Des Moines Water Works
Water You Can Trust for Life

DES MOINES WATER WORKS
Board of Water Works Trustees

Agenda Item No. III-A
Meeting Date: August 23, 2016
Chairperson's Signature ☐ Yes ☒ No

AGENDA ITEM FORM

SUBJECT: Receive and File the Corrosion Control Program Report

SUMMARY:

- Des Moines Water Works (DMWW) has experienced main breaks in our distribution system at an increasing rate throughout our history.
- Main breaks cost DMWW more money to repair each year.
- In 2003, DMWW found a way extend the life of existing water mains, lower the number of main breaks, and protect new water mains.
- Since 2004, DMWW has implemented four elements of our Corrosion Control Program.
  - Anode Retrofit Program
  - Anode Installation During Main Break Repairs
  - Cathodic Protection on New Small Ductile Iron Water Mains
  - Corrosion Control Systems on New Feeder Mains
- The Corrosion Control Program Report, describing each program, was completed in June of 2016.
- DMWW Staff recommends the following:
  - Continue installing the Anode Retrofit Program on existing 8-inch and 12-inch cast iron water mains with a break rate of at least 0.35 breaks/100 feet in five years.
  - Continue Anode Installation During Main Break Repairs, phase out using the clamp to attach the anode to the iron water main, and begin using an exothermic weld to attach the anode to the iron water main.
  - Continue the Cathodic Protection on New Small Ductile Iron Water Mains.
  - Continue the Corrosion Control Systems on New Feeder Mains.
  - Add a new Corrosion Control Program in 2016 to install an Anode Retrofit Program on Existing Ductile Iron Water Mains.

FISCAL IMPACT:

None at this time. Information from the Corrosion Control Report will be used to continue to develop capital and operating budgets that will be presented to the Board in future years.

RECOMMENDED ACTION:

Receive and file the Corrosion Control Report for Des Moines Water Works.

BOARD REQUIRED ACTION:

Motion to receive and file the Corrosion Control Report for Des Moines Water Works.

_____/_____	_____/_____	_____/_____
Katrina L. Kinsey, P.E. (date)	Danny J. Klopfer, P.E. (date)	William G. Stowe (date)
Professional Engineer	Engineering Services Manager	CEO and General Manager

Attachments: Planning Committee Memo and Presentation Slides
View the Corrosion Control Report here: http://www.dmww.com/upl/documents/library/corrosion-control-report.pdf

DES MOINES WATER WORKS
Board of Water Works Trustees

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MEMORANDUM

DATE: July 26, 2016

TO: William Stowe, CEO and General Manager

FROM: Dan Klopfer, Engineering Services Manager
Katie Kinsey, Professional Engineer

SUBJECT: Des Moines Water Works' Corrosion Control Program Report

Background

Water utilities throughout the United States and Canada have been dealing with the deterioration of underground water distribution systems for a number of years. These distribution systems were primarily constructed using cast iron pipe. The issue we are facing using iron products is that they are susceptible to corrosion when exposed to environmental elements. Corrosion is accelerating the deterioration of these water mains thus accelerating them to reach their life expectancy. The need to rehabilitate or replace these water mains is escalating at an increasing rate.

Des Moines Water Works (DMWW) is no different than other water utilities throughout the United States and Canada. DMWW has experienced main breaks in the distribution system at an increasing rate throughout our history. When DMWW staff repairs a main break, rarely do we find a main break where corrosion has not contributed to its failure. Main breaks are costing DMWW more and more money each year. In 2015, the direct cost to repair a main break was $7,826.62. Prior to 2003, the only way we knew how to stop corrosion on a water main was to replace the water main.

In 2003, DMWW actively searched for a way to extend the life expectancy of our metallic water mains, so to extend their life expectancy and lower the number of main breaks. Since 2003, DMWW has worked closely with a corrosion engineer to develop our four elements for the corrosion control program ([1] **Anode Retrofit Program**, [2] **Anode Installation During Main Break Repairs**, [3] **Corrosion Protection on New Small Ductile Iron Water Mains**, and [4] **Corrosion Control Systems on New Feeder Mains**) within the distribution system. In June 2016, DMWW staff completed a corrosion report which will be received and filed at the August 2016 Board Meeting.

Anode Retrofit Program

The anode retrofit program began in 2004 and utilizes a cathodic protection system that welds a 32-pound sacrificial anodes to existing cast iron water mains spaced at specified intervals over the water main. This program includes test stations so readings can be obtained to help determine the effectiveness of the program. To date, the program has been implemented on 117, 628 feet (22.28 miles) of existing cast iron water mains. On these 117,628 feet of water mains, DMWW has seen a 60.5 percent reduction in main breaks.

DMWW completed a backfill study in 2016 to determine if a particular kind of backfill material around the anode yielded better results. At this point, the study is still being evaluated and a recommendation to a backfill material will be given at a later date.

DMWW also completed a study to determine the life expectancy of an anode. Multiple anodes were dug up that were installed during the anode retrofit program to be weighed. These anodes were compared to the weight of a new off-the-shelf anode. It was found that an anode has an average of a 25-year life expectancy.

The economic analysis for the anode retrofit program indicates DMWW needs to install anode retrofit on only 8-inch and 12-inch cast iron water mains that have a break rate of at least 0.35 breaks per 100 feet over five years.

Anode Installation During Main Break Repairs

DMWW began a program in 2005 of adding anodes to existing cast iron and ductile iron water mains during a main break repair. When a main break is caused by a beam break or a hole in the pipe, the main break is repaired with a repair band. The anode is attached to the existing water main immediately adjacent to the repair band with a clamp. When the main break is caused by a split or a large failure that requires replacement of pipe, the main break is repaired using two couplings and a piece of pipe wrapped in a polyethylene encasement. The anode is attached to the existing water main with two clamps on either side of the two couplings.

DMWW completed a study to determine the effectiveness of installing anodes following broken water mains and which technique was the most effective to attach anodes to the water main. Our research found that the installation of anodes resulted in some cathodic protection in the area of the water main break repair.

We also evaluated attaching the anodes using an exothermic weld versus a clamp. The results of the study showed that clamps do not provide as good of a connection to the existing water main as the exothermic weld.

It is our recommendation that we continue installing anodes during a main break repair and that we begin attaching the anode with an exothermic weld.

Corrosion Protection on New Small Ductile Iron Water Mains

A program was started in 2010 to add cathodic protection to the new small diameter (8-inch to 16-inch) ductile iron water mains. The cost for adding cathodic protection to new small ductile iron water mains is approximately 3 percent of the total project cost. This cathodic protection system is designed to protect the water main where it comes in contact with the soil.

It is assumed if the water main did not have a polyethylene encasement, the life expectancy of the ductile iron water main would be approximately 50 years. With the polyethylene encasement around the ductile iron water main, it extends the life expectancy to 75 years. With the added cathodic protection to the ductile iron polyethylene encased water main, the life expectancy is extended to 100 years.

It is recommended to continue this program for the future. The small added cost for cathodic protection significantly increases the life expectancy for all new small ductile iron water mains.

Corrosion Control Systems on New Feeder Mains

Protecting and extending the life of new feeder mains (16-inch and larger) is very important for the longevity of the DMWW distribution system. DMWW has two different corrosion control systems for new feeder mains. Metallic feeder mains use a designed cathodic protection corrosion control system, and concrete feeder mains use a designed corrosion monitoring corrosion control system.

The cathodic protection on the feeder mains program began in 2003 and is currently protecting 19.3 miles of ductile iron and welded steel feeder mains. This program uses anodes, bonding cables, flange isolation kits, reference electrodes, and test stations. The test stations are used to obtain readings to help determine the effectiveness of this program. The cost for adding cathodic protection to new small ductile iron water mains is approximately 4.5 percent of the total project cost.

The corrosion monitoring on the feeder mains program began in 1997 and is currently monitoring 10.1 miles of prestressed concrete cylinder pipe (PCCP) feeder mains. This program uses bonding cables, reference electrodes, and test stations. The test stations are used to identify locations where corrosion may be occurring.

The recommendation for these programs is to continue to inspect the test stations and obtain readings to verify the corrosion control system is working properly.

Corrosion on Existing PCCP Feeder Mains

Since 2010, DMWW has seen two separate instances where there has been corrosion at the joints of PCCP feeder mains. The first instance was on a 30-inch feeder main that was installed in 2000. The 30-inch PCCP feeder main needed to be relocated because of development; and when the new 30-inch relocated feeder main was connected to the existing 30-inch PCCP feeder, DMWW found that there was corrosion at the joints.

In early 2016, DMWW staff found a leak on a 36-inch PCCP feeder main that was installed in 1997. When the leak was dug up, staff found that the leak was coming from a joint. The corrosion found on this joint was similar to the corrosion found in the first instance.

DMWW believes that improper diaper installations around the concrete joints during construction of the PCCP feeder mains created areas where corrosion was accelerated causing the joint to leak.

There is a workplan in the 2017 budget to determine if any of the other PCCP feeder main have leaks, broken wires, or corrosion occurring. This will help DMWW find locations where failures due to corrosion are likely to occur and prevent them from becoming costly failures.

Anode Retrofit Program on Existing Small Ductile Iron Water Mains

In 2017, DMWW plans to begin our fifth element of our corrosion control program. This element is to implement an anode retrofit program on existing small ductile iron water mains. Within the DMWW distribution system, there are small ductile iron water mains that were installed before polyethylene encasement was used. These ductile iron water mains are estimated to have a life expectancy of 50 years. It is estimated that implementing an anode retrofit program to these water mains will increase the 50-year life expectancy to 75 years.

AWWA Research Foundation

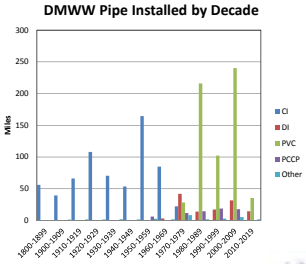
DMWW's Corrosion Program is one of the most premier programs in the United States for water utilities. DMWW is currently working with the American Water Works Association Research Foundation to prepare a Guidance Document for water utilities to manage corrosion control. At this time, it appears that most of our corrosion program will be incorporated into this document.

Des Moines Water Works' Corrosion Control Program

Dan Klopfer
Katie Kinsey

Des Moines Water Works
Water You Can Trust for Life

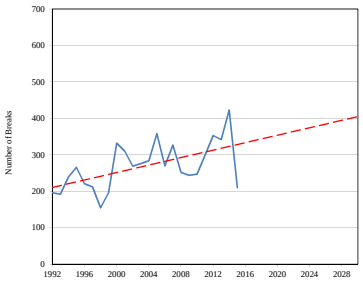
History of DMWW Distribution System



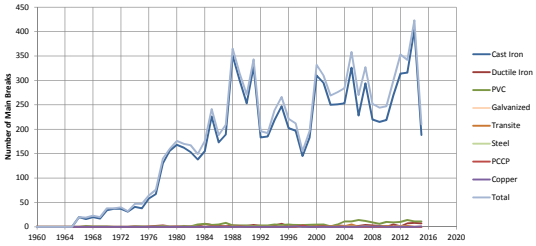
Pipe Install Date by Decade

Decade	CI	DI	PVC	PCCP	Other	Totals
1800-1899	56	0	0	0	0	**56**
1900-1909	39	0	0	0	1	**40**
1910-1919	66	0	0	0	2	**68**
1920-1929	108	0	0	0	1	**109**
1930-1939	70	0	0	0	2	**72**
1940-1949	53	0	0	0	2	**55**
1950-1959	165	0	0	6	3	**173**
1960-1969	85	3	0	0	2	**90**
1970-1979	22	42	28	12	8	**112**
1980-1989	0	14	216	14	2	**246**
1990-1999	0	17	102	19	3	**141**
2000-2009	0	32	240	18	5	**295**
2010-2019	0	14	35	0	2	**51**
Totals	**666**	**122**	**622**	**69**	**31**	**1510**

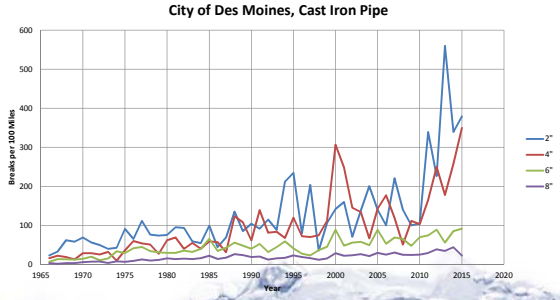
Main Breaks



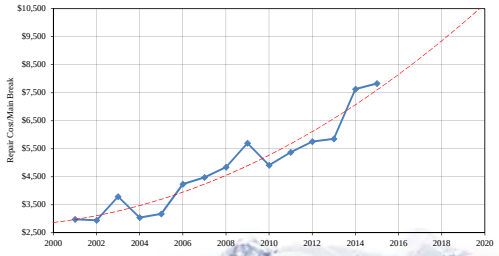
Main Breaks by Material



Main Breaks on Cast Iron Pipe in the City of Des Moines



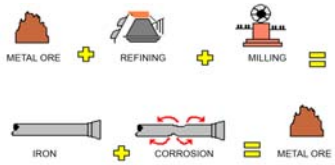
Direct Cost per Main Break Repair

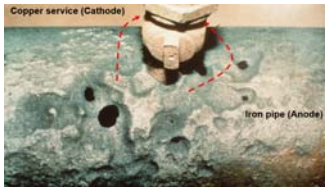


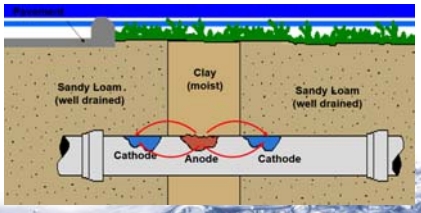
The Perfect Storm

- ⬆ Main Breaks + ⬆ Repair Costs = Catastrophe
- Stop Corrosion = Replace Water Mains
- Find a Way to Extend the Life of Water Main
- Find a Way to Lower Number of Main Breaks
- Find a Way to Protect New Water Mains

Corrosion







Components of DMWW's Corrosion Control Program

- Anode Retrofit Program
- Anode Installation During Main Break Repairs
- Corrosion Protection on New Small Ductile Iron Water Mains
- Corrosion Control Systems on New Feeder Mains
- Anode Retrofit Program on Existing Small Ductile Iron Water Mains (NEW)

Anode Retrofit Program

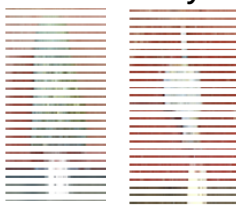
- Cathodic Protection System on Cast Iron Water Mains
- Uses 32-Pound Anodes and Test Stations

Anode Retrofit Program

- Water Main Protected – 117,628 feet (22.28 miles)
- Number of Anodes – 2,321
- Number of Test Stations – 253
- Total Cost – $1,518,780

Anode Life Expectancy/Backfill Study

- Assumed Life of 20 Years
- Found Life to be 25 Years



- Native Soil
- Manufactured Sand
- Low-Strength Concrete

Economic Analysis/Recommendations

- Direct Main Break Repair Cost = $7,826.62
- Reduction Factor = 60.5%
- Anode Life Expectancy = 25 Years

- Reduction Factor = 73.7%
- 8-inch and 12-inch Existing Cast Iron Pipe
- At Least 0.35 Main Breaks/100 Feet Over 5 Years

Anode Installation During Main Break Repairs

- Add Anodes to Repairs on Cast/Ductile Iron Water Mains

Anode Installation During Main Break Repairs

- Attachment Study

Corrosion Protection on New Small Ductile Iron Water Mains

- 8-inch and 12-inch New Ductile Iron Water Mains
- 3% Added Cost to Total Project Cost

Water Main Life Extension

50 Year Life

75 Year Life

100 Year Life

Corrosion Control Systems on New Feeder Mains (Core Network)

Cathodic Protection

Corrosion Monitoring

Length of Feeder Mains

Total Length of Feeder Mains

Material	Length (miles)
Pit CIP	13.7
Spin CIP	20.5
DIP	49.8
HDPE	0.4
PCCP	60.5
PVC	7.6
Steel	2.1
Total	152.4

Total Length of Cathodic Protection

DIP/WSP	Length (miles)
Protected	19.3
Unprotected	30.5

Total Length of Corrosion Monitoring

PCCP	Length (miles)
Bonded	10.1
Unbonded	50.5

Cathodic Protection

- 19.3 Miles on Ductile Iron Pipe & Welded Steel Pipe
- 4.5% Added Cost to Total Project Cost

Corrosion Monitoring

- 10.1 Miles on PCCP

Corrosion on Existing PCCP Feeder Mains

- 2010 – 30-inch PCCP (2000)

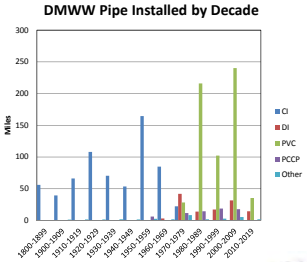
Corrosion on Existing PCCP Feeder Mains

- 2016 – 36-inch PCCP (1997)

Anode Retrofit Program on Existing Small Ductile Iron Water Mains

NEW

Bare Ductile Iron Water Main



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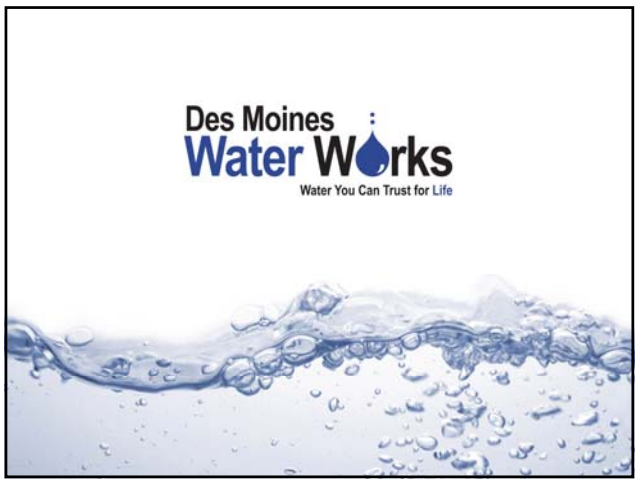
Bare Ductile Iron Water Main

AWWA Research Foundation

- Retrofit and Management of Metallic Pipe with Cathodic Protection: Guidance Document on Technical Feasibility and Economic Value (WRP 4618)
- Help Utilities Choose Cathodic Protection Management Techniques for Existing Pipes
  - Troubleshooting
  - Management
  - Value Analysis
  - Not Address Design of New Systems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