EXH. CAK-6 (Apdx. A)
DOCKETS UE-22___/UG-22___
2022 PSE GENERAL RATE CASE
WITNESS: CATHERINE A. KOCH

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, **Complainant,** **v.** **PUGET SOUND ENERGY,** **Respondent.**	**Docket UE-22____** **Docket UG-22____**

APPENDIX A (NONCONFIDENTIAL) TO THE FIFTH EXHIBIT TO THE PREFILED DIRECT TESTIMONY OF

CATHERINE A. KOCH

ON BEHALF OF PUGET SOUND ENERGY

JANUARY 31, 2022

Puget Sound Energy
Pipeline Replacement
And
Methane Emission Reduction
Program Plan
June 2021

Docket No. UG-120715
RCW 80.28.420

Table of Contents

1. Introduction

On December 31, 2012, the Washington Utilities and Transportation Commission (UTC) issued a policy statement under UG-120715 for the accelerated replacement of natural gas pipeline facilities with elevated risk. This policy statement requires each gas company, whether requesting a special pipe replacement cost recovery mechanism (CRM) or not, to file with the Commission a pipe replacement program plan containing the following elements:

1. A "master" plan for replacement or remediation of pipeline facilities that are demonstrated to have an elevated risk of failure
2. A two-year plan that specifically identifies the pipeline facility remediation goals for the upcoming two year period
3. A plan for identifying the location of pipe that presents elevated risk of failure

In accordance with this policy statement, Puget Sound Energy (PSE) prepared pipeline replacement program (PRP) plans beginning in 2013 for pipe that poses an elevated risk of failure. Through PSE's Distribution Integrity Management Program (DIMP), performance of the distribution system is continually analyzed and detailed analysis is conducted to identify those facilities considered high risk.

On June 11, 2020, the Washington Legislature passed House Bill 2518 for natural gas transmission and distribution that added a new section to chapter 80.28 of the Revised Code of Washington (RCW)[1]. The intent of the new section is to encourage safer and more efficient natural gas transmission and distribution system through investments that address and minimize leaks in the natural gas pipeline system. The new section allows a natural gas company to seek interim recovery between rate cases as part of a commission-approved interim rate treatment mechanism for equipment and new facilities that aid in the reduction of methane emissions including a list of projects and changes to operational procedures including, but not limited to, venting, blowdowns, and others, to expedite the replacement of pipeline facilities that present an elevated risk of failure and expedite the repairs of hazardous leaks and nonhazardous leaks. Requirements of this new section of the RCW include:

---

[1] **RCW 80.28.420 – Note – sections bolded highlight key concepts incorporated in this request**

Gas company recovery of costs associated with replacing certain pipeline facilities—Information to be submitted to the commission—Definitions.

(1) The commission must initiate a proceeding to provide conditions concerning the interim recovery between rate cases by a gas company of the costs associated with replacing pipeline facilities that are demonstrated to have an elevated risk of failure and the costs associated with measures to expedite the reduction of hazardous leaks and reduce as practicable nonhazardous leaks from the gas company's gas pipelines.

(2) A gas company seeking an interim recovery between rate cases may submit to the commission, as part of a general rate case or a commission-approved interim rate treatment mechanism regarding the replacement of pipeline facilities, a description of equipment and new facilities that aid in the reduction of methane emissions and a list of projects and **changes to operational procedures** including, but not limited to, venting, blowdowns, and others, to expedite the replacement of pipeline facilities that present an elevated risk of failure and **expedite the repairs of hazardous leaks and nonhazardous leaks**. Items on the list must be ranked according to risk, severity, complexity, and impact to the environment and public health. A gas company may also include in its filing methods to implement and deploy **leak detection technology capable of rapidly identifying leaks**. As part of its filing, the gas company must include a cost-effectiveness analysis and propose a cap for annual expenditures recoverable through a cost recovery mechanism to be approved by the commission. The cost-effectiveness analysis must include considerations of risk and impacts to the environment and public health. A gas company may consider a percent of rate base, percent of revenues, total expenditures, or other basis for its proposed cap. As part of the proposal, the gas company must address the expected impact to ratepayers and other factors that may be required by the commission by rule.

1. A list of projects ranked according to risk, severity, complexity, and impact to the environment and public health
2. A proposed spending cap using percent of rate base, percent of revenues, or total expenditures

With the Pipeline Replacement Plan and Cost Recovery Mechanism in place for many years, it is most effective to leverage the established process and expand focus to include actions that aid in the reduction of methane emissions as envisioned by RCW 80.28.420. The examples provided in the RCW include both capital and operating and maintenance opportunities. PSE's 2021 PRP will now include projects and changes to operational procedures as described in the RCW.

PSE also recognizes that consideration of the environment is part of a strong pipeline safety management system as highlighted in API RP 1173 principles. For example "g) Prompt and effective incident response minimizes the adverse impacts to life, property, and the *environment*."[2]

2. PSE's Distribution Integrity Management Program (DIMP)

As required by the DIMP regulations, PSE analyzes many aspects of system performance including trends on identified system threats. The threats that are identified and evaluated in DIMP include:

- Corrosion failure
- Natural force damage
- Excavation damage
- Other outside force damage
- Pipe, weld or joint failure
- Equipment failure
- Incorrect operations
- Other cause

The analysis includes reviewing active and repaired leak data, failure analysis information, and system condition reports to identify trends affecting the distribution system. Results and conclusions of the review are reported in PSE's Continuing Surveillance Annual Report. A copy of the report is provided to the UTC after each annual update. The analysis provides insight into the risks associated with pipe and assets identified as having an elevated risk of failure that are included in the PRP plan. In addition, PSE reviews the emissions from natural gas facilities to report out the estimated methane emissions amounts from repaired and active leaks. A report is provided to the UTC per House Bill 2518 new section 81.88 RCW. PSE is evaluating the impact of methane emissions to the environment and public health and determining how it will be incorporated into DIMP.

PSE continues to improve pipeline safety and system reliability through the ongoing iterations of its integrity management activities. The assessment, prioritization, and mitigation of system risks continue to be refined as new and additional risk knowledge is incorporated into DIMP through normal O&M and DIMP activities. Activities related to DIMP include gathering data, conducting targeted inspections, and completing remediation and replacement work associated with integrity management driven programs. Based on additional risk knowledge and the results of the system trends analysis, the Master Plan may be modified to further accelerate or

[2] Introduction of Pipeline Safety Management Systems ANSI/API Recommended Practice 1173 First Edition, July 2015, emphasis added.

decelerate pipe replacement and mitigation schedules consistent with the identified risk. Additionally, PSE is actively monitoring system threats and performance and may identify additional materials or assets that have an elevated risk of failure. PSE has also begun incorporating methane emissions risk knowledge into DIMP. The Active Leak Reduction Program was created within DIMP to address emissions from nonhazardous leaks. If any material changes are made to the PRP plan, PSE will submit the changes to the Commission as required by the Commission's Policy Statement.

3. Methane Release Reduction

On January 21, 2021, PSE announced its Beyond Net Zero Carbon pledge, setting an aspirational goal to reach net zero carbon emissions for natural gas sales by 2045, with an interim target of a 30% emissions reduction by 2030. As part of that goal, PSE aspires to transform its natural gas distribution business to reduce carbon emissions for natural gas use in customer homes and businesses, through a combination of energy efficiency, use of low carbon fuel sources and blending (renewable natural gas and hydrogen), among other things and to reduce emissions from PSE's gas and electric operations and supply with focus on such things like leak reduction.

PSE is developing a plan to address the effect carbon emissions have on climate change. The majority of greenhouse gas emissions, gases that trap heat in the atmosphere, are from Carbon dioxide (CO_2), at about 80 percent. Methane (CH_4), which is the primary constituent of natural gas is the second largest contributor at 10 percent. Methane may be emitted during production and transport of coal, natural gas, and oil as well as from livestock, land use, and by the decay of organic waste in landfills. Methane's lifetime in the atmosphere is much shorter than carbon dioxide at 12 years compared to 300 to 1,000 years, but methane is more efficient at trapping radiation than CO_2. Pound for pound, methane is 25 times greater than carbon dioxide at trapping heat over a 100-year period. Thus focusing on methane released from PSE's system becomes an important part of PSE's Beyond Net Zero commitment.

Per RCW 81.88.160, PSE has reported on the emissions from the different leak causes in its distribution system beginning in 2021 for 2020. The table below shows that excavation damage is the largest emitter of methane to the atmosphere. In this report, PSE uses a carbon dioxide equivalent as a metric to compare the emissions from methane on the basis of its global-warming potential, by converting amounts of methane to the equivalent amount of carbon dioxide with the with the same global warming potential. For example, the global warming potential of methane is 25. That means that emissions of 1 metric ton of methane is equivalent to emissions of 25 metric tons of carbon dioxide.

Leak Cause	2020 Metric Tons CO2e
Excavation Damage	11,489
Natural Force Damage	1,443
Pipe, Weld, or Joint Failure	1,226
Other Outside Force Damage	1,050
Active Nonhazardous Leaks	874
Equipment Failure	387
Other Cause	374
Incorrect Operations	125
Corrosion Failure	90

The following table summarizes the tactics that PSE reviewed for emission reduction amounts and cost effectiveness as part of the methane release reduction plan. The most effective tactics were incorporated into the master plan and if accepted in PSE's PRP, would be eligible for PSE's cost recovery mechanism in 2022. PSE will continue to mature its review and evaluation process with this greater focus on environmental and public health impacts.

Leak prevention and management	
Tactic	**Status**
Leak repair methodology - Repair leak upon discovery	Implement
Leak survey frequency change based on pipe type; geographic location; year installed, etc.	Evaluated
Nonhazardous release of gas (NARGS) management	Implement
Advanced Leak detection technology	Investigate
Evaluate results from Material Failure Analysis lab -Proactively Replace Bolt-On Tees	Evaluated
Evaluate results from Material Failure Analysis lab -Proactively Replace Caps	Implement
Evaluate results from Material Failure Analysis lab -Use new Continental Punch Tee retirement cap	Implement
Leverage AMI (methane sensor in module; real-time monitoring)	Investigate
Damage Prevention	
Tactic	**Status**
Reduce locate related damages	Investigate
Reduce homeowner damages through advertising	Evaluated
Expand damage prevention team to reduce 3rd party contractor damages	Implement
Improve accuracy and timeliness of maps used in locating	Implement
Intentional Release of Gas	
Tactic	**Status**
Meter change out purging practices	Evaluated
Review purging practices; continued refinement of purging procedures, use of nitrogen	Investigate
Evaluate flaring and recompression for methane impact; methane capture tools	Investigate
Pipeline replacement construction practices	Investigate
Partner with Williams on their purging procedures	Implement
Emergency Release of Gas	
Tactic	**Status**
Expand valve inspections and accessibility for shut-down in lieu of dig up and squeeze (e.g., emergency section valves that shut off too many customers, redefining "critical" so more valves are inspected)	Evaluated
Dynamically scheduled valve inspections - ID valves on either side of third party excavations and create work orders to inspect them prior to construction, so we can shut breaks down more efficiently	Evaluated
Emergency response process that considers reducing broken and blowing time	Investigate
Equipment we should install for shut down processes; e.g., retrofitting services with EFVs	Evaluated
Adding valve locations to material tracking and traceability, GPS coordinates for valve locations, proactive approach to newly installed; add installed locations during scheduled asphalt restoration, at site visits	Evaluated
Engineering Design and Standards	
Tactic	**Status**

Valve requirements (install more valves)	Future evaluation
Meter change out philosophy (when to replace a meter during pipeline replacement)	Future evaluation
Meter philosophy of SAP improvements, meter replacements/maintenance, avoid unnecessary meter change-outs	Future evaluation
Risers, soil to air interface (SAI): to replace or to repair in the field	Evaluated
Replace threaded fittings with flanges on MSA	Evaluated
Evaluate IMO Design to replace relief and minimize leakage points	Implement
Evaluate RS design to minimize leakage points and prove relief has minimal leakage	Evaluated
Evaluate current commodities for methane release potential over time and phase them out	Evaluated
Atmospheric corrosion SAI inspection process (soil to air interface on steel risers)	Evaluated
Riser designs	Evaluated

4. PSE's Master Plan and Progress

Master Plan

PSE's Master Plan has included five programs historically. The following assets were identified through PSE's risk modeling to have an elevated risk relative to other assets in its system:

Program/Asset	Pipeline Integrity Risk	Methane Emission Risk	Program Status
DuPont Aldyl "HD" Plastic Pipe	High consequence of fusion failure and brittle like cracking	Moderate	Existing
Buried Meters	High consequence of external corrosion failure in close proximity to a building wall	Low	Existing
Sewer Cross Bores	High likelihood of failure and consequence of gas migration directly into a structure	Low	Existing
Older Vintage wrapped steel mains	Elevated risk reduced through implementation of master plan	Moderate	Removed from plan
Older Vintage wrapped steel services	Elevated risk reduced through implementation of master plan	Moderate	Removed from plan

Leveraging the exhaustive list of tactics focused on reducing methane release in PSE's gas operations and in accordance with RCW 80.28.420 and House Bill 2518, PSE's initial inclusion in the 2021/2022 plan focuses on three key DIMP accelerated actions to reduce leaks on the system that contribute to methane emissions. It should be noted that per PSE DIMP model, excavation damage is PSE's highest risk, but to date has not been included in the Master Plan.

Program/Asset	Methane Emission Risk	Pipeline Integrity Risk	Program Status
Active Leak Reduction Program	Nonhazardous belowground leaks (Grade B & C)	Low	New
Damage Prevention Program	Excavation Damage from improper excavation practices and from unmapped facilities	High	New
Above Ground Meter Set Remediation	Nonhazardous releases of gas (NARG)	Low	New

Master Plan Progress

The following table summarizes the miles of pipe, number of meters, number of cleared sewer segments, and the number of services replaced under the replacement programs according to the Master Plan since 2013. PSE also originally identified bare steel pipe as a material having an elevated risk of failure.

Table 1. Summary of Programs from 2013-2020

	DuPont Aldyl "HD" Plastic Pipe (Active)		Buried Meter Remediation (Active)		Sewer Cross Bore Remediation (Active)		Older Vintage Wrapped Steel Mains (Removed)		Older Vintage Wrapped Steel Services (Removed)	
Program (Calendar) Year	**Miles of Pipe**	**Expenditures (Millions)**	**Number of Meters**	**Expenditures (Millions)**	**Cleared Sewer Segments**	**Expenditures (Millions)**	**Miles of Pipe**	**Expenditures (Millions)**	**Services**	**Expenditures (Millions)**
2013	6.5	$6.9					3.2	$3.7	163	$1.6
2014	10.5	$13.5					4.5	$7.1	187	$2.1
2015	28.6	$41.4					4.0	$6.5	208	$2.7
2016	27.4	$32.7					5.0	$7.9	215	$2.8
2017	27.9	$41.9					5.2	$10.3	212	$3.3
2018	38.8	$64.5								
2019	27.7	$62.8								
2020	14.6	$44.5	6,283	$5.3	8,009	$3.3				
Total	**182.0**	**$308.2**	**6,283**	**$5.3**	**8,009**	**$ 3.3**	**21.9**	**$35.5**	**985**	**$12.5**

The following table summarizes the emission savings from implementing the three key actions as part of PSE's Master Plan. Stating the obvious, PSE's historical programs while focused on pipeline integrity, had a methane release reduction benefit in the past and will into the future with the remediation of leak prone assets. Table 2 focuses on the methane release reduction benefit from the added actions that are now included in the plan.

Table 2. Summary of Programs Addressing Methane Emissions starting in 2022

	Active Leak Reduction			Excavation Damage Prevention Measures			NARG Repairs		
Program (Calendar) Year	Leak Repairs	Emission Reduction (tCO2e)	Expenditures (millions)	Avoided Damages	Emission Reduction (tCO2e)	Expenditures (millions)	NARG Repairs	Emission Reduction (tCO2e)	Expenditures (millions)
2022	TBD		$	TBD		$	TBD		$
2023	TBD		$	TBD		$	TBD		$
Total	**TBD**		**$**	**TBD**		**$**	**TBD**		**$**

5. DuPont Aldyl "HD" Plastic Pipe

Master Plan

Pipeline Integrity Risk Assessment

PSE identified an increased risk of premature, brittle-like cracking of the larger diameter (1-1/4" and larger) Aldyl "HD" plastic pipe manufactured by DuPont. PSE installed this pipe in the 1970s and early 1980s and originally estimated there to be approximately 400 miles remaining in service as of 2013. After further review, PSE estimates the total to be nearly 435 miles in service at the beginning of 2013, prior to any pipe replacement completed under the PRP plan.

The brittle-like cracking is due to slow crack growth (SCG) at locations where there is a stress concentration. Based on PSE's experience, the brittle-like cracking is primarily due to rock impingement but also occurs where the pipe has been squeezed or where other stress concentrations have been introduced due to inconsistent joining practices. The failure is referred to as brittle-like cracking because it occurs without any localized plastic deformation. While the failure occurs without plastic deformation, the pipe is not brittle. Even when a failure occurs due to SCG, the PE pipe is still resistant to crack propagation preventing it from becoming a larger crack. A study by GTI (Gas Technology Institute) performed at PSE's request provides additional insight into how installation and operating practices, environmental conditions, and operating pressures impact the life expectancy of the pipe.

PSE developed and implemented a program in 2010 to prioritize larger diameter DuPont Aldyl "HD" plastic pipe for replacement based on the likelihood and consequence of failure. The program was incorporated into DIMP and evaluates the risk of brittle-like cracking based on installation and operating practices and environmental conditions. These segments of larger diameter DuPont Aldyl "HD" plastic pipe have an elevated risk of failure as validated by DIMP system performance data.

Industry Experience

PSE's experience with the larger diameter DuPont Aldyl "HD" material is similar to industry experience with many of the older PE materials. This is highlighted by many of the Safety Recommendations issued by the National Transportation Safety Board (NTSB) on April 30, 1998. These recommendations were based on findings from NTSB's investigation of PE pipe following several natural gas distribution accidents that involved plastic piping that cracked in a "brittle-like" manner. The following summarizes many of the issues identified in the NTSB's investigation that correlate to PSE's experience with the DuPont Aldyl "HD" material:

- Nationally, brittle-like failures represent a frequent failure mode for older plastic piping.
- The procedure used to rate PE materials from the 1960s through the early 1980s may have overrated the materials long term strength and resistance to brittle-like cracking.
- The test methods used at the time did not reveal the susceptibility of many early PE materials to brittle-like cracking.
- Plastic pipe was assumed to perform in a ductile manner; therefore, plastic pipe design focused primarily on stress due to operating pressure. As a result, little consideration was given to stress due to external loading as it was assumed that these stresses would be reduced by localized yielding.
- Experts in gas distribution plastic piping indicate that some of the PE pipe manufactured from the 1960s through the early 1980s has demonstrated poor resistance to brittle-like cracking. There is evidence that some early vintage PE materials have a lower SCG resistance than other PE materials. Newer test methods more accurately predict the pipe's resistance to SCG.

Aldyl "HD" vs Aldyl "A"

In addition to the Aldyl "HD", DuPont also manufactured a medium density PE pipe marketed under the name Aldyl "A". While PSE only purchased and installed the Aldyl "HD" pipe, information on both Aldyl "A" and Aldyl "HD" pipe is included to highlight the similarities and differences in the risks of these two materials. Similar to PSE's experience with Aldyl "HD", the Aldyl "A" pipe has been found to be susceptible to brittle-like cracking.

The Aldyl "A" pipe manufactured from 1970 through early 1972 had a manufacturing issue that resulted in a brittle inside surface also referred to as low ductile inner wall (LDIW). This characteristic resulted in premature failures. In early 1972, DuPont changed the manufacturing process to address the LDIW phenomena. While only early 1970s vintage Aldyl "A" pipe had the LDIW inner surface, both Aldyl "HD" and later vintage Aldyl "A" have exhibited brittle-like cracking failure characteristics in pipes 1 ¼" and larger in diameter. The smaller diameter piping is more flexible and not as susceptible to the brittle-like cracking experienced in larger diameters.

Both Aldyl "HD" and Aldyl "A" were made with state-of-the-art PE resins at the time of manufacture and met applicable industry standards and complied with federal regulations. However, by today's standards they both have low resistance to SCG and are susceptible to SCG field failures. This is particularly true when these pipes are subjected to secondary loads, such as rock impingement and squeeze-off.

Predictions on the Remaining Useful Life Expectancy

PSE consulted with Gas Technology Institute (GTI) to develop data, information, and predictions on the remaining useful life expectancy based on samples of DuPont Aldyl "HD" plastic pipe extracted from PSE's distribution system. The purpose for the evaluation performed by GTI is to provide additional risk knowledge into the failure mode of DuPont Aldyl "HD" plastic pipe and information on the pipe characteristics, operating conditions, and environmental factors that may impact the material's performance. This study also provides a means to predict the remaining useful life expectancy of the pipe to validate the current remediation schedule or determine the appropriate remediation timeframe. Based on the testing and analysis performed, the study concludes that the expected useful life is impacted by temperature, operating pressure, and the severity of stress risers.

Based on the evaluation, there may be specific pipelines operating at relatively low pressures that even under extreme stress risers pose minimal risk. These facilities may be deemed to be low risk and not replaced as part of the Master Plan. The overall pipe replacement strategy will continue to prioritize based on the highest risk pipe from historical performance, however may be adjusted considering the new risk knowledge.

DuPont Aldyl "HD" Plastic Pipe Replacement Program Plan

PSE is actively replacing the larger diameter DuPont Aldyl "HD" plastic pipe that poses an elevated risk of failure. The current plan is to replace this pipe within 20 years beginning in 2013. PSE will continue monitoring the performance of larger diameter DuPont Aldyl "HD" pipe. By acquiring new risk knowledge through DIMP, PSE will update the replacement schedule and timeframe as necessary.

Based on current risk knowledge and historical performance, PSE currently plans to replace approximately 245 miles of larger diameter DuPont Aldyl "HD" plastic pipe within the first 12 years of the 20-year plan beginning in 2013. The plan was updated from 10 years to 12 years due to rising unit costs increasing the time needed to replace 245 miles. The pipe replacement in the first 12 years targets the higher risk population with a history of brittle-like cracking and fusion failures. The schedule should not create an undue burden on rate payers. Throughout the program duration, PSE is able to secure valuable contractor resources to keep a normalized work load while reducing the overall risk. By 2024, the Master Plan will be reviewed to determine the appropriate replacement schedule for the remaining pipe in service. The current replacement schedule is provided in the Table 2 and Figure 1.

Table 2. DuPont Aldyl "HD" Plastic Pipe Replacement Schedule, Miles, and Estimated Expenditures

Program Years	Total Planned Replacement Miles	Estimated Expenditures[1]
1 – 12	245 Miles	$503.9 million
12 – 20	190 Miles	$478.0 million
Total	**435 Miles**	**$981.9 million**

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

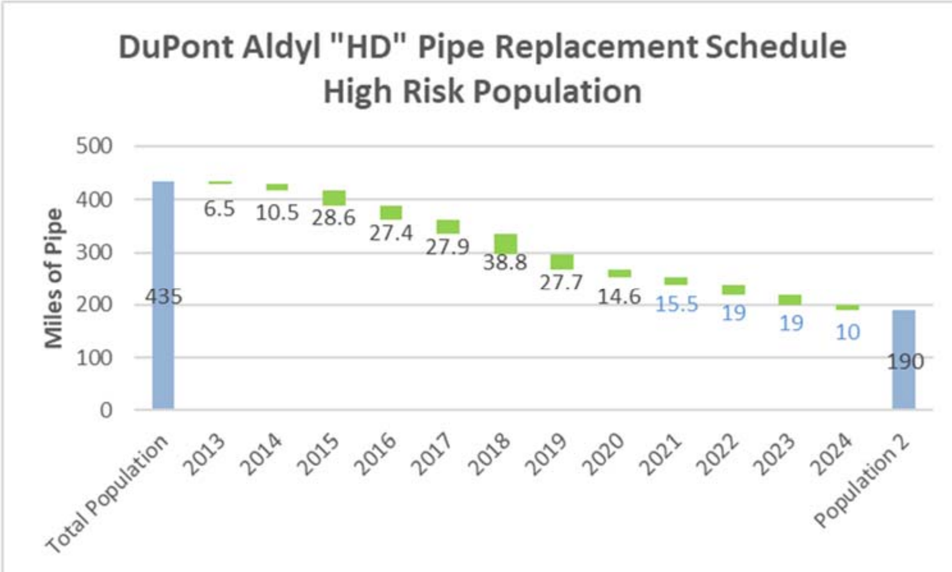

Figure 1. DuPont Aldyl "HD" Plastic Pipe Replacement Schedule for High Risk Population
(Black – actuals, Blue – proposed)

Two-Year Plan

The two-year plan is to continue replacing DuPont Aldyl "HD" plastic pipe according to the Master Plan. The following table shows the planned replacement miles and expenditures of DuPont Aldyl "HD" plastic pipe for the current year and in calendar years 2022 and 2023.

Table 3. Planned Replacement Miles and Expenditures

Year	Planned Replacement Miles	Planned Expenditures[1]
2022	19 Miles	$54.8 million
2023	19 Miles	$55.6 million
Total	38 Miles	$110.4 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

Adjustments to projects and specific locations will be made as required while managing to the Master Plan and overall system risk.

Identification Plan

PSE purchased and installed DuPont Aldyl "HD" plastic pipe in the 1970s and early 1980s. During this timeframe, PSE also purchased and installed Phillips Driscopipe M8000 and Plexco pipe. PSE's historical construction records did not capture the pipe manufacturer and only indicated the location of the pipe, material type, pipe size, and date the pipe was installed. As a result, PSE developed and implemented a plan in 2013 to identify the manufacturer of larger diameter HDPE pipe installed in the 1970s and early 1980s. The plan focused only on identifying candidate pipe installations that may pose an elevated risk of failure.

Completion of Targeted Excavations

By the end of 2016, PSE completed the targeted excavations to identify locations of DuPont Aldyl "HD" plastic pipe in the system. Locations of the targeted excavations were strategically selected to identify all original installation jobs that potentially contain DuPont Aldyl "HD" plastic pipe. The identification effort confirmed that approximately 2,700 original installation jobs contain some amount of DuPont Aldyl "HD" plastic pipe and finalize the total population.

Ongoing Verification through Routine Operations and Planned Projects

PSE currently captures information on the pipe manufacturer through the Exposed PE Pipe Report whenever plastic pipe is exposed during routine operations and maintenance activities. Additional information is also gathered from confirmation excavations when refining the scope of DuPont Aldyl "HD" pipe replacement projects and opportunities through other planned pipe replacement projects. The information is used to further refine and verify the amount and location of DuPont Aldyl "HD" pipe remaining in service.

6. Buried Meters

Master Plan

Pipeline Integrity Risk Assessment

PSE has identified an increased risk on meter set assembly (MSA) piping where pipe, fittings, or equipment intended for above ground exposure are unintentionally buried. Referred to as "Buried Meters", this condition occurs when the homeowner/building owner makes changes to the ground elevation in the area of the MSA and may result in hazardous leaks due to corrosion occurring at or near a building wall. Buried meters are identified from routine leak surveys and subsequent field inspections. The remediation strategy may include recontouring the landscaping around the MSA, or complete pipe replacement/MSA relocation, depending on the situation. There are approximately 40,000 reports of buried MSAs in the system and approximately 5,000 new reports are identified each year.

The Buried MSA Remediation Program was first initiated in 2007 in response to increased reports of buried meters through the Abnormal or Unusual Operation Condition Report (Blue Card) as they were identified during routine leak surveys. Through the implementation of DIMP in 2010 the program was identified as a moderate risk relative to other assets in the distribution system. In recent years, there has been an increase in buried meter reports through continuing surveillance activities. Also, more hazardous leaks have occurred due to corroded meter set components over the same time period. In 2018, the risk model identified the buried meter program as a high risk and a new program strategy was developed to reduce the backlog of buried meters. A taller riser design was developed with greater ground clearance to prevent the burial of additional meter sets.

Buried Meter Replacement Program Plan

PSE is actively replacing buried meters that pose an elevated risk of failure. PSE will continue monitoring the performance of buried meters through DIMP and appropriately update the replacement schedule and timeframe as necessary. For meter sets currently not identified as having an elevated risk of failure, PSE will continue to incorporate new risk knowledge and evaluate whether this population warrants replacement under PRP in the future.

Based on current risk knowledge and historical performance, PSE will remediate approximately 40,000 buried meters within 6 years beginning in 2020. The 6 year term was chosen based on prioritizing higher risk locations first and remediating the remaining identified locations at an accelerated rate. New reports of buried meters will be added to the program as they are found, but adjustments to the program will be made as the impacts of installing the new taller riser are realized to reduce the number of new reports of riser burial or re-burial. The schedule should not create an undue burden on rate payers. Throughout the program duration, PSE is able to secure valuable contractor resources to keep a normalized work load while reducing the overall risk. The current replacement schedule is provided in Table 4.

Table 4. Buried Meter Replacement Schedule, Quantity, and Estimated Expenditures

Program Years	Number of Meters	Estimated Expenditures[1]
1-6	40,000	$35 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

Two-Year Plan

The two-year plan is to continue to replace/remediate buried meters according to the Master Plan. The following table shows the planned buried meter remediation and expenditures for 2022 and 2023.

Table 5. Planned Buried Meter Remediation and Estimated Expenditures

Year	Number of Meters	Planned Expenditures[1]
2022	7,000	$6.0 million
2023	7,000	$6.0 million
Total	14,000	$12.0 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

Adjustments to projects will be made as required while managing to the Master Plan and overall system risk.

Identification Plan

Meter set assemblies that present an elevated risk of failure are continually monitored by reviewing system information that includes leak survey and patrol data. The population of 40,000 buried meters with an elevated risk of failure was identified in 2019 through continuing surveillance activities. In conjunction with reviewing system performance data, PSE's geographic information system (GIS) is being utilized to proactively identify any new areas that may present an elevated risk of failure. As new reports of buried meters are identified the new reports will be added to the master plan as necessary or evaluated separately after completion of the original population.

7. Sewer Cross Bores

Master Plan

Pipeline Integrity Risk Assessment

The threat of sewer cross bores was identified through DIMP as an elevated risk to certain pipe installations. A sewer cross bore is a gas pipeline that has been inadvertently installed through an unmarked sewer pipe. Sewer cross bores occur when trenchless construction methods are utilized to install new natural gas pipe in areas where unmarked sewer lines exist. The state of Washington Damage Prevention Law requires excavators to use a One-call number locator service to alert underground facility owners of intended excavation activities and requires the marking of underground facilities in the area. However, sewer lines, and in particular, sewer laterals have proven to be difficult to locate. Sewer systems are often comprised of pipe that is not electronically locatable and sewer records are lacking in many areas. In addition, sewer lines on private property are the responsibility of the property owner, who does not possess the technology or records to be able to locate their sewer line. Sewer cross bores pose an elevated risk of failure due to the high consequence that would result if damage to the pipe occurs causing gas to leak into the sewer. If there is a sewer cross bore and it causes a blocked sewer, plumbers typically use a drain cleaning machine to clear the blocked sewer which could damage the gas line endangering people and property. Based on PSE's experience, it is more likely for plastic service lines in residential urban areas to be cross bored through sewers. Since 2013, more than 871 cross bores have been found in PSE's system.

A sewer cross bore pilot program was conducted in 2012 and in 2013 the Sewer Cross Bore Program was officially established. Hydromax USA ("HUSA") was selected as PSE's service provider to conduct sewer inspections that would help identify and remediate cross bores associated with new construction as well as sewer cross bores from legacy installations. A public awareness program was also launched to publicize PSE's cross bore safety program to make customers and plumbers aware of the sewer cross bore issue and to call PSE before clearing a sewer. The Sewer Cross Bore Program activity is tracked in the Continuing Surveillance Annual Report and has identified sewer cross bore as one of the highest risks in PSE's distribution system.

Sewer Cross Bore Replacement Program Plan

PSE is actively remediating pipe that poses an elevated risk from sewer cross bore. Based on detailed analysis of the characteristics associated with previously identified sewer cross bores, PSE, in concert with HUSA, has developed a computer model which assesses the likelihood that a sewer cross bore exists in an area. Utilizing the output of this model, PSE has developed a prioritized and systematic approach for alleviating the elevated risk that sewer cross bores pose. PSE will remediate the risk of sewer cross bore at the identified locations by documenting through inspection that no pipe is installed in the sewer and remediating any pipe that is found to have been cross bored through the sewer. PSE is also reducing the risk of future occurrences of new sewer cross bores being installed by contracting with HUSA to inspect sewer lines at a location after installation of any new gas line by trenchless methods.

The computer model utilizes machine learning algorithms to predict the likelihood that a cross bore exists. The model adjusts and learns as individual locations are confirmed and remediated. Additional locations are incorporated into the model as information is gathered on new side sewer segments, and the highest risk locations are recalibrated by the model. Using the model, PSE identified the top 10% of the model results to clear of risk, which is a population of 60,000 areas where the likelihood of a cross bore is higher. PSE revised the master plan to incorporate information learned during the last two years that a parcel may have multiple sewer segments. The original plan accounted for each parcel having one sanitary sewer. PSE will continue to focus on individual sewer segments and not whole parcels due to the lack of sewer lateral information in many areas. PSE has developed a plan to remediate the risk of sewer cross bore at these identified locations within 9 years beginning in 2019. The schedule should not create an undue burden on rate payers. Throughout the program duration, PSE will continue to incorporate new information to refine the program and adjust the plan as needed. The current schedule is provided in Table 6.

Table 6. Sewer Cross Bore Remediation Schedule, Units, and Estimated Expenditures

Program Years	Cleared Sewer Segments	Estimated Expenditures
1-9	60,000	$40.9 million

Two-Year Plan

The two-year plan will continue to prioritize the highest risk identified locations to remediate the risk of sewer cross bore. The following table shows the planned sewer cross bore remediations and expenditures for calendar years 2022 and 2023.

Table 7. Planned Sewer Cross Bore Remediations

Year	Cleared Sewer Segments	Estimated Expenditures
2022	7,300	$4.7 million
2023	7,300	$4.7 million
Total	14,600	$9.4 million

Adjustments to projects and specific locations will be made as required while managing to the Master Plan and overall system risk.

Identification Plan

The identification of the location of sewer cross bores utilizes a computer model to identify the higher risk pipe segments. Model inputs include pipe installation year, manufacturer, nominal diameter, material, pressure, install method, actual length, and who installed the pipe. Those inputs are then used along with sewer cross bores found in the gas system to identify the higher likelihood pipe segments for cross bore risk. Those segments are the identified locations with higher sewer cross bore risk.

Remediating the risk of a sewer cross bore is performed with a camera inserted in the sewer pipe and then repair or replacement of pipe when a cross bore is found. The program includes sewers in proximity to new gas trenchless installations to confirm that new cross bores are not created and at risk sewers in proximity to legacy trenchless gas installations are identified through the risk model.

8. Active Leak Reduction

Master Plan

Methane Emissions Risk Assessment

PSE has identified nonhazardous leaks, which include Grade “B” and “C” leaks, occurring in the natural gas distribution system as a high risk for methane emissions due to a potentially longer time leaking. A Grade “B” leak is a leak recognized as being not hazardous at the time of detection, but that justifies scheduled repair based on the potential for creating a future hazard. A Grade “C” leak is a leak that is not hazardous at the time of detection and can reasonably be expected to remain nonhazardous. PSE is committed to eliminating its backlog of active

Grade “C” leaks and to reduce the time needed for repairing Grade “B” leaks in order to reduce methane emissions from nonhazardous leaks. Grade “B” leaks are required to be repaired within 15 months of identification and Grade “C” leaks do not require repair, but are re-evaluated annually to ensure conditions have not changed. The repair timeframes are based on the fact that the leaks do not pose an eminent threat to public safety or pipeline integrity. Repairing Grade “C” leaks can be challenging compared to higher grade leaks due to the lower gas concentrations. Leaks with lower gas concentration are often more difficult to pinpoint which creates potential for higher cost and additional resource impacts.

In recent years, PSE reviewed the operating practices around Grade “B” and “C” leaks due to the active leak backlog and began accelerating the repair timeframe of these leaks. PSE began targeted repairs of Grade “C” leaks in 2014 to begin reducing the overall population. From this pilot, the backlog began decreasing and PSE began forming the master plan to repair these nonhazardous below ground leaks at a much faster pace. Currently, PSE has a population of approximately 100 Grade “B” leaks and a population of approximately 200 Grade “C” leaks. The rate of new leaks found for nonhazardous leaks is approximately 400 leaks per year. The current goal is to fix these nonhazardous leaks by accelerating the permit and construction timeframe initially to approximately 4 months compared to 15 months for Grade B leaks and approximately 2 years for Grade C leaks. Efforts will continue to determine how to further reduce the cycle time while managing costs.

PSE is currently looking at implementing new leak detection technology to further its ability to find leaks faster than through traditional survey methods. As mandated in Sections 113 and 114 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2020, PHMSA is currently developing a report for Congress on natural gas pipeline leak detection and repair. The RCW 80.28.420 specifically mentions the opportunity to including new leak detection technology. The industry has seen a dramatic increase in use of advanced leak detection technology to help find super emitters for prioritized repair at an increased speed and scale. One option that PSE has begun evaluating is the use of street reconnaissance technology by vehicle or at specific sites, such as at regulator stations.

PSE is also evaluating the Picarro advanced leak survey platform. Picarro, or similar technology, is capable of measuring parts per billion indications at distances up to 600 feet. This highly sensitive leak detection technology requires crews to pin point and grade leaks identified by the Picarro system as it is driven through a neighborhood. Picarro is able to identify the super emitters, the 5% of leaks that account for 50% of the emissions, through advanced leak detection and analytics.

Active Leak Remediation Program Plan

PSE plans to eliminate the on-going monitoring of active Grade “C” leaks and target a repair within 4 months of discovery to reduce the amount of methane emitted to the atmosphere. Grade “B” leak repairs would be accelerated to be repaired within 4 months of discovery. When possible, PSE would expedite the leak repair to upon discovery with proposed changes to PSE’s operational procedure for repairing nonhazardous leaks faster than 4 months.

PSE has found that continuous monitoring of nonhazardous leaks requires operating costs, causes CO_2 emissions from vehicles, and impacts the climate from methane emissions. Repairing nonhazardous leaks early after identification doesn’t change the total cost of the repair. Waiting to repair the leak only adds emissions to the environment and additional costs to monitor the leak. Since the cost does not change whether repairing the leak at a later date or earlier, PSE has found that early repair of nonhazardous leaks is the most cost effective and environmentally prudent decision.

Based on current leak knowledge and historical performance, PSE will change its operating procedures to remediate approximately 1,875 nonhazardous leaks earlier than required to reduce methane emissions within 5 years beginning in 2021. New reports of nonhazardous leaks will be added to the program as they are found, but adjustments to the program will be made as the impacts of replacing leaking facilities are realized to reduce the number of new reports of nonhazardous leaks. The schedule should not create an undue burden on rate payers. Throughout the program duration, PSE is able to secure valuable contractor resources to keep a normalized work load while reducing the overall emissions. The current remediation schedule is provided in Table 8.

Table 8. Nonhazardous Leak Repair Schedule, Quantity, and Estimated Expenditures

Program Years	Total Planned Nonhazardous Leak Repair	Estimated Emissions Savings (tCO_2e)[2]	Estimated Expenditures[1]
1-5	1,875	6,773	$22.5 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

2 Estimated Emissions Savings are Metric Tons CO2 equivalent

Two-Year Plan

The two-year plan is to replace/remediate nonhazardous leaks according to the Master Plan. The following table shows the planned active leak remediation, emissions savings, and expenditures for 2022 and 2023.

Table 9. Planned Nonhazardous Leak Repairs

Year	Planned Nonhazardous Leak Repairs	Estimated Emissions Savings (tCO_2e)[2]	Estimated Expenditures[1]
2022	375	1,355	$4.5 million
2023	375	1,355	$4.5 million
Total	750	2,710	$9.0 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

2 Emissions savings are based on repairing C leaks when they are not required to be repaired, so an annual emission savings and repairing B leaks 8 months earlier than required and the emissions saved.

Identification Plan

Currently, there are 100 Grade "B" leaks in the repair process that have a known location and there are approximately 200 Grade "C" leaks also have been previously identified. These nonhazardous leaks are not due to excavation damage and do not overlap with the Excavation Damage Prevention Measure Program or any other PRP programs. New leak locations are found through leak detection methods during an annual survey or through continuing surveillance reports.

9. Excavation Damage Prevention Measures

Master Plan

Methane Emissions Risk Assessment

Excavation Damage is PSE's leading cause of natural gas leaks in the distribution system and the highest risk from PSE's DIMP risk model. Approximately 800-900 damages occur each year to the gas system, releasing approximately 12,000 metric tons of CO2e in 2020.

The two parties most responsible for damage to PSE facilities are contractors, who account for 56 percent of the damages, and homeowners, who account for 20 percent. PSE has been working diligently to reduce these damages and has succeeded in reducing its 3rd party damages per 1,000 locates by more than 50 percent since 2015. However, the rate of improvement has plateaued. To resume progress, PSE seeks to increase the effectiveness of its damage prevention field team.

Increasing Field Team Effectiveness

In 2016, PSE launched a team of damage prevention representatives who visit excavation sites to educate contractors about safe digging and, when necessary, instigate enforcement actions through the Dig Law Safety Committee. This team uses the Urbint predictive analytics tool to identify which of the 300,000 dig tickets PSE receives annually pose the greatest likelihood of damage. PSE believes that expanding this team and extending use of the predictive analytics tool to PSE's public improvement (PI) inspectors will lead to fewer damages.

The tool bases its risk predictions on the correlation between data provided on the 811 ticket and past damages to PSE's gas system. Using data such as a contractor's history of damages and the nature of the work being performed, the tool is able to identify the 5 percent of dig tickets that will account for 38 percent of the damages. The tool currently is not able to take into account the pipe's size, material or pressure, nor can it factor in that the consequences of a break are greater in densely populated areas than in lightly populated ones. PSE believes that enhancing the Urbint tool with this data will increase the effectiveness of both the damage prevention representatives and the PI inspectors in preventing damages.

PI inspectors perform "watch and protect" duties around PSE's high profile facilities. Historically, they have chosen where to watch and protect based on pipe size and pressure and their street knowledge of the excavator and the neighborhood where the digging is occurring. If the Urbint tool were enhanced with data on the characteristics of the gas system and neighborhood, PI inspectors would have better visibility to excavations that presented both the highest excavation risk and the greatest potential damage and change operational practices to protect those sites.

PSE currently has five damage prevention representatives assigned geographically. This staffing level is sufficient to visit only 25 percent of the dig tickets flagged as high risk. Increasing the size of this team would enable them to visit a greater percentage of high risk excavation sites.

Increasing Mapping Accuracy

Another excavation damage prevention measure PSE is pursuing is mapping field completed work with an unknown mapping task category. PSE implemented mapping task management via SAP workload and asset management system to enhance capabilities for monitoring, managing mapping and improving processes for improved efficiency and timeliness. Through this monitoring, PSE has found a population of 5,000 field completed

SAP work orders not submitted to Maps, Records, and Technology (MRT) in a timely manner to be added to the maps. If the location of a facility has been modified by these field completed work orders without a completed Mapping task category, an elevated risk of excavation damage exists due to reduced mapping accuracy for locating and could result in additional methane emissions. This program will identify field activity types that are prone to excluding a mapping notification, and inform process improvements to ensure mapping updates are submitted if the work is significantly modifying location of facilities.

Excavation Damage Prevention Measures Program Plan

It is estimated that adding the Urbint risk prioritization tool and five new Damage Prevention Field Representatives would reduce the number of damages by approximately 120 per year after 3 years. Also, PSE intends to hire a new analyst to investigate all the field completed work with an unknown mapping task category and route them for timely mapping updates. Based on current SAP work monitoring, PSE will review approximately 5,000 field completed activities and update mapping records if necessary to reduce risk of potential excavation damage due to unmapped or inaccurately mapped facilities modifications. This effort is estimated to take 5 years beginning in 2022. The schedule should not create an undue burden on rate payers. The forecasted excavation damage prevention schedule is detailed in Table 10.

Table 10. Excavation Damage Prevention Schedule, Quantity, and Estimated Expenditures

Program Years	Total Avoided Excavation Damages (Over 5 years)	Estimated Emissions Savings (tCO2e)[2]	Estimated Expenditures[1]	Avoided Damage Savings
1-5	494	6,916	$5.9 million	$0.8 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

2 Estimated Emissions Savings are Metric Tons CO2 equivalent

Two-Year Plan

The two-year plan is to use a risk based model for determining what locate tickets to monitor with additional field reps and to research and map field completed work with unknown mapping task category so no excavation damage occurs according the Master Plan. The following table shows the avoided excavation damages, emission savings, and expenditures for 2022 and 2023.

Table 11. Excavation Damage Prevention

Year	Total Avoided Excavation Damages	Estimated Emissions Savings (tCO2e)[2]	Estimated Expenditures[1]
2022	42	588	$1.4 million
2023	82	1,148	$1.0 million
Total	124	1,736	$2.4 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

2 Estimated Emissions Savings are Metric Tons CO2 equivalent

Identification Plan

The identification of high risk excavation damage sites is found through a risk model that would incorporate GIS facility data into the model. The model would identify 5 percent of dig tickets that will account for 38 percent of the damages.

10. Aboveground Meter Set Remediation

Master Plan

Methane Emissions Risk Assessment

PSE has found that the common construction practice of utilizing multiple threaded joints at natural gas meter sets may create more methane release opportunities. In an effort to reduce methane releases, PSE has targeted repair of these nonhazardous release of gas (NARG) occurring at meter set threaded joints and unions. These gas releases are very small and typically only produce small bubbles when leak detection soap is applied. Very sensitive leak detection instruments can detect the NARG, but normally they are not detectable by people in the area. NARGs are transient based on air temperature and rain can also affect their detection. PSE currently has two leak grades for aboveground facilities, Grade "A" hazardous leaks, and NARG for nonhazardous releases of gas. There is no requirement to fix NARGs due to their small and nonhazardous nature.

PSE reviewed a study performed by Gas Technology Institute (GTI) for the U.S. Department of Energy that provided the classification of methane emissions from industrial meters, vintage vs Modern plastic pipe, and plastic-lined steel and Cast-iron pipe. The study indicated that for the Pacific region the mean emissions rates for Industrial/commercial meter sets from leaker only sets was 3.57 gCH4/h, which was the lowest emission rate across the regions studied. This emission factor was applied to PSE's NARG population based on the amount of gas detected in parts per million. The first population is top emitting meter sets with readings above 10,000 ppm which includes approximately 1,495 risers. The second population has a ppm reading between 5,000 and 10,000 which includes approximately 3,083 risers. The third population with the least amount of emissions of less than 5,000 parts per million includes approximately 22,556 risers. Only the large and medium emitters from population one and two are proposed to be repaired that would result in over 50% emission reduction from the total population of NARGs identified.

Aboveground Meter Set Remediation Program Plan

PSE's plan is to eliminate the largest NARG emissions from meters in PSE's distribution system. Based on current leak survey knowledge and historical performance, PSE will remediate approximately 7,300 nonhazardous NARGs to reduce methane emissions within 5 years beginning in 2022. New reports of NARGs will be added to the program as they are found, but adjustments to the program will be made as the impacts of repairing NARGs are realized. The schedule should not create an undue burden on rate payers. Throughout the program duration, PSE is able to secure valuable contractor resources to keep a normalized work load while reducing the overall emissions. The current replacement schedule is provided in Table 12.

Table 12. NARG Repair Schedule, Quantity, and Estimated Expenditures

Program Years	Total Planned NARG Repairs	Estimated Emissions Savings (tCO2e)[2]	Estimated Expenditures[1]
1-5	7,300	4,000	$3.6 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

2 Estimated Emissions Savings are Metric Tons CO2 equivalent

Two-Year Plan

The two-year plan is to repair large and medium sized NARGs at meter sets according to the Master Plan. The following table shows the planned NARG repairs, emissions savings, and expenditures for 2022 and 2023.

Table 13. Planned NARG Repairs

Year	Planned NARG Repairs	Estimated Emissions Savings (tCO2e)[2]	Estimated Expenditures[1]
2022	1,495	1,165	$0.75 million
2023	3,083	1,346	$1.5 million
Total	4,578	2,252	$2.3 million

1 Estimated expenditures are in 2021 dollars and do not include AFUDC

2 Estimated Emissions Savings are Metric Tons CO2 equivalent

Identification Plan

The location of nonhazardous aboveground releases of gas is found through leak detection methods during an annual survey.

11. Public Interest

The pipe replacement plans for the materials that pose an elevated risk of failure included in this PRP plan have been developed considering many factors. These factors include:

- Improving the safety of the distribution system by replacing pipe based on the relative level of risk presented for each material and location
- Minimizing the replacement costs by maximizing efficiencies and productivity
- Minimizing the impacts to municipalities and the general public
- Minimizing the methane emissions to protect the environment and public health

12. Rates Impact

The replacement programs included in this PRP plan that would be requested in the CRM starting with the 2022-2023 CRM rate period would include DuPont Aldyl “HD” plastic pipe, buried meter remediation, and sewer cross bores remediation. The programs that reduce methane emissions in this PRP plan that would be requested in the CRM starting with the 2022-2023 rate period would include active leak reduction program, damage prevention measures, and NARG repairs. The historical rate impact should be modified to account for the additional policy change allowing rate recovery for methane emission reductions as described by RCW 80.28.420.

Consistent with the requested potential rate impact analysis discussed in paragraph 55 of the policy statement and paragraph 2 in RCW 80.28.420, PSE’s best estimate at this time is that the current impact on the overall customer rates for the six PRP plan programs would be 0.64%, while the long-term impact is expected to be approximately -0.07% for the 2022 through 2032 period.