# NATURAL RESOURCES CONSERVATION BOARD

## Technical Guideline
## TG 2004-01: Leak Detection and CFOs

November 29, 2004

To: All Confined Feeding Operation (CFO) Owners and All Livestock Owners

### LEAK DETECTION MONITORING: PARAMETERS AND SAMPLING SCHEDULE

*This Natural Resources Conservation Board (NRCB) technical guideline describes leak detection and monitoring requirements for earthen manure storage (EMS) facilities where monitoring is required.*

This guideline is designed to provide further clarification and direction to Section 18(1) and (2) on leak detection for EMS facilities, and must be differentiated from the groundwater monitoring programs for natural water and wells addressed by Section 7(2)(b).

Section 18(1) of the Agricultural Operation Practices Act Standards and Administration Regulation (AR 267/2001) gives the NRCB the discretion to require an operator who constructs a new EMS facility or expands an existing EMS facility to install and maintain a leak detection system. Leak detection systems can identify seepage that is occurring through the liner of an EMS facility. If monitoring wells are required, Section 18(1) requires that the leakage detection system must consist of at least one monitoring well up-gradient from the facility and at least two wells down-gradient. Section 18(2) requires the operator to monitor the wells installed under subsection (1) at regular intervals, as determined by the Board. The chemical and microbial parameters to be monitored and sampling intervals are not established in the Regulation.

This guideline deals with the monitoring protocols to be followed once the decision has been made to monitor for leakage. In consultation with AFRD and other stakeholders, the Board has identified the sampling schedule and parameters to be measured when monitoring wells are required. If a site-specific situation warrants deviating from this guideline, the NRCB will provide reasons in a written decision. This guideline does not deal with risk assessment for EMS facilities.

### ESTABLISHMENT OF MONITORING WELLS

Monitoring wells are to be located as directed by AOPA and/or a qualified professional (e.g. geologist, hydrogeologist, engineer), and approved by the NRCB. Construction of the wells shall be overseen by the qualified professional. Changes to an existing leak detection system require notification of the NRCB prior to any modification.

## MONITORING PARAMETERS AND SAMPLING FREQUENCIES

### Baseline Parameters

Leakages from EMS facilities are detected by monitoring changes in groundwater levels and chemistry over time. The baseline conditions at a site before it is used to store manure serve as the reference for future comparisons.

Baseline conditions are affected by a site's geologic and hydrogeologic settings and in some cases the impacts of human activities. Groundwater chemistry may also vary seasonally. A comprehensive picture of baseline groundwater chemistry is needed to identify changes and to distinguish the impacts of an EMS leakage from other sources of impact and from natural variation.

The baseline parameters include the indicator parameters used to detect change (see below) and the major ions that characterize groundwater chemistry. These baseline parameters provide a reasonably comprehensive picture of baseline groundwater chemistry at the monitoring site.

**Frequency**

Initial baseline sampling is to be done twice during the first year, preferably in the spring and fall, or as directed by the NRCB. At least one set of these samples should be taken before any manure is added to a new lagoon.

### Indicator Parameters

Parameters chosen as indicators are those that are commonly present in high concentrations in manure, but in much lower concentrations in groundwater. Indicator sampling is done to determine if there is manure leakage. If elevated levels in the indicator sampling are discovered, a comparison to an established baseline will confirm if the elevations are naturally occurring or if the manure storage facility is leaking. Parameters sampled are those that strongly indicate the possibility of manure seepage. If an increase in the measured parameters is documented, additional evaluations will be required to determine the potential risk to the groundwater and the need for further action.

**Frequency**

Indicator sampling will be completed at one or two-year intervals at the discretion of the Board. The sampling program should be carried out in the same month (whether spring or fall) in which the baseline sampling was completed for the purpose of consistency. If leakage is detected, the Board may require supplemental sampling, which may include bacteriological parameters including total coliforms and *E.coli*.

The parameters listed in the following table have been selected because they characterize leakage from lagoons. Multiple parameters are required to interpret relative changes in groundwater chemistry.

| MONITORING PARAMETERS | Baseline | Indicator |
|---|---|---|
| Potassium ($K^+$) | ✓ | ✓ |
| Chloride ($Cl^-$) | ✓ | ✓ |
| Nitrate + Nitrite ($NO_3^- + NO_2^-$) | ✓ | ✓ |
| Total Kjeldahl Nitrogen (TKN) | ✓ | ✓ |
| Total Dissolved Phosphorous (TDP) | ✓ | ✓ |
| Electrical Conductivity (EC) | ✓ | ✓ |
| Sodium ($Na^+$) | ✓ | |
| Calcium ($Ca^{+2}$) | ✓ | |
| Magnesium ($Mg^{+2}$) | ✓ | |
| Bicarbonate ($HCO_3^-$) | ✓ | |
| Sulphate ($SO_4^{-2}$) | ✓ | |
| Dissolved Organic Carbon (DOC) | ✓ | |
| pH | ✓ | |
| Total Dissolved Solids (TDS) | ✓ | |

## ASSESSMENT AND ANALYSIS

A suitably qualified professional will be responsible for the sampling protocol, and analysis and assessment of the chemical data. Sampling must be conducted by a properly trained individual, under the guidance of a professional.

## REPORTING

Reports are to be submitted as requested by the NRCB, if an abnormality is discovered, or as specified by the conditions of an Approval, Registration, or Authorization.

## PARAMETER RATIONALE

**Potassium:** Potassium is a nutrient that is generally present in high amounts (1000 mg/L or more) in manure, but in low amounts (<10 mg/L) in groundwater. Potassium does adsorb to clay minerals and its concentration will decrease in groundwater as it moves through the subsurface.

**Chloride:** Chloride concentrations in manure are high (500 to >2000 mg/L). Chloride does not adsorb readily to clay minerals and will travel at or near the rate of groundwater. Concentrations of chloride ions in shallow groundwater (i.e., at or just below the water table) are generally low (from <10 to 30 mg/L). Exceptions are areas of naturally occurring saline soils or areas where the water table is developed in marine or marine-derived sediments, where concentrations may be higher.

**Nitrogen Compounds:** Nitrogen is a major component of manure. It can be detected as ammonium, nitrate or nitrite depending on the redox potential of the groundwater. Ammonium exists under the reducing conditions in manure lagoons. In shallow groundwater and under aerobic conditions, ammonium is generally oxidized, microbially, to nitrate. Nitrate is highly soluble in groundwater, does not adsorb to clay minerals, and is highly mobile. The presence of either or both of these nitrogen compounds near manure lagoons may indicate that leakage has occurred. As ammonium ions are oxidized to nitrate, nitrite will be formed as an intermediate compound. Under normal oxidative conditions, nitrite is a transitory compound, being quickly transformed to nitrate. Total Kjeldahl Nitrogen (TKN) analysis measures organo-nitrogen compounds, including ammonium, present in a sample. It is generally well below detection limits in groundwater. Nitrate and nitrite compounds are quantified in separate analyses.

**Total Dissolved Phosphorous (TDP):** Phosphorus compounds occur in high concentrations in liquid manure (55-6500 mg/L) (Malley et al., 2001). TDP is normally only present in trace amounts (< 0.1 mg/L) in groundwater. TDP accounts for all phosphorus compounds that are potentially mobile in groundwater.

**Electrical Conductivity:** Electrical conductivity (EC) is a measure of the ability of water to conduct an electric current and is related to the amount of dissolved ionic constituents within the liquid, or the total dissolved solids (TDS) content. A general indication of the total dissolved ionic constituents can therefore be obtained from the electrical conductivity. With some exceptions, total dissolved solids content and electrical conductivity are generally quite low (TDS <1000 mg/L, EC<1500 µS/cm) at or near the water table. Liquid manure, on the other hand, generally has much higher TDS content and EC values ranging from 8,000 to 27,000 µS/cm have been documented.

***Total Coliforms and *Escherichia coli (E. coli):***

The presence of *E. coli* in a groundwater sample indicates fecal contamination. As an "indicator" group of bacteria, total coliforms do not necessarily correlate directly to fecal contamination. Testing to confirm the presence of true fecal coliform bacteria (i.e., *E.coli*) is required before a conclusion regarding fecal contamination can be reached. As the numbers of total coliform organisms are generally much greater than *E. coli*, there is a greater probability of detecting total coliform organisms than *E. coli* in environmental feces (i.e., $10^9$ organisms/g).

The Colilert™ culture technique allows both *E. coli* and total coliforms to be analyzed at the same time within 18-24 hours. Other comparable culture techniques to analyze *E. coli* and total coliforms may also be used.

***Testing for *E. coli* and total coliforms may be required if indicator parameters indicate potential EMS leakage. If coliforms are detected, it will be necessary to rule out the possibility of surface contamination.**

**Sodium, Calcium, Magnesium, Bicarbonate, Sulphate:**

Chemical and biochemical interactions occur between groundwater and the geological materials through which it flows. The chemistry of groundwater reflects this interaction. Groundwater may contain a wide variety of dissolved inorganic chemical constituents in various concentrations. The analyses for major cations and anions, therefore, provide a fundamental chemical characterization of groundwater.

**Dissolved Organic Carbon:**

Dissolved organic carbon is generally present in groundwater in only small amounts (0.1 to 10 mg/L) but can be expected in high concentrations in liquid manure. Its presence in significantly greater amounts (tens of mg/L) in monitors adjacent to manure lagoons could indicate leakage.

**PH:**

The acidity will influence the chemical composition of the water.

**Total Dissolved Solids:**

TDS values for groundwater vary greatly and provide a simple means of assessing and categorizing groundwater. TDS in groundwater is determined by weighing the solid residue obtained by evaporating a measured volume of filtered groundwater to dryness. The solid residue includes inorganic constituents and very small amounts of organic matter. TDS values can be estimated since an approximate correlation exists between electrical conductivity and TDS, depending upon sulphate or bicarbonate dominated water chemistry.

**Reference**

Malley, A.F., Martin, P.D., Woods, S.E., and Dettman, L. (2001) Analysis of Minor Elements and Metals in Hog Manure by Field-portable Near-Infrared Spectroscopy: Results for Foss NIR Systems Inc. Model 6500 Spectrophotometer in the Laboratory.