Soil Issues Related to Pipeline Construction

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The following statement is based on my 58 years of experience as a soil scientist and several consulting jobs related to pipeline construction.

The primary issue in the construction of the pipeline on agricultural land is the fact that there can be adverse impacts on the soil and environment resulting from the disruption of natural soil processes and properties that have developed over the past few thousand years of soil formation. Trenching and vehicular traffic can result in soil compaction in the surface horizons and subsoil. Mixing of topsoil and subsoil can lower organic matter content and soil fertility. The volume of soil that crop roots can exploit may be reduced. These and other factors that affect soil productivity make restoration to an optimal conditions very difficult.

Documentation

Based on past experience I recommend the landowner/proxy document activities (using photographs or video and notes) in the trench and easement area prior to, during, and following the installation of the pipeline. Photograph the fences, heavy equipment, and trucks loaded with pipe. Take photographs of drainage lines that are exposed by the trenching and check to be sure they are repaired. Weather records, especially precipitation and temperature, are also important variables to document by date and time. If crop yield records for the areas of installation and easement are available keep them for future reference.
There are several related issues :

Compaction

Soil is a three phase system composed of solids, liquids and gases. The volume composition of an average mineral surface soil horizon is shown in Figure 1. Solids comprise 50% of the volume and the other 50% of the volume is pore space. Under ideal conditions 50% of the pore volume (25% of the total volume) is equally divided between pores that hold water and air, respectively. The Iowa soils developed under prairie vegetation will contain about 5% organic matter and 45% mineral particles in the solid phase. Bulk density is the soil parameter that is used to characterize this relationship. For medium- textured soils the bulk density for the conditions listed above would be 1.2 to 1.3 grams per cubic centimeter. The bulk density of soil horizons beneath the surface horizon for soils formed in uniform parent material and in their natural state would generally increase with increasing depth in the soil profile.

Soil compaction is a process that occurs when soil particles are pressed together reducing the pore space between them. Soils compact when a load applied to soils such as wheel traffic is greater than

the strength of the soil. This increases the weight of solids per unit volume of soil and is characterized by the bulk density. Soil compaction occurs in response to pressure (weight per unit area) exerted by machinery or animals and results in increased bulk density. The major cause of soil compaction is wheel traffic and is directly related to the weight per unit area, soil texture, organic matter content, and the moisture content at the time a load is applied to the soil. Reports of compacted conditions extending to two or more feet are not uncommon. The negative effects of soil compaction are magnified when associated with other plant stress situations and therefore the weather pattern is an important variable in how crops respond to compacted conditions. There is near universal agreement that compaction of soils results in damage to the soil and decreases yield for some period of time.

For construction purposes such as road building it is desirable to compact the soil material to make a good road base. To obtain maximum compaction, construction engineers employ the concept of optimal moisture content, that is the moisture content corresponding to maximum density when using the same compactive force, generally between 20 and 30 percent moisture by weight, for medium textured materials. In layman's terms this would correspond to moisture content in the upper part of the soil after a significant rain and after the soil had been allowed to dry for approximately 24 hours without significant evaporation and/or respiration. Soil scientists refer to this soil moisture content as "field capacity". Pipeline installation generally has a time schedule and so installation activities will continue regardless of weather conditions and without consideration of the moisture content of the soil.

Separation of soil horizons

The topsoil (A horizon), subsoil (B horizon), and parent material (C horizon) should be stockpiled separately and replaced in the trench in the order they were before they were removed. Even if the horizons are replaced in the correct order, there will still be contrasts in the contacts between materials that will affect water movement and root penetration. There should be no traffic over the stockpiled areas.

Soil fertility

The A horizon contains the highest concentration of nutrients so it is important that it be replaced. However, the depth of rooting for corn and soybeans is 5 to 6 feet so proper replacement of the subsoil and parent material is also important.

Natural drainage

Soil forming factors have developed this system over the past few thousand years. Pore size and continuity, macro and micro flora and fauna will have been disturbed . The pipe itself is a barrier that disrupts the natural system of water movement.

Surface and subsurface drainage

After construction generally the surface elevation will be higher due to more material placed on top of the filled trench to allow for subsidence of the fill material. This can result in interruption in the path of

surface water flow and develop wet spots as a result of the topographic change. Subsurface drainage systems can also be affected by breakage and disruption of the system.

Changes in soil temperature due to pipeline presence

Soil temperature will be affected by the presence of the pipeline. Freezing and thawing cycles will probably be reduced which can affect correction of compaction and will also affect micro and macro fauna and flora. The latter could result in increased potential for crop diseases.

Changes in soil biology

The disturbance will affect the macro and micro fauna and flora.

Changes in traffic pattern

If the soil above the pipeline does not freeze this could cause disruption in some field activities such as manure application.

Rocks brought to the soil surface

Soils and parent materials that contain rock and boulders could be brought to the surface due to excavation of the trench. They should be removed from the site so as not to cause harm to machinery.

Weed control issues

Disturbance will probably create more heterogeneous conditions in the soil which can contribute to increased problems of weed control.

Loss in soil productivity

One of the greatest areas of uncertainty relates to the magnitude and duration of productivity loss due to the activities associated with pipeline installation. Productivity loss will vary greatly depending on the soil properties, especially natural drainage, degree of compaction, cropping system, and weather patterns. Most researchers agree that there will be a loss in productivity but the amount and duration of the loss are dependent on the factors listed above.

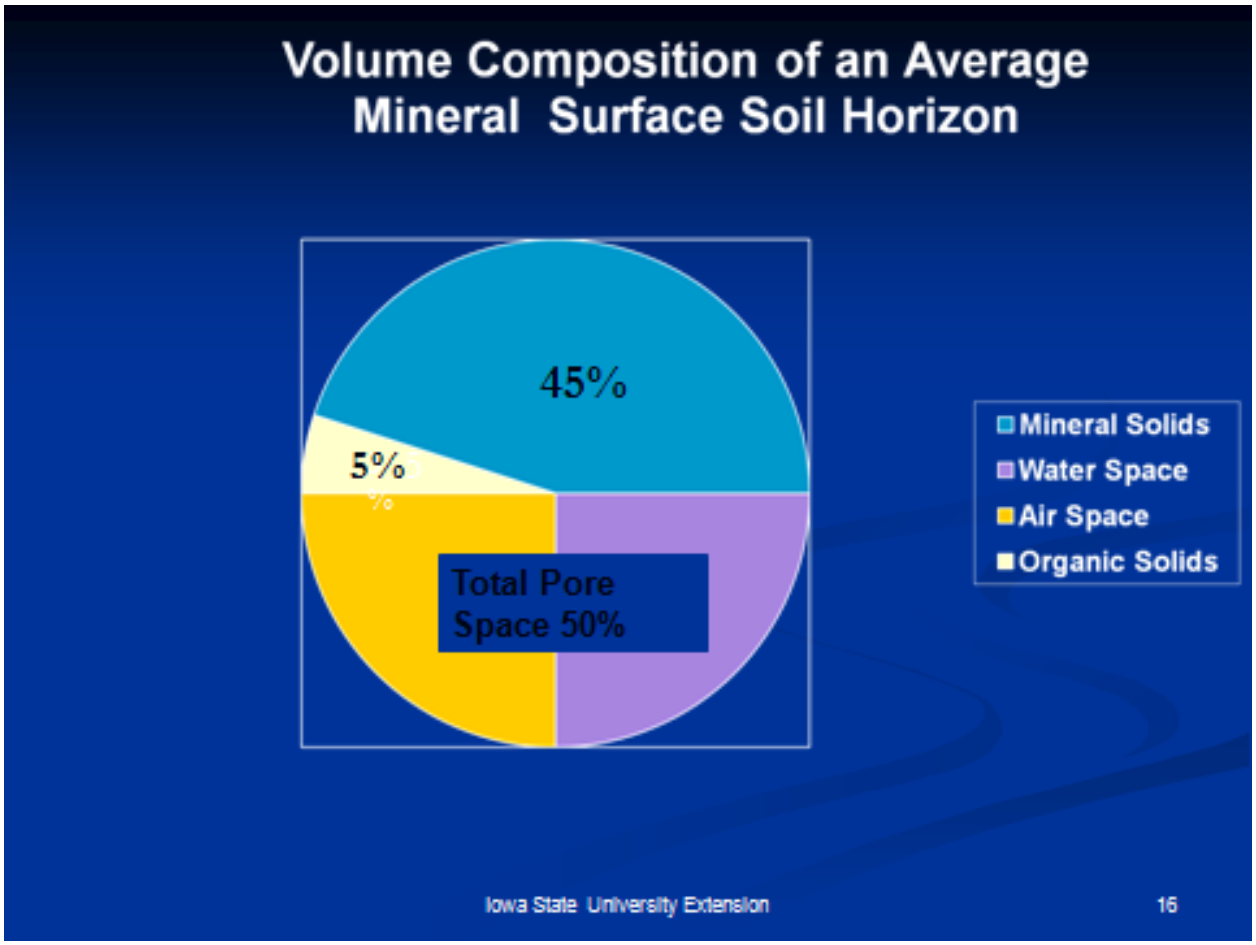

Figure 1. Volume Composition of an Average Mineral Surface Soil Horizon