Key Indicators for Corrosion and Scaling in Ground Water

Introduction

Selecting the type of steel that will best tolerate the water quality conditions at a specific site requires careful consideration of several key indicators. Using the results of laboratory analyses, these indicators can forecast the potential for corrosion that the ground water exhibits. Sampling an exploratory well or a monitoring well is a straightforward and relatively quick exercise. And, the laboratory cost is minor for general minerals analysis that will yield information on the key indicators. Once those results are in hand, one can judge which type of steel for casing and screen would be the ideal choice for the well. A brief discussion of each indicator is presented herein.

Indicators

- **pH** – This is the effective concentration of Hydrogen (H^+) ion. In general, the pH of ground water ranges from 6.0 to 8.4. For drinking water supplies, the recommended range of pH, as stipulated in the National Secondary Drinking Water Regulations, is 6.5 to 8.0. Water that exhibits pH less than 7.0 is acidic and considered to be corrosive.

- **Dissolved Oxygen (DO)** – DO is considered to be the most important factor that controls the rate of corrosion. Uhlig (1955) demonstrated that the rate of corrosion increases as DO concentration increases up to about 20 to 25 mg/L. As a general rule, ground water with DO greater than 2 mg/L is considered to be corrosive. Oxygen also promotes the growth and sustenance of aerobic bacteria.

- **Hydrogen Sulfide (H_2S)** – Most often identified by its “rotten egg” odor, hydrogen sulfide is generated by the anaerobic decomposition of organic matter or action of sulfate-reducing bacteria. Although hydrogen sulfide in ground water is not, of itself, corrosive, the presence of hydrogen sulfide does accentuate galvanic attack.

- **Total Dissolved Solids (TDS)** – While TDS is defined as the residue of filtered water after evaporation, it is generally considered as an indicator for inorganic salts. The secondary standard for drinking water is 500 mg/L. For agricultural purposes, TDS is significant for crops when it exceeds 500 to 1,000 mg/L. Ground water that exhibits TDS greater than 1,000 mg/L is considered brackish and, therefore, corrosive.

- **Carbon Dioxide (CO_2)** – Carbon dioxide reacts with water to form carbonic acid, which lowers pH. It does not, of itself, participate directly in corrosion.

- **Chlorides (Cl)** – Seawater contains chlorides at levels of nearly 19,000 mg/L. It follows then that high chloride (greater than 500 mg/L) is an indicator of brackish water, and therefore potentially corrosive.

Predictors

Two indices are useful to predict the potential for corrosion or scale-formation of water. These are the Langlier Index and the Ryznar Index, as described below.

- **Langlier Index** – This index predicts the scaling of water based on the calcium carbonate equilibrium values.
    - If the actual pH of water is below the calculated pHs, the Langlier Index is negative, indicating that the water will dissolve calcium carbonate, and that it will be corrosive, particularly if DO is present.
    - If the actual pH of water is is higher than the calculate pHs, the Langlier Index is positive, indicating that incrustants (i.e., scaling) will likely occur.

- **Ryznar Index** – This index predicts the tendency for scaling and corrosion. It is widely used to predict the reaction of metal in saturated subsurface conditions. Water is corrosive if the index is higher than 7, and incrusting if it is less than 7.

The American Water Works Association has a very useful calculator for the Langlier and Ryznar Indices. It can be easily accessed using the following link:
http://www.awwa.org/Resources/RTWCorrosivityCalc.cfm?navItemNumber=1576

Summary

Understanding the corrosion and scaling potential of ground water is vital if one hopes to construct a water well that will be able to tolerate the site-specific water quality conditions. If one characterizes the water quality, then considers the indicators listed above, and properly interprets the laboratory results, it becomes a straightforward exercise to select the most appropriate type of steel for both casing and screen.

References

- American Water Works Association (website)
- Roscoe Moss Company, 1990, *Handbook of Ground Water Development,* John Wiley and Sons, New York, NY.
- Uhlig, H., D. Triadis and M. Stern, “Effect of Oxygen, Chlorides and Calcium on Corrosion Inhibition, *Journal of Electrochemical Society*, 1955.

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