

28. Corrosion Control.

a. Abbreviation.

NACE National Association of Corrosion Engineers (NACE International)

b. General.

- 1) This section includes the specific corrosion control design requirements for buried ductile iron pipe and general guidance on the type of corrosion control to be provided for other ferrous metal pipelines. The topics addressed include when corrosion control is necessary, design and submittal procedures, and site evaluation criteria for selecting the type of corrosion control required.
- 2) **Future/proposed extension of WMATA Metrorail lines and Maryland Transit Administration (MTA) Rail Lines, see Table “32” (Stray Current Analysis).**
- 3) All ferrous metal pipelines, particularly ductile iron and steel are to be evaluated to determine what corrosion control measures will be required. The specific pipe sizes, materials, and conditions which are to be evaluated for corrosion control include:
 - a) All sizes of Ductile Iron Pipe (DIP). Corrosion control is required for all buried DIP as follows:
 - (1) DIP smaller than 16-inch. Generally, polyethylene encasement will be used on all pipes in this size range and can be expected to provide adequate corrosion control except when stray currents are encountered or anticipated. Follow the procedures and guidelines in this section to evaluate the pipeline for sources of stray currents. Determine the type of material of the existing pipe that is being connected to in order that protection can be provided against galvanic corrosion between dissimilar pipe metals. Also, determine if the existing pipe has some form of corrosion control. Based on stray current and existing pipe analyses, protection beyond that provided by polyethylene encasement may be required, such as coating DIP or selecting coated steel pipe or a non-metallic pipe material.
 - (2) 16-inch and larger DIP. Ductile iron water pipelines 16-inch and larger at a minimum will require polyethylene encasement. Complete evaluation is required to determine the corrosion control requirements as outlined in this section.
 - b) All sizes of exposed (non-buried) DIP. Provide paint or coating material to protect the pipe from the environmental effects to which it is exposed such as road salts, submersion, etc. The analysis and design guidelines for exposed DIP are not included in this section.
 - c) All sizes of steel pipe. Corrosion control is required for all exposed and buried steel pipe. This includes pipe coatings, cathodic protection, electrical isolation and a cathodic protection monitoring system. The analysis and design guidelines for steel pipe are not included in this section.
- 4) Corrosion design qualifications. A Corrosion Engineer, a NACE Certified Senior Corrosion Technologist or a NACE Certified CP or Corrosion Specialist is **required to oversee all work required under this section of the Pipeline Design Manual.**
- 5) Test station numbering. If the design requires corrosion monitoring test stations, WSSC will provide the test station numbering. Existing test stations are numbered and recorded on control cards on file at WSSC. Show on drawings the location and number of the existing test stations.



c. Corrosion Design Procedure and Submittal Requirements.

- 1) The corrosion control design procedure consists of up to three (3) submittal stages. A detailed description of the submittal requirements is included below. For convenience, the submittals for stages one and two are standard forms, a checklist and a documentation form contained at the end of this section. The third submittal consists of the corrosion design drawings and specifications, which are required, only if more stringent corrosion control measures prove to be necessary. A summary of the three specific submittal stages is as follows:
 - a) First submittal. For all ductile iron pipe sizes, submit the completed Corrosion Survey Checklist including preliminary plans showing the pipeline alignment and proposed soil boring locations as required in Appendix "E" (Subsurface Investigation Requirements for Water and Sewer Design and Construction). Detailed instructions for completing the Checklist are included at the end of this section. Perform the Existing Pipe Analysis as indicated in this section and include the results from Chart "D" on the Checklist in the space provided.
 - b) Second submittal.
 - (1) DIP smaller than 16-inch. If there are no sources of stray currents or any additional corrosion considerations from the checklist, then submit plans with corrosion control provisions if connecting to existing pipe according to Chart "D". If there are stray current sources complete the Stray Current Analysis and submit the results along with the completed Corrosion Documentation Form "B".
 - (2) DIP 16-inch and larger. Perform the Stray Current Analysis and Soil Condition Analysis and submit the results along with the completed Corrosion Documentation Form "B", including the recommended corrosion control measures.
 - c) Third submittal. DIP 16-inch and larger and DIP smaller than 16-inch with stray current submit plans and specifications, including the corrosion control design, if required.

d. Soil Condition Analysis.

- 1) A Soil Condition Analysis is required for all 16-inch and larger water pipelines.
- 2) Obtain soil samples along the alignment in accordance with Appendix "E" (Subsurface Investigation Requirements for Water and Sewer Design and Construction). Perform laboratory or field tests (in situ, where appropriate) for pH, chloride content, redox potential, soil description, and soil resistivity on soil samples taken at the pipeline depth. Intervals of the soil samples should not exceed one thousand (1000) feet, unless the pipeline alignment is less than two thousand (2000) feet in length, then the intervals should not exceed seven hundred (700) feet. A minimum of two (2) soil samples is required for each pipeline alignment.
- 3) Consideration must also be given to the possible exposure to roadway deicing salt. If the pipeline is located next/parallel to and below the bottom of a roadway ditch, follow the recommendations in Chart "D", under Stray Current Analysis, Moderate Exposure for the corrosion control requirements.
- 4) Decision Process.
 - (1) Obtain laboratory or field results from soil sample tests. Using the Analysis Type and Analysis Range columns in Table "30" determine Points that will apply to each Analysis Type and total them to get the "Overall Corrosivity Rating" from Table "31" for the condition of the pipeline trench.



- (2) Match Overall Corrosivity Rating Total Points from Table "31" with Chart "C" and obtain a preliminary determination of the corrosion control requirements.

TABLE "30"
Soil Condition Analysis

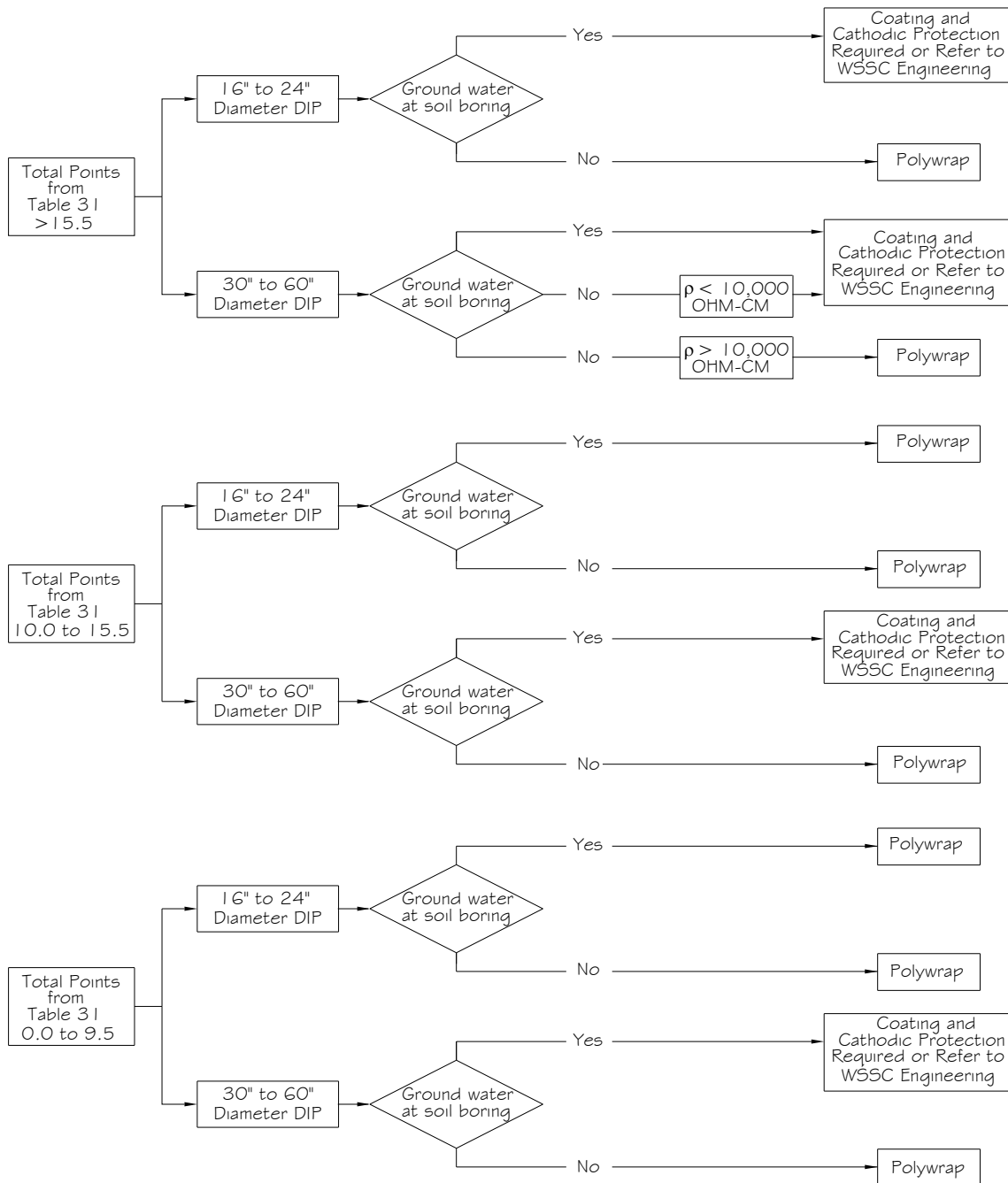
ANALYSIS TYPE	ANALYSIS RANGE	POINTS	ANALYSIS TYPE	ANALYSIS RANGE	POINTS
PH	0 – 2	5	Soil Description	Clay (Blue-Gray)	10
	2 – 4	3		Clay/Stone	5
	4 – 8.5	0		Clay	3
	> 8.5	3		Silt	2
Chloride Content	> 1000 ppm	10		Clean Sand	0
	500 – 1000 ppm	6		---	--
	200 – 500 ppm	4	< 1,000 ohm-cm	10	
	50 – 200 ppm	2	1,000 – 1,500 ohm-cm	8	
	0 – 50 ppm	0	1,500 – 2,500 ohm-cm	6	
Redox Potential	Negative	5	Soil Resistivity	2,500 – 5,000 ohm-cm	4
	0 – 100 mV	4		5,000 – 10,000 ohm-cm	2
				> 10,000 ohm-cm	0
				---	--
	> 100 mV	0			

TABLE "31"
Overall Corrosivity Rating

SOIL CORROSIVITY	TOTAL POINTS
Severe	> 15.5
Appreciable	10.0 – 15.5
Moderate	5.0 – 9.5
Mild	0 – 4.5

- 5) Not included in Table "30" and "31" are conditions for stray current exposure, road salt run-off and foreign pipeline crossing.
- 6) Table "30" and "31" are adapted from Table 20.1 "Assessment of Overall Soil Corrosivity to Steel", C.P. Dillon *Corrosion Control in the Chemical Process Industries*. Materials Technology Institute of the Chemical Process Industries, 1994.





NOTES:

1. "Polywrap" means polyethylene encasement in accordance with WSSC specifications.
2. "Coating" means a bonded high performance coating.

CHART "C"

Flowchart - Overall Soil Corrosivity Rating Points for DIP



e. Stray Current Analysis.

- 1) A Stray Current Analysis is required for all sizes of water pipelines.
- 2) First, identify the source of stray currents. Examples of stray current sources are listed below:
 - a) Impressed current cathodic protection systems which may be located along natural gas and petroleum products pipelines, at bulk storage facilities with ground level or buried tanks, at gas stations with buried steel storage tanks, along buried pipe-type oil filled high voltage cables, along buried telephone cables, and at public or private housing complexes with on-site gas distribution systems (including military bases).
 - b) Electrified rail systems, such as at-grade WMATA Metrorail lines, subway WMATA Metrorail lines and Maryland Transit Administration (MTA).
 - c) Welding shops and other industrial facilities.
- 3) Testing for Stray Current.
 - a) When there is an existing stray current source within two thousand (2000) feet of water pipeline, use a recording type instrument for detecting possible stray current influence. A Corrosion Engineer, a NACE Certified Senior Corrosion Technologist or a NACE Certified CP or Corrosion Specialist is to oversee the stray current testing.
 - b) No testing is required if there are no stray current sources identified within two thousand (2000) feet or if the ductile iron pipeline will be within two hundred (200) feet of WMATA Metrorail lines. When within 200 feet of WMATA Metrorail lines, take protective measures in accordance with "Severe Exposure" in Table "32".
- 4) Decision Process.
 - a) Make a site visit and determine the presence of possible stray current sources and perform testing as required to verify and quantify stray current in the vicinity of the pipeline.
 - b) Using Table "32" determine the level of exposure to stray currents and go to Chart "D", to determine what, if any, corrosion control measures are needed.
- 5) For the purpose of this analysis, *ground bed* refers to impressed current cathodic protection anodes, and *foreign* refers to another buried utility pipe or cable, including an existing WSSC pipeline. Foreign pipe that is not of concern includes non-metallic materials such as PVC and prestressed concrete cylinder pipe that typically does not have impressed current cathodic protection.



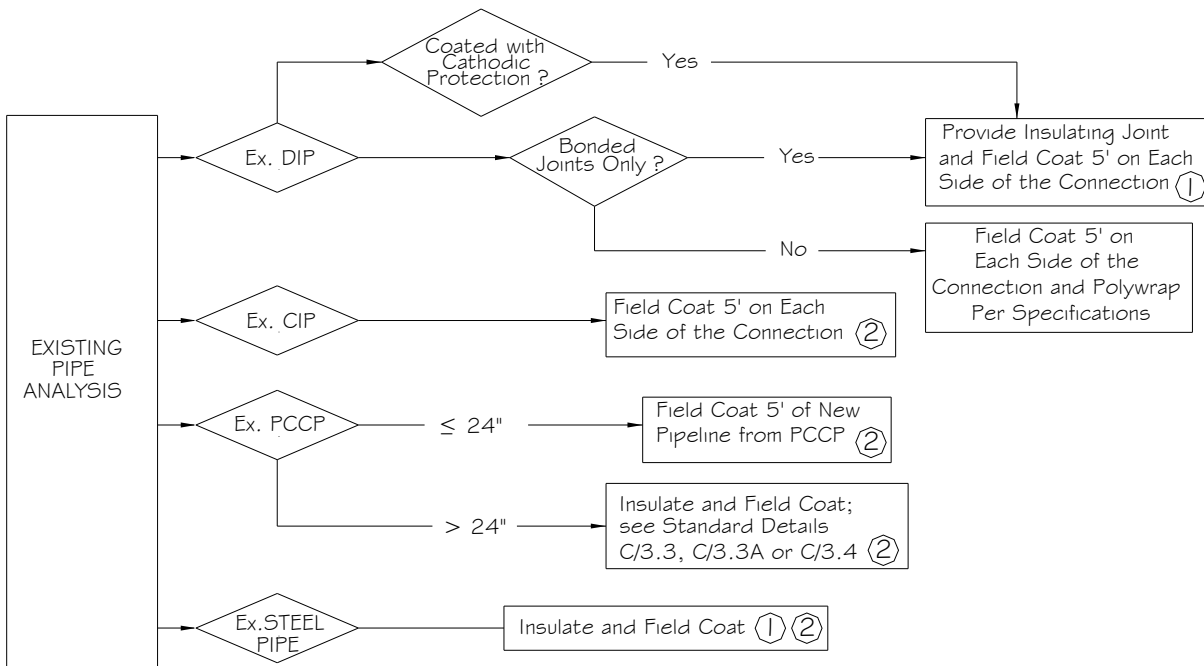
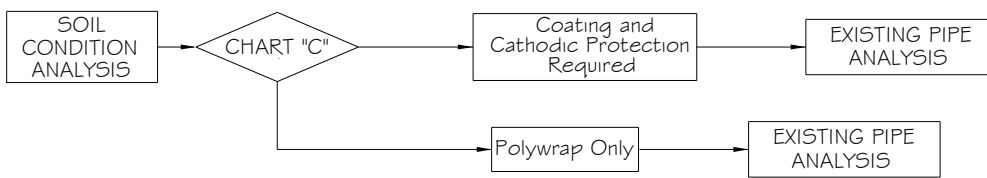
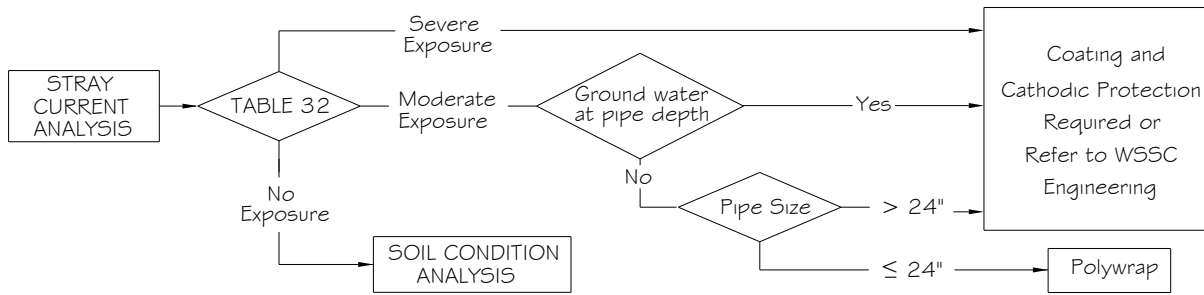
TABLE "32"
Stray Current Analysis

<u>Exposure Level to Stray Currents</u>	<u>Pre-Construction Survey and Test Results</u>
<u>SEVERE EXPOSURE</u>	<ul style="list-style-type: none"> • Continual stray current that results in more than 50 mV potential variation (any source). • WMATA Metrorail lines that are within 200 feet of the pipeline. • Future/proposed extension of WMATA Metrorail lines and Maryland Transit Administration (MTA), within 500 feet of the pipeline. • Cathodically protected foreign buried pipes or cables that cross or come within 100 feet of the pipeline and have a ground bed within 2000 feet.
<u>MODERATE EXPOSURE</u>	<ul style="list-style-type: none"> • Moderate or sporadic stray current that results in 50 mV or less potential variation (any source). • WMATA Metrorail lines and Maryland Transit Administration (MTA), that is within 200 to 500 feet of the pipeline. • Cathodically protected foreign buried pipes or cables that are within 100 to 500 feet of the pipeline and have a ground bed within 2000 feet or that cross the pipeline and have a ground bed over 2000 feet away.
<u>NO EXPOSURE</u>	<ul style="list-style-type: none"> • No stray current detected during testing. • WMATA Metrorail lines and Maryland Transit Administration (MTA), beyond 500 feet away from the pipeline. • Cathodically protected foreign utility buried pipes and cables are more than 500 feet away from the pipeline.

f. Existing Pipe Analysis.

- 1) An Existing Pipe Analysis is required for all sizes of water pipelines. Determine what corrosion control measures will be required at the connection between the existing and new pipeline(s).
- 2) Determine if any corrosion control measures were used on the existing pipe to which the new pipe will be connected.
- 3) Identify the existing pipeline material (ductile iron, cast iron, prestressed concrete cylinder, steel, etc.).
- 4) Decision Process.
 - a) Using Chart "D" and the type of existing pipe material, determine what corrosion control measures are required.
 - b) **If Stray Current Analysis indicates Moderate or Severe Exposure these results shall supersede the results of the Soil Condition Analysis and Existing Pipe Analysis.**





① If existing pipe has a bonded coating (epoxy, coal tar enamel, polyethylene back tape, etc.), over lap field coating onto existing pipe coating a minimum of 6".

② When polywrap is used on new pipe, overlap it onto the field coating.

CHART "D"

Corrosion Control Decision Tree For New Ductile Iron Pipelines

g. Corrosion Survey Checklist.



- 1) The information below includes instructions on how to complete the Corrosion Survey Checklist and describes the items on the checklist in greater detail. Select an alignment that avoids areas where special corrosion control measures are likely to be required. Note the results of the investigation of these issues on the Corrosion Survey Checklist and include the completed checklist with the **first submittal**.
 - a) Complete the existing pipe analysis for all connecting pipe sizes, to include type of pipe material, sizes, pipeline type, existing corrosion control, if any, and corrosion control required from Chart "D".
 - b) Identify the sources of stray currents, including buried utilities or transportation facilities in the vicinity (crossing, parallel or within two thousand (2000) feet) of the pipeline alignment that may be a source of stray current. Potential stray current sources are listed below.
 - (1) Washington Metropolitan Area Transit Authority (WMATA) DC transit lines and **Maryland Transit Administration (MTA)**, especially surface routes.
 - (2) **Petroleum Product or Natural Gas** pipelines with impressed current cathodic protection systems.
 - (3) **Direct Burial or Pipe Type communication or power cables with impressed current cathodic protection systems.**
 - (4) **Overhead** mounted high voltage electrical lines that are in a parallel right of way.
 - (5) Service stations with impressed current cathodic protection systems for buried fuel tanks and pipes.
 - c) Indicate on the checklist, if the pipeline will be exposed to any of the following corrosive conditions which will impact the corrosion rate of a metallic pipeline and influence the selection of pipe coatings or the need for cathodic protection or alternative materials.
 - (1) Deicing salt exposure, typically encountered when the pipeline is located beneath a roadway stormwater drainage ditch, infiltration trench, etc.
 - (2) Relocation of pipelines in older areas where the streets have cinders that may have been dumped before the streets were paved.
 - (3) Exposure to chemical or animal waste runoff from nearby farms.
 - (4) Wetlands and sites containing significant deposits of organic soils, such as peat.
 - (5) Pipe exposed to continuously wet or submerged environments.
 - (6) Cyclic wetting and drying due to a fluctuating groundwater table.
 - (7) Soil type generally corrosive to buried metals, as indicated in the United States Department of Agriculture Soil Conservation Services Soil Surveys for Prince George's County and Montgomery County, such as acid sulfate soils.
 - (8) History of pipe leaks or breaks in the vicinity.



- (9) Proximity of highly break or leak sensitive land use features, such as alignments directly adjacent to large structures or within dams.
- (10) Size and importance of the pipeline. Water pipelines 16-inch and greater are typically candidates for more stringent corrosion control measures. For all water pipelines 16-inch and greater, perform the soil and groundwater testing indicated at the bottom of the checklist and submit the results with the **second submittal**.
- (11) If the pipeline will be connected to an existing pipeline or another pipeline which was or will be constructed with dissimilar metal that may create conditions for a galvanic corrosion cell, identify the type and size of the existing pipe and the original WSSC contract number. For prestressed concrete cylinder pipe, also identify the manufacturer's project number and if the pipe is embedded cylinder type (SP-12) or lined cylinder type (SP-5). Also, identify the type of corrosion control on the existing pipeline, if any.

h. FORM "B" Corrosion Documentation.

- 1) Following the completion of any required Soil Condition Analysis, Stray Current Analysis and Existing Pipe Analysis complete the Corrosion Documentation, Form "B" and submit it with the **second submittal**.
- 2) Determine what type of corrosion control is required and indicate the type at the bottom of Form "B".



CORROSION SURVEY CHECKLIST

PROJECT NAME _____ CONTRACT NO.: _____

PREPARER (Please print): _____ TITLE: _____

SIGNATURE OF PREPARER: _____ DATE: _____

a) Existing Pipe Analysis: (all pipe sizes).

Size(s) _____

Pipeline Type:

Connecting to:

- CIP
 DIP
 PCCP
 Steel
 Other

- Water Pipeline
 Force Main
 Other _____

Note: Provide any additional supporting information on a separate sheet of paper.

Existing Pipe Corrosion Control:

- none
 Bonded Joints
 Coated: Type: _____
 Cathodic Protection: Type: Galvanic Anodes
 Impressed Current

Corrosion Control Required (from Chart "D"): _____

b) Identify Sources of Stray Currents (crossing, parallel or within 2000 feet).

- (1) Yes No WMATA DC transit lines and **Maryland Transit Administration (MTA)**, especially surface routes.
- (2) Yes No **Petroleum or Product or Natural Gas** pipelines with impressed current cathodic protection systems.
- (3) Yes No **Direct Burial or Pipe Type** communication or power cables with impressed current cathodic protection systems.
- (4) Yes No Overhead high voltage electrical lines that are in a parallel right of way.
- (5) Yes No Service stations with impressed current cathodic protection systems.

c) Additional Corrosion Considerations.

- (1) Yes No Exposure to deicing salts.
- (2) Yes No Relocation in older streets.
- (3) Yes No Exposure to chemical or animal waste runoff from nearby farms.
- (4) Yes No Wetlands and sites containing significant deposits of organic soils, such as peat.
- (5) Yes No Pipe exposed to continuously wet or submerged environments.
- (6) Yes No Cyclic wetting and drying due to a fluctuating groundwater table.
- (7) Yes No Soil type generally corrosive to buried metals (i.e., acid sulfate soils).
- (8) Yes No History of pipe leaks or breaks in the vicinity.
- (9) Yes No Proximity to highly break or leak sensitive areas (dams, buildings, bridges, etc.).
- (10) Yes No Size and importance of the proposed pipeline. Water pipelines 16-inch or larger?
If yes, perform the soil and groundwater testing indicated below and include the results with the second submittal.
- (11) Yes No Connecting to dissimilar pipe materials? If yes, indicate type(s) of pipe _____ and type of corrosion control on the existing pipe, if any. _____

d) Field Soil And Groundwater Testing Requirements for All Ductile Iron Pipelines 16-inch and Larger. (See Appendix "E" for Specific Testing Requirements; submit with second submittal).

- (1) Redox potential (ASTM D 1498) of soil at the proposed pipe depth.
- (2) Water soluble chloride content (ASTM D 512) of soil at the proposed pipe depth. Chloride ion extraction using accepted industry methodology prior to testing.
- (3) Carbon Dioxide (CO₂) content (ASTM D 513) of groundwater, if present.



FORM "B" Corrosion Documentation

Date _____

1. Job Description:

Contract Number _____ Location: _____
 County _____ Map Book Page: _____ Map Book Grid: _____
 Type of Job: _____ New Pipeline. _____ Relocation. _____ Other: _____
 New Pipe: Size(s): _____ Type of Pipeline
 ___ DIP _____ Water Pipeline
 ___ Steel _____ Force main
 ___ PCCP _____ Other _____

2. Site Evaluation:**a) Existing Pipe Analysis:** (all pipe sizes).

Size(s) _____ Existing Pipe Corrosion Control:
 Connecting to: _____ none
 ___ CIP _____ Bonded Joints
 ___ DIP _____ Coated: Type: _____
 ___ PCCP _____ Cathodic Protection: Type: _____ Anodes
 ___ Steel _____ Impressed Current
 ___ Other _____
 Corrosion Control Required (from Chart "D"): _____

b) Stray Current Analysis: (all pipe sizes).

___ Cathodically Protected Gas Lines or **Natural Gas** Pipelines:
 ___ Impressed Current. ___ Magnesium Anode. ___ Proximity of Ground Beds (feet): _____
 ___ Electric: **Direct Burial** Cables. ___ Pipe-Type Cables ___ Overhead High Voltage. ___
 ___ Telephone.
 ___ WMATA Rail Line:
 ___ Parallel (feet): _____ ___ Crossing. ___ Subway. ___ At Grade.
 ___ Other: _____

c) Soil Condition Analysis: (16-inch and larger pipeline).

___ Soil Borings: Groundwater. ___ Clay soil. ___ Mixed Soil. ___
 ___ Soil Chemical Analysis:
 pH. _____ Chlorides (ppm): _____
 Sulfate (ppm) _____ Resistivity (ohm-cm): _____
 Redox Potential (mv) _____ Others: _____
 ___ County Soil Survey – Risk of Corrosion:
 ___ Low. ___ Medium. ___ High.
 ___ Potential for Exposure to Road Salts.
 ___ Other: _____

3. Corrosion Control Requirements:

___ Liquid Epoxy Coating. ___ Bonded Joint(s). ___ Field Applied Mastic Coating.
 ___ Tape Coating. ___ Insulated Joint(s). ___ Polyethylene Encasement.
 ___ Cathodically Protect Pipe. ___ Install Test Station(s).
 ___ Other: _____
 ___ Remarks: _____

