documentation and sampling equipment should have minimum encumbrance and weight.

Except where the inspector is extremely familiar with a permit, drainage or hydrology maps and notes accumulated during the Permit Application Package study should always be on hand during a field review. To avoid overlooking areas or items which may have problems, make a brief list of specific areas or facilities to be checked. A more detailed version might include a point-to-point itinerary and a list of items to be inspected at each location along the route.

Use facts and insight gained through review of the Permit Application Package and prior inspections to identify specific areas, items, facilities, etc. to be inspected and to choose the equipment needed to make the necessary measurements and take the necessary samples. Some nearly indispensable items are:

- a camera with extra film;
- "quick check" water quality indicators, such as a Hach Kit;
- several clean, prenumbered sample bottles;
- nitric acid;
- 0.45 micron filters;
- a device for measuring water level in wells;
- a 6- to 12-foot retractable tape measure; and
- a note pad.

These items may be managed easily in a knapsack. By using them correctly an inspector can adequately identify and document most water violations common to mining.

Hydrologic Aspects of the Permit Application Package

Nearly every step of the mining/reclamation process, and every structure designed and built to serve the permit site, may be viewed as a technique for the control of drainage and erosion. Preparing mining and reclamation plans and maps, designating the sequence of operations, designing structures, and selecting methods and processes by which the overburden and spoils are to be removed, handled, and placed are all aimed toward controlling water.

Specific inspection duties of the reclamation inspector may vary with circumstances and time of involvement. Some inspectors become involved during permit application review, and may be required to verify in the field the various statements, conditions, and site situations described in the Permit Application Package. For others, duties begin only after the Permit Application Package has been approved. Still others exercise what is primarily an oversight role; their duties involve periodic inspection of mining and reclamation operations.

Regardless of an inspector's specific duties, their scope, or when during the permitting and inspection process they begin, it is important that inspectors understand and be able to interpret the various permit documents in light of the requirements, and understand the assumptions and principles upon which the spoil handling methods, construction techniques, and reclamation practices have been selected.

Equally important in the day-to-day performance of an inspector's duties is the ability to recognize in the field any conditions that support or contradict these assumptions and any clues to inappropriate mining, construction, and reclamation practices.

Field-checking the Permit Application Package

The Permit Application Package identifies measures that are approved for use on a given site. The major questions are: (1) Are the proposed control measures appropriate for the site conditions and mining practices described in the Permit Application Package? (2) Are the site conditions, as they are presented in these documents, verifiable in the field? (3) Are they supported by the inspector's independent observations made on the site? and (4) Do the measures and practices set forth in the Permit Application Package, with any requested variances, meet requirements?

Answers to these questions can be found from evaluations such as the three given here. This is not intended to be a complete list. Any specific case may involve any or all of the listed items—plus others.

Evaluation of the Completeness and Applicability of the Mining and Reclamation Plan with Respect to Hydrology

I. Investigation pertinent to the particular permit area.
   A. Study maps of geology, hydrology, and topography along with other permit documents to see if the plan is complete and meets regulatory requirements. Pertinent items may include:
      1. general strike and dip of strata;
      2. variations in strike and dip in and near the permit area;
      3. slope of land surface;
      4. location of natural surface drainage courses;
      5. location of previous man-made alterations to the natural surface and drainage patterns as caused by roads, such as logging roads, skid trails; previous mining, as evidenced by spoil piles, deep mine adits, auger holes, subsidence; irrigation facilities, such as ditches and pipes;
      6. surface water and groundwater monitoring programs should address sampling site locations, sampling methods, sampling schedules, sample preservation and chain of possession, testing methods, and names and qualifications of testing lab personnel; and
      7. determine whether an aquifer exists and if so, verify:
         a. description of physical characteristics of matrix materials
         b. description of hydrologic characteristics of the aquifer(s). Some items of interest are:
            (1) Is the potential yield to wells of consequence?
            (2) Is it of a pressurized (artesian) or unpressurized (free water table) type?
            (3) Seasonal flow and stage characteristics
            (4) Chemistry of the water.
         c. What are the geographic limits of the aquifer? For example: Is the aquifer entirely within the permit area or does part of it extend beyond that area?

d. Current use of water from the aquifer(s) within the permit area and nearby as deduced from:
   (1) Water rights records
   (2) Well yield and water quality records and measurements etc.

B. Investigate geology, hydrology, and topography to verify information presented in the permit documents and determine whether the plan reflects site conditions.

1. Locate and map springs, seeps, wells, and water holes. Clues to these would be:
   a. Outcrops on down dips
   b. Axes of geologic synclines
   c. Sources of domestic water at existing or abandoned house sites
   d. Animal trails
   e. Local residents and property owners
   f. Records from other mining operations in the area
   g. Court records concerning water rights
   h. Pipelines, irrigation facilities, roads, etc.
   i. Patches of vegetation typical of marshy areas or indicative of groundwater tapped by deep roots
   j. Sudden changes in stream discharge that cannot be explained by surface or meteorological phenomena.
2. Determine whether descriptions of flow stage, duration, and water quality are sufficient and correct as given in the permit.
3. Look for possible interaction between elements of the subsurface hydrologic regime and structures proposed for control of surface drainage and sediments. Things to look for are:
   a. Position, location, and elevation of structures with respect to the water table, aquifers, and watershed boundary;
      (1) Does the structure promote or inhibit exchange between surface and subsurface flow regimes? Look for conditions that have the potential to allow:
         (a) Subsurface shortcuts under or around impoundments
         (b) Subsurface contributions into impoundments.
      (2) Does the structure promote or inhibit containment of impacts within the permit area? Drainage could cross watershed boundaries by:
         (a) Exceeding the design capacity of proposed control structures, or
         (b) Leaving the permit area without passing through a control structure.
   b. Subsurface flows that exit beyond control devices may be indicated by:
      (1) A dip of an aquifer within the area affected by mining, which outcrops within the watershed but below the treatment and control structures, or
      (2) A dip of an aquifer affected by mining that outcrops in adjacent areas or continues laterally to unmonitored areas beyond the control structures.

      NOTE: If either condition exists, then the layout of the monitoring well system may need to be changed.
4. Look for unreported, unmapped mine adits, auger holes, or subsidence. These may be indicated by:
   a. Direction, quantity, and quality of observed flows
   b. Absence of active flow (where the stream flows into a mine)
   c. Topographic expressions on the surface that indicate collapse of subsurface structures; i.e., sink-hole-like depressions in a geometric pattern
   d. Past active flows may be indicated by:
      (1) Erosion rills and gullies; land surface discoloration typical of overland flow
      (2) Atypical appearance of vegetation or lack of vegetation
      (3) Standing water within adit entrances or abandoned pits or along an existing highwall.

The above list is by no means complete. It is offered as a guide to aid in identifying likely omissions, discrepancies, or errors in mining and reclamation plans and permit applications.

II. Evaluation of Operation Sequence

A. As it is presented in the Permit Application Package:
   1. Does the operation sequence call for drainage and sediment control structures and water treatment facilities to be installed before mining commences?
   2. Are construction access routes to structure locations adequately described and do the described routes appear reasonable and within guidelines?
   3. Are spoil disposal areas identified by location, size, and position within the operation sequence and by their intended land use after mining?
   4. Are topsoil handling procedures addressed, with particular attention to removal, storage, and redistribution methods?

B. Does the Permit Application Package describe how criteria for "minimization of unreclaimed surface area" are to be satisfied?
   1. Is the beginning point of mining operation identified?
   2. Are zones of concurrent disturbance identified? Is the area of each zone correctly measured? Are the material characteristics and placement practices applicable to the design life of the drainage and sediment control structures?
   3. Are anticipated needs for temporary vegetative cover identified and are species, planting densities, and methods of application described?

C. Does the Permit Application Package address the maintenance and cleaning of sediment control structures?
   1. Are criteria given to identify when cleaning and maintenance are necessary?
   2. Do the maintenance schedules presented conflict with other operations?

D. Do Permit Application Package documents identify those stages of the proposed mining and reclamation operations when specific effects upon the water regime (both surface and subsurface) will become evident?

III. Evaluation of structure design and construction practice

A. Structure design (runoff detention and sediment catchment structures, culverts, flumes, contour trenches, diversion channels, etc.)

Here the primary concern is to develop an accurate assessment of how well the proposed structure is suited to the size and nature of the task it is expected to accomplish, and whether it will perform its task under the various conditions to which it will likely be subjected during its design life. Note that the three major components in that assessment — design life, conditions under which construction and performance will likely occur, and the nature and size of the anticipated task — interact markedly. They can, however, be evaluated independently.

Documents in the Permit Application Package that present the planned sequence of operations and describe their duration provide data upon which to judge the design life required for each structure. These documents will usually allow one to determine whether a given structure should be classed as temporary or permanent. Its class can then be related to questions of structure capacity.

Maps included in the Permit Application Package show the structures in relation to various site attributes. Documentation in the Permit Application Package addresses critical flow stages and tests of water samples. These documents may include a detailed geologic map of the area, maps and documents describing the soils, vegetation, hydrology, and area precipitation records, and a stratigraphic column. Maps delineating the horizontal and elevational limits of the total area contributing flow and the zone to be disturbed within that area are pertinent, as are maps and descriptions of pre- and postmining topography and land use.

Demands that will be placed upon a structure depend primarily on the size and shape of the area contributing drainage to the structure, the storm patterns in the area, the effective topographic slope, vegetative cover, and the water storage capacity of soils within the contributing zone. Vegetative cover and soil water storage will be influenced by mining and this influence should be evaluated. Likewise, the size and topography of the area contributing surface drainage waters are sometimes modified during the mining process. If this will be so, then the extent and timing of those and related modifications must be investigated. The key here is to focus upon the "worst case" condition and the likelihood of its occurrence, and compare the findings with the design information presented in the Permit Application Package and the requirements of that permit.

It is important that foundations of drainage control structures be strong enough to withstand forces that might be caused by a local high water table, subsidence, or other conditions peculiar to the site. Selection of proper materials for the flow transmission components of the facility, such as spillway pipes and dewatering devices, provisions for a clay core, and a keyed foundation are important. These items are directly related to the acidity of inflow and outflow and to the flow transmission rates of those geologic strata within the construction site. Acidity of inflow and outflow over the life of a particular structure will be influenced by the mineralogy of any overburden disturbed by the mining. However, appropriate spoil handling and placement techniques may be used to isolate the acid-producing materials or to slow their reaction rate. The keys here are to ascertain whether subsurface flows are likely to have volumetric importance at the site and hence upon the appropriate design capacity of the structure or the size of flow transmission components; and whether the flow can be expected to develop undesirable chemical attributes.

Structure designs may be evaluated in two different contexts. The first encompasses the form and continuity of flow models, support data, and assumptions used to develop the design presented in the Permit Application Package. Evaluation within the second context consists of determining whether the model, data, and assumptions used in the design correctly and completely represent the attributes that actually exist in the field. In other words, how good are the models?

B. Construction Practices

During the actual construction of structures to control water flow, erosion, and sediment on surface mine operations, an inspector is concerned with the validity of the structure's design. At this stage one can actually perform observations and tests that were not possible before construction began. If both phases—office and field—of the permit approval process have been carefully executed, few errors in design will be found during construction, but it does occur.

Before a construction site is cleared and excavated, the data presented in the Permit Application Package may have been only an educated guess. Only after excavation will the actual condition be known. The key here is to determine whether the actual condition differs significantly from that presented in the approved Permit Application Package, or if some particular crucial element has been overlooked or misrepresented in the approved design.

The primary concern during construction is to be sure that the materials and practices employed in each phase of construction are capable of producing a finished product that will meet the appropriate strength and performance criteria.

It is important that the inspector know the characteristics of the materials being used, appropriate construction practices for those materials, and appropriate equipment for those practices. The inspector must be on the site during critical periods of construction. To do that, the inspector must be aware of the sequence and timing of operations.

When the Permit Application Package calls for construction of an impervious clay core for a dike or dam, or a clay wall to isolate toxic spoil, the clay will not likely perform its task if it is not of the proper type and purity, is used in scant quantity, or is in the wrong position.

When compaction is specified at 95% Proctor, the use of uncalibrated materials, or of calibrated materials that are excessively moist or dry, is unlikely to yield a finished product that meets the stated requirements. Likewise, to bed an uncoated metal pipe, a concrete culvert, or a metal culvert in pyritic materials or where acid water is likely to be encountered is unwise and, in many situations, unacceptable.

To produce a finished structure of the proper strength and performance requires that appropriate equipment be used in the proper manner. Compaction equipment should be matched by both type and weight to the materials receiving the compactive effect. Sheepsfoot rollers are for cohesive materials—the clay core of a dam—but rubber-tired rollers are for sandy, noncohesive materials such as might be used in the outer portions of the dam embankment.

Five passes with a 4-ton roller will not necessarily produce the same compaction as one pass with a 20-ton roller, and vice-versa. Layer placement and compaction does not mean to place all the layers and then compact, but to apply compactive effort *uniformly* over the *entire* surface of *each* individual layer after it is placed.

And "walking-in" culvert bedding and cover materials with dozer tracks does not accomplish the same consistent compaction as compacting thin layers with a hand-guided mechanical tamper. To allow installation of any pipe or culvert that has anti-seep collars without using a mechanical tamper to achieve proper compaction is asking for trouble.

The key points in construction are that the materials be of the proper kind, that they be correctly positioned, that the equipment be matched by size and type to the material, and that the equipment be used in an appropriate manner, to a sufficient extent, and at the proper time during each stage of construction. These points apply whether the structure is a diversion ditch, an embankment to detain runoff or trap sediment, a haul road, or a massive head-of-hollow or valley fill.

On-Site Indicators of Hydrologic Problems

The following indicate conditions with a potential to adversely affect local surface and groundwater:

- Spoil and geologic debris placed where surface drainage may exit beyond control structures. Examples are: clearing the mine site or removing overburden before installing drainage controls, and development roads or clearing operations that extend beyond contour trenches currently in place.
- Encroachment by spoil or geologic debris—whether deliberately placed, or the result of slope failure—upon Permit Application Package-designated zones of nondisturbance parallel to stream courses.
  - Mass slope movements on reclaimed surfaces indicate the slope is too steep. The development of tension cracks indicates movement has occurred and that additional movement is likely.
  - Rill development on finish-graded surfaces. Channels or gullies at the midpoint or toe of slopes and deposits of eroded materials whether on the graded surface or at the toes of slopes.
  - Deposits of eroded material at locations or in volumes that may disrupt planned drainage patterns and defeat control structures. Excess deposits may block road culverts, fill diversion ditches, overload contour trenches and sediment catchment structures, and fan out on "flat" portions of the reconstructed topography to cover newly seeded areas.
  - Evidence that waters are moving from subsurface to surface flow conditions. Some indicators are active seeps and a marshy, spongy surface, or marsh grass on finished slopes. Slumps and hummocky terrain on slopes indicate that the waters have already contributed to mass failure.
  - Evidence that improper methods or materials, or both, were used in construction of durable rock fills. Some indicators are trucks being loaded with, hauling, or dumping materials that are too small or are not durable —shales, claystones, or finely stratified material of any rock type, and the lack of increasing particle size from top to bottom in the constructed face.
  - Improper construction sequence, such as mine site clearing before construction of drainage and sediment control structures, or drilling and blasting before removal and disposition of topsoil.
  - Drainage or sediment control structures not located or not sized in accord with Permit Application Package.
  - Improper provision for, or improper handling of active drainage. Some indicators are: improper direction of flow or standing water in ditch lines, equipment for pit drainage at locations where drainage is not allowable, evidence of concentrated overland flows—rills, gullies, alluvial deposits—but no evidence of the flow source.
  - Evidence of flow into or out of underground working or auger holes, or conditions that could allow such flow at locations or times not approved in the