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City of Oxnard

Public Works Integrated Master Plan

WATER

PROJECT MEMORANDUM 2.7
CATHODIC PROTECTION ASSESSMENT

REVISED FINAL DRAFT
September 2017

Engineers...Working Wonders With Water™

2700 YGNACIO VALLEY ROAD • SUITE 300 • WALNUT CREEK, CALIFORNIA 94598 • (925) 932-1710 • FAX (925) 930-0208

PREFACE

The analysis and evaluations contained in these Project Memorandum (PM) are based on data and information available at the time of the original date of publication, December 2015. After development of the December 2015 Final Draft PMs, the City continued to move forward on two concurrent aspects: 1) advancing the facilities planning for the water, wastewater, recycled water, and stormwater facilities; and 2) developing Updated Cost of Service (COS) Studies (Carollo, 2017) for the wastewater/collection system and the water/distribution system. The updated 2017 COS studies contain the most recent near-term Capital Improvement Projects (CIP). **The complete updated CIP based on the near-term and long-term projects is contained in the Brief History and Overview of the City of Oxnard Public Works Department's Integrated Planning Efforts: May 2014 – August 2017 section.**

At the time of this Revised PWIMP, minor edits were also incorporated into the PMs. Minor edits included items such as table title changes and updating reports that were completed after the December 2015 original publication date.

City of Oxnard

Public Works Integrated Master Plan

WATER

PROJECT MEMORANDUM 2.7
CATHODIC PROTECTION ASSESSMENT

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION 1
1.1 PMs Used for Reference 1

2.0 FINDINGS 1

APPENDIX A ASSET CORROSION ASSESSMENT AND CP EVALUATION SURVEY (SEPTEMBER 2014)
APPENDIX B CATHODIC PROTECTION SURVEY AND CONDITION DRAFT ASSESSMENT SUPPLEMENTAL REPORT (DECEMBER 2015)

CATHODIC PROTECTION ASSESSMENT

1.0 INTRODUCTION

As part of the Public Works Integrated Master Plan (PWIMP), JDH Corrosion Consultants, Inc. (JDH) was contracted to conduct an asset corrosion assessment and CP evaluation survey for both the water and wastewater infrastructure within the City of Oxnard (City). Water transmission mains, water and wastewater treatment facilities, and other important City assets were included in this report. A survey was done to assess the existing level of cathodic protection and recommendations were made that outline needed improvements. The combined water and wastewater report (September 2014) can be found in Appendix A. A supplemental report entitled Cathodic Protection Survey and Condition DRAFT Assessment Supplemental Report (December 2015), located in Appendix B, expanded further on the cathodic protection needs for the water system only.

1.1 PMs Used for Reference

The findings outlined in the Cathodic Protection Assessment were made in concert with recommendations and analyses from other related PMs:

- PM 2.1 - Water System - Background Summary.
- PM 2.4 - Water System - Condition Assessment.

2.0 FINDINGS

Below is a summary of the findings and recommendations for the City's water infrastructure as it relates to cathodic protection.

- Del Norte Pipeline: excavate and install new test stations; install test leads; replace existing rectifiers and ground beds; locate and repair discontinuity near the east end of Del Norte Pl.
- Gonzalez Pipeline: Replace the seized test traffic box lids; test the CP system.
- Oxnard Conduit: Replace deep anode bed at Rectifiers #1, #2, and #3; excavate and install new test stations at six (6) locations; install new test station in existing manhole; corrosion engineer to conduct CIS; locate, excavate and bond across at least three (3) points of electrical isolation.
- Wooley Road/United: Replace missing test station and add two additional test stations along the pipeline, replace rectifiers and anode-ground-beds.

- 3rd Street Lateral: Replace the failed rectifier and deep anode bed; locate and repair discontinuity at Chemical Building 1' provide electrical isolation at the main treatment plant.
- 3rd St 27" UWCD: Bond UWCD Pipeline to Oxnard Extension at rectifier; conduct interference testing.
- Industrial Lateral: Excavate and install new test stations along the pipeline.
- Water Treatment Facility: Locate the record documents; install electrical isolation at all steel and cast iron water risers; design and install CP on buried water piping.
- 600,000 Gallon Steel Water Tank at the Water Treatment Facility: Install internal CP system.

In addition to the projects recommended above, this PWIMP also recommends conducting an annual cathodic protection survey and report for all City facilities as well as bi-monthly rectifier monitoring. A more detailed discussion of these findings and their associated costs can be found in the December 2015 report located in Appendix B.

APPENDIX A - ASSET CORROSION ASSESSMENT AND CP EVALUATION SURVEY (SEPTEMBER 2014)

Asset Corrosion Assessment

&

CP Evaluation Survey

City of Oxnard

September 2014

jdh corrosion consultants, inc.

1100 Willow Pass Court, Concord, CA 94520 *Tel. No. 925.927.6630 Fax No. 925.927.6634*

Asset Corrosion Assessment and CP Evaluation Survey

City of Oxnard

Table of Contents

Section I - Introduction 1
1.1 Project Description 1
1.2 Project Pipelines, Water and Waste-Water Facilities and Soil Corrosivity Investigation 2
1.2.1 Water Transmission Pipelines (Mains) 2
1.2.2 Wastewater Treatment Facility at 6001 South Perkins Road 3
1.2.3 Water Treatment Facility at 352 South Hayes Avenue 3
1.2.4 Soil Corrosivity Investigation 3

Section II - Test Methods 4
2.1 General 4
2.2 Pipe/Structure to Soil Potentials 4
2.3 Insulating Joints 5
2.4 Cathodic Protection Systems 6

Section III - Conclusions 7
3.1 General 7
3.2 Project Pipelines and Structures 7
3.2.1 Water Transmission Mains 7
3.3 Wastewater Treatment Facility at 6001 South Perkins Road 11
3.4. Water Treatment Facility at 251 South Hayes Avenue 12
3.5. Soil Corrosivity Investigation 12

Section IV - Recommendations 18
4.1 General 18
4.2 Project Pipelines and Structures 18
4.2.1 Water Transmission Force Mains 18
4.2.2 Wastewater Treatment Facility at 6001 South Perkins Road 20
4.2.3 Water Treatment Facility at 251 South Hayes Avenue 21

Attachments

Attachment 1 – Summary of Field Test Results with Cost Estimates
Attachment 2 – Google Earth Images of Cathodic Protection Systems
Attachment 3 – Pipe to Soil Potential Data for ICCP Systems on Water Mains
Attachment 4 – Water Pipelines Rectifier Data
Attachment 5 – Field Data Wastewater Treatment Facility
Attachment 6 – Field Data Water Treatment Facility
Attachment 7 – Figure 1 – Potential Measurement
Attachment 8 – Figure 2 - ICCP
Attachment 9 – Figure 3 – Galvanic CP
Attachment 10 - In-situ Soil Resistivity Table of Results

SECTION I – INTRODUCTION

1.1 PROJECT DESCRIPTION

The structures which are the subject of this evaluation include water transmission mains, water and waste-water treatment facilities, along with other important assets that are owned and operated by the City of Oxnard, CA. The water transmission mains are located throughout the City of Oxnard. The waste-water treatment facility is located at 6001 South Perkins Road and a potable water treatment facility is located at 251 South Hayes Avenue. There are also various water blending stations that are located throughout the City of Oxnard.

The primary focus of this survey was to perform a comprehensive survey of the existing cathodic protection (corrosion control) systems on both the water transmission mains and the water/waste-water treatment facilities. The existing cathodic protection systems consist of both galvanic (sacrificial anode) systems using magnesium or zinc anodes and impressed current cathodic protection (ICCP) systems, which consist of CP rectifier transformers and associated deep well anode ground-beds.

Our task during this phase of the project was to measure and record pipe-to-soil (structure-to-soil) potentials at all test stations in order to determine the operational status of the cathodic protection systems and the level of protection being afforded to the subject structures. The results of the pipe-to-soil, cathodic protection surveys were to be used to determine the existing status of the CP systems in order to get a "snap shot" of how the systems are operating at the present time. We are relying on industry standards set by the National Association of Corrosion Engineers (NACE) International, which have established the Criteria for cathodic protection of various types of structures. The pertinent NACE International Criteria for this project is SP 0169, Revised 2013 is as follows:

CRITERIA FOR CATHODIC PROTECTION

The criteria used to determine whether a structure is adequately protected from corrosion is the National Association of Corrosion Engineers (NACE) Standard SP-0169, Rev. 2013, Section 6.2: One or more of the listed criterion was used to determine the adequacy of cathodic protection level.

- *"A negative (cathodic) (structure-to-soil) potential of at least 850 mV with the cathodic protection current applied relative to a saturated copper, copper-sulfate reference electrode."*

- *"A minimum of 100 mV of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarization* can be measured to satisfy the criterion."*

  *The difference between the OFF potential and the Long OFF potential is the magnitude of polarization attained by the structure under test.

This report includes structures and facilities that were tested during June and July of 2014. This report is comprehensive and includes all of the structures that are reportedly under cathodic protection or considered for future cathodic protection systems.

Soil Corrosivity Investigation

The other objective of this city-wide corrosion assessment project was to perform a soil corrosivity investigation (study) throughout the City of Oxnard. This work included performing in-situ soil resistivity measurements at select locations throughout the City and collecting soil samples, which were tested for corrosive properties at a State California Certified Laboratory. The goal of the soil corrosivity study was to determine how corrosive the soil is when it comes into intimate contact with buried metallic pipes such as iron, steel and cement mortar coated pipes, and other related infrastructure in order to assess the degree of risk associated with underground structures that are determined to have inadequate or non-existent cathodic protection. The soil corrosivity study will be discussed in greater detail later in this report.

1.2 PROJECT PIPELINES, WATER AND WASTE-WATER FACILITIES AND SOIL CORROSIVITY INVESTIGATION

1.2.1 Water Transmission Pipelines (Mains)

1.2.1.1 Del Norte Lateral Pipeline

This pipeline consists of a concrete cylinder pipe and is routed from the Springville Reservoir located in the Spanish Hills residential community, to Central Avenue, and then to Vineyard Avenue at Blending Station #4. The cathodic protection system for this pipeline consist of four (4) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

1.2.1.2 Oxnard Conduit Pipeline

This 36-inch diameter pipeline consists of a concrete cylinder pipe and is routed from the Springville Reservoir located in the Spanish Hills residential community, to the south side of US Highway 101 in a westerly direction, south on Rice Road, and West on E. 5th Street. The cathodic protection system for this pipeline consist of three (3) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

1.2.1.3 Wooley Road Main/United

This 24-inch diameter pipeline consists of a concrete cylinder pipe and is routed from the intersection of Wooly Road and Richmond Avenue to the intersection of Wooley Road and Rose Avenue. The cathodic protection system for this pipeline consists of one (1) impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

1.2.1.4 3rd Street Lateral (30-inch Metro Line) & 27" Pipeline

This 30-inch diameter pipeline consists of a concrete cylinder pipe and is routed in an east-west direction along East 3rd Street. The cathodic protection system for both pipelines consist of one (1) shared impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

1.2.1.5 Industrial Lateral

This pipeline consists of a concrete cylinder pipe and is routed in a north-south direction along Arcadia Street, Acacia Street and San Simeon Avenue, along the west side of a fenced-off water canal. The cathodic protection system for this pipeline consist of one (1) impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

1.2.2 Wastewater Treatment Facility at 6001 South Perkins Road

The waste-water treatment facility is located at 6001 South Perkins Road. This waste-water treatment facility has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations, which are located throughout the facility. The cathodic protection test stations were found at over 227 locations and tested by JDH Corrosion field personnel as part of this project.

This waste-water treatment facility also has six (6) waste-water clarifiers, three (3) digesters, and other large equipment which reportedly do not have actively installed or maintained cathodic protection system to protect the metallic (steel and iron) rake arms and other metallic equipment from water-side (submerged) corrosion activity. We will discuss options for corrosion (cathodic) protection of this equipment later in this report.

1.2.3 Water Treatment Facility at 251 South Hayes Avenue

A water treatment facility is located at South Hayes Avenue. This water treatment facility has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations, which are located throughout the facility. The cathodic protection test stations were found at over eight (8) locations and tested by JDH Corrosion field personnel as part of this project.

There is also a 600,000-gallon water, steel above-grade water storage tank at this facility. This water tank is 70 feet in diameter, 25 feet high, and was installed in year 2005. The tank's internal wetted (submerged) surfaces are susceptible to water-side corrosion activity. This tank does not currently have a corrosion control (cathodic protection) system of any kind to mitigate water-side (internal) corrosion activity. The tank reported has an internal protective coating system. We will discuss options for corrosion (cathodic) protection of this tank later in the report.

1.2.4 Soil Corrosivity Investigation

One of our objectives for this city-wide corrosion/cathodic protection assessment project was to perform a soil corrosivity study throughout the City of Oxnard. This work included performing in-situ (on-site) soil resistivity measurements at multiple locations and collecting soil samples, which were tested for corrosive properties at a State California Certified Laboratory, CERCO Analytical located in Concord, CA. The goal of the soil corrosivity study was to determine how corrosive the soil is when it comes into intimate contact with buried metallic pipes such as iron, steel and cement mortar coated pipes, and other related infrastructure.

SECTION II –TEST METHODS

2.1 GENERAL

The primary focus of this cathodic protection and corrosion assessment project was to determine the operational status of the subject cathodic protection systems and the current level of protection being afforded to the associated structures. The other phase of the project was to perform a soil (site) corrosivity investigation in order to determine how corrosive the soil conditions are throughout the City of Oxnard when the metallic and reinforced concrete structures exposed to those soils.

2.2 PIPE/STRUCTURE-TO-SOIL POTENTIALS

Pipe-to-soil potentials are measured using a Fluke 87V, high impedance multi-meter. Potentials were measured versus a copper, copper-sulfate reference electrode placed in contact with the soil at the existing test stations. The Fluke 87V is a high impedance voltmeter used to reduce the effects of contact resistance between the electrode and the soil and to prevent the electrode from polarizing.

Figure 1) Fluke 87 V High-Impedance Multimeter

Figure 2) MC Miller Copper/Copper-Sulfate Portable Reference Electrode

When the soil is very dry, tap water is poured on the ground and the electrode is set in the wet soil to reduce contact resistance between the reference electrode and the soil. The pipeline/structure test lead (or by directly contacting the structure) is connected to the positive terminal of the meter and the reference electrode is connected to the negative terminal of the referenced meter. See Attached Figure for an illustration of measuring pipe-to-soil potentials on a metallic pipeline.

Photo 1) Measuring and Recording Pipe-to-Soil Potentials on a Pipeline

The voltage of the pipeline cannot be directly measured and therefore, the measurement we use during corrosion studies is the voltage difference or potential between the structure and a copper/copper-sulfate reference electrode ($Cu/CuSO_4$) placed on the soil immediately above the pipeline. The potential between the pipeline and reference electrode can be measured using a high input impedance voltmeter such as a Fluke 87V. Reference electrodes utilized have been developed that have stable and reproducible potentials. By measuring the voltage difference between a standard reference electrode and a structure, a value is obtained for the potential of the structure. Pipe-to-soil potentials listed in the tables were measured with a copper, copper-sulfate reference electrode (CSE).

The criteria used to determine whether a structure is adequately protected from corrosion is the National Association of Corrosion Engineers (NACE) Standard SP-0169, Rev. 2007, Section 6.2.2.1.2. “On” and “Instant Off” potentials were taken during this survey and compared with previous potentials in order to determine the degree of protection being afforded to the subject structures.

2.3 INSULATING JOINTS

The effectiveness of the insulating joints was determined by measuring the pipe-to-soil potential on either side of the flange using a stationary reference electrode. A structure is determined to be electrically isolated from above grade structures if there is a significant difference in the potentials measured on either side of the joint.

A Tinker and Rasor Model RF-IT Insulation Tester, manufactured by the Tinker and Rasor was also used to test the insulating effectiveness of the insulating joints installed at the facility.

Figure 3) Tinker and Rasor Model RF-IT Insulation Tester

The insulation checker uses radio frequency skin effect and only reads the immediate joint to determine insulating effectiveness. The insulation checker operates by placing two prongs in contact with the insulating joint, one prong on each side of the insulating element. The instrument indicates the shorted or not shorted condition of the joint and the resistance of the joint is not indicated by this instrument.

2.4 CATHODIC PROTECTION SYSTEMS

As mentioned in Section 1 of this report, both impressed current and sacrificial anode cathodic protection systems are utilized to protect various pipelines, water and waste-water treatment facilities and other related metallic/reinforced concrete structures throughout the City of Oxnard.

Impressed current cathodic protection (ICCP) systems use an external electrical power source to provide electric current to the pipeline or structure (see figure 2). ICCP uses a rectifier to convert AC to DC and discharge the DC current through an anode. Anode materials such as high silicon cast iron, graphite or mixed metal oxide coated platinum or titanium. These anode materials are chosen to discharge large amounts of current for long periods of time at low anode consumption rates. ICCP can be designed for many types of structures and can be designed for either very high current output or relatively low current output.

Photo 2) Cathodic Protection Rectifier on Del Norte Pipeline

The impressed current cathodic protection systems are monitored by measuring the rectifier voltage and current output once every two months to ensure the rectifier is operating properly at the correct output. Pipe-to-soil potentials are measured at each test station annually and the rectifier output is adjusted as required to ensure the potentials meet NACE criteria for corrosion protection.

Sacrificial anode cathodic protection systems for pipelines or structures use an anode made from zinc or magnesium connected to the structure (see figure 3). The anode is more active than the steel structure and the cathodic protection current is provided by corrosion of the anode. These anodes have a lower current output than the ICCP systems and the anodes will also consume sooner than the ICCP anodes and have a shorter life. Sacrificial anodes are typically usually used on small diameter or short length pipelines or well coated structures.

Pipe-to-soil potentials are the primary test method used to determine if a pipeline meets NACE criteria for corrosion protection. Pipe-to-soil potentials are measured at each test station for impressed current and sacrificial anode cathodic protection systems.

SECTION III – CONCLUSIONS

3.1 GENERAL

The cathodic protection systems for many of the water pipeline force mains is still operational but reaching the end of their useful life. Most of the anode tests station were missing or could not be located. Three (3) of the ten (10) rectifiers for the water piping force mains were not operational at all and will require immediate replacement of the CP rectifiers and anode ground-beds.

In general, the design life for the galvanic (sacrificial anode), cathodic protection systems at the waste-water treatment facility failed and require immediate replacement. The CP system at most locations is now exceeded and the overall condition of the subject cathodic protection systems is unsatisfactory for the protection of the subject structures. A few systems were found to be operational and are providing an adequate level of protection but most were either non-operational or totally depleted and in need of a complete overhaul. The case was the same for the water treatment facility on South Hayes Ave.

3.2 PROJECT PIPELINES AND STRUCTURES

3.2.1 Water Transmission Mains

3.2.1.1 Del Norte Lateral

The cathodic protection system for this pipeline consist of four (4) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey. The CP rectifiers at these locations were still operating and providing a satisfactory amount of corrosion protection to the subject pipeline.

Photo 3) Cathodic Protection Rectifier #9 on Del Norte Pipeline

Many of the CP test stations (CTS) were missing. Additional cathodic test stations will need to be installed in order to provide an adequate number of test locations to represent the general information on the pipe-to-soil potentials along the entire length of the pipeline. In other words that test stations represent the pipe's potential in the general vicinity of that test station. An adequate quantity of test stations are recommended at certain frequencies along the entire length of the pipe so that the corrosion engineers can establish the cathodic protection levels along the pipeline and make necessary adjustments to the current output of the rectifiers and anode ground-beds so that the pipeline is adequately protected against soil-side corrosion.

On this pipeline we found test stations at twelve different locations. In general we recommend test stations at every 1,000 to 2,000 feet with 2,000 feet being the maximum recommended distance between test points along a pipeline.

Although the twelve (12) test locations are better than having less test stations, we recommend the design and installation of additional test stations so that there is at least one (1) cathodic test station (CTS) at every 1,000 to 2,000 feet.

3.2.1.2 Oxnard Conduit Pipeline

The cathodic protection system for this pipeline consist of three (3) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Rectifiers #1 and #2 have failed and we recommend immediate design and replacement of these rectifiers and anode ground-beds. The entire section of pipe in the vicinity of these two failed rectifier and anode ground-beds is presently not receiving any cathodic protection and therefore we do not have an active corrosion control system to mitigate soil-side corrosion activity.

Rectifier #3 and its associated anode ground-bed are presently operating in a satisfactory manner.

Most of the cathodic test stations (CTS) on this pipeline were missing and could not be located. A cathodic protection rehabilitation project is recommended to install CTS at every 1,000 to 2,000 feet along the entire length of pipeline

Photo 4) Cathodic Protection Testing on Oxnard Conduit

The Rectifiers #1 and #2 and CTS installation project can be implemented as part of a large cathodic protection rehabilitation project for the Oxnard Conduit.

3.2.1.3 Wooley Road Main/United

The cathodic protection system for this pipeline consist of one (1) impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Photo 5) Cathodic Protection Test Station on Wooley Road Main/United

Although this rectifier and anode ground-bed are still operational, we recommend design and replacement of this system with a new one. The rectifier and anode ground-bed for this pipeline have been in place since the year 1977 and have far exceeded their expected operating life. We recommend a new system that would provide another 20 or more years of cathodic protection for this pipeline.

As for the test stations along the pipeline, we were able to locate some test stations at the corner of Wooley Road and Richmond Avenue. However, we did not locate any other cathodic test stations along this pipeline and recommend the design and installation of new cathodic test stations at increments of 1,000 feet.

3.2.1.4 3rd Street Lateral (30-inch Metro Line) & 27" Pipeline

The cathodic protection system for these pipelines consist of one (1) shared impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Rectifier #6 and its anode ground-bed, for these pipelines have sustained physical damage, have failed and we recommend immediate design and replacement of this rectifier and anode ground-bed. The entire section of pipe in the vicinity of this failed rectifier and anode ground-bed is presently not receiving any cathodic protection and therefore we do not have an active corrosion control system to mitigate soil-side corrosion activity.

Photo 6) Cathodic Protection Rectifier on 3rd Street Lateral.
Rectifier and Anode Ground-Bed have Failed and Require Replacement.

Most of the cathodic test stations (CTS) on this pipeline were missing and could not be located. A cathodic protection rehabilitation project is recommended to install CTS at every 1,000 to 2,000 feet along the entire length of pipeline.

The Rectifier #6 with its associated anode ground-bed along with the CTS installation project can be implemented as part of a large cathodic protection rehabilitation project for the 3rd Street Lateral.

3.2.1.5 Industrial Lateral

The cathodic protection system for this pipeline consist of one (1) impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Rectifier #4 for this pipeline along with its associate anode ground-bed was found to be operating in a satisfactory manner and providing cathodic protection for the Industrial Lateral pipeline.

We found only one (1) cathodic test station for this pipeline. All but one of the cathodic test stations (CTS) on this pipeline were missing and could not be located. A cathodic protection rehabilitation project is recommended to install CTS at every 1,000 to 2,000 feet along the entire length of pipeline.

3.3 Wastewater Treatment Facility at 6001 South Perkins Road

This waste-water treatment facility has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations, which are located throughout the facility. The cathodic protection test stations were found at over 227 locations and tested by JDH Corrosion field personnel as part of this project.

This waste-water treatment facility also has six (6) waste-water clarifiers, three (3) digesters, and other large equipment which reportedly do not have actively installed or maintained cathodic protection system to protect the metallic (steel and iron) rake arms and other metallic equipment from water-side (submerged) corrosion activity. We will discuss options for corrosion (cathodic) protection of this equipment later in this report.

Most of the galvanic cathodic protection systems at this facility have failed and a facility-wide project is recommended to design and install a new cathodic protection system. This would require new galvanic (sacrificial) anodes at almost all of the existing anode test stations (ATS). The pipe-to-soil potentials at these failed locations did not meet the NACE International Criteria (SP 0169-13) as described above. Therefore we conclude that at these failed locations there is no mitigation of soil-side corrosion activity.

Photo 7) Cathodic Protection Testing at Waste-Water Treatment Plant

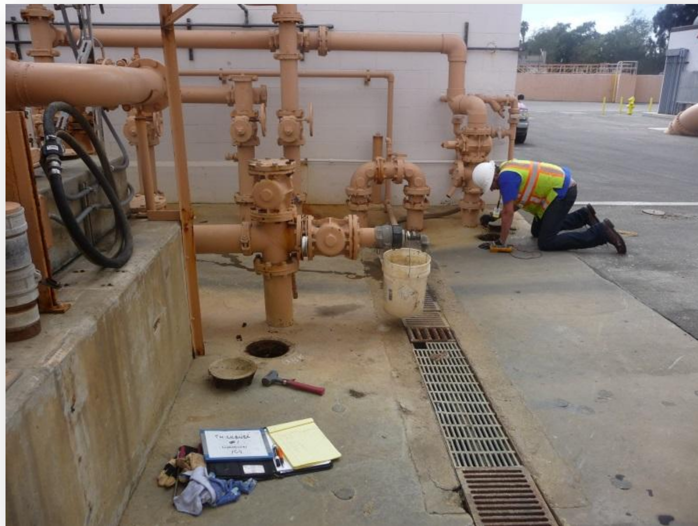


Photo 8) Cathodic Protection Testing at Waste-Water Treatment Plant

There is also another option we can consider for cathodic protection at this waste-water treatment facility and that would be to provide impressed current cathodic protection (ICCP) systems for all of the metallic, underground pipes at this facility. This would require that all of the pipes be made electrically continuous using electrical continuity bond cables and then to implement impressed current rectifier and anode ground-beds at various locations. Then the protective current from the impressed currents systems could provide soil-side corrosion mitigation to the buried metallic pipes at this facility.

Both galvanic and ICCP systems would require a large effort, as we have more than 227 locations with existing test anode test stations, along with a very complex array of buried metallic pipes throughout this facility. The time and budget for this cathodic protection project would be large in comparison to one where only a few anode test station require rehabilitation work.

3.4 Water Treatment Facility at 251 South Hayes Avenue

This water treatment facility has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations, which are located throughout the facility. The cathodic protection test stations were found at over eight (8) locations and tested by JDH Corrosion field personnel as part of this project. At most of these anode test stations (ATS) the pipe-to-soil potentials did not meet the NACE Criteria (SP 0169-13). Additional work will be required to design and install new, galvanic (sacrificial) anodes in order to provide adequate soil-side corrosion control.

There is also a 600,000-gallon steel, above-grade water storage tank at this facility. This water tank is 70 feet in diameter, 25 feet high and was installed in the year 2005. The tank's internal wetted (submerged) surfaces are susceptible to water-side corrosion activity. This tank does not currently have a corrosion control (cathodic protection) system of any kind to mitigate water-side (internal) corrosion activity. The tank reportedly has an internal protective coating system.

Photo 9) Cathodic Protection Anode Test Station at Water Treatment Plant

We recommend the design and implementation of a new, internal (wetted surface) cathodic protection system for this tank. This new CP system would mitigate the corrosion activity for the submerged surfaces of this tank to include the tank internal walls and floor. The CP system, if implemented, would not only stop the corrosion activity on the tank walls and floors but would also assist in keep the internal coating system intact and providing a longer coating service life.

The way the CP system protects the coating system occurs in such a manner that whenever there is a slight coating damage (coating holiday), the protective current from the CP anodes would stop any further corrosion activity at the coating defect. Usually the corrosion activity creates lot of outward force and the coating does not have the ability to stop this force and additional corrosion activity, which usually leads to eventual coating failure. When the coating system is supplemented with CP, the corrosion activity at that coating defect is stopped in its tracks by the CP system's protective current. Cathodic protection of for steel water storage tanks is widely used throughout the United States and is "standard practice" to control corrosion activity for the submerged portions of the tank interior.

3.5 Soil Corrosivity Investigation

One of our other objectives for this city-wide corrosion/cathodic protection assessment project was to perform a soil corrosivity study throughout the City of Oxnard. This work included performing in-situ soil resistivity measurements at multiple locations and the work also consisted of collecting soil samples, which were tested for corrosive properties at a State California Certified Laboratory. The goal of the soil corrosivity study was to determine how corrosive the soil is when it comes into intimate contact with buried metallic pipes such as iron, steel and cement mortar coated pipes, and other related infrastructure.

<u>In-Situ Soil Resistivity Measurements</u>

The in-situ resistivity of the soil was measured at thirty three (33) new locations by **JDH Corrosion Consultants, Inc.** field personnel. Another twelve (12) locations were also tested during a previous project in the year 2012. Resistance measurements were conducted with probe spacing of 2.5, 5, 7.5, 10, and 15-feet at each location. For analysis purposes we have calculated the resistivity of soil layers 0-2.5, 2.5-5, 5-10 and 10-15' using the Barnes Method as follows:

$$\rho_{b-a} = KR_{(b-a)}$$

Where;

ρ_{b-a}	=	soil resistivity of layer depth b-a (ohm-cm)
a	=	soil depth to top layer (ft)
b	=	soil depth to bottom layer (ft)
R_a	=	soil resistance read at depth a (ohms)
R_b	=	soil resistance read at depth b (ohms)
R_{b-a}	=	resistance of soil layer from a to b (ft)
K	=	layer constant = $60.96\pi(b-a)$ (cm)

and $$\frac{1}{R_{b-a}} = \frac{1}{R_a} - \frac{1}{R_b}$$

The visual diagrams below describe the Wenner 4-pin testing configuration.

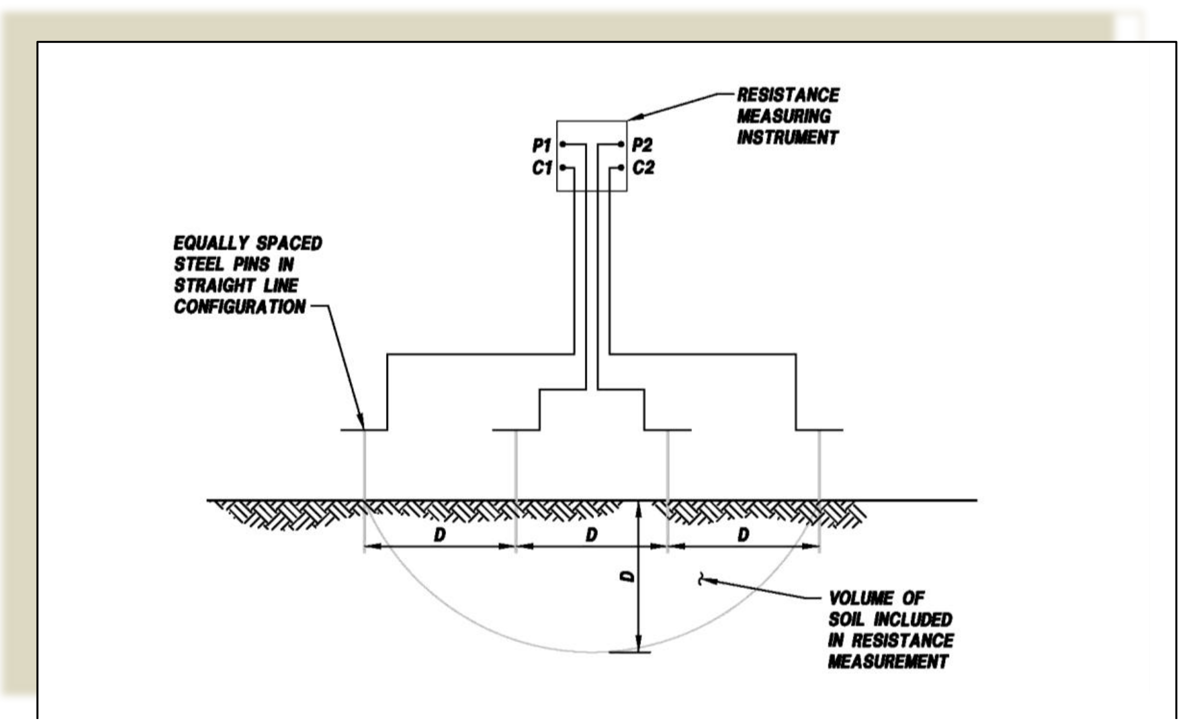


Fig 1: Wenner 4-Pin Resistivity Schematic No.1

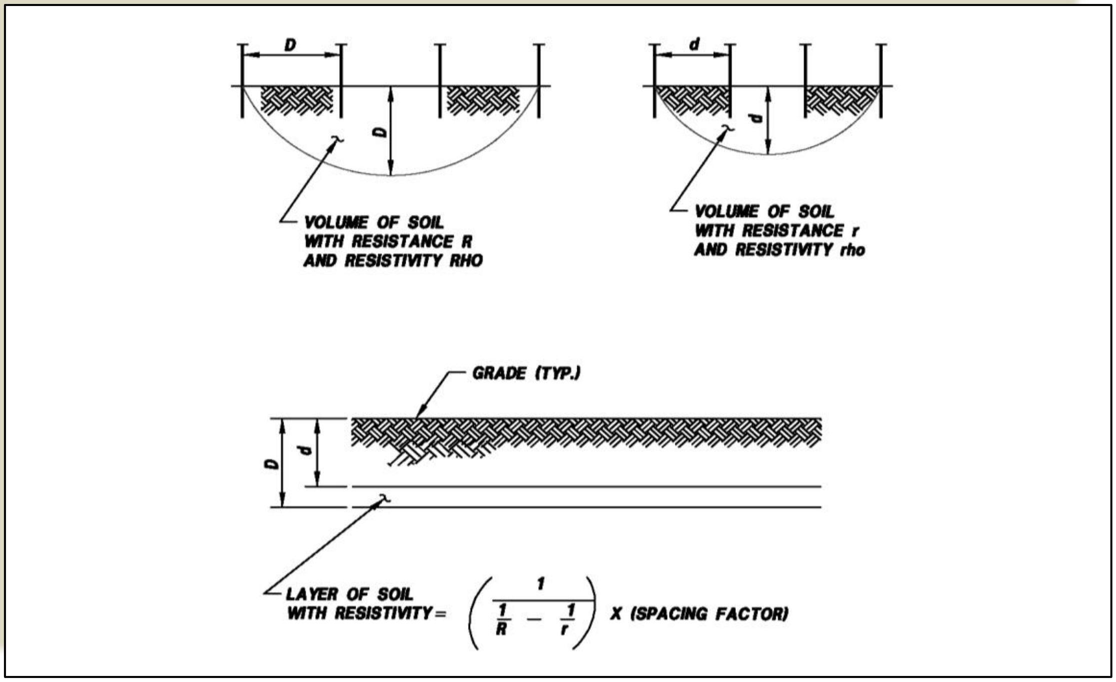


Fig 2: Illustration of Barnes Layer Calculations

In-Situ Soil Resistivity Analysis

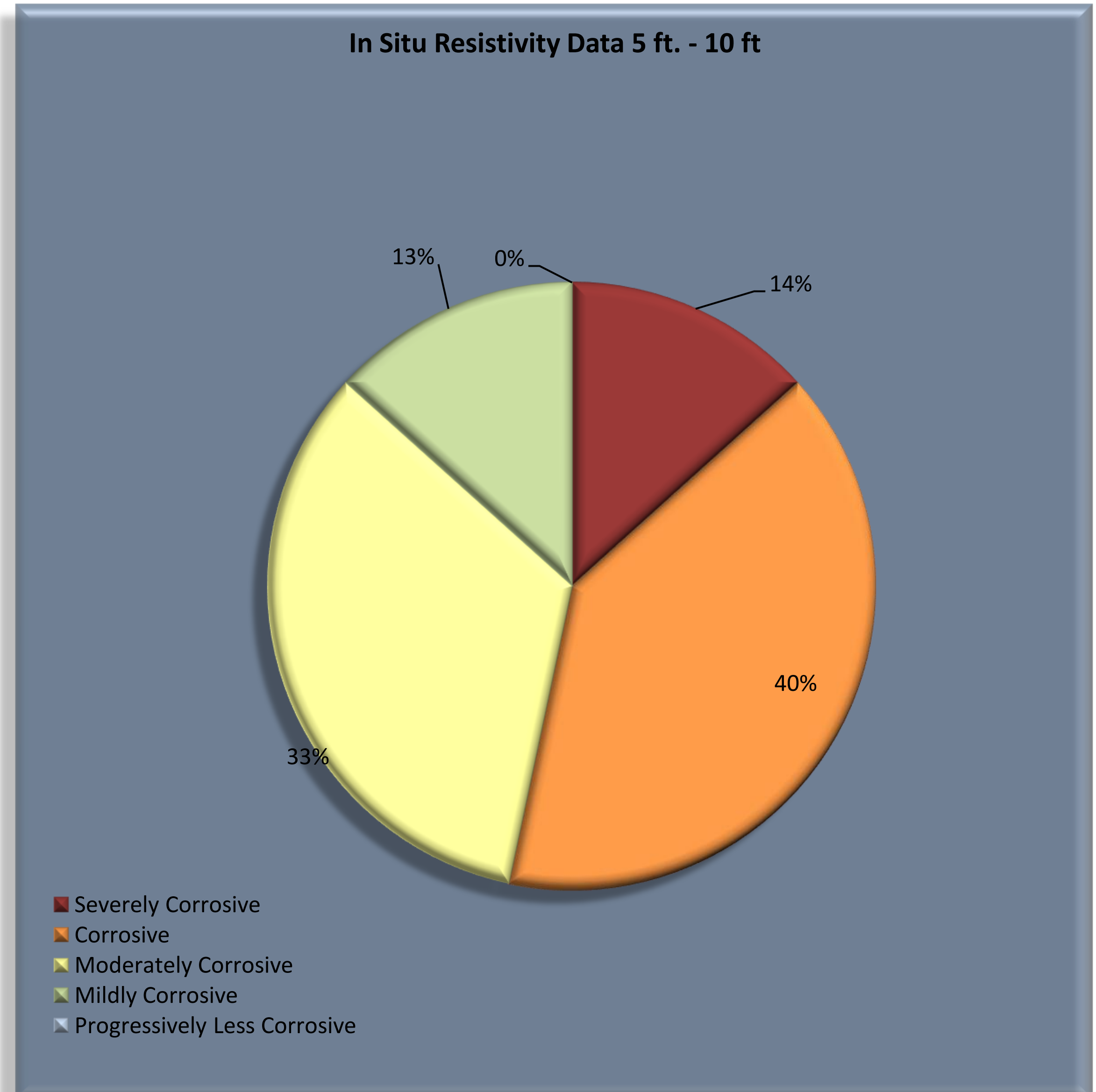
Corrosion of a metal is an electro-chemical process and is accompanied by the flow of electric current. Resistivity is a measure of the ability of a soil to conduct an electric current and is, therefore, an important parameter in consideration of corrosion data. Soil resistivity is primarily dependent upon the chemical content (i.e. pH, chlorides, sulfates, other soluble salts, etc.) and moisture content of the soil mass.

The greater the amount of chemical constituents present in the soil, the lower the resistivity will be. As moisture content increases, resistivity decreases until maximum solubility of dissolved chemicals is attained. Beyond this point, an increase in moisture content results in dilution of the chemical concentration and resistivity increases. The corrosion rate of steel in soil normally increases as resistivity decreases. Therefore, in any particular group of soils, maximum corrosion will generally occur in the lowest resistivity areas.

The following classification of soil corrosivity, developed by William J. Ellis[1], is used for the analysis of the soil data for the project site.

Resistivity (Ohm-cm)	Corrosivity Classification
0 – 500	Very Corrosive
501 – 2,000	Corrosive
2,001 – 8,000	Moderately Corrosive
8,001 – 32,000	Mildly Corrosive
> 32,000	Progressively Less Corrosive

The above classifications are appropriate for the force main alignment and the results are presented in the chart below and in the Findings section of this report.



Based on the field results of the "In-Situ" soil resistivity tests throughout the City of Oxnard, 14% of the soil samples are categorized at "Severely Corrosive", 40% "Corrosive", 33% "Moderately Corrosive", 13% "Mildly Corrosive" and 0% at Progressively Less Corrosive.

Soil Samples

Soil Testing Results

Twelve (12) soil samples were collected from select locations throughout the City of Oxnard by **JDH Corrosion** field personnel. The samples were transported to a state certified testing laboratory, **CERCO Analytical, Inc.** (DOHS certificate no. 2153) located in Concord, CA for chemical analysis. Each sample was analyzed for pH, chlorides, resistivity (@ 100% saturation), sulfates and Redox potential using ASTM test methods as detailed in the table below. The preparation of the soil samples for chemical analysis was in accordance with the applicable specifications.

Soil Analysis Test Methods

Chemical Analysis	ASTM Method
Chlorides	D4327
pH	D4972
Resistivity (100% Saturation)	G57
Sulfate	D4327
Redox Potential	D1498

The results of the chemical analysis are provided in the CERCO Analytical, Inc. report dated June 24, 2014. The results are summarized as follows:

CERCO Analytical, Inc.
Soil Laboratory Analysis (Hueneme Road)

Chemical Analysis	Range of Results	Corrosion Classification*
Chlorides	N.D. – 540 (mg/kg)	Corrosive *
pH	6.99 - 7.97	Non corrosive*
Resistivity	310 – 2,800 ohms-cm	Severely Corrosive **
Sulfate	N.D. – 600 (mg/kg)	Mildly corrosive**
Redox Potential	190 - 370 mV	Moderately-corrosive*

* With respect to bare steel or ductile iron.
** With respect to mortar coated steel

Chemical Test Results Analysis

Cement mortar and concrete create an alkaline environment which is favorable for steel and which alleviates corrosion when in intimate contact with the metal surface. In order for corrosion to occur, the cement mortar or concrete coating must be removed from intimate contact with the steel, or alkalinity of the environment must change. Therefore, in analyzing soil data for corrosivity, it is necessary to consider the presence of specific ions which are aggressive to steel in concrete and which produce changes in alkalinity of the cement mortar or concrete environment.

Resistivity alone cannot be used to predict the corrosiveness of soil-to-steel in concrete; however, it can be used to locate soil areas containing aggressive ions. The carbonate ion, frequently present in low resistivity soil, is not considered aggressive to steel in concrete. However, chloride and sulfate ions are frequently found in low resistivity soil areas and are known to be aggressive to steel in concrete when present in high concentrations. Chloride concentrations in excess of 300 mg/kg are considered to be "corrosive" to cement mortar coated steel, and concentrations greater than 1,500 mg/kg are considered "severely corrosive". Sulfates in excess of 1,000 mg/kg are considered "potentially corrosive" to buried cement mortar coated pipelines and concentrations exceeding 2,000 mg/kg are considered to be detrimental. Values of pH above 7.0 indicate alkaline soil conditions which are favorable to cement mortar-coated steel. Values below 7.0 indicate acidic conditions, and pH values below 6.0 are normally considered to be potentially detrimental to cement mortar coated steel pipe. Results of the chemical analysis are presented in the tables at the end of this report and are summarized in the CERCO Analytical Results table above.

The chemical analysis provided by **CERCO Analytical, Inc.** indicates that based on this soil data, the soils are generally classified as "Corrosive to Severely Corrosive" based on the resistivity measurements. The chloride levels indicate "Corrosive" conditions to steel and ductile iron, and the sulfate levels indicate "Mildly Corrosive" conditions for concrete structures that exist in these soils with regard to sulfate attack. The pH of the soils is alkaline which classifies them as "Non-Corrosive" to buried steel and concrete structures.

To conclude, based on the in-situ soil resistivity tests and laboratory analysis of the soil samples, the pipelines, and other buried piping and other metallic infrastructure throughout the City of Oxnard are exposed to soil conditions which range from "Corrosive" to "Severely Corrosive". For these reasons JDH Corrosion Consultants recommends that proactive measures be taken to rehabilitate the corrosion protection systems such as protective coatings and cathodic protection systems on the water force mains, the facilities at the waste-water and water treatment plants and other vital locations on the City of Oxnard infrastructure.

SECTION IV – RECOMMENDATIONS

4.1 GENERAL

In general, the design life for the subject cathodic protection systems for most of the cathodically protected infrastructure throughout the City of Oxnard facilities is now exceeded and the overall condition of the systems is unsatisfactory for the protection of the subject structures. Therefore, remedial work is required in order to continue to provide cathodic protection for the subject structures. At most locations for the water and waste-water treatment facilitates, the anodes have been depleted to a point where little or no cathodic protection is being provided to their intended structure. The impressed current cathodic protection systems for the water force main pipelines also require a lot of work to replace defective CP rectifier/anode ground-bed, cathodic test stations and other related work.

At many other locations, there is no evidence of cathodic protection at all. All metallic pipes that are exposed to the corrosive soil matrix should be supplemented with cathodic protection in order to mitigate soil side corrosion.

We also recommended that surveys should be performed on all of the cathodic protection systems and make adjustments and repairs, annually, as needed.

We have provided budgetary cost estimates for the all of the recommended work in an Excel spreadsheet that is attached to this written report.

4.2 PROJECT PIPELINES AND STRUCTURES

4.2.1 Water Transmission Force Mains

4.2.1.1 Del Norte Lateral Pipeline

The cathodic protection system for this pipeline consist of four (4) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

We recommend installing additional cathodic test stations in order to provide an adequate number of test locations to represent the general information on the pipe-to-soil potentials along the entire length of the pipeline. An adequate quantity of test stations are recommended at certain frequencies along the entire length of the pipe so that the corrosion engineers can establish the cathodic protection levels along the pipeline and make necessary adjustments to the current output of the rectifiers and anode ground-beds so that the pipeline is adequately protected against soil-side corrosion.

On this pipeline we found test stations at twelve different locations. In general we recommend test stations at every 1,000 to 2,000 feet with 2,000 feet being the maximum recommended distance between test points along a pipeline.

Although the twelve (12) test locations are better than having less test stations, we recommend the design and installation of additional test stations so that there is at least one (1) cathodic test station (CTS) at every 1,000 to 2,000 feet.

4.2.1.2 Oxnard Conduit Pipeline

The cathodic protection system for this pipeline consist of three (3) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Rectifiers #1 and #2 have failed and we recommend immediate design and replacement of these rectifiers and anode ground-beds. The entire section of pipe in the vicinity of these two failed rectifier and anode ground-beds is presently not receiving any cathodic protection and therefore we do not have an active corrosion control system to mitigate soil-side corrosion activity.

Most of the cathodic test stations (CTS) on this pipeline were missing and could not be located. A cathodic protection rehabilitation project is recommended to install CTS at every 1,000 to 2,000 feet along the entire length of pipeline.

The Rectifiers #1 and #2 and CTS installation project can be implemented as part of a large cathodic protection rehabilitation project for the Oxnard Conduit.

4.2.1.3 Wooley Road Main/United

The cathodic protection system for this pipeline consist of one (1) impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Although this rectifier and anode ground-bed are still operational, we recommend design and replacement of this system with a new one. The rectifier and anode ground-bed for this pipeline have been in place since the year 1977 and have far exceeded their expected operating life. We recommend a new system that would provide another 20 or more years of cathodic protection for this pipeline.

For the cathodic test stations, we recommend the design and installation of new cathodic test stations at increments of 1,000 feet.

4.2.1.4 3rd Street Lateral (30-inch Metro Line) & 27" Pipeline

The cathodic protection system for this pipeline consist of one (1) shared impressed current CP rectifier along with its associated, impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Rectifier #6 and its anode ground-bed, for this pipeline have failed and we recommend immediate design and replacement of this rectifier and anode ground-bed. The entire section of pipe in the vicinity of this failed rectifier and anode ground-bed is presently not receiving any cathodic protection and therefore we do not have an active corrosion control system to mitigate soil-side corrosion activity.

Most of the cathodic test stations (CTS) on these pipelines were missing and could not be located. A cathodic protection rehabilitation project is recommended to install CTS at every 1,000 to 2,000 feet along both entire lengths of pipeline.
The replacement of Rectifier #6 and associated anode ground-bed, along with the CTS installation project can be implemented as part of a large cathodic protection rehabilitation project for the 3rd Street Lateral.

4.2.1.5 Industrial Lateral

The cathodic protection system for this pipeline consist of one (1) impressed current CP rectifier along with its associated, impressed current anode ground-bed.

Rectifier #4 for this pipeline along with its associate anode ground-bed was found to be operating in a satisfactory manner and providing cathodic protection for the Industrial Lateral pipeline.

We found only one (1) cathodic test station for this pipeline. All but one of the cathodic test stations (CTS) on this pipeline were missing and could not be located.

We recommend a cathodic protection rehabilitation project is recommended to install CTS at every 1,000 to 2,000 feet along the entire length of pipeline.

4.2.2 Wastewater Treatment Facility at 6001 South Perkins Road

This waste-water treatment facility has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations, which are located throughout the facility. The cathodic protection test stations were found at over 227 locations and tested by JDH Corrosion field personnel as part of this project.

This waste-water treatment facility also has six (6) waste-water clarifiers, three (3) digesters, and other large equipment which reportedly do not have actively installed or maintained cathodic protection system to protect the metallic (steel and iron) rake arms and other metallic equipment from water-side (submerged) corrosion activity. We will discuss options for corrosion (cathodic) protection of this equipment later in this report.

Most of the galvanic cathodic protection systems at this facility have failed and a facility-wide project is recommended to design and install a new cathodic protection system. This would require new galvanic (sacrificial) anodes at almost all of the existing anode test stations (ATS). The pipe-to-soil potentials at these failed locations did not meet the NACE International Criteria (SP 0169-13) as described above.

There is also another option we can consider for cathodic protection at this waste-water treatment facility and that would be to provide impressed current cathodic protection (ICCP) systems for all of the metallic, underground pipes at this facility. This would require that all of the pipes be made electrically continuous using electrical continuity bond cables and then to implement impressed current rectifier and anode ground-beds at various locations. Then the protective current from the impressed currents systems could provide soil-side corrosion mitigation to the buried metallic pipes at this facility.

Both galvanic and ICCP systems would require a large effort, as we have more than 227 locations with existing test anode test stations, along with a very complex array of buried metallic pipes throughout this facility. The time and budget for this cathodic protection project would be large in comparison to one where only a few anode test station require rehabilitation work.

To confirm we highly recommend a facility-wide cathodic protection rehabilitation project to consist of either providing a galvanic or impressed current cathodic protection system, as the current CP system has failed on most of the pipes and other related metallic structures throughout the waste-water treatment plant.

4.2.3 Water Treatment Facility at 251 South Hayes Avenue

This water treatment facility has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations, which are located throughout the facility. The cathodic protection test stations were found at over eight (8) locations and tested by JDH Corrosion field personnel as part of this project. At most of these anode test stations (ATS) the pipe-to-soil potentials did not meet the NACE Criteria (SP 0169-13). We recommend the design and installation of new, galvanic (sacrificial) anodes in order to provide adequate soil-side corrosion control.

There is also a 600,000-gallon steel, above-grade water storage tank at this facility. This water tank is 70 feet in diameter, 25 feet high and was installed in the year 2005. We recommend the design and implementation of a new, internal (wetted surface) cathodic protection system for this tank. This new CP system would mitigate the corrosion activity for the submerged surfaces of this tank to include the tank internal walls and floor. We recommend a new cathodic protection system for the submerged (wetted) surfaces of this steel, water storage tank (reservoir).

LIMITATIONS

The conclusions and recommendations contained in this report reflect the opinion of the author of this report and are based on the information and assumptions referenced herein. All services provided herein were performed by persons who are experienced and skilled in providing these types of services and in accordance with the standards of workmanship in this profession. No other warrantees or guarantees either expressed or implied are provided.

We appreciate the opportunity to assist the **Carollo Engineers** and **The City of Oxnard** on this interesting and challenging project. If you have any questions about our findings or analysis, or if we can be of any additional assistance at this time, please contact our office at (925) 927-6630.

Respectfully submitted,

J Darby Howard, Jr.

J. Darby Howard, Jr., P.E.
JDH Corrosion Consultants, Inc.
Principal

David A. Kashifi,
JDH Corrosion Consultants, Inc.
Cathodic Protection Specialist (NACE #7355)
Sr. Project Manager

Attachments: Field Data

ATTACHMENT 1

SUMMARY OF FIELD TEST RESULTS WITH COST ESTIMATES

City of Oxnard Cathodic Protection and Corrosion Assessment Project
Summary of Field Test Results with Cost Estimates
2014

Structure	Description	Cathodic Protection	Comments	Recommendations	Engineering Cost Estimates	Budgetary Cost Estimates
Del Norte Pipeline	Concrete Cylinder Force Main	4 – Impressed Current Rectifiers and Anode Ground-Beds	1. Pipe potentials met NACE Criteria (Passed) at Most locations 2. Most Cathodic Test Stations Missing	Immediate 1. Install 20 Missing test stations __________ < 5 Years 1.Replace Rectifiers and Anode-Ground-Beds in the next 5 years 2. Resurvey the system annually and make necessary repairs annually	Immediate $40,000 __________ < 5 Years $50,000	Immediate $200,000 __________ < 5 Years $250,000
Oxnard Conduit	Concrete Cylinder Pipeline	3 – Impressed Current Rectifiers and Anode Ground-Beds	1. Two (2) of the Three (3) Impressed Current Rectifiers and Anode Ground-Beds are in-operable. 2.Pipe potentials do met NACE Criteria at Most locations 3. Most Cathodic Test Stations are Missing	Immediate 1. Replace the Two (2) Failed Rectifiers and Anode-Ground-Beds. 2. Replace 20 Missing Test Stations __________ <5 years 1.Replace Third Working Rectifier and Anode-Ground-Beds in the next 5 years 2.Resurvey the system annually and make necessary repairs annually	Immediate $50,000 __________ < 5 Years $25,000	Immediate $270,000 __________ < 5 Years $100,000

City of Oxnard Cathodic Protection and Corrosion Assessment Project
Summary of Field Test Results with Cost Estimates
2014

Structure	Description	Cathodic Protection	Comments	Recommendations	Engineering Cost Estimates	Budgetary Cost Estimates
Wooley Road/United	Concrete Cylinder Pipeline	1 – Impressed Current Rectifier and Anode Ground-Bed	1. Impressed Current Rectifier and Anode Ground-Bed working but will need Replacement. 2. Pipe potentials met NACE Criteria at All locations 3. Many Cathodic Test Stations Missing	Immediate 1. Replace five (5) test stations along the pipeline route. — <5 Years 1. Replace Working Rectifier and Anode-Ground-Bed in the next 5 years 2. Resurvey the system annually and make necessary repairs annually	Immediate $10,000 — <5 Years $25,000	Immediate $40,000 — <5 Years $100,000
3rd Street Lateral (30-inch Metro Line)	Concrete Cylinder Pipeline	1 – Impressed Current Rectifier and Anode Ground-Bed	1. Impressed Current Rectifier and Anode Ground-Bed Failed and will need Replacement 2. Pipe potentials Did Not meet NACE Criteria at Any location 3. All Cathodic Test Stations Missing	Immediate 1. Replace Failed Rectifier and Anode-Ground-Bed Immediately 2. Replace all test stations at intervals of 1,000 feet minimum and 2,000 feet maximum 3. Resurvey the system annually and make necessary repairs annually	Immediate $40,000	Immediate $200,000

City of Oxnard Cathodic Protection and Corrosion Assessment Project
Summary of Field Test Results with Cost Estimates
2014

Structure	Description	Cathodic Protection	Comments	Recommendations	Engineering Cost Estimates	Budgetary Cost Estimates
Industrial Lateral	Concrete Cylinder Force Main	1 – Impressed Current Rectifier and Anode Ground-Bed	1. Impressed Current Rectifier and Anode Ground-Bed Operating Properly 2. Pipe potentials met NACE Criteria at Tested locations 3. Most Cathodic Test Stations Missing	Immediate 1. Replace all test stations at intervals of 1,000 feet minimum and 2,000 feet maximum 2. Resurvey the system annually and make necessary repairs annually	Immediate $25,000	Immediate $100,000
Waste-Water Treatment Facility at 6001 South Perkins Road	Multiples Metallic Pipes and Other Related Metallic Structures Throughout the Facility.	Galvanic Anode Test Stations at 227 Locations	1. Pipe potentials Did Not Meet NACE Criteria for protection for Almost All Locations 2. New anodes will be Required Immediately to Maintain the Integrity of the Corrosion Protection System for this Waste-Water Treatment Facility	Immediate 1. Require Complete Replacement (Rehabilitation) of the Entire Cathodic Protection System at the Entire Waste-Water Treatment Facility 2. Design and Install Galvanic or Impressed Current Cathodic Protection	Immediate $150,000	Immediate $1,000,000
Waste-Water Treatment Facility at 6001 South Perkins Road	Six (6) Waste-Water Clarifiers and Digesters	No Cathodic Protection Exists	1. Need to Design and Install Cathodic Protection for the Submerged (Wetted) Surfaces of the Metallic Components of these Equipment	Immediate 1. Require Design and Installation of Cathodic Protection at These Six (6) Clarifiers and Digesters	Immediate $50,000	Immediate $180,000

City of Oxnard Cathodic Protection and Corrosion Assessment Project
Summary of Field Test Results with Cost Estimates
2014

Structure	Description	Cathodic Protection	Comments	Recommendations	Engineering Cost Estimates	Budgetary Cost Estimates
Water Treatment Facility at 251 South Hayes Avenue	Multiples Metallic Pipes and Other Related Metallic Structures Throughout the Facility	Galvanic Anode Test Stations at 8 Locations	1. Pipe potentials Did Not Meet NACE Criteria for protection for Almost All Locations 2. New anodes will be Required Immediately to Maintain the Integrity of the Corrosion Protection System for this Water Treatment Facility	Immediate 1. Require Complete Replacement (Rehabilitation) of the Entire Cathodic Protection System at the Entire Waste-Water Treatment Facility 2. Design and Install Galvanic Current Cathodic Protection	Immediate $15,000	Immediate $50,000
600,000-Gallon, Steel Water Tank (Reservoir) at Water Treatment Facility at 251 South Hayes Avenue	Steel Water Storage Tank (Reservoir)	No Existing Cathodic Protection Tank Interior is Coated	1. Tank-to-Water potentials Do Not Meet NACE Criteria for protection for This Tank 2. Cathodic Protection Required for Internal (Wetted) Surfaces of this Tank	Immediate 1. Require New Cathodic Protection System for Internal Surfaces of Tank 2. Design and Install New Current Cathodic Protection	Immediate $7,500	Immediate $30,000

City of Oxnard Cathodic Protection and Corrosion Assessment Project
Summary of Field Test Results with Cost Estimates
2014

Structure	Description	Cathodic Protection	Comments	Recommendations	Engineering Cost Estimates	Budgetary Cost Estimates
Annual Cathodic Protection Survey and Report for All Cathodic Protection Systems Owned and Operated by the City of Oxnard	All Structures with Cathodic Protection that are Operational	All Existing Cathodic Protection Systems that are Operational	1. Water Pipeline Mains 2. Water and Waste-Water Treatment Faculties with Cathodic Protection Systems that are Operational	Immediate 1. Annual Testing and Report for All Operating Cathodic Protection Systems	Immediate $30,000 (On an Annual Basis)	Immediate $0
Summary of Cost Estimates	--	--	--	**Total Cost Estimates:**	**Immediate** **$442,500** **< 5 Years** **$100,000**	**Immediate** **$2,070,000** **< 5 years** **$450,000**

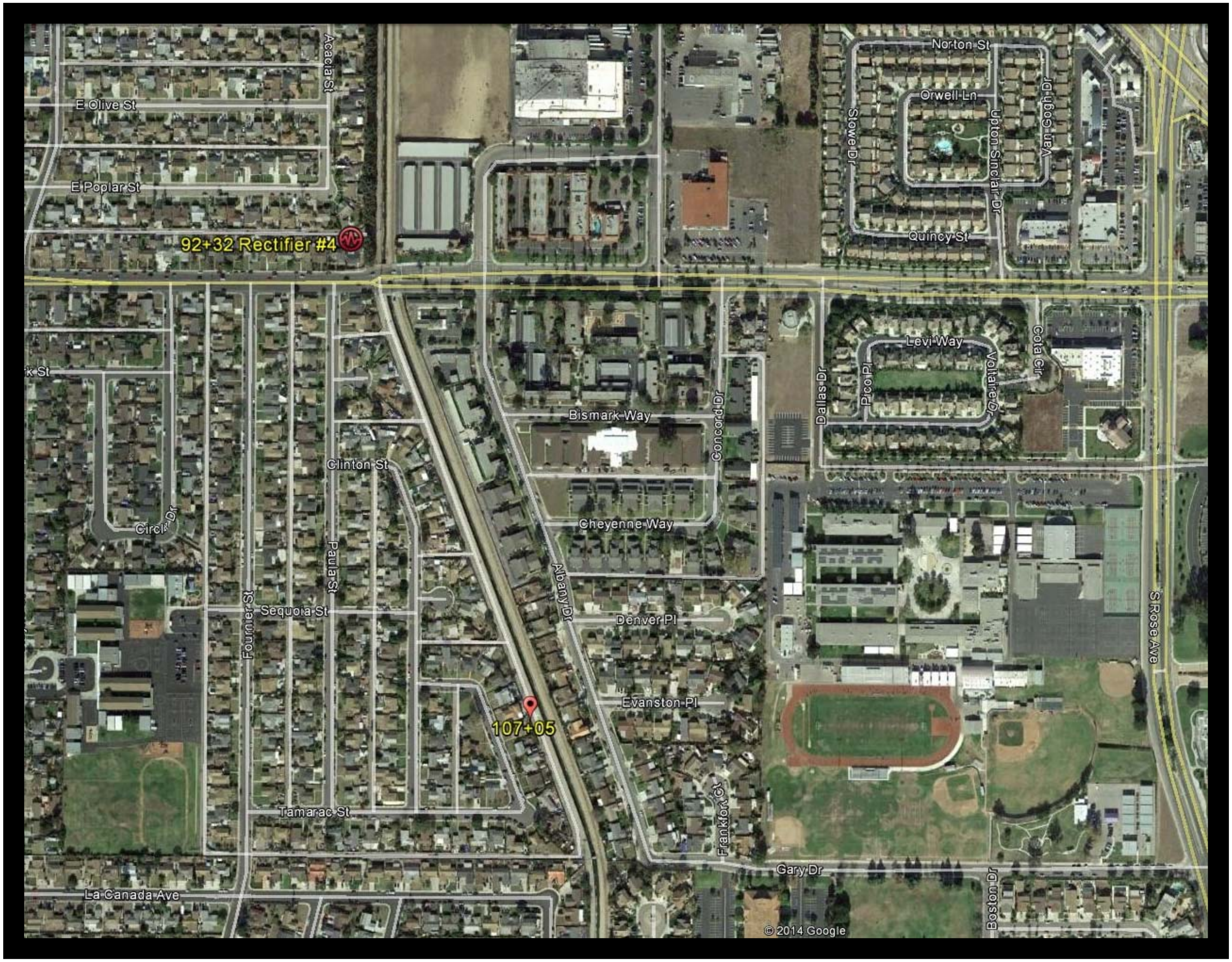
ATTACHMENT 2

GOOGLE EARTH IMAGES OF CATHODIC PROTECTION SYSTEMS

Del Norte Lateral – Rectifier and Test Station Locations

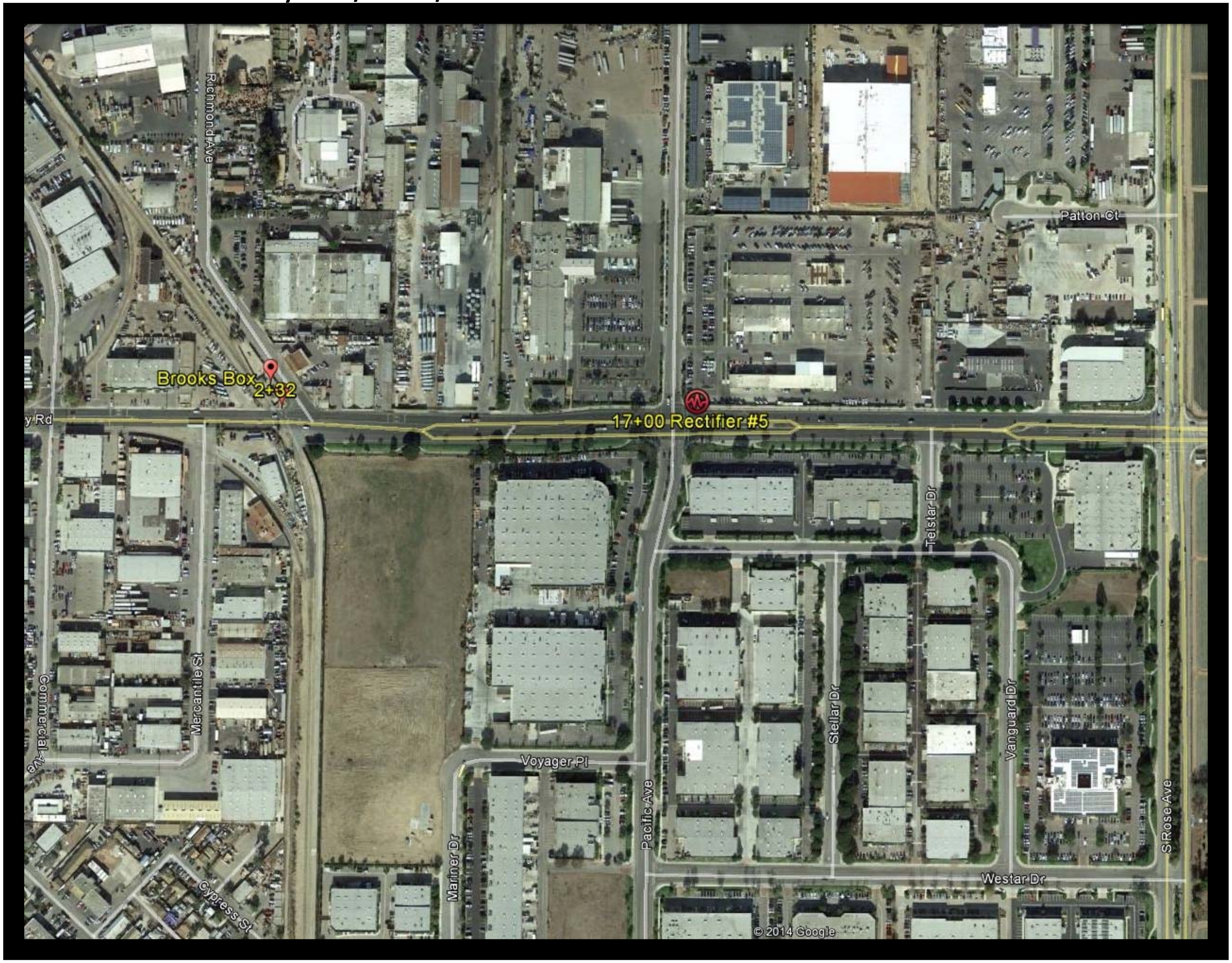
jdh corrosion consultants, inc.

Industrial Lateral – Rectifier and Test Station Locations



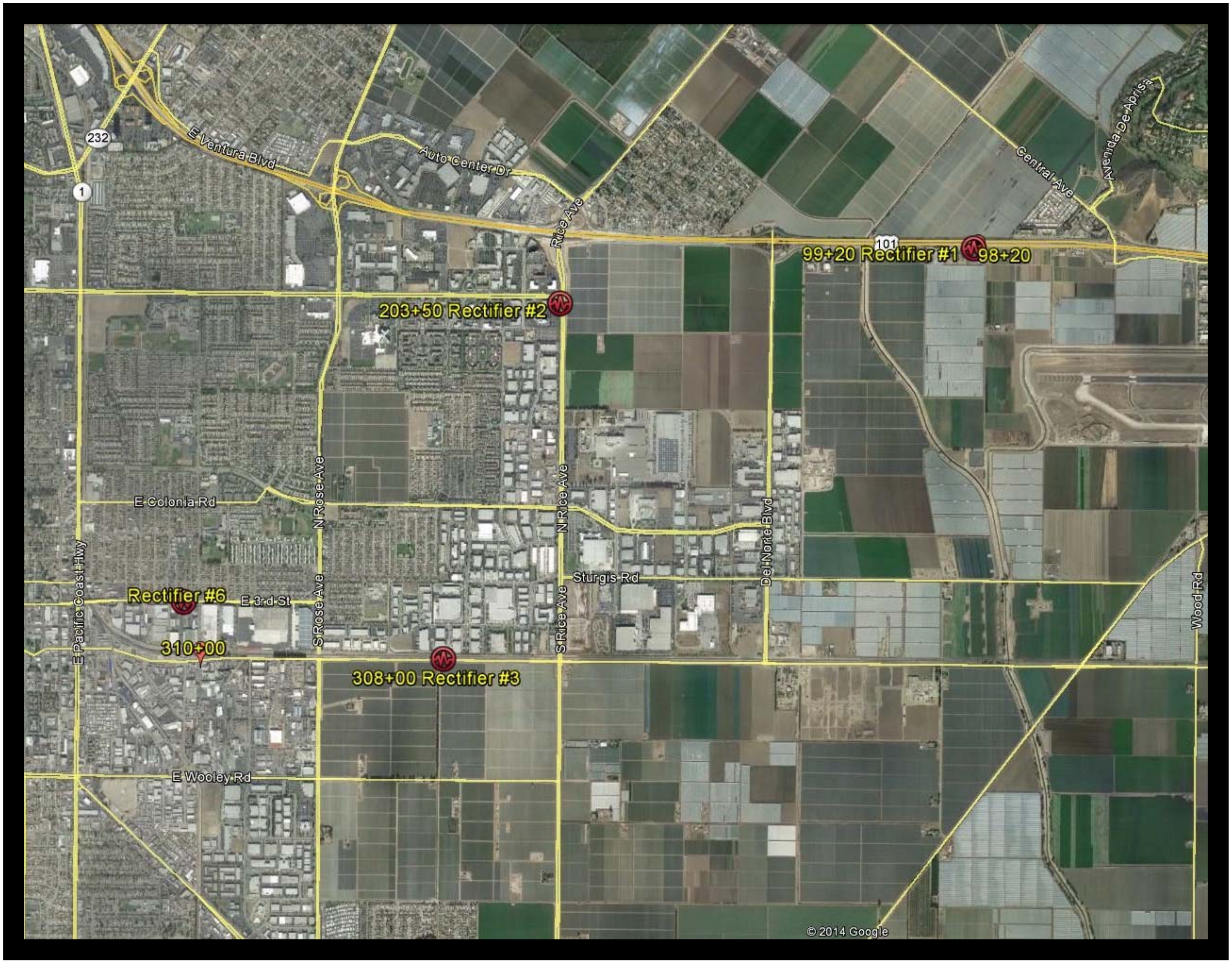
jdh corrosion consultants, inc.

Wooley Road/United/Industrial Lateral – Rectifier and Test Station Locations



jdh corrosion consultants, inc.

Oxnard Conduit – Rectifier and Test Station Locations

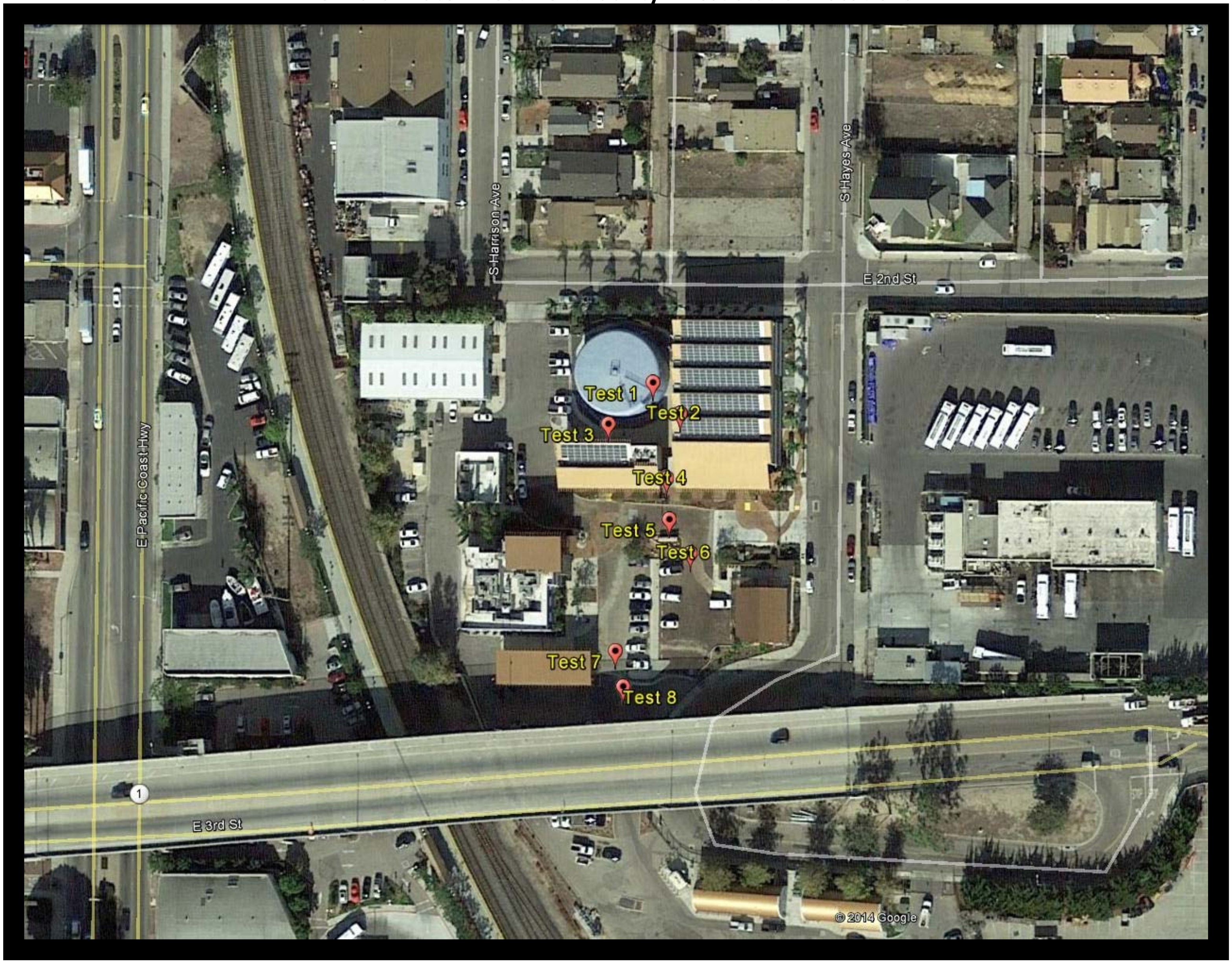


jdh corrosion consultants, inc.

Oxnard Waste Water Treatment Facility – Test Station Locations

jdh corrosion consultants, inc.

Oxnard Water Treatment Facility – Test Station Locations



jdh corrosion consultants, inc.

ATTACHMENT 3

PIPE TO SOIL POTENTIALS FOR ICCP SYSTEMS ON WATER MAINS

CITY OF OXNARD
WATER PIPING TRANSMISSION MAINS

PIPE-TO-SOIL POTENTIALS

JULY 2014

Station	Structure to Soil Potential (-mV)				
	Native	Rectifier On	Rectifier Off	Off – Native	Comments
Del Norte Lateral					
0+00 Vault					Could Not Locate/No Access
13+35 MH					Could Not Locate/No Access
25+70 MH					Could Not Locate/No Access
26+50 Rectifier #7 Test Lead		1505	874		At Rectifier Cabinet
38+00 CTS at Brooks Box					Could Not Locate
50+50 MH					Could Not Locate
63+00 CTS at Brooks Box					Could Not Locate
75+50 CTS at Brooks Box					Could Not Locate
"M.P.88.00 at Station 88+00 "CP TEST"		1730	1124		GPS N34.22804 W119.10946
Rectifier #8 Test Lead		1826	1210		At Rectifier Cabinet
"M.P.110.00 at Station 110+00 "CP TEST"		1728	1123		GPS N34.23191 W119.11504
"M.P.120.00 at Station 120+00 "CP TEST"		1690	1094		GPS N34.23367 W119.11761
130+00 CTS at Brooks Box					Could Not Locate
140+00 CTS at Brooks Box					Could Not Locate
150+00 CTS at Brooks Box					Could Not Locate
161+00 CTS at Brooks Box					Could Not Locate
173+00 CTS at Brooks Box					Could Not Locate
185+06 Rectifier #9 Test Lead		2114	1120		At Rectifier Cabinet
"M.P.197.50 at Station 197+50 "CP TEST"		2239	1100		GPS N34.24729 W119.13728

Station	Structure to Soil Potential (-mV)				
	Native	Rectifier On	Rectifier Off	Off – Native	Comments
Del Norte Lateral (Continued)					
"M.P.210.00 at Station 210+00 "CP TEST"		2210	1096		GPS N34.24947 W119.14046
"M.P.222.00 at Station 222+00 "CP TEST"		2246	1060		GPS N34.25019 W119.14343
Station 233+00					Could Not Locate
"M.P.244.00 at Station 244+00 "CP TEST"		2190	1068		GPS N34.24570 W119.14832
254+97 (S.)					Could Not Locate
Blending Station #4 Rectifier #10 @BS #4 T1 No. to 36" T2 to United T3 So. To 36"		1092 1114 1009	671 659 647		Potentials not meeting NACE - 850 mV Instant Off.
Risers@BS#4 Riser 1 Buried at IJ A/G at IJ Riser 2 Buried at IJ A/G at IJ Riser 3 Buried at IJ A/G at IJ Outside Paved Area At BS#4 "CP TEST" West 2 Wires East 2 Wires "CP TEST" Black Box South 2 Wire North 2 Wires		1245 1282 712 633 845 714 372 400 1070 2129	1076 1125 426 499 670 599 303 322 668 317		Insulating Joint Operating Properly Insulating Joint Operating Properly Insulating Joint Operating Properly Not Electrically Continuous w/ R#10 Not Electrically Continuous w/ R#10 GPS N34.24233 W119.15087 Continuous with Rectifier #10 GPS N34.24235 W119.15087
"M.P.269.00 at Station 269+00 "CP TEST"		2025	1014		GPS N34.23959 W119.15204
Station 279+00					Could Not Locate

Station	Structure to Soil Potential (-mV)				
	Native Static	Rectifier On	Rectifier Off	Off – Native	Comments
Oxnard Conduit					
6+33					Main Line Dresser – Could Not Locate/No Access
46+75 (east) Up Side Main Line Dresser					Could Not Locate/No Access
46+75 (west) Down Side Main Line Dresser					Could Not Locate/No Access
81+90 CTS					Could Not Locate
Post Mount CTS, Red Wire 1 Wire 2	 607 607	 -- --	 -- --		Rectifier #1 and its Associated Anode Ground-Bed is Not Operating. Potentials Did Not Meet NACE SP 0169 Criterion GPS N34.22168 W119.11192
Post Mount CTS, Red at 100 Feet East of Rectifier #1 Wire 1 Wire 2	 562 562	 -- --	 -- --		Rectifier #1 and its Associated Anode Ground-Bed is Not Operating. Potentials Did Not Meet NACE SP 0169 Criterion GPS N34.22168 W119.11192
99+20 Rectifier #1	542	--	--	--	Rectifier and Anode-Ground-Bed Not Operating. Need to Replace Rectifier and Anode Ground-Bed #1
124+15 CTS					Could Not Locate
152+00 CTS					Could Not Locate
178+40 Vault					Could Not Locate/No Access
191+50 Air Release					Could Not Locate/No Access. Rice Road.
203+50 Main Line Dresser and Rectifier #2					Could Not Locate/No Access to Dresser. Rectifier and Anode-Ground-Bed Not Operating. Need to Replace Rectifier and Anode Ground-Bed #2
211+00 CTS					Could Not Locate. Rice Road
225+25 CTS					Could Not Locate. Rice Road
239+50 CTS					Could Not Locate. Rice Road
254+00 Main Line Dresser					Could Not Locate/No Access. Rice Road
272+25 CTS					Could Not Locate. Rice Road
284+80 CTS at MH					Could Not Locate. 5^{th} Street

Station	Structure to Soil Potential (-mV)				
	Native Static	Rectifier On	Rectifier Off	Off – Native	Comments
Oxnard Conduit (Continued)					
308+00 Rectifier #3 Up-Side Down-Side	-- --	1369 1380	1087 1090	-- --	Rectifier and Anode Ground-Bed Operating Properly
310+00 Air Release Valve 200 Feet From Rectifier #3 Direct Contact to Pipe		1075	852		Potential Met NACE -850 mV Instant Off Criterion GPS N34.19730 W 119.16841
330+75 CTS					Could Not Locate. 5th Street Located 40' west of sign, 18' from Pole No. 13004 Y
346+60 CTS					Could Not Locate. 5th Street 30' W. of Hydrant, 10' N of white line
361+43.15 (east) Vault					Could Not Locate/No Access. 5th Street Diaz Vault. White test lead with black stripe in condulet under lid.

Station	Structure to Soil Potential (-mV)				
	Native	Rectifier On	Rectifier Off	Off – Native	Comments
Wooley Road/United/Industrial Lateral					
2+31.71 (East) Wooley Road and Richmond Ave (Oxnard City Facility) Rectangular Traffic Box Wire 1 Wire 2		931 931	933 933		Potentials Met NACE -850 mV On Criterion. This location is Electrically Isolated from the Pipe that is Connected to Rectifier #5 GPS34.19014 W119.16878
Brooks Box "CTS" with 4 Wires Wire 1 Wire 2		1046 1046	910 910		GPS34.19034 W119.16891 Potentials Met NACE -850 mV Instant Off Criterion. Wires 1 and 2 are Connected to Pipe that is Protected by Rectifier #5
Wire 3 Wire 4		910 910	931 931		Potentials Met NACE -850 mV On Criterion. This location is Electrically Isolated from the Pipe that is Connected to Rectifier #5
17+00 Rectifier #5 Structure Drain Lead		1560	1143		Potentials Met NACE -850 mV Instant Off Criterion GPSN34.19009 W119.16463
31+03.04 Main Line Insulator					Could Not Locate. Wooley Road and Rose Avenue

Station	Structure to Soil Potential (-mV)				
	Native	Rectifier On	Rectifier Off	Off – Native	Comments
Industrial Lateral					
1+11.26 CTS					Could Not Locate
4+10					Could Not Locate
17+65 MH					Could Not Locate
29+85 CTS					Could Not Locate
30+50 CTS					Could Not Locate
44+05 CTS					Could Not Locate
54+29 CTS					Could Not Locate
67+15 CTS					Could Not Locate
80+05					Could Not Locate
92+32 Rectifier #4 at 685 East Channel Islands Blvd. Structure Drain Lead		2430	972		Potentials Met NACE -850 mV Instant Off Criterion GPS N34.17375 W119.16903
107+05 CTS "CP TEST" Wire 1		1485	1025		Potentials Met NACE -850 mV Instant Off Criterion GPS N34.16945 W119.16705
119+55 CTS					Could Not Locate
134+55 MH					Could Not Locate
148+95 CTS					Could Not Locate
163+00 CTS					Could Not Locate

ATTACHMENT 4

WATER PIPELINES RECTIFIER DATA

TABLE I
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location	#1 on Oxnard Conduit GPS: N34.22166 W119.11224		
Manufacturer	Farwest Corrosion Control Company		
Model No.	ASAI	Serial No.	023687

Shunt Rating: -- Amps -- Millivolts

AC Input:	115/230 Volts Single	14.8/7.4 Amps Phase	Rated DC Output	40 30	Volts Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/2/2014	--	--	--	--	0	Rectifier and Anode Bed Not Operating. Need to Replace

TABLE II
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location: #2 on Oxnard Conduit
GPS N34.21836 W119.14227
Manufacturer: Unmarked
Model No.:
Serial No.:

Shunt Rating: 25 Amps 50 Millivolts

AC Input: -- Volts -- Amps Single Phase
Rated DC Output: 36 Volts, 22 Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/2/2014	19.81	0	--	25 Amps 50 mV	0	Anode Ground-Bed Not Operating. Need to Replace Anode Ground-Bed

TABLE III
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location	#3 on Oxnard Conduit GPS N34.19704 W119.15076		
Manufacturer	Goodall Electric		
Model No.	CSAYSA 12-22 AEFNRSZ	Serial No.	89C1504

Shunt Rating: 25 Amps 50 Millivolts

AC Input:	120 Volts	3.94 Amps	Rated DC Output	12	Volts
	Single	Phase		22	Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/2/2014	9.58	6.25	12.5 mV	25 Amps 50 mV	6.25 Amps	Rectifier and Anode Ground-Bed Operating

Anode Current Output 7/2/2014:

1)	1.90 Amps	4)	0.70 Amps
2)	1.62 Amps	5)	0.81 Amps
3)	1.16 Amps		
		Total:	6.19 Amps

Tap Settings: Coarse C of D, Fine 3 of 5

TABLE IV
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location	#4 on Industrial Lateral GPS N34.17375 W119.16903		
Manufacturer	Western Rectifiers		
Model No.	WATSA-60-50-DFIZ	Serial No.	01E103

Shunt Rating: 60 Amps 50 Millivolts

AC Input:	120 Volts	37 Amps	Rated DC Output	60	Volts
	Single	Phase		50	Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/22/2014	4.5	10.68	8.9 mV	25 Amps 50 mV	10.68 Amps	Rectifier and Anode Ground-Bed Operating

Anode Current Output 7/22/2014:

1)	2.10 Amps	4)	1.50 Amps
2)	2.00 Amps	5)	1.50 Amps
3)	2.10 Amps	6)	1.10 Amps
		Total:	10.30 Amps

Tap Settings: Coarse A of D, Fine 1 of 5

TABLE V
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location	#5 on United or Distribution Pipeline GPS N34.19009 W119.16463		
Manufacturer	Goodall Electric		
Model No.	CSAWSE 30-16 EGZ	Serial No.	77W3200

Shunt Rating: 20 Amps 50 Millivolts

AC Input:	115/230 Volts Single	6.8/3.4 Amps Phase	Rated DC Output	30 16	Volts Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/2/2014	9.35	5.16	12.9 mV	20 Amps 50 mV	5.16 Amps	Rectifier and Anode Ground-Bed Operating

Tap Settings: Coarse 2 of 4, Fine 2 of 5

Pipe-to-soil Potential at Rectifier Structure Connection: On: -1,560 mV, Instant Off: -1,143 mV

TABLE VI
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location	#6 on 3rd Street Lateral GPS N34.20046 W119.16963			
Manufacturer	Matcor			
Model No.	MASYSE 30-40 M	Serial No.	062846	
AC Input:	115/230 Volts 14.7/7.3 Amps Single Phase	Rated DC Output	30	Volts
			40	Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/22/2014	--	--	--	--	--	Rectifier and Anode Ground are Not Operational and Require Replacement

TABLE VII
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location	#7 on Del Norte Lateral GPS N34.22123 W119.09190		
Manufacturer	Goodall Electric		
Model No.	CSAYSE 40-22 AEFNRZ	Serial No.	94C1020

Shunt Rating: 25 Amps 50 Millivolts

AC Input:	120/240 Volts	11/6 Amps	Rated DC Output	40	Volts
	Single	Phase		22	Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/1/2014	5.08	4.40	8.8 mV	25 Amps 50 mV	4.40 Amps	Rectifier and Anode Ground-Bed Operating

Tap Settings: Coarse A, Fine 3

Anode Current Output 7/1/2014:

1)	0.3 Amps	5)	0.4 Amps
2)	0.5 Amps	6)	0.5 Amps
3)	0.4 Amps	7)	0.7 Amps
4)	0.4 Amps	8)	1.2 Amps
		Total:	4.4 Amps

TABLE VIII
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location #8 on Del Norte Lateral at M.P. 100.90 (Station 100+90)

Manufacturer Corrpower
Model No. CAYSE 60-34 FOZ 72,117,203,287 Serial No. C-031906

Shunt Rating: 40 Amps 50 Millivolts

AC Input: 115/230 Volts Single 27/13.5 Amps Phase Rated DC Output 60 Volts 34 Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/1/2014	7.13	6.08	7.6 mV	40 Amps 50 mV	6.08 Amps	Rectifier and Anode Ground-Bed Operating

Tap Settings: Coarse A of E, Fine 3 of 6

Anode Current Output 7/1/2014:

1)	0.0 Amps	4)	1.0 Amps
2)	0.6 Amps	5)	1.2 Amps
3)	0.8 Amps	6)	2.3 Amps
		Total:	5.9 Amps

TABLE IX
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location #9 on Del Norte Lateral at M.P. 185.06 (Station 185+96)

Manufacturer Goodall Electric
Model No. CAYSE 40-22 AEFNRZ Serial No. 94C1019

Shunt Rating: 25 Amps 50 Millivolts

AC Input: 120/240 Volts Single 11/6 Amps Phase Rated DC Output 40 Volts 22 Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/1/2014	6.10	3.0	6.0 mV	25 Amps 50 mV	3.0 Amps	Rectifier and Anode Ground-Bed Operating

Tap Settings: Coarse A of D, Fine 3 of 5

Anode Current Output 7/1/2014:

1)	0.0 Amps	4)	0.3 Amps
2)	0.8 Amps	5)	0.4 Amps
3)	0.5 Amps	6)	0.9 Amps
		Total:	2.9 Amps

TABLE X
CITY OF OXNARD
WATER PIPING FORCE MAINS

RECTIFIER AND ANODE OUTPUT

JULY 2014

Rectifier Location #10 on Del Norte Lateral at Blending Station #4

Manufacturer Goodall Electric
Model No. CAYSE 30-16 37AEFNRZ Serial No. 93C2237

Shunt Rating: 20 Amps 50 Millivolts

AC Input: 120/240 Volts 6.2/3.1 Amps Single Phase Rated DC Output 30 Volts 16 Amps

Date	Volts	Amps	Voltage Drop Across Shunt	Shunt Calibration Factor	Calculated Current Output	Comments
7/1/2014	11.45	5.17	12.9 mV	20 Amps 50 mV	5.17 Amps	Rectifier and Anode Ground-Bed Operating

Tap Settings: Coarse C of D, Fine 4 of 5

Anode Current Output 7/1/2014:

1) 0.8 Amps 4) 1.2 Amps
2) 0.0 Amps 5) 0.8 Amps
3) 1.1 Amps 6) 1.3 Amps

Total: 5.2 Amps

ATTACHMENT 5

FIELD DATA WASTEWATER TREATMENT FACILITY

Oxnard Waste Water Treatment Facility
CP Assessment Survey
July 2014

Name	Structure-to-Soil Potential (-mV)	Anode Potential (-mV)	Discription	Latitude	Longitude
Direct Contact	433		Chlorine Contact Chamber, West Side, Ground Level 8" Pipe		
Direct Contact	20		Chlorine Contact Chamber, West Side, Ground Level 8" Pipe		
Direct Contact	25		Chlorine Contact Chamber, West Side, Ground Level 6" Pipe		
Direct Contact	18		Chlorine Contact Chamber, West Side, Upper Level 6" Pipe		
Direct Contact	68		Chlorine Contact Chamber, East Side, 30" Pipe		
E132	162		Plant Control Center	34.1416422	-119.1847711
E138\185	65		Chlorine Contact Chamber	34.14146459	-119.1848499
187	180		Chlorine Contact Chamber	34.14146176	-119.1847862
E134	95		Chlorine Contact Chamber	34.14145456	-119.1847809
E135\188	177		Chlorine Contact Chamber	34.14145559	-119.1847572
189	180		Chlorine Contact Chamber	34.14147188	-119.1847237
Unknown	97		Chlorine Contact Chamber, North of TS 189	34.14148247	-119.1847212
Direct Contact	361		Effluent Pump Station, South Side, 12" Pipe		
Direct Contact	367		Effluent Pump Station, South Side, 30" Pipe Under Tank		
CP TEST	557		Effluent Pump Station, North of Tank	34.1414517	-119.1844987
Direct Contact	331		Effluent Pump Station, North of Tank, 8" Pipe		
E175\192	831		Effluent Pump Station	34.14157694	-119.1846251
E142\195	859		Main Electrical	34.14171162	-119.1845209
E143\196	675		Main Electrical	34.14174245	-119.1844138
E144\197	845		Main Electrical	34.14168656	-119.1843262
E148\201	534		Main Electrical	34.14172563	-119.1842047
E172\205	580		Inter Stage Pump Deck	34.14199505	-119.1842191
206	34		Inter Stage Pump Deck	34.14202514	-119.1841806
207	573		Inter Stage Pump Deck	34.14204058	-119.1841248
E154\208	581		Inter Stage Pump Deck	34.14210893	-119.1842197
28N	239		Inter Stage Pump Deck	34.14209384	-119.1842343
Direct Contact	653		Inter Stage Pump Deck, East Side, South End 30" Pipe		
Direct Contact	648		Inter Stage Pump Deck, East Side, South Middle 30" Pipe		
Direct Contact	648		Inter Stage Pump Deck, East Side, North Middle 30" Pipe		
Direct Contact	400		Inter Stage Pump Deck, East Side, North End 24" Pipe		
Direct Contact	503		Inter Stage Pump Deck, West Side, South End 30" Pipe		
Direct Contact	482		Inter Stage Pump Deck, West Side, South Middle 30" Pipe		
Direct Contact	482		Inter Stage Pump Deck, West Side, North Middle 30" Pipe		
Direct Contact	482		Inter Stage Pump Deck, West Side, North End 30" Pipe		
E151\212	490		Inter Stage Pump Deck	34.14205577	-119.1844097
E156\214	503		Inter Stage Pump Deck	34.14196056	-119.1843956
E155\216	335		Bio Tower #1	34.14206888	-119.1844959
148	436		Bio Tower #1	34.14213908	-119.1848828
CP TEST	110		Drive Way East of Bio Tower #1, South TS	34.14220062	-119.1842223
CP TEST	1113		Drive Way East of Bio Tower #1, North TS	34.1422156	-119.1842177
Direct Contact	751		Drive Way East of Bio Tower #1, 42" Pipe		
CP TEST	842		Solids Processing, South Side	34.14256754	-119.1842529
CP TEST	643	1538	Solids Processing, Northeast Corner	34.14293166	-119.1841944
CP TEST	615	1320	Solids Processing, Along North Wall, East of TS N44	34.14288932	-119.1843147
N44	390	1515	Solids Processing, Along North Wall		
CP TEST	390		Solids Processing,West Side, North TS	34.14279019	-119.1845454
N48	417	196	Solids Processing, West Side, South TS	34.14276996	-119.1845613
CP TEST	742		Eastern Trunk Pump Station, West Side		
N45	727		Eastern Trunk Pump Station, West Side		
N46	532		Eastern Trunk Pump Station, West Side		
N32	442		Between Digersters #2 & #3, North Side	34.14315139	-119.184898
N33	50		Between Digersters #2 & #3, North Side	34.14312452	-119.1848982
N57	506		Digester #3, West Side	34.1428854	-119.184869
CP TEST	452		Digester #3, Southwest Corner, Between TS N53 & N56	34.14278213	-119.1848516
N53	466		Digester #3, South Side	34.14279273	-119.1847959
N51	400		Digester #3, South Side	34.14275462	-119.1846518
N49	601		Digester #3, South Side	34.14279326	-119.1846146
N56	537		Between Digester #2 &# 3, South Side	34.14278708	-119.1848896
N103	545	1727	Between Digester #2 & #3 South Side	34.1427914	-119.1849471
CP TEST	636	364	Between Digester #2 & #3, Southwest of TS N57	34.14286472	-119.184898
N58	501		Digester #2	34.14293242	-119.1849334
N59	626		Digester #2, South Side	34.14284433	-119.1850056
N60	570		Digester #2, South Side	34.14284438	-119.1850091
N61	640		Digester #2, South Side	34.14284505	-119.1850139
N62	726		Digester #2, South Side	34.14284551	-119.1850182
N63	598		Digester #2, South Side	34.14284548	-119.1850216
N64	564		Digester #2, South Side	34.14284592	-119.1850243
E3\14	483		Digester #2, South Side		
E3\15	811		Digester #2, South Side		
N98	784		Digester #2, North Side	34.1431779	-119.1849908

N99	402		Digester #2, North Side	34.14317972	-119.1849695
CP TEST	456		Digester #2, North Side, West of TS N98	34.14318644	-119.1851374
E1\3	515				
5	632		Digester #2, West Side		
E20\8	538		Digester #2, West Side		
E12\12	574		Digester #2, South Side		
E11\13	527		Digester #2, South Side		
E13\18	513		Digester #2, South Side		
E9	200		Digester #2, South Side		
E7\33	585		Heat Loop	34.14282999	-119.1850791
E6\31	338		Heat Loop	34.14282871	-119.1851025
E5\30	522		Heat Loop	34.14282899	-119.1851268
E14\29	628		Heat Loop	34.14283387	-119.1852234
E30	633		Heat Loop	34.14280643	-119.1851995
E32	571		Heat Loop	34.142795	-119.1852229
E31	488		Heat Loop	34.14278154	-119.185201
E42\37	560		Heat Loop	34.14278237	-119.1852956
Visable Anode			Heat Loop	34.14284271	-119.1853055
E33\28	585		Heat Loop	34.14283981	-119.1853862
E28\26	511		Heat Loop	34.14285246	-119.1853878
E27\25	586		Heat Loop	34.14290485	-119.1854003
E22	709		Heat Loop	34.14288769	-119.185315
Unknown Wire "ANODE"	555		Heat Loop	34.14287071	-119.1852054
E10	590		Heat Loop	34.14289623	-119.1851577
E4	48		Heat Loop	34.14286726	-119.1851062
E26\24	929		Digester #1	34.14292336	-119.1853986
E25\23	936		Digester #1	34.14288578	-119.1854015
22	665		Digester #1	34.14288043	-119.1853709
E23\21	1069		Digester #1	34.14288358	-119.1853478
Visible Anode			Digester #1	34.14287953	-119.185291
E16\11	448		Digester #1	34.14292386	-119.1852839
E21\10	572		Digester #1	34.14292557	-119.1852826
E17\9	420	1333	Digester #1	34.14294028	-119.1852804
E18\7	620	1718	Digester #1	34.14303938	-119.1852538
E158	512		Digester #1	34.14310289	-119.1852868
E159\2	606		Digester #1	34.14309652	-119.1853435
N67	655	1115	Open Area Between Digester Control Bldg & Headworks Bldg	34.14256233	-119.1848037
43	540		Open Area Between Digester Control Bldg & Headworks Bldg	34.14249233	-119.1853169
N40\46	494		Open Area Between Digester Control Bldg & Headworks Bldg	34.14249598	-119.1853747
N187\43	514		Open Area Between Digester Control Bldg & Headworks Bldg	34.14242673	-119.1854533
49	488		Open Area Between Digester Control Bldg & Headworks Bldg	34.14242526	-119.1855281
CP TEST	526		Open Area Between Digester Control Bldg & Headworks Bldg, North of TS 49	34.14246729	-119.1855199
N95	1405		Open Area Between Digester Control Bldg & Headworks Bldg	34.14251757	-119.1857992
E44\53	1187		Open Area Between Digester Control Bldg & Headworks Bldg	34.14253705	-119.1856525
N31	719		Open Area Between Digester Control Bldg & Headworks Bldg	34.14272706	-119.1860109
N25	1098		Open Area Between Digester Control Bldg & Headworks Bldg	34.14285248	-119.1860119
N26	1288		Open Area Between Digester Control Bldg & Headworks Bldg	34.14285227	-119.1860056
N27	313		Open Area Between Digester Control Bldg & Headworks Bldg	34.14285212	-119.1859983
N28	693		Open Area Between Digester Control Bldg & Headworks Bldg	34.14285148	-119.1859919
N17	121		DAF Unit #1	34.14287895	-119.1858859
N18	786		DAF Unit #1	34.14287942	-119.185881
N19	786		DAF Unit #1	34.14287945	-119.1858768
N20	1092		DAF Unit #1	34.14288105	-119.1858724
N21	732		DAF Unit #1	34.14288193	-119.1858674
N22	1092		DAF Unit #1	34.14288289	-119.1858631
N23	1092		DAF Unit #1	34.14288425	-119.1858587
N24	1128		DAF Unit #1	34.1428849	-119.1858546
N11	61		DAF Unit #1	34.14296291	-119.1858274
N10	849	1723	DAF Unit #1	34.14295848	-119.1858269
N8	550		DAF Unit #1	34.14299449	-119.1858305
N13	491		DAF Unit #2	34.14289849	-119.1857366
N14	573		DAF Unit #2	34.14289791	-119.1857315
N15	535		DAF Unit #2	34.14289789	-119.1857254
N16	1640		DAF Unit #2	34.14289819	-119.1857199
N12	847		DAF Unit #2	34.14294642	-119.1857485
CP TEST	567	1668	DAF Unit #2, East of TS N8	34.14299098	-119.1857479
CP TEST	860	1723	DAF Unit #2, Northeast of TS N8	34.14303971	-119.1857741
E39\39	396		DAF Unit #2	34.14279367	-119.1855908
E38\38	440		DAF Unit #2	34.14277946	-119.1854813
E36\146	437		Digester Control Bldg, West Side	34.14270835	-119.185202
E37\145	403		Digester Control Bldg, Southwest Side	34.14263137	-119.1852174
42	444		Ferric Chloride & Sodium Hydroxide Tanks, South Side	34.1426358	-119.1853239
N79	573		Headworks Area	34.14237428	-119.1854245
138	591		Headworks Area	34.14211355	-119.1852886
E125	530		Headworks Area	34.14208947	-119.1852775
E94\134	553		Headworks Area	34.1421176	-119.1853777
E95\133	566		Headworks Area	34.14210581	-119.1853732
E93\132	566		Headworks Area	34.14210257	-119.1855118
E92\131	573		Headworks Area	34.14209723	-119.1855375

N78	444	659	Headworks Area	34.14217899	-119.1854543
12	406		Headworks Area	34.14221039	-119.1854889
127	521		Headworks Area	34.14215968	-119.1855372
E91\126	584		Headworks Area	34.14215116	-119.185598
130	928		Headworks Area	34.14222403	-119.1855529
E45\51	523		Headworks Area	34.14231047	-119.1856103
N71	462		Thickener #1, North Side	34.14229192	-119.1851441
N72	479		Thickener #1, North Side	34.14229359	-119.1851411
N73	497		Thickener #1, North Side	34.14229367	-119.1851399
N74	339		Thickener #1, North Side	34.14229474	-119.1851307
N75	445		Thickener #1, North Side	34.14229471	-119.185128
N76	175		Thickener #1, North Side	34.14229589	-119.1851241
N77	448		Thickener #1, North Side	34.14229461	-119.1851207
140	581		Thickener #1, North Side	34.1422576	-119.1850654
147	580		Thickener #1	34.14214686	-119.1850147
E116\149	576		Thickener #1	34.14209393	-119.1850182
E120	539		Thickener #1	34.1420575	-119.1850342
E117\151	552		Thickener #1	34.14201414	-119.1849727
E123\156	545		Thickener #1	34.14201656	-119.185212
154	457		Thickener #1	34.14203706	-119.1851972
CP TEST	495		Thickener #1	34.14205251	-119.1851897
159	460		Thickener #1	34.14206145	-119.1852698
E121\155	488		Thickener #2	34.14201413	-119.1852133
163	454		Thickener #2	34.14196363	-119.1852408
ANODE	437		Thickener #2	34.1420349	-119.1852535
E130\164	461		Thickener #2	34.14183187	-119.1852373
162	436		Thickener #2	34.1418667	-119.1852308
E48/54	582	674	Clarifier Area	34.14240339	-119.1857129
N95	1401		Clarifier Area	34.14251259	-119.1857956
E47/56	611		Clarifier Area	34.14249653	-119.1858659
E52/57	968		Clarifier Area	34.14250034	-119.185955
E53/58	1152		Clarifier Area	34.14247355	-119.1860455
E54/59	540		Clarifier Area	34.14234578	-119.186092
E57/60	565		Clarifier Area	34.14229258	-119.186086
E59	576		Clarifier Area	34.14223601	-119.1860841
E60/62	519		Clarifier Area	34.14223005	-119.1860733
E64/121	950		Clarifier Area	34.14218768	-119.1858767
E63/120	587		Clarifier Area	34.14214684	-119.1859381
119	435		Clarifier Area	34.14213031	-119.1859838
E90/125	556		Clarifier Area	34.14217496	-119.1856651
E89/124	678		Clarifier Area	34.14215153	-119.1856654
111	615		Clarifier Area	34.14209909	-119.1856713
123	560		Clarifier Area	34.14214111	-119.1858039
E65/122	586		Clarifier Area	34.14213553	-119.185857
E67/114	581		Clarifier Area	34.14207102	-119.1857742
72	630		Clarifier Area	34.14228883	-119.1865092
E102/70	589		Clarifier Area	34.14234565	-119.1865036
67	1258		Clarifier Area	34.14249924	-119.1862331
E97/66	1175		Clarifier Area	34.14245039	-119.1861568
E55/65	560		Clarifier Area	34.14232115	-119.1861198
E56/54	574		Clarifier Area	34.14230567	-119.1861181
E58/63	847		Clarifier Area	34.14223986	-119.1861194
78	605		Clarifier Area	34.14216316	-119.1863183
E112/79	618		Clarifier Area	34.14213059	-119.1862408
E111/80	593		Clarifier Area	34.14210342	-119.1862446
E109/81	707		Clarifier Area	34.14204033	-119.1862367
E171/77	578		Clarifier Area	34.14209279	-119.1864473
75	579		Clarifier Area	34.14203353	-119.186496
83	575		Clarifier Area	34.14190947	-119.1865062
84	598	572	Clarifier Area	34.14176528	-119.1865484
N80	1074		Clarifier Area	34.14174543	-119.1865512
85	977		Clarifier Area	34.14165064	-119.1864106
E161/87	879		Clarifier Area	34.14169721	-119.1861164
E77/88	1415		Clarifier Area	34.14177051	-119.1861134
95	518		Clarifier Area	34.14185664	-119.1861034
Unknown	542		Clarifier Area	34.14188417	-119.1860969
E73/91	568		Clarifier Area	34.14196511	-119.1861044
E69/116	553		Clarifier Area	34.14200269	-119.1859914
E70/115	1252		Clarifier Area	34.14199203	-119.1858792
99	831		Clarifier Area	34.14165587	-119.1858168
E78/97	557		Clarifier Area	34.14166692	-119.1860146

ATTACHMENT 6

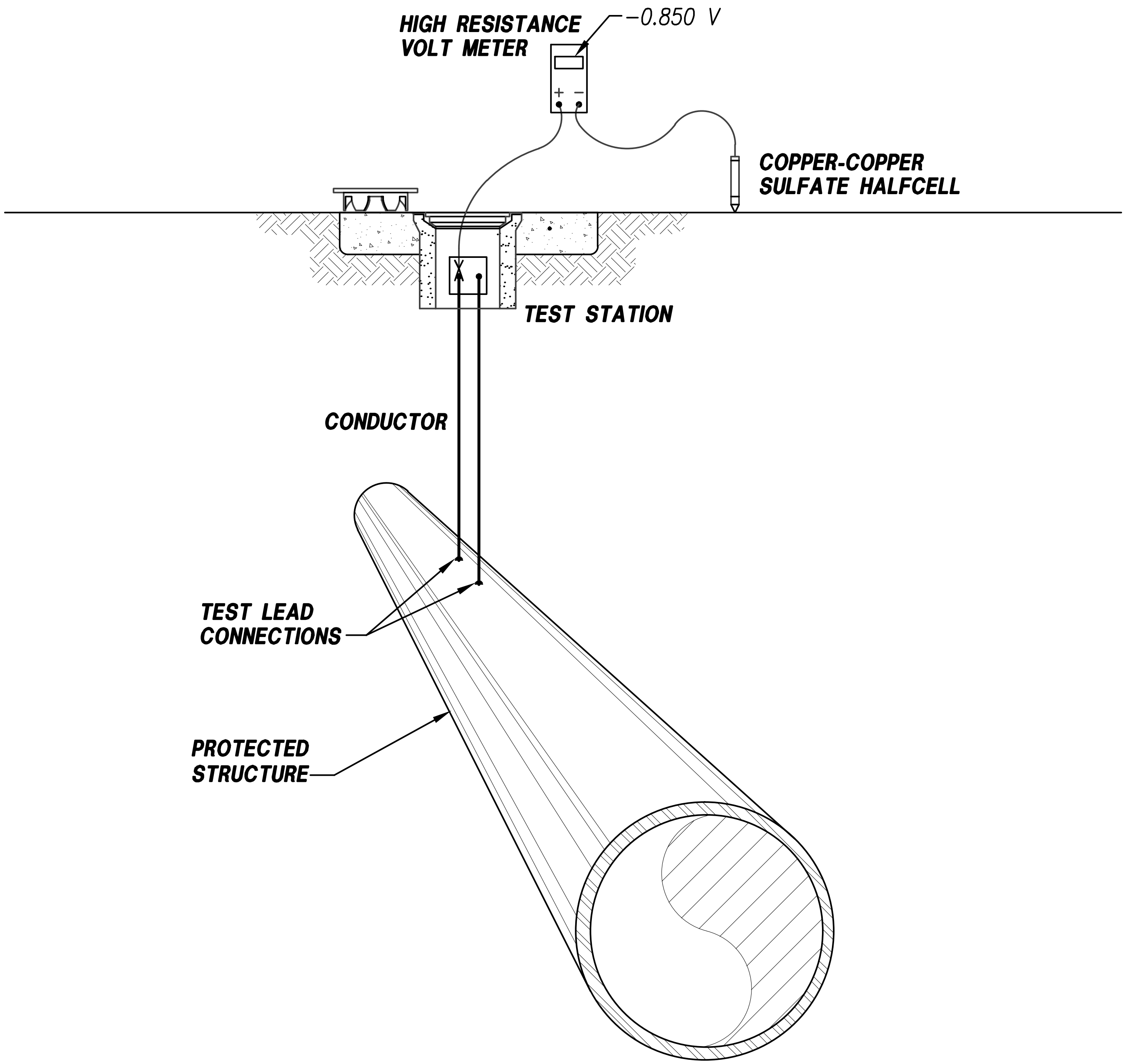
FIELD DATA WATER TREATMENT FACILITY

Oxnard Water Treatment Facility
CP Assessment Survey
July 2014

Name	Structure-to-Soil Potential (-mV)	Instant OFF (-mV)	Anode Potential (-mV)	Current (mA)	Discription	Latitude	Longitude
Test 1	368	350	1776	30	24 " PM IN (at Tank)	34.20134189	-119.1759003
Test 2	370	358	1886	10	Fire Riser Desalter Building	34.20127271	-119.1758268
Test 3	641	467	1728	70	24 " PM OUT (at Tank)	34.2012497	-119.1760203
Test 4	498	470	1086	30	30 " SW	34.20112828	-119.1758633
Test 5	618	440	1765	80	PW	34.20103707	-119.1758559
Test 6	70		1080		RE 30	34.20096179	-119.1757994
	460		1100		SW 30		
	460		1100		IN 30		
Test 7	287/293				Chloramination Disinfection Facility (NE Corner)	34.20074422	-119.1760014
Test 8	296/309				Chloramination Disinfection Facility (SE Corner)	34.200665	-119.1759805

ATTACHMENT 7

FIGURE 1 – POTENTIAL MEASUREMENT



jdh corrosion consultants, inc.

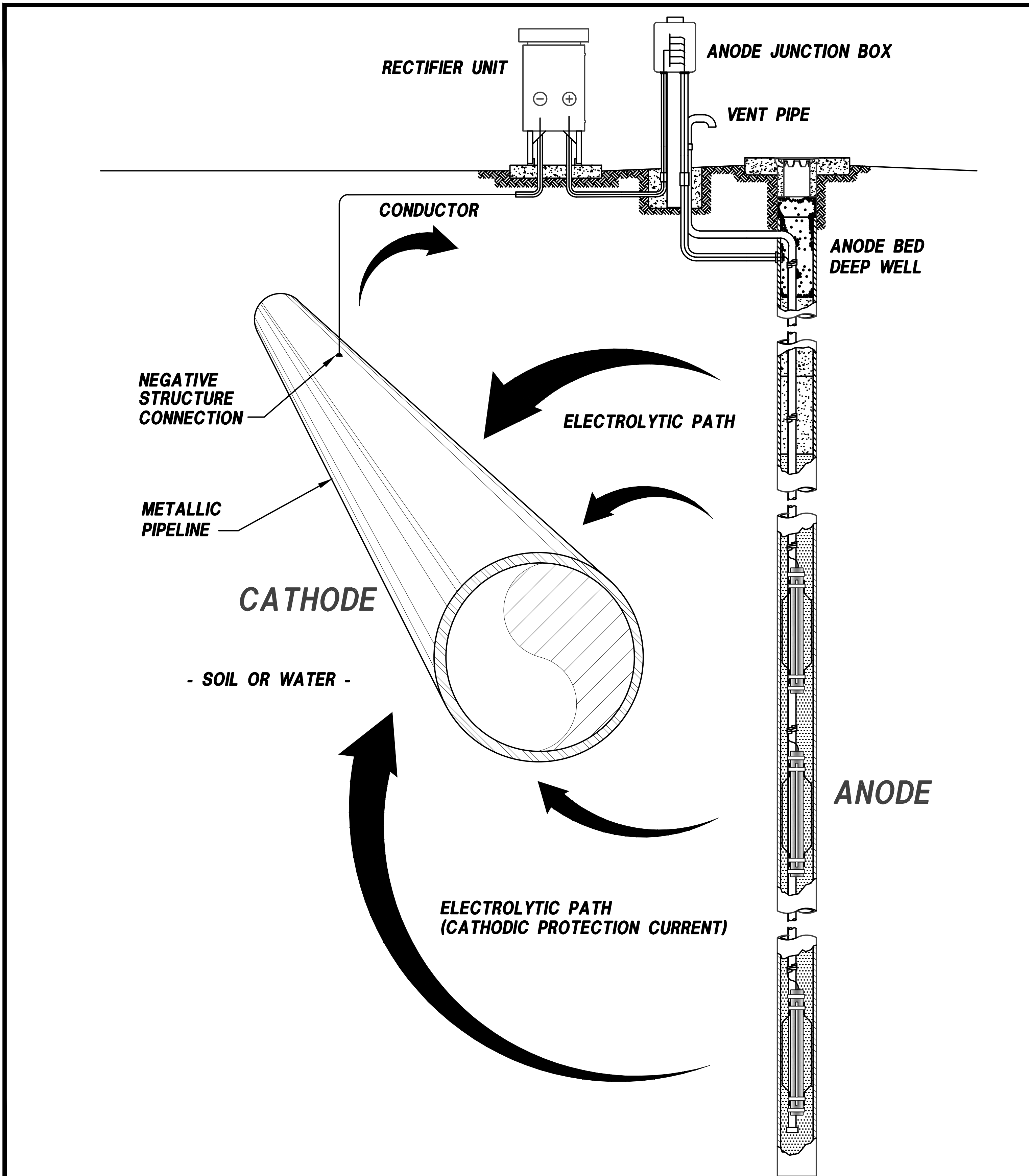
**CATHODIC PROTECTION/
CORROSION CONDITION ASSESSMENT
CITY OF OXNARD**

POTENTIAL MEASUREMENT

ENG:	CAD:	JOB:	FILE:	SCALE:	DATE:	DWG:
JDH	TH	14097	14097–FIG	N.T.S.	8/15/14	FIGURE 1

ATTACHMENT 8

FIGURE 2 – ICCP



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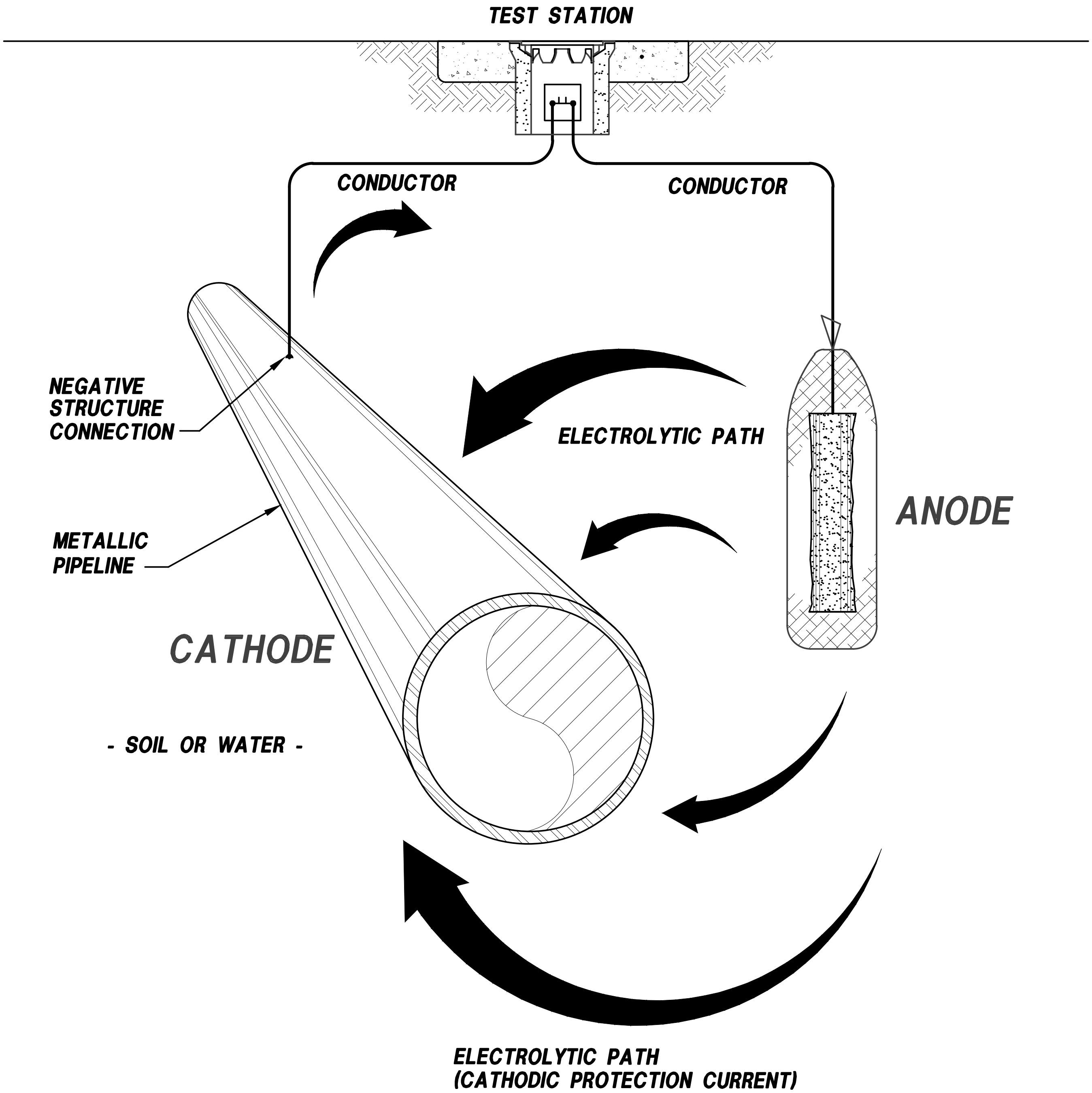
CATHODIC PROTECTION/
CORROSION CONDITION ASSESSMENT
CITY OF OXNARD

IMPRESSED CURRENT CP

ENG:	CAD:	JOB:	FILE:	SCALE:	DATE:	DWG:
JDH	TH	14097	14097–FIG	N.T.S.	8/15/14	FIGURE 2

ATTACHMENT 9

FIGURE 3 – GALVANIC CP



jdh corrosion consultants, inc.

CATHODIC PROTECTION/
CORROSION CONDITION ASSESSMENT
CITY OF OXNARD

GALVANIC ANODE CP

ENG:	CAD:	JOB:	FILE:	SCALE:	DATE:	DWG:
JDH	TH	14097	14097–FIG	N.T.S.	8/15/14	FIGURE 3

ATTACHMENT 10

IN-SITU SOIL RESISTIVITY TABLE OF RESULTS

Client:	*Carollo Engineers*
Project:	*Oxnard Condition Assessment*
Location:	*Oxnard, CA*
Date:	*6/18/2014*
Subject:	*In-Situ Soil Resistivity Data*

Legend: **Severely Corrosive** · **Corrosive** · **Moderately Corrosive** · **Mildly Corrosive** · **Progressively Less Corrosive**

*Test	Location	Resistance Data From AEMC Meter					Soil Resistivities (ohm-cm)					Barnes Layer Analysis (ohm-cm)				
#	Description	2.5	5	7.5	10	15	2.5	5	7.5	10	15	0-2.5'	2.5-5'	5-7.5'	7.5-10"	10-15'
1	Central & Rose	36.20	12.50	10.10	6.31	6.80	17331	11969	14506	12084	19533	17331	9141	25184	8050	NA
2	1701 Central	9.70	2.08	0.59	0.40	0.35	4644	1992	847	766	1005	4644	1268	394	595	2681
3	Central & Santa Clara	2.15	1.04	0.63	0.54	0.54	1029	996	905	1034	1551	1029	964	765	1810	NA
4	Central & Beardsley	3.11	1.30	0.25	0.23	0.33	1489	1245	359	440	948	1489	1069	148	1376	NA
5	Central & Del Norte	7.71	2.06	0.92	0.57	0.44	3691	1972	1321	1092	1264	3691	1346	796	717	1847
6	Springville Reservoir	2.16	1.04	0.68	0.66	0.60	1034	996	977	1264	1724	1034	960	940	10743	6320
7	Blending Station # 4	13.90	7.21	4.45	3.50	3.20	6655	6904	6391	6703	9192	6655	7172	5565	7849	35747
8	Rose & Gonzales	6.30	3.57	2.18	1.80	1.54	3016	3418	3131	3447	4424	3016	3944	2681	4944	10208
9	Blending Station # 3	3.07	1.21	1.26	1.09	1.13	1470	1159	1810	2087	3246	1470	956	NA	3868	NA
10	Rice & Gonzales	4.45	3.21	1.77	1.42	1.23	2130	3074	2542	2719	3533	2130	5515	1889	3438	8802
11	Camino & Del Norte	5.87	1.53	0.63	0.41	0.46	2810	1465	905	785	1321	2810	991	513	562	NA
12	Ventura & Central	2.50	1.26	0.43	0.37	0.27	1197	1206	618	709	776	1197	1216	313	1269	957
13	4110 Ventura	4.50	1.47	2.51	0.98	0.59	2154	1408	3605	1877	1695	2154	1045	NA	770	1420
14	Ventura near Lift Station 20 (?)	2.45	1.07	0.56	0.42	0.36	1173	1025	804	804	1034	1173	909	562	804	2413
15	Rice & Latigo	3.41	2.21	1.41	1.10	1.22	1633	2116	2025	2107	3504	1633	3007	1865	2395	NA
16	Rice & Camino Del Sol	6.40	2.47	1.69	1.35	1.28	3064	2365	2427	2585	3677	3064	1926	2562	3213	23637
17	Rice & 5th	5.95	3.61	1.34	0.81	0.86	2849	3457	1925	1551	2470	2849	4395	1020	980	NA
18	5th West of Rice	6.16	5.50	4.34	3.94	4.13	2949	5266	6233	7545	11863	2949	24576	9852	20466	NA
19	5th & Rose	36.00	16.70	9.92	8.35	8.77	17235	15990	14248	15990	25192	17235	14913	11698	25258	NA
20	5th & Richmond	92.80	33.60	12.00	8.66	4.20	44428	32172	17235	16584	12065	44428	25216	8937	14896	7809
21	Blending Station # 1	17.00	10.40	6.43	5.76	3.50	8139	9958	9235	11030	10054	8139	12825	8064	26465	8541
22	Blending Station # 2	6.18	4.33	2.53	1.79	1.88	2959	4146	3634	3428	5400	2959	6925	2914	2930	NA
23	Yarnell Pl	15.00	7.70	4.47	3.43	2.37	7181	7373	6420	6568	6808	7181	7575	5102	7058	7343
24	Channel Islands & Albany	4.05	1.59	0.80	0.59	0.47	1939	1522	1149	1130	1350	1939	1253	771	1076	2213
25	Bard & RR Crossing	5.23	2.94	1.89	1.52	0.85	2504	2815	2715	2911	2442	2504	3215	2534	3717	1846

APPENDIX B – CATHODIC PROTECTION SURVEY AND CONDITION DRAFT ASSESSMENT SUPPLEMENTAL REPORT (DECEMBER 2015)

Supplemental Report

Cathodic Protection Survey & Condition Assessment

City of Oxnard - Carollo Engineers

November 30, 2015

jdh corrosion consultants, inc.

1100 Willow Pass Court, Concord, CA 94520 Tel. No. 925.927.6630 Fax No. 925.927.6634

City of Oxnard
Draft Supplemental Report
Cathodic Protection Survey and Condition Assessment
Water Transmission Pipelines & Treatment Facilities

Table of Contents

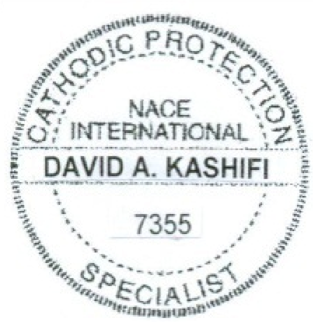
REFERENCES 1
EXECUTIVE SUMMARY....................2
....................3
SECTION I – INTRODUCTION & SYSTEM DESCRIPTIONS....................3
1.1 BENEFITS OF CATHODIC PROTECTION SURVEYS....................3
1.2 PIPELINE, TREATMENT & PUMPING PLANT DESCRIPTION....................3
1.2.1 General....................3
1.3 TRANSMISSION MAINS 4
1.3.1 3rd St – 30” Oxnard Extension....................4
1.3.2 3rd St – 27” United Water Conservation District Pipeline 4
1.3.3 Del Norte Pipeline....................5
1.3.4 Gonzalez Blending Station 3 Pipeline 6
1.3.5 Industrial Lateral 6
1.3.6 Oxnard Conduit....................7
1.3.7 Wooley Road – United Industrial PL 7
1.4 TREATMENT PLANTS AND reservoir....................8
1.4.1 General....................8
1.4.2 Water Treatment Facility at 251 South Hayes Avenue....................8
SECTION II – STATUS AND RECOMMENDATIONS....................9
2.1 GENERAL 9
2.2 TRANSMISSION PIPELINES 9
2.2.1 3rd St – 30” Oxnard Extension Pipeline 9
2.2.2 3rd St – 27” UWCD Pipeline....................9
2.2.3 Del Norte Pipeline....................10
2.2.4 Gonzalez Pipeline....................10
2.2.5 Industrial Lateral 10
2.2.6 Oxnard Conduit....................11
2.2.7 Wooley Road Pipeline....................13
2.4 TREATMENT PLANTS AND Reservoirs....................13
2.4.1 South Hayes Water Treatment Plant....................13
SECTION III - DISCUSSION AND TEST METHODS....................14
3.1 GENERAL 14
3.2 CATHODIC PROTECTION SYSTEMS....................15
APPENDIX I: CATHODIC PROTECTION PIPE-TO-SOIL DATA....................1
APPENDIX II: RECTIFIER DATA....................2
APPENDIX III: REMEDIATION & COST ESTIMATES 3

City of Oxnard
Water Transmission Pipelines & Treatment Facilities

Cathodic Protection Survey and Condition DRAFT Assessment Supplemental Report
Oxnard, CA

Respectfully submitted,

J. Darby Howard, Jr., P.E.
JDH Corrosion Consultants, Inc.
Principal



David Kashifi
JDH CORROSION CONSULTANTS, INC.
Senior Corrosion Engineer

Sean Carey
JDH CORROSION CONSULTANTS, INC.
Supervisor, Corrosion Projects

REFERENCES

1. NACE Standard Practice SP0169-2013, "Control of External Corrosion on Underground or Submerged Metallic Piping Systems" (Houston, TX: NACE).

2. NACE Standard Practice SP0177–2007, "Mitigating Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems" (Houston, TX: NACE).

3. NACE Standard Practice SP0100-2008, "Cathodic Protection to Control External Corrosion of Concrete Mortar-Coated Steel Pipelines for Water or Waste Water Service" (Houston, TX: NACE).

4. Conceco Engineering, Inc., "City of Oxnard Cathodic Protection Survey" (Simi Valley, CA: Conceco Engineering, Inc., 1997, 1990, 1988).

5. JDH Corrosion Consultants, Inc., "Annual Survey: Water Transmission Pipelines" (Concord, CA: JDH Corrosion Consultants, Inc., 2005).

6. JDH Corrosion Consultants, Inc. & City of Napa, "How to Protect Aging Water Mains: A City of Napa Case History" (Concord, CA: JDH Corrosion Consultants, Inc. & City of Napa, 2010).

EXECUTIVE SUMMARY

Potable Water Cathodic Protection

JDH Corrosion Consultants, Inc. has conducted a survey of all existing cathodic protection (CP) systems installed on the critical water transmission mains and treatment facilities owned & operated by the City of Oxnard. As part of this survey, JDH collected field data from various buried metallic pipelines and their cathodic protection systems in order to determine the condition and effectiveness of the City's existing corrosion control systems.

The scope of this investigation includes the major transmission pipeline cathodic protection systems, as well as the corrosion control systems at the South Hayes water treatment facility. The City also owns and operates a large amount of distribution piping which is not part of the current investigation.

The primary goal of this survey was to supplement findings from the original assessment of the City's CP systems for the purpose of determining specific requirements to repair and upgrade the existing CP systems. JDH has surveyed and adjusted the CP systems associated with the piping network and treatment plants that the City owns and operates. We are providing herein recommendations and cost estimates for upgrade and/or repair of the existing systems.

Provided with this report are electronic files, including copies of this report, .kmz format mapping files, and MS Excel spreadsheets with our survey data. .kmz files and excel spreadsheets should be updated on an ongoing basis to ensure that cathodic protection electronic data files remain current.

Section II of this report contains a brief description of our cathodic protection findings and repair recommendations, and we have included a cost estimate for the referenced recommendations in Appendix III.

This CP system evaluation report provides a baseline from which the City can generate short, medium, and long-term maintenance and capital project planning and funding. In order for corrosion control costs to be manage efficiently, however, it is critical that the City regularly survey and maintain their existing cathodic protection and other corrosion control systems. Going forward, JDH recommends that the City's corrosion control consultants and internal personnel survey their CP, and other corrosion control systems, as described in Section III of this report.

Wastewater Cathodic Protection

AECOM is currently developing infrastructure improvement plans for the wastewater treatment plant renovation project. Cathodic protection systems will be coordinated with the pending improvement plans as developed by AECOM in 2015. A cost estimate for upgrade of the wastewater treatment plant's CP systems is included in the Appendix III of this report; however, no additional findings or recommendations relating to the wastewater system are included in this report. For our findings related to the wastewater treatment plant, reference our "Asset Corrosion Assessment & CP Evaluation Survey", dated September 2014.

SECTION I – INTRODUCTION & SYSTEM DESCRIPTIONS

1.1 BENEFITS OF CATHODIC PROTECTION SURVEYS

The City of Oxnard owns and operates a network of piping systems and treatment facilities in the Valley, which the City has been proactive in preserving. By continuing to provide cathodic protection to buried pipelines and Permeate Water Storage Tanks, where warranted, the City will continue to benefit from the extended life of those assets, along with reduced costs.

Studies of cathodic protection costs and benefits generally indicate that the value of installing and maintaining cathodic protection systems provides approximately $7 saved in for every $1 spent on corrosion prevention measures.

Cathodic protection has proven, over decades of use in the oil & gas industry, and in water & wastewater infrastructure, that they can help maintain the integrity of protected structures for an indefinite period. More stable systems result in significant cost savings through reductions in maintenance repair & lost water resources, reduction in replacement costs, as well as improved public safety.

1.2 PIPELINE, TREATMENT & PUMPING PLANT DESCRIPTION

1.2.1 General

As mentioned above, the primary goal of this survey was to supplement findings from the original assessment of the City's CP systems for the purpose of determining specific requirements to repair and upgrade the existing CP systems. Where possible, JDH conducted additional field studies to determine CP system deficiencies as a part of this study.

JDH has compiled documents, electronic files, and conducted interviews of City personnel related to the City's cathodic protection systems. In some cases, however, no existing documents were located for review. Structures, such as casings and concrete encasements, generally cannot be field verified. Whenever possible, however, during our survey, rectifiers and test station records were field verified for continued accuracy.

The remainder of Section I describes the assets for which JDH conducted additional evaluation of the City's cathodic protection systems during this survey. In order to ensure accuracy and provide a complete accounting of the cathodic protection systems installed on the CIty's infrastructure, we ask that the City notify JDH of any critical pipeline infrastructure that may be missing from this report.

1.3 TRANSMISSION MAINS

1.3.1 3rd St – 30" Oxnard Extension

Pipe Material	Limits	Connections	No. of Rectifiers
30" Cement Mortar Coated Welded Steel	Sta. 1+43 to Sta. 37+70	Oxnard Conduit and South Hayes WTP	1 (Sta. 21+76)

This 30-inch diameter pipeline consists of a concrete cylinder pipe and is routed in an east-west direction from South Hayes WTP, along East 3rd Street, turning south at about S. Juanita Avenue to join the Oxnard Conduit at 5th Street. The cathodic protection system consists of one (1) shared impressed current cathodic protection (ICCP) system with corrosion test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

The following pipeline assets are significant elements of the 3rd St – 30" Oxnard Extension, and require consideration during any evaluation of its cathodic protection system:

Rectifiers:
21+76 – E.3rd Street between Wilson Ave and Harding Ave

Electrical Isolation (Insulating) Joints:
No information available

Steel Casings:
1+87 – G-5 traffic box located immediately south of RR balast
4+10 – Missing test station lost during parking lot repaving prior to 1997

Concrete Encasements:
No information available.

1.3.2 3rd St – 27" United Water Conservation District Pipeline

Pipe Material	Limits	Connections	No. of Rectifiers
Del Valle A			
27" Cement Mortar Coated Welded Steel	Sta. 0+05 to Sta. 51+55	South Hayes WTP and Rose Avenue connection to UWCD	1 (Sta. 17+16 on 30" PL)

This 27-inch diameter UWCD pipeline consists of a concrete cylinder pipe running in an east-west direction along East 3rd Street. There is no cathodic protection system for this pipeline.

The UWCD pipeline alignment runs roughly parallel to the 30" Oxnard Extension from the Hayes Water Treatment Plant to S. Juanita Avenue, where the 30" pipeline turns south to joint Oxnard Conduit at 5th Street. The 27" UWCD pipeline continues east along 3rd St to its connection to UWCD at Rose Ave.

The following pipeline assets are significant elements of the 3rd St – 27" United Water Conservation District Pipeline, and require consideration during any evaluation of its corrosion monitoring system:

Rectifiers:
17+16 – On 30" Pipeline; however care should be taken to prevent detrimental CP interference from the rectifier onto the 27" UWCD service pipeline.

Insulating Joints:
0+05 – IJTS in Brooks valve box near SW corner of vault.
51+55 – IJTS in center island at Rose Ave.

Steel Casings:
No information available.

Concrete Encasements:
No information available.

1.3.3 Del Norte Pipeline

Pipe Material	Limits	Connection	No. of Rectifiers
45" & 36" Cement Mortar Coated Welded Steel	Sta. 0+00 to Sta. 279+00	Oxnard Conduit and BS #4, 42" UWCD PL, 16" PVC to unknown, and 12" lateral to unknown	4 (Sta. 26+50, 100+90, 185+06, 256+60)

Del Norte Pipeline is a concrete cylinder pipe that is routed from the Springville Reservoir located in the Spanish Hills residential community, to Central Avenue, and then to Vineyard Avenue at Blending Station #4. The CP system for this pipeline consists of four (4) impressed current CP rectifiers along with their associated, impressed current anode ground-beds. There is a set of corrosion test stations (CTS) along the pipeline route for the purpose of measuring pipe-to-soil potentials as part a CP survey.

The following pipeline assets are significant elements of the Del Norte Pipeline, and require consideration during any evaluation of its CP system:

Rectifiers:
26+50 – W. Daily Dr. Camarillo
100+90 – Central Ave near Beardsley Rd. Intersection
185+06 – Driveway of 1701 Central Ave.
256+60 – Del Norte Blending Station #4 N. Rose Ave.

Insulating Joints:
256+60 – Three Insulating joints at Blending Station #4 N. Rose Ave.

Steel Casings:
No information available.

Concrete Encasements:
No information available.

1.3.4 Gonzalez Blending Station 3 Pipeline

Pipe Material	Limits	Connection	No. of Rectifiers
36" Concrete cylinder pipe	Sta. 1+00 to Sta. 52+96	Gonzalez 27" PL, 27" CMWD, 24" UWCD, and BS #3.	none

The Gonzalez Pipelines were not part of the original scope of investigation for this project; however, JDH determined that this set of piping is critical to the City's transmission system, and an effort has been made to account for this system with the expectation that future survey work will continue to build on what was started here.

The following pipeline assets are significant elements of the Gonzalez BS3 Pipeline, and require consideration during any evaluation of its cathodic protection system:

Rectifiers:
None

Insulating Joints:
Unknown

Steel Casings:
No information available.

Concrete Encasements:
No information available.

1.3.5 Industrial Lateral

Pipe Material	Limits	Connection	No. of Rectifiers
30" & 27" WSP (coating?)	Sta. 1+11 to 163+00	Oxnard Conduit, Wooley Road PL	1 (Sta. 92+36)

This pipeline consists of a concrete cylinder pipe and is routed in a north-south direction along Acacia Street and San Simeon Avenue, along the west side of a fenced-off water canal. The CP system for this pipeline consists of one (1) impressed current CP rectifier along with its associated impressed current anode ground-bed. There are also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring pipe-to-soil potentials as part a CP survey.

The following pipeline assets are significant elements of the Industrial Lateral, and require consideration during any evaluation of its CP system:

Rectifiers:
92+36 – Behind 675 E. Channel Island Blvd – access via back alley off Gisler Ave

Insulating Joints:
No insulating joints.

Steel Casings:
No information available.

Concrete Encasements:
No information available.

1.3.6 Oxnard Conduit

Pipe Material	Limits	Connection	No. of Rectifiers
36" CMCL	Sta. 6+33 to Sta. 361+43	Del Norte Pipeline and Industrial Lateral	3 (Sta. 99+20, 203+50, 308+00)

The Oxnard Conduit is a 36-inch diameter pipeline consisting of a concrete cylinder pipe that is routed from the Springville Reservoir located in the Spanish Hills residential community, to the south side of US Highway 101 in a westerly direction, south on Rice Road, and West on E. 5th Street. The CP system for this pipeline consists of three (3) impressed current CP rectifiers along with their associated impressed current anode ground-beds. There is also a set of corrosion test stations (CTS) along the pipeline route for the purpose of measuring and recording pipe-to-soil potentials as part a CP survey.

Rectifiers:
99+20 – E. Ventura Blvd
203+50 – N. Rice Ave near intersection E. Gonzales Rd.
308+00 – E. 5th Street

Insulating Joints:
No insulating joints.

Steel Casings:
No information available.

Concrete Encasements:
No information available.

1.3.7 Wooley Road – United Industrial PL

Pipe Material	Limits	Connection	No. of Rectifiers
24" CMCL	Sta. 2+31 to Sta. 31+03	BS #2 and 36" UWCD at Rice Ave	1 (Sta. 17+00)

The United Industrial Pipeline is a 24-inch diameter pipeline consists of a concrete cylinder pipe, routed from the intersection of Wooly Road and Richmond Avenue to the intersection of Wooley Road and Rose Avenue. The CP system for this pipeline consists of one (1) impressed current CP rectifier along with its associated impressed current anode ground-bed. There is also a set of cathodic protection test stations (CTS) along the pipeline route for the purpose of measuring pipe-to-soil potentials as part a CP survey.

The following pipeline assets are significant elements of the Wooley Road – United Industrial Pipeline, and require consideration during any evaluation of its CP system:

Rectifiers:
17+00 – E. Wooley Rd near intersection with Pacific Ave.

Insulating Joints:
No insulating joints.

Steel Casings:
No information available

Concrete Encasements:
No information available.

1.4 TREATMENT PLANTS AND RESERVOIR

1.4.1 General

During this supplemental survey, an additional evaluation of all existing operational cathodic protection and monitoring systems for the water treatment facility during this supplemental survey.

1.4.2 Water Treatment Facility at 251 South Hayes Avenue

The water treatment facility, located at South Hayes Avenue, has an existing cathodic protection system consisting of galvanic (sacrificial anode) test stations located throughout the facility. Eight (8) cathodic protection test stations at the plant.

The treatment plant's 600,000-gallon, steel, above-grade Permeate Water Storage Tank, installed in 2005, is 70 feet in diameter by 25 feet tall. The tank's internal wetted (submerged) surfaces are susceptible to water-side, internal corrosion activity; however, the tank does not currently have a cathodic protection system to mitigate water-side, internal corrosion activity. The tank reportedly has an internal protective coating system. We will discuss options for corrosion (cathodic) protection of this tank later in the report.

SECTION II – STATUS AND RECOMMENDATIONS

2.1 GENERAL

Portions of the cathodically protected pipelines indicate adequate levels of protection (according to NACE standard SP-0169-13, Section 6.2). Investigation and testing of the CP systems for several structures; including significant sections of the Oxnard Conduit, South Hayes WTP, and the steel Permeate Water Storage Tank at the South Hayes WTP, indicate insufficient protection levels due to either: lack of a CP system, deficiencies in electrical isolation or continuity, and/or anode depletion. These deficiencies require repair, upgrade, or further document review and testing, as identified in more detail below.

In addition to acting on the recommendation identified in this report, the City should conduct annual CP system surveys as a part of regular system maintenance.

2.2 TRANSMISSION PIPELINES

2.2.1 3rd St – 30" Oxnard Extension Pipeline

Status
At some time after 1998, a vehicle struck the rectifier at foot station 17+16, damaging the rectifier, and preventing operation of the CP system. The Oxnard Conduit and the 3rd St Oxnard Extension Pipeline are electrically continuous, however, and pipe-to-soil potential measurements between the connection to the Oxnard Conduit and foot station 27+88 indicated satisfactory cathodic protection levels, according to NACE SP0169-13 criteria. This CP is provided by electrical continuity of the Oxnard Extension with the cathodically protected Oxnard Conduit.

Electrical continuity does not extend from station 27+88 to Chemical Building 1 (Chloramination building) at South Hayes WTP, as well as pipe-to-soil measurements indicate insufficient cathodic protection at test points within the WTP.

Recommendations
Electrical continuity testing should be conducted between foots station 27+88 and Chemical Building 1 (Chloraminaton building) at the south end of the South Hayes WTP, and electrical continuity should be established if possible.

2.2.2 3rd St – 27" UWCD Pipeline

Status:
The mortar coated UWCD pipeline does not have a CP system, and the pipeline is electrically isolated from the UWCD connection at Rose Avenue. Pipe-to-soil potentials indicate that the transmission pipe may be electrically isolated from the Chloramination building at the South Hayes WTP; however, additional testing is required to confirm isolation.

Recommendations:
Electrical continuity testing should be conducted between foots station 10+50 and the Chloraminaton building at the south end of the South Hayes WTP.

After the impressed current system on the 30" Oxnard Extension pipeline is replaced and energized, interference testing should be conducted to determine whether any detrimental interference exists as a result of the 30" pipeline's ICCP system.

2.2.3 Del Norte Pipeline

Status:
The Del Norte Pipeline's CP system testing indicates that all rectifiers are operating, and adequate protection is being achieved at all tested locations. On the east section of the Del Norte Pipeline, however, JDH did not locate the test wires required for testing electrical continuity and CP protection levels during the current investigation.

In the past, it appears that Oxnard maintained control of the Oxnard Conduit eastward to the east side of the reservoir. JDH was not able to confirm whether the City transfers operational or ownership control of the pipeline at foot station 0+33, or east of that location. Wherever ownership of the pipeline is transferred, owner/operators should install electrical isolation in order to prevent cathodic protection current from reaching foreign structures.

Further testing of the pipeline's continuity and electrical isolation are pending installation of a test station at foot station 4+13. This will allow for testing and resolution of questions about electrical continuity between station 4+13, along with the pipeline's CP system.

Recommendations:
The City should excavate and install test stations at approximately station 4+13, and the City should install test wires at the metering station located at about foot station 0+54.

In addition, at the location of ownership transfer of the pipeline from Oxnard to an outside agency, the City should confirm electrical isolation in order to prevent CP current from reaching foreign structures. JDH assumes this point is located at foot station 0+33 on the Del Norte Pipeline. If electrical isolation does not exist, the City should design remediation, and install an insulating joint test station to allow for future testing of isolation.

2.2.4 Gonzalez Pipeline

Status:
The 36" CMCL Gonzalez Pipeline's sacrificial cathodic protection system is likely providing full cathodic protection according to NACE criterion SP0169-2007; however, no native potentials are available in order to confirm a 100mV shift required in order to satisfy the criterion. In additional, several test station traffic box lids are seized shut, and cannot be tested. The seized lids will have to be destroyed, and replaced in order to access the test finks for testing.

Recommendations:
The City should destroy and replace the seized lids, and then conduct further evaluation of the pipeline's CP system in order to determine whether the anodes are failing, or whether adjustments to the variable resistors require adjustment.

2.2.5 Industrial Lateral

Status:
The Industrial Lateral's CP system testing indicates that all rectifiers are operating normally, and

indicates adequate protection levels is being achieved at all tested locations. At several locations near the north and south end of the pipeline, however, JDH did not locate the needed CP test wires.

Recommendations:
The City should replace missing test stations at approximately six (6) locations along the Industrial Lateral.

2.2.6 Oxnard Conduit

Status:
Of the three installed rectifiers with deep well anode beds on the Oxnard Conduit, only one is currently operational. The ground beds at rectifier no. 1 (Ventura Blvd.) and at rectifier no. 2 (Rice Ave.) are depleted, and rectifier no.1 is not operating properly.

During several construction projects over the life of the pipeline, electrical isolation has been installed along the Oxnard Conduit at several locations where electrical continuity is required for proper operation of the cathodic protection system. This has had the effect of blocking cathodic protection current from reaching sections of the pipe designed to be protected by the three rectifiers and their associated anode bed systems.

In addition, a lack of test stations installed at industry standard intervals along the pipeline has prevented a full and proper assessment of the effectiveness of the cathodic protection systems. JDH has installed one test station on the pipeline at approximately foot station 39+10, in order to conduct further electrical continuity testing on the pipeline. This test station was used to confirm electrical continuity between 32+90 and 39+10, and also to confirm a discontinuity between 39+10 and 46+75 on Ventura Blvd.

JDH suspects or confirmed electrical discontinuities at the following locations or sections of the pipeline:

1. Possible discontinuity between Oxnard Conduit and Del Norte Pipeline at the Del Norte/Oxnard Conduit connection (approx. foot sta 4+20 of the Del Norte Pipeline)
2. Discontinuity between Station 39+10 and 46+75 of the Oxnard Conduit
3. Discontinuity between Station 124+15 and 152+00
4. Discontinuity at approx. Station 173+50 (IJ at east end of Rive Ave replacement section)
5. Discontinuity at approx. Station 202+60 (IJ at west end of Rice Ave replacement section)
6. Discontinuity between Station 203+50 (Rectifier No.2) and 211+00
7. Discontinuity on 3rd St extension between Station 27+88 and the Blending Station No.1

The pipeline failure which occurred immediately north of Hwy 101 is believed to be an isolated occurrence; however, JDH does not believe there is a significant and imminent risk to the pipeline due to corrosion. JDH does believe there is moderately elevated risk along the pipeline north of Hwy 101, between station 9+00 and 32+90, due primarily to the following influences:

1. Eucalyptus trees applying an external load to the pipeline, which may flatten the pipe, creating cracks in the pipeline's mortar coating. Damage to the external mortar coating removes the mortar from intimate contact with the steel pipe surface. As a result, the low pH environment provided to the steel by the mortar coating is removed from these locations, allowing areas of the steel pipe surface to be placed in direct contact with corrosive soils, thus corrosion activity is initiated at the steel soil interface.

2. The Del Norte rectifier No.7 has been operating in close proximity to the Oxnard Conduit since installation of the pipeline in 1992 or 1993, or approximately 20 years. Since the Oxnard Conduit crosses the Del Norte Pipeline at approximately sta 33+00, the risk of current discharge from CP current is significantly increased. Current picked up on the Oxnard Conduit may discharge onto the Del Norte Pipeline at the crossing, which, along with mechanical failure of the mortar coating, may have contributed to the failure of the Oxnard Conduit approximately 20-ft south of this location.

3. The Oxnard Conduit parallels the Del Norte Pipeline for approximately 2,100-ft, from the connection point on the Oxnard Conduit at about 9+00 to the crossing at about 33+00. Depending upon the close proximity between the pipelines, this configuration may allow the Oxnard Conduit to pass current through the soil to the Del Norte pipeline. At any location where the Oxnard Conduit discharges current into the soil, corrosion will occur.

Unfortunately, the problem of the tree line also inhibits our ability to conduct direct assessment of the pipeline where risk is likely highest. As a result, unless the City chooses to remove the trees, both direct and indirect assessment of the pipeline appears impracticable.

The configurations of the pipelines with respect to each other, lack of existing test stations on the east end of the pipeline, and alignment features, including the eucalyptus tree line and the utility roadway over the two pipes on the hillside, make collection of useful test data problematic. JDH believes, however, based on the general lack of leak history, and the generally robust nature of rod-wrapped, mortar coated pipe, that the risk of imminent failure of the pipeline is relatively low.

However, JDH does recommend conducting direct inspection of the pipeline at the City's convenience. JDH further recommends installing test stations as recommended on the east end of the pipeline to allow further testing for, and clearing of electrical discontinuities on, the Oxnard Conduit.

Recommendations:
The City should replace all three of the existing rectifiers and deep anode beds, reusing existing AC power. The City should also excavate and install test stations at approximately eight (8) locations on the pipeline, and establish electrical continuity by installing bond stations at each end of the Rice Avenue replacement pipeline section.

JDH recommends bonding the Del Norte Pipeline to the Oxnard Conduit immediately north of the 101 at station 32+90. This may be a temporary measure, taken in order to provide cathodic protection to the east end of the Oxnard Conduit until the City can establish electrical continuity along the length of the Oxnard Conduit. In particular, if the City cannot establish electrical continuity between the Oxnard Conduit's rectifier No.1 and the pipe section north of US 101, this approach may be required indefinitely.

At this time, JDH is also aware of approximately three (3) additional areas where we suspect, or where we have confirmed, electrical discontinuities on the Oxnard Conduit. However, additional locations of electrical isolation may be revealed as the City clears electrical discontinuities. The process of locating and clearing discontinuities should continue until the City establishes complete electrical continuity along the entire length of the pipeline.

2.2.7 Wooley Road Pipeline

Status:
The rectifier is operating properly, and current output appears to be providing sufficient current to protect the pipeline. Test data at test stations also indicated cathodic protection levels are sufficient on the pipeline.

The insulating joint test station at 31+03, used to test electrical isolation and CP protection levels between the UWCD pipeline and the Wooley Road pipeline, is missing – likely following road work circa 2011.

Recommendations:
Although this rectifier and anode ground-bed are still operational, we recommend the design and replacement of this system with a new one. The rectifier and anode ground-bed for this pipeline have been in place since 1977 and have far exceeded their expected operating life. To ensure an additional twenty or more years of cathodic protection for this pipeline, we recommend that the City replace the existing CP system with a new system.

JDH was able to locate test stations at the corner of Wooley Road and Richmond Avenue, and pipe-to-soil potentials can be tested at the rectifier; however, an additional corrosion test station should be installed at approximately 25+00, and the insulating joint test stations should be installed at the Rose Avenue connection to the UCWD pipeline.

2.4 TREATMENT PLANTS AND RESERVOIRS

2.4.1 South Hayes Water Treatment Plant

General

Findings:
Construction drawings of treatment plant process piping is incomplete; therefore, JDH referenced the citywide pipeline "Atlas" pdf drawing in conjunction with some treatment plant project drawings, and conducted personnel interviews, in order to try to determine locations of buried pipelines.

Recommendations:
JDH recommends that a discovery effort to locate the record documents continue in the future, in order to determine the size, location, and material specifications of the existing underground piping at the plant.

Treatment Plant Yard Piping

Findings:
Generally, electrical shorting exists between the plant's buried steel and ductile iron water piping and plant buildings and the Permeate Water Storage Tank, putting the buried piping at increased risk of galvanic corrosion, and preventing cathodic protection systems for operating properly.

Recommendations:
The City should install electrical isolation kits at all steel, ductile iron water risers at the water treatment plant, and the City should install cathodic protection on all non-insulated ductile iron, or

steel riser pipes at the site that are owned and operated by the City of Oxnard.

<u>Steel Permeate Water Storage Tank</u>

Findings:
The City has not installed cathodic protection on the steel Permeate Water Storage Tank at the treatment plant.

Recommendations:
The City should install cathodic protection inside the water tank in order to prevent corrosion of the submerged portions of the tank interior. An impressed current cathodic protection system may be used; however, a sacrificial CP system will likely provide sufficient protection at lower overall capital and maintenance cost.

The City should also conduct an inspection of the tank lining and internal coatings at five (5) year intervals, in order to assess coating condition and corrosion of floor, walls, and tank roof structures.

SECTION III - DISCUSSION AND TEST METHODS

3.1 GENERAL

Testing results from the 2015 Survey consisting of pipe-to-soil potentials surveys, electrical continuity surveys, insulating joint testing, and GPS locating have been summarized in the data tables in Appendices I & II.

Previous survey reports have made recommendations for repairs or additional testing to the pipelines and the cathodic protection systems, however, our recommendations are based on the results of our testing and investigation. We reviewed the recommendations provided in previous reports and evaluated the recommendations based on the current data collected during this investigation.

The survey included annual surveys of the structures with cathodic protection, a detailed evaluation of each structure's cathodic protection system (e.g. electrical continuity tests), and adjustment of the cathodic protection systems. Issues requiring additional troubleshooting and repair have been identified in this report for future remediation.

With assistance from City of Oxnard staff, an extensive review of City records was conducted to collect all available reports and data from previous corrosion investigations and annual surveys. JDH reviewed these reports to determine the historical operation of the cathodic protection systems.

<u>Criteria for Cathodic Protection</u>

The criteria used to determine whether a structure is adequately protected from corrosion is the National Association of Corrosion Engineers (NACE) Standard SP-0169, Rev. 2013, Section 6.2.2.1.2, states the following:

> *"A negative polarized (structure-to-soil) potential of at least 850 mV relative to a saturated copper, copper-sulfate reference electrode."*

OR

> *"A negative minimum of 100 mV of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured to satisfy the criterion."*

A polarized potential is measured when the cathodic protection current is momentarily interrupted, also called the “Instant Off” potential.

JDH conducted surveys of pipelines protected with impressed current cathodic protection (ICCP) by temporarily installing a current interrupter unit at each rectifier on the system. During the pipeline surveys, the current interrupter is temporarily installed in the output circuit of the rectifier to cycle the cathodic protection current “ON” and “OFF” and the polarized or “OFF” structure-to-soil potentials were measured at the accessible test stations. Based upon the results of the structure-to-soil potentials, the current output of the rectifier was adjusted as required until the potentials satisfied one of the aforementioned criteria. This was done especially when the structure-to-soil potentials were out of acceptable range and may result in possible corrosion losses to the pipe. JDH accomplished all required adjustments during the detailed evaluation survey.

3.2 CATHODIC PROTECTION SYSTEMS

The City of Oxnard uses both Impressed Current Cathodic Protection (ICCP) systems, and sacrificial systems for corrosion control of their buried pipelines. Each of these system classes operate differently, and each system type requires discrete methods of monitoring and maintenance.

ICCP systems use an external electrical power source to provide electric current to the pipeline or tank. ICCP uses a rectifier to convert AC to DC and discharges the DC current through an anode. Impressed current anodes are typically constructed from materials such as high silicon cast iron, graphite, or mixed metal oxide coated platinum or titanium materials. These anode materials are chosen to discharge large amounts of current for long periods of time at low anode consumption rates. ICCP can be designed for many types of structures and can be designed for either very high current output or relatively low current output.

The impressed current cathodic protection systems are monitored by measuring the rectifier voltage and current output to ensure the rectifier is operating properly at the correct output. Rectifier monitoring should be performed on a monthly basis by City personnel, and on an annual basis by a qualified cathodic protection engineer. Pipe-to-soil potentials should be measured at each test station annually and the rectifier output should be adjusted as required to ensure the potentials meet NACE criteria for corrosion protection.

Sacrificial anode cathodic protection systems for pipelines and water tanks use an anode made from zinc or magnesium connected to the structure. The anode is more active than the steel structure and provides cathodic protection current. These anodes have a lower current output than the ICCP systems and the anodes typically consume sooner than the ICCP anodes and have a shorter life. Sacrificial anodes are usually used on small diameter or short length pipelines, or well-coated water storage tanks due to lower installation and maintenance cost. The pipe-to-soil potentials and anode current output of such systems are monitored once a year for optimal performance.

Pipe-to-soil potentials are the primary test method used to determine if a pipeline meets NACE criteria for corrosion protection. Pipe-to-soil potentials are measured at each test station and used for both impressed current and sacrificial anode cathodic protection systems.

APPENDIX I: CATHODIC PROTECTION PIPE-TO-SOIL DATA

OXNARD

30" Rod-wrapped (band and spigot joints) CMCL 3rd St Metro Lateral

Station	Structure	Test Leads	Pipe-To-Soil Potential (-mV)							Comments	GPS Location
			Native	2014		1997		1990			
				Rectifier On	Rectifier Off	Rectifier On	Rectifier Off	Rectifier On	Rectifier Off		
1+43		Black	596	-		-	-			Diaz Vault at 5th St	
1+87	30" PL	Black	528	-		1,148	528			G-5 traffic box located immedately south of RR balast.	
	Casing	Black	573	-		584	573				
4+10	30" PL	-	554							Missing test station lost during parking repaving prior to 1997.	
	Casing	-	542								
8+77	30" PL	(2) Black		-		992	-			Manhole (no test wires - 2015)	
12+82	30" PL	Up-Side	525							Lost pior to 1997 survey	
17+16	30" PL	(2) Black	-	1,132		1,778				Rectifier #6 (sta 21+76 on parallel 27" PL)	
22+75	30" PL	Direct	-	-		-				Manhole (no test wires - 2015)	
27+88	30" PL	(2) Black	457	1,145		1,106				2-wire TS (approx 54' east of 27" PL TS sta 10+50). Cracked fink. Remove 6" of soild from can, and replace fink w/Tinker & Rasor T-3.	
37+70	US PL (East)	Direct	338	-		606				IJ inside vault at treatment plant.	
	DS PL (West)	Direct	323	-		160					

OXNARD
27" CMCL 3rd St Pipleline

Station	Structure	Test Leads	Pipe-To-Soil Potential (-mV)							Comments	GPS Location
			Native	2014		1997		1990			
				Rectifier On	Rectifier Off	Rectifier On	Rectifier Off	Rectifier On	Rectifier Off		
0+00	West	Pump Side								IJ inside Chloramination building (?)	
	East	Wall Side									
0+05 (?)	DS 27" PL (West)	Red tape				364	408			IJTS in Brooks valve box near SW corner of vault. (In treatment plant?)	
	US (East)	Black tape				946	264				
10+50	27" PL	-			248	1,222	213			In roadway. Cell extended to sidewalk. 27" TS located approx 54' west of 30" PL TS sta 27+88	
21+76	27" PL	-			223	1,778	197			Rectifier (station 17+16 on 30" PL)	
30+50	27" PL	-			250	1,256	211			In south sidewalk near Maquita St.	
41+00	27" PL	-			241	1,141	178			In south sidewalk.	
51+55	27" PL (West)	Red			239	895	156			IJTS in center island at Rose Ave.	
	East	Black			817	125	354				

OXNARD
Del Norte

Station	Structure	Test Leads	Pipe-To-Soil Potential (-mV)						Comments	GPS Location
			Native	2014		1997	1990	1988		
				Rectifier On	Rectifier Off	Rectifier Off	Rectifier Off	Rectifier Off		
0+00 Vault	36" CMCL								Could Not Locate/No Access	
13+35	36" CMCL	R. M. Wire		1,378					Manhole	
	36" CMCL	R. Wire		1,385						
25+70	45" CMCL	(2) L.Wires		429					Manhole. Blow off and test leads from 45" Oxnard Conduit and 36" Del Norte PL.	
	36" CMCL	R. M. Wire		1,667						
	36" CMCL	R. Wire		1,684						
26+50 Rectifier #7	36" CMCL			1,505	874				Test lead in rectifier cabinet	
38+00	36" CMCL	(2) L.Wires		1,770					G-5 Traffic Box	
	unknown	(2) R. Wires		1,695						
50+50	36" CMCL			1,725					Manhole	
63+00	36" CMCL								G-5 Traffic Box	
75+50	36" CMCL			1,725					G-5 Traffic Box	
88+00	36" CMCL			1,730	1,124				G-5 Traffic Box	GPS N34.22804 W119.10964
Rectifier #8	36" CMCL			1,826	1,210				Test lead in rectifier cabinet	
110+00	36" CMCL			1,728	1,123					GPS N34.23191 W119.11761
120+00	36" CMCL			1,690	1,094					GPS N34.23367 W119.11761
130+00		L. Wire		1,855					G-5 Traffic Box	
		L. M. Wire		1,752						
		R. M. Wire		1,833						
		R.Wire		1,860						
140+00 CTS at Brooks Box	36" CMCL								**Could Not Locate**	
150+00 CTS at Brooks Box	36" CMCL								**Could Not Locate**	
161+00 CTS at Brooks Box	36" CMCL								**Could Not Locate**	
173+00 CTS at Brooks Box	36" CMCL			1,930					G-5 Traffic Box	
185+06 Rectifier #9	36" CMCL			2,114	1,120				Test lead in rectifier cabinet	
"M.P.197.50 at Station 197+50 "CP TEST"	36" CMCL			2,239	1,100				G-5 Traffic Box	GPS N34.24729 W119.13728
"M.P.210.00 at Station 210+00 "CP TEST"	36" CMCL								G-5 Traffic Box	
"M.P.222.00 at Station 222+00 "CP TEST"	36" CMCL								G-5 Traffic Box	
233+00	36" CMCL			2,208					G-5 Traffic Box	
"M.P.244.00 at Station 244+00 "CP TEST"	36" CMCL								G-5 Traffic Box	
254+97	36" CMCL	(4) Wires		2,250	1,648				G-5 Traffic Box	
Rectifier #10	Blending Station #4									
at BS #4				1,092	671					
T1 No. to 36"				1,114	659					
T2 to United				1,009	647					
T3 So. To 36"										
Risers at BS#4									Insulating Joint Operating Properly	
Riser1										
Buried at IJ				1,245	1,076					
A/G at IJ				1,282	1,125					
									Insulating Joint Operating Properly	
Riser 2										
Buired at IJ				712	426					
A/G at IJ				633	499					
									Insulating Joint Operating Properly	
Riser 3										
Buried at IJ				845	670					
A/G at IJ				714	599					
Outside Paved										GPS N34.24233 W119.15087
Area At BS#4										
"CP TEST"										
West 2 Wires				372	303					
East 2 Wires				400	322					
"CP TEST"									Not Electrically continuous w/ R#10	GPS N34.24235 W119.15087
Box									Not Electrically continuous w/ R#10	
South 2 Wire				1,070	668					
North 2 Wire				2,129	317				Continuous with Rectifier #10	
Station 269+00	36" CMCL			2,025	1,014				Labeled, "M.P.269.00".	GPS N34.23959 W119.15204
Station 279+00	36" CMCL								36" PL. Could Not Locate	
Station 293+00	16" CMCL								Rose & Walnut in edge of Center lane.	
Station 304+10	16" CMCL								Flush ARV in sidewalk at NE corner of Rose & Collins.	
Station 0+00	20" CMCL								Junction Box in BS4 near rectifier	
Station 16+28	42" CMCL								IJTS connection to 42" UWCD PL.	
	20" CMCL									

OXNARD 36" I.D. CMCL Gonzalez Transmission Main											
Station	Structure	Test Leads	Pipe-To-Soil Potential (-mV)							Comments	GPS Location
			Native	2015		-		2015			
				On	Off	On	Off	On	Off		
1+04		blk								Unkown structures. Further investigation is required to determine which structures are associated with test leads at three test stations behind curb on north side of Gonzalez.	
1+29	36" CMCL									G-5 behind curb in island. Seized	
4+30	36" CMCL									G-5 behind curb in landscaping. Seized	
4+50 (?)	36" CMCL	blk						401		G-5 in sidewalk @ SW corner of Gonzalez & Rose. Unconfirmed BS3 PL.	
	Casing?	blk						772		G-5 in sidewalk @ SW corner of Gonzalez & Rose. Unconfirmed BS3 PL.	
6+10 (?)	36" CMCL	blk						590		G-5 in sidewalk @ SE corner of Gonzalez & Rose. Unconfirmed BS3 PL.	
	Casing?	blk						964		G-5 in sidewalk @ SE corner of Gonzalez & Rose. Unconfirmed BS3 PL.	
11+00	36" CMCL									G-5 behind curb in sidewalk S of Gonzalez.	
18+00	36" CMCL									G-5 behind curb in sidewalk S of Gonzalez.	
26+11	36" CMCL									G-5 behind curb in sidewalk S of Gonzalez.	
34+22	36" CMCL	blk						747		G-5 behind curb in sidewalk S of Gonzalez.	
41+58	36" CMCL	blk						444		G-5 behind curb in sidewalk S of Gonzalez. ARV test station.	
42+35	36" CMCL									G-5 behind curb in sidewalk S of Gonzalez.	
48+34	36" CMCL									G-5 behind curb in sidewalk E side of roadway.	
51+82	36" CMCL	blk						735		G-5 behind curb in sidewalk E side of roadway.	
BS3 PS	unknown									Unknown	

OXNARD
Industrial Lateral

Station	Structure	Test Leads	Native	2014 Rectifier On	2014 Rectifier Off	1990 Rectifier On	1990 Rectifier Off	1988 Rectifier On	1988 Rectifier Off	Comments	GPS Location
1+11.26 CTS						854	682	784	630	Diaz Vault	
4+10	MH?	Wire 1		923				912		Install test wires in AV manhole at Richmond and 5th.	
		Wire 2		895							
17+65						914	684	876	684	Could Not Locate	
29+85 CTS		(2) WR Wires		1,032						Immediately inside center gate. WR = Wooley Road.	
		(2) IL Wires		939						IL = Industrial Lateral.	
30+50 CTS	Brooks Box	(2) Wires		966		814				3 ft inside south corner gate, near Wooley	
44+05 CTS		BK. Wire		1,350		1,018	585	927	585		
		Red Wire		1,354		1,021	584	927	584		
		BL. Wire		1,356		1,022	586	931	586		
		G. Wire		1,347		1,016		926			
54+29 CTS		Black				1,050	577	1,024	577	Could Not Locate	
		Red						1,022	579		
67+15 CTS							528	1,035	528	Could Not Locate	
80+05		Black				1,080	558	1,024	558	Could Not Locate	
		Red				1,089	558	1,028	558		
92+32	Rectifier #4	Wire		2,430	972	1,420	568	1,232		Potentials Met NACE -850 mV Instant Off Criterion	GPS N34.17375 W119.16903
107+05 CTS "CP TEST" Wire 1				1,485	1,025			1,110		Potentials Met NACE -850 mV Instant Off Criterion	GPS N34.16945 W119.16705
119+55 CTS		Black				1,136	582	1,054		Could Not Locate	
		Red				1,129	582	1,057			
134+55 MH						1,160				Could Not Locate	
148+95 CTS										Could Not Locate	
163+00 CTS		Black				1,036	593	1,003			
		Red				1,040	573	1,004		Could Not Locate	

Pipe-To-Soil Potential (-mV)

OXNARD
45" Rod-Wrapped CMCL Oxnard Conduit

Station	Structure	Test Leads	Pipe-To-Soil Potential (-mV)							Comments	GPS Location
			Native	2014		1990		1988			
				Rectifier On	Rectifier Off	Rectifier On	Rectifier Off	Rectifier On	Rectifier Off		
6+33						150	557	149	557	Main Line Dresser removed during Del Norte PL installation.	
46+75 (east)	MH	Blue Wire			397		434	391	434		
46+75 (west)		White Wire			542		747	909	747		
81+90	PMTS	(2) Black			548	893		993			
98+20	PMTS	(2) Black			572					Dresser coupling TS.	
99+20	Rectifier #1	Wire				1,190	935	1,202	940	Rectifier and its Anode-Ground-Bed Not Operating. Replace Rectifier and Anode Ground-Bed #1.	
124+15 CTS						939		837		Could Not Locate	
152+00 CTS						893	707	894	707	Could Not Locate. (Buried under pile of soil)	
178+40 Vault						1,007		802		Pipeline relocated from approx 173+50 (MH & TS) to 203+30 (Rice/Gonzales intersection). Could Not Locate/No Access	
191+50 Air Release										Pipeline relocated from approx 173+50 (MH & TS) to 203+30 (Rice/Gonzales intersection). ARV now MH approx 180' E of Rice Ave CL.	
203+50	Rectifier #2					1,325	743			Test lead in rectifeir cabinet. Rectifier and Anode-Ground-Bed Not Operating. Need to Replace Rectifier and Anode Ground-Bed #2	
211+00 CTS						1,066			743		
225+25 CTS						1,131		984			
239+50 CTS						1,018		885			
254+00 Main Line Dresser						951	775	805	775	Coulld Not Locate/No Access. Rice Road	
272+25 CTS						973		752		Could Not Locate. Rice Road	
284+80 CTS at MH						1,050		848		Could Not Locate. 5th Street	
308+00	Rectifier #3	Up-Side		1,369	1,087	1,360	880	1,462	880		
		Down-Side		1,380	1,090	1,364	830	1,458	830		
310+00	ARV	Direct		1,075	852					200 Feet from Rectifier # 3	GPS N34.19730 W119.16841
330+75 CTS	MH			1,088		1,025		986			
346+60 CTS	MH			1,124		956		1,012			
361+43	MH	Wire 1		898		815	838	861	838	Diaz Vault - connection to 3St Lateral (& Industrial Lateral?)	
		Wire 2		926							
-											

OXNARD
Wooley Road/UWCD Lateral

Station	Structure	Test Leads	Pipe-To-Soil Potential (-mV)						Comments	GPS Location
			Native	2014		1997	1990	1988		
				Rectifier On	Rectifier Off	Rectifier On	Rectifier On	Rectifier On		
2+31.71	24" WSP	2-black (WR)	635	1,046	910	942	913		Rectangular Brooks Box "CTS" with 4 Wires. WR = Wooley Road. IL = Industrial Lateral Pipeline.	GPS N34.19014 W119.16878
		2-black (IL)		910	931	636	698			
17+00	24" WSP	Black	558			1,584	1,696	1,886	Rectifier #5 Structure Drain Lead.	GPS N34.19009 W119.16463
31+03.04 Main Line Insulator	24" WSP	Black	710			1,270	1,257	772	Could Not Locate. Wooley Road and Rose Avenue. Main line insulator between 24" Wooley Road Lateral and 36" UWCD water main. Likely destroyed during road work at intersection in circ. 2011.	
		Red				449	452			

Oxnard Water Treatment Facility
CP Assessment Survey

Name	ON (-mV)	Instant OFF (-mV)	Anode Potential (-mV)	Current (mA)	Description	Latitude	Longitude
Test 1	368	350	1776	30	24 " PM IN (at Tank)	34.20134189	-119.1759003
Test 1b					24 " PM IN (Tank Side)		
					24 " PM IN (Soil Side)		
Test 2	370	358	1886	10	Fire Riser Desalter Building	34.20127271	-119.1758268
Test 3	641	467	1728	70	24 " PM OUT (at Tank)	34.2012497	-119.1760203
Test 3b					24 " PM OUT Flange (Soil Side)		
					24 " PM OUT Flange (Tank Side)		
Test 4	498	470	1086	30	30 " SW	34.20112828	-119.1758633
Test 5	618	440	1765	80	PW	34.20103707	-119.1758559
Test 6	70		1080		RE 30	34.20096179	-119.1757994
	460		1100		SW 30		
	460		1100		IN 30		
Test 7	287/293				Chloramination Disinfection Facility (NE Corner)	34.20074422	-119.1760014
Test 8	296/309				Chloramination Disinfection Facility (SE Corner)	34.200665	-119.1759805
Test 9					No location attempted. Will attempt location on followup visit.		

APPENDIX II: RECTIFIER DATA

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City of Oxnard

3rd Street Lateral

Rectifier No 6. Manufacturer:Matcor, Model: MASYSE 30-40 M, Serial No.: 062846

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV)		Anode Current (Amps)							GPS (Lat/Lon)	Comments
							ON	OFF	A1	A2	A3	A4	A5	A6	Total		
E.3rd Street between Wilson Ave and Harding Ave (Station 21+76)	8/19/1997		F	5	20.80	18.2			2.71	4.34	2.49	2.68	2.59	3.62	18.43	34°12'1.66"N 119°10'10.67"W	Original rectifier details: Manufacturer ERP, Model:3040G Serial No.:P6615 Replaced after 1997 survey. 2014 Rectifier and groundbed non operational
	7/1/2014	DK			0.00	0.00											

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City of Oxnard

Del Norte

Rectifier No 7. - Manufacturer: Goodall, Model: CSAYSE40/22AEFNRZ Serial No.: 94C1020

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV)		Anode Current (Amps)									GPS (Lat/Lon)	Comments
							ON	OFF	A1	A2	A3	A4	A5	A6	A7	A8	Total		
W. Daily Dr. Camarillo (Station 26+50)	8/19/1997		A	3	5.18	5.53			0.36	0.67	0.57	0.55	0.51	0.55	0.88	1.28	5.37	34°13'16.43"N 119° 5'30.84"W	
	7/1/2014		A	3	5.08	4.40			0.30	0.50	0.40	0.40	0.40	0.50	0.70	1.20	4.40		

Rectifier No 8. - Manufacturer: Corrpower, Model: CAYSE 60-34 FOZ 72 117 203 287, Serial No:C031906

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV)		Anode Current (Amps)									GPS (Lat/Lon)	Comments
							ON	OFF	A1	A2	A3	A4	A5	A6	A7	A8	Total		
Central Ave near Beardsley Rd Intersection (Station 100+90)	8/19/1997		A	2	5.15	4.80			0.36	0.36	0.64	0.75	0.77	1.58			4.46	34°13'49.15"N 119° 6'45.76"W	Original rectifier details: Manufacturer Goodall, Model CASYSE 60-34 AEFNRZ Replaced after 1997 survey.
	7/1/2014	DK	A	3	7.13	6.08			0.00	0.60	0.80	1.00	1.20	2.30			5.90		

Rectifier No 9. - Manufacturer: Goodall, Model: CAYSA 40-22 AEFNRZ, Serial No.:94C1019

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV)		Anode Current (Amps)									GPS (Lat/Lon)	Comments
							ON	OFF	A1	A2	A3	A4	A5	A6	A7	A8	Total		
Driveway of 1701 Central Ave. (Station 185+06)	8/19/1997		A	3	7.90	5.80			1.27	0.88	0.59	0.44	0.64	1.67			5.49	34°14'42.43"N 119° 8'2.69"W	
	7/1/2014	DK	A	3	6.10	3.00			0.00	0.80	0.50	0.30	0.40	0.90			2.90		

City of Oxnard

Industrial Lateral

Rectifier No 4. - Manufacturer: Western, Model: WATSA-60-50-DFIZ, Serial No.: 01E103

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV)		Anode Current (Amps)											GPS (Lat/Lon)	Comments
							ON	OFF	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total		
Behind 675 E. Channel Island Blvd- access via back alley off Gisler Ave (Station 92+32)	3/7/1988				10.67	4.01			1.31	1.13	1.64								4.08	34°10'25.50"N 119°10'8.51"W	Original rectifier details: Manufacturer: Lester, Model: 10/20 L10P, Serial No.: 4102. Replaced after 1997 survey
	1/31/1990				16.00	5.82			2.97	1.38	1.48								5.83		
	8/5/1997				21.00	7.61			4.31	3.36	0.03								7.70		
	7/1/2014	DK	A	1	4.50	10.68			2.10	2.00	2.10	1.50	1.50	1.10					10.30		

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City of Oxnard

Oxnard Conduit

Rectifier No 1. - Manufacturer: Farwest, Model: ASAI 40V-30A Serial No.: 023687

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV) ON	Pipe-To-Soil (-mV) OFF	Anode Current (Amps) A1	A2	A3	A4	A5	A6	A7	A8	Total	GPS (Lat/Lon)	Comments
E. Ventura Blvd (Station 99+20)	3/7/1988		A	3	10.20	6.58			0.94	0.59	0.92	1.91	2.19				6.55	34°13'17.98"N 119° 6'44.06"W	Original rectifier details: Manufacturer ERP, Model 8040G 40V/80A Replaced after 1997 survey. 2014 Rectifier and anode bed not operating. Need to replace.
	1/31/1990				9.84	6.27			0.86	0.64	0.92	1.91	1.96				6.29		
	8/19/1997		B	5	14.58	8.70			1.91	1.33	2.13	3.35	0.00				8.72		
	7/1/2014	DK			0.00	0.00													

Rectifier No 2. - Manufacturer: Goodall, Model: CSAYSA3222, Serial No:86C1550

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV) ON	Pipe-To-Soil (-mV) OFF	Anode Current (Amps) A1	A2	A3	A4	A5	A6	A7	A8	Total	GPS (Lat/Lon)	Comments
N. Rice Ave near intersection E. Gonzales Rd (Station 203+50)	3/7/1988				0.00	0.00			2.32	2.16	2.61						7.09	34°13'6.10"N 119° 8'32.17"W	2014 Rectifier and anode bed not operating. Need to replace.
	1/31/1990				11.27	7.68			1.41	2.14	0.77	1.30	1.87	0.08			7.50		
	8/19/1997		B	1	10.80	6.88			1.74	1.95	0.01	1.70	1.32	0.01			6.73		
	7/1/2014	DK			0.00	0.00													

Rectifier No 3. - Manufacturer: Goodall, Model: CSAYSA 12-22 AEFNRSZ, Serial No.:89C1504

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV) ON	Pipe-To-Soil (-mV) OFF	Anode Current (Amps) A1	A2	A3	A4	A5	A6	A7	A8	Total	GPS (Lat/Lon)	Comments
E. 5th Street (Station 308+00)	3/7/1988		C	2	18.80	7.15			2.32	2.16	2.61						7.09	34°11'49.34"N 119° 9'2.74"W	Original rectifier details: Manufacturer ERP, Model 3040G 40V/30A Replaced after 1990 survey.
	1/31/1990				7.95	7.95			2.33	1.91	0.84	0.91	2.17				8.16		
	8/5/1997		C	3	9.55	8.21			2.16	2.25	1.09	0.96	1.62				8.08		
	7/1/2014	DK	C	3	9.58	6.25			1.90	1.62	1.16	0.70	0.81				6.19		

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City of Oxnard

Wooley Road Main

Rectifier No 5. - Manufacturer: Goodall, Model: CSAWSE 30-16 EGZ, Serial No.: 77W3200

Location	Date	Inspected By	Tap Coarse Setting	Tap Fine Setting	Meter Voltage (Volts)	Meter Current (Amps)	Pipe-To-Soil (-mV)		Anode Current (Amps)											GPS (Lat/Lon)	Comments
							ON	OFF	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total		
E. Wooley Rd near intersection with Pacific Ave. (Station 17+00)	3/7/1988		2	2	9.63	5.80			1.65	1.28	0.82	0.72	1.27						5.74	34°11'24.32"N 119° 9'52.67"W	
	1/31/1990		3	2	9.57	7.52			2.28	1.81	1.16	1.05	1.72						8.02		
	8/5/1997		2	2	9.43	5.60			1.55	1.12	0.84	0.81	1.29						5.61		
	7/1/2014	DK	2	2	9.35	5.16	1,560	1,143													

APPENDIX III: REMEDIATION & COST ESTIMATES

Engineering and Construction Cost Estimate*
Cathodic Protection Upgrades & Field Studies

Cathodic Protection Engineering & Construction - Capital Improvements & Investigations

Project Start	System	Structure	Recommendation	Engineering Services	Construction	Subtotal
Priority 1						
2016	3rd St Oxnard Extension	30" CMCL PL	Replace deep anode bed and Rectifier.	$ 25,000	$ 85,000	$ 110,000
2016	3rd St 27" UWCD	27" CMCL PL	Bond UWCD Pipeline to Oxnard Extension at Rectifier.	$ 500	$ -	$ 500
2016	Oxnard Conduit	45" CMCL PL	Replace deep anode beds and Rectifiers #1 , #2, & #3.	$ 60,000	$ 270,000	$ 330,000
Total (2016)				**$ 85,500**	**$ 355,000**	**$ 440,500**
Priority 2						
2018	3rd St Oxnard Extension	30" CMCL PL	Locate & repair discontinuity between 27+88 and Chemical Building 1 (Chloramination Building) South Hayes WTP.	$ 7,000	$ 30,000	$ 37,000
2018	3rd St Oxnard Extension	30" CMCL PL	Provide electrical isolation at the main treatment plant.	$ 5,000	$ 5,000	$ 10,000
2018	Del Norte Pipeline	48" & 36" CMCL PL	Locate and repair discontinuity near the east end of Del Norte PL.	$ 12,000	$ 15,000	$ 27,000
2018	Gonzalez 36" Pipeline	36" WSP	Replace test station lids, and test CP	$ 5,000	-	$ 5,000
2018	Industrial Lateral	30" & 27" CMCL PL	Excavate & install new test stations at approximately six (6) locations.	$ 7,000	$ 20,000	$ 27,000
2018	Oxnard Conduit	45" CMCL PL	Excavate & install new test stations at foot stations 9+10 (near connection to Del Norte sta 4+13), 39+10, 57+45, 69+50, 111+50, 165+20.	$ 7,000	$ 15,000	$ 22,000
2018	Oxnard Conduit	45" CMCL PL	Install new test stations in existing manhole at 284+80.	$ 500	$ 1,000	$ 1,500
2018	Oxnard Conduit	45" CMCL PL	Corrosion engineer to conduct CIS.	$ 20,000	-	$ 20,000
2018	Oxnard Conduit	45" CMCL PL	Locate, excavate, and bond across approximately three (3) points of electrical isolation.	$ 20,000	$ 100,000	$ 120,000
2018	South Hayes WTP	Water Tank	Install internal CP system.	$ 7,500	$ 30,000	$ 37,500
2018	South Hayes WTP	Buried Yard Piping	Install electrical isolation at all steel and cast iron water risers	$ 5,000	$ 25,000	$ 30,000
Total (2018)				**$ 96,000**	**$ 241,000**	**$ 337,000**
Priority 3						
2021	Del Norte Pipeline	48" & 36" CMCL PL	Excavate & install new test stations at 63+00, 140+00, 150+00, 161+00, 210+00, 222+00, 244+00, and install test leads in vault at 0+00.	$ 8,000	$ 20,000	$ 28,000
2021	Del Norte Pipeline	48" & 36" CMCL PL	Replace existing rectifiers and ground beds.	$ 70,000	$ 320,000	$ 390,000
2021	Wooley Road PL	24" PL (unknown coating)	Replace missing test station by excavating to the insulating flange connection to UWCD at 31+03, and install two (2) additional test stations.	$ 5,000	$ 20,000	$ 25,000
2021	Wooley Road PL	24" PL (unknown coating)	Replace existing rectifier & ground bed.	$ 25,000	$ 100,000	$ 125,000
2021	South Hayes WTP	Buried Yard Piping	Design and install CP on buried water piping.	$ 20,000	$ 25,000	$ 45,000
Total (2021)				**$ 128,000**	**$ 485,000**	**$ 613,000**
Wastewater Treatment Facility						
TBD**	Wastewater Treatment Facitlity	Buried Yard Piping	Investigate requirements for electrical isolation and CP of buried piping, and design and install capital project as warranted.	$ 150,000	$ 1,000,000	$ 1,150,000
TBD**	Wastewater Treatment Facitlity	Six (6) Clarifiers & Digesters	Design & Install CP systems.	$ 50,000	$ 180,000	$ 230,000
Total (TBD)				**$ 200,000**	**$ 1,180,000**	**$ 1,380,000**

* Cost Estimates are based on 2015 dollars including a 10% contingency.

** Wastewater Treatment Plant cathodic protection will be scheduled in coordination with rehabilitation, and costs will be dependent upon the City's decision to rehabilitatate or to relocate and rebuild the treatment plant facility.

Abbreviations

CIS	Close Interval Survey
CMCL	Concrete Mortar Coated & Lined
CP	Cathodic Protection
PL	Pipeline
UWCD	United Water Conservation District
WSP	Welded Steel Pipe
WTP	Water Treatment Plant