

The water hydraulic modeling software programs being considered as part of this evaluation are listed in Table 1.

Today's commercially available water modeling applications come in two varieties; those that use the Kentucky Pipe (KYPIPE) algorithm; and those that use the EPANET algorithm. Each algorithm is widely used and universally accepted as accurate in the water modeling industry. The two leading commercially available software manufacturers, Bentley (formerly Haestad Methods and Autodesk (formerly Innovyze) both use the EPANET algorithm. The advantage of the EPANET algorithm is its highly advanced water quality simulation capabilities. Recognizing the difficulty to use, update and modify models through KYPIPE combined with its complex interface with GIS data, eliminated KYPIPE from consideration and therefore is not included as an alternative listed in Table 1.

Table 1 – Water Modeling Software

Model	Distributed By
EPANET	U.S. Environmental Protection Agency
InfoWater	Autodesk/Innovyze
InfoWater Pro	Autodesk/Innovyze
WaterGEMS	Bentley/Haestad Methods

Each of the software listed in Table 1 was evaluated based upon the criteria discussed above, with the leading consideration for the City being compatibility with the GIS database. A spreadsheet outlining the details of each software application is attached as Table 2. The evaluation includes pricing and software annual maintenance based on a 5,000 link version. Bentley prices their software according to the number of links required. They sell 250, 1,000, 2,000, 5,000, 10,000 and unlimited link versions at varying price points. Our preliminary estimates indicate that a 5,000 link version will be adequate to model City's water distribution system, as the City's GIS database contains approximately 3,000 links.

3.0 Summary of Analysis

Each of the software applications listed in Table 1 was evaluated in the comparison matrix presented in Table 3 (attached). The comparison matrix defined the following criterion and weighting factors:

- Ease of Use (15%)
- Technical Accuracy (5%)
- Cost (15%)
- Ease of Updates (20%)
- GIS Compatibility (30%)
- Results and Report Generation (15%)

Since all of the models being considered use the same hydraulic engine, the weighting factor of the Technical Accuracy criteria has been reduced to 5%, as all models are assumed to be equally accurate.

This leaves either the Bentley product or the Autodesk family of products. The City currently maintains their water system mapping in AutoCAD format, however, HDR is converting the CAD files to a GIS database as part of the Master Plan project. GIS integration for not only the model build, but for future update and maintenance is a key factor when recommending a software platform for the City.

This narrows the selection down to either WaterGEMS or InfoWater /InfoWater Pro. Info Water runs within the ESRI ArcGIS Desktop environment, while InfoWater Pro runs in the ESRI ArcGIS Pro environment. It is important to note that ESRI plans to retire AcGIS Desktop in March 2026. InfoWater and InfoWater Pro use the same modeling database and contain the same features. For the purposes of this evaluation, only InfoWater Pro is being considered.

A few years ago, the biggest distinguisher between WaterCAD and InfoWater was that WaterCAD used the KYPIPE algorithm, which at the time did not support water quality analysis, and InfoWater used the EPANET algorithm. Today, both software applications use the EPANET algorithm, and both solve water quality hydraulic simulations. The models will yield similar hydraulic results, so the choice between models comes down to price, technical support and features.

A 5,000-pipe version of WaterCAD with AutoCAD support costs $8,785 for a 12-month subscription. InfoWater Pro is only available in an unlimited link version and is $13,425 annually and the pricing can be locked in for a period of 3 years at a time.

We have worked extensively with both WaterGEMS and InfoWater Pro and based upon our experience, when using heavy GIS integration, the InfoWater Pro platform is superior, as the modeling database uses an open architecture database that can be accessed outside of the software platform. The WaterGEMS platform uses a proprietary database that presents challenges when trying to perform advanced data manipulation and GIS integration. Additionally, the WaterGEMS software typically is one version behind in ArcGIS Pro compatibility (currently, they only support ArcGIS Pro 2.9), while InfoWater Pro is typically compatible with the current ArcGIS Pro version (they currently support the latest ArcGIS Pro 3.1 release).

EPANET is listed as an option in Table 1 and presents a low cost alternative to the City for running simple hydraulic analyses. There are limited features in EPANET that make scenario management difficult, but as mentioned previously, all EPANET models will yield similar results.

4.0 Recommendation

Based on the results of our criteria evaluation and our extensive experience with water modeling software, we are recommending InfoWater Pro as the modeling software for the Master Plan. EPANET files can be provided to the City for "in-house" hydraulic analysis in the future. The final scoring matrix is shown in Table 2.

Table 2- Water Hydraulic Model Evaluation Matrix

Software	Evaluation Criteria Weighting Factor						Total Score
	Ease of Use 15%	Technical Accuracy 10%	Cost 15%	Ease of Updates 20%	GIS Compatibility 30%	Results and Report Generation 10%	
EPANET	4	5	5	1	1	1	2.3
InfoWater[1]	5	5	2	5	5	5	4.6
InfoWater Pro	5	5	2	5	5	5	4.6
WaterGEMS	4	5	3	2	3	5	3.4

[1]InfoWater is not preferred due to discontinuation of ArcGIS Desktop in March 2026

Appendix E. Risk Assessment Factors

Risk Assessment Technical Memorandum

Fort Bragg – Water Distribution Master Plan

May 23, 2025

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Contents

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1 Introduction

1.1 Purpose and Objectives

Risk analysis is an asset management technique used to help prioritize decision-making for maintaining infrastructure. From an asset management perspective, the goal of a utility is to provide the level of service that its customers and stakeholders expect at the 'lowest cost of asset ownership'. 'Cost of asset ownership' includes not only those costs that impact the utility's direct expenditures, but also external social and economic costs to the community such as traffic disruption or environmental impacts etc. so the 'lowest cost of asset ownership' may be better described as the appropriate investment in infrastructure that provides the expected level of services for the 'smallest impact on the community'.

There are many types of risks to consider when assessing the possible failures of a water distribution system to provide the expected levels of service. Risk management drives decisions regarding expansions, improvements, and new facilities such as risk of not meeting growth in demand, risk of failing to comply with regulatory guidelines as well as risks related to maintaining and replacing aging infrastructure. Many of these risks were assessed in other sections of the Master Plan. Ultimately risk and the perception of risk drive all asset decision making, including decisions regarding preventive maintenance, repair, and replacement of assets to avoid the risk of unexpected failure.

So how do we compare these risks to one another? A successful utility will define a practical framework. Risk is evaluated in asset management by developing a numerical risk score for each asset. The risk score provides a numerical ranking that is calculated by evaluating a set of risk factors for all assets. The risk score is a relative value, meaning that it compares the assets to each by assigning numerical scores for each of the factors. The risk score is not an objective score, meaning that there is no specific value that determines how quickly an asset is going to fail. The risk model generates a risk score for every asset and is composed of two main components:

- Consequence of Failure (CoF) – factors that describe the impact to the District and community if the asset fails
- Likelihood of Failure (LoF) – factors that determine the condition of the asset and how soon the asset may fail

Some assets that have a high consequence of failure are termed "critical" assets. These are assets that will have a significant impact on the level of service if they fail. A utility may focus on these assets and be willing to invest more to monitor the condition of these assets or to maintain contingency plans and proactively replace these assets to reduce their likelihood of failure. On the other hand, many assets may be less critical and will not have a signifianct impact on the level of service if they fail. These assets may be fixed or replaced as time allows. The City may consider simply monitoring or using some of these assets until failure.

This Technical Memorandum (TM) documents the methodology and analysis used for calculating risk scores for each of the City's water distribution mains. It describes likelihood of failure and consequence of failure factors and weights, and summarizes data sources, assumptions, dependencies, and risk assessment outcomes.

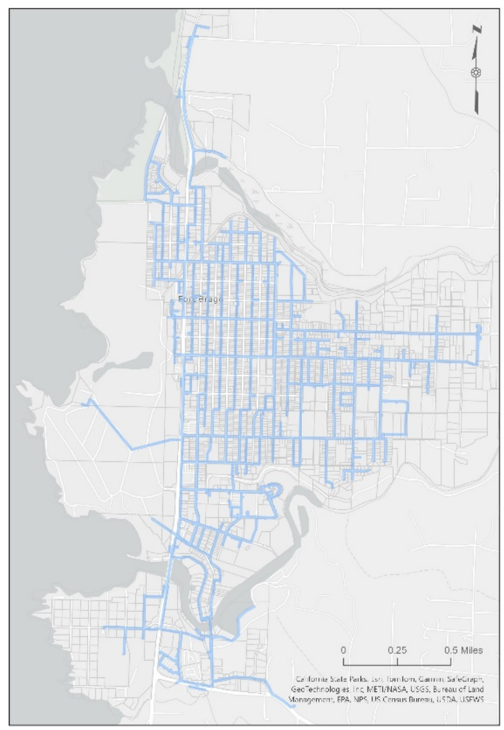
1.2 Organization

This report is organized into the following sections:

- **Section 1: Introduction**
- **Section 2: Project Background**
- **Section 3: Risk Assessment Framework**
- **Section 4: Summary of Findings and Recommendations**

1.3 System Description

Figure 1 – System Map



City of Fort Bragg (City) owns and operates a water distribution system including 41 miles of distribution pipes that provide potable water to 7,000 residents through 3,000 service connections (2,700 residential and 300 commercial/industrial). Although the City owns and maintains both water tanks and mains, this risk assessment pertains only to water mains.

Prior to starting work on this assessment, the City identified a few key concerns:

- **Aging Infrastructure:** Water Mains may be approaching the end of their expected useful lives.
- **Seismic Risk**: Fort Bragg is in a seismically active area with higher probabilities of water infrastructure failure near the Pudding Creek and Noyo River bridges.
- **Shallow Pipes**: Shallow pipes may be prone to damage from heavy use on the surface above.
- **Mains on Private Property**: Water mains crossing private can be difficult to access and maintain.

2 Risk Assessment Framework

A risk model was developed for the treated water pipelines in the distribution system. Because there is only one pump station and very few other major assets in the system, only pipelines were included. The model calculates a LoF score, CoF Score and a Total Risk Score for each pipe. The CoF and LoF scores for a water main are first multiplied by a relative group weight, then added together to calculate the main's Total Risk Score. The LoF score is often weighed higher than CoF to bias high risk mains towards those with a high likelihood of failure. This is because rehabilitation actions typically change the LoF calculation much more than the CoF calculation and therefore the weighting makes it easier to identify assets that will benefit the most from rehabilitation and to measure the overall risk reduction results.

The relative weights of Likelihood of Failure and Consequence of Failure are defined in Table 1 below.

Table 1. Total Risk – LOF and COF Weighting

Factor	Weighting Factor (%)
Likelihood of Failure	60
Consequence of Failure	40

2.1 Risk Factors

To develop the risk model, potential risk factors were identified based on the City's level of service objectives and common water distribution failure factors. This initial list, along with factor weightings, was refined through two virtual workshops on August 15th 2023 and September 20th 2023.

Each of the risk factors was assigned a weighting factor to reflect the relative importance compared to the other factors. Development of the weightings for each factor was completed using a pair-wise comparison analysis. This analysis compared each pair of criteria within each of the categories and assigned points based on a 1 to 3 scale. When considering each pair of factors the considered to be more important will receive a higher score (e.g. a 3). The less important factor will receive a 1. If the factors are considered equal they will both receive a score of 2. The points received for each factor were then summed and the percent of the grand total of points was calculated for each. The total weighting will equal 100 percent each for the LoF and CoF factors.

2.2 LOF Factors and Weights

Six criteria were established to evaluate likelihood of failure. These are listed along with their descriptions, and relevant data sources in Table 2 below.

Table 2. Likelihood of Failure Factors, Data Sources, and Weights

No.	Factor	Data	Data Source(s)	Weight (%)
1	Remaining Service Life	Pipe Material	Fort Bragg UN	22
		Approximate Install Date	1986 Water System Master Plan City of Fort Bragg Water System Comprehensive Engineering Study Dec 1974	

No.	Factor	Data	Data Source(s)	Weight (%)
2	Taps per 10ft	Number of Taps	Fort Bragg UN	13
		Pipe Length	Fort Bragg UN	
3	Seismic Risk	River Crossings	Fort Bragg UN/ ESRI Maps/ City Information	10
		High Risk Landslide Susceptibility	California Geological Survey – Susceptibility to Deep-Seated Landslides (May 2011)	
4	Pipe Depth	Known Shallow Pipe	Operations Staff Experience	13
5	Break History	Break History	2023_05_18_Main Breaks Google Earth.xls	25
6	Groundwater Fluctuations	Known Groundwater Fluctuation	Operations Staff Experience	17

- **Remaining Service Life -** Pipes that are approaching or are past their estimated service life, may be more likely to fail and will receive an elevated LoF score. It should be noted that approximate remaining useful life is not always a reliable indicator of pipe condition. Pipes may fail much sooner or later than their estimated useful life based on other conditions.
- **Taps per 10 ft** – Pipes with greater numbers of lateral connections have more potential failure points and will be assigned a higher LoF score.
- **Seismic Risk** – Some pipes like bridge crossings or pipes in known landslide zones are more likely to be impacted by seismic activity will receive a higher LoF Score.
- **Pipe Depth** – Shallow pipes are more susceptible to damage from surface use and will receive an elevated LoF score.
- **Break History** – Pipes with a known break history may indicate poor overall condition will receive an elevated LoF score.
- **Groundwater Fluctuations** – Pipes in locations with known groundwater fluctuation may experience more stress from ground movement and will receive an elevated LoF score.

Appendix A lists the score tables for each factor.

2.3 COF Factors

Six criteria were selected to evaluate the consequences of failure, including the following. These are listed along with their descriptions, and relevant data sources in Table 3 below.

Table 3. Consequence of Failure Factors Data Sources and Weights

<table>
<tr><th>No.</th><th>Factor</th><th>Data</th><th>Data Source(s)</th><th>Weight (%)</th></tr>
<tr><td>1</td><td>Critical Customers</td><td>Critical Customers</td><td>Fort Bragg UN/ ESRI Maps/ City Information</td><td>25%</td></tr>
<tr><td>2</td><td>Hydraulic Risk Score</td><td>Hydraulic Risk Score</td><td>Fort Bragg Hydraulic Model</td><td>22%</td></tr>
<tr><td>3</td><td>Damage from Break</td><td>Pipe Material</td><td>Fort Bragg UN</td><td>17%</td></tr>
<tr><td>4</td><td>Land Use and Zoning</td><td>Zoning</td><td>Fort Bragg UN</td><td>17%</td></tr>
<tr><td>5</td><td>Repair Difficulty</td><td>Pipes within Easements</td><td>Fort Bragg UN/ City Information</td><td>12%</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Geotechnical Risk</td><td>Flood Zone</td><td>Special Flood Hazard Area FEMA.gov</td><td rowspan="2">8%</td></tr>
<tr><td>Fire Risk</td><td>Cal Fire Severity Zones (April 1, 2024)</td></tr>
</table>

- **Critical Customers -** Pipes that supply water to essential services like hospitals, emergency services, and schools may face operational disruptions from pipe failure and will receive a higher CoF score.
- **Hydraulic Risk Score -** Pipes that convey more flow or provide flow to densely populated areas will receive a higher CoF score. These pipes can lead to significant water loss in the event of a failure and may have broader impact compared to other pipes. To calculate the hydraulic risk score, the model was used to isolate or remove each pipe from the system to measure these hydraulic impacts. One pipe was removed at a time to determine in impact on the system and the availability of water to customers.
- **Break Damage -** In the event of a break: PE, PVC, AC, and DIP pipes are known to break more catastrophically and may cause more damage to surrounding ground and infrastructure than other material types. These pipes will receive a higher CoF score.
- **Land Use & Zoning -** While Critical Customers identify specific entities requiring uninterrupted water supply, Land Use and Zoning focuses on geographic areas designated for specific types of development where the impact of water pipe failure can impact a broad range of activities and functions. Commercial and Industrial zones, for example, depend on water for operations and may suffer financial losses from a loss of service. Land Use zones that may face more of an impact from water main failure will receive a higher CoF score.
- **Repair Difficulty -** Water mains crossing private properties are more difficult to repair and maintain and should be prioritized for preventive maintenance or prioritized for relocation. These pipes will receive a higher CoF score.
- **Geotechnical Risk** - Pipes within a FEMA Special Flood Hazard Area may pose higher impact to nearby infrastructure and will receive a higher CoF score. Pipes within a moderate to very high fire risk zone should be prioritized to be able to function adequately in the event of a wild fire and will receive an elevated risk score.

Appendix A lists the score tables for each risk factor.

2.4 Data Preparation

To accurately score the criteria listed above, some data processing was required. Data preparation processes are detailed below.

2.4.1 Consequence of Failure

- **Break Damage** – No data processing was required.
- **Critical Customers** – In discussion with the City, HDR identified parcels associated with essential services and vulnerable customers.
- **Land Use & Zoning** – Water mains that intersected land use and zoning parcels were assigned factor scores as defined in Appendix A. If a main line intersected with multiple zones, the higher score was assigned.
- **Hydraulic Risk Score** – The hydraulic risk score was calculated in the Fort Bragg Hydraulic Model to assess the hydraulic impact of pipe failure and used four parameters – percentage of total system demand not supplied, number of critical customers without supply, percentage of critical customers demand not supplied and number of connected low pressure junctions. To evaluate pipe criticality, model inputs included a selection set of all pipes in the system excluding the pipes representing pump station connections. Including these specific pipes would skew the criticality results, so their exclusion ensures a realistic comparison of criticality among the remaining system pipes.
- **Geotechnical Risk** – Water Mains intersecting with either FEMA Flood Boundary Zones or Cal Fire Hazard Moderate or higher Severity Zones were assigned an elevated risk score.
- **Repair Difficulty** – HDR developed an intersect layer of water mains crossing through privately owned parcels. This layer was further refined both internally and in collaboration with the City with the goal of identifying only those mains located within parcels in a way that impedes the City's ability to access them.

2.4.2 Likelihood of Failure

- **Remaining Service Life** – The installation date is unknown for much of the water system. In lieu of this information, HDR digitized system maps from the 1974 Comprehensive Engineering Study and the 1986 Water System Master Plan to estimate the ages of the mains. Pipes found on the 1974 map were assigned an approximate installation year of 1974. Mains found on the 1986 map, which were not already shown on the 1974 map, were assigned an approximate installation year of 1986 Mains installed between 1986 and the current utility network were assigned an approximate Installation Year of 2005 (the median year between then and today). These estimated installation years were used to calculate the remaining service life as a percentage, by subtracting the approximate age from the estimated useful service life of the main based on its material type. Pipes were then assigned scores according to their percentage of remaining service life.
- **Taps per 10 ft** – A 'Junction Count' was included as a water main attribute in the Fort Bragg Utility Network. This junction count represented the number of taps along a main and was normalized to taps per 10 feet based on the pipe length

recorded in the Utility Network. A normal distribution of the resulting taps per 10 feet was analyzed to determine how to score the tap counts in relation to each other.

- **Seismic Risk** – First, the California Department of Conservation's CGS Seismic Hazards Fault Traces map was reviewed to identify mains near active faults. Since there are no faults in close proximity to the City, it was determined that water mains crossing rivers or intersecting with areas with a landslide susceptibility rating of seven or above (on a scale from 0 to 10, low to high) would be assigned an elevated risk score.
- **Pipe Depth** – City staff identified known shallow mains.
- **Break History** –City records were used to identify pipes with a known break history. Mains with a history of breaks were assigned elevated risk scores.
- **Groundwater Fluctuations** - City staff identified mains within areas of known groundwater fluctuation.

3 Summary of Findings and Recommendations

A total of 1,818 active water main segments, approximately 41 miles, were assessed using the risk framework. A risk score was calculated for each pipe based on the formula in Figure 2 and the process described above. The risk scores can potentially range from 0 to 5, with 5 indicating the highest relative risk. In this assessment, risk scores ranged from 0 to 2.7. As discussed earlier, due to limited data on pipe age and condition, these scores represent relative, not absolute, risk. They can help prioritize segments for repair or replacement based on condition or hydraulic needs and can also guide system renewal or further condition assessment. The uses of this risk model are discussed in the next section.

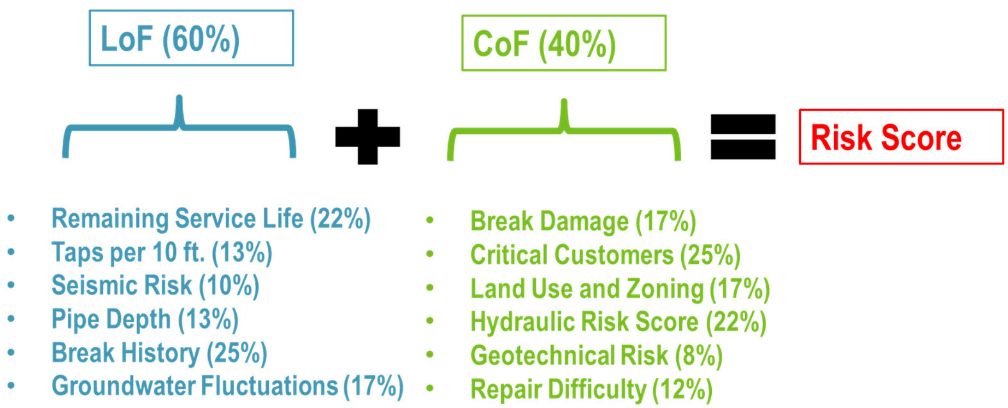


Figure 2 Water Distribution Risk Formula

Based on this analysis, the following conclusions are provided:

- The system has very low relative risk scores. The highest risk score calculated is 2.7 out of 5. Approximately 92 percent of the system has a risk score of 2 or below.
- The system has relatively low LoF scores. The highest calculated score is 3.4 out of 5. Approximately 95% of the system has a risk score of 2 or below
- Biggest drivers of LoF are pipe age, high water table, landslide area and river crossing. Break history also contributes to the top 10 highest risk pipes. Factors affecting LoF are the most likely areas to drive the overall risk down through replacement or renewal of infrastructure. CoF factors will likely remain the same even if an existing pipe is replaced with a new one.
- CoF scores have a big impact on some of the highest risk pipes. CoF scores range from 0.2 to 3.9 out of 5. In the top one mile of the highest risk pipe in the system, about half a mile has a CoF score above 3. This indicates that these pipes will likely be critical even if they are rehabilitated or replaced.

Figure 3 compares the risk scores with the cumulative pipe length for the distribution system. The figure supports the conclusion that there is low relative risk in the system based on the parameters and formulas used in this analysis. The figure shows that there are approximately 3 miles of pipe that have a risk of 2 or higher, and that only 11 miles have a risk of 1.5 or higher.

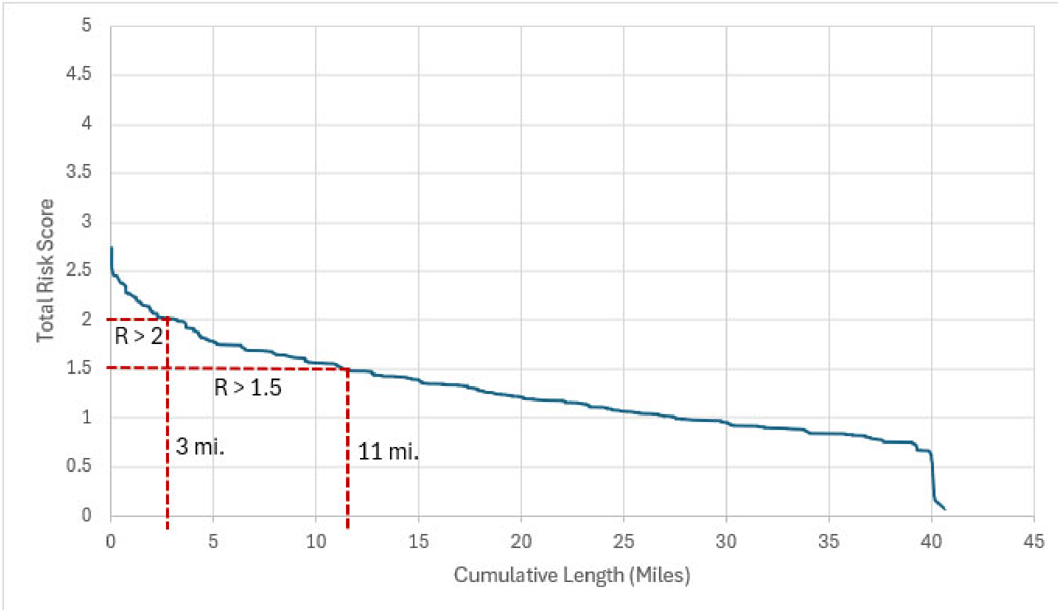
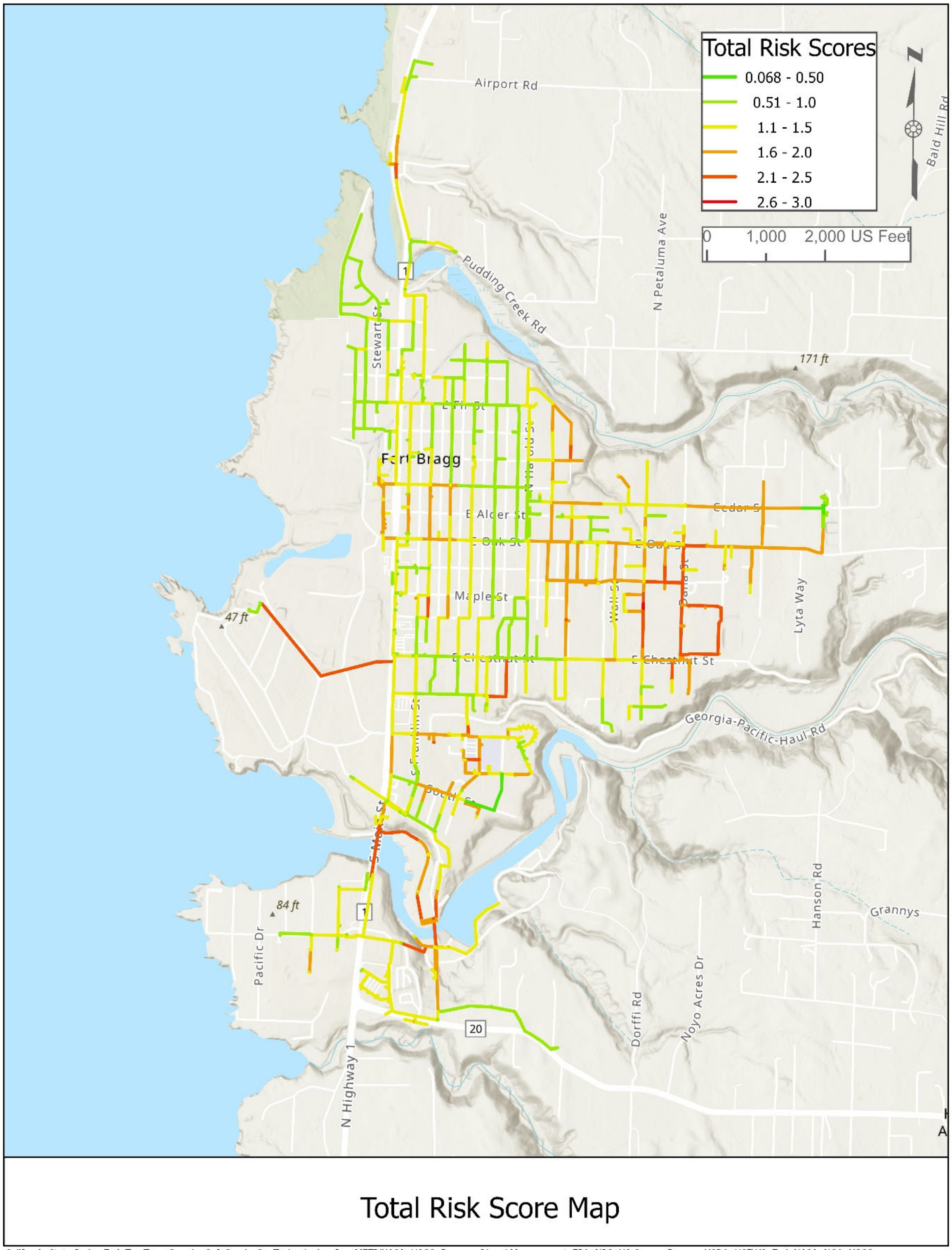


Figure 3 - Cumulative Length Compared to Total Risk

Figure 4 - Total Risk shows the distribution of total risk scores across the water system. High-risk segments are concentrated near the high school, the infrastructure surrounding or crossing the Noyo River, and the Georgia Pacific (GP) Mill build-out site. Medium-risk areas are primarily located near Mendocino Coast Hospital and along or near Cedar and Oak Streets.

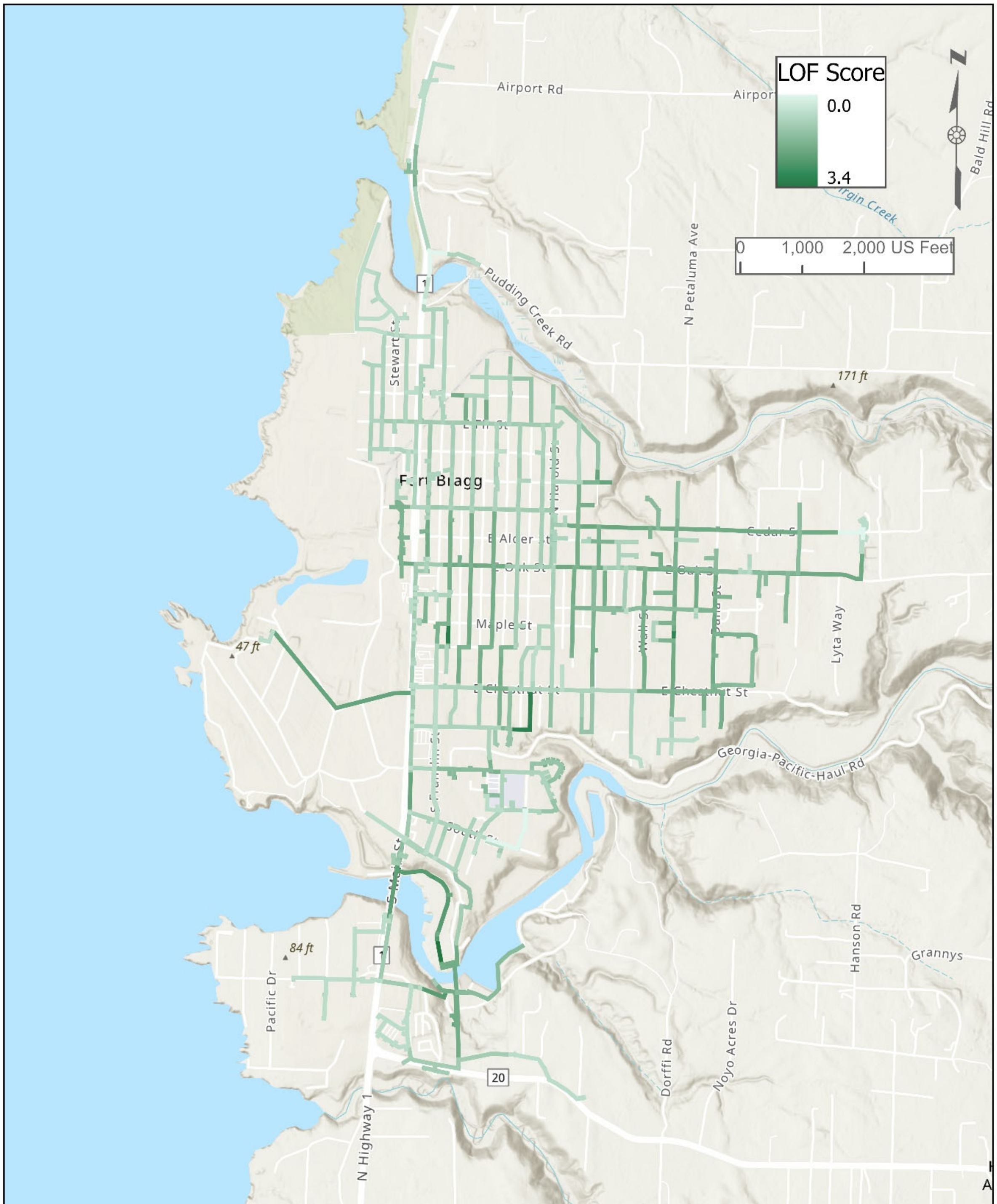
Figure 5. Likelihood of Failure shows the estimated likelihood of failure across the system. Elevated scores are observed near the Noyo River, the GP Mill site, and in scattered areas throughout the system. These higher likelihood areas are largely driven by break history, zones of known landslide risk, groundwater fluctuations, or locations where pipe depth is shallow.

Figure 6. Consequence of Failure shows the consequence of failure for each pipe segment. The highest consequence areas include those near the high school, Mendocino Coast Hospital, and Mendocino College Coast campus, reflecting the more critical nature of infrastructure in these locations compared to the rest of the system based on the defined risk framework.



California State Parks, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, Esri, NASA, NGA, USGS

Figure 4 - Total Risk



Likelihood of Failure (LOF) Map

California State Parks, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, Esri, NASA, NGA, USGS

Figure 5. Likelihood of Failure

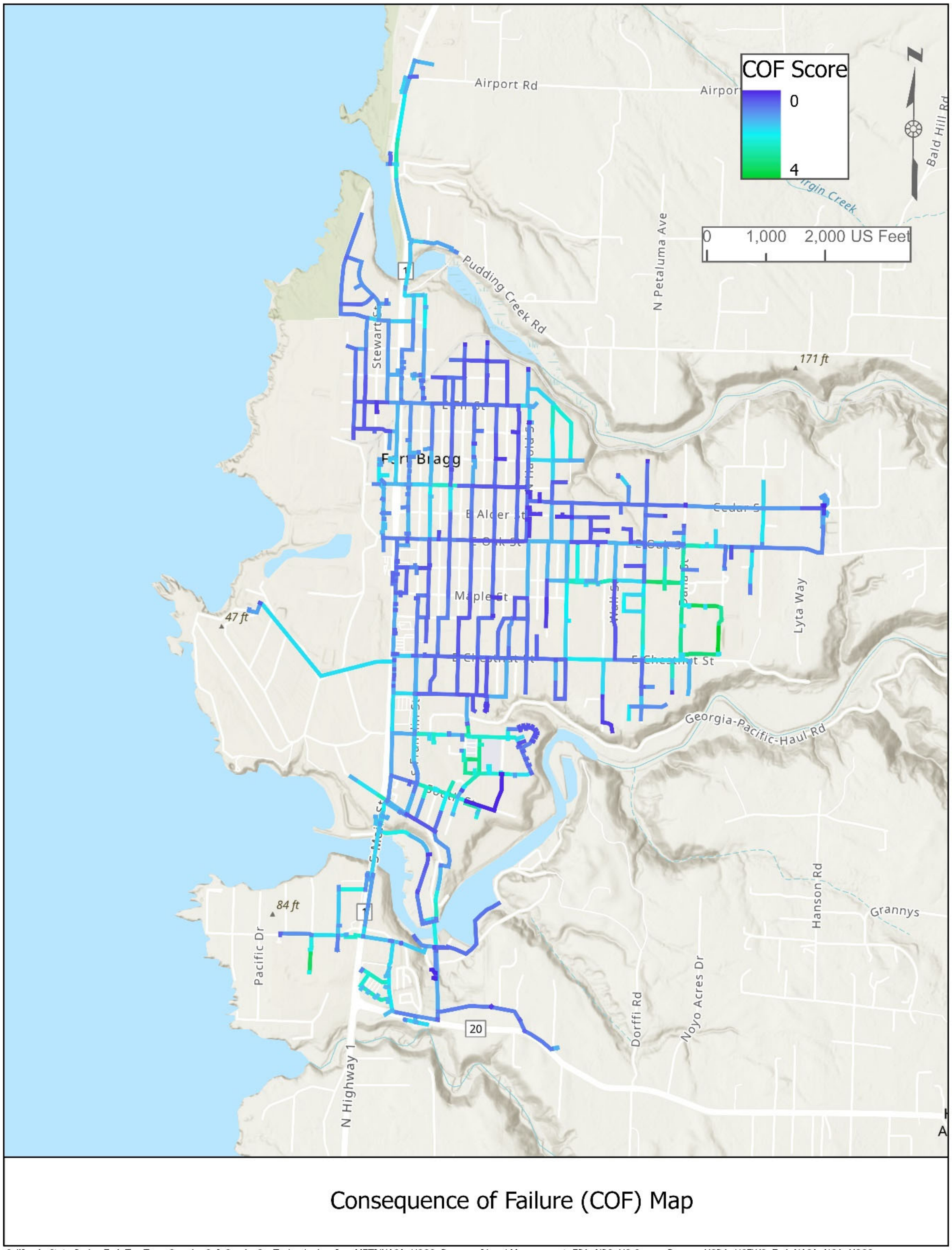


Figure 6. Consequence of Failure

4 Applying the Risk Model

The risk model provides a numerical value that quantitates the risk factors analyzed for the City. It provides a risk score for each of the pipes relative to the other pipes in the system. Because the risk model incorporates factors that the City believes are major risks to the water distribution infrastructure, it can be used as a guide to reduce risk of service failure in the system. The factors used for LoF and CoF represent indirect evidence of the condition and criticality of each of the pipes, however none of the factors used provide direct evidence of pipeline condition. Therefore, the risk model should be used to prioritize assessment and rehabilitation work, however it should not be relied upon as direct evidence that a rehabilitation action is needed. Additional assessment will be needed to determine the true condition and expected useful life of any given asset.

Examples of how the risk model can be used are:

Prioritizing existing capital projects – When two or more projects are proposed (e.g. valve installation, pipeline expansion or enlargement) the risk model can be used to break a tie when other considerations are equal. If all other considerations are equal and one or more project must be delayed, the pipe segment with the lowest risk score can be differed because the risks are comparatively lower.

Prioritizing condition assessment – One of the programs initiated during this master plan is the testing of asbestos cement pipeline walls to determine the residual calcium remaining. This is a good indicator of pipeline condition. The risk model can be used to determine where to sample next. This enables the District to focus on the higher risk pipes and mitigate any issues that will have a high consequence of failure.

Prioritizing maintenance – Frequently maintenance staff must choose between multiple demands on their time. Using the risk model to determine what maintenance activities should be done first enables the City to make risk-based maintenance decisions.

The risk model can also be continually improved as the City collects more data, learns more about the system and implements system changes. Periodically the model should be evaluated against additional information to determine if it should be updated. If there are additional pipeline breaks, it would be useful to look at the risk model to see if the risk results are consistent with the conditions that caused the break. If additional asbestos testing is completed, it can be compared with the model results. As new infrastructure is added or replaced, the model can be updated to accurately reflect current conditions.

Appendix A – Risk Factor Scoring Tables

Consequence of Failure

- Maximum COF score: 5
- Minimum COF score: 0

Break Damage

- Weighting: 17%
- Max score: 3
- Minimum score: 1

Value	Grade
PVC	3
DIP	2
AC, SP, PE, COP, CAS, or Unknown	1

Critical Customers

- Weighting: 25%
- Max score: 5
- Minimum score: 0

Value	Grade
Hospitals & Clinics	5
Schools	4
Pomo Tribal Land, Community Resilience Centers, Senior Living	3
Law Enforcement, Fire Stations, Grocery Stores	2
Public Facilities	1
Other	0

Land Use & Zoning

- Weighting: 17%
- Max score: 5
- Minimum score: 0

Value	Grade
Harbor District, Highway Visitor Commercial, Central Business District	5

Value	Grade
Heavy Industrial, Public Facilities and Services	4
General Commercial, Light Industrial, Neighborhood Commercial, Office Commercial	3
Very High/High Density Residential	2
Other Residential, Timber Resources Industrial	1
Open Space, Parks and Recreation	0

Hydraulic Risk Score

- Weighting: 22%
- Max score: 5
- Minimum score: 0

Value	Grade
20	5
10	3
7	2
5	1
0	0
No Data	0

Geotechnical – Fire & Flooding

- Weighting: 8%
- Max score: 5
- Minimum score: 0

Value	Grade
Flood Risk	5
Fire Risk	4
None	0

Repair Difficulty

- Weighting: 12%
- Max score: 5
- Minimum score: 0

Value	Grade
Located within Private Property	5
Other	0

Likelihood of Failure

- Weighting: 60%
- Max score: 5
- Minimum score: 0

Remaining Service Life

- Weighting: 22%
- Max score: 5
- Minimum score: 0

Value	Grade
< -100%	5
10 to -100%	4
40 to 10%	3
90 to 40%	2
90 to 100%	1

Taps per 10 ft

- Weighting: 13%
- Max score: 5
- Minimum score: 0

Value	Grade
3	5
2	4
1	3
0 to 1	2
0	0

Seismic Risk

- Weighting: 10%
- Max score: 5
- Minimum score: 0

Value	Grade
River Crossings	5

Value	Grade
High Risk Landslide Zone	4
Other	0

Pipe Depth

- Weighting: 13%
- Max score: 5
- Minimum score: 0

Value	Grade
Shallow Pipe	5
Not Shallow/Unknown	0

Break History

- Weighting: 25%
- Max score: 5
- Minimum score: 0

Value	Grade
2 or more	5
1	4
None	0

Groundwater Fluctuations

-

Value	Grade
Known Groundwater Fluctuation	5
No Known Groundwater Fluctuation	0

Appendix F. 10-Year Capital Plan and Preliminary Engineering Reports

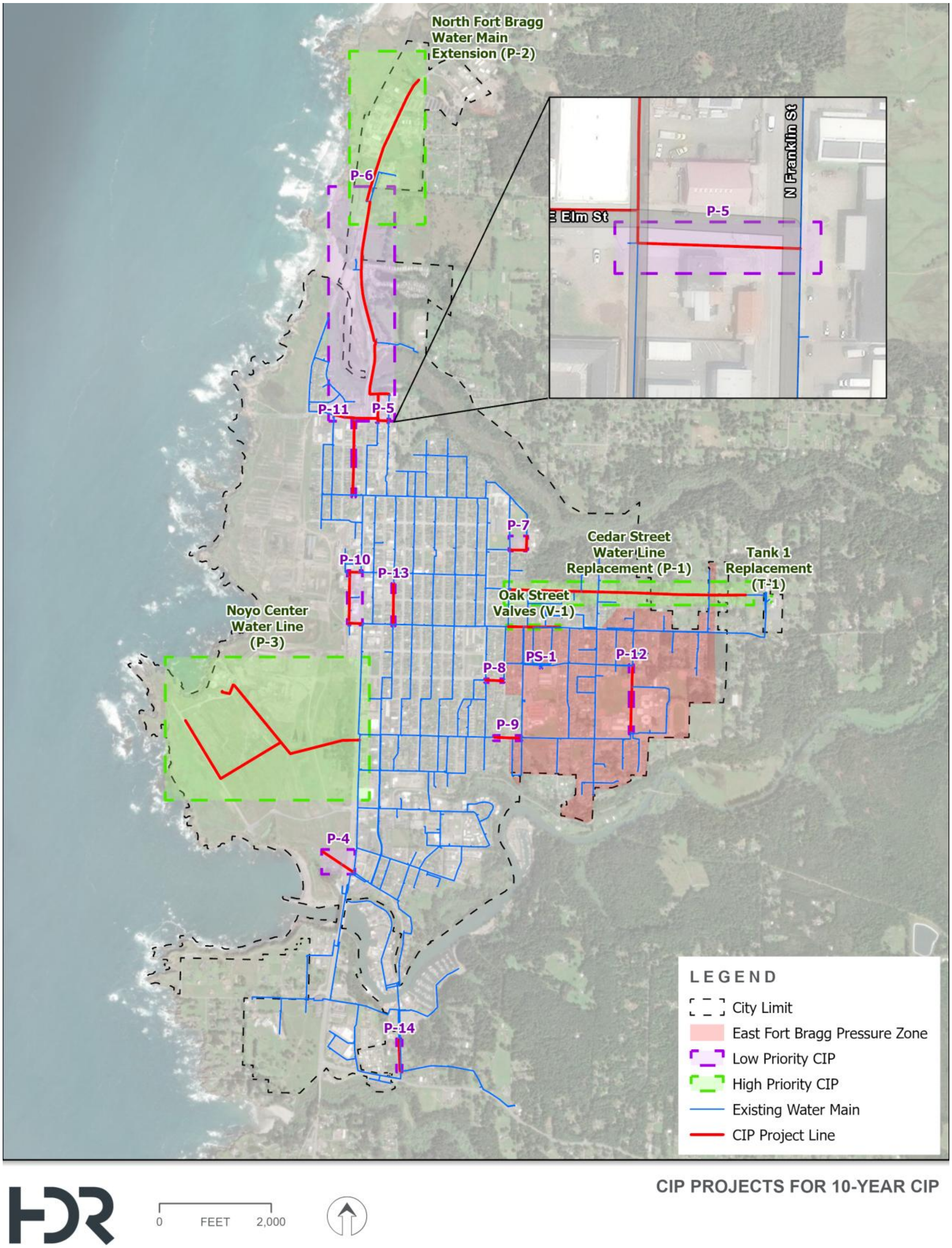
Ten-Year Capital Improvement Plan

Priority Ranking	CIP ID	Project Name	Project Description	Total Pipe Footage (FT)	Time Frame (years)	Risk Score	Category	Escalated Project Cost[a]
1	PS-1	Pump Station Upsize	Upsize Willow Street Pump Station capacity to 2,000 GPM.	-	< 5	-	Capacity or Fire Flow Deficiency	$8,141,000
2	V-1	Oak Street Valves	Addition of two 10-inch isolation valves and one 18-inch isolation valve to water main on Oak Street.	930	< 5	1.746	Operational Improvements	$93,000
3	P-1	Cedar Street Water Line Replacement	Replacement of Cedar Street water main. Increase 53 FT of 6-inch pipe diameter to 16-inch. Increase 4,195 FT of 8-inch pipe diameter to 16-inch.	4,248	< 5	1.646	Capacity or Fire Flow Deficiency	$3,357,000
4	T-1	Tank 1 Upgrade	Replacement of Tank 1 at WTP.	-	< 5	0.988	Asset Renewal	$8,955,000
5	P-2	North Fort Bragg Water Main Extension	North Fort Bragg Water Main Extension. Place new 2,144 FT of 10-inch main.	2,144	< 5	0.98	Capacity or Fire Flow Deficiency	$1,384,000
6	PL-1	System Renewal- Pipe Replacement	Provision for additional projects to meet 1% annual system renewal goal, based on condition.	5,000	< 5	-	Asset Renewal	$2,830,000
7	O-1	Opportunistic Pipe Sampling	Collect and test condition of 3-5 AC pipe samples per year.	-	< 5	-	Other	$69,000
8	O-2	CIP Update	Update capital project list every 5 years	-	< 5	-	Other	$110,000
9	O-3	CMMS Needs Analysis	Evaluate Computer Maintenance Management Software (CMMS) Needs.	-	< 5	-	Other	$39,000
							Next 5 Year Sub-Total	**$24,978,000**
10	P-7	East Laurel Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch.	539	5 to 10	2.194	Capacity or Fire Flow Deficiency	$354,000
11	P-3	Noyo Center Water Line	Noyo Center Water Line Replacement. Upsize 1,500 FT of existing 4-inch main to 12-inch. Place new 2,500 FT of 12-inch main.	4,018	5 to 10	2.018	Capacity or Fire Flow Deficiency	$2,985,000
12	P-6	North Main Street Water Main Replacement	Increase 32 FT of 6-inch pipe diameter to 8-inch. Increase 867 FT of 6-inch pipe diameter to 10-inch. Increase 220 FT of 6-inch pipe diameter to 12-inch. Increase 3,665 FT of 10-inch pipe diameter to 12-inch. Increase 645 FT of 8-inch pipe diameter to 10-inch.	5,429	5 to 10	2.014	Capacity or Fire Flow Deficiency	$4,016,000

Ten-Year Capital Improvement Plan

13	P-13	East Alder Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch.	717	5 to 10	1.784	Capacity or Fire Flow Deficiency	$470,000
14	P-10	Chief Celeri Dr Water Main Replacement	Increase 6-inch pipe diameter to 10-inch.	1,362	5 to 10	1.622	Capacity or Fire Flow Deficiency	$951,000
15	P-4	Noyo Point Road Water Main Replacement	Increase 6-inch pipe diameter to 10-inch.	651	5 to 10	1.416	Capacity or Fire Flow Deficiency	$455,000
16	P-8	Maple Street Water Main Loop	Install new 8-inch pipe.	313	5 to 10	1.34	Capacity or Fire Flow Deficiency	$206,000
17	P-5	East Elm Street Water Main Loop	Install New 12-inch Pipe.	194	5 to 10	1.33	Capacity or Fire Flow Deficiency	$145,000
18	P-9	East Chestnut Street Water Main Replacement	Increase 6-inch pipe diameter to 10-inch.	472	5 to 10	1.182	Capacity or Fire Flow Deficiency	$330,000
19	P-11	Spruce Street Water Main Replacement	Increase 6-inch pipe diameter to 8-inch.	1,330	5 to 10	1.156	Capacity or Fire Flow Deficiency	$873,000
20	PL-2	System Renewal- Pipe Replacement	Provision for additional projects to meet 1% annual system renewal goal, based on condition.	5,000	5 to 10	-	Asset Renewal	$3,280,000
21	O-4	Opportunistic Pipe Sampling	Collect and test condition of 3-5 AC pipe samples per year.	-	5 to 10	-	Other	$80,000
22	O-5	CMMS Acquisition & Implementation	Acquire and implement new CMMS. Only if recommended in O-3 CMMS Needs Assessment.	-	5 to 10	-	Other	$191,000
23	O-6	CIP Update	Update capital project list every 5 years	-	5 to 10	-	Other	$127,000
							5-10 Year Sub-Total	**$14,463,000**
							Total	**$39,441,000**

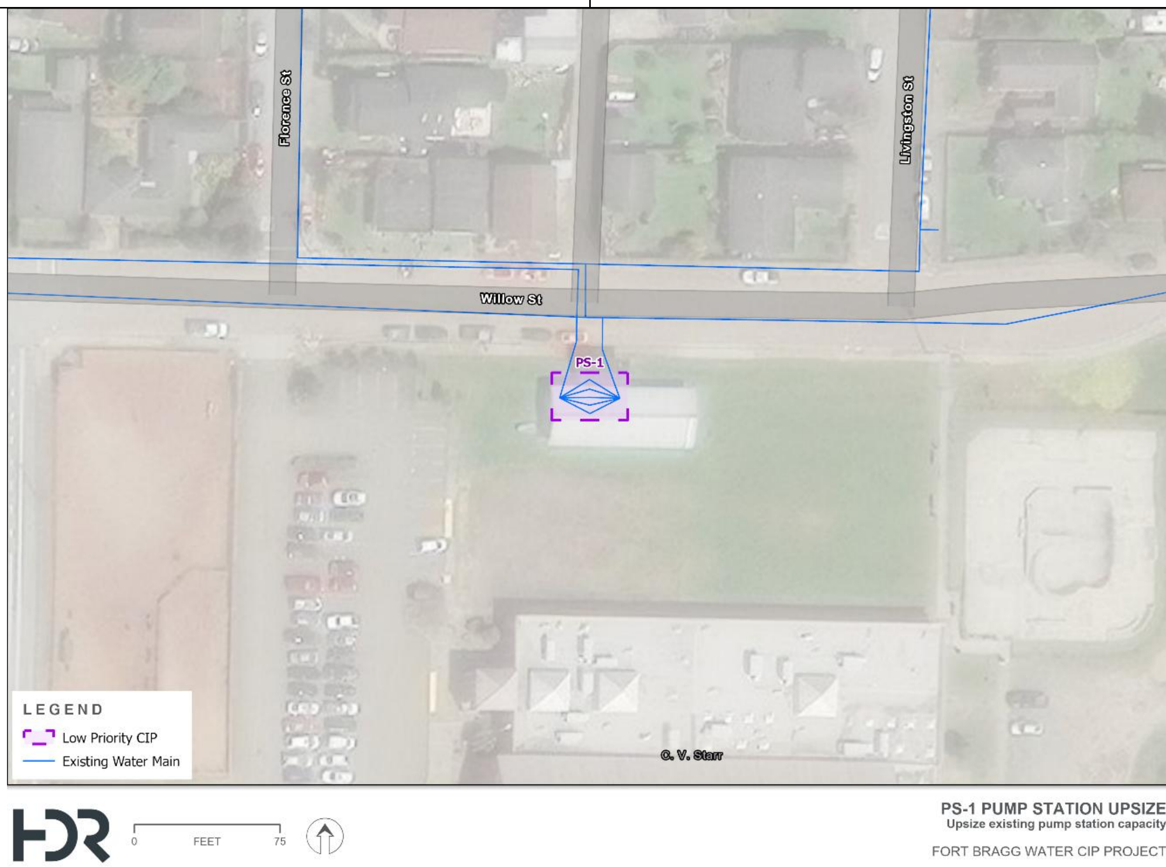
[a]Project Costs Escalated For Inflation



CIP PROJECTS FOR 10-YEAR CIP

Preliminary Engineering Report: PS-1

Improvement Name:	Pump Station Upsize
Project ID:	PS-1
CIP Year:	2030

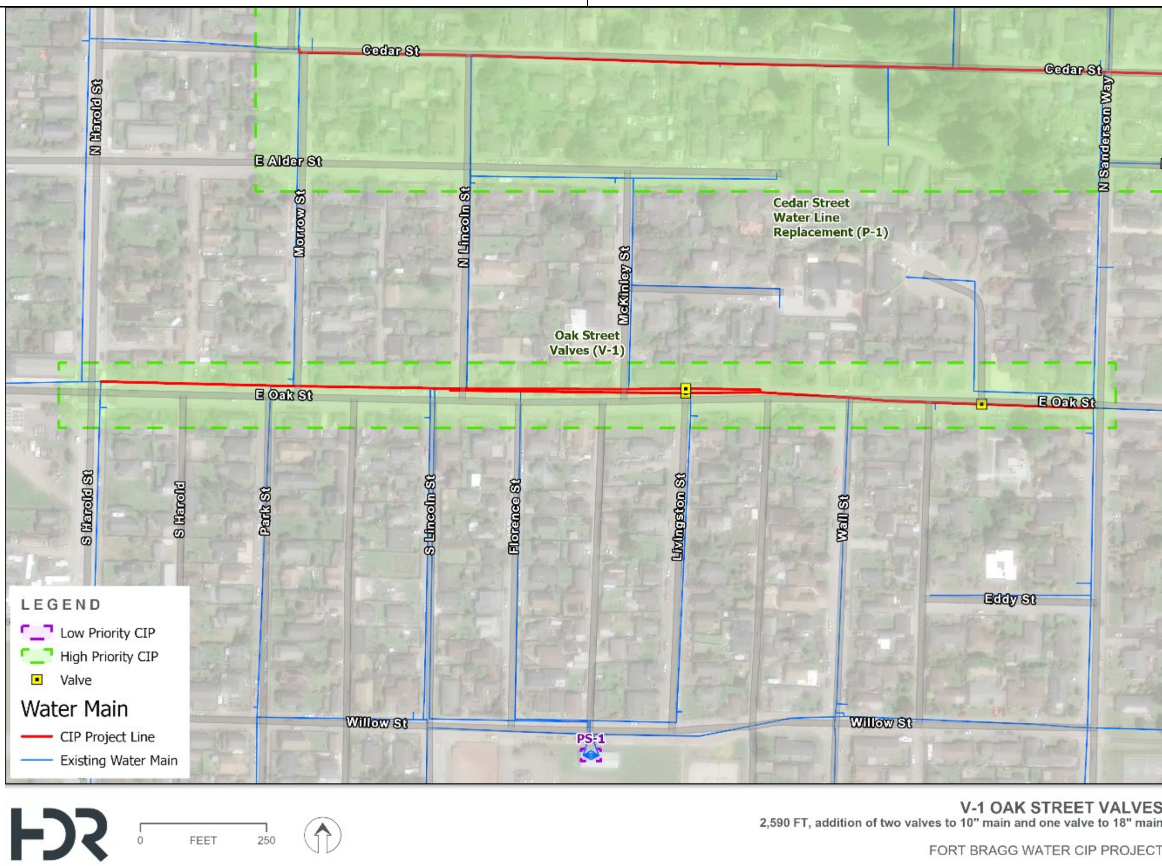


Description:	Increase the capacity of the existing Willow Street Pump Station to meet fire flow requirements of the East Fort Bragg Booster Zone. The pump station is currently undersized to provide the required 2,000 gpm fire flow.
Purpose:	The main purpose of this project is to provide adequate fire flow to the East Fort Bragg Pressure Zone to meet the current fire flow requirement of 2,000 gpm. The existing fire pumps are sized to provide 1,000 gpm.
Hydraulic Model Results	During fire flow conditions, pressures drop below 20 psi at hydrants requiring 2,000 gpm fire flow.
Alternatives Analysis	There are limited alternatives to improving pressure in a “closed”, boosted pressure zone. However, there is always a “no project” alternative that can be considered. The “no project” alternative for PS-1 results in not providing the fire flow requirement during a fire flow demand scenario.

Project Trigger:	The primary driver for PS-1 is mitigating an existing fire flow deficiency at the Willow Street Pump Station.
Expected Environmental Compliance:	This project may qualify as categorically exempt as the increased size is required to meet existing system requirements. However, the increased size may trigger an Initial Study (IS). If the IS identifies no significant impact, the project may adopt a Negative Declaration and proceed with implementation. If the IS identifies significant impacts, but the impacts can be reduced to a less than significant level through mitigation then the project may adopt a Mitigated Negative Declaration (MND) and proceed. Projects with significant impacts that cannot be mitigated to less than significant levels must be evaluated in an Environmental Impact Report (EIR).
OPCC (2025 dollars):	$7,450,000
Funding Opportunities:	Funding would need to be evaluated further. WIFIA funding may be an option, as this project is potentially over the $5 million project minimum. Projects can be combined to reach the minimum project size. Fort Bragg qualifies as a small and rural community based on the USDA's eligibility criteria of providing loans to populations of 10,000 or less and USDA loans may be available at a lower than market interest rate. A cost-benefit analysis should be used to evaluate if a USDA loan would be worth applying for when compared to water revenue bonds. To qualify, Fort Bragg must propose projects that expand services to very small, rural parts of the town. Eligible activities include legal and engineering fees, acquisitions, start-up operations and maintenance, interest incurred during construction, and the purchase of facilities to expand service. Other potential funding sources include EDA Public Works and EPA SRF.

Preliminary Engineering Report: V-1

Improvement Name:	Oak Street Valves
Project ID:	V-1
CIP Year:	2030

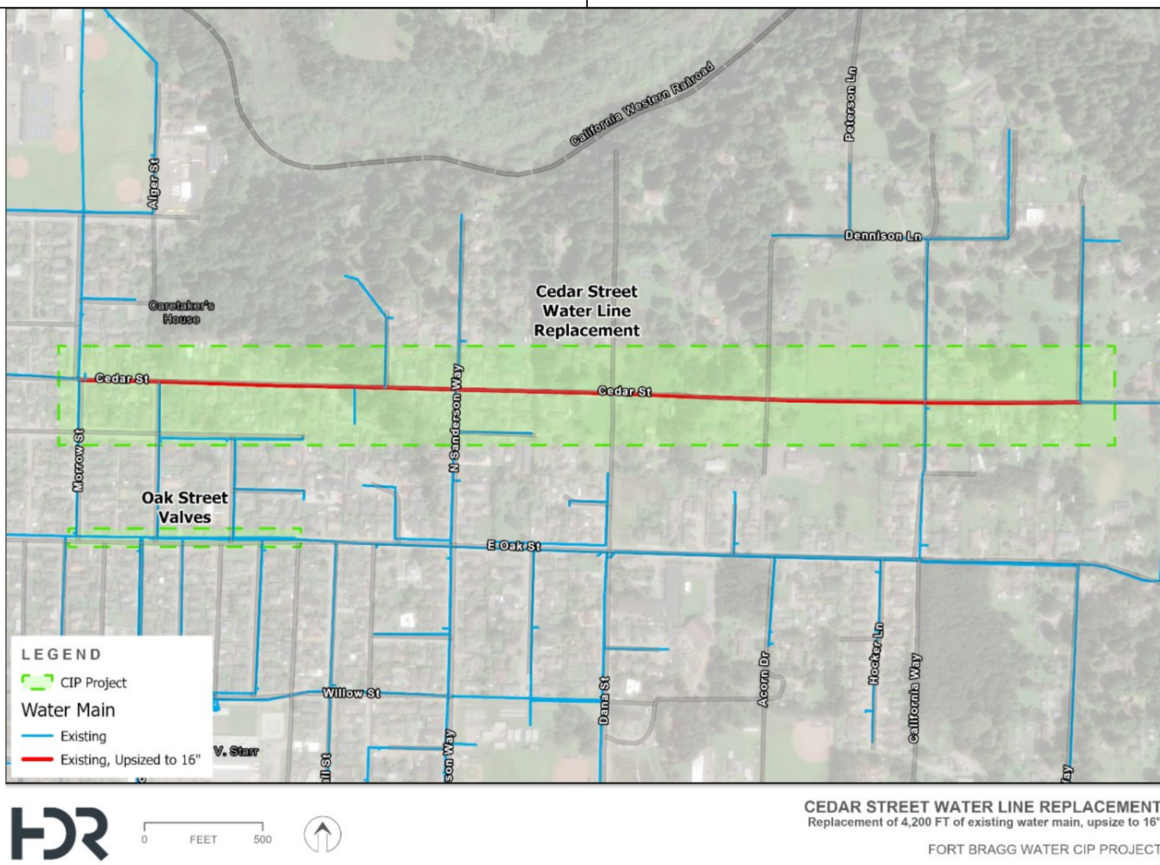


Description:	Addition of 3 isolation valves on water mains in Oak Street per recommended valve spacing of 100 feet per inch diameter of pipe. 2 valves on each parallel 10” main at the intersection of Oak Street and Livingston Street and 1 valve on the existing 18” main at Oak Street and Oak Terrace Court. The depth of the existing water mains are unknown at this time. According to the City’s existing utility maps, there is an existing 6” gravity sewer main in Oak Street, approximately 5’ in depth. Additional utility conflicts will need to be identified during pre-design.
Purpose:	Reduces risk if pipeline isolation is required for repairs or to isolate a main break.

Hydraulic Model Results	While there is some additional minor loss through a valve, the addition of isolation valves does not significantly impact the model results.
Alternatives Analysis	Valve replacement has a very limited set of alternatives. The exact location of the valves could be moved slightly to avoid conflicts, if those are detected in pre-design. there is always a "no project" alternative that can be considered. The "no project" alternative for V-1 results in higher than desired amount of pipeline that must be isolated in the event of a main break or needed repair on the water mains within Oak Street.
Project Trigger:	Existing pipeline risk mitigation.
Expected Environmental Compliance:	Class 1 Exemption for Existing Utilities. Class 1 consists of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use beyond that existing at the time of the lead agency's determination. The key consideration is whether the project involves negligible or no expansion of an existing use.
OPC (2025 dollars):	$85,000 (2-10" valves and 1-18" valve)
Funding Opportunities:	Funding would need to be evaluated further. WIFIA funding may be an option, however, there is a $5 million project minimum. But projects can be combined to reach the minimum project size. Fort Bragg qualifies as a small and rural community based on the USDA's eligibility criteria of providing loans to populations of 10,000 or less and USDA loans may be available at a lower than market interest rate. A cost-benefit analysis should be used to evaluate if a USDA loan would be worth applying for when compared to water revenue bonds. To qualify, Fort Bragg must propose projects that expand services to very small, rural parts of the town. Eligible activities include legal and engineering fees, acquisitions, start-up.

Preliminary Engineering Report: P-1

Improvement Name:	Cedar Street Water Line Replacement
Project ID:	P-1
CIP Year:	2030



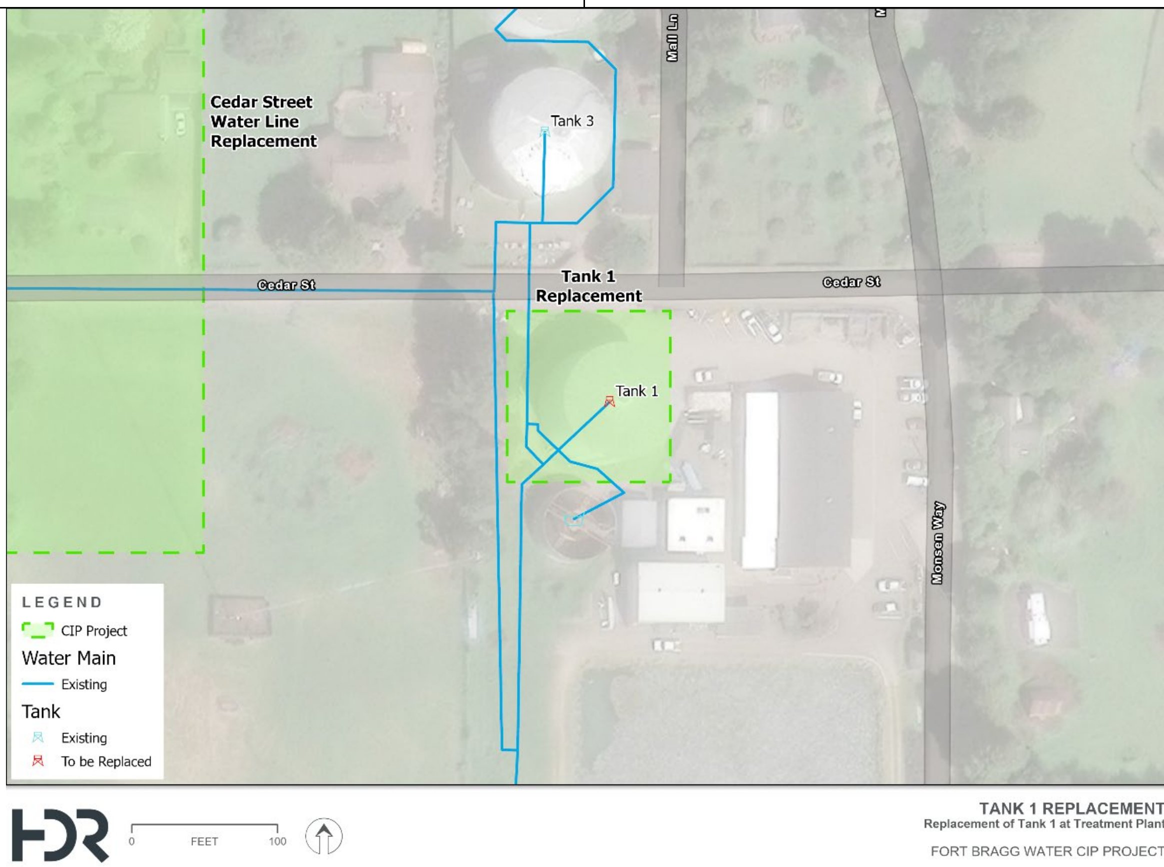
Description:	Replace approximately 4,200 LF of existing 6-8" main in Cedar Street to a 16" C900 pipe. The project area extends from the terminus of the existing 16" main from the Water Treatment Plant (approximately at the intersection of a private road between Dennison Lane and Mall Lane, westerly to Morrow Street. The depth of the existing water mains are unknown at this time. According to the City's existing utility maps, there is an existing 6" gravity sewer main in Cedar Street, approximately 6' in depth. Additional utility conflicts will need to be identified during pre-design.
Purpose:	The main purpose of this project is to extend the recently constructed 16" main from the City's Water Treatment Plant in Cedar Street westerly to Morrow Street. This project will also improve fire flow availability and serve future peak demands to the western portion of the water service area (specifically growth in the GP Mill site area).

Hydraulic Model Results	During fire flow conditions, velocities in the existing 6" main exceed 13 feet per second. This is reduced to less than 5 feet per second with the system improvement.
Alternatives Analysis	Pipeline replacement projects have a limited alternative alignment and associated alternatives analysis; however, there is always a "no project" alternative that can be considered. The "no project" alternative for P-1 results in higher than desired velocities during fire flow conditions and increases the risk of main breaks on ageing Asbestos Cement Pipe.
Project Trigger:	There are multiple project triggers for P-1. The primary driver is the age and condition of the existing 6/8" main, which is Asbestos Cement Pipe and is an older main. The secondary driver is to improve flow to support growth projected by the City's current LCP Amendment 1-24, which includes growth in the GP Mill Site.
Expected Environmental Compliance:	This project may qualify as categorically exempt. However, the increased size to support future growth may trigger an Initial Study (IS). If the IS identifies no significant impact, the project may adopt a Negative Declaration and proceed with implementation. If the IS identifies significant impacts, but the impacts can be reduced to a less than significant level through mitigation then the project may adopt a Mitigated Negative Declaration (MND) and proceed. Projects with significant impacts that cannot be mitigated to less than significant levels must be evaluated in an Environmental Impact Report (EIR).
OPCC (2025 dollars):	$3,072,000
Funding Opportunities:	Funding would need to be evaluated further. WIFIA funding may be an option, however, there is a $5 million project minimum. But projects can be combined to reach the minimum project size. Fort Bragg qualifies as a small and rural community based on the USDA's eligibility criteria of providing loans to populations of 10,000 or less and USDA loans may be available at a lower than market interest rate. A cost-benefit analysis should be used to evaluate if a USDA loan would be worth applying for when compared to water revenue bonds. To qualify, Fort Bragg must propose projects that expand services to very small, rural parts of the town. Eligible activities include legal and engineering fees, acquisitions, start-up

	operations and maintenance, interest incurred during construction, and the purchase of facilities to expand service.

Preliminary Engineering Report: T-1

Improvement Name:	Tank 1 Replacement
Project ID:	T-1
CIP Year:	2030

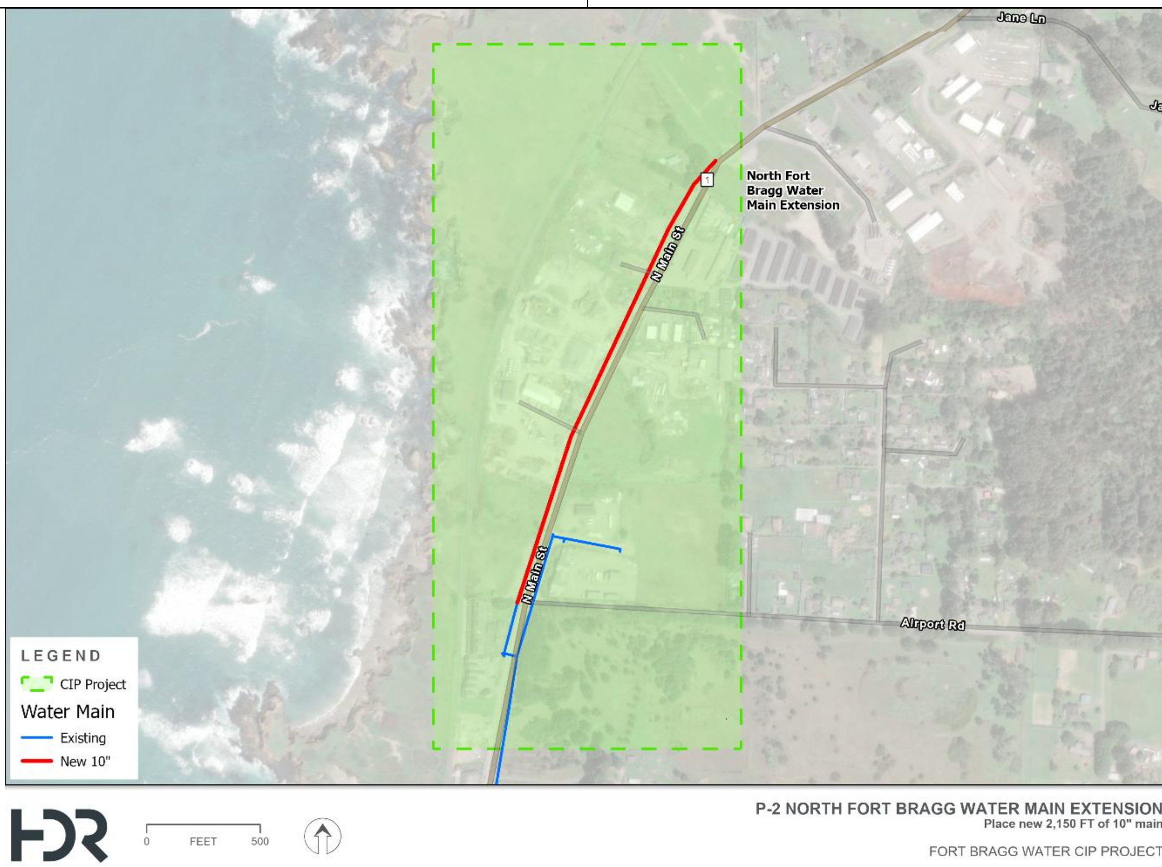


Description:	Replace existing Tank 1 at the Water Treatment Plant.
Purpose:	The main purpose of this project is the replacement of an existing ageing tank at the Water Treatment Plant.
Project Trigger:	Existing repairs are necessary, and the existing tank is in poor condition.
Hydraulic Model Results	Replacement of existing infrastructure does not impact hydraulic modeling results.
Alternatives Analysis	Replacement of existing infrastructure on an existing site has a limited number of alternatives. However, there is always a “no project” alternative that can be

	considered. The “no project” alternative for T-1 results in higher increased risk of asset failure, which can often result in higher project costs to mitigate emergency scenarios.
Expected Environmental Compliance:	Class 2 Exemption for Replacement or Reconstruction. Class 2 consists of replacement or reconstruction of existing structures and facilities where the new structure will be located on the same site as the structure replaced and will have substantially the same purpose and capacity as the structure replaced.
OPC (2025 dollars):	$8,195,000
Funding Opportunities:	Funding would need to be evaluated further. WIFIA funding may be an option, as this project is potentially over the $5 million project minimum. Projects can be combined to reach the minimum project size. Fort Bragg qualifies as a small and rural community based on the USDA’s eligibility criteria of providing loans to populations of 10,000 or less and USDA loans may be available at a lower than market interest rate. A cost-benefit analysis should be used to evaluate if a USDA loan would be worth applying for when compared to water revenue bonds. To qualify, Fort Bragg must propose projects that expand services to very small, rural parts of the town. Eligible activities include legal and engineering fees, acquisitions, start-up operations and maintenance, interest incurred during construction, and the purchase of facilities to expand service. Other potential funding sources include EDA Public Works and EPA SRF.

Preliminary Engineering Report: P-2

Improvement Name:	North Fort Bragg Water Main Extension
Project ID:	P-2
CIP Year:	2030



Description:	Construction of a new 10" C900 water main to the northern extents of the City's water service area. The project area extends from an existing 8" C900 water main at the intersection of North Main Street and Airport Road, northerly to the northern extents of the City's water service area (approximately 2,144 LF). The depth of the existing water mains are unknown at this time. According to the City's existing utility maps, there are no additional water, sewer or storm drain utilities along this alignment. Additional utility conflicts will need to be identified during pre-design.
Purpose:	Provide water service and fire flow to the area north of Airport Road in North Main Street.
Hydraulic Model Results	The proposed pipeline has been sized to maintain a velocity of less than 5 feet per second during peak

	demands and less than 10 feet per second during fire flow demands.
Alternatives Analysis	Pipeline construction projects have a limited alternative alignment and associated alternatives analysis; however, there is always a “no project” alternative that can be considered. The “no project” alternative for P-2 results in the City not being able to provide water service to parcels north of Airport Road and within their existing water service area.
Project Trigger:	The main purpose of this project is to provide water service to the parcels north of Airport Road that are within the City’s existing water service area.
Expected Environmental Compliance:	Initial Study (IS). If the IS identifies no significant impact, the project may adopt a Negative Declaration and proceed with implementation. If the IS identifies significant impacts, but the impacts can be reduced to a less than significant level through mitigation then the project may adopt a Mitigated Negative Declaration (MND) and proceed. Projects with significant impacts that cannot be mitigated to less than significant levels must be evaluated in an Environmental Impact Report (EIR).
OPC (2025 dollars):	$ 1,266,000
Funding Opportunities:	Funding would need to be evaluated further. WIFIA funding may be an option, however, there is a $5-million project minimum. But projects can be combined to reach the minimum project size. Fort Bragg qualifies as a small and rural community based on the USDA’s eligibility criteria of providing loans to populations of 10,000 or less and USDA loans may be available at a lower than market interest rate. A cost-benefit analysis should be used to evaluate if a USDA loan would be worth applying for when compared to water revenue bonds. To qualify, Fort Bragg must propose projects that expand services to very small, rural parts of the town. Eligible activities include legal and engineering fees, acquisitions, start-up operations and maintenance, interest incurred during construction, and the purchase of facilities to expand service.

Appendix G. AC Pipe Condition Assessment

AC Pipe Condition Assessment Methods

AC Condition Assessment Methods

The predominant drivers for AC pipe deterioration in the US are cement leaching and salt cracking. Salt cracking occurs when salts migrate into the pipe wall through capillary and evaporation processes and then expand when hydrated.

Stain Test Method

The first step of free lime conversion to calcium carbonate can be measured by spraying phenolphthalein stain (i.e. stain test) on a freshly exposed cross-section of the pipe wall. The portion of the pipe wall that is stained is un-carbonated whereas the portion of the pipe wall that is unstained is carbonated. Figure 2 shows a pipe that has been recently tested where the left side is the inner portion of the pipe wall, and the right side is the outer portion of the pipe wall.

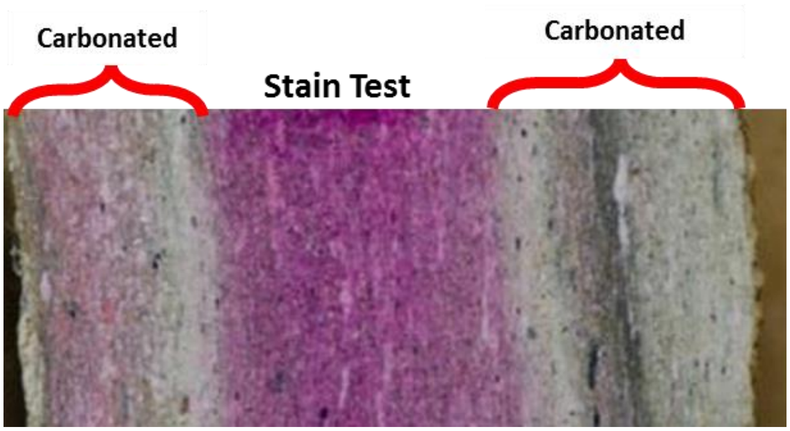


Figure 2. Stain Test Results

Carbonation starts at both the inner and outer wall surfaces. Over time, it progresses towards the center of the pipe, which is typically un-carbonated. In AC and other non-reinforced concrete applications, carbonation itself does not weaken the pipe. In fact, studies in non-reinforced concrete actually show a minor strengthening effect after carbonation. However, in AC pipes, carbonation is a precursor to corrosion.

EDS Testing Method

In step two of the AC pipe corrosion process, if the environment allows for calcium carbonate to be dissolved and carried away from the calcium-silicate-hydrate and other cement products in the concrete matrix, strength is lost and the pipe becomes more susceptible to failure.

The extent of this degradation process can be measured by assessing the remaining calcium (Ca) content using the Energy Dispersive X-Ray Spectroscopy (EDS) test. Figure 3 shows the EDS test results for the same sample shown in Figure 2. In this test, calcium content is measured at multiple points along the thickness of the pipe. At installation, calcium content is relatively uniform across the pipe wall thickness. As the AC pipe wall corrodes from the inner and outer wall surfaces, the calcium content will be significantly lower than the calcium content at the center of the pipe wall.

The remaining calcium content at each wall location is reported as a percentage and calculated as the calcium content at that location divided by the maximum calcium content measured at all locations along the wall. Where the remaining calcium content is high, the pipe is healthy and strong and less likely to break. Where the remaining calcium content is relatively low, the pipe is not healthy and is more likely to break. Typically, active corrosion occurs over a relatively narrow portion of the pipe wall.

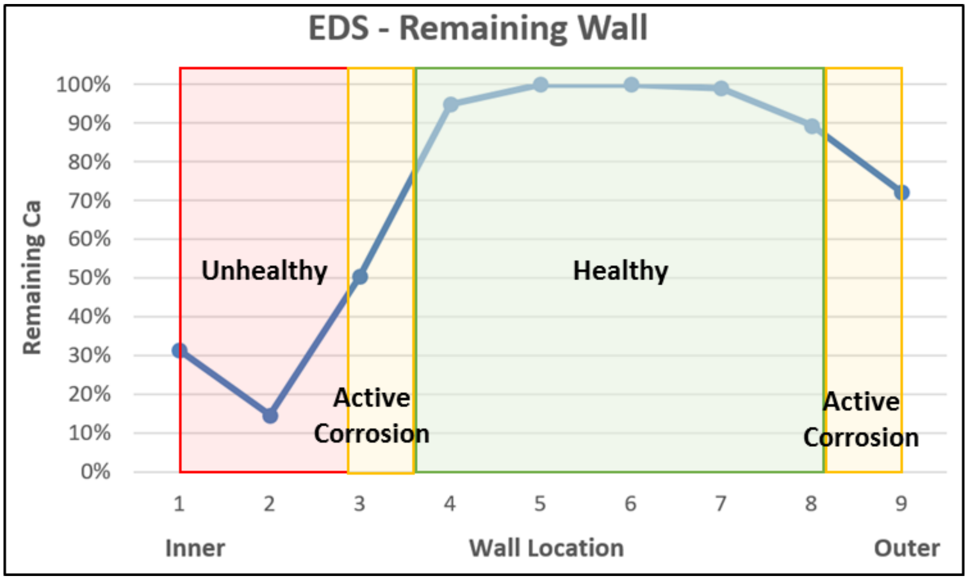


Figure 3. EDS Test Results

While the physical wall thickness does not change over time, the effective wall thickness decreases over time as calcium carbonate leaches from the pipe wall. This thinning of the effective wall will continue until the effective wall thickness can no longer resist the stresses on the pipe (e.g. internal pressure, external loads, bending due to ground movement) resulting in a break. Since larger pipes require thicker walls to resist a particular load, the percentage of the thickness remaining is used to determine the condition of a pipe. Therefore, the percent of the design thickness remaining is calculated as:

$$T_R = (Ca_{Ave} * T_{Measured}) / (Ca_{Max} * T_{Design})$$

Where:

T_R = *Percent of the original class 200 design thickness remaining*

Ca_{Ave} = *Average calcium content across the sample thickness*

Ca_{Max} = *Maximum calcium content across the sample thickness*

T_{Design} = *The design wall thickness for class 200 pipe*

$T_{Measured}$ = *The measured wall thickness*

Measured pipe wall thicknesses should be collected and used in the future since the thickness of a particular pipe of the same diameter can vary significantly. For the purposes of this assessment, it was assumed that the measured wall thickness equals the design wall thickness.

EDS and Stain Testing Results Comparison

Figure 4 orients both tests for a single sample to each other to correlate the results. On the inner pipe wall, the fresh water conveyed by the pipe is an ideal medium to dissolve and carry away calcium carbonate (Step 2 of the corrosion process). As a result, shortly after each layer carbonates (Step 1), the pipe corrodes (Step 2). This means that Stain and EDS tests typically correlate very well with each other on the inner pipe wall. However, on the outer pipe wall, there is not a consistent medium to dissolve and carry away the calcium carbonate. Therefore, carbonation can often penetrate deep into the pipe, but the pipe may not corrode nor lose strength. ***To confirm and correlate actual corrosion, it is recommended that EDS data be used to determine the severity of corrosion.***

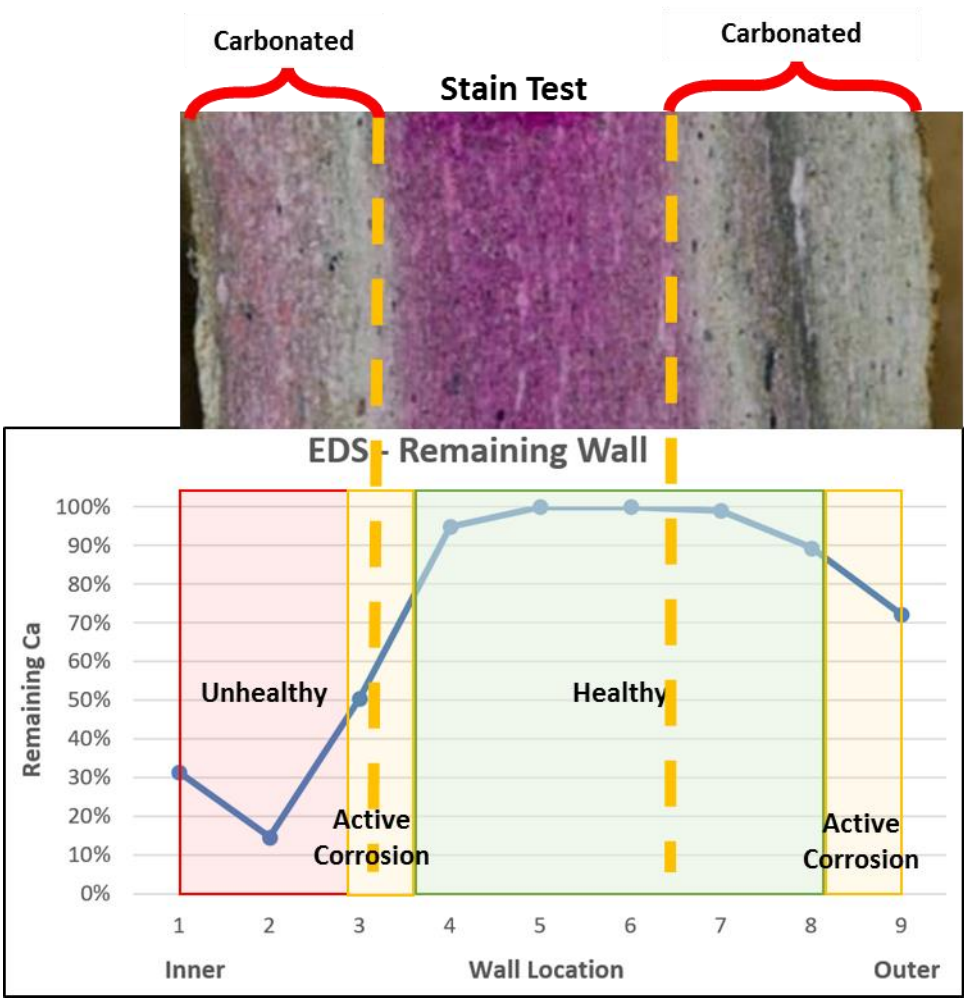
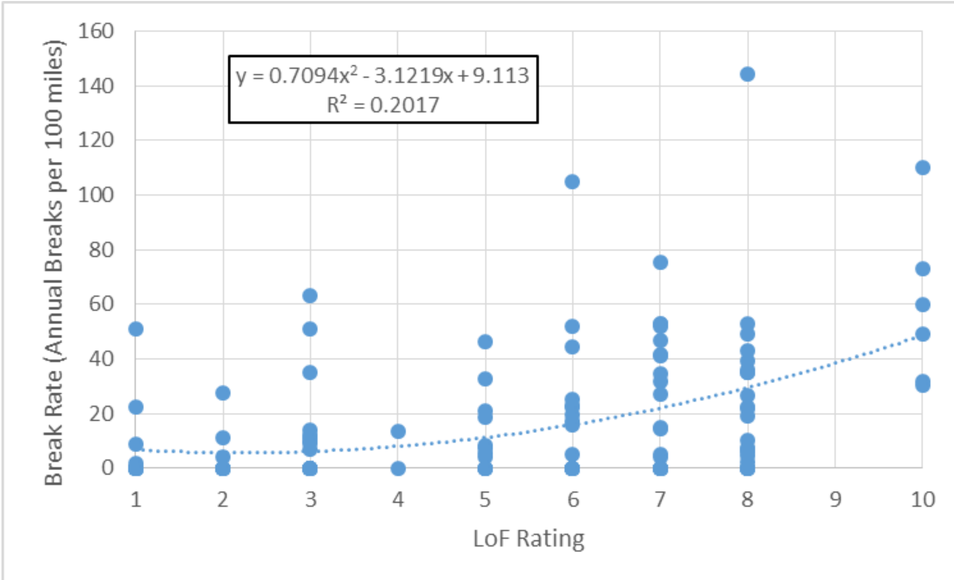


Figure 4. EDS versus Stain Test Correlation



Comparing data from different utilities can be useful in understanding how this can be used in the future. However, this approach does have limitations as risk tolerances, operating conditions, and data quality vary significantly from utility to utility. As a utility builds on their own data set and it becomes larger, the relationship between pipe condition, pipe stress, and breaks will become clearer within any utility's unique operating environment.

Extrapolating EDS Testing Results

While condition assessment data collected using EDS data accurately measures the condition at a certain point along a pipe, it is not yet clear how far that condition can be extrapolated along a pipe. In theory, the condition of AC pipe can vary significantly by project because of differences in installation practices and manufacturing quality. Differences in condition within a project should be less variable but will exist due to manufacturing flaws or isolated damage during construction. Therefore, these tests provide moderate confidence in extrapolating the condition to the project, and low confidence in extrapolating the condition beyond the project.