April 29, 2008 via email: RYoung@castlecooke.com

CASTLE & COOKE AVIATION
7415 Hayvenhurst Place
Van Nuys, CA 91406

Attention: Mr. Ross Young

Re: Soil Corrosivity Study
Century Aero Club Project
Van Nuys, California
SA #08-0395SCSP

## INTRODUCTION

Laboratory tests have been completed on two soil samples provided for the referenced project. The purpose of these tests was to determine if the soils might have deleterious effects on underground utility piping and concrete structures. Schiff Associates assumes that the samples provided are representative of the most corrosive soils at the site.

The proposed construction consists of a customer service building and aircraft parking. The site is located at the intersection of Hayvenhurst Avenue and Saticoy Street in Van Nuys, California. The water table depth was not provided; therefore, its effect on site corrosivity could not be accounted for in this analysis and report.

The scope of this study is limited to a determination of soil corrosivity and general corrosion control recommendations for materials likely to be used for construction. Our recommendations do not constitute, and are not meant as a substitute for, design documents for the purpose of construction. If the architects and/or engineers desire more specific information, designs, specifications, or review of design, Schiff Associates will be happy to work with them as a separate phase of this project.

## LABORATORY SOIL CORROSIVITY TESTS

The electrical resistivity of each sample was measured in a soil box per ASTM G187 in its as-received condition and again after saturation with distilled water. Resistivities are at about their lowest value when the soil is saturated. The pH of the saturated samples was measured per CTM 643. A 5:1 water:soil extract from each sample was chemically analyzed for the major soluble salts commonly found in soil per ASTM D4327 and D513. Test results are shown in Table 1.

**SOIL CORROSIVITY**

A major factor in determining soil corrosivity is electrical resistivity. The electrical resistivity of a soil is a measure of its resistance to the flow of electrical current. Corrosion of buried metal is an electrochemical process in which the amount of metal loss due to corrosion is directly proportional to the flow of electrical current (DC) from the metal into the soil. Corrosion currents, following Ohm's Law, are inversely proportional to soil resistivity. Lower electrical resistivities result from higher moisture and soluble salt contents and indicate corrosive soil.

A correlation between electrical resistivity and corrosivity toward ferrous metals is:[1]

| Soil Resistivity in ohm-centimeters | | | Corrosivity Category |
|---|---|---|---|
| over | | 10,000 | mildly corrosive |
| 2,000 | to | 10,000 | moderately corrosive |
| 1,000 | to | 2,000 | corrosive |
| below | | 1,000 | severely corrosive |

Other soil characteristics that may influence corrosivity towards metals are pH, soluble salt content, soil types, aeration, anaerobic conditions, and site drainage.

Electrical resistivities were in the mildly to moderately corrosive categories with as-received moisture. When saturated, the resistivities were in the moderately corrosive to corrosive categories. The resistivities dropped considerably with added moisture because the samples were dry as-received.

Soil pH values varied from 7.6 to 7.8. This range is mildly alkaline.[2] These values do not particularly increase soil corrosivity.

The soluble salt content of the samples ranged from low to moderate.

Ammonium and nitrate were detected in low concentrations.

Tests were not made for sulfide and negative oxidation-reduction (redox) potential because these samples did not exhibit characteristics typically associated with anaerobic conditions.

This soil is classified as corrosive to ferrous metals.

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[1] Romanoff, Melvin. *Underground Corrosion, NBS Circular 579*. Reprinted by NACE. Houston, TX, 1989, pp. 166–167.
[2] Romanoff, Melvin. *Underground Corrosion, NBS Circular 579*. Reprinted by NACE. Houston, TX, 1989, p. 8.

## CORROSION CONTROL RECOMMENDATIONS

The life of buried materials depends on thickness, strength, loads, construction details, soil moisture, etc., in addition to soil corrosivity, and is, therefore, difficult to predict. Of more practical value are corrosion control methods that will increase the life of materials that would be subject to significant corrosion.

The following recommendations are based on the soil conditions discussed in the Soil Corrosivity section above. Unless otherwise indicated, these recommendations apply to the entire site or alignment.

### Steel Pipe

Implement *all* the following measures:

1. Underground steel pipe with rubber gasketed, mechanical, grooved end, or other nonconductive type joints should be bonded for electrical continuity. Electrical continuity is necessary for corrosion monitoring and cathodic protection.
2. Install corrosion monitoring test stations to facilitate corrosion monitoring and the application of cathodic protection:
    a. At each end of the pipeline.
    b. At each end of all casings.
    c. Other locations as necessary so the interval between test stations does not exceed 1,200 feet.
3. To prevent dissimilar metal corrosion cells and to facilitate the application of cathodic protection, electrically isolate each buried steel pipeline per NACE Standard SP0286 from:
    a. Dissimilar metals.
    b. Dissimilarly coated piping (cement-mortar vs. dielectric).
    c. Above ground steel pipe.
    d. All existing piping.
4. Choose one of the following corrosion control options:

    ***OPTION 1***

    a. Apply a suitable dielectric coating intended for underground use such as:
        i. Polyurethane per AWWA C222 *or*
        ii. Extruded polyethylene per AWWA C215 *or*
        iii. A tape coating system per AWWA C214 *or*
        iv. Hot applied coal tar enamel per AWWA C203 *or*
        v. Fusion bonded epoxy per AWWA C213.
    b. Apply cathodic protection to steel piping as per NACE Standard SP0169.

    ***OPTION 2***

    As an alternative to dielectric coating and cathodic protection, apply a ¾-inch cement mortar coating per AWWA C205 or encase in concrete 3 inches thick, using any type of cement. Joint bonds, test stations, and insulated joints are still required for these alternatives.

NOTE: Some steel piping systems, such as for oil, gas, and high-pressure piping systems, have special corrosion and cathodic protection requirements that must be evaluated for each specific application.

**Iron Pipe**

Implement *all* the following measures:

1. Electrically insulate underground iron pipe from dissimilar metals and from above ground iron pipe with insulating joints per NACE Standard SP0286.
2. Bond all nonconductive type joints for electrical continuity. Electrical continuity is necessary for corrosion monitoring and cathodic protection.
3. Install corrosion monitoring test stations to facilitate corrosion monitoring and the application of cathodic protection:
    a. At each end of the pipeline.
    b. At each end of any casings.
    c. Other locations as necessary so the interval between test stations does not exceed 1,200 feet.
4. Choose one of the following corrosion control options:

    ***OPTION 1***

    a. Apply a suitable coating intended for underground use such as:
        i. Polyethylene encasement per AWWA C105; *or*
        ii. Epoxy coating; *or*
        iii. Polyurethane; *or*
        iv. Wax tape.

        NOTE: The thin factory-applied asphaltic coating applied to ductile iron pipe for transportation and aesthetic purposes does not constitute a corrosion control coating.

    b. Apply cathodic protection to cast and ductile iron piping as per NACE Standard SP0169.

    ***OPTION 2***

    As an alternative to dielectric coating and cathodic protection, concrete encase all buried portions of metallic piping so that there is a minimum of 3 inches of concrete cover provided over and around surfaces of pipe, fittings, and valves using any type of cement.

**Copper Tubing**

Implement *all* the following measures:

1. Place cold water copper tubing in an 8-mil polyethylene sleeve or encase in double 4-mil thick polyethylene sleeves and bed and backfill with clean sand at least 2 inches thick surrounding the tubing. Clean sand should have a minimum resistivity of no less than 3000 ohm-cm, and a pH of 6.0–8.0. Copper tubing for cold water can also be treated the same as for hot water.
2. Hot water tubing may be subject to a higher corrosion rate. Protect hot copper tubing by one of the following measures:
    a. Preventing soil contact. Soil contact may be prevented by placing the tubing above ground or encasing the tubing with PVC pipe with solvent-welded joints. *or*

b. Applying cathodic protection per NACE Standard SP0169. The amount of cathodic protection current needed can be minimized by coating the tubing.

**Plastic and Vitrified Clay Pipe**

1. No special precautions are required for plastic and vitrified clay piping placed underground from a corrosion viewpoint.
2. Protect all metallic fittings and valves with wax tape per AWWA C217 or epoxy.

**All Pipe**

1. On all pipes, appurtenances, and fittings not protected by cathodic protection, coat bare metal such as valves, bolts, flange joints, joint harnesses, and flexible couplings with wax tape per AWWA C217 after assembly.
2. Where metallic pipelines penetrate concrete structures such as building floors, vault walls, and thrust blocks use plastic sleeves, rubber seals, or other dielectric material to prevent pipe contact with the concrete and reinforcing steel.

**Concrete**

1. From a corrosion standpoint, any type of cement may be used for concrete structures and pipe because the sulfate concentration is negligible, 0 to 0.1 percent.[3,4,5,6]
2. Standard concrete cover over reinforcing steel may be used for concrete structures and pipe in contact with these soils due to the low chloride concentration[7] found onsite.

## CLOSURE

Our services have been performed with the usual thoroughness and competence of the engineering profession. No other warranty or representation, either expressed or implied, is included or intended.

Please call if you have any questions.

Respectfully Submitted,
SCHIFF ASSOCIATES

Leobardo Solis

LICENSED PROFESSIONAL ENGINEER
BRIEN L. CLARK
CH 6291
EXP. 12/31/09
CHEMICAL
STATE OF CALIFORNIA

Brien L. Clark, P.E.
4-29-08

Enc: Table 1

[3] 1997 Uniform Building Code (UBC) Table 19-A-4
[4] 2006 International Building Code (IBC) which refers to American Concrete Institute (ACI-318) Table 4.3.1
[5] 2006 International Residential Code (IRC) which refers to American Concrete Institute (ACI-318) Table 4.3.1
[6] 2007 California Building Code (CBC) which refers to American Concrete Institute (ACI-318) Table 4.3.1
[7] *Design Manual 303: Concrete Cylinder Pipe*. Ameron. p.65

SCHIFF ASSOCIATES

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# Table 1 - Laboratory Tests on Soil Samples

***Castle & Cooke Aviation***
***Century Aero Club Project, Van Nuys, CA***
***SA #08-0395SCSP***
***10-Apr-08***

| **Sample ID** | | | Sample A<br>B-1<br>@ 1-10' | Sample B<br>B-2<br>@ 1-10' |
|---|---|---|---|---|
| **Resistivity** | | **Units** | | |
| as-received | | ohm-cm | 6,800 | 11,600 |
| saturated | | ohm-cm | 2,320 | 1,720 |
| **pH** | | | 7.8 | 7.6 |
| **Electrical Conductivity** | | mS/cm | 0.25 | 0.19 |
| **Chemical Analyses** | | | | |
| **Cations** | | | | |
| calcium | $Ca^{2+}$ | mg/kg | 188 | 134 |
| magnesium | $Mg^{2+}$ | mg/kg | 30 | 21 |
| sodium | $Na^{1+}$ | mg/kg | 45 | 25 |
| potassium | $K^{1+}$ | mg/kg | 43 | 35 |
| **Anions** | | | | |
| carbonate | $CO_3^{2-}$ | mg/kg | ND | ND |
| bicarbonate | $HCO_3^{1-}$ | mg/kg | 668 | 357 |
| flouride | $F^{1-}$ | mg/kg | 5.4 | 1.6 |
| chloride | $Cl^{1-}$ | mg/kg | 6.8 | 3.6 |
| sulfate | $SO_4^{2-}$ | mg/kg | 78 | 143 |
| phosphate | $PO_4^{3-}$ | mg/kg | 3.9 | 4.8 |
| **Other Tests** | | | | |
| ammonium | $NH_4^{1+}$ | mg/kg | 9.1 | 9.6 |
| nitrate | $NO_3^{1-}$ | mg/kg | 2.5 | 15 |
| sulfide | $S^{2-}$ | qual | na | na |
| Redox | | mV | na | na |

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

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