UNDERGROUND PIPING AND TANKS INSPECTION AND MONITORING

ENTERGY NUCLEAR ENGINEERING PROGRAMS

APPLICABLE SITES

All Sites: ☒

Specific Sites: ANO ☐ GGNS ☐ IPEC ☐ JAF ☐ PLP ☐ PNPS ☐ RBS ☐ VY ☐ W3 ☐ HQN ☐

Safety Related: ☐ **Yes**

☒ **No**

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REVIEW AND CONCURRENCE SHEET

Program Section Title: Underground Piping and Tanks Inspection and Monitoring

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1.0 PROGRAM DESCRIPTION AND SCOPE

1.1 The Underground Piping and Tanks Inspection and Monitoring Program provides for the inspection and monitoring of selected underground piping and tanks for external corrosion, such as crevice corrosion, general corrosion, microbiologically influenced corrosion (MIC), and pitting corrosion.

1.2 Program controls are contained in EN-DC-343 (Reference 2.2.6)

1.3 Internal underground piping/component degradation due to Microbiologically Influenced Corrosion (MIC) is monitored in systems in accordance with EN-DC-340. (Reference 2.2.5)

1.4 Internal underground piping/component degradation due to Flow Accelerated Corrosion (FAC) is monitored in systems in accordance with EN-DC-315. (Reference 2.2.11)

1.5 This Program Section provides elements for the standardized Entergy Underground Piping and Tanks Inspection and Monitoring Program that are below the level of detail for which Nuclear Management Level controls are required.

1.6 Within the context of this Program Section, the term "underground piping" shall also include other underground components such as tanks, sumps, valves, or fittings.

1.7 Site specific line and component listings developed as a part of the program are maintained in a site database (e.g., IDDEAL® database using CEP-COS-0100 guidance (Reference 2.3.1)).

1.8 Changes to this Program Section are governed by EN-DC-174 (Reference 2.2.3).

2.0 REFERENCES

2.1 QAPM, Quality Assurance Program Manual

2.2 Nuclear Management Manual (NMM)

- 2.2.1 EN-DC-115, Engineering Change Process
- 2.2.2 EN-DC-167, Classification of Structures, Systems and Component
- 2.2.3 EN-DC-174, Engineering Program Sections
- 2.2.4 EN-DC-329, Engineering Programs Control and Oversight
- 2.2.5 EN-DC-340, Microbiologically Influenced Corrosion (MIC) Monitoring Program
- 2.2.6 EN-DC-343, Underground Piping and Tanks Inspection and Monitoring Program
- 2.2.7 EN-IS-112, Trenching, Excavating and Ground Penetrating Activities
- 2.2.8 Standard EN-EP-S-002-MULTI, Buried Piping and Tanks General Visual Inspection

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2.2.9 EN-LI-102, Corrective Action Process

2.2.10 EN-WM-100, Work Request (WR) Generation, Screening and Classification

2.2.11 EN-DC-315, Flow Accelerated Corrosion Program

2.3 Central Engineering Programs (CEP) Sections

2.3.1 CEP-COS-0100, Control and Use of IDDEAL Concepts Software

2.3.2 CEP-NDE-0100, Administration and Control of NDE

2.3.3 ENN-NDE-1.0, Administrative Controls for Non-Destructive Examination

2.3.4 CEP-WP-001, Program Section for the Control of Special Processes: Welding, Heat Treating, and Nondestructive Examination

2.4 External References

2.4.1 Electric Power Research Institute (EPRI) IR-2010-409, "Inspection Methodologies for Buried Piping and Tanks", June 2010

2.4.2 EPRI 1016276, "An Assessment of Industry Needs for Control of Degradation in Buried Pipe", March 2008.

2.4.3 EPRI 1021175, "Recommendations for an Effective Program to Control the Degradation of Buried and Underground Piping and Tanks (1016456 Rev 1)", December 2010.

2.4.4 EPRI 1000115, "Evaluation of Torsional Guided Waves for Inspection of Service Water Piping", December 2000.

2.4.5 EPRI 1011905, "Cathodic Protection System Application and Maintenance Guide", December 2005.

2.4.6 EPRI 1011836, "Design and Qualification of High-Density Polyethylene for ASME Safety Class 3 Piping Systems", December 2005.

2.4.7 EPRI 1019157, "Plant Support Engineering: Guideline on Nuclear Safety-Related Coatings, Revision 2 (Formerly TR-109937 and 1003102)", December 2009.

2.4.8 EPRI 1019115, "Buried Pipe Guided Wave Examination Reference Document", October 2009.

2.4.9 EPRI Report 1011829, "Condition Assessment of Large-Diameter Buried Piping, Phase 2: Vehicle Design and Construction", December 2005.

2.4.10 EPRI Report 1021470, "Balance of Plant Corrosion - The Buried Pipe Reference Guide", December 2010

2.4.11 NUREG-1801, Generic Aging Lessons Learned (GALL) Report, Nuclear Regulatory Commission (NRC)

2.4.11a Revision 1, Section XI.M34 "Buried Piping and Tanks Inspection", September 2005

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2.4.11b Revision 2, Section XI.M41 "Buried and Underground Piping and Tanks," December 2010

2.4.12 NUREG/CR-6679, "Assessment of Age-Related Degradation of Structures and Passive Components for U.S. Nuclear Power Plants", NRC, August 2000.

2.4.13 NUREG/CR-6876, "Risk-Informed Assessment of Degraded Buried Piping Systems in Nuclear Power Plants", NRC, June 2005.

2.4.14 Institute of Nuclear Plant Operations (INPO), "Cathodic Protection on Underground Piping, Operating Experience Digest", August 2005.

2.4.15 INPO, Operating Experience Digest 2007-09, "External Degradation of Buried Piping", April 2007.

2.4.16 Nuclear Energy Institute (NEI) 09-14, "Guideline for the Management of Underground Piping and Tank Integrity", Rev 1, December 2010.

2.4.17 NEI 07-07, "Industry Ground Water Protection Initiative, Final Guidance Document", August 2007.

2.4.18 NEI 95-10, "Industry Guideline for Implementing The Requirements of 10 CFR Part 54 - The License Renewal Rule", Rev. 6, June 2005

2.4.19 American Nuclear Insurers (ANI), Nuclear Liability Insurance Guideline 07-01, "Potential of Unmonitored and Unplanned Off-Site Releases of Radioactive Material", March 2007.

2.4.20 NACE Standard Practice SP-0502-2008, "Pipeline External Corrosion Direct Assessment Methodology".

2.4.21 NACE Standard Practice SP0169-2007, "Control of External Corrosion on Underground or Submerged Metallic Piping Systems".

2.4.22 NACE Standard Recommended Practice RP0285-2002, "Corrosion Control of Underground Storage Tank Systems by Cathodic Protection".

2.4.23 ASM Handbook, Volume 13B, "Corrosion: Materials, ASM International," November 2005.

2.4.24 EPRI 1022963, "Plant Engineering: Early Detection of Leaks in Buried Piping," June 2011

2.4.25 EPRI/NEI "Industry Guidance for the Development of Inspection Plans for Buried Piping", Final Draft Approved for Use, April 2011.

2.4.26 NRC IE Bulletin No. 80-10, Contamination of Non-Radioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment.

2.5 Site Engineering Program Section (SEP) Inspection Plans

2.5.1 SEP-UIP-JAF, JAF Underground Components Inspection Plan

2.5.2 SEP-UIP-PNPS, PNPS Underground Components Inspection Plan

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2.5.3 SEP-UIP-VTY, VTY Underground Components Inspection

2.5.4 SEP-UIP-RBS, RBS Underground Components Inspection Plan

2.5.5 SEP-UIP-ANO, ANO Underground Components Inspection Plan

2.5.6 SEP-UIP-GGN, GGN Underground Components Inspection Plan

2.5.7 SEP-UIP-IPEC, IPEC Underground Components Inspection Plan

2.5.8 SEP-UIP-005, PLP Underground Components Inspection Plan

2.5.9 SEP-UIP-WF3, WF3 Underground Components Inspection Plan

2.6 Engineering and Project Reports

2.6.1 Engineering Report ECH-EP-10-00001, "Radiological SSC Groundwater Initiative Risk Evaluation Criteria", June 2010

2.6.2 Engineering Project Report "Guidelines for Management of Reasonable Assurance of Integrity for Above and Underground SSCs Containing Radioactive Material". Note this reference contains the following attachments:

- Attachment A – ECH-EP-10-00001 (Reference 2.6.1)
- Attachment B - "Fleet Guidance for the Determination of Reasonable Assurance for Structural and/or Leakage Integrity for High Risk Underground Piping," September 29, 2010. Note that this Attachment is now superseded by reference 2.4.25.
- Attachment C - EPRI IR-2010-409 (Reference 2.4.1)

3.0 <u>DEFINITIONS</u>

3.1 The definitions utilized by this Program Section are provided in the latest revision of EN-DC-343 Section 3. (Reference 2.2.6).

3.2 Because of the evolution of this Program Section and NUREG 1801, the definitions differ between underground piping (and tanks) and buried piping (and tanks) as follows:

3.2.1 For this Program Section, "Underground Piping (and Tanks)" is defined as piping and tanks that are below grade and that may or may not be in direct contact with soil or concrete. This includes piping and tanks that are directly buried and those that are embedded in concrete or located in underground concrete vaults, tunnels, or guard pipes.

3.2.2 Per NUREG-1801 Rev 2, XI.M41 under Program Description, "….buried piping and tanks are in direct contact with the soil or concrete (e.g., a wall penetration). Underground piping and tanks are below grade but are contained within a tunnel or vault such that they are in contact with air and are located where access for inspection is restricted." (Reference 2.4.11b)

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3.2.3 NUREG-1801 Rev 1 is silent on the distinction between "buried piping (and tanks)" and "underground piping (and tanks)."NUREG-1801 Rev 1 Section XI.M34 notes in the Scope of Program that periodic inspection is used to detect the "loss of material caused by corrosion of the external surface of buried piping and tanks." However, in the Preventive Actions section it states that underground piping and tanks "are coated during installation with a protective coating system to protect the piping from contacting the aggressive soil environment." (Reference 2.4.11a)

4.0 RESPONSIBILITIES

4.1 The responsibilities utilized by this Program Section are specified in the latest revision of EN-DC-343 Section 4 (Reference 2.2.6).

5.0 DETAILS

5.1 REGULATORY BASIS AND INDUSTRY GUIDANCE

5.1.1 License Renewal Aging Management

- Each site is responsible for review of and compliance with the site specific license renewal requirements impacting underground piping and tanks.
- NUREG-1801, "Generic Aging Lessons Learned (GALL) Report" (References 2.4.11a and 11b) provides regulatory information on the identification of underground piping and tanks required to be addressed in the site's License Renewal Aging Management Program. Rev 1 and Rev 2 are both valid revisions. The appropriate revision is site dependent and is based on when a plant was relicensed, and what commitments were made associated with each revision.
- NEI 95-10 (1996), "Industry Guideline for Implementing the Requirements of 10 CFR Part 54; The License Renewal Rule" (Ref. 2.4.18), provides industry guidance associated with License Renewal.

5.1.2 Underground Piping and Tank Integrity Management

NEI 09-14 December 2010 (Reference. 2.4.16), describes the policies and practices that the Nuclear Industry has committed to in managing underground piping.

5.1.3 Groundwater Protection Initiative

NEI 07-07, "Industry Ground Water Protection Initiative, Final Guidance Document" August 2007 (Reference. 2.4.17), provides industry guidance addressing underground piping and tank systems that, if degraded, could provide a path for radioactive contamination to groundwater.

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5.1.4 Operating Experience

Site specific and general industry Operating Experience (OE) provide additional information with the potential to impact the program basis. Routine review of OE by the program owner as well as reporting leaks to INPO via EPIX is crucial to maintaining a proactive program.

5.2 COMPONENT IDENTIFICATION AND SAMPLE SELECTION METHODOLOGY

Methodology Overview

This section provides requirements for identifying components, establishing inspection populations and determining the inspection intervals applicable to the populations (Sites' inspection plans are presented in references 2.5.1 through 2.5.9). Additionally, requirements for expanding the scope of examination to determine the extent of the identified discrepancies are provided. An overview of the steps used to establish the inspection populations and intervals is as follows:

5.2.1 Identify the underground components in the program (Steps 5.2.9 through 5.2.15).

5.2.2 Perform an Impact Assessment for each component to determine the impact of a component failure on the plant and surrounding environs (Steps 5.2.16 through 5.2.18).

5.2.3 Perform a Corrosion Risk Assessment to determine the risk of component failure. (Steps 5.2.19 through 5.2.21)

5.2.4 Establish the inspection priority and interval based on the results of the Impact Assessment and the Corrosion Risk Assessment (Steps 5.2.22 through 5.2.25).

5.2.4.1 Consider any piping/tanks containing radioactive material high risk and automatically ranked as a "High Inspection Priority".

5.2.4.2 Conduct further risk ranking of piping/tanks containing radioactive material using the methodology developed in Engineering Report ECH-EP-10-00001, "Radiological SSC Groundwater Initiative Risk Evaluation Criteria" (Reference 2.6.1). This will prioritize radioactive or contaminated piping/tanks relative to each other. (Non radioactive piping/tanks are prioritized using Tables 9.2, 9.3, 9.4 & 9.5 and Steps 5.2.16 to 5.2.21).

5.2.5 Create line grouping in accordance with Reference 2.4.25. Grouping of pipes for inspection is recommended in order to reduce the overall inspection cost and duration. Pipes can be grouped based on attributes such as pipe material, coating type, soil/backfill, age, operating parameters, size, process fluid, use of cathodic protection (CP), and others.

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5.2.5.1 The specific grouping parameters will depend on the specific features of the components. The grouping of pipes with similar attributes may allow the results of the inspection to be extrapolated from one pipe to the others in the group, therefore reducing the number of excavations and cost. Completed direct examinations and results may be able to be applied to the entire underground line and to other pipes in the grouping.

5.2.6 Within each group, select the components for examination. (Reference 2.4.25)

5.2.7 Inspect portions of the selected components / segments using various examination techniques (Reference 2.6.2 Section 6)

5.2.8 Evaluate examination results for acceptability of the component / segment and the need to expand scope (Reference 2.4.25).

Component Identification

Each site maintains a list of all underground piping systems and their associated components within the site database. The listing includes:

5.2.9 All systems and underground segments that have been identified in the License Renewal Aging Management Program consistent with NUREG-1801, "Generic Aging Lessons Learned (GALL) Report" (Ref. 2.4.11a and 2.4.11b).

5.2.10 Underground or partially underground piping, tanks or sumps that, if degraded, could provide a path for radioactive or chemical contamination of groundwater, for example:

- Underground storage tanks (e.g., fuel oil tanks)
- Outdoor tanks (e.g., refueling water storage tanks, condensate storage tanks)
- Spent fuel pools
- Underground piping containing contaminated or potentially contaminated liquids
- Discharge canals
- Retention ponds or basins

5.2.11 Underground piping, tanks, or sumps determined to present a potential concern through review of site specific or general industry Operating Experience (OE).

5.2.12 Other underground piping, tanks, or sumps not covered by paragraphs 5.2.9, 5.2.10, or 5.2.11.

5.2.13 Identified components are evaluated for impact and corrosion risk as described under "Impact Assessment" and "Corrosion Risk Assessment" via Steps 5.2.16 through 5.2.21. As piping/tanks containing radioactive material are automatically ranked as a high risk, further risk ranking of those components relative to each other is conducted using Reference 2.6.1.

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Component Designation

5.2.14 Identified underground piping and tank/sump systems are typically divided into components / segments to aid in identification and scheduling. This will generally be accomplished by:

- Designating smaller piping runs which have the same parameters (e.g., pipe diameter, coating, backfill material, ground water conditions, etc.) for the length of the run as one component.
- Dividing larger piping runs into multiple components / segments with the same parameters.
- Designating individual tanks/sumps as separate components.

5.2.15 Component / Segment boundaries should:

- Include only one underground segment (including only portions of the system with like parameters) for impact and corrosion risk. While multiple components / segments may have the same parameters, there should not be significant variance of parameters within component / segment boundaries.
- Use logical break points such as valves, tank nozzles, and pipe branches.
- Comprise portions of the piping run with identical or nearly identical Impact and Corrosion Risk parameters.

Impact Assessment

5.2.16 Components are evaluated against the criteria of Table 9-2 to determine the impact/consequence that the component failure will have on the plant.

5.2.17 Any underground piping or tank identified through OE as potentially impacting the station shall be treated as High Impact until evaluated and its potential failure characterized.

5.2.18 The results of the Impact Assessment are input into the site database.

Corrosion Risk Assessment

5.2.19 The Program Owner shall perform the corrosion risk evaluation using Tables 9-3 and 9-4. These tables should NOT be used for radioactive components (classified automatically as "High Risk") as risk ranking of those components relative to each other is conducted using Reference 2.6.1. The time allowed for completion of the Corrosion Risk Assessment is as follows:

- The Corrosion Risk Assessment for components / segments evaluated as "High Impact" shall be completed within 3 months of their inclusion into the program.

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- The Corrosion Risk Assessment for components / segments evaluated as "Medium Impact" shall be completed within 4 months of their inclusion into the program.
- The Corrosion Risk Assessment for components / segments evaluated as "Low Impact" shall be completed within 6 months of their inclusion into the program.

5.2.20 The Corrosion Risk Tabulation (Table 9-4), must consider the following attributes contained in Table 9-3 using the following steps:

- Step 1: Using Table 9-3, take the Soil Resistivity Measurement results to determine the Soil Resistivity Risk Weight. This is the first weight number (1 -10).
- Step 2: Using Table 9-3, determine the Drainage Risk Weight. This is the second weight number (1 - 4)
- Step 3: Using Table 9-3, determine the Material Risk Weight. This is the third weight number (0.5 - 2)
- Step 4: Using Table 9-3, determine the cathodic protection and coating Risk Weight by considering the condition of both cathodic protection and coating. This is the fourth weight number (0.5 - 2).
- Step 5: Next, multiply together all weights from steps 1 thru 4 above to determine the final Corrosion Risk Assessment number (0.25 – 160).

5.2.21 The data generated shall be input into the site database.

<u>Determination of Inspection Priority and Inspection Intervals</u>

5.2.22 The inspection priority and applicable inspection intervals are determined using Table 9-1 and Engineering Report ECH-EP-10-00001, "Radiological SSC Groundwater Initiative Risk Evaluation Criteria" (Reference 2.6.1) for radioactive components and Table 9-5 for non-radioactive components.

CAUTION

Regardless of the examination method, selection and the inspection frequency, the program owner must also ensure that the examinations are sufficient to meet any site specific commitments such as those made in the License Renewal Application (LRA) or as part of the Nuclear Strategic Issues Advisory Committee (NSIAC) initiative presented in Reference 2.4.16.

The inspection/examination requirements included in References 2.4.25 and/or 2.6.2 shall be considered as minimum requirements unless License renewal commitments are more conservative or governing.

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Selection for Examination

5.2.23 Selection for Examination shall be performed as follows:

- Follow the process described in References 2.4.25 and/or 2.6.2
- Underground lines / segments shall be assigned to inspection groups based on various attributes, such as pipe material, line size, depth, coating, soil/backfill, age, proximity to ground water (height above or below the water table), etc. Line Grouping will optimize inspection scope, and schedule duration, while providing reasonable assurance of piping structural and/or leak integrity.
- Within each group, pipe segments shall be selected for examination in accordance with the guidelines provided in Reference s2.4.25 and/or 2.6.2.

Examination of Selected Components

5.2.24 Examination of selected components shall be performed as follows:

- Excavation and shoring work shall be performed in accordance with EN-IS-112 (reference 2.2.7)
- Required engineering evaluations for excavation and shoring work shall be documented in an Engineering Change (EC).
- Excavations should be large enough to expose a minimum of 10 feet of pipe for inspection. A Direct Examination at an individual excavation should assess the exposed length of pipe.
- Coating should be completely removed from the exposed section to allow for a comprehensive direct examination. Smaller areas of coatings may be removed for example when dealing with asbestos (and the coating is determined to be in good condition by a certified inspector).
- Coatings inspections must be conducted by experienced certified inspectors.
- A combination of indirect inspections and direct examinations may be conducted to provide reasonable assurance for the system structural integrity. Follow the guidelines provided in References 2.4.25 and/or 2.6.2 and document any evaluation in an EC.
- Portions of the selected components / segments shall be examined for the following parameters:
  1) External coating and wrapping condition (if applicable).
  2) Pipe wall thickness degradation
  3) Tank plate thickness degradation
  4) CP system performance (if applicable)

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5.2.25 Underground Components / Segments Made Accessible by Plant Activities

- Whenever plant activities result in the exterior of underground pipe being made accessible, an opportunistic inspection shall be performed to document the "as-found" conditions.
- Whenever plant activities result in a underground component being opened for maintenance or removed from the system, an inspection shall be performed on the interior/exterior to document the "as-found" conditions.

5.3 INSPECTION METHODOLOGIES FOR UNDERGROUND PIPES AND TANKS

5.3.1 EPRI Report IR-2010-409 (Reference 2.4.1) provides the available inspection and examination techniques that Entergy sites can use for underground piping and tank evaluation. Reference 2.6.2 Section 6 discusses the commonly used inspection methods including:

1) Internal Pig (Direct Examination)
2) Guided Wave (Indirect Examination)
3) Local Pipe NDE (Direct Examination)

5.4 LEAK DETECTION AND MONITORING

5.4.1 Reference 2.6.2 Section 7 provides a brief summary for examples of leak detection methods and provides information related to condition of the system components including:

1) Loss of pressure or flow
2) Changes to the tritium or other contaminant plume
3) Surface wetness
4) Potential for radionuclides to contaminate groundwater

5.4.2 Reference 2.6.2 Section 7 also discusses examples of available methods that may be used to detect and monitor leaks including:

1) Tracer gas
2) Acoustic signal
3) Dyes
4) Ground penetrating radar
5) Video cameras
6) Leak monitoring wells
7) Instrumentation

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5.5 EVALUATION OF INSPECTION DATA

Acceptance Criteria

5.5.1 Acceptance criteria for any degradation of external coating, wrapping, and pipe wall or tank plate thickness shall be developed **prior** to performing opportunistic and scheduled inspections.

5.5.2 Acceptance criteria are published in approved engineering documents. Piping with measured wall thickness less than 1/16" will be repaired / replaced.

5.5.3 A condition report shall be initiated when measured wall thickness is found to be less than 87.5% of the nominal thickness.

5.5.4 Refer to Reference 2.4.25, for Fitness for Service (FFS) calculations.

Corrective Actions

5.5.4 A Condition Report (CR) shall be initiated in the Paperless Condition Reporting System (PCRS) **IF** acceptance criteria are not met.

5.5.5 Engineering disposition is required for components that do not meet the acceptance criteria. The disposition shall include an evaluation determining the required expansion of sampling scope.

5.5.6 The corrective actions may include engineering evaluations, additional inspections, change of coating or replacement of corrosion susceptible components.

5.6 PREVENTIVE ACTIONS

Piping and Tanks

5.6.1 Newly installed piping and tanks should be coated as applicable in accordance with site specific specifications during installation to protect the piping and tanks from contacting the corrosive soil environment. Examples of acceptable protective coating systems include:

- Coal tar enamel with fiberglass wrap and a Kraft paper outer wrap.
- Polyolefin tape coating.
- Fusion bonded epoxy coating.

5.6.2 As part of preventive measures, the existing CP system may be upgraded or a new CP system may be installed.

5.6.3 For plants with installed CP systems for buried piping and tanks, the program owner and system engineer should:

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- Ensure Preventive Maintenance (PM) tasks exist to verify proper operation of these systems.
- Ensure the rectifiers and electrical anodes that make up the system are be tested periodically to ensure the minimum pipe to soil potentials as established by the site procedure. (NACE recommends a minimum limit of -0.85 VDC in the ground around the buried pipe.
- Ensure PM task frequency is set per current industry guidance.
- Ensure CP System is evaluated in accordance with EN-DC-343 Sections 4 and 5 (Reference 2.2.6).
- Ensure the Cathodic Protection system is formally assigned to a cognizant individual (e.g. a System Engineering)
- Verify CP system identified deficiencies are identified in PCRS and corrected on a schedule commensurate with the safety significance of the system/component being protected.
- For CP system degradation affecting Safety Related Structure, System or Component (SSC), recommend repair within the Work Week T- process
- For CP system degradation affecting Non-Safety Related SSC, recommend repair within 6 months of identification.

5.7 <u>REPAIR STRATEGIES</u>

5.7.1 When necessary, repairs to buried components are performed using existing Entergy processes for repair, replacement, or modification of plant components.

5.7.2 HDPE pipe may be considered for use when long lengths of piping are replaced. Considerations for the use of HDPE piping include:

- When HDPE is used, a tracer wire should be located on top of the piping to assist in locating the pipe after burial.
- Design and installation practices shall consider the potential for "Push-through" during the joining process of HDPE sections or fittings and resulting potential for flow restrictions.
- Design and installation should provide appropriate protection of HDPE piping to prevent unacceptable gouges in the material.
- It should be noted that the use of HDPE piping in the industry has been limited with no substantial reliability data. In addition several associated technical issues are still under review by industry groups.

5.7.3 Care must be exercised during backfilling operations to ensure repairs are not adversely affected.

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5.8 MITIGATION STRATEGIES

5.8.1 Reference 2.6.2 Section 8 provides the "pros and cons" of the mitigation strategies that sites can use for repair or replacement including:

- Routing tritiated and contaminated piping in an engineered trench or sealed vault
- Using pipe in a pipe and tunnel configurations
- Rerouting above ground
- Using carbon fiber wrap
- Replacing existing materials with upgraded materials (HDPE, SS, AL-6XN alloy, etc.)
- Replacing like-for-like
- Using cured-in place lining of piping
- Providing CP coverage as a barrier to external corrosion.

5.8.2 Other mitigation options include deleting or abandoning the system, redesigning the system so no radioactive material is contained in the system, installing berms to fully contain the radioactive material, application of corrosion inhibitors, improvement of water treatment, and performing internal cleaning to remove residual radioactive material.

5.8.3 Depending on the risk ranking and the extent to which the option selected is intended to mitigate the risk, these mitigation strategies may be used individually or a combination of these strategies may be implemented to provide added level of defense.

5.9 ADDITIONAL REQUIREMENTS/RECOMMENDATIONS

5.9.1 This Program Section interfaces with the Ground Water Monitoring Plans established at each site. It should be noted that the Ground Water Protection Initiative (GPI) and Underground Piping and Tanks Integrity Initiative (UPTI) have similar goals and overlapping activities. However, the function and scope of the UPT Program Engineer differ from that of the Ground Water Protection (GP) specialist as follows:

- UPT Engineer: Predicts and prevents leaks for underground radioactive and non-radioactive SSCs
- GP Specialist: Detects leaks early, contains spills, monitors and reports ground water contamination resulting from underground or above ground radioactive SSC leaks.

5.9.2 Therefore, the UPT Engineer and the GP Specialist must:

- Coordinate inspection and monitoring activities. Inspection activities should also involve the FAC and MIC Engineers as applicable.

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- Share operating experience and coordinate EPIX reporting.
- Have a clear knowledge of the two program scopes and associated SSCs (including monitoring wells) to ensure no ground contamination can occur by a SSC that is not covered by any one of the two programs.
- Periodically (recommended every 6 months) review and update scope and risk ranking. As an example, when ground water samples show changes in contamination or when systems that are non-radioactive become contaminated.
- Periodically review the GP and UPT program revisions and site inspection results.
- Have a good understanding of activities in place for monitoring the Spent Fuel Pool (SFP), building and storm drains, abandoned pipe, drinking water and sanitary waste effluent.
- Periodically interface with the Spill Prevention Control and Countermeasure (SPCC) program owner.
- The UPT Program Engineer must gain a general understanding of site geo-hydrology and SSC leakage vulnerabilities.
- The UPT Program Engineer must gain general knowledge of CP, FAC and MIC.

5.9.3 The UPT Engineer must ensure that in addition to UPT Program Health Report, related System and Component Health Reports reflect identified degraded conditions.

5.9.4 The UPT Engineer, when planning and implementing inspections, must involve the following individuals as appropriate:

- Chemistry / Environmental Specialist(s)
- System Engineer(s) (including CP Engineer)
- Design Engineering
- MIC Program Engineer
- FAC Program Engineer
- Maintenance
- Operations
- Radiation Protection
- Planning & Scheduling
- Security

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6.0 INTERFACES

6.1 The interfaces utilized by this Program Section are provided in the latest revision of EN-DC- 343 Section 6. (Reference 2.2.6).

7.0 RECORDS

7.1 The latest revision of EN-DC-343 Section 7 (Reference 2.2.6) specifies the needed records to implement the program.

7.2 Pertinent data generated during the course of Underground Piping and Tank inspections should be referenced or retained by the Program Owner within the site database.

8.0 OBLIGATIONS AND COMMITMENTS

8.1 All initial site program commitments to the Underground Piping and Tank Program are captured in LO-HQNLO-2008-00015.

8.2 Specific site commitments to the Underground Piping and Tanks Program are captured in PCRS and the latest revision of EN-DC-343 Section 8 (Reference 2.2.6).

8.3 License Renewal commitments for existing programs for examination and corrective action for the Underground Piping and Tanks Program are captured in EN-DC-343 Section 8 (Reference 2.2.6).

9.0 TABLES

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Table 9-1 Inspection Priority, Milestones and Intervals for Radioactive SSCs

Inspection Priority	Scope	Initial Inspection, Condition Assessment Milestone	Inspection Interval (years)*
High - High	Buried Piping	06/30/2013	10
High - Medium	Buried Piping	06/30/2013	10
High - Low	Buried Piping	06/30/2013	15
High - High	Underground Piping (not Buried) and Tanks	06/30/2014	10
High - Medium	Underground Piping (not Buried) and Tanks	06/30/2014	10
High - Low	Underground Piping (not Buried) and Tanks	06/30/2014	15
All	Sumps	To be determined by the sites	15

Notes:

1. Underground components containing radioactive material are automatically considered “High Inspection Priority” and are further prioritized relative to each other as “High-High”, High-Medium” and “High-Low” per Reference 2.6.1.
2. Inspections shall begin no later than June 30, 2012

Note *: or as determined by inspection results.

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Table 9-2 Impact Assessment

	High	Medium	Low
Safety Class per EN-DC-167	Safety Related	Augmented QP and Fire Protection	Non-Safety Related
Public Risk	Radioactive Contamination e.g. Tritium	Chemical/Oil Treated System gases	Untreated Water SW, Demin Water
Economics (Cost of failure)	>$1M or Potential Shutdown	>$100K<$1M	<$100K

Notes:

1. Any underground segment with at least one High Impact rating receives an overall High Impact rating.
2. Any underground segment with no High Impact Rating but at least one Medium Impact rating receives an overall Medium Impact rating.
3. Any buried segment with all Low Impact ratings is to be rated as Low Impact.
4. Any piping containing radioactive material will automatically be ranked as a “High Inspection Priority”. Further risk ranking of those components relative to each other is conducted using reference 2.6.1
5. Any piping containing chemicals / oil / treated gases will be ranked as a “Medium Inspection Priority”

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Table 9-3: Corrosion Risk Assessment for Non-Radioactive SSCs		
Soil Resistivity, Ω-cm (Note 1)	**Corrosivity Rating**	**Soil Resistivity Risk Weight**
>20,000	Essentially Non-corrosive	1
10,001-20,000	Mildly Corrosive	2
5,001-10,000	Moderately Corrosive	4
3,001-5,000	Corrosive	5
1,000-3,000	Highly Corrosive	8
<1,000	Extremely Corrosive	10
Drainage		**Drainage Risk Weight**
Poor	Continually Wet	4
Fair	Generally Moist	2
Good	Generally Dry	1
Material (Note 2)		**Material Risk Weight**
Carbon and Low Alloy Steel		2.0
Cast and Ductile Iron		1.5
Stainless Steel		1.5
Copper Alloys		1.0
Fiberglass		1.0
Concrete		0.5
Titanium		0.5
Cathodic Protection	**Coating**	**CP/Coating Risk Weight**
No CP	No Coating	2.0
No CP	Degraded Coating	2.0
No CP	Sound Coating	1.0
Degraded CP	No Coating	1.0
Degraded CP	Degraded Coating	1.0
Degraded CP	Sound Coating	0.5
Sound CP	No Coating	0.5
Sound CP	Degraded Coating	0.5
Sound CP	Sound Coating	0.5

Notes:

1. Soil resistivity measurements must be taken at least once per 10 years (or use conservative values) unless areas are excavated and backfilled or if soil conditions are known to have changed for any reason. Because soil resistivity can be impacted by significant temperature changes, consider taking two measurements, one during hot weather conditions and one during cold weather conditions.
2. Appendix A gives further insight to the corrosion of materials in soils.

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Table 9-4: Corrosion Risk Tabulation for Non-Radioactive SSCs		
Corrosion Condition		**Risk Weight Points**
<u>Soil Conditions</u>		
Resistivity	Section 5.2.20 Step 1	1 - 10
Drainage	Section 5.2.20 Step 2	1 - 4
<u>Materials</u>		
Materials	Section 5.2.20 Step 3	0.5 - 2
<u>Component Protection</u>		
Cathodic Protection/Coating	Section 5.2.20 Step 4	0.5 - 2
<u>Final Corrosion Risk Tabulation</u>		
Multiply all weights together	Section 5.2.20 Step 5	0.25 - 160
High Corrosion Risk **61-160 pts**	**Medium Corrosion Risk** **30-60 pts**	**Low Corrosion Risk** **0.25-29 pts**

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Table 9-5 Inspection Priority and Intervals for Non-Radioactive SSCs

Impact-Corrosion Risk	Inspection Priority	Initial Inspection Date	Inspection Interval (years)
High-High	High	To be determined by sites	10*
High-Medium	High		15*
Medium-High	High		15*
High-Low	Medium		As determined by inspection results
Medium-Medium	Medium		
Low-High	Medium		
Medium-Low	Low		
Low-Medium	Low		
Low-Low	Not required	Not required	Not required

Notes:

1. High priority initial inspections schedule shall be determined by the site. Subsequent High priority inspections shall be scheduled within 10 to 15 years thereafter.
2. Medium and Low priority initial inspections schedule shall be determined by the site. Subsequent Medium and Low priority inspections shall be scheduled based on the initial inspection results (i.e. if degradation is identified).
3. Components / Segments with low impact and low corrosion risk need not be inspected.
4. Once inspections are performed and conditions become known, a re-prioritization may maintain, decrease, or increase a component future inspection priority.
5. In cases of piping placed in service after original plant construction, initial inspections may be established based on installation date and 40 year design life.

Note *: or as determined by inspection results.

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Corrosion of Materials in Soils

The corrosion of metals in soils can be divided into two broad categories: corrosion in undisturbed soils and corrosion in disturbed soils. Corrosion in undisturbed soils is always low, regardless of soil conditions, and is limited only by the availability of the oxygen necessary for the cathodic reaction.

Corrosion of metals in disturbed soils is strongly affected by soil conditions, electrical resistivity, mineral composition, dissolved salts, moisture content, total acidity or alkalinity (pH), redox potentials, microbiological activity, and concentration of oxygen. Any metal buried by backfilling is in a disturbed soil and is subject to corrosion attack, depending on the characteristics of the soil, Reference 1, page 497.

The supply of oxygen is comparatively large above the groundwater table but is considerably less below it and is influenced by the type of soil. It is high in sand but low in clay. The different aeration characteristics may lead to significant corrosion problems due to the creation of oxygen concentration cells, Reference 2, page 8.

Cast and Ductile Irons

Neither metal-matrix nor graphite morphology has an important influence on the corrosion of cast irons in soil. Corrosion of cast irons in soils is a function of soil porosity, drainage and dissolved constituents in the soil. Irregular soil contact can cause pitting, and poor drainage increases corrosion rates substantially above the rates in well-drained soils, Reference 2, page 48.

Carbon and Low-Alloy Steels

The corrosion rate of carbon and low alloy steels in soil depends primarily on the nature of the soil and certain other environmental factors, such as the availability of moisture and oxygen. The water content, together with the oxygen and carbon dioxide contents are major corrosion-determining factors. The redox potential in the soil becomes nobler with the increase of oxygen concentration in the soil.

In the pH range of 5 to 8, factors other than pH have greater influence on the corrosion of steel. The risk of localized corrosion (pitting) is high if the soil resistivity is lower than 1000 ohm-cm.

Sulfate-reducing bacteria, which occur under anaerobic conditions such as in deep soil layers, form iron sulfide as a corrosion product. Anaerobic bacterial corrosion is more serious when it is combined with a differential aeration cell, in which the anaerobic cell works as a local anode.

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Steel buried in the ground provides a better electrical conductor than the soil for stray return currents from electrical systems such as electrical grounding equipment and cathodic protection systems on nearby buried metal. Accelerating corrosion occurs at the point where the current leaves the steel to the earth, Reference 2, pages 8-9.

Stainless Steels

Generally, buried stainless steels suffer from soil corrosion because of one or more of the following conditions: high moisture content, pH less than 4.5, resistivity less than 1000 ohm-cm, presence of chlorides (> 500ppm), sulfides and bacteria and the presence of stray currents.

Oxygen takes part in the cathodic reaction and a supply of oxygen is therefore, in most circumstances, a prerequisite for corrosion in soil. The supply of oxygen changes with the type of soil and the different oxygen levels may lead to corrosion problems due to the creation of oxygen concentration cells. The oxygen concentration of the soil moisture generally will determine its redox potential. The higher the oxygen content the higher the redox potential. However, low redox values may provide an indication that conditions are conducive to anaerobic microbiological activity.

Another of the most important conditions for corrosion to occur is the chloride ion (Cl^-) concentration in the soil and the moisture, which can contain different dissolved species such as sulfate ions (SO_4^{-2}) and some others e.g.: H^+, HCO_3^-, etc., Reference 3.

Copper Alloys

Copper exhibits high resistance to corrosion by most soils. National Bureau of Standards (NBS) study results indicate that tough pitch coppers, deoxidized coppers, silicon bronzes and low-zinc brasses behave essentially alike. The corrosion rate of copper in quiescent groundwater tends to decrease with time due to the formation of a protective film in which the underlying layer consists of species from the groundwater as well as copper.

For copper and copper alloys, corrosion rate depends strongly on the amount of dissolved oxygen present; deoxygenation results in ground water tests show at least an order of magnitude decrease in the short-term corrosion rate. In aerated solutions, the addition of nickel (90 Cu-10 Ni) decreases the uniform corrosion rate of copper by the formation of a more highly protective surface film.

Soils containing high concentrations of sulfides, chlorides, of hydrogen ions (H+) corrode these materials. Where local soil conditions are unusually corrosive, it may be necessary to use some means of protection, such as cathodic protection, neutralizing backfill (limestone, for example), protective coating or wrapping, Reference 2, pages 132 to 138.

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Titanium Alloys

There are no indications in the literature that titanium alloys are susceptible to corrosion in soils; however, some reference to the corrosion resistance of titanium alloys in waters that would be present in soils is beneficial to this understanding.

"Titanium and its alloys are fully resistant to water, all natural waters, and steam to temperatures in excess of 600°F. Titanium alloys exhibit negligible corrosion rates in seawater to temperatures as high as 500°F. Pitting and crevice corrosion will not occur in ambient seawater, even if marine deposits form and biofouling occurs", Reference 2, page 260.

"Crevice attack of titanium alloys will generally not occur below a temperature of 160°F regardless of solution pH or chloride concentration or when solution pH exceeds 10 regardless of temperature", Reference 2, page 268.

References:

[1] ASM Handbook, Volume 13A, "Corrosion: Fundamentals, Testing and Protection, ASM International", October 2003

[2] ASM Handbook, Volume 13B, "Corrosion: Materials, ASM International", November 2005

[3] "Corrosion Resistance of Stainless Steels in Soils and in Concrete", by Pierre-Jean Cunat. Paper presented at the Plenary Days of the Committee on the Study of Pipe Corrosion and Protection, Ceocor, Biarritz, October 2001

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