Factors that bear on the evaluation process and govern the nature and extent of appropriate remedial work include:

- The gross location of the site where the damage is occurring:
  - Is it on or off the permit area?
  - Will it be necessary to get a right-of-way easement to access the work area?
- The physical, chemical, and vegetational characteristics of that area, zone, or structure identified as the source or cause of the damage:
  - What are its topographic and hydrologic parameters?
  - Is a selected or designated vegetation growth medium (topsoil or selected spoil) present?
  - What is the stage of vegetation establishment in and near the damage source area? (No vegetation planted; poor, good, nearly ready for bond release, etc.)
  - To what degree has the damaging circumstance or condition (rill or gully depth, acid water production, severity, or seepage flow quantity, exposure of toxic spoil, etc.) developed?
- The climate and season of the year as they pertain to precipitation patterns, potential for establishing temporary or permanent vegetation, freeze and thaw frequency, etc.
- The position of the damage source and the area where the damage is occurring with respect to its potential for becoming more serious.
  - Is there (little, moderate, great) potential for the present damage level to — intensify, extend?
    - Is the damage area on moderate or steep terrain?
    - Is it on the surface or below—in a stream, or aquifer?
    - Is it primarily a problem of size, of position, or of quality?
  - If the damage does grow what are the chances that it will pose a threat to property or life or permanent change in the character of downgradient ecosystems?
- The planned (as presented in the approved Permit Application Package) post-mining land use.
  - Will the remedial measures chosen (proposed by the operator) be compatible, have little impact, be detrimental, or improve, the implementation of the post-mining land use?
    - How soon can treatment be started? Completed?
    - Historically, has a problem of this type been amenable to treatment of the type proposed?
    - Are the equipment and materials required to implement the proposed measure available?
- The prospects for the problem to recur before or after bond release.
  - Is it appropriate to seek a "permanent" solution at this time?
  - Is the planned post-mining land use such that it would be reasonable to expect continued remedial treatment applications when such are needed in the future?
  - Is the nature of the problem and are its surroundings and contributing conditions such that it is reasonable to expect recurrence?
  - If the problem should recur after bond release is it likely to develop to the degree that life, property, and/or ecosystem values are threatened? Is it likely to be limited to levels such that its surroundings will buffer its effects and keep them within tolerable limits?

Sampling Site Selection and Sampling Frequency

Water-quality sampling sites for enforcement purposes should be selected so as to assess clearly the impact of mining activities on the water resource and to assure that comparisons can be made with subsequent samples. Because physical conditions at mining sites are continually changing, a sampling scheme must have enough flexibility to provide comparable data over a wide range of physical and hydrologic conditions. In addition, permitted point-source discharges from disturbed areas are always considered in sampling because of specific operator liabilities for discharge quality.

Effluent violations are most likely to occur during very low or very high flows. For surface water the common ions (calcium, magnesium, sodium, potassium, sulfate, chloride, and bicarbonate) and total dissolved solids are usually near their maximum when flows are very low. Suspended solids, on the other hand, are generally highest during high flows.

Inspection personnel are required to collect samples of surface water and groundwater from such diverse sources as: streams, impoundments, wells, mine openings, and springs and seeps.

Emphasis is placed on the need to obtain representative samples, properly collected and adequately documented in the field at the time of collection. The inspector should exercise proper care and custody of samples until they are delivered for appropriate analysis. The following pages present a general discussion of sample site selection and sampling frequency for the source mentioned above.

No one scheme can be considered the only correct approach to selecting water-quality sampling sites and establishing sampling frequency. One or a combination of schemes may be utilized by either the inspector or the operator to verify the extent to which requirements set forth in the Permit Application Package are being met.

Long-term monitoring sites may be needed for:

- stream quality during and after mining, to determine the success of reclamation or to provide information for bond-release analysis;
- well-water sampling during and after mining to determine off-site impact.

Short-term sampling sites can be established to collect data on:

- surface water or groundwater, to evaluate ambient conditions before mining
- stream discharge during high flow to evaluate the effectiveness of sediment-control measures.

Streams

The customary approach to determining the effects of mine drainage is to sample the receiving stream above and below inflow from the mine area. This scheme is useful to both the inspector and the operator in evaluating the extent to which the receiving stream has changed. Flow measurements of both the mine discharge and receiving stream are also needed. In cases of nonpoint discharges to streams, the effect of mine drainage may be gradually imposed on the receiving stream over a geographically wide front. In such cases it may be necessary to sample the receiving stream at a number of points along the affected portion to identify reaches receiving the major impact from mining.

It is important to choose sampling sites that will minimize the "masking" effect of extraneous inflow from tributaries or other nonpertinent sources. Avoid sampling streams at points, such as backwaters, that are not representative of the main body of flowing water. If streaks or swirls of sediment or color are apparent in the flowing stream, include a representative portion of each in the sample. Prior planning with maps and a sampling outline will often reduce effort and prove more effective, especially when multiple samples are to be collected at various locations.

The frequency with which streams are sampled for background information will vary according to the quantity and quality of disturbed-area discharge, the rate of streamflow, and the relation of natural daily and seasonal variations to water-quality characteristics. In some cases where effluent violations are suspected, one-time samples may provide the data necessary for enforcement decisions. Other cases, for example where stream contamination is apparently related to precipitation events, may require that sampling be coordinated with changing streamflow or stage. Suspected instances of deliberate pollution require preparation and often unusual inspection hours and techniques.

Impoundments

Because effluents from sediment ponds are usually sampled at the point of discharge there is little flexibility in selecting sites. Sampling can usually be facilitated by "catching" the sample as it falls from the discharge pipe. Point source discharges are subject to permitting and reporting requirements of the National Pollutant Discharge Elimination System and the applicable effluent limits of the issued permit.

It is difficult to obtain representative samples from impoundments. Standing bodies of water become stratified after a time, and physical influences that control chemical and biological activities tend to become layered. In small sheltered ponds, extreme temperature and chemical stratifications can be observed. If it is necessary to sample an impoundment, collect several discrete samples representing water from different areas and depths of the impoundment, and analyze each individually.

If there is interest in the pH of ponded water which is subsequently to be released, it is important to know inflow and outflow pH values, as well as pH in the cross-sectional area of the pond. Unless there is a boat available, however, it will be impossible for the inspector to collect cross-sectional samples. As an alternate, several pH measurements taken along the periphery of the pond can be useful in mapping pH variations. Because impounded waters may be poorly mixed, different releases of water from the same impoundment but from different levels or at different times may differ markedly in quality.

The inflow of mine discharge may change the dissolved-oxygen concentration, pH, and rates at which metals precipitate. Chemical precipitation, mixing, turbulence, treatment, and other changes may be in progress during sampling. Unless the ultimate extent of such changes is known, the inspector may have no way of reliably predicting the quality of water to be released.

Wells

The inspector is to assure that the operator is monitoring groundwater according to the permit requirements. Well location, sampling frequency, and parameters to be measured will vary from site to site, but all are usually specified in the Permit Application Package. On a given permit site the operator may be required to verify that existing wells have been inventoried and to obtain drilling and other construction data in addition to sampling such sources for water-quality data.

Observation-well data are used to determine the effects of mining activities on groundwater quantity and quality and to predict quality changes in streams during low flows when streamflow consists mainly of the groundwater component. Existing wells are not always suitably located to provide all the data that may be needed. Permit application packages often note that the wells of nearby residences will be used to monitor changes in groundwater elevations or characteristics. In some areas, these may be above or below the strata being mined. Horizontal movement just above an impermeable stratum is much more likely than downward percolation of water. A relatively small number of groundwater samples may be adequate to describe water-quality characteristics in an unmined area. Random sampling may suffice in undisturbed areas or in areas where groundwater is not extensively used. However, in mining areas where groundwater must be pumped for disposal or where excavation appreciably influences recharge or discharge, it may be necessary to collect samples more frequently. At times the inspector may find it desirable to collect a well-water sample in order to validate or supplement those supplied by the operator.

Underground Mine Openings

Occasionally, groundwater samples may be taken from underground mine openings (shafts, drifts, slopes, tunnel outflows). Such samples may be useful in determining the source of intercepted water at a surface mine. Generally, it is difficult to relate the quality of water standing in a mine to the quality of water moving through the rocks. Stratification may occur in mine water pools in the same way that it occurs in impoundments, resulting in some of the same sampling and data-interpretation difficulties. In mines where water is standing several tens or hundreds of feet deep, temperature variations of several degrees typically exist, and the oxidizing potential for metals may vary from a strong oxidizing environment near the surface to a reducing environment at depth.

Water sampling in mine shafts should be correlated with major changes in the water level in the shafts. These changes may easily be determined by measuring the distance from the ground surface or some reference point to the water level. Where extensive underground mining has been conducted, sudden unexplained flow increases at openings or adjacent to the mine area may be the result of subsidence activity. The subsiding material displaces water that must flow out.

Springs and Seeps

Springs and seeps, when they occur, provide a means of assessing groundwater quality. It is essential that ground water from springs be identified as to the geologic horizon from which the water discharges. Map location and elevation should be noted. Collect samples from springs and seeps as near as possible to the point of discharge before surface contamination can occur. Reference the location of the discharge to area maps and geologic cross-section materials for more meaningful evaluation.

Sampling

A great variety of water sources must be sampled by inspection personnel. Therefore, a knowledge of many water-quality sampling techniques will be useful. Collecting a sample from a discharge pipe requires one technique, whereas collecting a sample from a flowing stream requires another.

The purpose of this section is to describe sampling techniques most likely to be used by mining and reclamation inspectors. Brief mention will also be made of some other sampling methods that inspectors should know about. The decision on what method to use will be dictated by the existing field conditions and the judgment of the inspector. Always give highest priority to recognized, accepted practices, particularly when the data may result in enforcement actions.

Wells, springs, seeps, and other difficult-to-sample sources may require makeshift sampling techniques. Once a sample is obtained from any source, the processing and preservation techniques are identical to those described in the next section, "Sample Preparation, Treatment, Documentation, and Field Analysis."

The sampling method used should be stated on the sample label and eventually reported with the analytical results.

Guidelines for Representative Samples

A sample is worthless unless it adequately represents the water in the stream or impoundment being sampled. To obtain representative samples, follow these guidelines:

1. Collect the sample where the water is well mixed, if possible immediately downstream from a point of hydraulic turbulence such as a waterfall or flume. Samples may also be collected from free-falling water (as in a small waterfall); however, care should be taken to move the sampling device through the full thickness of the falling water at several points so that a fully representative sample is obtained.
2. Avoid sampling where floating solids and oil tend to accumulate, such as downstream from certain types of weirs and flumes.
3. In a well-mixed stream, collect the sample in the center of the channel at from 4/10 to 6/10 of its depth where the velocity of flow is average or higher than average. This depth avoids the inadvertent collection of part of the stream bottom or top-floating materials such as oil, grease, or debris. In streams that may not be well mixed, force the mouth of the sampling vessel across the entire cross section of the stream to the fullest extent possible without collecting bottom materials or surface scum and debris. If the surface scum, oil, or grease is flowing with the stream (not just accumulated in a stagnant area) there may be need to include a representative portion of these materials in the sample—but only if the analysis is to include these parameters.
4. To avoid contaminating the sample, collect samples with the mouth of the sample bottle pointed upstream. Keep hands and other potential contaminants away from the mouth of the bottle.
5. Do not walk on, or in any way disturb, the stream bottom upstream from the sampling site.
6. Do not sample backwaters or deep standing pools found along the stream.
7. Do not sample streams immediately below tributaries or other significant points of inflow. Sample far enough downstream for thorough mixing to have occurred, or sample both main stream and tributary just above their confluence.
8. Wide shallow streams should be sampled using the equal width increment (EWI) technique described later in this section. Shallow lakes or impoundments should be sampled at several points and the samples analyzed either as individual samples or as a composite sample.
9. Water quality can vary with depth so deep lakes or streams should be sampled with depth-integrating samplers, or samples should be taken at different depths for analysis as individual or composite samples.
10. Collect sufficient sample volume to allow duplicate analyses and quality assurance testing. The required sample volume is the sum of the volume required for each analysis requested. Refer to the laboratory director for minimum volumes to be collected.
11. Not all sample containers should be filled to the same level. Sample bottles should be filled completely if the samples are to be analyzed for O_2, CO_2, H_2S, free chlorine, volatile organics, oil and grease, pH, SO_2, NH_3, NH_4^+, Fe^{++}, and acidity or alkalinity. Full bottles must be protected from freezing. When sampling for bacteria or suspended solids, it is desirable to leave an airspace in the sample container to facilitate mixing before subsampling in the laboratory. In depth-integrated sediment samples it is essential that the sample bottles not be filled more than ¾ full.
12. If samples are taken from a closed conduit via a valve or faucet, allow sufficient flushing time to insure that the sample is representative of the supply, taking into