THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

BOARD ACTION

- Board of Directors
  Engineering and Operations Committee

9/13/2011 Board Meeting

8-1

Subject

Appropriate $7.76 million; and authorize (1) initiation of the PCCP Rehabilitation and Replacement Program; (2) final design of carbon fiber repairs for eight PCCP lines; and (3) agreement with Pure Technologies US, Inc. for pipeline inspections and monitoring (Approp. 15471)

Description

This action authorizes the initiation of a comprehensive long-term program for monitoring, rehabilitation, and/or replacement of Metropolitan's prestressed concrete cylinder pipe (PCCP) lines. This action also authorizes final design of carbon fiber lining repairs for eight PCCP lines, and an agreement for electromagnetic inspection and acoustic fiber optic monitoring of PCCP lines.

Timing and Urgency

In the late 1990s, in response to industry concerns about the reliability of PCCP lines, Metropolitan began to assess the condition of its 163 miles of PCCP within the conveyance and distribution system. In 1999, a rupture occurred in a segment of PCCP on the Allen-McColloch Pipeline. Since that incident, Metropolitan has aggressively inspected its PCCP lines and has completed repairs to 197 distressed PCCP segments. These repaired segments have a total length of 0.75 miles, and represent less than one percent of Metropolitan's 42,053 PCCP segments. A typical PCCP segment is 20 feet long.

Over the last decade, Metropolitan and other PCCP owners have collaborated closely to identify best practices for inspection, monitoring, and repair of PCCP lines. As a result of forensic analyses of PCCP ruptures, multiple inspections of PCCP lines to determine changes in their condition over time, and improved techniques for inspection and analysis of PCCP, an industry consensus has developed that PCCP lines may have a reduced service life and elevated risk of failure versus other types of pipe. The potential for reduced service life is dependent on the unique conditions of each PCCP line: its internal operating pressure, external soil loading, pipe wall construction, soil corrosivity, stray current interference from others' cathodic protection systems, and properties of the pipe materials. Numerous agencies are developing long-term strategies for assessment and rehabilitation of their PCCP lines, and at least one agency has initiated a complete replacement/relining program.

To maintain Metropolitan's water delivery reliability and reduce the risk of costly emergency repairs of PCCP lines, staff recommends initiating the PCCP Rehabilitation and Replacement Program. This program will develop a strategy to enhance long-term reliability of PCCP lines, monitor distressed PCCP sections for a five-year period, and initiate and prioritize the replacement/relining of PCCP lines throughout Metropolitan's conveyance and distribution system. The second project in this action will upgrade some of Metropolitan's early carbon fiber lining repairs of distressed PCCP segments so that those PCCP repairs will fully comply with a newly developed AWWA standard.

These projects have been reviewed by Metropolitan's updated Capital Investment Plan (CIP) prioritization criteria, and are categorized as Infrastructure Reliability projects. Initiation of the PCCP Rehabilitation and Replacement Program is budgeted within Metropolitan's CIP for fiscal year 2011/12. The carbon fiber lining repairs are not budgeted within the fiscal year, as the need and opportunity to perform the repairs were not

identified until after the budget was adopted. Moving forward at this time will take advantage of scheduled shutdown opportunities during winter 2011/12 to repair these PCCP sections.

Background

Metropolitan's water delivery system includes approximately 830 miles of pipelines, of which 163 miles are PCCP lines. These PCCP lines were installed between 1965 and 1985, and range in diameter from 54 to 201 inches. The lines are located in both dense urban areas and remote regions. A detailed description of the development of PCCP, the available techniques for inspection and repair, and Metropolitan's own experience, appear in **Attachment 1**. A summary list of Metropolitan's PCCP feeders appears in **Attachment 2**.

To date, Metropolitan has inspected all 163 miles of its PCCP lines at least twice with a technique called electromagnetic inspection, which is the primary means within the industry for identifying distressed PCCP lines. Electromagnetic inspection can identify broken prestressing wires within the pipe wall of a PCCP segment. Broken prestressing wires can significantly reduce the strength of a PCCP line.

Following the 2009/10 winter inspection season, Metropolitan had identified a total of 160 PCCP segments (0.61 miles) with 10 to 140 prestressing wire breaks. These 160 segments were found in 14 feeders, while 137 of those 160 segments (86 percent) were found in five feeders. To date, Metropolitan has repaired 103 (0.4 miles) of these 160 distressed PCCP segments. An additional 33 segments (0.12 miles) are planned to be repaired by fiscal year 2012/13, and 24 (0.09 miles) will be repaired in the following years.

If a crack occurs in the outer mortar coating of a PCCP segment, the prestressing wires may be exposed to moisture in the surrounding soil, leading to corrosion. This cracking may be caused by a condition referred to as a "broken back". A total of 113 PCCP segments (0.43 miles) with broken back cracks have been identified to date on Metropolitan feeders. Of these 113 segments, 94 (0.36 miles) have already been addressed, while 19 segments (0.07 miles) are planned to be repaired by fiscal year 2014/15.

For the last decade, Metropolitan's approach for management of its PCCP lines has been to aggressively inspect the lines and make repairs to individual PCCP segments when they are identified as being in distress. While this approach has thus far prevented additional failures of PCCP segments, the repair costs are relatively high per segment, and there is no guarantee that other failures may not occur in the future. In considering the inspection data gathered and repairs completed on distressed PCCP segments since 1999, staff believes that at least five of Metropolitan's PCCP feeders will have a shortened service life. These feeders include the Allen-McColloch Pipeline, Calabasas Feeder, Rialto Pipeline, Second Lower Feeder, and Sepulveda Feeder.

As industry experience and data regarding the risk of PCCP failure continue to build, staff recommends that a new long-term strategy be adopted to manage Metropolitan's PCCP lines. The proposed long-term strategy includes three components:

1. Repair of Distressed PCCP Segments – Metropolitan will continue to perform urgent and scheduled repairs of distressed PCCP segments. Several of these repair projects are included within Metropolitan's fiscal year 2011/12 capital budget and are already underway.

2. Monitoring of PCCP lines – Metropolitan will continue to aggressively inspect its PCCP lines using state-of-the-art inspection techniques.

3. Development and Prioritization of Long-Term Rehabilitation and Replacement Program – Metropolitan will commence the planning for replacement or relining of all at-risk pipelines. This effort will initially focus on the five PCCP feeders noted above.

Each of the three components of this long-term strategy is described in **Attachment 1**.

Project No. 1 – PCCP Rehabilitation and Replacement – Stage 1 ($6,260,000)

The PCCP Rehabilitation and Replacement Program will address the second and third components of the proposed long-term strategy to manage Metropolitan's PCCP lines. The three tasks planned initially in this program include:

Task 1: Prioritize the Relining/Replacement of At-risk PCCP Lines An assessment of the risks and vulnerabilities of Metropolitan's PCCP lines will be conducted. Five feeders will form the primary focus of Stage 1 of this effort: the Allen-McColloch Pipeline, Calabasas Feeder, Rialto Pipeline, Second Lower Feeder, and Sepulveda Feeder. Based on Metropolitan's 11 years of experience with inspection and repair of PCCP lines, these five feeders are the most likely to have a reduced service life.

The assessment effort of these PCCP lines will include: (1) review of pipeline age and history; (2) evaluation of number and severity of wire breaks and broken backs; (3) assessment of pipeline characteristics (design, construction records, fabrication drawings, as-built conditions, repair history, pipe operating conditions, and pipe pressures); and (4) evaluation of deterioration factors (soil corrosivity and third-party stray currents).

This task will also develop an overall plan of execution by assessing the repair logistics, identifying the extent of major repairs needed, and identifying cost-effective rehabilitation/replacement options. The plan will include: (1) a review of the operational flexibility and redundancy of Metropolitan's distribution system with isolation and operational shutdown restrictions (isolation valves, reservoirs, service connections); (2) evaluation of permitting and right-of-way needs, and environmental constraints; and (3) impacts to member agency deliveries.

Upon completion of this execution plan, a staging plan will be developed which will include conceptual level project descriptions, an overall program schedule, and conceptual level construction cost estimates for each pipeline. This effort is anticipated to be completed by October 2012.

Staff will return to the Board to report on the conclusions from this effort. Identified capital projects will be recommended for evaluation and inclusion in Metropolitan's Capital Investment Plan in conjunction with the annual budget process, and will be the subject of future board actions.

Task 1 will address the third component of the proposed long-term strategy to manage Metropolitan's PCCP lines. The estimated cost for Task 1 is $448,000, which includes $276,000 for development of the execution and staging plans, review of system operations and constraints, acquisition of right-of-way, and permitting; $132,000 for conceptual level cost estimates, joint planning with member agencies, and project management; and $40,000 for remaining budget. All work will be performed by Metropolitan staff.

Task 2: Conduct Electromagnetic Inspections As discussed above, electromagnetic inspections are an integral component of Metropolitan's long-term strategy for management of PCCP lines. The results of these inspections will expand knowledge of the pipelines' baseline condition, track wire breakage over time, and identify portions of feeders containing distressed PCCP segments. The information provided will be used to evaluate and schedule both short-term repairs of distressed PCCP segments and the long-term comprehensive repair/replacement of pipeline reaches or entire pipelines.

The initial stage of the PCCP Rehabilitation and Replacement Program will include one cycle of electromagnetic inspections of all 163 miles of PCCP lines within the conveyance and distribution system. Since inspections can only be accomplished during shutdown seasons with the pipelines dewatered, only 35 to 45 miles of PCCP lines are planned to be inspected each year. As a result, these inspections will take place over a five-year period. Upon completion of this cycle of electromagnetic inspections, the results will be used to update the assessment and plan of execution developed under Task 1.

At the present time, electromagnetic inspection is the industry's primary means for identification of wire breaks. However, as technologies advance, Metropolitan will continue to assess and improve its inspection and monitoring capabilities. The use of electromagnetic inspections along with other newly developed technologies will be assessed on a five-year basis.

The planned activities under Task 2 include: scheduling and coordinating shutdowns; conducting the electromagnetic inspections; conducting visual inspections; performing soundings and impact echo tests;

analyzing the inspection results; and preparing comprehensive inspection reports. The electromagnetic inspections are recommended to be performed by Pure Technologies US, Inc., as discussed below. All other work will be performed by Metropolitan staff.

Task 2 and Task 3 (discussed below) will address the second component of the proposed long-term strategy to manage Metropolitan's PCCP lines. The estimated cost for Task 2 is $4,663,000, which includes $3.38 million for electromagnetic inspections over a five-year period by Pure Technologies; $513,000 for Metropolitan forces to perform visual and sounding inspections, and provide shutdown support over a five-year period; $80,000 for planning, analysis, and quality control of inspection results; $160,000 for a specialty firm to provide protective equipment and safety support during pipeline inspections; $130,000 for project management and permitting; and $400,000 for remaining budget.

Task 3: Conduct Pilot Testing of Acoustic Fiber Optic Monitoring Acoustic fiber optic monitoring allows real-time monitoring of wire breaks. With this technology, sensors "listen" for prestressing wire breaks while the pipeline is in service. The location of wire breaks is calculated from sensor locations based on the speed of sound, so once the sensors are installed, information is collected on a continuous real-time basis. There is a significant amount of signal processing required to determine the wire breaks, so the real-time monitoring is delayed by the processing lag time. However, the monitoring results can be used to calculate rates of prestressing wire breakage.

The planned pilot testing will monitor five miles of PCCP lines over a one-year period. The acoustic fiber optic monitoring system will be installed over a total length of five miles in up to three pipelines. The locations will be dependent on pipeline attributes, including communication and power constraints. Upon completion of one year of pilot testing, staff will return to the Board to report on the conclusions of this effort, and will make recommendations regarding continued use of acoustic fiber optic monitoring.

The planned activities under Task 3 for the acoustic fiber optic monitoring system include: compiling pipeline information such as pressures, flow rates, turbulence, and physical features; evaluating locations for installation of fiber optic acoustic cable, data acquisition cabinets, communication connections and power supply; modifying existing manhole flanges as necessary for monitoring equipment; and performing monitoring for one year. The equipment installation and monitoring are recommended to be performed by Pure Technologies US, Inc., as discussed below. All other work will be performed by Metropolitan staff.

The estimated cost for Task 3 is $1,149,000, which includes $800,000 for Pure Technologies to design, install, and monitor the acoustic fiber optic monitoring systems; $289,000 for Metropolitan forces to design and install the ancillary connections, power supplies, and communications; $24,000 for project management; and $36,000 for remaining budget.

Stage 1 Results Upon completion of Stage 1, a summary of the results of electromagnetic testing and acoustic fiber optic monitoring will be used to update the PCCP data base and identify vulnerable portions of Metropolitan's 27 PCCP lines. Based on previous experience, staff anticipates that this effort may also identify distressed segments of PCCP which may require urgent repair. A summary report will also be prepared, and projects will be recommended for evaluation and inclusion in Metropolitan's Capital Investment Plan.

This action appropriates $6.26 million and authorizes Stage 1 of the PCCP Rehabilitation and Replacement Program. Stage 1 activities are anticipated to have a duration of five years. Upon completion of Stage 1, staff will return to the board with recommendations for Stage 2, which will address the remaining 22 of Metropolitan's PCCP lines.

Project No. 2 – Carbon Fiber Repairs for Eight PCCP Lines – Final Design Phase ($1,500,000)

Metropolitan was among the first water agencies in the United States to employ carbon fiber lining to repair PCCP lines. The technique was first used by Metropolitan in 2003 to repair the Allen-McColloch Pipeline. Since that time, the use of carbon fiber lining has expanded significantly within the industry, while knowledge of design and performance-related issues has increased. Over the past decade, Metropolitan has actively collaborated with AWWA and has participated on the AWWA Standards Committee in the development of a new standard for carbon fiber lining repair of water pipelines. This new AWWA standard is scheduled to be issued in late 2011.

Prior to development of this new standard, the water industry lacked a uniform design approach for carbon fiber repairs of PCCP lines. As a result, design criteria and application procedures varied between agencies.

One important feature incorporated into the new AWWA standard is the lapping of carbon fiber reinforcement over the pipe joints. Based on feedback from some early carbon fiber repairs, this feature protects against water migrating into the pipe wall via a compromised joint, which could reduce the bond and strength of the carbon fiber lining. Since 2003, Metropolitan has repaired 46 PCCP segments on nine feeders with carbon fiber lining, of which 22 segments on eight feeders did not incorporate the lapping feature. Based on feedback results which were considered during development of the new AWWA standard, staff has assessed these 22 early carbon fiber installations and recommends that they be upgraded to be consistent with the new standard. These upgrades will involve the extension of carbon fiber lining on the 22 previously repaired PCCP segments over their adjacent pipe joints. This work will be scheduled to take advantage of planned shutdowns of PCCP lines over the next several shutdown seasons.

The 22 PCCP segments recommended to receive carbon fiber repairs are located on eight feeders: the Allen-McColloch Pipeline, Auld Valley Pipeline, Lake Skinner Outlet Conduit, Foothill Feeder, Rialto Pipeline, San Diego Pipelines Nos. 4 and 5, and Sepulveda Feeder. In order to avoid shutdowns during peak demand season and to minimize outage durations, these repairs will be staged to take advantage of planned feeder shutdowns. Thirteen PCCP segments on the Allen-McColloch Pipeline, Foothill Feeder, and Sepulveda Feeder are planned to be repaired in January and February 2012. In order to complete the repairs during the planned shutdowns, staff recommends commencing final design at this time. Staff will return to the Board in November 2011 to award construction contracts to repair these three lines. The remaining nine PCCP segments on five feeders will be scheduled for repair via construction contracts during planned shutdowns in the 2012/13 and 2013/14 shutdown seasons.

Planned final design phase activities include preparation of drawings and specifications; acquisition of permits and temporary right-of-way; preparation of environmental documentation; development of construction cost estimates; receipt of competitive bids; and all other activities in advance of award of construction contracts. Final design will be performed by Metropolitan staff with assistance from a specialty consultant, Simpson Gumpertz & Heger, to perform detailed analyses of the lapping reinforcement.

This project is one of several efforts that address the first component of the proposed long-term strategy to manage Metropolitan's PCCP lines. Several additional projects are planned in fiscal year 2011/12 that will repair distressed PCCP segments, and which will be the subject of future board actions.

This action appropriates $1.5 million and authorizes final design of carbon fiber lining repairs for eight PCCP lines including the Allen-McColloch Pipeline, Auld Valley Pipeline, Lake Skinner Outlet Conduit, Foothill Feeder, Rialto Pipeline, San Diego Pipelines Nos. 4 and 5, and Sepulveda Feeder. The requested funds include $633,000 for final design, $100,000 for Simpson Gumpertz & Heger to perform specialized structural modeling of the PCCP sections; $50,000 for preparation of environmental documentation; $525,000 for advertisement and receipt of competitive bids for up to eight construction contracts, and for project management; and $192,000 for remaining budget. The final design cost as a percentage of the estimated construction cost is 9.3 percent. Engineering Services' goal for design of projects with construction cost more than $3 million is 9 to 12 percent. The total construction cost for these projects is anticipated to range from $8 million to $9 million.

Specialized Technical Support (Simpson Gumpertz & Heger) – No Action Required

The structural analysis of the distressed PCCP segments is recommended to be performed by Simpson Gumpertz & Heger under an existing agreement. Simpson Gumpertz & Heger was selected through a competitive process via Request for Qualifications (RFQ) No. 884. This structural analysis is a technical specialty which Metropolitan does not maintain the expertise to perform in-house. The estimated cost for these services is $100,000. Due to the specialized nature of the work, Metropolitan did not establish an SBE participation level for this agreement.

Pipeline Inspections (Pure Technologies US, Inc.) - New Agreement

Electromagnetic inspection of Metropolitan's 163 miles of PCCP lines and installation of acoustic fiber optic monitoring systems on PCCP lines are recommended to be performed by Pure Technologies US, Inc. under a new professional services agreement. Pure Technologies was selected through a competitive process via RFQ No. 945. Due to the unique expertise required for this work, Metropolitan did not establish a Small Business Enterprise participation level. Staff reviewed and evaluated the firm's qualifications, staffing plan, cost, record of past performance, references, technical approach and methodology, environmental sensitivity and project schedule. The scope of work includes conducting electromagnetic testing of four to six PCCP lines per year (averaging 40 miles per year) over a five-year period. After each inspection, the results will be analyzed and compared with previous inspection results to determine the condition of the prestressing wire breaks. The estimated cost for Pure Technologies US, Inc. to perform electromagnetic testing of 163 miles of Metropolitan's PCCP lines is $3.38 million.

The scope of work for the acoustic fiber optic system includes the installation of a fully functional monitoring system including fiber optic cable, data acquisition cabinet, and connections to communication lines and power supply, and performing continuous monitoring. The acoustic fiber optic system will be installed over a cumulative length of five miles in up to three pipelines. The system will continuously monitor for sounds of wire breakage, and the resulting data will be furnished to Metropolitan on a daily basis for a period of one year. The estimated cost for Pure Technologies US, Inc. to install acoustic fiber optic monitoring systems on five miles of PCCP lines and perform monitoring for one year is $800,000. Upon completion of one year of monitoring under the pilot testing program, staff will assess the results and return to the Board with recommendations regarding expanded use of acoustic fiber optic monitoring.

This action authorizes an agreement with Pure Technologies US Inc., in an amount not to exceed $4.18 million, to perform electromagnetic inspections and install and monitor acoustic fiber optic monitoring systems.

Summary

This action appropriates $7.76 million for initiation of the PCCP Rehabilitation and Replacement Program, authorizes final design of carbon fiber repairs for eight PCCP lines, and authorizes an agreement with Pure Technologies US, Inc. for electromagnetic inspections and acoustic fiber optic monitoring. This work has been evaluated and recommended by Metropolitan's CIP Evaluation Team. Project No. 1 is budgeted within Metropolitan's CIP for fiscal year 2011/12. Project No. 2 has not been budgeted within the fiscal year because the need and opportunity to perform the repairs were not identified until after the budget was adopted. Moving forward at this time will take advantage of scheduled shutdown opportunities during winter 2011/12. Upon approval of this action, the fiscal year 2011/12 capital expenditure plan will be adjusted to reflect the new work. See **Attachment 3** for the Financial Statement and **Attachment 4** for the Location Map.

This work is included within capital Appropriation No. 15471, the PCCP Replacement and Rehabilitation Program. This is the initial action for Appropriation No. 15471.

This work is consistent with Metropolitan's goal for sustainability by enhancing the reliability of the existing conveyance and distribution system in order to maintain reliable water deliveries in the future.

Planned Actions

November 2011 – Board award of three construction contracts for carbon fiber repairs of the Allen-McColloch Pipeline, Foothill Feeder, and Sepulveda Feeder

November 2011 – Board authorization of preliminary design for repair of broken back PCCP segments on the Rialto Pipeline

December 2011 – Board authorization of preliminary design for repair of PCCP segments with broken prestressing wires on the Second Lower Feeder

October 2012 – Completion of PCCP Rehabilitation and Replacement Program execution and staging plans

Policy

Metropolitan Water District Administrative Code Section 5108: Appropriations

Metropolitan Water District Administrative Code Section 8121: General Authority of the General Manager to Enter Contracts

California Environmental Quality Act (CEQA)

CEQA determinations for Option #1:

Project No. 1 – PCCP Rehabilitation and Replacement – Stage 1; Project No. 2 – Pipeline Inspections (Pure Technologies US, Inc.) – New Agreement

The proposed actions of funding, developing a long-term strategy for PCCP rehabilitation and replacement, and authorizing a new agreement for electromagnetic inspections and acoustic fiber optic monitoring are not subject to CEQA, because they involve continuing administrative activities (Section 15378(b)(2) of the State CEQA Guidelines). In addition, the proposed actions are not subject to CEQA because they involve other government fiscal activities, which do not involve any commitment to any specific project which may result in a potentially significant physical impact on the environment (Section 15378(b)(4) of the State CEQA Guidelines).

The CEQA determination is: Determine that the proposed actions are not subject to the provisions of CEQA pursuant to Sections 15378(b)(2) and 15378(b)(4) of the State CEQA Guidelines.

Project No. 2 – Carbon Fiber Repairs for Eight PCCP Lines – Final Design Phase

The proposed action is categorically exempt under the provisions of CEQA and the State CEQA Guidelines. The proposed action consists of basic data collection and resource evaluation activities, which do not result in a serious or major disturbance to an environmental resource. This may be strictly for information gathering purposes, or as part of a study leading to an action which a public agency has not yet approved, adopted, or funded. Accordingly, the proposed action qualifies as a Class 6 Categorical Exemption (Section 15306 of the State CEQA Guidelines).

The CEQA determination is: Determine that pursuant to CEQA, the proposed action qualifies under a Categorical Exemption (Class 6, Section 15306 of the State CEQA Guidelines).

CEQA determination for Option #2:

Project No. 1 – PCCP Rehabilitation and Replacement – Stage 1; Project No. 2 – Pipeline Inspections (Pure Technologies US, Inc.) – New Agreement

None required

Project No. 2 – Carbon Fiber Repairs for Eight PCCP Lines – Final Design Phase

The proposed action is categorically exempt under the provisions of CEQA and the State CEQA Guidelines. The proposed action consists of basic data collection and resource evaluation activities, which do not result in a serious or major disturbance to an environmental resource. This may be strictly for information gathering purposes, or as part of a study leading to an action which a public agency has not yet approved, adopted, or funded. Accordingly, the proposed action qualifies as a Class 6 Categorical Exemption (Section 15306 of the State CEQA Guidelines).

The CEQA determination is: Determine that pursuant to CEQA, the proposed action qualifies under a Categorical Exemption (Class 6, Section 15306 of the State CEQA Guidelines).

CEQA determination for Option #3:

None required

Board Options

Option #1

Adopt the CEQA determination and

a. Appropriate $7.76 million;
b. Authorize initiation of the PCCP Rehabilitation and Replacement Program;
c. Authorize final design of carbon fiber repairs for eight PCCP lines; and
d. Authorize agreement with Pure Technologies US, Inc., in an amount not to exceed $4.18 million, for pipeline inspections.

Fiscal Impact: $6.26 million in budgeted funds under Approp. 15471, and $1.5 million in unbudgeted funds under Approp. 15471

Business Analysis: These projects will enhance the reliability of water deliveries to member agencies, and reduce the risk of costly emergency repairs for PCCP lines.

Option #2

Adopt the CEQA determination and

a. Appropriate $1.5 million;
b. Authorize final design of carbon fiber repairs for eight PCCP lines;
c. Do not authorize initiation of the PCCP Rehabilitation and Replacement Program; and
d. Do not authorize the agreement with Pure Technologies US, Inc.

Fiscal Impact: $1.5 million in unbudgeted funds under Approp. 15471

Business Analysis: This option will bring Metropolitan's early installations of PCCP lines with carbon fiber repairs into conformance with the newly developed AWWA standard. Staff will continue to follow Metropolitan's present approach of repairing individual segments of PCCP when they are identified as being in distress. Staff will return to the Board with a recommendation for electromagnetic inspections on an annual basis. Under this option, there would be an increased future risk of unplanned disruption of water deliveries to member agencies.

Option #3

Do not proceed with the two PCCP projects at this time.

Fiscal Impact: None

Business Analysis: This option would forego an opportunity to enhance the long-term reliability of Metropolitan's PCCP lines. Staff would return to the Board to authorize limited electromagnetic inspections. Pipeline inspections would continue, and urgent repairs would be made as needed. Under this option, there would be an increased future risk of unplanned disruption of water deliveries to member agencies.

Staff Recommendation

Option #1

8/30/2011
Gordon Johnson, *Date*
Manager/Chief Engineer, Engineering Services

8/31/2011
Jeffrey Kightlinger *Date*
General Manager

Attachment 1 – Background on Prestressed Concrete Cylinder Pipe

Attachment 2 – Metropolitan's PCCP Feeders

Attachment 3 – Financial Statement

Attachment 4 – Location Map

Ref# es12610443

Background on Prestressed Concrete Cylinder Pipe

Prestressed concrete cylinder pipe (PCCP) is a composite-walled pipe which consists of a steel cylinder that is spirally wound with high-strength steel prestressing wire. The wire is wrapped around a cement slurry bed and is then coated with cement mortar, which serves as the finished outer surface. The strength of PCCP is provided in large measure by the prestressing wire. PCCP has been used by water utilities in North America since the early 1940s. The first standard for large diameter PCCP was introduced by the American Water Works Association in 1952 (AWWA C301). In the early 1960s, PCCP began to see widespread use in municipal, industrial, and irrigation systems. PCCP was viewed as a favorable alternative to welded steel pipe due to its often lower initial cost and its ability to be designed for many combinations of internal water pressures and external soil loads.

Beginning in the early 1970s, an increasing number of PCCP failures were observed in water systems throughout the United States. At the present time, nearly 600 failures of PCCP are known to have occurred in the United States (AWWA Research Foundation, 2008). PCCP's vulnerability stems from the potential for its prestressing wires to deteriorate under certain conditions. The final mortar coating generally protects the wires from moisture, corrosive soils, and the effects of stray currents in the soil. However, when the mortar coating becomes cracked or damaged, which exposes the wires to moisture, the prestressing wires can deteriorate from corrosion. One common form of cracking is referred to as a "broken back." Stray currents created by cathodic protection systems installed on other pipelines may also damage the prestressing wires through the process of hydrogen embrittlement. Continued deterioration of the wires will lead to their eventual breakage. Due to wire friction with the mortar and compression from the backfill material, a single wire break may not cause the wire to unravel. However, multiple wire breaks close together can significantly reduce the strength of a pipe section. PCCP ruptures can be catastrophic, as they typically provide little or no forewarning. The sudden failure of a PCCP segment may result in significant costs due to interruption of service, costly urgent repairs, and potential property damage.

Inspection Techniques

During the 1990s, the increasing number of PCCP failures prompted many PCCP owners to conduct internal visual inspections of their pipelines. These efforts led to the development of alternative technologies to assess the condition of PCCP lines. Modern inspection technologies include soundings, impact echo tests, remote field eddy current inspections, and acoustic fiber optic monitoring. Metropolitan has actively collaborated with other PCCP owners to identify best practices for inspection of PCCP lines, and to develop cost-effective methods of repair. The primary means of identifying prestressing wire breaks within the industry is the remote field eddy current testing technique, which is referred to as electromagnetic inspection. Electromagnetic inspection involves recording and interpreting changes to an induced electromagnetic field within the pipe's composite wall section. The changes to the electromagnetic field are normally caused by broken wires. Wire breaks of less than 5 are typically considered anomalies due to limitations in the precision of the electromagnetic inspection technique. Over the last decade, Metropolitan has focused its repairs primarily on segments identified to have 10 or more wire breaks.

A real-time monitoring technique (acoustic fiber optic monitoring) has also been developed. Acoustic monitoring collects a continuous timeline of prestressing wire breaks. Sensors are installed in the pipeline to "listen" for the distinctive sound of prestressing wires breaking while the pipeline is in service. The location of the wire break is calculated from the sensor locations based on the speed of sound. A significant amount of signal processing is required. Impact echo inspection also uses sound waves to identify corrosion and separation of the inner steel cylinder from the outer layer of mortar coating and prestressing wires. Impact echo is effective for smaller localized areas of concern, because investigations are time-consuming and not practical for longer, more extensive pipeline inspections.

While electromagnetic inspections are the primary means for identification of wire breaks, visual inspections are used to identify broken back conditions on PCCP segments. Broken backs are cracks around the circumference of the pipe caused by differential settlement of the PCCP segment at or near structures, often adjacent to a manhole

structure. This type of cracking exposes the pipe to accelerated rates of corrosion and eventual leakage. Broken back pipe segments do not typically require urgent repair, but are prioritized and repaired in the order of severity and risk.

Repair Options

To repair a PCCP line or restore its service life to the original term, there are generally three options available: (1) Removal and replacement of existing PCCP segments with new steel pipe; (2) Insertion of steel cylinders as a liner inside an existing PCCP segment; and (3) Strengthening of existing PCCP segments with carbon fiber lining.

Complete replacement with steel pipe sections is the most costly option because it is often disruptive, requiring significant design effort, construction, traffic control, and utility relocations, and may have considerable impacts to the repair site and community. Lining an existing PCCP segment with a steel cylinder consists of designing, fabricating, and installing slightly smaller diameter pipe inside the existing PCCP line. Open excavation is only required at the location used to introduce the new steel pipe liner. Grout is installed within the annular space between the PCCP line and the new steel pipe liner. The cost of this option is less than complete replacement because less right-of-way is required for construction, which primarily occurs inside the pipeline. Surface impacts are limited to staging areas and the excavation necessary for pipeline entry.

Carbon fiber lining repair consists of cleaning, sandblasting, applying layers of carbon fiber composite materials across the interior surface of the existing PCCP segment, and curing the material. The advantages of this option are that surface impacts are limited to staging and pipeline entry. No open excavation is required, and all work is contained within the existing right-of-way. A disadvantage of this technique is that it cannot be used for all types of PCCP repairs such as broken back segments, and is not practical or cost-effective for long reaches. In addition, since it is a recently developed pipe repair technique, carbon fiber lining does not yet have the same long-term performance experience as the other repair methods.

Carbon fiber lining was first used by Metropolitan to repair the Allen-McColloch Pipeline in 2003. Since that time, the use of carbon fiber lining repairs has evolved as a result of improved understanding of the material properties, more efficient construction practices, and a better understanding of the technical design. Metropolitan has played an active role in development of a new AWWA standard for design and installation of carbon fiber lining that is anticipated to be issued by the end of 2011. This new AWWA standard includes specific design criteria and a number of important features whose inclusion is based on performance data and feedback from earlier carbon fiber repairs. In order to fully comply with the new AWWA standard, many of these earlier repairs (including some of Metropolitan's) would need to be upgraded. This need is addressed in Project No. 2 within the present action.

Metropolitan's PCCP Experience

Metropolitan's water delivery system includes approximately 830 miles of pipelines, of which 163 miles are PCCP lines. These PCCP lines were installed between 1965 and 1985, and range in diameter from 54 to 201 inches. The lines are located in both dense urban areas and remote regions. A summary list of these lines appears in **Attachment 2.** In 2000, Metropolitan initiated the inspection of all 163 miles of PCCP lines using electromagnetic and visual inspection methods. Since that date, inspections have been performed annually during the winter shutdown season, with an average of 35 to 40 miles of pipeline inspected each year. Metropolitan has completed electromagnetic inspection of all 163 miles of PCCP lines at least two times, while pipelines judged to be of higher risk have been inspected three times. This inspection data provides information on the "baseline" condition of Metropolitan's PCCP lines which will be useful in tracking changes in condition over time.

Based on a survey conducted by AWWA in 2008, approximately 4 percent of PCCP segments nationwide are suspected to have broken prestressing wires. In comparison, less than 1 percent of Metropolitan's 42,053 PCCP segments have been identified with greater than 5 prestressing wire breaks. While Metropolitan's risk of failure of PCCP lines may be somewhat less than other agencies when considering the distribution system in its entirety, there are local conditions with corrosive soils or stray current interference which may place Metropolitan's PCCP lines at risk. Following the 2009/10 winter inspection season, Metropolitan had identified a total of 160 PCCP segments (0.61miles) with 10 to 140 wire breaks. These 160 PCCP segments were found in 14 feeders, while 137

of those 160 segments (86 percent) were found in five feeders (the Allen-McColloch Pipeline, Calabasas Feeder, Rialto Pipeline, Second Lower Feeder, and Sepulveda Feeder). To date, Metropolitan has repaired 103 (0.4 miles) of the 160 distressed PCCP segments. An additional 33 segments (0.12 miles) are planned to be repaired by fiscal year 2012/13, and 24 will be repaired in the future.

To date, a total of 113 PCCP segments (0.43 miles) with broken back cracks have been identified on seven feeders. Of these 113 segments, 94 (0.36 miles) have already been repaired with welded steel pipe. Repair of the remaining 19 segments (0.07 miles), which are on the Rialto Pipeline, are planned to be completed by fiscal year 2014/15.

Long-Term Strategy

Awareness of the risk of PCCP failure has steadily grown within the water industry. Similar to Metropolitan, other PCCP owners have embarked on inspection, monitoring, and repair programs. Through these inspection efforts, many existing PCCP lines have been found to appear in good condition. No signs of distress were discovered which would indicate the likelihood of reduced service life. However, other PCCP lines were identified as being in distress due to broken prestressing wires or cracks, or to be at higher risk over time due to potential corrosion. In the latter situations, the PCCP lines will most likely not attain their original intended service life. A major challenge for PCCP owners has been the accurate identification of the condition and stability of their PCCP lines, along with characterization of their true service life.

As industry experience and data regarding the risk of PCCP failure continue to build, it is prudent at this time to assess the cost-effectiveness and risks of continuing with Metropolitan's present approach to management of PCCP lines, or to consider initiating a long-term replacement/relining program in recognition of PCCP's reduced service life. Under the present approach, Metropolitan aggressively inspects its PCCP lines and makes repairs to individual PCCP segments, when they are identified as being in distress. While this approach has thus far prevented additional failures of PCCP segments, the repair costs are relatively high per segment, and there is no guarantee that other failures may not occur in the future (through third-party damage, for example.)

The proposed long-term strategy for managing Metropolitan's PCCP lines includes three components:

1. Repair of Distressed PCCP Segments – Metropolitan will continue to prioritize and repair PCCP segments with 10 or more prestressing wire breaks, broken back cracks, or other indications of risk or distress. As noted previously, several projects are planned within Metropolitan's CIP to repair known PCCP segments with broken prestressing wires and broken back cracks. If any new distressed PCCP segments are identified, they will be recommended for inclusion in the CIP, prioritized, and repaired. This preemptive repair approach will minimize the risk of service interruptions. An example of a repair project which is being addressed in this manner is Project No. 2 in the present action (Carbon Fiber Repairs for Eight PCCP Lines-Final Design Phase.)

2. Monitoring of PCCP Lines – Metropolitan will continue to aggressively inspect its PCCP lines using state-of-the-art inspection techniques. This will expand knowledge of the pipelines' baseline condition, track wire breakage over time, and identify portions of feeders containing distressed PCCP segments. The primary inspection technique to be relied upon is electromagnetic inspection, with localized use of impact echo tests and sounding. Complete visual inspections will also be performed as pipelines are shut down. Staff proposes to conduct a pilot testing program of acoustic fiber optic monitoring to assess its effectiveness in measuring the rate of prestressing wire breaks, and in identifying portions of PCCP lines with elevated risk of failure. Initiation of this pilot testing program is included in Project No. 1 in the present action (see below.)

3. Development of Long-Term Rehabilitation and Replacement Program – To initiate this proposed program, staff will develop a strategy to enhance the long-term reliability of PCCP lines, and commence the planning for replacement/relining of at-risk pipelines. The initial stage of this program is included in Project No. 1 in the present action (PCCP Rehabilitation and Replacement Program – Stage 1.) The long-term comprehensive strategy will include:

- Assessment of the cost-effectiveness and risks of repairing individual PCCP segments, or moving forward with complete PCCP line replacement or relining. This includes:
    - Review of existing PCCP line design, construction records, fabrication drawings, as-built conditions, pipe operating conditions, and pipe pressures
    - Study of soil corrosivity and third-party stray current interference
- Review of repair logistics in terms of system operational flexibility and redundancy, isolation and operational shutdown restrictions, permitting and right-of-way needs, environmental constraints, and impacts to member agency deliveries.
- Continued collaboration with other PCCP owners, Metropolitan member agencies, and AWWA on developing improved PCCP repair techniques and more accurate monitoring and testing systems.

The goal of this long-term strategy is to manage the risk of entire pipelines or significant reaches of pipelines while optimizing the remaining useful life of PCCP lines. The effort will include development of a multi-year schedule and conceptual-level cost estimates with a comprehensive rehabilitation and replacement plan for specific at-risk PCCP lines. This plan would allocate limited resources to systematically contain the costs of PCCP rehabilitation while reducing the risk of PCCP pipeline failure. The cost of a properly managed PCCP rehabilitation program may yield significant savings over the costs associated with PCCP line failure or overly conservative rehabilitation strategies.

Metropolitan's PCCP Feeders

Feeder	Length of PCCP (miles)	Feeder	Length of PCCP (miles)
Allen-McColloch Pipeline (AMP)	8.9	Orange County Feeder	0.9
Auld Valley Pipeline	2.2	Rialto Pipeline	16
Balboa Inlet Connection	0.2	San Diego Pipeline No. 4	8.0
Box Springs Feeder	2.4	San Diego Pipeline No. 5	7.8
Calabasas Feeder	9.1	San Jacinto Pipeline	0.6
Corona/Temescal Penstocks	0.3	Second Lower Feeder	29.8
Diemer AMP Bypass	0.1	Sepulveda Feeder	36.8
East Lake Skinner Bypass	1.3	Skinner Plant No. 2 Inlet Line	0.2
Foothill Feeder	5.9	Skinner Outlet Line No. 2	0.3
Irvine Cross Feeder	0.4	South Coast Feeder	7.2
Jensen Bypass Pipeline	0.4	West Valley Feeder No. 1	7.7
LaVerne Pipeline	1.9	West Valley Feeder No. 2	2.9
Lake Perris Bypass	2.5	Yorba Linda Feeder	8.2
Lake Skinner Outlet Conduit	1.0		

Financial Statement for PCCP Rehabilitation and Replacement Program

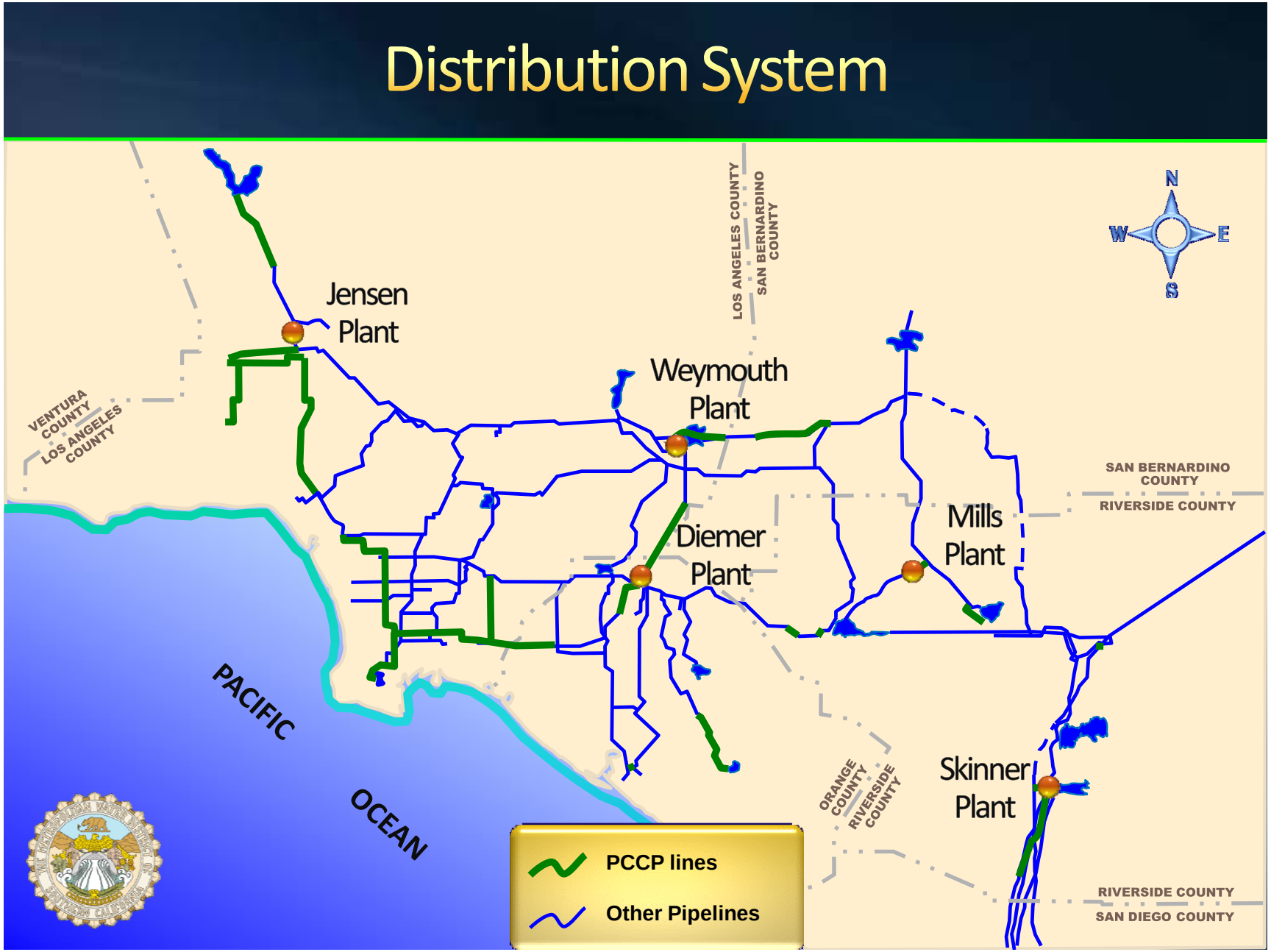
A breakdown of Board Action No. 1 for Appropriation No. 15471 for initiation of the PCCP Rehabilitation and Replacement Program, and final design for carbon fiber repairs of eight PCCP lines*, is as follows:

	Current Board Action No. 1 (Aug. 2011)	New Total Appropriated Amount
Labor		
Studies and Investigations	$ 1,210,000	$ 1,210,000
Final Design	633,000	633,000
Owner Costs	771,000	771,000
Construction Inspection and Support	-	-
Metropolitan Force Construction	-	-
Materials and Supplies	50,000	50,000
Incidental Expenses	88,000	88,000
Professional/Technical Services	4,280,000	4,280,000
Equipment Use	-	-
Contracts	60,000	60,000
Remaining Budget	668,000	668,000
Total	**$ 7,760,000**	**$ 7,760,000**

Funding Request

Program Name:	PCCP Replacement and Rehabilitation Program		
Source of Funds:	Revenue Bonds, Replacement and Refurbishment or General Funds		
Appropriation No.:	15471	**Board Action No.:**	1
Requested Amount:	**$** 7,760,000	**Capital Program No.:**	15471
Total Appropriated Amount:	**$** 7,760,000	**Capital Program Page No.:**	314
Total Program Estimate:	**$** 68,529,000	**Program Goal:**	I- Infrastructure Reliability

* This is the initial action for the PCCP Replacement and Rehabilitation Program


Distribution System
Jensen Plant
Weymouth Plant
Diemer Plant
Mills Plant
Skinner Plant
LOS ANGELES COUNTY
SAN BERNARDINO COUNTY
VENTURA COUNTY
LOS ANGELES COUNTY
SAN BERNARDINO COUNTY
RIVERSIDE COUNTY
ORANGE COUNTY
RIVERSIDE COUNTY
RIVERSIDE COUNTY
SAN DIEGO COUNTY
PACIFIC
OCEAN
N
W
E
S
PCCP lines
Other Pipelines