Olympic Gravity Water System
Capital Analysis White Paper

October 13, 2021

Preface

The City of Port Townsend and Port Townsend Paper Mill have a historical partnership of supplying water to the Quimper Peninsula, City of Port Townsend, and the Port Townsend Paper Mill dating back to 1928. The City and Port Townsend Paper Company are in the process of developing a new partnership agreement that will address water supply looking forward to the next 100 years.

Like the development of the Olympic Gravity Water System in the late 1920's, the development of an agreement between the City of Port Townsend (City) and Port Townsend Paper Company (PTPC) is a significant undertaking with the stakes being high for both parties. As such, the negotiation of a mutually beneficial agreement warrants thoughtful collaboration based on the best data possible.

As a way to ensure good factual data is available for the negotiation, eight technical white papers break down information into manageable segments. In the following specific white paper categories, the City and PTPC have worked together to develop these white papers to provide information for consideration during the negotiation of the agreement.

1. Assets: Understanding each entities assets and capacities that support investment decisions.
2. Stakeholders: The public as well as many governmental organizations may be potentially interested stakeholders.
3. Planning and Environmental Considerations: Future water supply needs, climate change and water supply availability are important factors to include in planning for the future.
4. Operations: Operational requirements, efficiencies, cost, and reliability as well as distinguishing between capital and ordinary maintenance is a major part of any public private partnership agreement.
5. Capital Investments: Capital needs are extensive and should be informed by a value engineering study for system reliability and to reduce costs.
6. Funding and Resources: In order to address operational and capital needs, a plan is necessary to fund system needs ensuring that sustainability is achieved.
7. Legal considerations impact the form of the agreement depending on negotiation outcomes. Surety and performance are two key legal discussion points.

The intent of developing these white papers is to provide a resource to inform negotiations and as background for the public and decision makers. All of the white papers will be assembled into a comprehensive technical report in support of the development of a comprehensive recommendation for the City of Port Townsend City Council and the Port Townsend Paper Mill Board of Directors.

The following white paper addresses an analysis of capital needs, costs and timing for the next 20, 40, as well as projecting forward 100 years. It is anticipated that an agreement with the Mill will have a time frame on the order of 40 years.

Introduction

The OGWS system is a capital intensive system with a total estimate value of $200 to $300 Million if it were to all be constructed from scratch today. The City of Port Townsend struggled with maintaining a reliable water supply at the turn of the century. The investments made in 1927 and 1928 are providing tremendous benefit for the community today. This benefit is manifested in the cost of water essentially being the cost to operate the system. Under the current lease agreement, there are no obligations for capital and the Mill covers the cost of operations. However, the City and PTPC have significant investment needs in the relatively near future to sustain this water system. If the partnership begins saving funds, the system can be replaced without massive debt issuance. This white paper identifies a number of capital needs have been identified including several related to replacement of existing infrastructure. An analysis of the following capital components is included:

1. Historical capital investment and asset studies.
2. Inventory and condition assessment of assets, providing a synopsis of system components and capital replacement needs.
3. Identification of failure risk potential, providing a summary of risks.
4. Capital Investments to support operational efficiencies includes capital needs to improve operations and save annual O&M costs.
5. Capital investment needs driven by regulatory agencies, providing capital estimates for needs to comply with permits.
6. Capital investment for system capacity, identifies capacity improvements.
7. Capital improvement plan, providing a summary of planned investments over time.
8. Unanticipated capital needs identify possible capital reserve necessary for unforeseen needs.

Utilizing the information provided in this white paper with a value engineering approach to balancing operational costs, reliability, and sustainability results a recommended capital investment program.

History of Capital Investment and Past Studies

Construction of the Big Quilcene diversion and transmission pipeline was completed in 1928 for the cost of $750,000 or $11,400,000 in today's dollars. Replacement of the wooden pipeline sections and construction of the Little Quilcene diversion and Lords Lake reservoir cost around $2,200,000 or $21,700,000 in today's dollars. The table below details some of the capital improvements undertaken since the construction of the OGWS.

Asset Desc.	Year Constructed	Design Life If Avail.	Dollar Value @ $Install YR$	Dollar Value @ $ 2021 $	Notes
Big Quilcene Diversion	1928				
Big Quilcene Diversion Upgrades	1952				Construction of sluiceway
Big Quilcene Diversion Upgrades	1986				Construction of concrete apron
Big Quilcene Diversion Upgrades	1994	100			Generator oil tank containment
Big Quilcene Diversion Upgrades	1995	75			Rotating screen building replacement

Big Quilcene Diversion Upgrades	2018	30-40	$2,319,698	$2,549,591	Repair of timber crib structure and apron
Little Quilcene Diversion	1955				
Little Quilcene Diversion Reconstruction	1995	100	$500,000	$1,134,075	Replacement of timber crib diversion
Lords Lake Reservoir					
City Lake Reservoir					
City Lake Outlet Repair	2012/2013	100	$4,354,076	$5,601,877	Outlet pipe and flow control replacement
Transmission Pipeline	1928				
Transmission Pipeline Replacement	1945	100			Replacement of wood stave pipeline
Transmission Pipeline Replacement	1955-1972				Replacement of wood stave pipeline
Transmission Line Upgrades	1986				Snow Creek pipeline crossing replacement
Transmission Line Upgrades	1994	100	$59,320	$138,852	Lords Lake inlet pipeline extension
Transmission Line Upgrades	1995				Little Quilcene River bridge replacement
Transmission Line Upgrades	2015		$83,242	$100,558	Andrews Creek crossing support replacement
Transmission Line Repair	2015		$32,072	$38,743	Snow Creek bank stabilization
Transmission Line Repair	2015		$228,252	$275,735	Big Quilcene storm damage road repairs
Big Quilcene House	1941	100			
Big Quilcene House Upgrades	2013	40	$11,697	$15,049	Roof replacement
Big Quilcene House Upgrades	2018		$21,425	$23,548	???
Big Quilcene House Upgrades	2020	10	$3500?		Generator replacement
City Lake House		100			
City Lake House Upgrades	2013		$3000?		Electrical rewiring
City Lake House Upgrades	2013	40			Roof replacement
City Lake House Upgrades	2014	40	$12,762	$15,910	Insulation and siding replacement
SCADA	2013	7	$28,380	$36,513	Big Quilcene SCADA system
SCADA Upgrade	2020	10	$7,848	$8,099	Changing service for mill connection

Water system studies related to the condition and capital improvements since 1990 are noted below.

Study	Year	Dollar Value @ $Study YR$	Dollar Value @ $ 2021 $	Notes
Lords Lake Dam Seismic Study	1990/91	$42,515.18		
Special Use Permit Renewal	1998-2009	$373,463.17		
AGI Geological Hazards Analysis of OGWS Pipeline	1999	$14,000		
RW Beck OGWS Estimated Replacement Cost Study	2000			
CDM Engineering Evaluation and Preliminary Cost Estimate Increased Reservoir Capacity Lords Lake	2001			
HDR Pipeline Replacement Opinion of Cost	2016			
HDR OGWS Hydraulic Analysis	2016	$9,950		
Norton Corrosion Close-interval Cathodic Protection Survey	2018	$21,909		

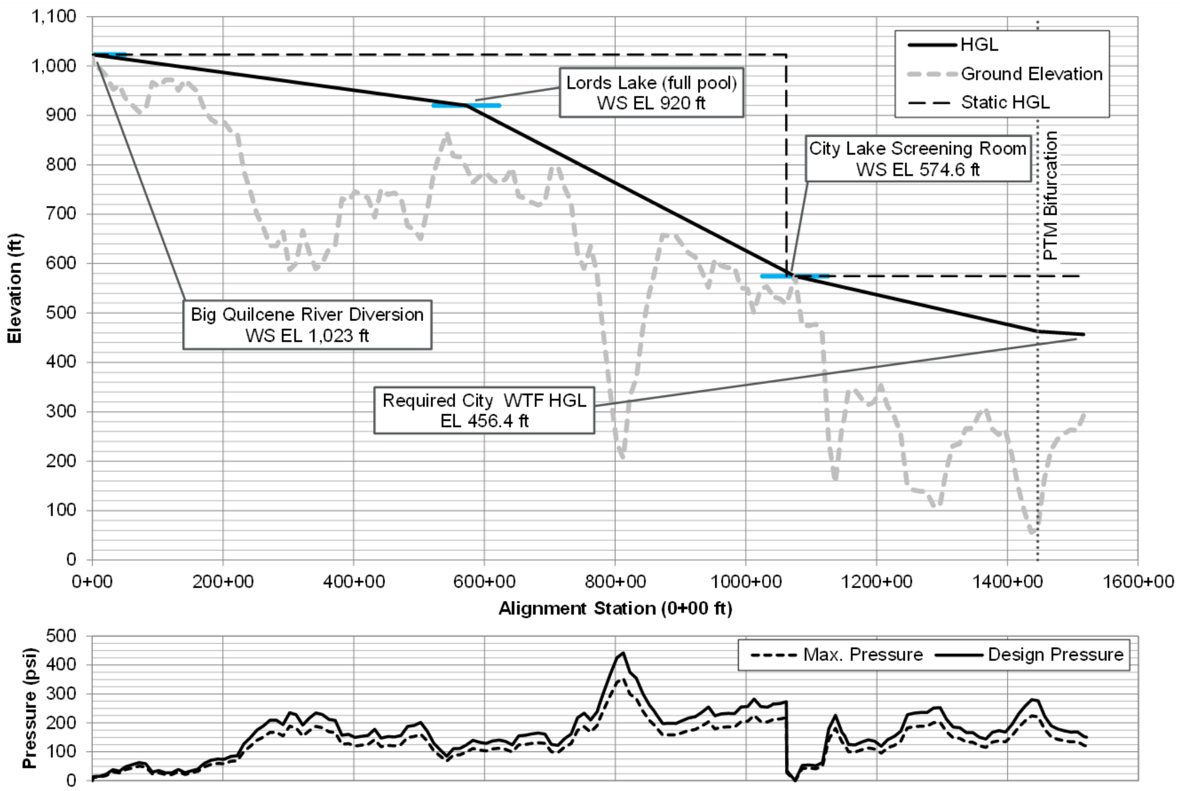
While not all costs are available and translatable to current year dollars, the reality of constructing this system today from scratch would be a major undertaking. Just the replacement of the pipeline and major component that need attention in the next 75 years is valued at $160 million in current year dollars. This estimate does not include the cost that were incurred when the system was built of buying right of way, developing the reservoirs or the recent work on the system. Without getting into these details, it is easy to approximate a total system value of well over $200 million in today's dollars in order to build the system from scratch.

Inventory and Condition Assessment

The OGWS consists three main asset categories. These categories include the gravity pipeline, two diversions, and two reservoirs. The following section provides an inventory and condition assessment of each of the assets. This information will be used to develop an investment strategy (Capital Improvement Plan) to facilitate continued reliable operations of the system as a whole.

Pipeline and Appurtenances

The OGWS Pipeline consists of approximately 29 miles of welded steel pipe. The table in the following section identifies the length of pipeline and its installation date. The length specified in this table represent horizontal projected length. The actual length is longer due to vertical changes in the profile of the pipeline. The actual length of pipe installed may be as much as 5 to 10 percent longer to account for the vertical changes in the pipeline as shown in the profile schematic below. The pipeline also includes a number of appurtenances that are important to consider. They include 30 feet of right of way, roads, gates, culverts, survey markers, air valves, blow off valves, valve boxes, mainline valves, and cathodic protection systems.



Exaggerated Vertical Profile (HDR 2016)

Right of Way, Roads, and Culverts

Access and maintenance of the typical 30-foot easement is an ongoing challenge for the miles of transmission pipeline. Clearing and brushing are also necessary to prevent vegetation from damaging the pipeline. Encroachment within the easement by fences and buildings hinders access in some of the more developed areas and could lead to unintentional damage to the pipeline. Available equipment for the maintenance of the easements is hand operated tools and a small tractor. The extent of ground to cover will likely require hiring a contractor specializing brushing on a regular basis, possibly every seven years, to keep up with the clearing. Larger trees growing on top of the pipe will require more specialized equipment and experience to safely remove. Additional needs include addressing the gates and access, road maintenance, culvert replacement as well as installing survey monuments that have been destroyed. The partnership needs to devote more resources to keeping in touch with property owners to prevent future encroachments.

Trees Growing Alongside Pipeline

Culverts within the National Forest, State lands and County roadway are maintained by contractors, County Public Works and/or pipeline crew. Many of these culverts have been replaced in recent years. Culverts in other areas of the transmission are generally older and maintained less frequently by the pipeline crew. Some of the culverts have been lost in the undergrowth and lack of access restricts maintenance of others. The pipeline crew has limited equipment, mostly hand tools, to maintain the culverts and clear storm debris. One such strategy for culvert replacement is to evaluate culverts for replacement coincident with logging operations, a wildfire, or other activity that increases the risk for washout. Culverts that feed large drainage areas and have periodic flowing water, should be evaluated and replaced if in poor condition or cleaned if they are blocked to reduce the risk of a washout exposing the pipeline

Finally, many of the easements cross Rayonier Timber property. The easements have very little enforcement power in preference of the pipeline in terms of use of the property creating a potential conflict for responsibility to protect the pipeline during landowner logging and maintenance operations. Strategies for securing more permanent and reliable protection of the pipeline could include land swaps/purchases or improving the protection of the pipeline by renegotiating the easements. Easements also are also coincident with the transmission lines owned by BPA and Jefferson County PUD. The priority of easements for these areas and maintenance program should be established in partnership with Jefferson County PUD for mutual benefit of the organizations and rate payers. Five year prior to pipeline replacement easements should be reevaluated and adjusted as necessary. Installation of crossings and parallel utilities are expected to increase over time driving the need to solidify agreements and roles and responsibilities.

Capital costs for each of these elements of easement and land management are estimated as follows:

Easement survey marking	$50,000	once in 20 years.
Vegetation Clearing to catchup	$75,000	every 10 years
Road Maintenance/gates	$25,000	every 10 years
Culvert Replacement	$25,000	replacing up to 5 culverts every 5 years
Land swaps or easement rights purchases opportunity permits	$200,000	prior to pipeline replacement/as

Air valves and Boxes

There are approximately 106 air valve boxes along the length of the pipeline constructed of pressure treated 2X material. The wooden boxes are in various states of repair and require around 40 hours of maintenance each year. Vehicles have periodically driven into the boxes shearing off the air valve resulting in water blasting from the transmission line. To provide protection from accidental damage and vandalism the wood air valve boxes should be replaced with locking lid concrete boxes. The estimated cost to upgrade 25 air valve boxes is $125,000 in 2021 dollars.

Many of the air valve boxes are filled with soil which allows the bi-metallic connections of the valves to affect the structure-to-soil potentials. The soil should be removed from inside these boxes to allow for the use of the 100 mV criterion for cathodic protection.

Air Valve Box

Blow-offs

Numerous pipeline blow-offs are inoperative. Generally located at the bottom of the pipeline, they are usually buried and inaccessible for maintenance. The blow-offs would be used to drain the pipeline and flush sediment from the low spots. At this point, there is no need to invest capital in these valves as they are seldom used and would be addressed during pipe replacement.

Steel Pipe Risk Assessment

The 30-mile pipeline is by far the largest individual asset in the OGWS system. As such, a considerable scope of this capital white paper dedicated to the pipeline. The analysis of the pipeline begins with a risk factor analysis concerning an inventory of the pipeline and it's age. The location survey developed in 2020 provides information concerning the pipelines location relative to geography, critical areas, and impacts to surrounding properties. The following risk factor analysis is intended to provide a high level relative rating of each section of pipeline based on age reflecting factors that result in higher consequences and/or higher likelihood of a pipeline failure. In brief, these risk factor categories are described and weighted as follows.

- **Cathodic Protection:** Corrosion impacts to the pipeline are likely higher in areas with partial or no cathodic protection making leaks more likely.
- The **pipeline age** is a risk is described in great detail in this white paper as it relates to quality of material. The longer the pipe is in the ground the more time corrosion can impact its integrity.
- **Pressure zones** identifies where areas of high pressure exist making a leak more likely and the resulting damage greater.
- **Surrounding infrastructure** is a category that identifies higher risk when a pipeline break would impact infrastructure such as HWY 20 or 101, or surrounding homes, powerlines, etc.
- **System redundancy** identifies how a pipeline break would impact reliability. This is described in the operations paper as:
    - A break between the Big Quilcene diversion and Lords Lake has the least impact due to the ability to continue to obtain water from Lords Lake.
    - A break between Lords Lake and City Lake requires Mill shutdown, but the City can continue to operate drawing on the City Lake reservoir.
    - A break between City Lake and town is the greatest risk to reliability which would require an immediate system shutdown for the Mill and the City would only have approximately 3 days of water supply.
- **Previous break** history identifies areas where there is a history of pipeline leaks.
- **Critical Areas** are areas identified by Jefferson County as requiring special conditions in terms of environmental impacts. These areas include wetlands, unstable and steep slopes, geologically hazards, erosion hazards, etc. Critical areas present not only risk to the pipeline, but also make repairs and replacement more challenging and costly.
- **Accessibility to Repair** identifies those areas that are inaccessible as having greater risk. In order to fix a pipeline break, these areas would require extra work in order to access the break with heavy equipment.

The following key provides 0-3 rating for each of these categories.

Risk Factor	Score
Cathodic Protection	
No Cathodic	3
Partial Cathodic	2
Full Cathodic	1
Pipe Age	
1928	3
1940s – 1950s	2
1960s – 1970s	1
Pressure Zone	
>200 psi	3
150-200 psi	2
100-150 psi	1
<100 psi	0
Surrounding Infrastructure	
State Highways	3
Airport	3
Mountain Roads	1
County Roads	2
Homes	2
Electric Transmission Lines	3
System Redundancy	
Big Quilcene - Lords Lake	1
Lords Lake - City Lake	2
City Lake – Town	3
Previous Break/Leak History	
3 or more breaks in 20 years	3
2 or less in 20 years	2
No break history	1
Critical Area (Jeff. Co.)	
3 or more overlapping critical areas	3
2 critical areas	2
1 critical area	1
0 critical areas	0
Accessibility to Repair	
Steep slopes/no roads/wetlands	3
Trails that need improvement/crossing highway	2
Easy access	1

Averaging the scores for each segment of pipe, this table provides valuable information to help the partnership prioritize making of investments over the next 50 years. The table illustrates that the 1928 sections of pipe rate the highest in terms of risk not only because of age, but due to the other risk categories as well.

OGWS Pipeline Segments and Risk Factors

Pipeline Segment	Install Date	Diameter (inches)	Thickness (inches)	Length (miles)	Cathodic Protection	Pipe Age	Critical Areas Land Slide, Steep Slopes etc.	Previous Break/Leak History	High Pressure Zone	Wet soils	Redundancy of Water Supply	Accessibility to Repair	Impacts to Other Infrastructure	Average Risk Score
A	1965	36	0.25	0.69	3	1	2	1	0	1	1	1	1	1.22
B	1963	30	0.25	1.98	3	1	2	1	0	1	1	1	1	1.22
C	1961	30	0.25	2.27	3	1	1	1	2	1	1	1	1	1.33
D	1960	30	0.25	2.82	3	1	1	1	2	2	1	1	1	1.44
E	1958	30	0.25	2.55	3	2	2	1	2	3	1	1	1	1.78
F	1958	30	0.25	2.07	2	2	1	1	1	1	2	1	1	1.33
G	1954	30	0.25	0.89	2	2	1	1	2	1	2	2	1	1.56
H	1957	30	0.25	0.81	2	2	1	1	2	1	2	2	1	1.56
I	1928	24	0.25	1.59	2	3	3	1	3	3	2	3	3	2.56
J	1967	24	0.25	0.09	1	1	2	1	3	1	2	3	3	1.89
K	1928	24	0.375	0.47	1	3	1	1	3	1	2	2	1	1.67
L	1957	28	0.25	0.4	1	2	1	1	2	1	2	2	1	1.44
M	1957	30	0.25	0.49	1	2	0	1	2	1	2	2	1	1.33
N	1957	28	0.25	1.04	2	2	0	1	2	1	2	1	1	1.33
O	1964	30	0.25	1.4	1	1	1	1	3	1	2	1	2	1.44
P	1952	30	0.25	0.34	1	2	1	1	3	1	3	1	3	1.78
Q	1952	24	0.25	1.16	1	2	1	1	2	1	3	2	3	1.78
R	1972	30	0.1875	0.8	1	1	3	1	2	1	3	3	3	2.00
S	1928	30	0.25	5.7	2	3	1	3	3	3	3	1	3	2.44
T	1928	20	0.25	0.4	3	3	1	2	3	1	3	2	2	2.22
U	1998	24	?	1.14	3	1	0	1	1	1	3	1	2	1.44
X	1956	20	0.25	1.49	3	2	2	1	1	1	1	1	1	1.44
Total				30.59										

Steel Pipe Investigation and Preliminary Condition Assessment

Except for a few stream crossings, the transmission pipeline is buried from a few inches to several feet below ground making it difficult to accurately assess its condition. Only a few areas have been excavated to examine the pipeline or to repair leaks since it has been installed. Jacob's Engineering was hired to provide advice on steel pipeline evaluation, rehabilitation, and replacement recognizing that pipeline replacement is the major cost factor looking forward. The following information is provided in light of key points provide by Jacob's Engineering pipeline specialists. These points include:

- Replacement of the pipeline with steel or ductile iron is the appropriate strategy as opposed to slip lining. This is based on the need to keep the pipeline functional, high pressure of the pipeline, loss of pipeline capacity, and costs. Slip lining technology either needs to sufficiently advance or would only be viable if water demands were to decrease significantly or possibly in small sections of difficult to access pipeline.
- Useful remaining life is a critical need to establish for budgeting and planning purposes. Life of the pipeline is approaching its expected end with approximately 1/3 of the pipeline 93 years old and the remaining pipeline between 49-76 years old.
- Recommendations include improvements to the cathodic protection system to maximize pipeline life.
- A comprehensive analysis of pipeline condition and continued monitoring is recommended to inform decision making in order to balance risks, reliability, while maximizing pipeline longevity.

Information provide by Jacobs, suggests that the partnership is in a good position to proactively create an investment program for the pipeline using the remaining life to save funds for a systematic replacement program that addresses needs before it becomes a necessary response to an increasing number of pipeline failures.

It is recommended to begin with a comprehensive pipeline evaluation, which includes a condition assessment followed by a remaining useful life analysis. The condition assessment program for the OGWS pipeline includes collecting information on the condition of exterior and interior pipe surfaces. A tiered condition assessment approach would start with lower-cost, non-disruptive technologies, and methods to identify suspected risk factors. Potentially followed by higher-cost, more-invasive investigations that could be implemented in a step-wise approach to target specific higher risk areas identified in the first phase. This will help establish the useful life of the entire pipeline and allow the partnership to plan for its eventual replacement. The estimated cost to conduct the evaluation is $500,000, with a target completion date by 2023 in coordination with cathodic system upgrades as described in the Cathodic Section below.

Pipeline Design

The longevity of the pipeline is based not only on its condition, but is impacted by the type of pipe, age of pipe (era), and it's design pressure rating. The risk table above illustrates the pipe age. Pipe age provides an indicator of the technology in steel pipe fabrication at the time of installation. In general, steel pipe technology, welding, and coating systems have advanced over the years. Welded steel pipe was a new technology in the 1920s when used for the construction of the 1928 steel sections of the OGWS. The pipe has longitudinal welds from the factory in 36' lengths with pieces welded together in the field using butt welds and potentially strap and lap welds. It is likely that the pipe was only welded from the exterior. Steel pipe prior to 1930 had a tensile strength of approximately 50,000 psi with a yield strength of 30,000 psi. The coatings were a bituminous or asphalt tar type coating. Both steel quality and coatings improved after the 30s and WWII with coal tar enamel coatings and slightly higher strength steel (36,000 psi on average yield strength). Based on observations without design drawings or specifications, it appears that the 1928 sections of the OGWS are consistent with the history of steel pipeline technology applied for water systems. The following table provides an estimate of pressure capacity of the existing 1928 sections of pipeline based on AWWA M11, C200 which specifies that the pipe pressure zones shall be designed for a maximum of 50% of yield at working pressure and 75% of yield at the maximum pressure. This table back calculates these two pressure capacities based on known wall thickness of the pipeline assuming the pipe yield strength is 30,000 psi. It should also be noted that lab tests of pipe material of this era have shown yield stress in the neighborhood of 25,000 psi.

Pipe Diameter (in)	Wall Thickness (in)	Allowable Working Pressure (50% Yield) (psi)	Transient Pressure (75% Yield) (psi)
30	0.125	125	188
30	0.1875	188	281
30	**0.25**	**250**	**375**
24	0.125	156	234
24	0.1875	234	352
24	0.25	313	469
24	0.375	469	703

With working, transient, and field-test pressures known, the pipe wall thickness is determined using Eq 4-1:

$$t = \frac{pD_o}{2s} \qquad \text{(Eq 4-1)}$$

Where:

t = pipe wall thickness for the internal pressure, in.
p = internal pressure, psi
D_o = outside diameter of steel pipe cylinder (not including coatings), in.
s = allowable design stress, psi

Based on static pressures of the 1928 section of the pipeline ranging from approximately 200 to 450 psi, there is not much safety factor in the 0.25 inch wall thickness sections of the 1928 pipeline. This is particularly important when considering wall thickness loss due to corrosion of the steel. The above table illustrates that wall thickness in high pressure locations is critical for the integrity of the pipeline and is a reasonable predictor of when leaks may start developing as corrosion continues. In particular there is a question of whether or not the butt welds are the limiting factor for the pipeline given that they were not likely coated from the interior of the pipe. This information also illustrates the importance of following careful operation procedures to prevent pressure surges (transients). Most leaks that have occurred so far have been a weld failure in the winter when the water is coldest. These failures could be further induced by steel contraction putting additional stress on the welds.

Given the design factors and leak history, more attention has been given to the 1928 pipeline sections than the sections installed in the 1950s through the 1970s.

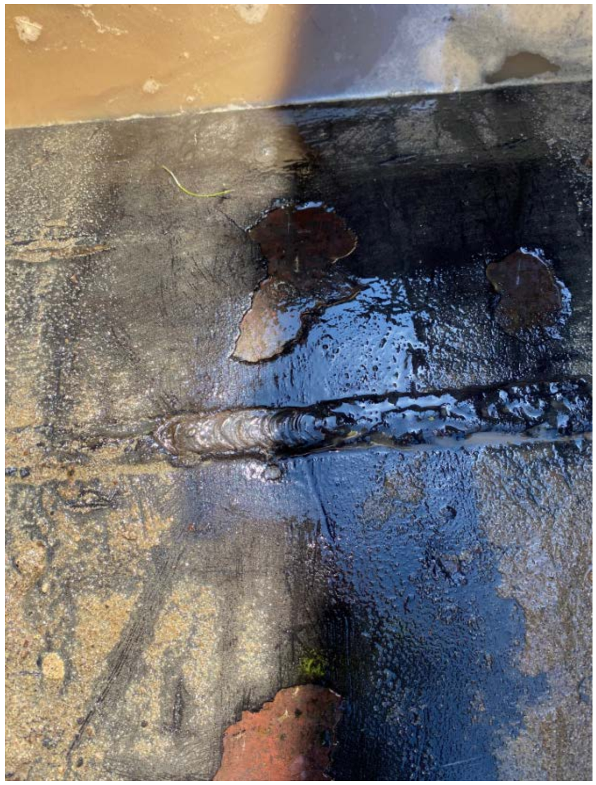
Thickness and Visual Condition Assessment

During the past few years, the pipeline has only had a few limited evaluations. PTPC staff have used an ultrasonic steel thickness measuring instrument to assess pipeline thickness when it has been exposed. Additionally, there has been visual inspections of the coating and welds at pipeline excavations. The following photographs and chart provide a summary of this data.

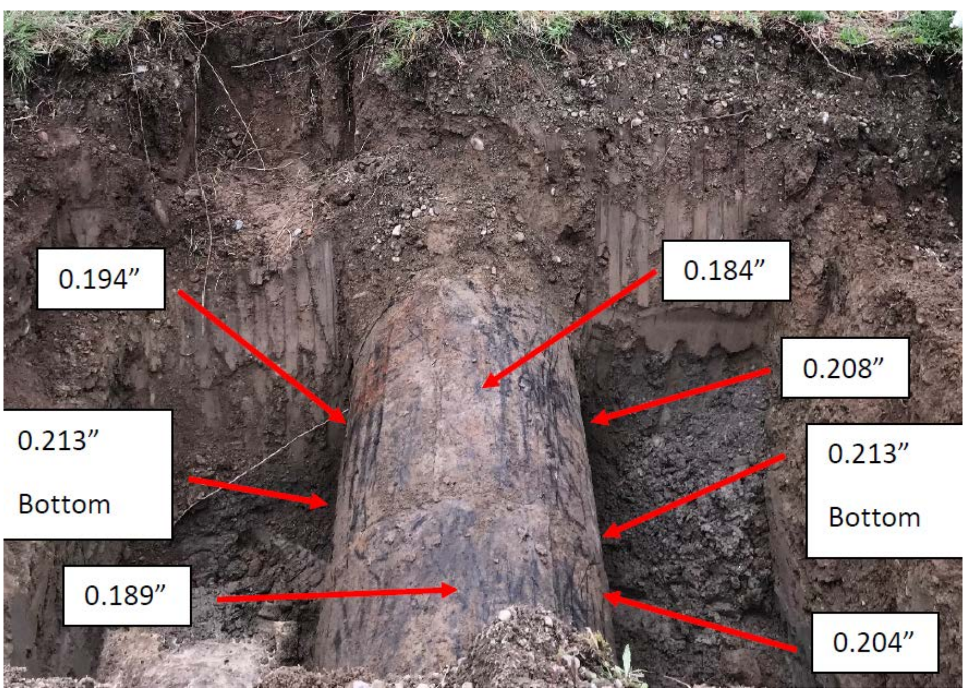
Thickness Measurement

Waterline Live Repair in 2003

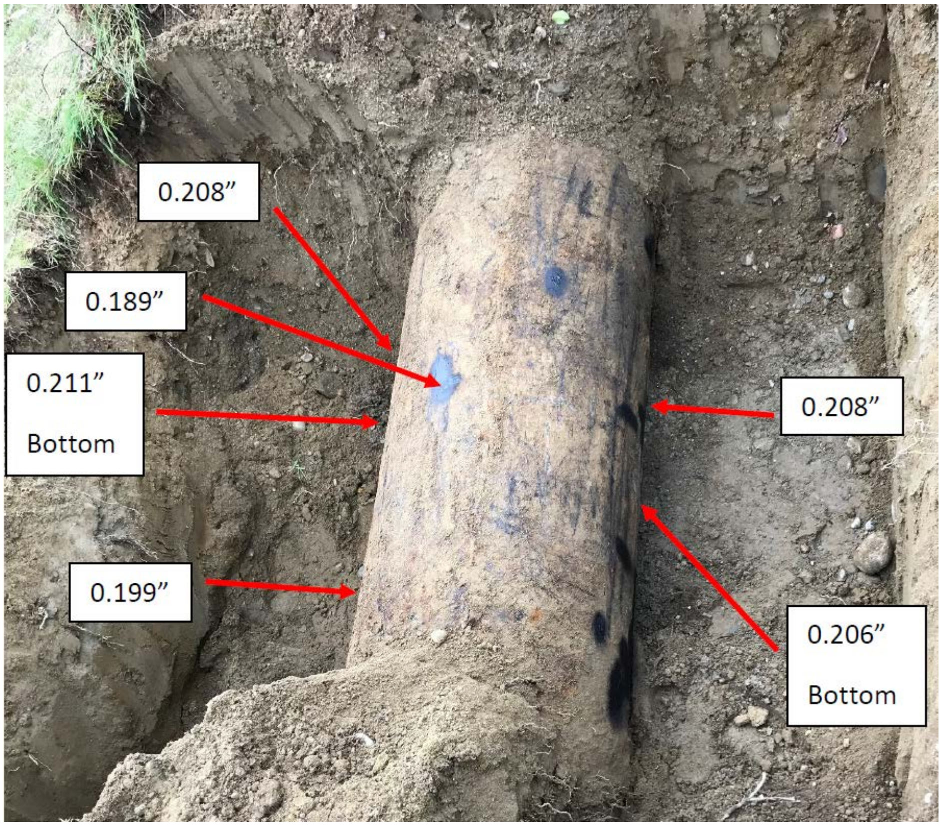
!928 Section at the Airport Illustrating Coating Loss – Photo Summer of 2020



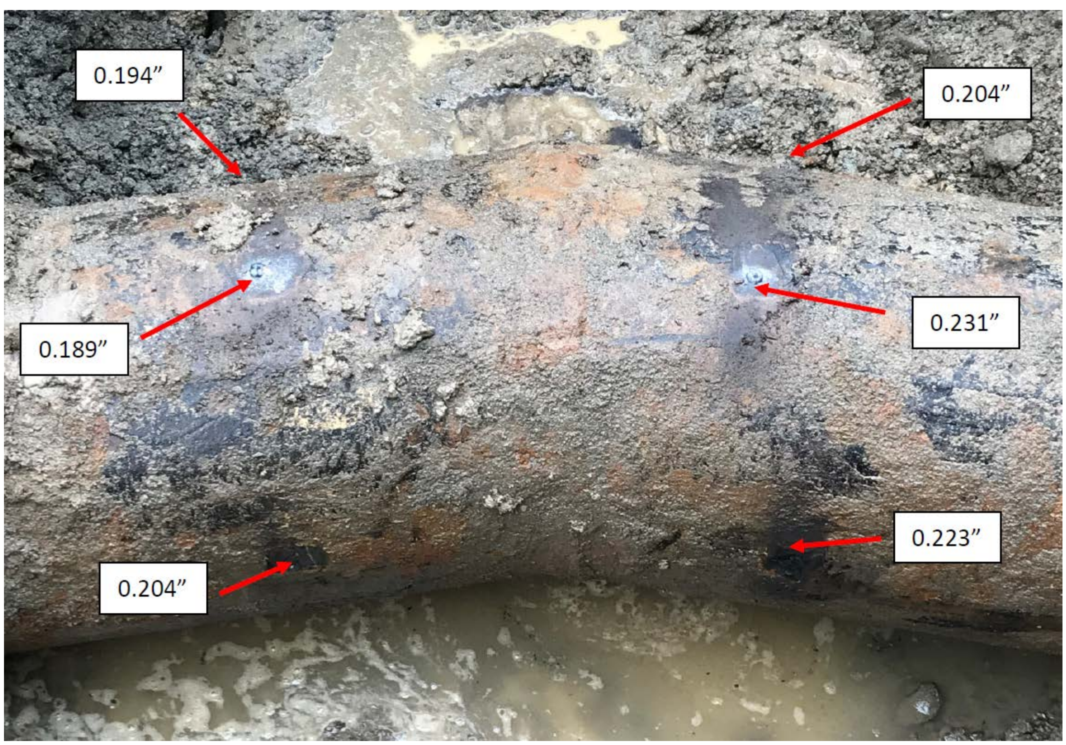
!928 Section at the Airport Illustrating Longitudinal weld and Coating – Photo Summer of 2020



1928 Section Near the Elks – 30-inch Diam. With ¼" Wall – Thickness Measurements 4-22-19

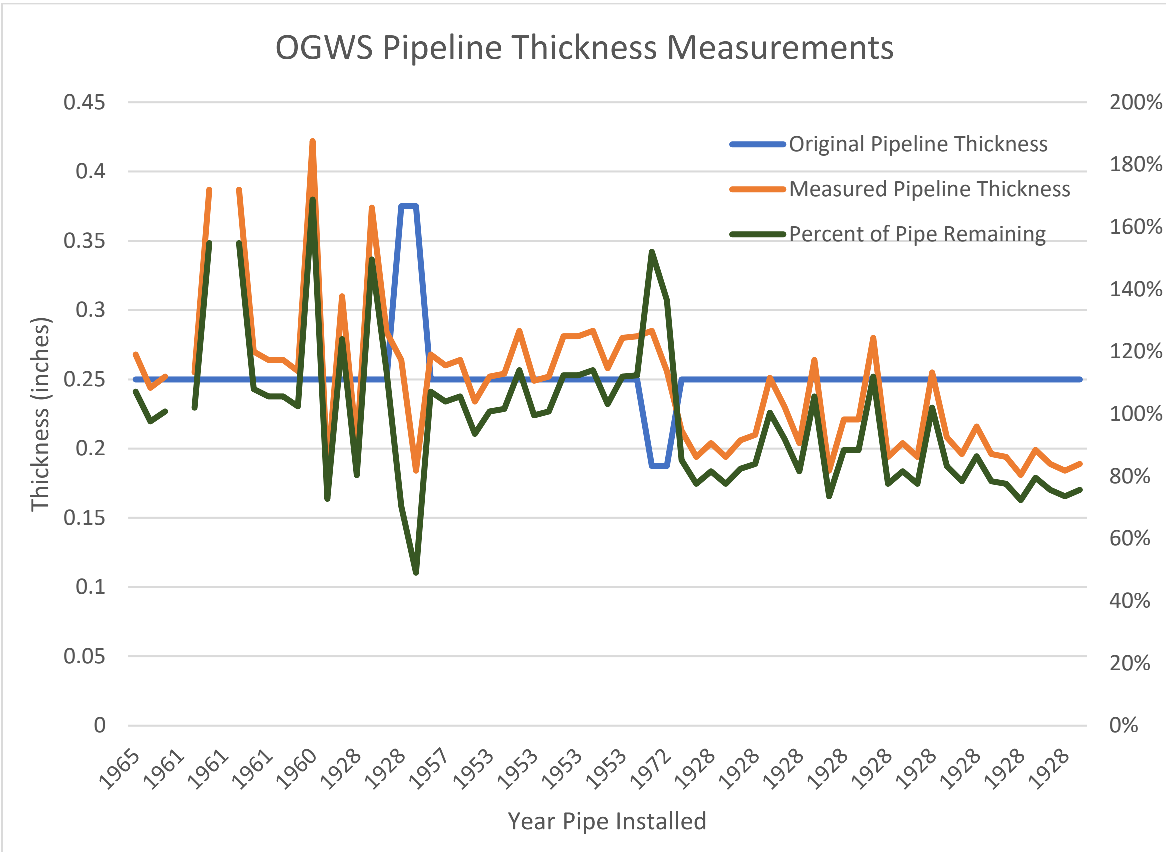


1928 Section Near Bayview – 30-inch Diam. With ¼” Wall – Thickness Measurements 4/22/19



1928 Section Between Les Schwab and Mill Road – 20-inch Diam. ¼” Wall – Thickness Measurements 4/19/19

Between 2019 and 2020 steel thickness measurements have been taken at 64 points along the transmission pipeline. Most measurements were taken at the top of the pipeline next to an air valve. Some of the measurements appear to be in excess of the original pipeline thickness, which is either due to problems with the measurement, coatings, welds, or rust nodules. The loss of pipeline thickness is most notable in the 1928 sections of the pipeline as record in the chart below.



Illustrating thickness condition versus age of pipeline

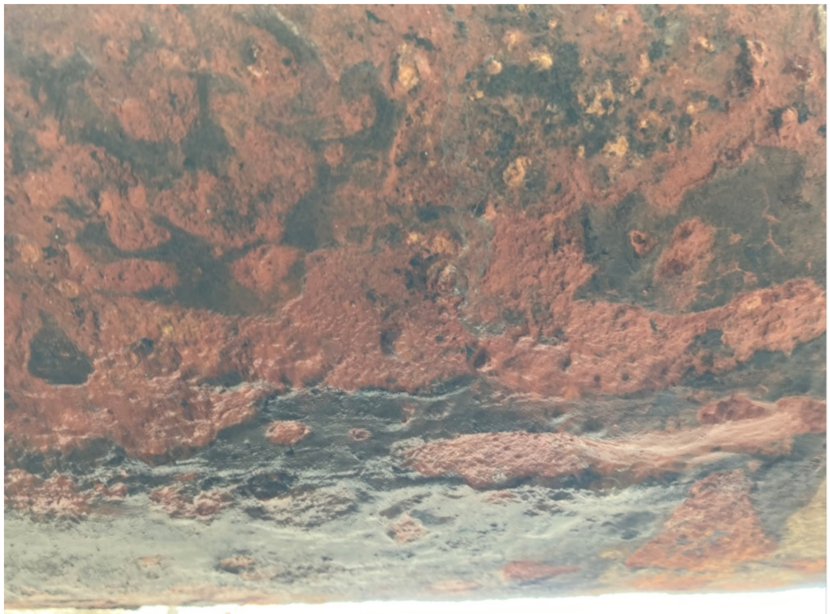
Most recently the pipeline was exposed at two locations in Section S for pipeline thickness measurements and at one location in Section T to replace a small section of pipe with pin hole corrosion leaks. These investigations included measuring thickness around the full circumference of the pipe. Soil samples were collected at the Section T location to assess the corrosion potential of the soils and determine if they may have been the cause of the leaks. Jacob's Engineering provided the following criteria for soil conditions.

- Soil Resistivity - Less than 2,000 ohm-cm is considered very corrosive, less than 10,000 ohm-cm is considered moderately corrosive, 10,000 to 30,000 is generally considered mildly corrosive. Corrosion is unlikely at resistivity values greater than 30,000 ohm-cm
- pH – Less than 6.5 is considered moderately corrosive; less than 5.5 is considered severely corrosive.
- Chlorides – of concern at concentrations greater than 100 ppm.
- Sulfates – any concentration can be a concern in wet soils (particularly wet, heavy clays) since sulfates support a certain type of corrosive bacteria.

In Section T at the connect with Section U the Amtest test results indicate the soil can be considered moderately to mildly corrosive. The soil resistivity indicates mildly corrosive conditions, while the pH indicates moderately corrosive conditions. The chloride and sulfate concentrations are both low, and these constituents are not considered a corrosive factor in this situation. Jacobs Engineering also assessed that bacterial induced corrosion was occurring inside a newer pipeline coupling where there was an absence of water flow.

The following photographs illustrate conditions at this particular location near the valve that separates the OGWS from the City Ductile Iron CT Pipeline.

1928 Section of Pipeline at City CT Connection – 20" Mitered bend approx. 10 feet from valve. Illustrates weld condition and coatings failure on exterior of pipe (LT) and interior weld corrosion and small coating failures on inside of pipe (RT).



1928 Section of Pipeline at City CT Connection – 20" underside of pipe 10 feet from valve. Illustrates pitting in steel measure at approximately 0.09 inches.

The general condition of the pipe appears to be consistent with the soil corrosivity tests. The general exterior condition of the exposed pipe did not appear to have significant metal loss, except for significant pitting and pipe penetration at the flange coupling adapter. As previously discussed, it is possible that the corrosion at the location was due to a site specific condition, such as microbial induced corrosion (MIC) or stray current. Some corrosion was also observed along the bottom of the pipe. Metal loss due to corrosion is often more concentrated on the bottom of a metal pipe due to higher probability of contact with groundwater, bedding conditions, and oxygen differential cells.

Cathodic Protection Systems

The OGWS pipeline needs additional rectifiers/anode beds installed to establish adequate protection in areas with little or no corrosion protection. A number of studies have been performed and cost estimates have been obtained to address this need. The following section provides a summary of these improvements.

Mill Continuity

The OWGS piping is electrically shorted to the Mill piping. There are two underground vaults at the turbine pump house, one on each side of the building, with isolation kits and bond wires inside the vaults. All isolation flange kits tested 100% effective. Until recently bond wires connected the mainline and bypass piping from one side of the building to the other, effectively shorting the mainline to the Mill piping. However, the piping remains shorted after all bond wires were disconnected. This testing indicates an electrical short still exists between the OGWS and Mill piping. The combination of piping at the mill is a large drain on the impressed current for transmission line protection.

Elks Area

Structure-to-soil potential data from the survey indicates the pipeline is not adequately protected at the majority of locations tested based on the impressed current -850 mV criterion for corrosion protection. The OGWS pipeline needs additional rectifiers/anode beds installed to establish adequate protection in areas with little or no protection. Previous surveys have indicated that the new rectifier would likely be in the vicinity of the Elks Club. A full corrosion protection survey should be completed after the pipeline has been electrically isolated from the Mill piping. The new data can then be used to determine protection levels across the pipeline and confirm the location requirement for an additional rectifier(s).

City Lake and Airport
The City Lake and Airport cathodic protection systems do not appear to have anode junction boxes for testing. This should be corrected to determine if the anodes are consumed or if there are connection issues in the circuit.

Pipeline between Big Quilcene Diversion and Snow creek
Impressed DC current drops off between Snow Creek and Andrews Creek after the southernmost rectifier at Crocker Lake. Cathodic protection between Snow Creek and the Big Quilcene diversion relies upon a limited number of galvanic sacrificial anodes along the pipeline.

The estimated cost to upgrade and repair the cathodic protection system is $145,000 in 2021 dollars as described below. These investments need to occur sooner than later and are suggested for 2022.

A new impressed current cathodic protection (CP) system has been recommended for installation in the vicinity of the Elks Club where protection is currently lacking. There are two types of recommended systems depending on budget and ability to excavate:

- **$90,000- $110,000** Anode Deepwell – Estimate includes the driller for the well (subcontractor), rectifier, anodes, anode components/hardware, junction box, installation support by construction foreman and all mob/demob costs, etc. for installation but does not include costs for trenching or power.
  $25,000-$35,000 Anode Distributed Bed – Estimate includes one pre-installation onsite visit for design measurements, a rectifier, anodes, anode components/hardware, construction foreman and all mobilization/demobilization costs, etc. for installation. Ideally, a distributed ground bed will be installed perpendicular to the pipeline and ~200 ft away. This allows for better distribution of the CP current. However, if installation is restricted to the right of way, it may require installing the ground bed horizontally along the pipeline.

Pipeline Investment Needs Summary
Based on the information available at this time the recommendation for the purposes of this analysis is to assume a 100 year life for the 1928 sections of pipeline. The newer sections of the pipeline may have a useful life beyond 100 years, but likely not more than 125 years. This assumption assumes that cathodic protection is actively working to protect the pipe as much as possible. Cathodic protection should be upgraded as soon as possible, or it will become less effective as the coatings and pipeline continue to deteriorate. At a minimum, a tier 2 evaluation of the pipeline condition and ongoing evaluations of the pipeline condition is recommended.

See OGWS CIP spreadsheet for OGWS pipeline capital improvement project funding for 1928 and 1952-1972 pipeline replacement.

Diversions

Big Quilcene Diversion
Overall, the Diversion Facility is in good condition and functioning well. Structural repairs in 2018 corrected known deficiencies and are expected to provide a projected 30-40 years of service life to the diversion. The

manual chores of screen cleaning and valve operation are concerns that should be addressed in future improvements.

The caretaker house and outbuilding are in only fair condition. The rotating screen house was totally rebuilt 20 or so years ago but the other buildings are 70-90 years old. The house roof has been replaced recently but due to the building's small size, would not provide a suitable residence for most families. If the caretaker function is continued at the Big Quilcene diversion the house and outbuildings should be replaced within the next 20 years.

The estimated cost for replacement of the Big Quilcene Diversion is $6,462,967 in 2021 dollars. The project should be planned to be initiated in 25 years to begin NFS permitting process that will likely take 5-10 years. The estimated cost for replacement of the house and outbuildings is $450,000 which should be planned for in 15 years.

Little Quilcene Diversion

Major reconstruction of the Little Quilcene River diversion occurred in 1995. Only minor repairs to the concrete structure from debris erosion and maintenance of the building structure are expected in the foreseeable future.

The estimate cost for capital improvements for this diversion is $50,000 in 2021 dollars and is planned for 30 years in the future.

Reservoirs

Lords Lake

The Lords Lake North Dam and East Dam are well maintained and operated according to the Washington State Department of Ecology Dam Safety Office. The condition assessment of the Lords Lake North Dam is considered to be Satisfactory. This condition assessment is in line with the system used by the National Inventory of Dams (USACE, 2008) to classify dams with no existing or potential dam safety deficiencies recognized.

The Lords Lake East Dam is considered to be in Poor condition. This condition assessment is in line with the system used by the National Inventory of Dams to classify dams with a dam safety deficiency recognized for loading conditions which may realistically occur, and remedial action is necessary. This assessment is based on the East Dam not meeting the minimum stability requirements under seismic loading.

The Washington Department of Ecology Office of Dam Safety is requiring the City to have an engineering consultant develop alternatives to improve the stability of the East Dam under seismic loading conditions to ensure the dam meets the minimum stability requirements as per the dam safety guidelines; and, to reduce earthquake-induced embankment deformations to minimize the risks of an uncontrolled release of the reservoir contents. The estimated cost of the engineering study is $250,000 and improvements $4 million.

Security at Lords Lake is an ongoing concern due to its remote location and limited staff visits. The lake is an attractive nuisance primarily due to fishing, even though it is closed to public access. Vandalism of the fence around the lake is frequent problem. Incorporating remote monitoring/alarms and stepped-up prosecution could reduce the trespassing and damage.

The estimated cost for security improvements at Lords Lake is $10,000 for cameras and replacement of half the fencing in 20 years at $100,000.

City Lake

Recent improvements to City Lake outlet piping replaced much of the infrastructure between the lake and screen room. However, drain lines from the caretaker's yard to Discovery Bay and screen chamber piping date back to 1928. In addition, the City Lake bypass line was installed in 1954 and inlet piping in 1964. The screen room will eventually have to be replaced as the concrete basins are eroding from cleaning. Incorporating automated screen cleaning should be considered when upgrading or replacing the screen room. The caretaker house is in only fair condition. Due to the building's small size it would not provide a suitable residence for most families. If the caretaker function is continued at City Lake the house and outbuildings should be replaced within the next 20 years.

The estimate cost for capital improvements for the City Lake house, screen chamber and outbuildings is $650,000 in 2021 dollars and is planned to occur in 15 years. Fence repairs at City Lake are estimated at $100,000 during the next 20 years

Equipment Needs

Additional equipment such a dump truck, backhoe and articulating brush cutter would allow the pipeline crew members to accomplish more maintenance along the pipeline, saving time and equipping them to undertake larger jobs. The PTPC has funded all equipment purchases for the OGWS maintenance in the past.

The estimate capital cost for equipment is $90,000 in 2021 dollars and is planned to occur in five years.

Spare Part Needs for Reliability

PTPC maintains a variety parts on hand to expedite pipeline repairs. The materials listed below provide coverage to deal with the common types of pipeline leakage. WAWARN organizations could also be a potential source of replacement parts in an emergency. A large scale system failure from an event like an earthquake would require Federal and State assistance.

OGWS Transmission Line Spare Parts	
Number	**Item**
3	1/0 Bonding wires
1	1" Air valve
8	20" Backing flange
14	24" Backing flange
6	28" Backing flange
28	30" Backing flange
3	36" Backing flange
6	24" Romac coupler (complete)
4	30" Romac coupler (complete)
14	30" Romac coupler (middle)
3	24" X 30" Romac reducer
1	20" Repair band
1	30" Repair band

2	30" X 40' Pipe section
2	36" X 4' Pipe spool
2	Wax tape corrosion protection kits

Most emergency excavation requests have been handled by PTPC contracting with local construction firms. The City of Port Townsend has heavy equipment such as backhoes and dump trucks that could also be used in an emergency.

Purchasing an additional 80 feet each of 24” and 30” steel pipeline would improve the ability to respond to pipeline failures. Spare piping should be stored under cover to preserve the coatings. The estimated cost for purchasing 160’ of new pipe is $22,000 and should be purchased in 2023 after a condition assessment is completed.

Summary of Capital Investments to Offset Operational Costs

Manual control of the water system, equipment shortfalls, and lack of automated monitoring capability has led to excessive time spent in hands-on operation and commuting between facilities. Capital improvements that would provide time and possible future cost savings include:

- Automated control valves at the Big Quilcene Diversion, Little Quilcene Diversion, and Lords Lake. This would allow an operator to remotely make adjustments and avoid having to commute between facilities.
- Telemetry for remote monitoring of the Little Quilcene River stream flow.
- Telemetry for Big and Little Quilcene diversion meter monitoring.
- Remote security system monitoring of diversions, Lords Lake and City Lake facilities.
- Automated screen cleaning of Big and Little Quilcene diversions.
- Clearing large trees from rights-of-way and improvements in vegetation management.
- Establishing a clear marking of the right of way and a systematic vegetation control program.

Summary Capital Investments Driven by Regulatory Agencies and Environmental Factors

The Washington Department of Ecology Office of Dam Safety is requiring the City to conduct an engineering evaluation to develop alternatives to improve the stability of the East Dam as described above. The City is planning to contract with an engineer in 2022 for this study at an estimated cost of $250,000.

Future reconstruction of the Big Quilcene River diversion is likely to trigger a requirement for resident fish passage around the diversion as was required for the Little Quilcene diversion reconstruction.

Lords Lake Expansion

Climate change is predicted to reduce watershed snowpack and summertime stream flows. Reservoir storage and/or conservation will be required to meet industrial demand for the predicted change in stream flow timing. Historically water withdrawals from Lords Lake began between late August to early October and, without significant rainfall, could continue for two and a half months before Lords Lake was empty. Fall rains that typically replenished stream flows by mid-October provided an adequate buffer in reservoir storage. Increasingly the historical precipitation patterns have shifted and it has been necessary to draw down Lords Lake earlier leaving less of a buffer. One possible solution would be to expand the capacity of Lords Lake. A study in 2001 examined a couple of alternatives including doubling the size of the reservoir for approximately $5 million at that time, which would be an estimated $9.3 today.

Increasing the capacity of Lords Lake would incorporate necessary stability improvements for the east dam, potentially making the expansion more cost effective. An evaluation of the expansion size should be one of the first steps. As part of the dam improvements, consideration should be made for the modification of the transmission line connection to Lords Lake. Changing the lake outlet configuration could allow simultaneous filling of Lords Lake and City Lake. A future Little Quilcene diversion Lords Lake bypass line may be needed as well.

The cost estimate for the Lords Lake east dam retrofit will be determined with an engineering study in 2022 as required by the Department of Ecology. For the purposes of this capital white paper the estimated cost is $4,000,000. Cost to retrofit this dam could be offset by FEMA hazard mitigation grants. If the partnership decides to combine retrofit of the east dam with raising the height for future capacity improvements the cost is estimated at $6,000,000 in 2021 dollars.

Capital Investment for Current System Capacity Improvements

The OGWS does not need substantial capacity improvements to address anticipated system growth. However, there are some capacity improvements to address current deficiencies. The following section identifies these improvements that will improve the operations of the system. Some of these improvements could also support the addition of the Tri-Area Customer base.

- During certain times of the year or when demand of both the City and the Paper Mill are at their highest, the inlet pressure to the City's Water Treatment Facility declines below the threshold required for plant operation. If pressure drops below the treatment plant PRV setpoint the valve ceases to work for a period of time until after pressure is restored. Loss of pressure in the transmission line at flows above 14 mgd restricts plant production and may trigger the filters to shut down. The following solutions can address this operational and capacity restriction.
  - Change flushing flow rate into the Mill to decrease 5-10 minute demand spikes.
  - Add a reservoir tank to support Mill flushing operations.
  - Replace 6,100 feet of 24-inch sections of steel pipeline north of City Lake Screens coincident with the Olympic Discovery Trail development. The pipe replacement in 2021 dollars is estimated at $4.7m. Much if not all of the costs could be offset by grants for the Olympic Discovery Trail development. The City is in the process of requesting grant funding for a portion of a $24 million to build the section of the ODT between Anderson Lake and Discovery Bay which includes purchase of Rayonier Timber property and installation of a new pipeline to be placed under the trail.
  - Install a booster pump at the inlet to the Port Townsend Water Treatment Facility at an estimated cost of $450,000.

- OGWS transmission pipeline connection at Lords Lake does not allow the simultaneous filling of City Lake and Lords Lake. When the valve is only partially closed downstream of Lords Lake to create backpressure on the line to direct water to Lords Lake and City Lake, there is cavitation in the pipeline downstream of the valve. Installation of flow control valves at the appropriate locations in the pipeline can provide the operators with the ability to fill both reservoirs at the same time and to run the system at a level of higher efficiency. The cost in 2021 dollars is estimated at $2,500,000 for this work.

Capital Needs for Growth or to Address Water Supply

Growth in water demand was analyzed in the Planning and Environmental White Paper. Based on this analysis, there are no capital investment needs to expand the current OGWS system to accommodate growth for either the PTPC or the City of Port Townsend. The only exception to this conclusion would be if the City was to add wholesale water delivery to the Tri-Area. The addition of the Tri-Area would require system analysis to determine if the transmission system could handle the increased maximum day demand as future storage requirements.

Alternatively, as described in the Assets white paper, if PTPC were to leave the partnership, the system could easily accommodate the Tri-Area demand. Additionally, if conservation by the PTPC and the City result in reduced Maximum Day Demand, this could also result in adding the Tri-Area to the system without the need for capital expansion. The following description of the City and Tri-Area illustrate the total water demand if they were added without considering conservation.

With a growing population Port Townsend municipal water use is anticipated to increase at 1.12% compounded rate through 2039, while PTPC's water demand is not expected to increase in their current planning horizon. At the City's full build out, including PTPC industrial demand, water consumption is projected to be around 17 mgd. Available water resources are in excess of 20 mgd, however, the maximum flow possible in the transmission system is approximately 20 mgd. The difference between system capacity and projected use could be marketed to other water purveyors to help offset OGWS capital and operation costs as outlined in the Planning and Environmental White Paper. Most of the Quimper Water System was previously served with surface water from the OGWS and, with the necessary water treatment, could be served again. In order for this to happen Section Q of the transmission pipeline north of City Lake will have to be addressed to resolve ongoing pressure problems at the Port Townsend Water Treatment Facility, which would be exacerbated by the additional Tri-Area water demand. Lords Lake reservoir expansion may also be required to compensate for the lack of water availability during the dry months

Projected Water Demand (mgd)	2020	2030	2040
City of Port Townsend Water System			
ERUs	8,290	9,276	10,379
ADD	1.01	1.13	1.27
MDD	2.12	2.38	2.66
PUD Quimper Water System			
ERUs	5,588	6,807	7,884
ADD	0.887	1.080	1.251
MDD	1.987	2.421	2.804
Total Projected Demand			
ERUs	13,878	16,083	18,263
ADD	1.898	2.212	2.517
MDD	4.111	4.797	5.463

For the purposes of this white paper, no capital investments for system growth are planned. The partners anticipate that if the Tri-Area were added to the OGWS system by brining on the PUD as a third partner, a re-evaluation of system improvements would be necessary as part of a partnership negotiations between the PUD and City and City and PTPC.

Reserves and Unanticipated Capital

Reserves for unanticipated capital repairs or unforeseen conditions impacting the cost of capital are required. These reserves also will be necessary for the issuance of debt. Determination of the appropriate reserve level will be determined based on the following factors.

- Annual Operation Cost – 90 days of operations
- Emergency repairs and unanticipated capital - $1,000,000
- Reserves required for adequate bond rating – To be determined

Reserves are typically allowed to be nested and reserves typically required for bonding are greater than operational and emergency reserves. In addition, typically net annual revenue needs to be 1.25 times the sum of all debt payments to meet bond coverage factors. This section of the whitepaper will be addressed with the assistance of bond counsel and is subject to change.

Capital Improvement Program

The Capital Improvement Plan provides a working blueprint for sustaining and improving the OGWS infrastructure. It is a dynamic planning and fiscal management tool used to coordinate the location, timing, and financing of capital improvements over a multi-year period. As a working document it will be reviewed and updated regularly to reflect changing needs, priorities, and funding opportunities.

An estimated $161 million in current value infrastructure and other capital assets will need to be refurbished or replaced within the next 40 years, which includes setting aside funds beginning in 2037 to be held in reserve to implement a 125 year replacement schedule for the transmission pipeline installed between 1952 and 1972. This capital improvement program estimates an investment of $64 million in the next 20 years. The cost and replacement schedule are provided in the OGWS CIP tables below.

OGWS Capital Improvement Projects

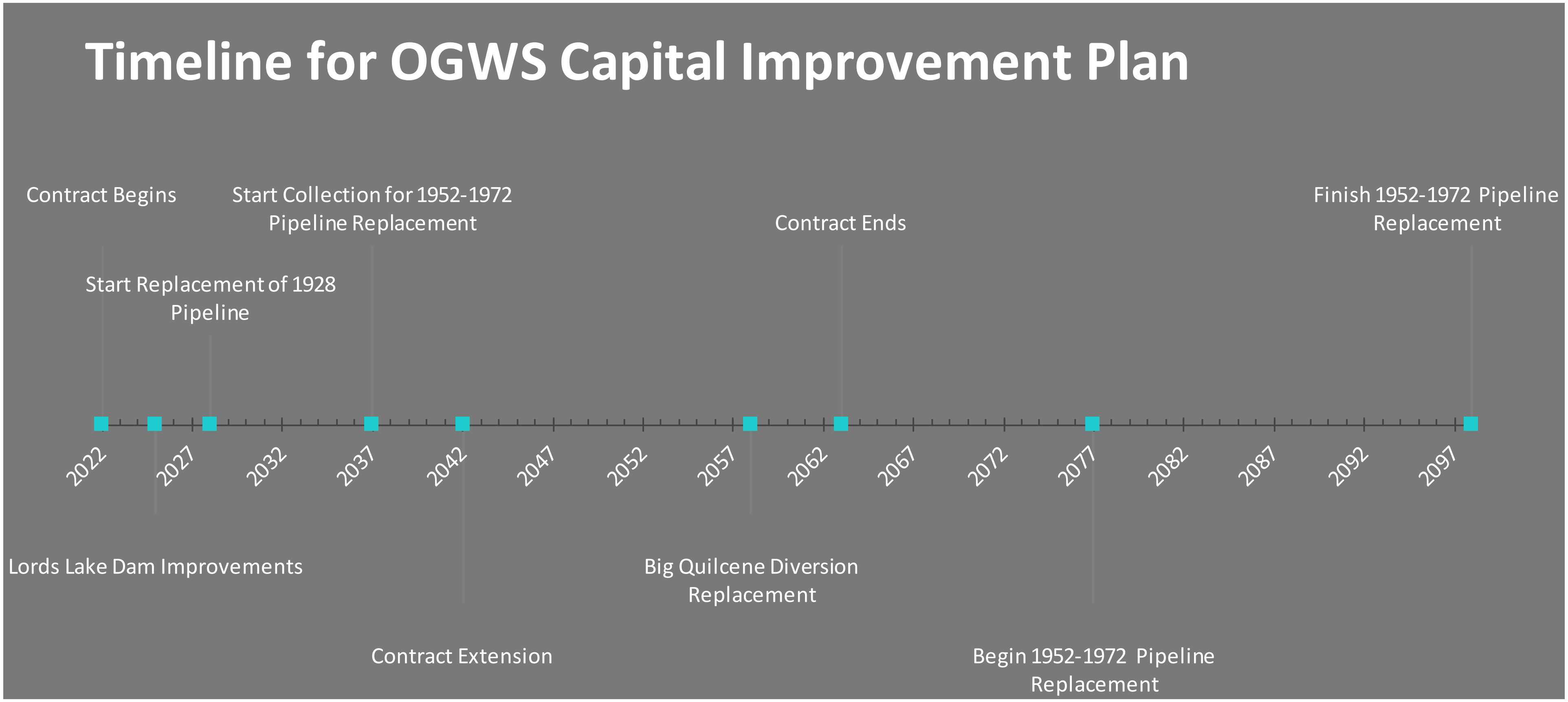
	Inflation Rate	3.2%										
	Current value											
Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Pipeline and Appurtenances												
Easement survey marking	$ 50,000											
Vegetation clearing - contracted	$ 75,000		$ 79,877							$ 99,581		
Road maintenance	$ 25,000										$ 34,256	
Culvert replacement (5 culverts per 5 years)	$ 25,000					$ 29,264					$ 34,256	
Land swaps - easement right purchases (2051)	$ 200,000							$ 249,338				
Air Valves and Boxes (25)	$ 125,000					$ 146,322						
Cathodic Protection	$ 145,000	$ 149,640										
Condition assessment	$ 500,000		$ 532,512									
Steel Pipe Replacement (1928) Phase 1 (High Pressure Sections)	$ 21,965,168					$ 800,000	$ 800,000	$ 800,000	$ 800,000	$ 24,915,507		
Steel Pipe Replacement (1928) Phase 2	$ 13,184,808											
Steel Pipe Replacement Sinking Fund (all other sections)	$ 99,969,551											
Diversions												
Big Quilcene Diversion Replacement (2058)	$ 6,462,967											
Big Quilcene Diversion House and Buildings (2036)	$ 450,000											
Little Quilcene Diversion Rehabilitation (2051)	$ 50,000											
Reservoirs												
Lords Lake Security Cameras	$ 10,000		$ 10,650									
Lords Lake Fencing Replacement	$ 100,000											
City Lake Fencing	$ 100,000											
City Lake House and Outbuildings (Year?)	$ 650,000											
Equipment												
Tractor, Mower, Backhoe?	$ 90,000					$ 105,352						
Spare Parts												
Pipe (4 sections 24")	$ 13,570		$ 14,452									
Pipe (4 sections 30")	$ 7,300		$ 7,775									
Regulatory Capital Needs												
Lords Lake East Dam Engineering Assessment	$ 250,000	$ 258,000										
Lords Lake East Dam Rehabilitation	$ 4,000,000		$ 200,000	$ 200,000	$ 4,083,394							
Capital Needs Operations and Current Capacity Improvements												
Lords Lake Expansion (in addition to east dam rehab)	$ 5,300,000											
Lords Lake Pipeline Improvements	$ 2,500,000				$ 2,835,690							
Capital Needs for Growth (Including adding Tri - Area)												
Section Q 24" Pipeline Replacement and Upsizing	$ 4,680,417											
Reserves and Unanticipated Capital												
Periodic Investment into Emergency Reserve												
Totals	$ 160,928,781	$ 407,640	$ 845,266	$ 200,000	$ 6,919,084	$ 1,080,938	$ 800,000	$ 1,049,338	$ 800,000	$ 25,015,088	$ 68,512	$ -

OGWS Capital Improvement Projects

Project	Inflation Rate Current value 2021	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043-2062 in 2043$
Pipeline and Appurtenances												
Easement survey marking	$ 50,000										$ 96,882	
Vegetation clearing - contracted	$ 75,000					$ 124,147						$ 449,921
Road maintenance	$ 25,000									$ 46,939		
Culvert replacement (5 culverts per 5 years)	$ 25,000				$ 40,099					$ 46,939		$ 99,982
Land swaps - easement right purchases (2051)	$ 200,000											
Air Valves and Boxes (25)	$ 125,000											
Cathodic Protection	$ 145,000											
Condition assessment	$ 500,000											
Steel Pipe Replacement (1928) Phase 1 (High Pressure Sections)	$ 21,965,168											
Steel Pipe Replacement (1928) Phase 2	$ 13,184,808		$ 600,000	$ 600,000	$ 600,000	$ 600,000	$ 18,423,294					
Steel Pipe Replacement Sinking Fund (all other sections)	$ 99,969,551											$ 234,631,849
Diversions												
Big Quilcene Diversion Replacement (2058)	$ 6,462,967											$ 12,923,654
Big Quilcene Diversion House and Buildings (2036)	$ 450,000		$ 36,000	$ 36,000	$ 606,300							
Little Quilcene Diversion Rehabilitation (2051)	$ 50,000											$ 99,982
Reservoirs												
Lords Lake Security Cameras	$ 10,000											
Lords Lake Fencing Replacement	$ 100,000									$ 187,756		
City Lake Fencing	$ 100,000									$ 187,756		
City Lake House and Outbuildings (Year?)	$ 650,000		$ 50,000	$ 50,000	$ 882,182							
Equipment												
Tractor, Mower, Backhoe?	$ 90,000											
Spare Parts												
Pipe (4 sections 24")	$ 13,570											
Pipe (4 sections 30")	$ 7,300											
Regulatory Capital Needs												
Lords Lake East Dam Engineering Assessment	$ 250,000											
Lords Lake East Dam Rehabilitation	$ 4,000,000											
Capital Needs Operations and Current Capacity Improvements												
Lords Lake Expansion (in addition to east dam rehab)	$ 5,300,000											
Lords Lake Pipeline Improvements	$ 2,500,000											
Capital Needs for Growth (Including adding Tri - Area)												
Section Q 24" Pipeline Replacement and Upsizing	$ 4,680,417											
Reserves and Unanticipated Capital												
Periodic Investment into Emergency Reserve												
Totals	$ 160,928,781	$ -	$ 686,000	$ 686,000	$ 2,128,581	$ 724,147	$ 18,423,294	$ -	$ -	$ 469,390	$ 96,882	$ 248,205,388

OGWS Pipeline Replacement Capital Improvement Project Funding (1952-1972 Pipeline)																		
		Inflation Rate		3.2%		53												
		Current Value	Repl. Date															
Pipeline Segment	Install Date	2021		2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
A	1965	$ 3,646,007	2090	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 801,045	$ 801,045
B	1963	$ 9,210,663	2088	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075
C	1961	$ 10,571,550	2086	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665
D	1960	$ 13,132,908	2085	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913
E	1958	$ 11,854,873	2083	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191
F	1958	$ 9,661,061	2083	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574
G	1954	$ 4,145,239	2079	$ -	$ -	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039
H	1957	$ 3,790,034	2082	$ -	$ -	$ -	$ -	$ -	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209
J	1967	$ 362,853	2092	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L	1957	$ 1,768,695	2082	$ -	$ -	$ -	$ -	$ -	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033
M	1957	$ 2,291,648	2082	$ -	$ -	$ -	$ -	$ -	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336
N	1957	$ 4,847,718	2082	$ -	$ -	$ -	$ -	$ -	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826
O	1964	$ 6,522,384	2089	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,388,564	$ 1,388,564	$ 1,388,564
P	1952	$ 4,680,417	2077	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791
Q	1952	$ 4,680,417	2077	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791
R	1972	$ 3,409,060	2097	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
X	1956	$ 5,394,025	2081	$ -	$ -	$ -	$ -	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555
Total		$ 99,969,551		$ 1,365,581	$ 1,365,581	$ 2,009,620	$ 2,009,620	$ 2,902,175	$ 5,070,578	$ 8,862,344	$ 8,862,344	$ 11,327,256	$ 13,374,922	$ 13,374,922	$ 15,274,996	$ 16,663,560	$ 17,464,604	$ 17,464,604

OGWS Pipeline Replacement Capital Improvement Project Funding (1952-1972 Pipeline)														
		Inflation Rate												
		Current Value	Repl. Date											
Pipeline Segment	Install Date	2021		2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062
A	1965	$ 3,646,007	2090	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045	$ 801,045
B	1963	$ 9,210,663	2088	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075	$ 1,900,075
C	1961	$ 10,571,550	2086	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665	$ 2,047,665
D	1960	$ 13,132,908	2085	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913	$ 2,464,913
E	1958	$ 11,854,873	2083	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191	$ 2,089,191
F	1958	$ 9,661,061	2083	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574	$ 1,702,574
G	1954	$ 4,145,239	2079	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039	$ 644,039
H	1957	$ 3,790,034	2082	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209	$ 647,209
J	1967	$ 362,853	2092	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904	$ 84,904
L	1957	$ 1,768,695	2082	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033	$ 302,033
M	1957	$ 2,291,648	2082	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336	$ 391,336
N	1957	$ 4,847,718	2082	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826	$ 827,826
O	1964	$ 6,522,384	2089	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564	$ 1,388,564
P	1952	$ 4,680,417	2077	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791
Q	1952	$ 4,680,417	2077	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791	$ 682,791
R	1972	$ 3,409,060	2097	$ -	$ -	$ -	$ -	$ -	$ 933,752	$ 933,752	$ 933,752	$ 933,752	$ 933,752	$ 933,752
X	1956	$ 5,394,025	2081	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555	$ 892,555
Total		$ 99,969,551		$ 17,549,508	$ 17,549,508	$ 17,549,508	$ 17,549,508	$ 17,549,508	$ 18,483,260	$ 18,483,260	$ 18,483,260	$ 18,483,260	$ 18,483,260	$ 18,483,260


Timeline for OGWS Capital Improvement Plan
Contract Begins
Start Collection for 1952-1972 Pipeline Replacement
Contract Ends
Finish 1952-1972 Pipeline Replacement
Start Replacement of 1928 Pipeline
2022
2027
2032
2037
2042
2047
2052
2057
2062
2067
2072
2077
2082
2087
2092
2097
Lords Lake Dam Improvements
Big Quilcene Diversion Replacement
Contract Extension
Begin 1952-1972 Pipeline Replacement

Conclusion

The Capital White paper takes a pragmatic look at capital investment needs to support continued operation of the system for the next 100 years with a focus on the next 40 years. Furthermore, additional details are addressed in the planning horizon of 20 years in order to facilitate expeditious and financially responsible planning. Capital needs will undoubtedly change over time and thus continuous review and assessment of the system is required to make timing adjustments over time. The capital program in this white paper is as realistic as possible based on the best information available at this time, neither conservative nor aggressive. Economic conditions, availability of grants, and the actual condition of the pipeline will have an impact on the capital program.

This capital program will be inserted into a utility rate model to create a sustainable estimate for revenues necessary to support the investments to be included.

References

1. Pipeline Replacement Matrix spreadsheet
2. Estimated Cost of Potential, Future Desalination Water Treatment Plant, Jacobs April 13, 2021
3. OGWS Section S Wall Thickness Testing 4/22/19
4. OGWS Section T Wall Thickness Testing 4/19/19
5. Soils Analysis – Re: AmTest Data email 4/13/2021
6. Big Quilcene River Diversion Dam – Structural Condition Assessment, HDR 12/7/2016
7. Olympic Gravity Water System – Pipeline Replacement Opinion of Cost, HDR 10/11/2016
8. OGWS Opinion of Cost – Attachments A & B, HRD 2015
9. Hydraulic Analysis TM, HDR 2010
10. OGWS Hydraulic Grade Profile, HDR 2010
11. Olympic Gravity Water System Estimated Replacement Cost Draft Report, RW Beck 4/20/2000
12. Engineering Evaluation and Preliminary Cost Estimate Increased Reservoir Capacity Lords Lake CDM 3/15/2001
13. 2020 DOE Dam Safety Letter – Lords Lake
14. Technical Memorandum: Impact of Key Factors on Planning the Eventual Systematic Replacement of the OGWS Pipeline, Jacobs April 27, 2021
15. OGWS Capital Improvement Projects