10. CULVERTS

The District Materials Branch (or the consultant under contract) is responsible for conducting a corrosion investigation for drainage facilities. This includes culverts to be repaired or replaced in addition to proposed new sites. For a rehabilitation project, it is common practice to perform a culvert survey of existing drainage facilities to determine the need for clean-out, repair, and/or replacement.

When a culvert has failed prematurely, sampling and testing of in-situ soil and water for selection of appropriate replacement culvert materials is suggested. Representative samples of both the soil and drainage water should be collected and tested. Detailed photos of the distressed pipe can be sent to the Corrosion Branch to assist in an analysis of the causes and for recommendations on repair.

10.1 Corrosion Sampling and Testing for Culverts

Corrosion investigations for culverts should include sampling of in-situ soil within the limits of the existing or proposed culvert, sampling of water that will or does flow into the culvert, and sampling of any fill material used as backfill for the culvert. If a project will have multiple culverts, samples of soil and water should be obtained from each specific location on the project site.

Representative surface water samples taken for proposed off-site drainage should be selected from the live stream or existing standing water at the inlet end of the facility. Water samples should never be taken when the water level is elevated due to recent storm runoff or flooding. Elevated stream flows dilute chemical concentrations in the stream making the sample concentrations appear lower than usual. Corrosion testing of soil samples (both surface and subsurface soil samples) and water samples shall follow the methods outlined in the ***California Tests*** (see References).

When imported material is used as structure backfill for metal products such as steel pipe culverts or reinforced concrete culverts and headwalls, the imported backfill should be less corrosive than the native soil material. Consequently, the contract special provisions should specify corrosive parameters for the imported fill that are less corrosive than those of the native soil. The imported backfill should be tested in accordance with ***CTs 643***, ***417***, and ***422*** prior to placement. This applies to imported soil and lightweight aggregate fill.

Slag based materials high in sulfate concentrations can attack the cement mortar in reinforced concrete pipe. If slag aggregate has been or is proposed for use as culvert backfill, it must be tested to determine its' suitability as structure backfill material.

Field screening tests for resistivity and pH can be used to quickly identify the most aggressive on-site soil samples for corrosion testing. This simple screening

test can eliminate the need for obtaining multiple soil samples for lab tests. If suitable field- measuring equipment is not available to perform the screening tests, it is important to obtain sufficient soil material to be representative of all material within the proposed limits of the culvert.

10.2 Culvert Material

The selection of culvert material is based on the corrosion test results from ***CT 643*** (both soil and water testing) and the criteria presented in Chapter 850 of the ***HDM***. The software, *ALTPIPE* see Reference, (***Alternative Pipe Culvert Selection (ALTPIPE)***) is available for selecting culvert material based on site conditions. *ALTPIPE* requires a value for chlorides and sulfates and the Corrosion Branch occasionally receives request to run the program without actual values for chlorides and sulfates for the soil. If the resistivity and pH are greater than specified in Section 6.1 of these Guidelines a placeholder of 100 ppm can be used to run the program. Whenever possible, it is recommended that water samples be collected and tested for chlorides, sulfates and other halides. The Corrosion Branch has an extensive database of soil values available for additional reference values.

Galvanized Steel Pipe

The years to first perforation and the maintenance-free service life are based solely on the minimum resistivity and pH of the soil and/or water samples as shown in Figures 855.3A (Minimum Thickness of Metal Pipe for 50 Year maintenance-Free Service Life) and 855.3B (Chart for Estimating Years to Perforation of Steel Culverts), Chapter 850 of the ***HDM***. Galvanized steel pipe is not recommended where high sediment load exist as the galvanized coating can be worn away in as little as 15 years. The Corrosion Branch has investigated numerous galvanized metal culverts and it is common to see abrasion wearing down the metal ribs (along the flowline) at a faster rate than that of corrosion. The Corrosion Branch has a standard detail for paving and repairing the inverts of galvanized metal culverts that have degraded sufficiently that to reveal the bedding underneath.

In corrosive environments, protective coatings, linings, and pavings on the inside and/or outside of steel pipe and culverts can be used to extend the maintenance-free service life. Chapter 850 of the ***HDM*** and ***Section 66-1.02C Protective Coatings, Linings, and Paving*** **of the** ***Standard Specifications*** (see References) describes the various types of coatings and linings that may be selected to extend the maintenance-free service life.

Any damage to galvanizing, protective coatings, linings, and pavings that occurs during handling, installation, or construction must be rejected or repaired as specified in accordance with manufacturer's recommendations. Damage includes

scratches, pinholes, cracks, or coating de-bonding.

Aluminum and Aluminized Steel (Type 2) Pipe

Aluminum culverts include corrugated aluminum pipe and pipe arches, aluminum spiral rib pipe, and structural aluminum plate pipe and arches. For a 50-year maintenance-free service life, aluminum can only be used if the soil, backfill, and drainage water meet the following:

1. Minimum resistivity must be greater than 1500 ohm-cm, ***CT 643***

2. pH must be between 5.50 and 10.0, ***CT 643***

As an alternative to coating steel pipe with zinc (i.e., hot-dip galvanizing), steel pipe can be aluminized (Type 2). Aluminized steel pipe is steel pipe that is protected against corrosion by hot-dipping in an aluminum coating. For a 50-year maintenance-free service life, aluminized steel (Type 2) pipe can only be used if the soil, backfill, and drainage water meet the following:

1. Minimum resistivity must be greater than 1500 ohm-cm, ***CT 643***

2. pH must be between 5.50 and 10.0, ***CT 643***

3. Minimum thickness of 0.0629 in (16 gauge)

Bituminous or polymerized coatings are not recommended for corrosion protection of aluminized steel, but may be used for abrasion resistance.

Non-reinforced Concrete Pipe

The use of non-reinforced concrete pipe can be advantageous when reinforcing steel is not required to provide strength. Without reinforcing steel, the presence of chloride and stray current cannot compromise the service performance of the pipe. Acidity and sulfates in the soil and/or water, however, can affect this type of pipe by attacking the cement. For corrosive environments (see Section 6.1 of these Guidelines), ***Section 90-1.02H Concrete in Corrosive Environments*** of the ***Standard Specifications*** applies.

Reinforced Concrete Pipe, Box Culverts and Arch Culverts

Reinforced concrete pipe (RCP) is typically precast, performs well under most conditions, and is commonly selected when a corrosive environment exceeds the limits for using corrugated metal pipe. For corrosive environments (see Section 6.1 of these Guidelines), ***Section 90-1.02H Concrete in Corrosive Environments*** of the ***Standard Specifications*** applies.

Plastic Pipe

Plastic pipe is not subject to corrosion and can be a good performer in areas that are corrosive. In general, exposure to sunlight (ultraviolet rays) has an adverse effect on the service life of plastic pipes and products. For a plastic pipe, ultraviolet (UV) rays from the sun can induce degradation and ultimately cause loss of mechanical properties, which may result in premature failure of the pipe. HDPE and PVC plastic pipes approved for use by the Department have UV inhibitors added for protection against sunlight.

When plastic pipe is installed in areas that may be subject to fire, consider using concrete headwalls or metal flared end sections to reduce the potential damage to the ends of the pipe. Also, accumulated debris and trash may carry a fire into the pipe.

10.3 Cement Slurry, Controlled Low Strength Material (CLSM) or Concrete Backfill for Culverts

When placing culverts in existing roadways, it is sometimes necessary to use fast setting concrete backfill. Admixtures used to accelerate the set time of concrete must be on the ***Departments Authorized Materials Lists (AML)*** (see References). Placement of a cementitious backfill material does not negate the requirement to perform corrosion analysis of the native soil and water.