Steel underground how long will it last?

Introduction
Buried steel items are subjected to a range of corrosive forces quite unlike those experienced in atmospheric exposure conditions, and the performance of both steel and galvanized steel in-ground is not as well understood as is the durability of these materials in above-ground applications.

Considerable research into the management of underground corrosion has been done, particularly with pipelines and related services.

Corrosion Factors In-Ground
Both steel and zinc react in different ways when in contact with soil and an understanding of the performance of each material when in contact with soil allows structure service life to be determined with reasonable accuracy.

Steel requires oxygen, moisture and the presence of dissolved salts to corrode. If any one of these is absent, the corrosion reaction will cease or proceed very slowly. Steel corrodes quickly in acidic environments and slowly or not at all as alkalinity is increased.

Zinc requires the presence of stable oxide films on its surface to provide its corrosion resistance. It performs best in neutral pH environments although it can tolerate exposures in the range from pH 5.5 to pH 12. In the absence of air, the stable oxide films do not form on the zinc surface, and corrosion can be accelerated if moisture is present under these conditions.

For this reason, galvanized steel is the best combination where structures are partly buried and partly exposed to the atmosphere, as the zinc provides the durability above ground while the steel performs predictably in-ground.

Soil Types and Corrosion
Corrosion of metals in soil is extremely variable and while the soil environment is complex, it is possible to make some generalizations about soil types and corrosion. Any given soil is a very heterogeneous material consisting of three phases:

The solid phase is made up of the soil particles that will vary in size and will vary in chemical composition and the level of entrained organic material.

The aqueous phase which is the soil moisture – the vehicle that will allow corrosion to proceed.

The gaseous phase, which consists of air entrained in the soil's pores. Some of this air may dissolve in the aqueous phase.

The Solid Phase
Soils are classified according to their average particle size and their chemistry. Convention classifies particles over 0.07 mm to around 2 mm as sands, particles from 0.005 mm to 0.07 mm as silts and 0.005 mm and smaller as clays. Soils rarely exist with only one of these components present. Clay soils are characterized by their ability to absorb water readily. For this reason, clay soils present a significantly higher corrosion risk than sandy soils.

The Aqueous Phase
There are three types of soil moisture. These are free ground water, gravitational water and capillary water.

Free Ground Water
This is determined by the water table, which may range from ground level in swampy areas to many metres below the surface. This is the least important factor in determining corrosion as most buried structures are above the water table. High water tables will result in the buried structures behaving as if they were in an immersed environment.

Gravitational Water
This arises from rainfall, irrigation or condensation and will soak into the soil at a rate determined by its permeability. The frequency of contact will determine the period of wetness of the metal surface. In areas of regular heavy rainfall, most soluble salts may have been leached from the soil. Desert areas of low rainfall may have very high salt levels and can thus be more corrosive to buried metals than tropical environments.

Capillary Water
This is water entrained in the pores and on the surfaces of the soil particles. The ability of soil to retain moisture is vital to plant growth but it is the capillary water that is the prime source of moisture in determining corrosion rates of metals in soil.

The Gaseous Phase
Access of gas (air) into the soil depends on the soil's permeability. Drier soils or coarser grained soils will allow more oxygen access to the sub-surface and increase the rate of steel corrosion relative to the oxygen deficient areas.

Corrosion Rates And Australian Standards
AS/NZS 2041-1998 –Standard for buried corrugated metal structures contains much useful information in table for to allow product life in-ground to be determined. These tables take into account resistivity of the soil (which factors in related issues such as levels of dissolved salts), pH and soil characteristics. This information is then related to in-ground corrosion rates for both zinc and steel.

Summary
The corrosion rate of steel in soil can range from less than 20 microns per year in favourable conditions, to 200 microns per year or more in very aggressive soils. Similarly, galvanized coatings may corrode at less than 5 microns per year in mild conditions to 25 microns/year or more in unfavourable soils.

By defining the range of these corrosion rates in a particular application, it is possible to design buried metal structures with barrier coating, providing conditioned soil in contact, or with a corrosion allowance on the steel to obtain the desired design life.

In moderate soil conditions, an extra 1mm of steel thickness can provide an additional 50 years of service life.

Source: Industrial Galvanizers Corp