The total discharge of the stream is the sum of the discharges in the partial sections: $Q = q_1 + q_2 + q_3 + \ldots q_n$

Where:

Q = total discharge of stream

q_1 = discharge of stream section 1

q_2 = discharge of stream section 2

q_n = discharge of last stream section.

The following characteristics should be sought when selecting a reach of stream for discharge measurement:

- A straight reach with the velocity threads parallel to each other
- Stable streambed free of large rocks, weeds, brush, or other obstructions that would create turbulence
- A flat streambed profile to minimize vertical components of velocity.

Effluents or streams too small to be measured with a current meter may sometimes be accurately measured volumetrically with a bucket and timer. Results obtained in gpm (gallons per minute) may be converted to ft^3/s as follows:

Cubic feet/sec = gpm $\times$ 2.228 $\times$ 10^{-3}

Inspectors are not normally equipped to measure large streams. If such measurements are needed, get help.

Sampling Equipment

Many varieties of field-testing equipment, sampling devices, and sample containers are in use by State and Federal agencies. The purpose of this section is to describe basic items. Many years of field experience by Federal agencies such as the U. S. Geological Survey, Environmental Protection Agency, and Federal Highway Administration have shown the items described here to be satisfactory. The following discussion is for identification purposes only. It does not imply endorsement nor does omission of certain brands imply that they are unsatisfactory.

Field-testing Equipment

The instability of certain chemical and physical constituents in natural water and waste water makes it desirable that some measurements be made on site or shortly after sample collection. Inspectors should know the operation and field use of these types of equipment:

pH meter
pH field testing kit (indicator only)
Specific conductance meter
Thermometer
Alkalinity kit
Acidity kit
Iron kit (indicator only)

These items must be transported and handled with care. Even though some have been designed for field use, they are subject to damage from shock, dust, and moisture. Use cushioned, waterproof carrying cases with all of these instruments.

Each instrument should be given frequent periodic calibration and maintenance. Meters measuring pH are routinely calibrated against standard buffered solutions; specific conductance meters are calibrated against a standard resistor or a standard potassium chloride solution.

Check all instruments frequently for corrosion on terminals and batteries and for moisture and dust on controls and circuitry. Because testing kits are subject to contamination and decomposition of reagents, keep glassware scrupulously clean and reagents freshly stocked from a quality-controlled supply.

Sampling Devices

The contaminants in water associated with mining operations are present in both liquid and solid states. To be representative, a water sample from a mining area must contain liquid water, dissolved solids, and undissolved solids in proportion to their occurrence in the source. Undissolved solids may include both suspended solids, such as clay, and transported solids, such as sand. The devices described in this section will provide a practical means of obtaining a representative sample with a minimum of effort.

Suspended-Sediment Samplers

An inspector will rarely need to sample streams so large as to require special depth-integrating samplers, but such devices may be needed to sample larger impoundments.

The Federal Inter-Agency Sedimentation Project of the Inter-Agency Committee on Water Resources, St. Anthony Falls Hydraulic Laboratory, has developed standard samplers and methods. The two depth-integrating samplers most likely to be used by inspection personnel are the US-DH-48 and the US-DH-59.

The US-DH-48, which is suitable for wadable streams at least 3.5 inches deep, consists of an aluminum casting and glass or plastic bottle. The sample is collected through a brass or Teflon nozzle. The sampler weighs about 4½ pounds and is held by a 3- or 4-foot rod.

The US-DH-59, which is used for larger streams that cannot be waded, is heavier and can be suspended by rope from a bridge or boat. The body consists of a bronze casting, weighing about 24 pounds. The DH-59 has a choice of nozzle sizes, depending upon flow velocity.

If Teflon nozzles and gaskets are used, both the DH-48 and DH-59 are suitable for collecting the kinds of samples upon which most inorganic, organic, and physical tests can be made.

Most discharges from mine sites will not be deep enough to permit use of these samplers. Neither will discharges move fast enough (1.5 ft/sec or more) for the standard suspended-sediment samplers to fill properly.

Bottle

Open-mouth bottle samples can be taken when stream velocities are low (less than about 2 feet per second) and the flow is tranquil, when only fine silt- and clay-sized particles are in suspension, and suspended-solids concentrations do not vary greatly either vertically or laterally. Standard suspended-sediment samplers do not fill properly at velocities less than about 1.5 ft/s.

Open-mouth bottle samples should be depth-integrated. A depth-integrated sample is one in which all depths accessible to the sampling device are uniformly represented. A narrow-mouth bottle, usually one liter or more in size, is commonly used. By equipping a sample bottle with tubing of the type shown in Figure 1 it is possible to control the rate of intake and thus facilitate the collection of a representative depth-integrated sample.

The sample bottle should be weighted so that it will sink readily to the bottom, taking sample on the trip from the surface to near the bottom and back to the surface. The trip must be at a uniform rate. Each point at which the sampling device is lowered to the bottom and hauled back is called a "vertical". The rate of lowering and raising the sampler must be such that the bottle is not more than three-fourths full, otherwise it will not contain a sample equally representative of all depths. If the bottle fills slowly or the stream is shallow, the sample bottle may be filled at more than one vertical or by lowering and raising several times at the same vertical.

Open-mouth bottle samples should be taken at several verticals in the cross-section to allow for the vertical and lateral variations in water quality that frequently exist in slowly moving waters. The number of verticals sampled is largely a matter of intuition; large variations in the water quality in the cross section will require sampling at more verticals than little variation.

A bottle is also acceptable for collecting samples from pipe discharges from streams that are too shallow (less than 3.5 inches) to accommodate a suspended-sediment sampler. Where the stream or pond is very shallow, it may be necessary to "dip and pour" from one container into another. Be careful not to scoop up any bottom material with the sample and be careful to transfer all of any suspended matter that may tend to settle out.

Pipe

Springs and groundwater seeps in unconsolidated material may sometimes be sampled by driving a slotted metal or plastic pipe a few feet into the source. Use a plastic pipe when samples for metal ions are being collected. Water flowing from the pipe will be relatively free of particulate matter and dissolved oxygen. The absence of dissolved oxygen is desirable when samples are being collected for dissolved trace metals or other easily oxidizable materials.

Thief Sampler or Bailer

For wells that do not have pumping facilities, a hand-operated thief sampler, such as the Forest sampler, is a practical method of collecting a sample. When the sampler is at the desired depth, a messenger weight is dropped to activate spring-tensioned rubber stoppers at each end of the sampler. The sample is lifted to the surface and poured into an appropriate container. A simple hand bailer may be used to collect water from near the surface after the "stale" water has been removed by bailing.

Syringe

Frequently small streams, springs, and seeps are so shallow that a grab sample cannot be dipped from them in the usual way. A 50-ml plastic syringe can be used to collect water from such sources for transfer to the final sample containers. This same syringe may also be used to force water through filters directly into bottles for the filtered samples. In using a syringe to collect water, care must be taken not to draw up any bottom material with the sample. It may be necessary to place a flat rock or a piece of metal or glass on the stream bottom, allow time for the stream to clear itself of any sediment stirred up in the process, then place the syringe tip on or above this solid material when the sample is being drawn up.

Sample Containers

Though there are few established rules that specify container size, shape, construction, or composition, the following should be considered:

- volume of sample
- stability of container in field
- storage convenience
- ease of sealing
- ease of labeling.

Do not use a sample container made of a material chemically similar to anything that is to be analytically determined. For example, samples to be analyzed for organic carbon should be collected in glass containers instead of plastic. Samples for boron analysis should be collected in a plastic container rather than a glass container. Make sure the bottle cap will not contaminate the sample.

Disposable plastic bottles (polyethylene) will serve as excellent sample containers for most of the routine analytical determinations required. Depending upon laboratory requirements, 8-ounce or 32-ounce bottles will suffice for most samples. The most common bottle design is the modern round one. It is easy to label, fits conveniently into weighted sampling devices, and is disposable.

Collapsible plastic containers are also suitable. They are easy to store when empty, but they are difficult to inflate and label and will not conveniently fit weighted sampling devices.

Water samples may be collected in presterilized plastic bags. The six-ounce bags are adequate for most samples. The bags are easily labeled with a waterproof marker directly on the outer surface.

Glass milk bottles have been used for years to collect sediment samples with the FISA samplers. Milk bottles are easy to use in the field and in the laboratory, but they are subject to breakage and are heavy to transport. Because of their initial cost they are not considered disposable and, therefore, must be thoroughly washed and rinsed before reuse.

Accessories

Other equipment required for sample identification, labeling, preservation, and shipping includes:

- acid preservative (nitric acid, hydrochloric acid)
- membrane filter, 0.45 micron
- filter holder
- syringe, plastic
- rope or nylon cord
- buffer solutions, pH 4, pH 7, pH 10
- specific conductance standards
- marker, waterproof

- labels, permanent
- bottle caps
- bottles
- tape for sealing sample (preferably "evidence" tape)
- chain of custody form
- sample log book with: sample number, time, date, temp., weather, refrigerated, who, split sample

Inspection: Procedures and Pitfalls

This section addresses procedural aspects of inspection. Its purpose is to help inspectors avoid enforcement pitfalls. Each program has different performance standards, language, structure, types of enforcement activities, and required documentation. Therefore, the information given below should not be interpreted as policy, but simply as points to consider.

When a potential violation related to water is detected, the inspector should approach each aspect of sample collection and documentation as though all issues surrounding the violation and its documentation would be subjected to formal review proceedings. This extra care will facilitate any enforcement actions that may later be necessary. The following discussion addresses hydrologic problems as they relate to a "generalized" set of performance standards. It also mentions items of reference that might be considered before enforcement. Each citation given here—the language, documentation methods, details, and the style and content of the narrative—is intended simply as a generalized example. Greater detail is not presented in the examples because site-specific conditions in actual cases and the remedial requirements of each real enforcement action will differ.

Permits and Hydrology

Point-Source Discharges

As a rule, an NPDES or an equivalent State water discharge permit (sometimes both) are required before establishing the location of a "point source," or any limits on the quality of effluents discharging from that location. Circumstances and requirements differ, but operators are generally required to have such permits "in hand". Generally the permit must state the effective period, the identity of the points of discharge, and the parameters to be monitored.

Keys:
- — the Permit Application Package usually contains a list of other permits required for the operation.
- — the Permit Application Package usually contains a copy of the discharge permit application.
- — check with the discharge-permitting authority to see if a permit has been issued or applied for.
- — discharge permits may be issued for other than "point source" discharge — examples are multiple point sources, for drainage areas rather than individual outflows, for deep mine bore holes, for sewage treatment, etc.
- — the point source for enforcement is usually where discharge flows from the permit or disturbed area onto an adjacent area.

Typical Citation:

Failure to have an approved point source discharge permit as required prior to the construction of, or discharge from, a point source.

Documentation:
- — photo of the discharge point and its relationship to the permitted area.
- — record of conversations or discussions with the permittee/operator concerning permit availability for inspection.
- — references to pertinent regulations.
- — records — lab analyses, etc. — pertinent to the waters discharged from the point source in question.

The narrative report should clearly indicate the requirement for a permit, the efforts made by the inspector to document its existence, and any correspondence or applications in which the operator/permittee acknowledged the need for such a permit.

Groundwater Problems

The sequence or other operational aspects of mining such as overburden handling or blasting can cause unanticipated disruption of groundwater flow as well as degradation of groundwater quality. Issues related to groundwater are often brought into question when a complaint is raised or when there is an obvious change in flow volume or pressure at sampling points on either the permit or adjacent areas. Since determinations of cause and effect relationships are usually interpretive and sometimes complicated or extremely technical, the inspector may want additional technical assistance before drawing conclusions as to the cause of any observed effects. Before requesting help, an inspector should reread the Permit Application Package as it relates to the problem and make a tentative finding of cause for the observed effect.

Keys:
- — collect all information relevant to the site and the known affected area.
- — investigate other possible water sources and users who may also be affected to determine the probable scope of the problem.
- — consult the Permit Application Package geology and hydrology sections of the permit in question for premine conditions.
- — review the Permit Application Package(s) for adjacent or nearby permits having similar geologic and hydrologic structure and problem histories.
- — examine the PHC and CHIA for the permit.
- — contact local sources of information, including the operator, to accumulate a working reference of site conditions for obvious clues.
- — judge current conditions against previous conditions in light of mining sequence or techniques.