

Exhibit D

**Distribution and
Distribution-Transport Mains
Asset Management Plan**

Excerpt

EXCERPT

Portland Water Bureau
Asset Management Plan For

Distribution and Distribution-Transport Mains

July 2012



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1. Introduction and Asset Profile

The purpose of this Asset Management Plan is to provide information that will assist PWB in maintaining more than 2,000 miles of distribution piping in a rational and cost-effective manner.

The distribution mains asset group contains some of the oldest PWB assets, including some pipes that are more than 120 years old. There is also a variety of piping materials. The vast majority of pipes are cast iron or ductile iron, but there are also pipes made of steel, polyvinyl chloride (PVC), high-density polyethylene (HDPE), copper, concrete cylinder, asbestos cement, and other miscellaneous materials. Pipe sizes vary from 3/4-inch pipes that supply a single service to 40-inch mains that deliver water to large sections of the city. This variety of pipe characteristics and the large number of individual assets makes the distribution mains a challenging asset group to manage and maintain.

Asset Category	Distribution	Asset Sub-Category	Distribution and Distribution-Transport Mains
AMSC Champion	Ty Kovatch	Budget Program Lead	Charles Smith
AMP Lead or Co-Lead	Dave Evonuk, and Jeff Leighton	Support	Holly Walla, Vill Villanueva, Teri Liberator, Crystal Yezman, Jennifer Gardner
Plan Author	Dave Evonuk and Jeff Leighton	Version Number	3
Last Reviewed	July 2012	Next Review	July 2015

1.1. Definition

PWB has classified water mains within the City of Portland's water system into six categories: collection mains, conduits, transmission, distribution-transport, site piping, and distribution. **Collection mains** bring untreated water to treatment sites. **Conduits** convey treated Bull Run water to the 162nd Ave Interties with the In-town system. **Transmission mains** are pipes that carry water from the Groundwater Pump Station site or the 162nd Avenue Interties to all the Terminal Storage reservoirs in the City, and to large wholesale customers west of Portland (such as the Washington County Supply Line). The primary purpose of **Distribution-Transport mains** is to move water from terminal reservoirs to pump stations, tanks or other distribution supply facilities, or between these distribution supply facilities. Although the Construction and Maintenance Group is responsible for repairing these pipes, the Operations Group is involved in ensuring that adequate water supply is maintained during shutdowns and Operations inspects and maintains appurtenances on these lines, such as valves. **Site piping** includes pipe that exists on city owned property that moves water around the site and between facilities located at that site. It is considered a child asset to the site itself and is operated and maintained with repair, renewal and upgrades to it being charged as a cost against the site. **Distribution mains** are all other pipes in the system. They are typically smaller in diameter than the

transmission and distribution-transport mains and deliver water directly to individual services. The term "critical mains" has been proposed as a subset of the distribution and distribution-transport mains. Critical mains are those that pose a greater risk to, or are more critical for, supplying a larger number of key customers or that pose a greater risk to the PWB or its customers if one should fail. Examples of critical mains are those located on bridges, under freeways, in landslide-prone areas and soil liquefaction zones. Critical mains may also be the sole supply to a large number of service connections.

This asset management plan (AMP) primarily covers the distribution-transport and distribution mains; transmission mains are covered in a separate AMP. A number of other appurtenances associated with distribution mains are also addressed in this AMP:

- Pipe fittings (tees, crosses, etc.) Generally considered as a component of the pipe itself, not separate assets.
- Miscellaneous valves (air release, blowoff). Only treated as separate assets for distribution transport or critical mains. They are treated as components of the pipe for distribution mains since no separate maintenance programs are recommended for them.
- Line valves on the distribution-transport mains and critical mains. Valves on ordinary distribution mains are covered in a separate AMP.
- Corrosion control
- Pipe coatings and linings - these are features of a pipe and help to distinguish its expected life, but are not separate assets.
- Polyethylene tube wrapping or pipe encasement -same as above. Features that affect useful life.
- Casings surrounding the main line - a pipe feature that affects its installation cost, consequences of failure and useful life; not treated as a separate asset.

System line valves (gate and butterfly valves) on distribution mains, hydrants, meters, and service lines are all addressed in other AMPs.

1.2. Purpose

Distribution mains primarily deliver water from terminal storage locations to retail water customers and wholesale water meters. The distribution piping system also supplies water to fire services and hydrants for fire protection. Adequately sized pipelines provide enough flow capacity to manage pressure loss in the piping system. This, along with the water elevation level in storage tanks and reservoirs, and pressure-reducing valves in the distribution piping system all help to provide adequate water pressure. The interconnection of distribution piping helps to maintain target water quality levels.

3.3. Physical Parameters

3.3.1. Inventory

GIS was used to determine the length of distribution main by material (Table 3-1). The majority of pipes are cast iron (CI) and ductile iron (DI)--making up 95% of all pipe. Most new pipe installations are DI. DI pipe has a wall thickness similar to CI pipe from the 1950s, but DI is stronger and more ductile, making it less susceptible to brittle rupture.

A comparison with similar data from 2005 in the 2006 Mains AMP shows how the makeup of the system is changing (2005 data from the 2006 AMP is used as a comparison to data from 2011). The percentage of the system that is cast iron has decreased from 70% to 65%, while ductile iron has increased from 25% to 31%. This is expected to continue into the future. The percentage of steel and galvanized steel pipe has dropped significantly (3.8% to 2.7%). This trend is expected to continue as well.

Table 3-1. Length of Active Distribution Main by Material as of February, 2011

Material	Length (feet)	Length (miles)	% of Total Length (2011)	% of Total Length (2005)
Cast Iron	7,119,216	1,348.3	64.94	69.63
Ductile Iron	3,417,157	647.2	31.17	25.24
Steel	178,502	33.8	1.63	2.07
Galvanized Steel	111,870	21.2	1.02	1.71
Polyvinyl Chloride (PVC)	44,239	8.4	0.40	0.21
Concrete Cylinder (CCP)	38,329	7.3	0.35	0.22
Unknown	28,984	5.5	0.26	0.22
High Density Polyethylene (HDPE)	8,777	1.7	0.08	0.01
Copper	6,600	1.2	0.06	0.06
Asbestos Concrete/Transite	5,054	1.0	0.05	0.15
Plastic	3,033	0.6	0.03	0.04
Other	666	0.1	0.01	0.00
Total	10,962,427	2,076.2		

3.3.1.1. Changes to Definitions for Types of Pipe

Between 2005 and 2011, the bureau has made changes to the definition of transmission, distribution and distribution transport. Some of this work is still in progress in GIS. New sites and projects have also been mapped that were not previously in the GIS system. These changes in definition of piping systems and additions and improvements to GIS since 2005 are reflected in the inventory numbers in Table 3-1. These changes are or will soon be reflected in other data systems as well, such as the CMMS and Team Plan.

In GIS a pipe segment is defined as the space between two other system elements such as a hydrant, fitting, or valve. Each pipe has a unique facility ID number and set of attributes and

4.3. Status and Condition Report

Section 4.1 provided narrative descriptions for rating the condition or likelihood of failure for pipes when more is known about the pipe besides just age. However, because it is impractical and extremely difficult to visually inspect pressurized water pipes, the condition for most pipes is based on the estimated percentage of remaining useful life.

As 95% of the PWB distribution main inventory is of CI and DI materials, the useful life for these classes of pipes was initially estimated based on the material, installation era, and/or diameter. This estimate is listed in Table 4-2.

The information in Table 4-2 was taken from Table 4.1.A in the 2009 Status & Condition Report. This assessment uses a scale that is similar to the 1-5 scale described in Section 4.1 for the Likelihood of Failure.

Table 4-2. Pipe Condition by Material and Age from 2009 Status and Condition Report^{a, b}

Material / Category	Size	Miles	Useful Life (yrs)	Mains Condition (percent)				
				Very Good	Good	Fair	Poor	Very Poor
Cast Iron	≤ 6"	509	150-200	---	40%	55%	5%	---
Cast Iron	8" - 14"	757	150-250	---	45%	53%	2%	---
Cast Iron	≥16"	10	200-250	---	45%	53%	2%	---
Ductile Iron	≤ 6"	304	150	40%	58%	---	2%	---
Ductile Iron	8" - 14"	268	150	42%	56%	---	2%	---
Ductile Iron	≥16"	10	200	35%	63%	---	2%	---
Steel	≤ 6"	10	65	---	20%	15%	50%	15%
Steel	8" - 14"	5	65-150	---	20%	15%	55%	10%
Steel	≥16"	3	65-150	---	40%	10%	45%	5%
Galv. Steel	All sizes	25	65	---	---	20%	40%	40%
Other/Unknown	≤ 6"	10	65-150	---	30%	50%	10%	10%
Other/Unknown	8" - 14"	2	65-150	5%	30%	50%	10%	5%
Other/Unknown	≥16"	5	65-150	5%	80%	5%	5%	5%
Pipes on Bridges	All sizes	10	150	50%	30%	10%	5%	5%
Vulnerable Mains	≤ 6"	25	150	15%	50%	30%	5%	---
Vulnerable Mains	8" - 14"	25	150	15%	50%	33%	2%	---
Dist Transport	All sizes	190	200	15%	45%	25%	10%	5%
Pump Mains	All sizes	30	65-200	10%	60%	15%	10%	5%
TOTAL MAINS		2,198		14%	47%	32%	6%	2%

^aSome pipes, such as vulnerable mains or pump mains, may have been counted twice in the total mains mileage.

^bRating scale: 1 = Very Good: ≥ 90% of more useful life remaining; 2 = Good: ≥ 60 to < 90% of useful life remaining; 3 = Fair: ≥ 30 to < 60% of useful life remaining; 4 = Poor: ≥ 10 to < 30% of useful life remaining; 5 = Very Poor: < 10% of useful life remaining

4.4. Condition Based on Age

As noted, the estimated useful life of CI pipe is 250 years and 150 to 200 years for DI pipe. The estimated useful lives shown in Table 4.3.1 for various pipe classes was similar to DIPRA estimates but were adjusted to the higher limit because of the absence of corrosive soils around the pipe and the excellent quality of the water carried by the pipe. Each main classification is then given a condition rating based on the estimated percentage of remaining useful life.

The 2008 mains AMP and 2009 S&C report used the following scale to rate pipe condition:

There is a concern about the condition of large steel pipes with Dresser joints, primarily due to the difficulty of ascertaining and maintaining electrical continuity at the joints. Such pipes were installed in greater lengths between about 1930 and 1970. PWB has documented causes of failure such as uncoated or poorly coated Dressers, with joint hold backs that were not coated in the field during installation, and cathodic protection discontinuity at joints. PWB has observed that these pipes leak at the joints more frequently than steel pipes that were installed using more careful construction practices. Steel pipes installed before and after this time frame tend to have been installed with better construction techniques (better quality coatings, welded joints, cathodic protection). Cathodically protected steel pipes (after 1970 or so) may actually have a much longer life than 150 years, as do some of the very old welded steel pipe used before and around the 1900s, when coal tar tape wrap was often manually wound around the entire joint after it was welded. Facility IDs should be added to steel pipe leak records to develop a more accurate useful life for large steel pipe.

Table 5-2 summarizes the useful life estimates for the various pipe materials and significant installation date ranges described in Section 5.4.

Table 5-2. Useful Lives for Various Main Materials

Pipe Material	Useful Life Estimate
CI, Constructed Before 1930	250 years
CI, Constructed Between 1930 and 1954	175 years
CI, Constructed 1955 or later	150 years
Concrete Cylinder Pipe (CCP), cathodically protected	200 years +
DI Pipe, Constructed 1955 to 1965 (transitional material)	150 years
DI, Constructed 1966 and later	200 years
Galvanized	100 years
Steel Pipe, cathodically protected	200 years +
Steel Pipe, Constructed Before 1930 or after 1970 and later, no protection	125 years
Steel Pipe Constructed 1930 through 1969, plus any steel under 8 inches	100 years
All Others ⁽¹⁾	100 years

⁽¹⁾ Very little is known about this pipe group because it contains pipes with unknown material type, unknown ages, etc. so a low value for useful life was assumed.

5.5. Actions to Extend Useful Life

5.5.1. CI Pipe

Some of the available techniques to extend useful life of CI pipe sections include adding cement mortar or structural lining. The most common way of extending CI pipe useful life in the PWB distribution system is by removing lead joints, replacing them with modern joints, and potentially adding cathodic protection in extremely corrosive soil environments (though joint

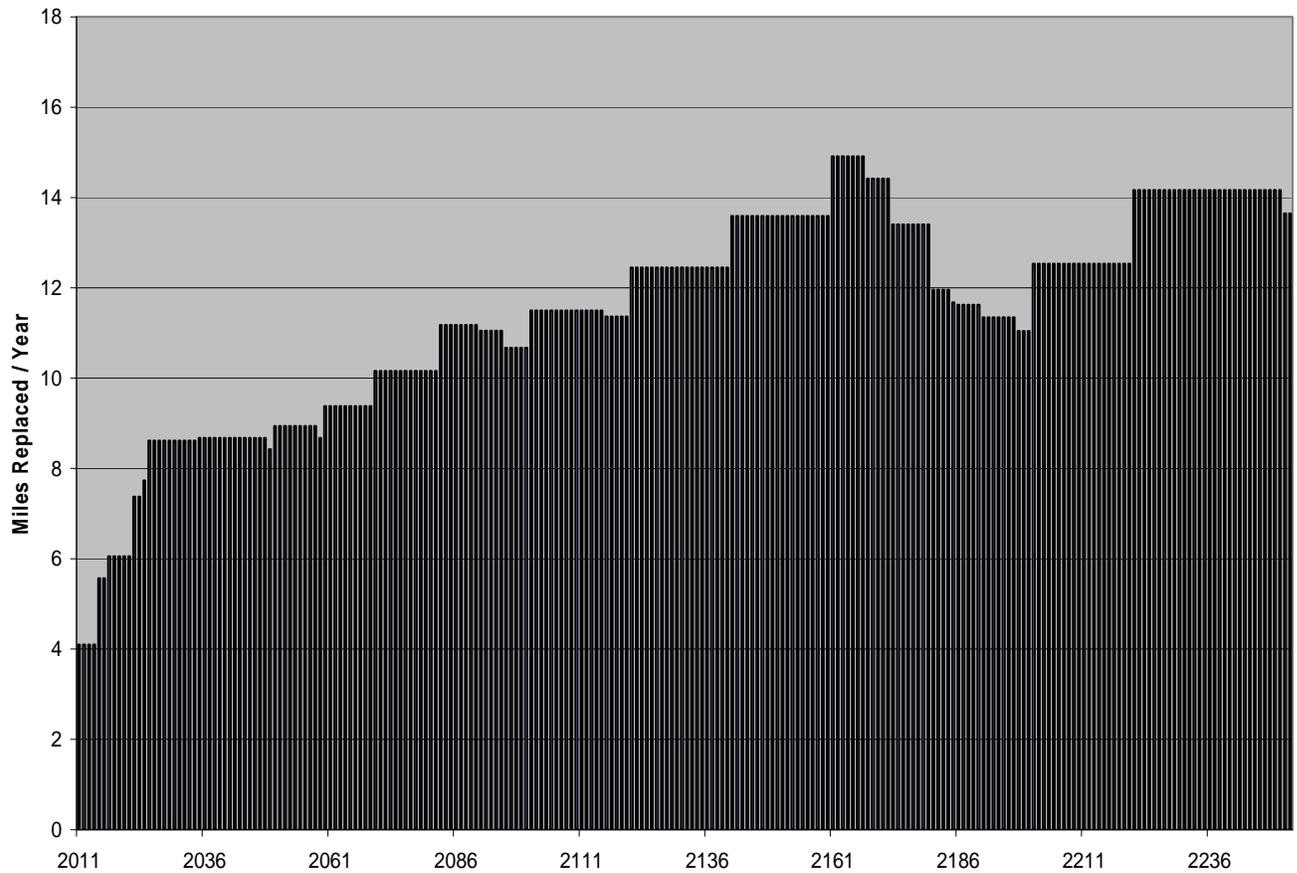


Figure 7-3. Pipe Replacement Needs in Miles per Year, based on Weibull Curves

The key assumptions used in the Weibull curve projections are the following:

- Mains fail according to skew 3 Weibull curve

- Begin replacing after 40% useful life has expired, and replace at a constant rate until 40% past the mean time to failure ("Weibull Example" tab)

- Mains beyond 40% of the mean time to failure, begin now to replace at a constant rate so that all pipe is replaced at 40% past the mean time to failure (see classes highlighted yellow in Column K on "Data" tab)

- Future classes of DI pipe will be created. Assume the length in these classes is equal to the calculated replacement rate in the spreadsheet, plus 25% to account for new pipe installations, development, etc. (rows 29-36 on "Weibull Data" tab)