

DIVISION OF WATER QUALITY
MONITORING MANUAL

August 31, 2006

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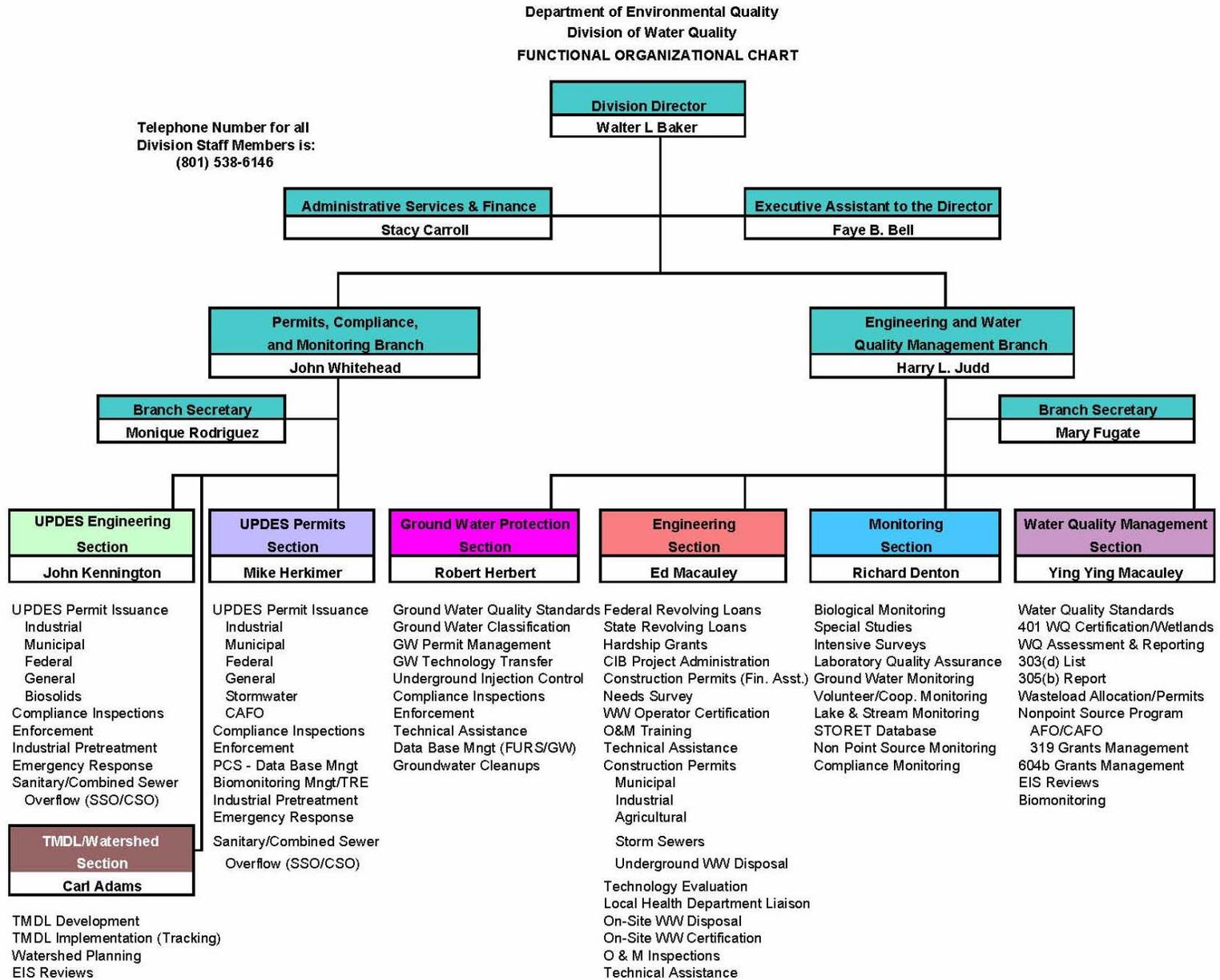
2.0 INTRODUCTION, PURPOSE AND SCOPE

This manual provides guidance on the activities of the Division of Water Quality's (DWQ) Monitoring Section. It contains standard operating procedures for sampling, and sample analyses as well as an overview of all monitoring activities. It provides a person unfamiliar with the State monitoring program not only an understanding of how we do monitoring but why we do monitoring. It also provides procedures to be followed in the Utah Division of Water Quality to ensure uniformity in methodology. The methods and means described are standard analytical and sampling procedures which have been proven in actual practice.

As new methods and equipment are developed and incorporated into the program, updates will be made to this manual. The program is extremely dynamic responding to technological improvements as well as changing environmental issues.

Figure 2.1 is a functional organizational chart for the Division of Water Quality.

2.1 Org Chart



3.0 MONITORING PERSONNEL POLICIES

The Utah Human Resources Personnel policies will be followed by monitoring personnel and management. The Department of Environmental Quality's (DEQ) personnel policies will be followed by monitoring personnel and management. The Division of Water Quality's personnel policies will be followed by monitoring personnel and management. A wide range of issues are addressed in the proceeding documents. Specific policies covering issues immediately applicable to monitoring personnel are described in the following sections.

3.1 Compensatory Time

The State Personnel Policy concerning compensatory time has been reviewed and will be implemented as follows. No overtime pay will be initiated for work accomplished in excess of 40 hours per week. The Fair Labor Standards Act (FLSA) will be used for determining employee classification and compensatory time pay rates. Non-exempt employees will be granted compensatory time at a rate of 1.5 hours per hour worked in excess of 40 hours worked. Exempt employees will be granted compensatory time off on an hour for hour basis. Overtime and compensatory time must be approved by an immediate supervisor before being worked or granted. At no time shall an employee work over 80 hours of compensatory time. Requests for compensatory time shall be made via e-mail prior to taking leave. Record of overtime incurred by each employee shall be kept by the Division of Human Resource Management.

3.2 Use of State Radios

State radios will be used when necessary by monitoring personnel as needed. Personnel using State vehicles equipped with radios will monitor channel Statewide 1 from 0800 to 0900, 1200 to 1300, and 1600 to 1700 hours. Use of State radios will follow the protocol of the Utah Department of Public Safety.

3.3 Use of State Motor Pool Vehicles

State motor pool vehicles assigned to DWQ will be used for official business only. No vehicles will be taken to an employee's residence overnight without prior approval by an immediate supervisor. Employees taking vehicles to their residence will not park on the street overnight. When monitoring vehicles are not being used for monitoring purposes or in a shop for repair and maintenance, the vehicles may be available for other official use. State motor vehicles will be used according to State Motor Pool's Policy and Procedures.

3.4 Utilization of Staff Resources

The DWQ policy for utilization of personnel on monitoring runs will be as follows:

1. At least two qualified employees will be sent on routine monitoring runs.
2. At least two qualified employees will conduct lake monitoring, conduct intensive surveys, conduct enforcement monitoring inspections when litigation may be incurred, conduct non-point source monitoring, conduct groundwater monitoring, and conduct special investigations as assigned by their supervisor.

3. Employees outside the monitoring section or from other agencies may be used for monitoring if they have been trained and are qualified.
4. Training of personnel will be conducted by at least one qualified employee.
5. A qualified employee may accompany personnel from other sections and/or agencies by request of that sections supervisor or agency.

3.5 Duplication of Monitoring Activities

When another agency is studying watersheds that are currently monitored by DWQ, the division will cooperate and attempt to assist the agency within its means to avoid duplication.

3.6 Requests for Monitoring Services

The DWQ has a statewide monitoring program with ambient stream and lake sites, wells and Utah Pollution Discharge Elimination System facilities. Inter-agency or intra-agency requests for additional monitoring, establishing sites, intensive surveys, and/or deletion of monitoring activities, shall be in the form of a memo, letter, e-mail or copy of the permit providing the following information:

1. Site specific location including;
 - a. Copy of USGS map with site indication.
 - b. Latitude and Longitude (accuracy to the second).
2. Parameters of interest.
3. Date sampling is to start and end.
4. Frequency of sampling.
5. Type of information desired.
6. Who will be interpreting or using the data
7. Justification for monitoring activity.

4.0 SAMPLE COLLECTION AND PRESERVATION

4.1 Sample Collection

Labeling

Grab Sampling

Grab samples of water are collected to determine the in situ concentration of the various water quality parameters in a given body of water. Care should be taken in selecting a sampling site and obtaining the sample. Stream velocity, flow, bottom type, depth and the existing stream and lake environments should be evaluated to choose the best representative site. Once a sampling site has been selected the sampling must be taken in a manner that will insure minimal contamination from external sources.

Sampling Procedure

Do not rinse bottles. Lab guarantees their integrity. Sample bottles will be filled either before or directly upstream of Hydrolab and flow analyses, about 2/3 up from the bottom in an area with the largest cross-sectional flow. Taking the sample below the surface will avoid introduction of any floating matter which would not reflect stream quality.

Sample bottle openings should be held upstream from the sampler and into the stream flow to avoid contamination. Special care must be taken with bacteriological sample bottles to maintain their sterility. Face upstream and sample against stream current. The sampler must not touch the inside or lip of the container.

Samples should be taken from the source whenever possible. Facilities with discharges should be sampled with strategies similar to those for streams. A sample bottle holder with an extension handle may be employed to reach the source. If sampling cannot be conducted directly from the source, a sampling device such as a properly decontaminated bucket on a rope may be used. For non-compliance monitoring the sampling device must be rinsed with water from the source at least three (3) times before the sample bottles are filled. For compliance monitoring, see Section 7 and for Chain of Custody sampling, see Section 15. Bacteriological sample bottles will be filled first to avoid contamination.

Filtering: Water Samples

Most stream and some facility sampling sites need to be monitored for filtered or dissolved constituents. Dissolved metals and phosphorus are the two most commonly requiring filtration. Field filtration will be performed with 0.45 micron filters using a peristaltic pump and cellulose filters for inorganic parameters. Special care must be taken to avoid contamination of filters. They will be handled with tweezers and never touch any object other than the filter holder. Other measures to prevent sample contamination include no smoking around sample collection, samplers who smoke must also wear latex gloves, turn the vehicle engine off to prevent contamination from exhaust fumes, and make sure the outside of the pump intake hose is clean. The pump, tubing and filter holder will be rinsed with water from the source before sample bottles are filled. The SOP is as follows. Purge the pump, lines and filter holder with 250 ml of the intended sample. Next, place the filter in the filter holder. Fill the sample bottle without letting the bottle come in contact with the filter holder. Water that is turbid will require a pre-filter to reduce clogging of the .45 micron filter. Place the pre-filter directly on top of the .45

micron filter. If clogging does occur, DO NOT BACKWASH the filter. Stop the pump, remove the clogged filter, replace it with a new filter, and finish filling the sample bottles. Samples that are extremely turbid may be stored for several hours on ice to allow settling. Upon completion of filtration, open the filter holder and discard the filter or save for chlorophyll. Reconnect filter holder.

Filtering: Phytoplankton and Periphyton

Lakes may require additional filtered samples for Chlorophyll A and biomass. Since 2004, as per EPA EMAP Procedures, a prefilter is utilized instead of a .45 micron filter for Chlorophyll A and biomass or periphyton and phytoplankton. If possible, 1000 ml will be filtered for chlorophyll analysis on lakes to get a representative sample. When anticipated phytoplankton densities clog the filter before 1000 ml can be filtered, 500 ml may be sampled. When clogging occurs before 500 ml is filtered, several successive filter will be utilized. In extreme densities, a minimum of 250 ml will be taken with several filter pads. In the event sediment or phytoplankton clog the filter, or the correct amount of water has been filtered to fill the bottles or to satisfy chlorophyll SOP's (see Section 9.3.4.5), turn off the pump. Wait several seconds until there is no pressure in the hose and filter. Disassemble the filter holder and connect the intake hose from the pump to the outlet port on the bottom half of the filter holder. Turn the pump on for several seconds until all water is visibly sucked off the filter pad. Remove the filter pad with a pair of forceps, fold the filter in-two, and store in a black film canister. Replace the filter if additional water need to be filtered, reassemble the filter holder and hose, and continue filtering until samples bottles are filled. Repeat water removal from filter pad as above described. For additional SOP's for chlorophyll, see Section 9.3.4.5. It is imperative that the amount of initial sample and the 25 ml measured be recorded on the canister containing the filter (s).

Stream filtering procedures are identical to lake monitoring with the following exception: The composited sample from 10 transects is vigorously shaken for several minutes to homogenize the sample as could be expected in the field. While the sample is completely homogenous, 25 ml is poured into a centrifuge tube. This 25ml is filtered as described above for lakes. Rinse the centrifuge tube with distilled water to recover any phytoplankton on the container walls. Place the filter in the dark canister and record initial volume and filtered volume. An additional 25 ml homogenous mixed is poured into a second centrifuge tube for biomass. The tube is labeled, wrapped in foil and frozen. An additional 50 ml sample amount completely homogenous is poured into another centrifuge tube, labeled and stored on ice for species identification. See section 20.

Automated Sampling

Composite sampling is accomplished with the model 2700 Isco Sampler. Normal procedures from the Instruction Manual follow.

Several older model Isco samplers are also available. Manuals are not available, but operation is similar for the model 2700. The difference between the two models is the instrument display and adjustment panel.

Composite Sampling with the Isco Model 2700

The model 2700 Isco is capable of numerous sampling regimes but it is used primarily to collect 24 hour composites. The method of setting up and programming the model 2700

for a 24 hour composite sample will be described briefly.

Isco's are built in three sections: (1) the bottom where the bottle or bottles receive the sample (2) the middle where the programmable pump draws and delivers water and (3) the lid.

Water is collected in either a single large bottle or in 24 small bottles. The 24 bottles are available in glass or plastic. They are fitted around the inside perimeter of the base and water is delivered into the bottles by a distributor. The bottles are held in place by a retaining ring. A simple wire ring holds the 350 ml glass bottles in place by fitting inside their ring and holding them against the outer wall of the base. The lighter 1000 ml plastic bottles must be held down as well as in place. A plastic retainer fits over a shoulder on the bottles and is held down with rubber bands.

The center of the base may be used to hold bottle caps or may be filled with ice to keep the sample cool.

Section two is buckled on the top of section one. The strainer assembly on the sample collection tube is placed in the water. Programming is now done.

The control panel holds a keypad, a liquid crystal display and a series of indicator lights. The indicator lights show what function is being programmed.

The right hand column of six red keys is the program controls. Turn the unit on by pressing black "on" key. Please note that the keys are designed to be activated by finger pressure. Use of other objects to depress the keys may damage them. The unit is now in the standby state. Press the start/reset key and let the distributor return to bottle #1 if necessary. Push the halt program key to return unit to standby.

Press the Program/Stop program (P/S) key. The "Mode" indicator light will come on and the LCD will display a number of 1-6. Select "one" and press enter if it is not already selected and press the P/S key. If "one" has already been selected just push the P/S key.

The Interval Between Samples light is now on and the LCD is displaying the minutes between samples. For a 24 hour composite 60 should be selected. Enter 60 if necessary and hit the P/S key.

Delay to First/Next Sample light. Enter a short time (such as three minutes) so that sampling can begin right away. Press P/S key.

Nominal Sample Volume (NSV) light. LCD readout is in 10's of ml (i.e. 35 on LCD equals 350 ml). The method of determining NSV will be discussed at the end of this section. The volume of water actually will depend on the proper setting of the next two functions. Set the desired sample volume and push the P/S key.

Type of Suction Line light. Determine which of the four suction lines is connected to the pump and enter the corresponding number then press P/S.

Note: For non standard lines see in Appendix 13.8.

Suction Head light. Suction head is the vertical distance from the water level to pump inlet. Suction head and volume per stroke of the pump are inversely related. Measure the suction head with the sampler in place and enter to the nearest foot. Press P/S.

Multiple Mode light. Enter one (off). Press P/S. Programming is complete.

Now press Start/Reset. The sample will be taken after the interval entered under TIME to First/Next Sample. The LCD will alternate between the time to the next sample and the next sample number. After the sample is taken, open up the Isco to see if the sample has been taken correctly. Correct any problems that may occur. Now, reclose the Isco and if security is an issue, seal it with a signed chain-of-custody seal and lock it with a padlock.

Retrieving the Sample

The LCD display should read full. Turn the unit off.

If a single bottle has been used for the composite just agitate to mix the water and pour off the sample. If individual bottles were used pour the 24 bottles into a clean, uncontaminated bucket and mix. Now pour off the samples.

Calculating Nominal Sample Volume (NSV)

The NSV is repeatable to within $\pm 10\%$ - if conditions (such as the water level) remain constant. The sample volume should be aimed at getting the largest sample size that can be comfortably accommodated by the smallest container used (including the mixing bucket). After the Isco is programmed a test volume should be taken to determine the actual yield.

Lake Sampling

Groundwater Sampling

4.2 Technique and Preservation

Sample Containers

Each sample container must be treated in a special manner to insure integrity and validity of the sample and analytical results. Bottles not needing special cleaning or preservation are to be filled WITHOUT rinsing. The integrity of the bottles is insured by the manufacturer and the Utah Division of Public Health Laboratory quality assurance practices.

Sample bottles (also see Section 12) must be labeled properly and the correct information supplied on the label. Labels are supplied by the State Laboratory and applied to bottles in the laboratory prior to field activities. Information on the labels will be written in permanent ink, preferably of the "Sharpie" (brand name) variety. The following information will be on the label:

STORET number, site location, date, time, and sampler. The last five digits of the STORET number will also be written on the sample bottle above the label. This is a secondary measure to ensure identification of the sample in the event the label comes off in transit to the laboratory. No writing is to occur on the shoulder of the bottle or lid.

The following list outlines the procedures and precautions necessary when collecting each sample (See Table 4.1 for additional requirements).

Total, Fecal Coliform/Fecal Strep, and e. coli. Using sterile technique, fill a sterile bottle to the fill line indicator. Close the container. Refrigerate or store on ice. Samples containing chlorine require $\text{Na}_2\text{S}_2\text{O}_3$ for dechlorination. DO NOT RINSE OR OVERFILL !

BOD. Fill a 2 liter plastic bottle, cap and refrigerate or store on ice. DO NOT RINSE !

Nutrient. Unfiltered: fill a 500 ml plastic bottle. Cap and invert to mix sample and preservative. Refrigerate or store on ice. CONTAINS STRONG ACID. DO NOT RINSE OR OVERFILL !

Filtered Nutrient. Fill a 250 ml plastic bottle with filtered sample. Cap and invert to mix sample and preservative. Refrigerate or store on ice. CONTAINS STRONG ACID. DO NOT RINSE OR OVERFILL !

Chemistry. Fill a 1 liter plastic bottle, cap and refrigerate or store on ice. DO NOT RINSE !

Filtered Metals. (dissolved). Fill a 250 ml plastic bottle with filtered sample. Cap and invert to mix sample and preservative. CONTAINS STRONG ACID. DO NOT RINSE OR OVERFILL !

Total Metals Filtered: (dissolved). Fill a 250 ml plastic bottle with filtered sample. Cap and invert to mix sample and preservative. CONTAINS STRONG ACID. DO NOT RINSE OR OVERFILL !

Oil and Grease. Fill a 1 liter wide mouth mason jar approximately 2/3 full. Cap and invert to mix sample and preservative. Refrigerate or store on ice. CONTAINS STRONG ACID. DO NOT RINSE OR OVERFILL!

Cyanide. Fill a 1 liter plastic bottle. Cap and invert to mix sample and preservative. Refrigerate or store on ice. CONTAINS STRONG PRESERVATIVE. DO NOT RINSE OF OVERFILL !

Sulfide. Fill a 100 ml plastic bottle. Cap and invert to mix sample and preservative. Refrigerate or store on ice.

Radiological. Fill (two) 2 liter plastic bottles. Do not overfill. Cap and invert to mix samples and preservative.

Pesticides/Herbicides. (EPA method 608, 515.1, and 6219). Fill a 1 liter amber glass bottle. Cap with Teflon lid. Refrigerate or store on ice. DO NOT RINSE OR OVERFILL !

Volatile Organic Compounds. (EPA methods 624.2 and 524.2) Fill (four) 40 ml glass bottles without bubbles, completely to the top making sure the bottle has a meniscus. Add 2 drops of HCl acid to each bottle, tapping the bottle to remove any small air bubbles, cap tightly with Teflon lid. Invert the bottles and tap them again to observe any minute air bubbles. If bubbles remain, unscrew cap, add several more drops of the sample, tap the bottle again, cap, invert and tap the bottle once more. NO AIR BUBBLES CAN BE IN THE BOTTLE. DO NOT RINSE OR OVERFILL ! Refrigerate or store on ice.

Semi-Volatile Organic Compounds. (EPA method 625). Fill two 1 liter amber glass bottles. Add 2 ml of the hydrochloric acid supplied with the bottle. Cap with Teflon lid. Refrigerate or store on ice.

Ethylene and Propylene Glycol. Fill (two) 40 ml glass bottles. Cap with Teflon lid. Refrigerate or store on ice.

Carbamates. (EPA method 531.1) Fill a 40 ml glass bottle. Cap with Teflon lid and invert to mix samples and preservative. Refrigerate or store on ice. DO NOT RINSE OR OVERFILL !

TABLE 4.1 SAMPLE PRESERVATION

Sample Type	Sample Bottle	Preservative	Maximum Holding Time
BOD	2 liter plastic	4°C	48 hours
Chemical	1 liter plastic	4°C	7 days, turbidity - 48 hours
Coliform	120 ml plastic bottle with or without Na ₂ S ₂ O ₃	4°C	30 hours or 8 hours for surface water
Cyanide	500 ml plastic	4°C NaOH to pH 12 0.6g ascorbic acid	14 days
Ethylene/Propylene Glycol	(Two) 40 ml glass bottles w/Teflon cap liner	4°C	28 days
Nutrient, unfiltered	500 ml plastic	4°C H ₂ SO ₄ to pH 2	28 days
Nutrient, filtered	250 ml plastic	4°C H ₂ SO ₄ to pH 2	28 days
Metals (Total & Filtered)	250 ml plastic	HNO ₃ to Ph 2	6 months Hg - 28 days
Oil & Grease	1 liter glass w/Teflon cap liner	4°C H ₂ SO ₄ to Ph 2	28 days
Pesticides (608)	1 liter amber glass w/Teflon cap	4°C pH 5-9	7 days until extraction. 40 days after extraction.
Herbicides (515)	Two 1 liter amber glass w/ Teflon cap	4°C Na ₂ S ₂ O ₃	14 days until extraction. 28 days for analysis.
Pesticides (531.1)	40 ml glass w/Teflon cap	monochloro acetic acid +Na ₂ S ₂ O ₃ to pH3	28 days
Haloacetic acids (6251B)	Three 40 ml glass w/ Teflon cap	4°C NH ₄ Cl	14 days until extraction. 7 days after extraction.
Radiological	(Two) 2 liter plastic	HNO ₃ to pH 2	6 months
Sulfide	100 ml plastic	4°C Zn Acetate + NaOH to pH 9	7 days

Sample Type	Sample Bottle	Preservative	Maximum Holding Time
Volatile Organics (624.2, 524.2, THM)	(Four) 40 ml glass bottles w/Teflon cap liner	4°C, Na ₂ S ₂ O ₃ HCl to pH < 2.0	14 days
Semi-Volatiles Organics (625)	Two 1 liter amber glass w/Teflon cap liner	4°C	7 days until extraction. 40 days after extraction.
Triazinines (6219)	Two 1 liter amber glass w/Teflon cap liner	4°C	7 days until extraction. 40 days after extraction.
TPH/BTEXN	Two 40 ml glass bottles w/Teflon cap line	4°C	14 days
Perchlorate	120 ml unpreserved plastic bottle	4° C	28 days
Chlorophyll A & Biomass	Glass fiber filter in Black container	Frozen	3 weeks
Surfactants	1 liter amber glass	4° C	48 hours
TOC	200 ml amber glass	4°C H ₂ SO ₄ to pH 2	28 days

4.3 Routinely Sampled Constituents

UPDES Discharges

Municipal Wastewater Treatment Plants

- BOD₅, TSS
- NH₃, diss NO₂+NO₃, diss phosphorus, total phosphorus, TKN
- MF total and fecal coliforms
- Field tests: temperature, dissolved oxygen, pH, specific conductance, chlorine residual, flow
- Additional parameters as per UPDES permit limits - Those facilities which treat industrial wastes. (organics, phenol, oil & grease, cyanide, sulfate, etc.)
- Flow

Industrial Facilities

- As per UPDES permit limits (organics, phenol, oil & grease, cyanide, sulfate, etc.)

- NH₃, Diss. NO₂+NO₃, diss phosphorus, total phosphorus.
- Field tests: temperature, dissolved oxygen, pH, specific conductance
- Flow

Receiving Water

- Receiving waters above discharges will require monitoring as per indicated for discharges.

Ambient Stream Monitoring

Streams

- Chemistry (major anions & cations)
- Metals (15 heavy metals)
- Nutrients (nitrates & phosphates)
- Pesticide and radiological constituents (when requested)
- e. coli (selected sites)
- Sediments (nutrients, metals, pesticides, organics, etc.)
- Organics
- Misc. (phenol, oil & grease, etc.)
- Sediments (nutrients, organics, metals, pesticides, etc.)

Ambient Lake Monitoring

- Nutrients (nitrates & phosphates)
- Chemistry (major anions and cations)
- Metals (12 heavy metals)
- Chlorophyll A
- Total and fecal coliform, fecal strep, e. coli
- Phytoplankton
- Zooplankton
- Sediments (nutrients, metals, pesticides)
- Transparency (secchi)

Groundwater Monitoring

- Chemistry (major anions & cations)
- Metals
- Nutrients
- Total and fecal coliform, fecal strep, e. coli
- Organics
- Misc. (phenol, cyanide, etc.)
- Misc. well measurements, (depth, head, purging rate, etc.)

Macroinvertebrates Monitoring

- Species identification & composition
- Number of species per square meter
- See Section 11

Phytoplankton/Periphyton Monitoring

- Chlorophyll A
- Biomass gm/l
- Species composition & identification

Zooplankton Monitoring

- Density
- Species Composition

Fish Monitoring

- Fish presence or absence & relative abundance
- Fish tissue for heavy metals (mercury) & pesticides

5.0 CURRENT MONITORING STRATEGY 2006

5.1 Objectives

1. To obtain and maintain a current database for chemical trend analysis, wasteload allocation analysis, and salinity analysis.
2. To determine ambient water quality for establishing and verifying attainment of State water quality standards.
3. To verify compliance of UPDES discharges, and to maintain the State's presence throughout the State.
4. To assist operation & maintenance inspections in evaluating treatment plants.
5. To obtain data that will assist water quality management in determining significant sources of non-point source pollution.
6. To obtain data that will assist water quality management in lake classification studies.
7. To obtain biological data to compliment water quality data and verify attainment of water quality standards.

5.2 Approaches to Meet Objectives

1. Sample a series of sampling locations for water quality constituents.

The State has established over 5000 ambient monitoring stations. A dynamic monitoring strategy allows flexibility in the sampling scheme. Historical data exist for strategically located stations. Currently about 200 sites are visited every six weeks in conjunction with UPDES permitted discharges. Specific work plans exist for some watersheds and lakes. The sampling strategy is outlined in their individual workplans. Other watersheds or areas are sampled as needed. It should be emphasized that the programs are dynamic. Active sampling stations and parameters are changed as programs or environmental situations dictate.

2. Maintain a data base consisting of sampling locations and water quality data throughout the state.

5.3 Typical Monitoring Program

Currently several major monitoring runs sampled on a six week rotation. An intensive monitoring run in the yearly watershed rotation is performed each month. These runs comprise the backbone of the program. They provide data on dischargers for the UPDES oversight program as well as the majority of the ambient stream data used in the 305(b) reports to the EPA. There are several monitoring runs (some in remote areas of the state) that are sampled at various frequencies. This data is used for trend analysis, macro invertebrate analyses and attainment verification of water quality standards.

The division is heavily committed to nonpoint source, waste load allocations, total maximum daily loads, and lake monitoring. Study areas are sampled according to their work plans. The data is used for assessments, evaluation of management practices and activities related to NPDES permits.

The division is also committed to cooperative agreements with various government

agencies. These cooperative agreements allow the state to expand its sampling program without a large increase in expense. It provides the opportunity for outside organizations to study areas of importance without a large burden to their budgets.

Biological monitoring includes macroinvertebrates, periphyton, and fish at selected sites throughout the state. Sites are sampled late September/October. Physical habitat data is collected in conjunction with the biological data. This information in conjunction with chemical data is valuable in assessing a stream's water quality.

In recent years groundwater monitoring for aquifer classification has taken place in various portions of the state in cooperation with the USGS. The State will monitor up and down gradient wells and injections wells for permitted groundwater discharges as part of an oversight program. Laboratory analysis for special studies in ground water is available.

The Division is also charged with supporting other agencies within the Department and throughout the State. This support is scheduled on an as needed basis. Monitoring actions can vary from a composite sample on a particular wastewater treatment plant process to assisting in sampling after a fish kill. Some of the agencies assisted are local health departments, DEQ district engineers, divisions within the Department of Environmental Quality, the Division of Wildlife Resources, the Division of Oil, Gas and Mining, the Department of Agriculture, the National Forest Service, the Bureau of Land Management, the Bureau of Reclamation, several Water Conservancy Districts, and local government agencies.

The Division of Water Quality's annual monitoring activities can be reviewed on the Department of Environmental Quality/Division of Water Quality web site.

6.0 AMBIENT CHEMISTRY MONITORING PROGRAM

6.1 Annual Monitoring Program

The stream monitoring program consists of basin intensive, long term, and total maximum daily load(TMDL) ambient water quality monitoring stations. The long term monitoring network consists of 55 stations. These stations are used primarily to evaluate long-term water quality trends. Samples are collected every six weeks (eight times per year).

Basin intensive surveys are used to assess water quality, identify causes and sources of pollution, determine beneficial use support, and to provide data for developing watershed management plans. The data are also used to develop the 303(d) list of impaired waters and to select those streams or segments for Total Maximum Daily Load analysis. Requirements under section 305(b) of the Clean Water Act (CWA) are also met using intensive survey data. The State Of Utah has been divided into five areas (see figure 6.1). Each area consists of 75-80 sites and is sampled on a five year rotation. Basin intensive stream sites are collected every other week during the runoff period (April-June), and monthly the rest of the year except during December. Samples are collected for a 1 year period from July 1 to May 30.

Intensive surveys also allow water quality programs to be focused on critical areas, allows the Division of Water Quality to prioritize its management plans, determine the effectiveness of its water quality management plans and assist individuals and agencies involved in protecting the quality of the State's waters.

Waste load allocation sites are assessed to determine the amount, if any, of a water quality parameter that can be safely discharged to the State's waters under the UPDES program without causing harm to the aquatic ecosystem and are sampled quarterly.

Data are also collected to complete Total Maximum Daily Load analyses(TMDLs). Under section 303(d) of the clean water act, each state is required to identify those waters that are not supporting their beneficial uses. Waterbodies are then selected for TMDL assessment. The TMDL process is used to determine the sources and amounts of pollution that are entering a water body. Calculations can then make to determine how much each source would have to reduce their input so that the water body meets the state water quality standards and supports its beneficial uses. Sites are sampled either monthly or every six weeks on the regular monitoring runs.

Cooperative agreements between the Division and other agencies involved in water quality management were developed to assist other agencies in meeting their responsibilities for the protection of water resources, to reduce program costs for the State and other agencies, and improve the monitoring program by assisting each other. The Division has cooperative monitoring programs with the U.S. Forest Service, Bureau of Land Management, Bureau of Reclamation, National Park Service, Grand Staircase National Monument, Glen Canyon National Recreation Area, Salt Lake City, Davis County, Kane County and Central Utah Water Conservancy Districts.

Sampling sites for all programs can be found the Utah Division of Water Quality Monitoring Work Plan accessed on the division's web site.

7.0 COMPLIANCE MONITORING PROGRAM

Municipal and industrial discharges in the State are permitted under the Utah Pollution Discharge Elimination System (UPDES) to meet certain pollution limits established by the State of Utah, Division Of Water Quality. To verify these permittees are within their UPDES permit limits, programs of oversight and inspection have been developed. The programs consist of sample collection, data interpretation, notice of violations, and onsite evaluations.

7.1 Sampling Inspections

Compliance Sampling Inspections and Compliance Enforcement Inspections are scheduled by the Permits and Compliance section with the cooperation of the monitoring section. In general, the inspection consists of a physical inspection of plant operations, a review of self monitoring data and records, and sampling for parameters listed in the permit. Sampling is performed by qualified personnel of the Division of Water Quality. Grab samples are collected using standard techniques listed in Section 4. If the facility has composite sample limits in their permit, composite sampling with automated samplers (ISCO's) will be performed by qualified personnel of the Division of Water Quality. Composite samples are collected using standard techniques listed in Section 4. All sampling done during inspections will use chain of custody procedures outline in Section 15.

7.2 Oversight Monitoring

Oversight monitoring is performed concurrently with ambient monitoring on the seven surveys. Facilities are sampled every six weeks for parameters limited in the facility permit. Other parameters of interest to the Division of Water Quality staff are sampled as needed. Grab sampling is performed using standard techniques listed in Section 4.

Each UPDES permit has limitations for the parameters listed. After sample analysis, the data base generates a report for site visited. The report is given to the Permit and Compliance section. The individual permit write notes any exceedance and compares the report with the facilities latest Daily Monitoring Report (DMR). The report with notations is mailed to the individual permittee. Remedial action is at the discretion of the Permit and Compliance section.

8.0 319 NONPOINT SOURCE MONITORING PROGRAM

Program Objectives

- * Determine problem parameters
- * Develop background water quality data
- * Determine trends of problem parameters
- * Determine the effectiveness of Best Management Practices (BMP's)
- * Determine probable nonpoint source categories

Program Rationale

The rationale of the nonpoint source monitoring program is for the documentation of nonpoint source pollution contributions to a waterbody. The monitoring program also develops criteria for monitoring BMP effectiveness through a feed-back process. The program establishes background information and determines improvement in water quality. The monitoring program is mandatory under EPA for the 319 program.

Program Purpose

The monitoring program establishes water quality information to be utilized by agencies associated with watershed improvement activities. A coordinated resource management planning process documents improvement practices implemented in a watershed.

8.1 Monitoring Procedures

The objectives of the water quality monitoring program for the Non Point Source watersheds are to document progress in achieving improved water quality conditions. Nonpoint source control programs are implemented to document and review effectiveness of best management practices (BMP's).

The goals and work activities include the following:

1. Sampling frequency for chemical water quality sites will include sampling every six weeks on the regular monitoring runs.
2. Sampling is performed using Standard Techniques listed in Section 4.
3. Parameter sampling will include nitrates and nitrites, ammonia, total dissolved phosphate, total phosphate, total nitrogen, fecal and total coliform, total suspended sediments, and flow.
4. Review and evaluate all chemical and macroinvertebrate data to document progress in achieving improved water quality as nonpoint source control programs are implemented.
5. Develop data review process or feed back for evaluation of BMP effectiveness.

8.2 Non Point Source Monitoring Sites

Non Point monitoring stations are reviewed and updated on an annual basis. A list of sites currently being monitored can be found at the Utah Division of Water Quality website.

8.3 Evaluation Procedures

The information gathered from the physical, chemical and biological data will be used to track and document water quality trends and to evaluate BMP effectiveness. The following work will also be accomplished:

1. Update annual nonpoint source assessment report.
2. Develop annual watershed reports describing information gathered from water quality data and effectiveness of BMP's.
3. Implement data review process or feed back.
4. Sample biological and water quality sites within the individual watersheds.

The QA/QC will be done in accordance with guidelines and objectives that are currently outlined in the Utah Water Quality Monitoring and Quality Assurance Manual. EPA's Guidance for Quality Assurance Project Plans for Environmental Data Operations (EPA QA/R-5) will also be implemented.

9.0 THE UTAH LAKE MONITORING PROGRAM

9.1 Clean Lake Program

In the late 70's and early 80's the DWQ began to incorporate Section 314 of the Clean Water Act (CWA), the Federal Clean Lake Program as part of the overall water quality management effort. Under federal guidelines states were allowed to submit grant proposals to conduct lake inventory and water quality assessment studies. DWQ in an effort to comply with the act submitted a proposal and received a grant to conduct a Lake Inventory and Assessment Study. The purpose of the study was to gather information required in Section 314 of the CWA for Utah's lakes and reservoirs. Reporting requirements were to identify and classify all publicly owned lakes, to describe pollution controls for lakes, to describe restoration plans for lakes, describe mitigation plans for acidity, develop a list of impaired lakes, develop a priority listing for lakes and reservoirs, and assess the status and trends of water quality for lakes and reservoirs.

Assessment and restoration projects were initiated and completed in the 1980's and 1990's. They include: Bear lake (administered through the State of Idaho) phase I & II, Panguitch Lake phase I & II, Scofield Reservoir phase I & II, Deer Creek Reservoir phase I & II, Salem Ponds phase I & II, Pineview Reservoir phase I, Utah Lake phase I, East Canyon Reservoir phase I, Minersville Reservoir phase I, Otter Creek Reservoir phase I, and Navajo Lake phase I.

9.2 Lake Water Quality Assessment Program

Objective:

Provide essential lake assessment data in support of the Utah Water Quality 305(b) report, and to determine long term water quality trends for Utah's lakes and reservoirs.

Rationale:

Under section 305(b) of the CWA guidelines the state is required to assess and report the water quality status of its lakes and reservoirs. A priority listing of Utah's lakes and reservoirs is maintained to direct restoration efforts under various programs.

Purpose:

The purpose is to obtain productivity data for Utah's lakes and reservoirs. The focus of this plan is to determine general lake water quality with focus on lake transparency values, total phosphorus concentrations and chlorophyll-a concentrations. Other data is obtained to facilitate in the overall evaluation of each lake or reservoir.

Utilization:

Determine an overall Carlson Trophic State Index (TSI) value for each lake or reservoir. This provides the basis for assessing and tracking water quality changes of Utah's lakes and reservoirs. Data is used for 305(b) assessments, incorporation into the priority listing model for lakes and reservoirs, and assessment and evaluation of lake water quality.

Monitoring Program:

An ongoing plan of summer monitoring of essential lakes and reservoirs is conducted by personnel from the Division of Water Quality.

Lake Monitoring Stations

A list of the current Reservoir and Lake Monitoring Sites can be found in the Utah Division of Water Quality Annual Monitoring plan on the DWQ website

Under the routine state monitoring program, each lake is sampled during the two year assessment period. The list of impoundments is divided and half the lakes monitored on odd and even years. The sampling is conducted from June through August, the high productivity season.

9.3 Parameters, Site Selection, and Field Methodology

Parameters Sampled on Lakes

Chemical

Nutrients (T. Phos., T. Diss. Phos., NO₂ + NO₃, ammonia as N)
 Metals: (arsenic, cadmium, copper, lead, mercury, silver, manganese, barium, chromium, iron, selenium and zinc)
 Chemistry: (alkalinity, TDS, TSS, calcium, potassium, Magnesium, T. hardness, sulfate, sodium, chloride)

Biological

Chlorophyll A
 Macrophyte
 Phytoplankton
 Zooplankton
 T. coliform
 F. coliform
 F. Strep.
 e. coli
 Fish tissue contaminants
 Fish species composition
 Benthos

Parameters Sampled on Watersheds

Chemical

Nutrients: (T. Phos., T. Diss. Phos., NO₂ + NO₃, ammonia as N)
 Metals: (arsenic, calcium, copper, lead, mercury, silver, manganese, barium chromium, iron, selenium, and zinc)
 Chemistry: (alkalinity, TSS, TDS, calcium, potassium, T. hardness magnesium, silica, sodium, chloride, sulfate)

Biological

T. Coliform
 F. Coliform
 F. Strep.
 e. coli
 Benthos
 Periphyton
 Physical Habitat

Site and Depth Factors Effecting Sampling Protocol

Parameter selection varies according to prior water quality assessments and site. New reservoirs added to the monitoring list are monitored for all of the listed parameters. However, when tracking well established reservoirs, only those parameters required for proper assessments are monitored.

On any given waterbody, at least one site is established as the primary deep site. This site represents the deepest point for the water body and may not always be the site next to the dam. At this site all physical parameters, nutrient parameters and field tests including dissolved oxygen and temperature profiles are gathered. This site is also defined as the site where metal and chemistry parameters are obtained if those parameters are required. In addition, phytoplankton sampling occurs at this site. Depending on the depth of this site, a protocol for sampling is selected. If the site is deeper than six meters then at least four sampling intervals (surface, two intermediate depths, and a bottom sample) are defined. If a thermocline exists, the intermediate samples are from above and below the thermocline. If there is no established thermocline then the intervals are defined equally throughout the waterbody. Water from the surface sample is collected and analyzed for nutrient parameters, chlorophyll-a, bacteriological parameters and for the following chemistry parameters: total alkalinity, volatile suspended solids, residual suspended solids, sodium, potassium, calcium, magnesium, sulfate, chloride, silica, total dissolved solids, and turbidity (NTU). During the second sampling period (August/September), phytoplankton samples are sampled and processed at this sample site. The two intermediate water column samples are collected and analyzed for nutrient parameters. Water from the bottom is collected and analyzed for nutrients, metals and total hardness. Sediment samples may be collected for metal analysis. In addition, field (physical) data (temperature, conductivity, pH, and dissolved oxygen) is obtained at one meter intervals throughout the entire water column and a secchi depth (meters) obtained and reported for the site.

Secondary (shallow) sites water samples are collected at the surface and bottom only. Water from the surface is collected and analyzed for chlorophyll A, nutrients and bacteriological parameters. Water from the bottom is collected and analyzed for nutrient parameters. In addition, one meter interval profile data is obtained.

Field Sampling Methods

Temperature, Dissolved Oxygen, Conductivity, Ph

Temperature, dissolved oxygen, pH and conductivity are recorded at all stations at 1 meter intervals from surface to bottom. The 4 parameters are measured by a multiparameter measuring device (Hydrolab unit). In this matter, profiles of the 4 parameters are obtained. The Hydrolab is calibrated prior to each field usage.

Water Samples

Water samples are collected by three methods: grab sample on the surface by submersing the sample container, variable depth samplers such as a Kemmer or Van Doren sampler, and by pumping.

Grab Samples: A sample container is submersed several inches under the surface to avoid contamination by floating material. Care is exercised to avoid contact by the sampler with the container opening.

Variable Depth Sampler: The depth of the lake is determined prior to sampling. The depths to be sampled are determined as in Section 9.3.3. The bottom sample is collected 1/2 meter off the bottom to avoid contamination by bottom sediments. The sampler's trip mechanism is set and the sampler vigorously rinsed with lake water. The air vent and discharge valves are closed to prevent loss of the sample when removed from the water. The sampler is lowered to the determined depth by meter increment marks on the rope. A messenger (a weight that slides down the rope) is placed on the rope. The field person must insure that the sampler is hanging exactly vertical to insure the correct depth. The messenger is released and the sample collected when a slight tug of the rope is felt indicating that the trip mechanism has functioned. The sampler is quickly retrieved to the surface. Bottom samples should be immediately checked to insure that the sampler hasn't disturbed bottom sediments. A turbid or muddy would indicate disturbance. Another sample would be required after decontaminating the sampler. After rising to the boat, the sampler is placed on a flat surface so the sample can be drawn. The air vent is loosened, the sample container placed under the discharge spout, and the valve loosened. The sample is filled. Often, multiple sample containers will be required. The field person should quickly shut off the discharge valve to conserve water which will (1) eliminate the effort of collecting another sample, and (2) insure that all sample containers are filled from one aliquot. Quality assurance is increased and the data interpreter is assured that all chemical parameters are from homogeneous sample. Samples are preserved, labeled, and stored for transport to the laboratory as described in other sections.

Transparency

The Secchi Disk is lowered in the water until it disappears from view. The depth of water at which the Secchi disk vanishes and reappears is the Secchi Disk reading. The reading is taken on the sunny side of the boat without sun glasses.

Benthos

Four bottom samples may be taken with the Eckman or Ponar dredge at the primary station. The dredge is lowered to the bottom, tripped with a messenger, and raised to the surface. A sieve is quickly placed under the dredge while still in the water to prevent loss of organisms. The sample is released into the sieve, washed of muck and ooze, rinsed into a storage bottle, and preserved with 80% ethyl-alcohol.

Chlorophyll A

Samples are collected at 1 foot below the surface from all lake stations. The samples are placed in the dark and cooled to 4⁰C. or less. Samples are filtered immediately after returning to the vehicle. The amount filtered is dependent upon the concentration of the algae. Where feasible, 500 ml is filtered. The amount filtered, date, time, site, and the Stret number is recorded on the bottle. Samples are preserved on dry ice at 0 degree centigrade and in the dark until analysis.

Phytoplankton

Phytoplankton sampling is dependant on light penetration. The literature defines penetration as three times the Secchi disk depth. Therefore, the first step is determining the Secchi depth. Phytoplankton samples are taken from the surface to three times the Secchi depth.

1¼ inch reinforced acrylic hose is utilized for collection. The hose is weighted on one

end and also has a cord attached to the weight.. The hose is lowered slowly into the water column to collect a sample from the surface to 3 times the Secchi depth. The hose is crimped at the water level which creates a vacuum in the hose, and prevents the water sample from escaping. While keeping the hose crimped, the weighted end of the hose is brought to the surface with the cord. The sample is released into a tub or bucket. It is thoroughly mixed and collected into the pre-labeled sampling bottles. The sample is immediately placed in the dark and cooled to 4⁰C.

If the secchi depth makes it impractical to use a whole water column sample, the phytoplankton samples will be obtained using a Van Dorn sampling device at the following depths; surface, secchi depth, two times secchi depth, and three times secchi depth. These samples will be composited into a single half gallon bottle. Samples are preserved on ice at 4⁰C.

10.0 GROUND WATER MONITORING PROGRAM

10.1 Justification for the Ground Water Monitoring Program

- a. Regulatory compliance
- b. Pending or threatened litigation
- c. Establish preconstruction baseline competence
- d. Knowledge of accidental discharge
- e. Establish, evaluate types and characteristics of contaminants
- f. Oversight monitoring

10.2 Objectives of Ground Water Monitoring System

- a. Monitoring for presence and extent of contamination in ground water
- b. Ground water level monitoring
- c. Determination of natural seasonal variations
- d. Determination of man-induced variations
- e. Permittee compliance with self monitoring

10.3 Sampling Mechanisms

Sampling Mechanisms for the collection of ground water samples are among the most error prone elements of monitoring programs. Many of the sampling designs may be expected to provide adequate performance for conservative chemical constituents which are not (or minimally) affected by aeration, gas-exchange and degassing. Among these constituents are Na⁺, K⁺ and Cl⁻. The chemical constituents which can provide the most useful information to the investigation frequently are affected by the improper choice of sampling mechanisms. Evaluations of sampling performance based on the recovery of conservative, unreactive chemical constituents are simply not reliable for planning effective monitoring efforts.

Suction (peristaltic pumps):

Shallow wells to 0-20 feet. Good for conditions requiring low flows for volatile substances. Disadvantages include low flow rates during purging and the 25 foot limit on depth.

Dedicated Pumps:

In large volume wells or wells sampled frequently, a dedicated pump in the bottom of the well is the preferred method for obtaining samples. Several advantages are evident:

1. Efficiency:

Deep wells or with large diameter casings requiring large volumes purged, i.e. extra time.

2. Contamination:

No decontamination is needed on portable pumps or bailers. There is less likelihood of material being loosened in the well casing during sampling.

3. No portable pumping equipment is necessary

Disadvantage:

Requires an external power source on wells not near power lines.

Pumping Mechanisms:

Several types are available including positive displacement bladder pumps, suction-lift and air-lift devices and Grundfos type pumps.

Grab Mechanisms:

Perhaps the oldest and simplest method of sampling ground water from a well is the conventional bailer. While a bailer can be made of virtually any rigid tubular material that can be easily machined, or even of almost any flexible tubular material, most bailers used in monitoring wells are constructed of either polyvinylchloride (PVC), Teflon or stainless steel.

In all bailers, the top of the bailer is open: the bottom of the bailer usually contains a check valve that consists of a simple ball and seat arrangement. To take a sample, the bailer is lowered into the well on a line. In many applications, the line consists of no more than a polypropylene or nylon rope; however, when a ground water monitoring program is conducted for the purpose of detecting trace levels of specific contaminants, a non-contaminating material such as stainless steel wire or Teflon-coated wire should be used.

In addition to the single check valve bailer, a double check valve bailer (or “point source” bailer), which is designed for sampling a discrete interval in the water column in a well, is available. In this device, one check valve is installed at the bottom, as in a conventional bailer, and another check valve is installed at the top of the bailer. Ideally, water flows through the sample chamber as the unit is lowered through the water column and when the desired depth is reached, the bailer’s descent is stopped. Both check valves close simultaneously, and a sample that is supposed to represent the specific interval in which the bailer is situated is retrieved. Realistically, the water sample trapped in the bailer is probably an integrated sample of the water column through which the bailer has descended.

10.4 Field Sampling Procedures Outline

This guide is presented as an example of “how-to” collect samples. Refinement and modification will be necessary for application to specific sampling and analytical needs. In large measure, the degree of preparedness taken into the field will determine the actual number of samples which can be collected. Given the range of field conditions, network complexities and the analytical detail which ground water monitoring investigations demand, no single example can provide all of the elements needed in the sampling protocol. The following should provide the basis for application of effective sampling procedures for either detection or assessment monitoring investigations.

The following procedures in a sampling protocol are covered in detail in this Section:

- H₂O Level
- Purging Volume
- Purging – Verification
- Bailers
- Peristaltic Pumps
- Dedicated Pumps
- Flow Thru Cells
- Filtration Samples
- Splitting Samples
- Grundfos Pump
- Bladder Pumps

The importance of careful integration of the efforts of sampling staff at each point should not be underestimated. Mistakes, lost data or biased results may exact a heavy price if sampling efforts are not well planned. The same care taken in the laboratory to prevent mishaps or contamination should be followed in the field. Smoking or eating in the vicinity of well head field analytical setups is prohibited.

Water Level

Prior to the purging of a well or sample collection, the water level in the well must be known and recorded and recorded in the sampling well log book. The water level measurement is required to determine the amount of water needed for purging before sampling can proceed

The depth of the well and the static water level determined at drilling is obtained from the well drilling log or the well owner. Measure the distance from the ground surface to the top of the well casing. Enter all this information into the well log book. The electronic water level device is carefully lowered to just above the water depth noted in the well drilling log. It is slowly lowered until contact with the water where the water level device will audibly or visually react. Stop lowering. Record this initial level as marked on the water level indicator cord LESS the distance from the ground to the top of the casing. Raise and lower the sensor several more times to verify the water level. Record the verified water level in the well sampling log book. Remove the water level indicator from the well. Water level valves are measured to hundredths of a foot.

Documentation

Documentation of the actual well purging process is a part of the standard field sampling protocol. The number of well volumes to be purged from a monitoring well prior to collection of water samples is three (3). High well casing volumes (over several liters) will always require purging three volumes. In low volume where purging 3 well casing volumes depletes the well volume, the well is pumped dry, and allowed to recover overnight or when recovery is complete back to the initial water depth.

Purging is complete when the three volumes are complete, AND the physical water parameters (temperature, conductivity) become stable.

The following information and formula is required to determine the amount to be purged; well depth to ground or top of well casing, height of water in the well, diameter of well casing. The well drilling log will provide depth of well or to top of well casing and the casing diameter. Subtract the height of the water from the ground depth of the well of the top of the well casing. This gives depth of water. Formula is $(1/2 \text{ base} \times \text{height}) \times 3$ casing volumes = amount to be purged.

Verification of the Well Purging Requirement

Well purging requirements should be calculated and verified each day by measurement of the well-purging parameters. The pump is lowered to the point where the pump intake is at the top of the screened interval. It is useful to use a “keeper” which consists of a wooden or plastic rectangle with holes drilled in it to allow the gas and water tubes to slide through and be held in place with a knotted cord or wire tie. At this time, the pump should be started and adjusted to produce a steady output into a collection bucket or drum. At intervals equal to (10% of the calculated purging requirement), the readings of pH, temperature and conductivity are then recorded and the cumulative volume pumped should be measured and recorded. When the calculated purge volume is approached the readings should be made at more frequent volume intervals and the pump may be slowed. When the readings of the well purging parameters have stabilized to within +10% over three successive volume increments (i.e., no less than 20% of the required purge volume), the pump output may be considered equilibrated and sampling may begin.

Bailers

For shallow, small-diameter wells with low yields, evacuation of the well by bailer is feasible. However, bailing becomes labor and time-intensive for larger, deeper wells with large volumes of storage. Most bailers are removed from the well manually, by lifting on the wire or rope suspending the bailer in the well, but reels can be used to retrieve bailers from deep wells. Reels may also be used to keep the bailer line from becoming contaminated by contact with soil surrounding the well, as is frequently the case if care is not taken to avoid such contact. Tarps or sheets of plastic laid on the ground surrounding the well are an alternate means of minimizing contact between the

bailer line and soil provided they are kept clean. As the bailer is lowered into the well, the check valve remains open, allowing water to pass through the bailer. When the desired sampling depth is reached, the bailer's descent is stopped. The weight of the water column closes the check valve, trapping the sample (which is an integrated sample of the water column in the well) inside the bailer. The bailer is then removed from the well with the sample intact. When the bailer reaches the surface, the sample is decanted into a sample bottle.

The capacity of a bailer and thus the volume of sample that can be obtained from a bailer depends on the length and diameter of the device. Table 10.16.1 shows the volumes that can be obtained from a 1-foot section of various diameters of bailers, which will fit inside a 2-inch diameter well. Bailers can be custom-tailored to be used in wells of any diameter. Samples obtained by bailers are exposed to descending pressures as the bailer is raised from the sampling depth to the surface, and to contact with the atmosphere during decanting to the sample container. This may compromise sample quality, particularly if volatile contaminants or dissolved gases are of interest. At least one manufacturer offers a device to allow emptying the bailer from the bottom at a slow, controlled rate to avoid the aeration that can occur during decanting. This device has been found to improve sampling results obtained with conventional bottom check valve bailers (Barcelona et al. 1984). During the sampling process, bailers may introduce into the sample a certain amount of dissolved oxygen that may affect parameters sensitive to dissolved gas composition, such as pH, alkalinity and redox-dependent trace metals (Seanor and Brannaka 1981).

Gigg et al. (1981) offer a list of procedures that will aid in collecting representative samples with a bailer:

1. The bailer should be constructed of a non-contaminating material.
2. A pass-through type check valve should be used to minimize disturbance as the bailer is lowered through the water column to the proper sampling depth.
3. The bailer should be lowered to the same depth in the well every time.
4. Bailing should be timed to approach a constant pumping rate and should continue until the appropriate number of well volumes are removed prior to collecting a sample.
5. The line used to operate the bailer should be of a non-contaminating material and should be held off of the ground during the bailing process.
6. The bailer and line should be thoroughly cleaned before use in each well.

Table 10.16.1 summarizes the advantages and disadvantages of bailers used for sampling small-diameter monitoring wells.

Table 10.1**Bailer Sample Volumes Per One-Foot Section of Bailer**

I.D. Size (inches)	(Fluid oz.) [$V=5.22(I.D.)^2$]	Sample Volume (Gallons) [$V=0.0408(I.D.)^2$]	(Milliliters) [$V=154.4(I.D.)^2$]
1/2	1.31	0.01	38.6
3/4	2.95	0.02	86.9
1	5.22	0.04	154.4
1-1/4	8.16	0.06	241.3
1-1/2	11.74	0.09	347.3

Table 10.2
Advantages and Disadvantages of Bailers

Advantages

- Bailers can be constructed of virtually any rigid or flexible material, including those materials that are inert to chemical contaminants.
- Bailers are mechanically very simple, and thus are easily operated and disassembled for cleaning and repair
- Bailers are, in comparison with other sampling devices, very inexpensive, making them feasible for dedicated installation in monitoring wells
- Bailers can be used to sample water from wells of virtually any depth.
- Bailers require no external power source, and are lightweight and highly portable.
- Bailers made of flexible material will allow passage through non-plumb wells.
- Bailers can be made to fit any diameter well, and can be made virtually any length to accommodate any sample volume.
- Bailers can provide a “cut” of immiscible contaminants (i.e., petroleum hydrocarbons) from the top of the water column in a well. Transparent bailers are usually utilized for this purpose.
- The “swabbing” effect of bailers that fit tightly into a well casing may induce fines from the formation to enter the well, especially if the well has been poorly developed.

Disadvantages

- In deep wells, well evacuation can be difficult and therefore labor and time consuming.
- If the line used with the bailer is not a “non-contaminating” line and is not dedicated to a single well or is not adequately cleaned after each sampling event, cross-contamination between wells can result.
- Aeration, degassing and turbulence can occur while lowering the bailer through the water column or while transferring the sample from the bailer to the sample container.
- The person sampling the well is susceptible to exposure to any contaminants in the sample.
- Bailing does not supply a continuous flow of water to the surface.
- It may be difficult to determine the point within the water column that the sample represents.
- Bailer check valves may not operate properly under certain conditions (e.g., high suspended solids content and freezing temperatures).

Peristaltic Pumps

Peristaltic pumps such as the Geopump by Geotech is a quick, reliable and flow controllable for shallow, small diameter wells. The pump allows easy purging and control of flow for semi and volatile compounds. Care should be taken to decontaminate the device as discussed in 10.4.9 (filtration). A major limitation is the 28 foot maximum depth capability.

Dedicated Pumps

Large diameter and volume wells generally have a dedicated pump near the bottom of the well. Often these wells require an auxiliary power source (generator) to operate the pump. It is economically feasible to have a portable generator rather than a land power line or a generator at each well. Dedicated pumps allow quicker purging for large volumes. A disadvantage is that it is not possible to measure the depth to water because the well head may be sealed. Drilling and other operational records would be used to determine purging volumes.

Flow Thru Cells

A flow through cell may be attached to the pump for attachment of a multiprobe instrument measuring pH, conductivity or other physical parameters. The cell gives an insitu procedure for these parameters.

Filtration

Various methods of filtration are available and approved. Filtration procedures for DWQ sampling can be found in Section 4 of the Utah DWQ SOP and Monitoring Manual.

There are samples that call for filtration. It is important to minimize the disturbance of fines which accumulate in the well bore. This can be achieved by careful placement of the sampling pump intake at the top of the screened interval, low pumping rates, and by avoiding the use of bailers.

It is advisable to refrain from filtering TOC, TOX or other organic compound samples as the increased handling required may result in the loss of chemical constituents of interest. Allowing the samples to settle prior to analysis followed by decanting the sample is preferable to filtration in these instances.

Water samples for dissolved inorganic chemical constituents (e.g., metals and nutrients) should be filtered in the field.

Splitting

Samples may be split for quality control purposes such as duplicates for UDWQ, or at the request of the well owner to send samples to a second laboratory.

Samples may be split with a standard sample splitter or by filling two side-by-side bottles for the same parameter analysis. Care in filling side-by-side to ensure the water stream is split adequately by observation to ensure both bottles fill at the same rate.

For chain of custody samples or enforcement action, the sample splitter device is preferred.

Pumping procedures

This subsection reviews the steps involved in the operation of the Grundfos, Redi-Flow 2, Teflon/Stainless steel submersible pump, for well sampling. It gives detailed information regarding pump preparation and use while taking ground water samples and storage.

The following paragraphs give information pertaining to the preparation of the Grundfos, Redi-Flow 2 pump. All steps should be observed before using pump to collect samples. Following the procedure will maintain optimum pump operation and performance while sampling, reducing sample bias.

Priming Pump

Unscrew the filling screw located on the bottom of the pump. The motor cavity should be filled with deionized water up to the edge of the screw hole. If needed, add more deionized water to the motor cavity by using a syringe. Replace the filling screw and physically turn pump over several times, this allows the water to work its way into the motor. Remove the filling screw allowing excess air to escape, add more water if needed. Fluid should overflow when the cap is screwed back onto the motor cavity. Repeat procedures as many times as necessary. This water helps lubricate the internal components of the pump.

Inspecting Motor Lead, Discharge Hose and Safety Cable

Inspect motor lead for cracked, broken or frayed wires. Such electrical conditions are hazards to personnel and could lead to loss of sample integrity. Discharge hose should be examined carefully to detect cracks or other problems that may also cause sample degradation. Hose must be attached to the pump firmly, insure fitting is snug by pulling on pump. Check safety cable and safety cable fitting; make sure cable is secured to pump. The safety cable supports the majority of the weight of the pump, and has the durability to pull the pump out of wells. The discharge hose and motor lead can not be used to support the full weight of the pump.

Inspecting Control and Junction Boxes

Examine control box (converter), associated electrical wires and electrical connections for damage. Damaged wires and connections may cause shock hazards to personnel and affect sampling. Converter should also be periodically wiped clean of dust and debris, allowing for efficient air flow, which provides cooling during operation. The junction box has a sight-window that allows quick reference of water in the electrical system. Early detection of the condition may prevent personnel danger and system damage. Junction box should be cleaned periodically.

Determining Use of Pump Jacket

Review site specific information pertaining to well diameters. Sources of the information include Permit Writers and Permit Sampling Analysis Plans (SAP) and Permittees. The Redi-Flow 2 is designed to purge two-inch diameter wells. If sampling large diameter wells, attach the pump jacket, this allows the heat from the pump to defuse to the cooler surrounding water in the larger wells. The pump may be damaged or compromised in large diameter wells without the jacket.

Preventing Well Contamination

Grundfos Pump shall be decontaminated (deconed) before sampling the first well and between each subsequent well to be sampled. See Section 10.5. Special care should be taken to keep the decontaminated pump from contacting the ground before introducing it to the well; this may be accomplished by using a clean plastic sheet or bucket, in which to put sampling equipment. If foreign debris is introduced into the well it will contaminate the well consequently causing the well to produce non-representative samples, thus rendering the well useless.

An additional method that should also be used to prevent cross contamination between wells, is to sample wells in the order of the least contaminated (upgradient) to most contaminated (downgradient). See Section 10.13.

Placing Pump in the Well

The tubing should be laid out and marked with electric tape or permanent marker (depending on the material of tubing) in equally measured intervals determined by the operator. This allows the operator to lower pump to a designated depth in the well. See Section 10.7

The pump should be lowered slowly into the well to ensure that the electrical motor leads and discharge tubing are not damaged, and to avoid turbulence in the static water column. Turbulence can cause sediment from the bottom of the well to suspend in the water column. Suspended particles can damage different components (impellers) of the pump, including clogging the pump. Suspended

finer particles will also degrade the sample quality, by biasing both organic and inorganic chemical analysis results. Caution should be used not to hit bottom of well with pump, resulting in suspended particulates.

When lowered into position, the pump should be completely submerged into the static water column. The pump should be at least three feet from the surface of the water column and two-three feet from the bottom of the water column. Complete submersion of the pump ensures that the pump is being lubricated and cooled.

Determining Use of flow-Through Cell

A flow-through cell is a vessel that allows water from the pump to flow into a cell that contains instrumentation probes that take parameter readings at regular intervals.

Not all scenarios allow for the use of a flow through cell. In many instances, a dedicated well may not have the appropriate tubing size to properly connect the flow through cell. In other cases, a bailer is used to manually evacuate the well. These are only a few examples of circumstances that can prohibit the use of a flow-through cell.

A modified flow through cell can be fabricated in the field by using a bucket and instrumentation probes. Place discharge tube and instrumentation probes into the bottom of the bucket and allow the bucket to overflow.

When using any type of flow through cell periodically rinse the cell and probes between field parameter readings. The frequency of this action is determined by the amount of sediment in the discharge.

Determining Volume of Water to be Purged

Once water level for the particular well has been determined, the purge volume can be calculated. First calculate the height of the static water column by subtracting the DTW from the total depth (TD) of the well or bore hole. Secondly, multiply the height of water column by gallons/linear foot value, for the well diameter. The gallons/linear foot value is found on the (Pipe and Casing) chart in the ground water field book. This calculation gives the water to be purged for one casing volume. Finally, multiply one casing volume by three, this equals total amount of water to be evacuated from the well. The three well casing volumes are purged to ensure that formation water is sampled rather than the static water column. See section 10.8.

Total volume purged = Height of water column x Gals/Lin Ft x 3

Where:

Height of water column = DTW – TD

Purging Well

The operator should then assemble the pumping system. The pump is powered by connecting the pump components according to the operation manual as diagramed below:



Start the pump and gradually adjust the pumping rate to ensure that the purging volume is less than the recharge volume to limit drawdown. Drawdown can be detected by leaving the water level indicator in the well while the well is being purged.

The flow rate of the water evacuated is determined by the setting (measured in hertz (Hz)) on the converter or control box. The Hz rate is clearly marked on the control box and corresponds to a specific flow rate. This flow rate can range from 1 ml/min to 9 gals/min.

The flow rate should be checked and maintained manually throughout the purge, so changes can be detected and corrected. To calculate the flow rate, determine amount of time (in seconds) it takes for pump discharge to fill a calibrated bucket to the one gallon mark. Divide 60 by the time in seconds to get gal/min. The operator should not move the pump during purging to avoid turbulence which can clog the pump and degrade the sample quality, by biasing both organic and inorganic chemical analysis results.

The operator should take field parameters which include temperature, Ph and conductivity of the water being pumped from the well. See Section 10.16.7. Field parameters should be taken and documented initially and every three to five minutes there after, depending on the volume of water to be purged from the well. Purging is complete after casing has been pumped and the conductivity reading on the conductivity meter remains constant.

Sampling procedures

The operator should reduce the flow rate for sampling to prevent dissolved gasses and volatile organics from diffusing into the atmosphere (negative bias) if applicable. See Section 10.16.5. The operator(s) should hold sample bottle as close to sample discharge tube without the tube contacting the bottle. If the samples are to be split use a “Tee” or Splitter at the end of the discharge tube, or in succession one immediately following the other.

An alternate method of sampling is to use a dedicated, new, or decon bailer in lieu of the pump.

During a split sampling event, a representative for the permittee should hold the other sample bottle, which will be analyzed independently. See Section 10.16.5. The operator(s) should take care not to contact the water while flowing into bottle, by wearing gloves. The sample bottle should be capped immediately and stored according to protocol. See Section 10.15.

Safety Precautions

Always use safety precautions documented in Section (18). In addition, the operator should follow safety guidelines when using a generator during a sampling event. In general, the operator should know the controls of the generator and how to turn it off quickly in case of an emergency. The operator should be aware that the exhaust contains poisonous carbon monoxide gas. The operator should always use the generator in a well ventilated area.

The generator should be placed on a rubber mat (when available). Always keep the generator dry to avoid the risk of electrocution.

The exhaust system can get hot enough to ignite some materials. The generator should be at least 3 feet away from flammable or plastic materials during operation.

Maintaining and Storing Pump

The pump shall be periodically inspected to ensure that it is within the minimum operating tolerance. This inspection includes the examination of the impeller and Guide Vane for signs of visible wear. The Ware Ring should have a minimum thickness of .04 inches. All components should be inspected for cracks, corrosion, or signs of wear.

The pump should be thoroughly cleaned before placing in storage. This helps prevent contamination. The pump and converter should be stored in a clean dry storage area greater than 34-120 degrees Fahrenheit to prevent freezing and permanently damaging the pump.

Long term storage requires removing the bearing housing and filling screw to drain the deionized water. Replace accordingly.

Bladder Pump

Operating Procedures

This subsection presents detailed operating procedures for the Series 3600 system well sampler system. It provides information on preparing the sampler for use and placing it into operation;

Preparation for Use

The following sections present information on preparation al procedures which must be performed on the Series 3600 System before sampling can begin. Included are paragraphs describing the sample containers, installation of the Nicad Battery Pack, transporting the sampler, pump insertion into a well, and attachment of the tubing and portable compressor (or gas supply).

Installing the Nicad Battery Pack

To power the Series 3600 Well Sampler System, a Nicad Battery Pack must be mounted within and connected to the controller. To mount the Nicad Battery Pack, unscrew the finger screws and remove the cover over the battery cavity. Connect the battery cable to the connector within the battery cavity and place the battery in the cavity. The excess cable may need to be pushed down so the battery cover can be replaced and screwed down.

Transporting the Well Sampler Components

Normally, it is easiest to transport the well sampler pump, controller, portable compressor, and tubing as separate components. The components may then be assembled at the well site. To aid in transporting the controller and the portable compressor, carrying handles are provided. Also available is a spool to aid in transporting the tubing.

Attaching the Tubing to the Pumps

Three different standard lengths of tubing are available for use with the Series 3600 Well Sampler System: 50 ft. (15.2 m), 100 ft. (30.5m) and 150 ft. (45.7m). The tubing consists of a 3/8 inch (0.95 cm) O.D. supply gas tube, and a 1/2 inch (1.27 cm) O.D. liquid sample tube bonded together. The tubing is available in either polyethylene or Teflon. It is advantageous to use the shortest tubing that will reach the desired sample depth, since longer tubing lengths will result in a decreased pumping rate and an increased gas consumption.

Attaching the Tubing to the Teflon/Stainless Steel Pump:

The tubing connectors used on the Teflon/stainless steel pump are type 316 stainless steel clamps. To attach the tubing, first separate the gas tube and sample tube by splitting them to approximately 18 inches from the end of the tubing. Then slide the proper clamps over each of the tubes. Next, slide the sample tube and the gas tube over the barbed fittings until they are seated on the shoulders of

the connectors. Then, as shown in Figure 10.6.1, slide the clamps over the barbed fittings. Finally, as shown in Figure 10.6.1, crimp the clamps on to each tube using end cut nippers or clamp pincers which are available from Isco.

To use the clamp pincers, place them over the notch on the clamp and squeeze until the insides of the notch meet. To remove the clamp, take the pincers and clip off the notch. The tubing may have to be slit with a knife to remove it from the barbed fittings.

Attaching the Tubing to the Non-metallic Pump

The tubing connectors used on the non-metallic pump are constructed of Acetal plastic and made up of a fitting nut with male threads and nylon ferrules. To connect the tubing, first separate the gas tube and the sample tube by splitting them to approximately 18 inches from the end of the tubing. Then unscrew the pump fittings enough to loosen them but not to remove them. Next, insert the sample tube and gas tube into their appropriate fittings. Push in until a resistance is felt. Completely unscrew the fittings and check that the sample and gas tubes extend at least 1/8 inch beyond the ferrules as shown in Figure 10.6.2. If a tube does not extend 1/8 inch or more, push it into the fitting while holding the ferrule until the tubing does extend at least 1/8 inch. Replace the fittings and finger tighten until they are snug. Use a wrench to tighten the fittings 1-1/2 to 2 turns until tight. For further reconnections, only light wrench tightening is necessary.

Placing the Pump in the Well

Once the Series 3600 Well Sampler System pump has been attached to the tubing it can be lowered into the well. (For wells that are suspected of being too small or crooked for the pump, a 1.75 inc. O.D. X 50 in. long (4.44 cm X 127 cm) tube can be lowered into the well to insure sufficient clearance before the pump is lowered). It is important to note that unless an optional suspension cable or a suspension wire is used, it will be necessary to lower the pumps into the well by the tubing. This should be of no concern with the Teflon/stainless steel pump because the tubing is attached with barbed fittings and clamps. However, on the non-metallic pump, which is attached with quick disconnect fittings; precautions should be taken to insure that the fittings are tight. When connecting the fittings on the non-metallic pump, make sure they are tightened down enough to make them secure.

CAUTION

**Loose tubing fittings may result in
The loss of the pump into the well.**

Optional suspension lines – A type 316 stainless steel wire or a polyethylene jacketed cable is available for suspension of the pump in the well. These

suspension lines are to be used if it is anticipated that the well is crooked and pulling the pump up by its tubing may disconnect the pump, leaving it in the well. If that is the case, it is suggested that the optional suspension cable or suspension wire be used.

Unrolling the Tubing

When placing the pump into the well, it is important to note that the tubing should be unrolled. Otherwise, sever kinks and twisting will occur which may cause difficulty in lowering the pump into the well. If the optional spool is used, the tubing should also be unrolled, not picked off the side of the spool.

Cutting the Tubing to Length

If the pump is to be used for a number of sites and the maximum tubing length necessary is determined, and this does not correspond closely to one of the three standard tubing lengths available, it is advisable to cut the tubing to length. This will have two effects. The first is to increase pumping rate and the second is to reduce gas consumption.

Use of the Nonmetallic Pump Weight

When using the non-metallic pump, it will be necessary to have the pump weight holder and pump weight attached if the pump is to be submerged to depths of 10 feet or greater. This will prevent the pump from floating to the surface of the well. On the other hand, if the pump is going to be used in shallow water or the water will be drawn down to less than the length of the weight (7 in.) by pumping, the weight holder and weight should be removed from the pump. This will allow maximum inlet strainer submersion.

Attaching the Gas Tube to the Controller

Once the pump has been placed into the well, the gas tube may be attached to the controller. Figure 10.6.3. The smaller tube should be inserted into the controller fitting labeled GAS OUTLET fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is fingered tight. While holding the fitting body steady with a wrench, tighten the nut 1-1/2 to 2 turns until tight. Subsequent leak-free reconnections may be made with light wrench tightening. An optional controller to the gas tube quick connect package is available.

Attaching the Gas Supply

The Series 3600 pump action is operated by compressed gas shown in Figure 10.6.4. The minimum gas pressure supplied to the Series 3600 System should be no less than 20 psig and the maximum gas pressure should never exceed 115 psig. The necessary air pressure can be supplied to the Series 3600 Well Sampler

System by the Series 3600 Portable Compressor. Another source of clean, dry gas can be used, since the gas does not come in contact with the sample. If compressed gas is used, care should be taken that the pressure does not exceed the limit of 115 psig. Higher pressure sources must be regulated down. The controller has a pressure relief valve to protect the pump if excessive pressure is applied, but this situation should be avoided.

Attaching a non-Isco gas supply

The gas supply is attached to the controller using the ¼ inch NPT female threaded fitting labeled GAS INLET. If a gas supply other than the 3600 Portable Compressor is used, a fitting appropriate for the gas supply tubing with a ¼ inch NPT male termination should be obtained. Be sure that all the gas supply fittings are tight.

Optional Quick Disconnect Package

The Series 3600 Portable Compressor comes with a quick disconnect fitting package for disconnect package attachment to the controller. To attach it, first remove the adaptor, with the male NPT threads, from the check unit on the end of the compressor supply hose. Screw this adaptor into the controller fitting labeled GAS INLET. The check unit can then be quickly attached to or removed from the controller as needed.

Collecting a Sample

The following sections describe the use of the Series 3600 Well Sampler System. Included are paragraphs describing the controls, discussing the selection of gas pressure, and describing different pumping operations.

Wear on the Teflon Bladder

Since Teflon is not an elastomer, it has the mechanical disadvantage of cracking or wearing out. Therefore, the Teflon/stainless steel pump is designed with an inner bladder, made of silicone, to prevent the pumping gases from entering the sample. This patent pending system not only provides a highly reliable method of separating the pumping gas and the liquid sample, it also provides a means of detecting a failure of the Teflon bladder. If the Teflon bladder should leak, gas cannot enter the sample tube but some of the sample may enter the gas tube. The Teflon bladder leak is easily detected by sample discharge from the gas outlet.

Failure of the silicone bladder is indicated by a dramatic reduction or cessation of the pumping volume.

Description of Controls

The control panel of the Series 3600 Well Sampler System is shown in Figure 10.6.5. The operation of the individual controls is discussed in the following sections.

OFF/ON/SAMPLE VOLUME Switch

This rotary switch is used to perform two functions: 1) to control power to the sampler, and 2) to maximize delivered sample volume. When the OFF/ON/SAMPLE VOLUME switch is in the OFF position, all power is removed from the controller. When the switch is turned to the ON position, the controller is supplied with operating power and is fully functional. This condition is indicated by the illumination of the red LED lamp just to the right of the OFF/ON/SAMPLE VOLUME switch.

NOTE:

If the OFF/ON/SAMPLE VOLUME switch is left in the ON position, the Nicad battery will discharge in a relatively short time (approximately 8 hours). Therefore, this switch should be left in the OFF position, except when the pump is being used.

When the OFF/ON/SAMPLE VOLUME switch is rotated clockwise past the ON position (into the DECREASE/INCREASE region), it adjusts the degree of pump bladder inflation. This is used to maximize the delivered sample volume per pulse for the existing sampling conditions. This use of the OFF/ON/SAMPLE VOLUME switch is discussed in below.

Manual Sample Button – With the OFF/ON/SAMPLE VOLUME switch in the OFF position, this push button switch allows a manual sample to be collected. While the button is held down the bladder is pressurized, forcing the sample out of the pump, and when the button is released the bladder exhausts, allowing the pump to draw in another sample.

Selecting Gas Pressure

The first step in operating the Series 3600 Well Sampler System is to select a gas supply pressure. The pump will operate from approximately 20 psig to 115 psig. In order to minimize gas consumption, the gas supply pressure should be held to a minimum. For pump heads below 50 ft. the suggested minimum gas pressure is 50 psig. For pump heads greater than 50 ft., the suggested minimum gas pressure may be calculated using the following formula:

$$P = .6H + 20$$

Where:

P = Gas supply pressure, in psig
H = Lift head, from pump inlet to surface, in feet

For example, the minimum required gas pressure for a pump lift head of 80 feet is calculated as follows:

$$P = .6(80) + 20 = 68 \text{ psig}$$

If it is desirable to increase the pumping rate, the gas supply pressure may be increased from the calculated minimum pressure. This, however, may significantly decrease the bladder life and increase the gas consumption. There is a point at which increasing the supply gas pressure will result in no additional increase in the pumping rate. This point can be easily determined by experimentation.

Pumping Operation

The Series 3600 controller is in a sealed case. Therefore, exposure to water should not harm the internal circuitry but submersion of the controller should be avoided.

Placement of the sample tube:

When a sample is being collected, the liquid sample tube should be placed in the sample container, as shown in Figure 10.6.6. Note that, in operation, the sample tube tends to “jump.” Therefore, the liquid sample tube should be held in place over the sample container while the sample is being collected.

There are four different ways to collect a sample with the Series 3600 Well Sampler System as stated in the following paragraphs. They range from a swift automatic sample or well purge to an extremely low turbulence manual sample. The user is responsible for determining which best suits his/her application.

Swift Automatic Sample

The pump is operated and the controls set in the following manner. First, rotate the OFF/ON/SAMPLE VOLUME switch to the ON position. (note that the LED to the right of the switch should be illuminated when the switch is in the ON position.) The controller will now switch the gas pressure such that the pump bladder will be alternately inflated and deflated, forcing a liquid sample up the sample tube.

After it has been determined that the pump is operating (bladder inflating and deflating), the pumping efficiency may be maximized, using the OFF/ON/SAMPLE VOLUME switch as follows:

Rotate the OFF/ON/SAMPLE VOLUME switch in the increase direction until the total sample can be obtained before the controller causes the pump to exhaust. This can be easily determined by the sound of air escaping from the relief valve. Turn the switch in the decrease direction just a bit. Since the pump's output flow of water is cyclic in nature, the tubing goes through a small jerking action during pumping, which is normal. If the entire liquid sample cannot be obtained using the OFF/ON/SAMPLE VOLUME switch, it is possible that the gas supply pressure is not great enough.

Low Turbulence Manual Sample

To take a low turbulence sample, decrease the gas supply pressure until the pump does not cycle. Rotate the OFF/ON/SAMPLE VOLUME switch to OFF. Press the Manual Sample button and hold until the sample is obtained. The button can then be released. If it is desired to take a sample larger than what is collected, this process should be repeated until an adequate size sample is obtained.

Extremely Low Turbulence Manual Sample

To take an extremely low turbulence sample, turn the OFF/ON/SAMPLE VOLUME switch to OFF and lower the supply pressure to zero. Push in and hold the Manual Sample button while slowly increasing the gas pressure as a trickle comes out of the sample tube. When the sample is obtained, the manual sample button can be released. If a sample greater than what is collected is needed, the above procedure will need to be repeated by first returning the pressure to zero.

Disassembly

After the sampling operation has been completed, the pump can be removed from the well by first disconnecting the gas tube from the controller, then raising the pump while rolling up the tubing. An optional spool is available for transportation of the tubing.

Tubing Removal From the Non-Metallic Pump

After the initial installation of the tubing on the non-metallic pump, the ferrules in the fittings will be permanently connected to the sample and gas tubes. Therefore, to remove the tubing from the pump, the fitting nuts will have to be completely removed from the fittings. Note that the nuts will be captivated on the end of the tubes by the ferrules. If it is desired to change the tubing, it may have to be cut to free the nuts for reuse.

Tubing Removal From the Teflon/Stainless Steel Pump

To remove the sample and gas tubes from the Teflon/stainless steel pump, the stainless clamps must be clipped off.

10.5 Sampling Equipment Setup, Well Inspection

It is a good practice to have a detailed list of all sampling materials and supplies. The list should be reviewed before the sampling staff leaves for the field site. This somewhat tedious procedure will cut down on the frustration or anxiety which may arise later because of missing equipment, reagents or bottles.

On arrival at the well-head, the condition of the surface seal and well protector should be examined to see if any evidence of frost-heaving, cracks or vandalism are observed, they should be recorded in the field notebook. The area around the well may have to be cleared of weeds or other materials prior to beginning the sampling activity. A drop cloth should then be placed on the ground around the well head, particularly if the land surface is disturbed or potentially contaminated. This precaution will save time and the work of cleaning equipment or tubing should they fall on the ground during preparation or operation. The well protector should then be unlocked and the cap removed from the top of the well. The previous record of water levels for the well should be consulted prior to chalking the steel tape and making three successive measurements of the static water level. The readings should be recorded to the nearest +0.01 ft. If the well has a history of contamination, the water level measurements should be made with surgical gloves on and the tape should be rinsed with distilled water and wiped dry with lint-free towels as it is wound on the reel. While the water level is being measured, the other sampling personnel should prepare to set up the pumping equipment and the operation should be calibrated. The assembly of the Teflon on stainless steel pump and the tubing bundles should be performed as well. Gloves should be worn at all times during pump assembly. At this point, the sample bottles should be checked for proper labeling. Then the field and sampling logs should be readied for the next steps. It is important to record the stagnant water volume in the well from the water level reading and compare it to that calculated for the well from the evaluation of pumping requirements.

10.6 Sample Collection (An Overview)

The initial hydrologic and well purging measurements necessary for reliable ground water sampling should be entered into the same field notebook as that of the discrete samples for field or laboratory determinations. Regardless of the level of analytical detail in the monitoring program, it is essential that all samples be collected properly and that the actual conditions during each sample collection are completely documented. One member of the sampling staff should be designated as responsible for this documentation.

The format for documentation should be clear and constant during the overall program. Bottles with an identifying STORET number and site description

which, when combined with the date of sampling well and the sampler, uniquely identify it in a sampled set.

Water samples should be collected when the solution chemistry of the ground water being pumped has stabilized as indicated by pH, temperature and conductivity readings. In practice, stable sample chemistry is indicated when the purging parameter measurements have stabilized with +10% over 3 successive well volumes. First, samples for volatile constituents, TOC, TOX and those constituents which require field filtration or field determination should be collected. Then large volume samples for extractable organic compounds, total metals or nutrient anion determinations should be collected.

All samples should be collected as close as possible to the well head. Regardless of the sampling mechanism in use or the components of the sampling equipment, upgradient wells should be sampled first followed by the downgradient wells to minimize the potential for cross-contamination. Laboratory detergent solutions and distilled water should be used to clean the sampling equipment between samples. An acid rinse (0.1 N HCl) should be used to supplement these cleaning steps if necessary. All cleaning should be followed by distilled water rinses.

Samples should be taken in a prearranged priority so that all sample handling and preservation takes place as rapidly as possible.

The samples for dissolved gases, volatile organic constituents, TOC and TOX are taken by carefully slowing the delivery rate to 100 ml/min or less and directing the flow to the bottom of the sample vessel (e.g., or by flowing into a syringe of appropriate volume) and allowing the vessel to overflow at least 1.5 volumes. The samples should be rapidly capped, excluding any headspace, preserved and put in the sample cooler as soon as possible. Samples for extractable organic compounds and other samples can then be collected. In filling the large volume bottles, the flow rate can be increased by should not exceed the pumping rate during purging.

At this point, samples nutrients, dissolved metals, and other inorganic constituents can be collected.

10.7 Sample Storage and Transport

The storage and transport of ground water samples are often the most neglected elements of the sampling protocol. Due care must be taken in sample collection, field determinations and handling. If proper planning of transport is neglected, the samples may be stored for long periods before laboratory analysis. Every effort should be made to inform the laboratory staff of the approximate time of arrival so that the most critical analytical determinations can be made within recommended storage periods. This may require that sampling schedules be adjusted so that the samples arrive at the laboratory during working hours.

Most samples collected by DWQ staff will not require chain of custody, but will be properly labeled, preserved and transported to the laboratory with the proper field and laboratory sheet.

The documentation of actual sample storage and treatment may be handled by the use of chain of custody procedures. Briefly, the chain of custody record should contain the dates and times of collection, receipt and completion of all the analyses on a particular set of samples. The sampling staff members who initiate the chain of custody should require that a copy of the form be returned to them with the analytical report. Otherwise verification of sample storage and handling will be incomplete.

The procedures should be followed explicitly from this point until delivery to the laboratory. Any unique circumstances (e.g. extreme heat or cold, delays in sample handling, etc.) should be recorded in the field notebook. It is essential that the laboratory receive all information which may affect analytical processing. Notice of any extreme turbidity, reactivity with the preservation reagents, etc. should be provided in writing to the laboratory personnel.

These sampling procedures are sufficient to the needs of most ground water sampling programs. If unusual conditions exist, they should be reported to the person in charge of the monitoring effort at once. This will help prevent undue exposure of sampling staff or water samples to conditions that may jeopardize health or the collection of high quality data.

10.8 Field-Chain-of-Custody

Chain-of-Custody procedures for sampling personnel that will be followed are those found in Section 13.

1. All samples will be sealed in the field at the time of collection.
2. A chain-of-custody record will be filled out in the field at the time of sample collection for each sample. As a result of these combined procedures, each chain-of-custody record sample will be accompanied by a completed: sample, label, sample tag, sample seal, and chain-of-custody record. In addition, sampling methods, procedures, and conditions shall be recorded in the sampler's field notebook. Examples of the sample labels and the chain-of custody tag are found in Figures 11.2 and 8.2 respectively.

10.9 Decontamination Supplies

Laboratory detergent solutions and distilled water will be used to clean the sampling train before and between samples. An acid rinse (0.1N HCl) or solvent

rinse (i.e., hexane or methane) may be used to supplement these cleaning steps if necessary. All cleaning should be followed by distilled water rinse.

10.10 References

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11.0 MACROINVERTEBRATE PROGRAM

Benthic macroinvertebrates are important for use in water quality monitoring. They are sensitive to environmental change and stress. Their limited mobility and relatively long life spans makes the presence or absence of a species at a site a meaningful record of environmental quality. In addition, they are an important link in the food web, functioning as primary consumers of plant and microbial matter that become available to secondary consumers such as fish. Their abundance lends itself to statistical analysis which can play an integral role in a water quality assessment program. The benthic monitoring program was begun in 1977 to augment other water quality programs. A total of 16 Long Term Sites are located in major drainage basins of the state are monitored. Twelve sites are currently associated with Non Point Source studies. Twenty five sites are associated with Waste Load Allocation, Total Maximum Daily Loads, or impaired sites needing further study. Twenty five sites are sampled each year to further determine reference conditions. Lists of sites sampled in conjunction with all programs may be found in the DWQ Annual Monitoring Plan on the DWQ Website. Sampling of these benthic sites occurs in late September and October. Analysis of samples proceed after each seasonal collection period and a report is prepared to include the species composition, numbers of organisms per square meter, and the community diversity. In addition, the benthic data is compared with water quality data as well as past benthic data to determine the viability of aquatic communities and water quality overtime.

11.1 Objectives

1. To determine the species, numbers and diversity of macroinvertebrates in the various drainages of Utah.
2. To assess the effect of instream water quality on benthic macroinvertebrate communities.

11.2 Approaches to Meet Objectives

1. An established network of sampling sites on various drainages in Utah.
2. Networks sampled using appropriate methods.
3. Analysis of benthic samples to determine the species of organisms, numbers per square meter, and the community diversity indices.
4. Compare the benthic data as a function of location and time for seasonal or annual trends.
5. Establish reference sites and conditions.
6. Establish metrics to develop an Index of Biotic Indices

11.3 Macroinvertebrate Sampling

Quantitative methods are conducted in lakes, rivers, and streams on an annual basis. These methods conform to documented and accepted procedures used in the study of benthic communities. Historically, all quantitative samples were collected by the Hess method. Beginning in 2006, all sites will be sampled with the kick method established by the EPA Environmental Monitoring Assessment Program (EMAP). A description of these methods and procedures follows:

Modified Hess Sampler (Waters 1961)

This quantitative sampling device is designed for use in rivers and streams where a current exists and bottom substrates range in size from fine gravel to small cobble size stones. The sampler is circular in cross section consisting of frame made of 6mm brass rods welded between two rings 6 cm in width by 2 mm thick. The frame's sides are covered with 30 mesh nylon netting. A 60 cm long net sleeve is sewn perpendicular to the main sampler just above the bottom ring which directs dislodged organisms into a collection bag at the end of the sleeve. The emptying of the collection bag is facilitated by attaching it to the sleeve with velcro fasteners. To obtain a sample, the sampler is randomly placed in the riffle area, rotated quickly back and forth to grind it into the river bed, which obtains a tight seal around the bottom. The attached sleeve and collection bag are oriented downstream so that the current washes all organisms, debris and other dislodged materials into the bag. The substrate within the sampler is agitated, rocks scrubbed and stirred until all visible material has been washed into the net. The sampler is gently removed from the bottom and all material clinging to the net is allowed to wash into the collection bag. Often, some organisms have to be picked off the netting with forceps and placed in the collection bag. Once the sample is in the collection bag, it is detached and the sample transferred to a 30 mesh net for washing and concentration. The sample is then washed into a 500 ml plastic sample bottle and preserved with 80% ethyl alcohol. Sample bottles are labeled with location, Storet number, date, time, method, and name of the collector. Four bottom samples are collected randomly from each riffle site. This type of sampling protocol is referred to as "Stratified Random" and is recommended (Weber 1973) for obtaining statistically valid results.

Basket Samplers (Weber 1973)

In rivers and streams where depth, low current velocity or lack of suitable substrate, precludes the use of Hess type samplers, basket samplers as described by Weber 1973, can be used effectively for sampling benthic macroinvertebrate communities. These samplers consist of wire baskets (10 cm x 25 cm x 25 cm) constructed of 2.5 cm hardware cloth and are filled with uniform sized 6.5 cm diameter stones. Statistically valid samples are achieved by placing four baskets at each site, thus, establishing a known area of riffle type substrate which can be colonized by benthic microorganisms. These basket samplers are normally suspended in the stream or river from bridges, or other permanent structures and are left in place 6 weeks to allow colonization by the surrounding benthic macroinvertebrate communities. After the accepted exposure or colonization period, the baskets are retrieved by placing a 30 mesh dip net around the baskets, to prevent loss of organisms, and each basket is placed in a large water filled tub. The basket is emptied of rocks and examined for clinging organisms, debris, and detritus which are removed by hand with forceps and placed with the rock samples. The rocks are individually scrubbed with a stiff bristled brush and rinsed. After all rocks have been scrubbed and rinsed, the water and remaining material in the tub are poured through a 30 mesh sieve. The resulting benthic sample is placed in a 500 ml plastic sample bottle, preserved and labeled in the same manner as are those samples collected by the Hess samplers. Unlike the Hess sampler, basket samplers are not quantitative in a strict sense and do not reflect the true number of organisms per square meter, however, they provide an approximate measurement and an indication of kinds of organisms present.

Dredge Sampler

Two types of dredges, the Eckman and the Peterson/Ponar types are commonly used to quantitatively sample bottom substrates ranging from soft mud to coarse gravel in lakes, large rivers and streams. The Eckman dredge is a spring operated device in which the jaws are tripped by a messenger once the dredge has reached the bottom. This dredge is available in a variety of sizes depending upon sample requirements, although most common are those which sample a 6" x 6" area. This dredge works well in a soft mud or sand bottom which is free of vegetation. The Peterson/Ponar types are mechanically operated by allowing a precocked arm to release when the dredge strikes the bottom allowing the jaws to close as the dredge is retrieved. These type of dredges are designed for most bottom substrates except hard clay and large rock. These dredges are usually operated from a boat on lakes but may also be used from bridges as well as boats on rivers and streams. In use, the jaws of both types of dredges are cocked before lowering to the bottom, where the mechanism is tripped either by messenger or contact with the substrate. In either case, as the jaws close the sample is retained within the body of the dredge and is then raised to the surface. A fine dip net is placed under the dredge as it clears the water surface and both net and dredge are placed over sample tub to prevent loss of organisms. The samples are then removed from the net and dredge into the 30 mesh sieve, the mud rinsed out, and the remaining sample transferred to the sample jar. Preservation and labeling are the same as with the samples from the Hess sampler. A minimum of 4 samples are taken at each site for statistical validation.

Kick Samples

This method of assessing the benthic macroinvertebrates was historically qualitative in nature and provided no quantitative data as far as the abundance of organisms are concerned. This method has been modified to provide quantitative data. The net used in kick sampling is a 30 mesh (500 micron) with a 20 cm x 35 cm rectangular opening attached to a long handle. In use, the operator places the net on the bottom of the stream and standing upstream, overturns or agitates the substrate for 30 seconds allowing the macroinvertebrates to be washed by the current, into the net. Ten (10) individual kick samples from ten (10) transects riffles are composited. (See Western EMAP protocols). If a riffle doesn't exist at the transect, the sample will be collected at the nearest riffle to the transect. At sites with limited riffles, several individual samples may be taken from a single transect and noted on the field benthos form.

Everything in the kick net except stones and sticks from each transect sample are collected from the net by washing or hand picked with forceps into a composite container (bucket). This includes all algae, leaves, detritus, ECT. The composited sample is placed in the collection container, preserved and labeled in the same manner as described previously.

Care must be taken to assure proper preservation. The sample container must not be filled over 2/3 full to allow enough preservative (90 % ethanol) to be added. Fill the container to the top. Samples with large amounts of organic matter must be checked several days after collection to assure preservation. If samples appear to be deteriorating or decaying, the liquid is poured through a proper sieve, the sample replaced in the container, and fresh preservative added to fill the

container.

11.4 Macro invertebrate Processing Prior to 1998 at the BYU Lab

Samples transferred to the laboratory were logged in to assure quality control. Checks were made to ascertain if four samples are present, labeling is correct, and samples had been properly preserved.

Dominance and Taxa Diversity Index (DAT)

Dominance and Taxa Diversity Index (DAT) is run on each sample. To run the DAT:

1. Pour part of a sample into a linear grid petri dish and stir so the material is randomly mixed.
2. Following the grid, identify the first organism and record it on a digital counter under "organisms".
3. Continue following the grid, identify the next organism. If it is the same as the last one, hit the "organism" key on the counter. If it is a different organism than the last one, hit the "organism" key plus a key marked "run".
4. Continue this procedure until a minimum of 200 organisms have been identified. This will make results statistically valid.
5. Divide the number of series by the number of "organisms". This will give a figure of less than unity.
6. Taxonomically, identify the total sample. Multiply the total number of taxa by the decimal figure in #5 above. This will give a resulting DAT.

Based upon ten years of stream macroinvertebrate data and analysis by the US Forest Service Region 4 Macroinvertebrate Laboratory, community structure based on the DAT can be interpreted according to the following scale: 18-26 excellent, 11-17 good, 6-10 fair, and 0-5 poor (Mangum, 1975).

The DAT is defended as a valid technique based upon the operators ability to taxonomically identify each organism and not merely as to the organisms shape, size or color as was originally proposed by Cairns, 1971.

Sub-sampling

Sub-sampling is performed on the sample according to faunal density. Most samples are subdivided and only a percentage is analyzed. It would be advantageous to analyze the complete sample, but time and the number of samples will not allow it. The amount to be analyzed is left to the discretion of the operator. On samples where the volume of material is very small, 85% to 100% may be examined. Moderate samples would require 25% to 50%, while heavy volumes would only require 12.5% or less. The desired amount to be analyzed is stored in a small jar of 80% alcohol and the remaining amount is stored for reference in 80% ethanol. Analyzing 12.5% to 100% of the sample has been shown to be statistically valid, (Mangum, 1975).

Description of Subsampler (Waters 1969)

The sampler is basically an eight compartmented, open-topped doughnut-shaped device set atop a turntable. The sample is washed from a beaker into the eight containers as they spin. The compartments have 30 mesh screen on the bottoms to collect the sample and allow the water to escape. All organisms are completely washed from the beaker and the compartments as they are rinsed.

Taxonomic Analysis and Interpretation

The sample is examined under the microscope for organisms. All taxa are identified to the lowest taxonomic level as possible as the sample is sorted. Each taxon is placed in individual micro containers containing 70% alcohol. The contents of these small containers from each sample are placed in an aluminum pan and oven dried to determine the dry weight biomass of the community at that sample site. Upon completion of sorting, the unprocessed portion of a sample for each station is placed in a 2oz. storage jar. The detritus is discarded. The results of taxonomic identification is a species list of all taxa in the sample, and the number of organisms in each taxon. The number per sample allows conversion to numbers per square meter. A species list of each sample can be combined with other samples for a master species list for a particular area.

From the taxa found, a representative of each species is held on file in reference collection. This allows future confirmation of taxonomic identifications without looking at all organisms in question in all samples.

Taxonomic identifications are in accordance with the latest and most authoritative texts and keys. A list is included in the bibliography.

Numeric data are prepared for computer analysis which will yield number of taxa, standard deviation, density (number/M²), species diversity \div , a community tolerance quotient, percent standard error of the mean and coefficient of variation.

Species diversity values were computed using the formulae:

$$\div = - (n^i/N) \log^2(N_i/N) \text{ (Sannon and Weaver, 1963)}$$

Where: \div , and DAT are species diversity indices

N_i = number of i th species (Taxa)

N = total number of all individuals

s + total number of species (taxa)

These formulae were selected because they are based upon dominance diversity and express the relative importance of each species, not merely the relationship between total numbers of species and individuals. These indices are also independent of sample size.

The species diversity indices (\div and DAT) can be interpreted as follows. Various pollutants or environmental stresses within the system result in changes in community structure of benthic macroinvertebrates which are reflected as a depression in the index value. Generally, with \div , values less than one occur in areas of heavy pollution or environmental stress, values from 1-3 in areas of moderate pollution, and values greater than 3 in clean water area. DAT diversity index values of 0-5 indicate poor conditions, 6-10 indicate fair conditions, 11-17 good conditions and 18-26 indicate excellent conditions.

Ecosystem evaluations also include the Biotic Condition Index (BCI) which is based upon the tolerances of taxa in the sampled benthic invertebrate community.

The BCI - Biotic Condition Index - developed by the USDA Forest Service over the past 18 years provides a versatile monitoring tool for evaluating conditions in aquatic ecosystems and associated drainages.

This Index –

1. Measures a stream against its own potential, not that of another stream.
2. is sensitive to most forms of environmental stress.
3. is applicable to various types and sizes of streams.
4. provides a basis for assessment of unstressed to stressed conditions.
5. is independent of sample size, if sample contains a representative assemblage of the species in the community.
6. is based upon data easily acquired.
7. (meshes with and supports, stream habitat and water quality data).
8. is easily understood, like a score on a test.
9. is particularly useful for monitoring trends
10. is based mainly upon tolerances (TQ's) of benthic invertebrate taxa (in the sampled community).

The BCI scale is:

<u>BCI Value</u>	<u>Stream Condition</u>
Above 90	Excellent
80 to 90	Good
72 to 70	Fair
below 72	Poor

A statistical analysis of selected samples is also generated to evaluate sampling efficiency. This is a step analysis program which provides number of taxa, mean number per unit area, standard deviation, 80% confidence limits, the percent standard error of the mean and the co-efficient of variation for succeeding pooled samples.

To assure reliable estimate of the benthic population, the percent standard error of the mean should be 20 percent or less (Elliot, 1971) and the co-efficient of variation should be less than 40 percent.

Final data outputs consist of species lists with accompanying computer read-outs giving number of taxa, density, diversity, and percent composition of the community at each site. The data analysis, interpretation, and presentation in written form will be supervised and coordinated closely with the planning section to ensure that draft reports are written and submitted according to guidelines.

Quality Control

Care must be taken in each step in the collection from the field through laboratory analysis to prevent contamination or loss of organisms. Validity in quantitative sampling will not be accomplished if quality control is not insured. Quality control requires competent people who are conscientious enough to see quality is insured.

11.5 The Utah State University BugLab Quality Assurance Plan

How To Preserve and Send Samples to the Laboratory

1. Fix samples with 95% ethanol. If samples contain large amounts of organic matter, fix samples with 10% formalin. Replace formalin with 70-95% ethanol within 10 days, then ship us the samples.
2. Label samples inside and outside. Pencil on waterproof paper works well for inside labels and paper on masking tape works well for outside labels. Labels should include information on the location of the sample and the date of sampling. Place a consecutive sample number on the lid of each jar, samples requiring more than one jar should be labeled as 1a, 1b, 1c, etc. We will composite all like numbers (1a, 1b, 1c) into a single sample in the laboratory. On a separate sheet list all the samples and the location and date of sampling:

<u>Sample</u>	<u>Location</u>	<u>Date</u>
1	Big Creek, Station 1	06/02/98
2	Big Creek, Station 2	06/02/98
3	Big Creek, Station 1	09/12/98
4	Big Creek, Station 2	09/12/98
5	Little River	07/01/98

3. Provide information on where, when, and how the samples were collected.

Please fill out a separate sheet for each sampling location with the following information:

- A. Where you collected the sample; latitude/longitude, elevation, county and state.
- B. Information on the collection of the sample; Follow above example.
 1. sampling date
 2. sampling device (Surber, Kicknet, etc.)
 3. habitat sampled (riffle, pool, etc.)

4. area sampled in square meters or square feet and
 5. mesh size of the sampler (e.g., 500 microns)
- C. Box up the samples.
1. Make sure the lids are on tightly, to be extra careful, wrap duct tape around the lids.
 2. Put the jars in a big plastic bag
 3. Surround the jars with packing material.
 4. Place data sheets and other documentation in a separate zip-lock plastic bag
- D. Ship samples, data sheets, and any additional information concerning the samples to:
- The BugLab
Department of Aquatic, Watershed, and Earth Resources (AWER)
Utah State University
Logan, UT 84322-5210
- E. Upon receipt of your samples we will notify you with a post-card.

Laboratory Standard Sample Sorting Procedures

Preserved samples are sent for processing to the National Aquatic Monitoring Center, which is administered by the Bureau of Land Management and Utah State University in Logan, Utah. The procedures applied by the Lab are described on their website (<http://www1.usu.edu/buglab/>) and are summarized here. The general procedures followed by the National Aquatic Monitoring Center for processing samples are similar to those described by the USGS NAWQA program (Cuffney and others 1993, Moulton and others 2000). These procedures were also described in Vinson and Hawkins (1996).

The following is a step-by-step description of how quantitative benthic macroinvertebrate samples are typically processed:

- 1) Pour the preservative from the sample through a 500-micron sieve into the laboratory waste container.
- 2) If the sample contains a lot of sand and gravel you will need to separate the organic matter from these inorganic particles. To do this, pour the entire sample from the sieve into a bucket. Partially fill the bucket with water. Swirl the bucket so that the organisms and organic matter become suspended in the water column and the heavier sand and gravel fall to the bottom. Carefully decant the water and floating organisms back through a 500-micron sieve. Continue to add water to the bucket and swirl and decant until no organic matter remains in the bucket. When finished,

closely examine the remaining material in the bucket and pick out any caddis flies, snails, clams, or other organisms that remain. Add these organisms to those on your sieve.

- 3) Keep the sample in the sieve and rinse the sample under the faucet to wash additional fine particles and silt into the sink.
- 4) Place the sieve in an enamel pan or bucket that is partially filled with water and "float" the sample so that it becomes level within the sieve. Once leveled, carefully remove the sieve from the enamel pan. Place an appropriately sized separator bar (see photo of sieves with separators above) into the sieve to split the material on in the sieve in half. Make sure it appears that there is an equal amount of sample material in each half.
- 5) Flip a coin to determine which half of the sample is to be processed; heads = right or top, tails = left or bottom. Keep the portion of the sample to be processed in the sieve. Place the other half into a cup using a spoon and/or rinse the material into the cup using an alcohol filled squeeze bottle. Cover the cup with ParaFilm and write the portion or split of the sample on the lid, e.g., 50%.

If you judge that you will start with less than 50% of the sample, place the sieve back in the enamel pan and re-float the material to level it. Re-flip the coin and divide this portion in half again. Place the material you are not going to immediately sort through in a different cup, cover with ParaFilm, and label with the split percentage, e.g., 25%. Repeat this process until it appears that approximately 600 organisms remain in one-half of the sieve. *It is best to start with small splits to assess how many bugs you will find (3.125%, 6.25%).* The goal is to sort at least 600 organisms from the sample. Once you start a split you must finish it in its entirety. If you start to sort through a split and realize that this split will contain considerably more than 600 organisms, e.g., 1000 or more critters; stop and pour all the material, including the bugs you have already removed from the sample back into a sieve and split it down to a more appropriate percentage.

- 6) The material to be sorted is placed little-by-little into a petri dish and all organisms within the petri dish are removed under a [dissecting microscope](#) at 7x magnification. The material under the microscope is illuminated by a fiber optic light source. Petri dishes are divided into sections by lines drawn on the bottom of the dish with a permanent marker. The lines subdivide the dish so that you can systematically move across the dish. Move along these "guides" removing all organisms that you encounter.
- 7) As you remove the organisms count them using a clicker and drop them into vials separated by the major [taxonomic orders](#), i.e., Diptera, Coleoptera, Ephemeroptera, Plecoptera, Trichoptera, other insects, and non-insects. You need to remove all of the organisms from the debris, but not all organisms will be counted. [Remove, but do not count the following in your 600 minimum count:](#)

- a. damaged and immature organisms
- b. molt skins (exuviae)
- c. adult insects [excluding water-dwelling adults such as beetles (Coleoptera) and true bugs (Hemiptera)]
- d. eggs
- e. empty snail shells
- f. brooding juveniles
- g. zooplankton
- h. Collembola
- i. pupae
- j. worms

Additional portions of the sample (splits) are sorted until at least 600 organisms are found. Once you start a split, remove all the organisms within it. It is fine if you exceed 700 organisms, but beware of exceeding 1000.

- 8) When you have removed a minimum of 600 bugs, perform a "Big/Rare" search. This search is called a "Big/Rare" search because we tend to find larger individuals, but the goal is to collect rarer taxa that may not have been present in the split samples. Spread the entire un-sorted portion of the sample into an appropriately sized white enamel pan. Place this pan under the lighted magnifier lamp. Systematically search the pan and remove any organisms that you did not find in your split samples. Perform this search for 10 minutes. If you are in doubt that a critter is new, it is much better to pick up duplicates than to miss a bug. Put these bugs into a separate vial labeled "B/R" for "Big/Rare".
- 9) Print a sheet of labels off our website www.usu.edu/buglab/forms/vials.pdf onto waterproof paper. The label will contain the following information:

Sample #, Sample Set/Customer name	#3, Wasatch-Cache National Forest
Site name/Station I.D., Date collected	Wood Camp- Logan River, 12/12/03
County, State	Cache County, UT
Sorter, Date sorted, Total split percent, Total # bugs sorted	BB, 12/23/03, 25%, 616 bugs
I.D.er, Date I.D.ed	MT, 01/05/04
# of each Chironominae, Orthocladinae, Tanypodinae counted	5 C, 12 O, 20 T

Use waterproof paper and either a waterproof pen or pencil. Put the label into one of the vials. If you do not know the county, search for it at www.topozone.com.

- 10) Place a smaller label with the sample number (#3, from the example above) in each vial and label the lids of the vials with this same number using a dry erase marker. Label the "Big /Rare" vial "B/R". Put a rubber band around the vials and put them on the appropriate shelf.

- 11) The remaining portions of the sample, the debris that has been sorted, and any unsorted portions of the sample should be returned to the original sample jar and covered with preservative (70% ethanol). Place an "X" on the jar lid to indicate that the sample has been sorted and place it on the appropriate shelf.
- 12) Record your sample sort time, the sample sort dates, and your initials on the sample tracking [data sheet in the folder](#).

Equipment

preservative (70% ethanol) 500 & 250 micron meter sieves (of various diameters) waste container bucket enamel pans (of various sizes) separator bars (that fit each diameter of the sieves) coin plastic spoon and cups alcohol (ethanol) filled squeeze bottle distilled water filled squeeze bottle Parafilm dry erase marker	petri dish (with permanent marker drawn lines) dissecting microscope (7-20x magnification) fiber optic light source clicker/counter tweezers/forceps (both flat and pointed tipped) vial holder (vial sized holes drilled into a wooden block) scintillation vials desk lamp waterproof label paper waterproof pen or sharp tipped pencil rubber bands data recording sheet
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All the organisms removed during the sorting process are then identified by qualified taxonomists. We try to identify organisms to a consistent taxonomic level. Small (early instar) and poorly preserved specimens may be identified to a higher level than specified. Insects are normally identified to genus, some to species, and others to family. Non-insects are identified to the lowest taxonomic level feasible without slide-mounting. If you want your samples processed differently than described above, call us at (435) 797-3945.

See [Results and Reports](#) for our normal level of taxonomic resolution for all taxa. The identification keys we use most often can be found in [commonly used identification books](#).

References Cited- Standard Laboratory Sorting Procedures

Cuffney, T.F., Gurtz, M.E. and Meador, M.R.. 1993. Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program. United States Geological Survey Open-File Report 93-406.

Moulton, S.R. II, J.L. Carter, S.A. Grotheer, T.F. Cuffney and T.M. Short. 2000. Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory - processing, taxonomy, and quality control of benthic macroinvertebrate samples. United States Geological Survey Open-File Report 00-212.

Vinson and Hawkins. 1996. Effects of sampling area and subsampling procedures on comparisons of taxa richness among streams. Journal of the North American Benthological Society 15:393-400.

Laboratory Processing Sample Results

The National Aquatic Monitoring Center Lab provides sample results as hand written lab bench sheets or as [computer generated reports](#). Reports are written in standard scientific format and include information on field and laboratory methods, data analysis procedures, data summary tables, taxonomic lists, and a list of references. It is possible to obtain all or part of each report in a variety of electronic formats, e.g., spreadsheets with data summary fields or taxa by sample matrix. Occasionally, the Lab will modify their standard methods to meet particular needs. For example, they will determine invertebrate biomass or organic matter ash free dry mass of samples.

Standard taxonomic resolution:

Taxon or Taxa group	Standard Taxonomic Level
Annelida	
Hirudinea	Genus/species
Oligochaeta	Order
Arthropoda	
Hydracarina	Order
Crustacea	
Anostraca	Genus/species
Cladocera	Genus/species
Copepoda	Genus/species
Decapoda	Genus/species
Ostracoda	Order/Family/Genus
Amphipoda	Genus/species
Isopoda	Genus
Insecta	

Taxon or Taxa group	Standard Taxonomic Level
Collembola	Order
Coleoptera	Genus/species
Except Curculionidae, Heteroceridae, Ptiliidae	Family
Diptera	
Atherceridae	Genus
Blephariceridae	Genus/species
Ceratopogonidae	Genus
Chaoboridae	Genus/species
Chironomidae	Subfamily
Culicidae	Genus
Deuterophlebiidae	Genus/species
Dixidae	Genus
Dolichopodidae	Family
Empididae	Genus
Ephydriidae	Family
Muscidae	Family
Pelecorynchidae	Genus
Psychodidae	Genus
Ptychopteridae	Genus
Sciomyzidae	Family
Simuliidae	Genus
Stratiomyidae	Genus
Tabanidae	Genus
Tanyderidae	Genus
Thaumaleidae	Genus
Tipulidae	Genus
Ephemeroptera	Genus/species
Ephemerellidae	Species
Hemiptera	Genus/species
Lepidoptera	Genus
Megaloptera	Genus/species
Odonata	Genus/species
Plecoptera	Genus/species

Taxon or Taxa group	Standard Taxonomic Level
Pteronarcyidae	Species
Taeniopterygidae	Family/Genus
Trichoptera	Genus/species
Coelenterata	Class
Mollusca	
Gastropoda	Family/Genus/species
Pelecypoda	Order/Family/Genus
Sphaeriidae	Genus/species
Nematoda	Phylum
Nematomorphora	Phylum
Porifera	Phylum
Turbellaria	Class

Most Commonly Used Identification References

Listed below are the most common references used to help identify aquatic invertebrates. Not listed are the numerous original research papers that are routinely used for species determinations. If you have specific questions on what identification keys to use for particular taxon, write us and we will share our extensive literature data base.

- Brown, H. P. 1976. Aquatic Dryopoid beetles (Coleoptera) of the United States. Water Pollution Control Research Series 18050 ELD04/72.U. S. EPA. Cincinnati, Ohio. 82 pp.
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- Burch, J. B. 1973. Freshwater Unionacean Clams (Mollusca:Gastropoda) of North America. U. S. Environmental Protection Agency, EPA-600/3-82-023. Contract # 68-03-1290. 193 pp.
- Edmunds, G. F., Jr., S. L. Jensen and L. Berner. 1976. *The Mayflies of North and Central America*. North Central Publishing Co., St. Paul, MN. 330 pp.
- Johannsen, O. A. 1977. *Aquatic Diptera: Eggs, Larvae, and Pupae of Aquatic Flies*. Published by Cornell University Press, Ithaca, N.Y. 210 pp.
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- Larson, D.J., Alarie, Y. and Roughley, R.E. 2000. *Predaceous Diving Beetles (Coleoptera: Dytiscidae) of the Neractic Region, with emphasis on the fauna*

- of Canada and Alaska*. National Research Council of Canada Research Press, Ottawa, Ontario, Canada, 982 pp.
- Merritt, R. W. and Kenneth W. Cummins (editors). 1996. *An Introduction to the Aquatic Insects of North America*, Third Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa. 862 pp.
- Needham, J.G., M. J. Westfall, and M. L. May. 2000. *A manual of the dragonflies of North America (Anisoptera)*. Scientific Publishers, Inc. Gainesville, Florida.
- Pennak, R. W. 1989. *Freshwater invertebrates of the United States*, Third edition. John Wiley and Sons, Inc, New York, 628 pp.
- Stewart, K. W. and B. P. Stark. 1988. *Nymphs of North American Stonefly Genera (Plecoptera)*. Entomological Society of America. 460 pp.
- Thorp J. H. and A. P. Covich (editors). 1991. *Ecology and Classification of Freshwater Invertebrates*. Academic Press, Inc., San Diego, CA. 911 pp.
- Westfall, M.J., Jr. and M.L. May. 1996. *Damselflies of North America*. Scientific Publishers. Gainesville, Florida.
- Wiederholm, T. (editor) 1983. *Chironomidae of the Holarctic Region. Part 1. Larvae*. Entomologica Scandinavica. 457 pp.
- Wiggins, G. B. 1996. *Larvae of North American Caddisfly Genera (Trichoptera)*. University of Toronto Press, Toronto, Ontario, Canada. 457 pp.

BugLab Quality Control/Quality Assurance

The processing of aquatic invertebrate samples involves a number of distinct operations where errors to the data may occur. In the National Aquatic Monitoring Center laboratory these distinct operations include the following:

1. Sample sorting - The separation and removal of aquatic invertebrates from the entire sample.
2. Invertebrate identification - The identification of each individual invertebrate to the recommended or lowest practical taxonomic level.
3. Data processing - this includes filling out the taxonomic lists, i.e., the bench sheets, by taxonomists, the transcribing of codes to each bench sheet, the entry of the data into a computer data base, the matching of samples to sampling locations, and any subsequent analysis or transformations of the data.

Described below are the ways in which we attempt to reduce these potential errors and control for differences in taxonomic consistency among laboratory personnel.

1. Sample sorting
Sorting aquatic invertebrate samples involves removing aquatic macroinvertebrates from the organic and inorganic material within each sample. Error can occur if the sample is not split correctly and if all the organisms are not removed from a sample split. To reduce error associated with subsampling procedures we use a relatively easy subsampling method, record all information associated with each sample,

and review this information on a weekly basis. The information recorded for each sample includes who sorted each sample, the date the sample was sorted, the time required to sort the sample, the number of invertebrates removed from the sample, and the percent of the sample that was sorted. Any abnormalities are assessed and corrected.

To ensure that all organisms are removed from sample splits, all sorting is done using a binocular microscope at 7x magnification. We intensively train all new employees and check all of their samples for the first month. Spot checks are then done on individual employees if there appears to be any consistent abnormalities in their samples. Abnormalities typically include distinct differences in sample characteristics between one technician and other technicians working on the same set of samples. These differences include differences in the percent of the sample sorted, the time required to sort a sample, or the number of invertebrates removed during the sample splitting or the big-rare search.

Individuals invertebrates left on a sieve from a previous sample can also be a source of error. We try to prevent this from happening by carefully washing the sieves after a sample is split, by inspecting each sieve prior to putting a new sample into it, drying the sieves following their use, and by noticing if any invertebrates in a sample appear to look "dried out" with respect to other invertebrates in that sample. These desiccated invertebrates may have been leftover from a previous sample, i.e., they were not removed from the sieve during a previous subsampling event and were inadvertently added to a different sample. These invertebrates are removed from the current sample and discarded as there is no way of determining which sample they were supposed to belong to.

2. Verification of taxonomic identifications

The National Aquatic Monitoring Center attempts to reduce the number of misidentifications and improve the consistency in taxonomic resolution among taxonomists through a number of conscientious efforts. These efforts include:

- A. Conducting in-house workshops and participating in outside taxonomic seminars. Periodically (typically 3-4 times a year) National Aquatic Monitoring Center taxonomists visit with other regional taxonomists, e.g., Dr. Dick Baumann and Dr. Riley Nelson from Brigham Young University, to share specimens and discuss relevant taxonomic issues. We also bring questionable taxa to the Taxonomy Fair held at annual meetings of the North American Benthological Society. BugLab taxonomists also attend regional taxonomic seminars as offered by the Northwest Bioassessment Work Group.
- B. Insisting on constant and consistent communication among all taxonomists and dealing with any questionable taxa on the spot. Questionable specimens are immediately shared with all other

- taxonomists and compared to voucher specimens from our laboratory and the Utah State University insect collection. If consensus cannot be reached among our taxonomists, the specimens are shown to Dr. Wilford Hanson or Dr. Charles Hawkins, both eminent professional entomologists at Utah State University. If consensus is still not reached, the taxonomic resolution is backed off (e.g., genus to family) and the specimen is set aside to be shown to an outside expert.
- C. Each bench sheet is reviewed by the taxonomist a few days to a week after they finished that sample and prior to the data being entered into the computer. This procedure is done to re-evaluate each sample in light of information the taxonomists may have gained by identifying other samples from that set, while the information from a particular sample is still fresh in their mind. Problems identified during this procedure typically include incomplete bench sheets (e.g., counts or life stage not written in) and taxonomic resolution inconsistencies among samples. For example, the taxa identified in other samples from the same area and collected at different times of the year may allow for higher taxonomic resolution of other samples from the same sample set. Any questionable or incomplete information is corrected at this time.
 - D. After a set of samples has been completed the lab's QA/QC officer reviews each bench sheet for completeness and any abnormalities. This is a further attempt to improve the consistency among samples.
 - E. After the data has been entered into the computer all taxonomists review a composite taxa list for each set of samples. Three taxonomists and the lab director currently review a list of all taxa found in each sample set. They review this list for:
 - 1) taxonomic consistency, e.g., all monotypic taxa identified to species, and,
 - 2) rare taxa and any unusual taxa for the habitats sampled or geographical location sampled. These taxa are then re-examined to make sure the identifications are correct. This procedure has improved the consistency of identifications and helped in reducing misidentifications and data entry errors.
 - F. The National Aquatic Monitoring Center maintains a large reference collection. The voucher collection contains over 2000 specimens. The identification of most of these specimens has been verified by outside professional taxonomists. All new taxonomists are required to identify each of these specimens. The identification of any new taxon for our laboratory is currently verified by outside taxonomists and compared to known distribution records.
3. Data processing and sample verification

Data processing involves entering the data from the bench sheets and the sample information data sheets into a dBASE IV program. Bench sheet information includes the unique code for each invertebrate taxon, the life stage, the split count, the count from the big-rare search, and any notes. Once entered, the computer program then displays the taxonomic name for each code, the life stage, enumerations, and taxonomic notes. These data are then verified or corrected before the data are uploaded to the main data base. Once all the data from a set of samples have been entered into the computer a composite taxa list and the counts for each taxon is printed and reviewed for accuracy and consistency as described above.

Sample verification is the process of making sure that the taxonomic lists produced for each sample get assigned to the correct sampling location. When working with large numbers of samples and individual projects that may exceed 500 samples that were collected over a several month period by several crews, this issue becomes more complex than one might imagine. Our procedure for dealing with this issue is to assign each sample a sequential identification code. These codes are unique for each sample and sample jar and correspond to a list of samples, sampling dates, and locations. This number is retained throughout the life of the sample and is stored in hand-written and electronic formats.

4. Summary

The National Aquatic Monitoring Center professional laboratory staff members have 5-11 years experience tracking, processing, and identifying aquatic macroinvertebrate samples. The person responsible for data entry has been at the job for 5 years. QA/QC is a dynamic process and constructive comments are always welcome.

The National Aquatic Monitoring Center recently completed a comprehensive QA/QC evaluation of all of its field and laboratory procedures. Little bias or variation in several measures of accuracy and precision among different field crews, sample sorters, taxonomists, and the same taxonomist identifying the same sample several times over a several month period. See Table 1 for a summary of some of the data attributes evaluated.

Table 1. Summary of variability in data attributable to different activities associated with collection of field data, laboratory sample

processing and taxonomic identifications. These data were compiled during December of 2002.

Component of Variability Measured	Range in percent Similarity
Similarity in assemblage composition based on Jaccard Coefficient:	
Among field crews	92-96%
Among sample sorting technicians	Not yet determined
Among taxonomists	98%
Among identifications by the same taxonomist during different weeks	98%
Coefficients of Variation in taxa richness:	Range in Percent
Among field crews	4-7
Among sample sorting technicians	3-6
Among taxonomists	4-6
Among identifications by the same taxonomist during different weeks	2-3

12.0 FORM IDENTIFICATION AND CODING

Sampling forms are necessary for sample tracking and analysis requests. Coding simplifies the procedure and assists in computer data processing.

12.1 Field Sheets and Sample Labels

Field personnel are responsible for filling in the descriptive information, field test data, and appropriate codes for each sample collected. Sample bottles supplied by the Division of Public Health Service Laboratory are pre-labeled and pre-preserved for the appropriate requested analyses. The following information must be provided on the sample bottle or label

1. STORET number, See Annual Monitoring Plan or Master Storet Log Book (Red or Black Books) or DWQ Storet data base on computer.
2. Date (month, day year)and time (military)sample was taken.
3. Exact description of sampling site .
4. Initials of sample collector.

The following is an example of the label on all bottles.

Date: 01/30/06	Time: 1400
Storet #: 499 2970	Samplers: RD/AH
Site Description: Big Cottonwood Ck ab cnfl/ Jordan R @ 5 th W	

Information contained in this Section is needed to comply the lab Sheet (Figure 12.2), with the following information that must be recorded using permanent ink:

1. STORET number. See Annual Monitoring Plan or Master Storet Log Book (Red or Black Books) or DWQ Storet data base on computer.
2. Exact description of sampling point. Abrev.
3. Cost Code
4. Initials of sample collector.
5. Sampling agency
6. Date (month, day, year) and time (military) sample was taken.
7. Sample type
8. Weather Conditions
9. Field Conditions
10. Field measurement data (D.O., ph, Cond., Temp.)
11. Analyses constituent request code, or partial listing
12. Lake and periphyton samples also require an Volume filtered entry and starting Volume entry for Chlorophyll, Ash Free Dry Weight, and Species Composition.

In addition, on the master run sheet (Figure 12.3) the following information must also be recorded in permanent ink

1. Data and Time of Station Visit
2. Field measurement data (D.O., pH, Sp. Cond. Temp.)
3. Flow measurement value and type of measurement

Figure 12.3 Example Master Run Sheet

SAMPLE RUN: JORDAN RIVER INTENSIVE QUARTERLY
SAMPLE SUMMARY

DATE : 1/25/2005

SAMPLERS : [SCHMITT] [ENGLISH] [LAMPH] [] [] []

TRIP ID : JRI012505

DESCRIPTION : USE THESE SHEETS FOR YOUR QUARTERLY RUN

624	=	2	625	=	5	B.O.D.	=	57
BACTERIAL	=	21	CHEMISTRY	=	74	CYANIDE	=	14
EPG	=	1	FILTERED METALS	=	64	FILTERED NUTRIEN	=	47
NON-FILTERED NUTRI	=	93	OIL & GREASE	=	3	SULFIDE	=	3
TOTAL METAL	=	27		=			=	

Seq. #	Project	Storet Id.	Station Desc.	Date	Time	W.Temp	pH	DO	Conductivity	Flow	E/M
1	350	4990750	Trip Blank Metropolitan	[]	[]	[]	[]
2	357	4990670	AIR PRODUCTS AND CHEMICALS	[]	[]	[]	[]
3	357	4990070	N DAVIS WWTP	[]	[]	[]	[]
4	357	4990270	CENTRAL DAVIS WWTP	[]	[]	[]	[]
5	357	4990780	S DAVIS N WWTP	[]	[]	[]	[]
6	354	4990790	JORDAN R (STATE CNL) 20 FT AB S DAVIS N WWTP	[]	[]	[]	[]
7	362	4990880	JORDAN R AT STATE CANAL ROAD XING	[]	[]	[]	[]
8	357	4991810	S DAVIS S WWTP	[]	[]	[]	[]
9	359	4991820	JORDAN R AT CUDAHY LANE AB S DAVIS S WWTP	[]	[]	[]	[]
10	350	4991830	JORDAN R AT 26TH NORTH	[]	[]	[]	[]
11	354	4991050	SEWAGE CNL AT CUDAHY LANE XING	[]	[]	[]	[]
12	354	4991280	SEWAGE CNL AB SLC WWTP	[]	[]	[]	[]
13	357	4991250	SALT LAKE CITY WWTP	[]	[]	[]	[]
14	354	4991230	SEWAGE CNL AB CHEVRON OIL	[]	[]	[]	[]
15	357	4991210	CHEVRON OIL REFINERY OUTFALL 001	[]	[]	[]	[]
16	359	4991290	SURPLUS CNL NW OF AIRPORT	[]	[]	[]	[]
17	357	4991120	S.L.C. INTERNATIONAL AIRPORT 001	[]	[]	[]	[]
18	350	4991130	CANAL @ 1500 W AB CITY DRAIN	[]	[]	[]	[]
19	357	4991090	AIRPORT PARKING LOT OUTFALL SLCIA 002	[]	[]	[]	[]
20	357	4991330	Salt Lake City Airport 005 SE Corner	[]	[]	[]	[]
21	357	4991320	Salt Lake City Airport 004 SW Corner	[]	[]	[]	[]
22	357	4991170	SALT LAKE CITY INT AIRPORT 003 (W RUNWAYS)	[]	[]	[]	[]
23	359	4991310	SURPLUS CNL AT I80 XING	[]	[]	[]	[]

12.2 Tables of Abbreviations, Cost Codes, Agency Codes, Sample Type Codes, Weather Codes, Field Condition Codes, Analysis Request Codes, & Sample Suite Codes for Laboratory Sample Sheets and Labels.

The following abbreviations are to be used on forms, data sets, and the STORET system.

Above, ab	National Park Service, NPS
Arizona, AZ	Near, NR
Below, bl	Nevada, NV
Between, btn	North, N
Boundary, bndry	Northeast, NE
Bureau of Land Management, BLM	Northwest, NW
Bureau of Reclamation, USBR	Reservoir, Res
Canal, Cnl	River, R
Confluence, cnfl	South, S
County Road, CR	Southeast, SE
Creek, Ck	Southwest, SW
Crossing, Xing	Spring, Spr
Division of Wildlife Resources, DWR	State, St
East, E	State Road, SR
Effluent, Eff	United States Bureau of Reclamation, USBR
Feet, Ft	United States Geological Survey, USGS
Fork, Fk	Utah, UT
Great Salt Lake, GSL	West, W
Idaho, ID	With, /
Kilometer, Km	Wyoming, WY
Lake, L	1/2, 0.5
Line, Ln	3/4, 0.75
Meter, M	1-1/2, 1.5
Mile, Mi	
National Forest Service, NFS	

The following cost codes are to be used on forms:

350	General Monitoring Credit (State)
350B	General Monitoring Billed
351	General Lake Monitoring
352	Groundwater Permit Oversight Monitoring
353	Groundwater Studies
354	Waste Load Allocation Monitoring
356	Weber Basin Intensive Monitoring
357	UPDES Oversight Monitoring
358	Cooperative Interagency Monitoring
359	Utah Lake/Jordan River Basin Intensive Monitoring
362	Long Term Ambient Monitoring
363	Farmington Bay/Great Salt Lake Wetlands Monitoring
364	Bear River Intensive Monitoring
406	CUWCD Diamond Fork Study
552	Jordanelle Monitoring
555	Site Assessment Monitoring

840	Uinta Basin Intensive Monitoring
843	Navajo Lake
846	Utah Lake Monitoring
848	East Canyon Reservoir
851	Hyrum Reservoir
852	Minersville Reservoir
854	Total Maximum Daily Load
855	Mantua Reservoir
856	Southeast (Colorado and Lower Green R) Intensive
857	Sevier Virgin Intensive
858	Milford Groundwater Study
868	Non-Point Source Monitoring

The following agency codes are to be used on forms:

01	Division of Water Quality
02	Bureau of Land Management
03	National Forest Service
04	National Park Service
05	Mountain Lands Association of Governments
06	Central Utah Water Conservancy District
07	Bureau of Reclamation
08	Wasatch County
09	Salt Lake City/County Health Department
10	Salt Lake Water Conservancy District
11	Salt Lake County Water Reclamation
12	Utah State University
13	Division of Wildlife Resources
14	Other
15	Division of Air Quality
16	Division of Drinking Water
17	Division of Oil Gas and Mining
18	Utah County Health Department
19	Bear River Health Department
20	Division of Emergency Response and Remediation
21	Division of Solid and Hazardous Waste
22	Drinking Water Systems
23	Division of Radiation Control
24	Davis County
25	United States Geological Survey (USGS)
26	Native American Reservations
27	Utah Geological Survey

The following sample type codes are to be used on forms:

04	Grab Sample	17	3rd Quarter Composite
05	1st Trimester Composite	18	4th Quarter Composite
06	2nd Trimester Composite	19	Raceway Cleaning
07	3rd Trimester Composite	20	Field Data Only
08	8 Hour Composite	30	Sludge
09	Total Composite - 24 hour	40	Sediment
10	No Flow or Discharge	50	Soil
11	No Access	60	Air
15	1st Quarter Composite	70	Tissue
16	2nd Quarter Composite		

LAKE DEPTH CODING

21	Surface Sample	26	Indicate Depth
22	Indicate Depth	27	Indicate Depth or bl Thermocline
23	Indicate Depth or ab Thermocline	28	Indicate Depth
24	Indicate Depth	29	Bottom
25	Middle		

The following weather conditions codes are to be used on forms:

01	Clear
02	Overcast
03	Partly Cloudy
04	Wind
05	Fog
06	Dust
07	Rain
08	Hail
09	Light Snow
10	Heavy Snow

The following field conditions codes are to be used on forms:

01	Normal
02	Evidence of Recent High Water
03	Flood
04	Shore Ice
05	Anchor Ice
06	Solid Ice
07	Spring Runoff
11	Clear Water
12	Milky Water
13	Cloudy Water
14	Opaque Water

The following analysis request codes are to be used on forms:

For partial metals and chemicals, list individual parameters when feasible using chemical symbol such as follows:

5-day biochemical oxygen demand	BOD5
Total suspended solids	TSS
Total dissolved solids	TDS
Oil and grease	O&G
Fecal coliform	F Coli
Total coliform	T Coli
Escherichia coliform	E Coli
Specific Conductance	Sp Cond
Total Hardness	T Hard
Total Alkalinity	T Alk

Ammonia	NH ₃	Mercury	Hg
Carbonate	CO ₃	Arsenic	As
Nickel	Ni	Hydroxide	OH
Barium	Ba	Potassium	K
Nitrate + Nitrite	NO ₂ + NO ₃	Boron	B
Selenium	Se	Cadmium	Cd
Silver	Ag	Silica	Si
Calcium	Ca	Sodium	Na
Sulfate	SO ₄	Chromium	Cr
Zinc	Zn	Surfactant	MBAS
Copper	Cu	Cyanide	CN
Phosphorus	P	Sulfide	S
Turbidity	NTU	Iron	Fe
Fluoride	F	Lead	Pb
Chloride	Cl	Magnesium	Mg
Bicarbonate	HCD	Manganese	Mn
Carbon Dioxide	CO ₂	Total Organic Carbon	TOC

The following sample suite codes are to be used on forms:

Bacteriological

- Suite 1 Other combinations or tests as listed.
- Suite 2 Fecal Strep.
- Suite 6 MF Total and Fecal Coliform.
- Suite 7 Escherichia Coliform
- Suite 9 Total, Fecal and Fecal Strep Coliform

Biochemical Oxygen Demand (BOD)

- Suite 1 Other combinations or tests as listed.
- Suite 2 Total Suspended Solids.
- Suite 3 BOD5.
- Suite 4 BOD5, Total Suspended Solids.
- Suite 5 BOD5, Soluble BOD5, Total Suspended Solids.
- Suite 6 BOD5, Carbonaceous BOD5, Total Suspended Solids.

Non Filtered Nutrients

- Suite 1 Other combinations or tests as listed.
- Suite 2 Ammonia, Total Phosphorus.
- Suite 3 Ammonia, Nitrite + Nitrate, Total Phosphorus.
- Suite 4 Ammonia, Nitrite + Nitrate, Total Phosphorus.
- Suite 6 Nitrite + Nitrate, Total Phosphorus.
- Suite 9 Ammonia, Total Phosphorus.

Filtered Nutrients

- Suite 1 Other dissolved combinations or tests as listed.
- Suite 9 Dissolved Nitrite + Nitrate, Dissolved Total Phosphorus.

Chemistry

- Suite 1 Other combinations or tests as listed.
- Suite 2 Carbonate, Bicarbonate, Carbon Dioxide, Hydroxide, Chloride, Sulfate, Total Alkalinity, Turbidity, Specific Conductance, Total Dissolved Solids, Total Suspended Solids, Carbonate Solids,
- Suite 3 High Saline Chemistry: Total Dissolved Solids greater than 75,000 mg/l: includes all Suite 2 parameters, Calcium, Magnesium, Potassium, Sodium, Total Hardness.
- Suite 9 T-Antimony, T-Arsenic, T-Barium, T-Beryllium, T-Cadmium, T-Chromium, T-Copper, T-Lead, T-Mercury, T-Nickle, T-Selenium, T-Thallium, Cyanide, Fluoride, Sodium, Sulfate, Total Dissolved Solids, Turbidity.

Total Metals

- Suite 1 Other combinations or tests as listed.
- Suite 2 Total: Aluminum, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Zinc.
- Suite 3 Total: Aluminum, Arsenic, Barium, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Potassium, Selenium, Silver, Sodium, Total Hardness, Zinc.
- Suite 4 Total: Calcium, Magnesium, Potassium, Sodium, Total Hardness.
- Suite 7 Aluminum Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Zinc.
- Suite 8 Lead, Copper.
- Suite 9 Total: Barium, Cadmium, Chromium, Mercury, Selenium.

Filtered Metals

- Suite 2 Dissolved: Aluminum, Arsenic, Barium, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Nickel, Potassium, Selenium, Silver, Sodium, Zinc, Total Hardness
- Suite 3 Dissolved: Aluminum, Arsenic, Barium, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Nickel, Potassium, Selenium, Silver, Sodium, Zinc, Total Hardness
- Suite 4 Dissolved Calcium, Magnesium, Sodium, Potassium, Total Hardness

Organics - List each method on lab sheet.

Haloacetic Acids EPA Method 6251B-HAA

Trihalomethanes (THM) EPA Method 524.2-THM
Volatile Organic Compounds (VOC) Method 524.2-VOC Drinking Water
Volatile Organic Compounds (VOC) Method 624.2-VOC Surface Water
Volatile Organic Compounds (VOC) Method 8260-VOC RCRA
Pesticides and Semi-Volatiles (SVOC) Method 525-SVOC Drinking Water
Pesticides and Semi-Volatiles (SVOC) Method 625-SVOC Surface Water
Pesticides and Semi-Volatiles (SVOC) Method 8270-SVOC RCRA
Herbicides Method 515.1-Water
Herbicides Method 8151-RCRA
Carbamates (insecticides and aldicarbs) Method 531.1-Water
Total Petroleum Hydrocarbons (TPH) Method 8015-TPH
Benzene, Ethyl Benzene, Toluene, Xylene, and Naphtalene Method BETX N
PolyChlorinated byphenols & Organochlorine Pesticides Method 608-PCB/Ocpest water
PolyChlorinated byphenols & Organochlorine Pesticides Method 8081-PCB/Ocpest rcra
Glycols (Ethylene and Propylene Glycol) Method EPG water
Triazine Herbicides (6219)

Miscellaneous

Oil and Grease,
Cyanide,
Sulfides
Odor
Surfactants
Chlorophyll A
Ash-Free Dry Weight

12.3 Calibration Forms For Field Sampling Instrumentation

When calibrating the Hydrolab Multiprobe a Hydrolab Multiprobe Calibration Worksheet is used; dissolved oxygen calibration tables used are referred to as Hydrolab Multiprobe Calibration.

Hydrolab Multiprobe Calibration Worksheet

MULTIPROBE CALIBRATION		DATE			
Analyst	Run:	Location			
DID YOU TURN OFF CIRCULATOR YES___ NO					
pH	Buffer Value	Initial Reading	Reading After	SRM Value	Surveyor Reading
4:00					
7:00					
10:00					
COND	Cond Value	Initial Reading	Reading After	SRM Value	Surveyor Reading
Low Value					
High Value					
DO	Barometric Pressure	Initial Reading	Reading After	Winkler Value	Surveyor Reading
Value					
DATE TIME	Today's Date	Watch Time	Surveyor Date	Surveyor Time	Adjustments
Value					Yes__ No
BATTERY COLTAGE	SRV3 IBV	SRV4 IBV	SRV4 IBV%	Unit Number	Backup EBV
PROBLEMS & REMARKS					
DID YOU TURN ON CIRCULATOR Yes___ No					

Figure 12.5 Hydrolab Muliprobe Calibration DO Worksheet

Elevation	K-Value	Elevation	K-Value	Elevation	K-Value	Elevation	K-Value
2800	0.91	3900	0.87	5000	0.84	6100	0.80
2900	0.90	4000	0.87	5100	0.83	6200	0.80
3000	0.90	4100	0.87	5200	0.83	6300	0.79
3100	0.90	4200	0.86	5300	0.83	6400	0.79
3200	0.89	4300	0.86	5400	0.82	6500	0.79
3300	0.89	4400	0.86	5500	0.82	6600	0.78
3400	0.89	4500	0.85	5600	0.82	6700	0.78
3500	0.88	4600	0.85	5700	0.81	6800	0.78
3600	0.88	4700	0.85	5800	0.81	6900	0.77
3700	0.88	4800	0.84	5900	0.81	7000	0.77
3800	0.88	4900	0.84	6000	0.80	7100	0.77

$$760 - \{.025\} \{elevation\} = K$$

$$\{K\} \{Temperature\ Value\ Reading\} = D.O.\ Reading$$

Temp	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	14.16	14.12	14.08	14.04	14.00	13.97	13.93	13.89	13.85	13.81
1	13.77	13.74	13.70	13.66	13.63	13.59	13.55	13.51	13.48	13.44
2	13.40	13.37	13.33	13.30	13.26	13.22	13.19	13.15	13.12	13.08
3	13.05	13.01	12.98	12.94	12.91	12.87	12.84	12.81	12.77	12.74
4	12.70	12.67	12.64	12.60	12.57	12.54	12.51	12.47	12.44	12.41
5	12.37	12.34	12.31	12.28	12.25	12.22	12.18	12.15	12.12	12.09
6	12.06	12.03	12.00	11.97	11.94	11.91	11.88	11.85	11.82	11.79
7	11.76	11.73	11.70	11.67	11.64	11.61	11.58	11.55	11.52	11.50
8	11.47	11.44	11.41	11.38	11.36	11.33	11.30	11.27	11.25	11.22
9	11.19	11.16	11.14	11.11	11.08	11.06	11.03	11.00	10.98	10.95
10	10.92	10.90	10.87	10.85	10.82	10.80	10.77	10.75	10.72	10.70
11	10.67	10.65	10.62	10.60	10.57	10.55	10.53	10.50	10.48	10.45
12	10.43	10.40	10.38	10.36	10.34	10.31	10.29	10.27	10.24	10.22
13	10.20	10.17	10.15	10.13	10.11	10.09	10.06	10.04	10.02	10.00
14	9.98	9.95	9.93	9.91	9.89	9.87	9.85	9.83	9.81	9.78
15	9.76	9.74	9.72	9.70	9.68	9.66	9.64	9.62	9.60	9.58
16	9.56	9.54	9.52	9.50	9.48	9.46	9.45	9.43	9.41	9.39
17	9.37	9.35	9.33	9.31	9.30	9.28	9.26	9.24	9.22	9.20
18	9.18	9.17	9.15	9.13	9.12	9.10	9.08	9.06	9.04	9.03
19	9.01	8.99	8.98	8.96	8.94	8.93	8.91	8.89	8.88	8.86
20	8.84	8.83	8.81	8.79	8.78	8.76	8.75	8.73	8.71	8.70
21	8.68	8.67	8.65	8.64	8.62	8.61	8.59	8.58	8.56	8.55
22	8.53	8.52	8.50	8.49	8.47	8.46	8.44	8.43	8.41	8.40
23	8.38	8.37	8.36	8.34	8.33	8.32	8.30	8.29	8.27	8.26
24	8.25	8.23	8.22	8.21	8.19	8.18	8.17	8.15	8.14	8.13
25	8.11	8.10	8.09	8.07	8.06	8.05	8.04	8.02	8.01	8.00
26	7.99	7.97	7.96	7.95	7.94	7.92	7.91	7.90	7.89	7.88
27	7.86	7.85	7.84	7.83	7.82	7.81	7.79	7.78	7.77	7.76
28	7.75	7.74	7.72	7.71	7.70	7.69	7.68	7.67	7.66	7.65
29	7.64	7.62	7.61	7.60	7.59	7.58	7.57	7.56	7.55	7.54
30	7.53	7.52	7.51	7.50	7.48	7.47	7.46	7.45	7.44	7.43
31	7.42	7.41	7.40	7.39	7.38	7.37	7.36	7.35	7.34	7.33
32	7.32	7.31	7.30	7.29	7.28	7.27	7.26	7.25	7.24	7.23
33	7.22	7.21	7.20	7.20	7.19	7.18	7.17	7.16	7.15	7.14
34	7.13	7.12	7.11	7.10	7.09	7.08	7.07	7.06	7.05	7.05
35	7.04	7.03	7.02	7.01	7.00	6.99	6.98	6.97	6.96	6.95

- | | | | |
|----------------------|-----|----------------------|-----|
| ___ PLANKTON SAMPLER | ___ | ___ LONG GLOVES | ___ |
| ___ DEPTH FINDER | ___ | ___ INSULATED GLOVES | ___ |
| ___ MESSENGER | ___ | ___ FUNNEL | ___ |
| ___ ISCO | ___ | | |
| ___ ISCO BATTERY | ___ | ___ EXTENSION CORD | ___ |
| ___ PLASTIC BUCKET | ___ | | |
| ___ METAL BUCKET | ___ | ___ DIPPER | ___ |
| | | | |
| QUALITY CONTROL | | | |
| ___ BLANKS, # OF | ___ | | |
| ___ DUPLICATES, # OF | ___ | | |

VEHICLE AND BOAT CHECKLIST

- | <u>VEHICLE</u> | | <u>BOAT</u> | |
|--------------------------|-----|-----------------------|-----|
| OUT | IN | OUT | IN |
| ___ VEHICLE | ___ | ___ BOAT | ___ |
| ___ KEYS | ___ | ___ KEY | ___ |
| ___ SPARE TIRE | ___ | ___ SPARE TIRE | ___ |
| ___ JACK | ___ | ___ JACK | ___ |
| ___ STAR WRENCH | ___ | ___ STAR WRENCH | ___ |
| ___ SHOVEL | ___ | ___ LIFE JACKETS | ___ |
| ___ AXE | ___ | ___ BOAT PLUG | ___ |
| ___ TOOLS | ___ | ___ TOOLS | ___ |
| ___ CELL PHONE | ___ | ___ CELL PHONE | ___ |
| ___ TIRE CHAINS | ___ | ___ OARS | ___ |
| ___ TOW CHAIN | ___ | ___ TIE DOWNS (2) | ___ |
| ___ ICE SCRAPER | ___ | ___ ANCHORS(2) | ___ |
| ___ TRAILOR HITCH & BALL | ___ | ___ ANCHOR ROPE | ___ |
| ___ LIGHT SOCKET | ___ | ___ ROPE | ___ |
| ___ GAS CARD | ___ | ___ STARTING FLUID | ___ |
| ___ REAR POWER | ___ | ___ GAS TANK | ___ |
| | | ___ GAS TANK HOSE | ___ |
| ___ WINDSHIELD | ___ | ___ GAS CANS (EXTRA) | ___ |
| ___ BODY DAMAGE | ___ | ___ OUTBOARD OIL | ___ |
| ___ INTERIOR DAMAGE | ___ | ___ TRAILOR LIGHTS OK | ___ |
| ___ TIRES | ___ | ___ PROP OK | ___ |
| | | ___ BOAT LIGHTS OK | ___ |
| ___ CLEAN EXTERIOR | ___ | ___ CLEAN | ___ |
| ___ CLEAN INTERIOR | ___ | ___ EVERYTHING TIGHT | ___ |
| | | ___ SPARE BULBS | ___ |
| ___ GREYHOUND LABELS | ___ | ___ TRAILER BEARINGS | ___ |

12.5 Other Forms

Various other forms are used by the Division of Water Quality Monitoring Section. Those forms listed below are pedantically described in their appropriate sections:

Chain of Custody Forms	Section 15
Fish Collection Forms	Section 21
Stream Habitat Forms	Section 19
Lake Assessment Forms	Section 9
Incident Report Forms	Section 7

13.0 FIELD INSTRUMENTATION

13.1 Multiprobe Instruments

Reliable field readings are an essential part of any good monitoring program. Field readings, consisting of temperature ($^{\circ}\text{C}$), pH, dissolved oxygen (mg/l), and specific conductance (us/cm) are taken at each site. Readings are taken with a multiprobe instrument. Two commercial brands are utilized: Hydrolab & InSitu.

Three Hydrolab models are used. The Surveyor 4 is the current production model while the Surveyor 3 and 4000 models as backups to the Surveyor 4. This practice will continue as long as replacement parts are available for the 3 and 4000 models.

The Insitu model TROLL 9000 is currently in use.

Readings for all multiprobe instrumentation are recorded on run forms and stored as hard copies in DWQ files. Readings are also stored electronically on the instrument and downloaded to the database after a monitoring trip is completed.

13.2 Multiprobe Calibration (Insitu/Hydrolab)

In order to assure the reliability of these readings, the instruments are calibrated each morning prior to sampling and at any time during the day that a reading may be considered questionable. pH and conductivity are further validated with standard reference materials supplied by the quality assurance officer .

The calibration procedure follows the format of the "Hydrolab Analysis" sheet where the work is recorded. The general procedure, common to Hydrolab also applies to the Insitu as well.

Temperature: Factory calibrated. No adjustment necessary.

pH: Rinse and fill the calibration cup and probes with distilled water or the pH 6.86 standard solution. Read and record the pH. If adjustment is needed for 6.86, the pH is zeroed on 6.86 with the 6.86 standard. The standard solution is removed. The unit is rinsed with distilled water or pH 9.18 standard solution and filled with the 9.18 solution. Read and record the pH. If pH doesn't read 9.18, adjust the slope to 9.18 with pH 9.18 standard solution. Allow adequate time to stabilize. Standards are made from commercially prepared powders by the Q.A. officer. The pH Quality Assurance is completed by measuring the pH of a standard reference material prepared by the Q.A. Officer in the laboratory. The reading is recorded and the value verified at a later date.

Dissolved Oxygen (D.O.): Dissolved oxygen air calibration is done with deionized water. Care must be used to allow the D.O. to fully stabilize. A soft rubber end cap should not be pushed over the end of the cup. It will seal the chamber causing positive pressure adversely affecting the membrane permeability, thus resulting in erroneous calibration.

For the Surveyor III, begin by removing the white, D.O. sensor guard and screwing on an open calibration cup. Rinse the probes thoroughly with deionized water and pointing the sensors up, fill the cup with the deionized water until the

level is just below the O-ring that secures the D.O. membrane. For the Surveyor IV and Insitu there is no D.O. sensor guard. Gently blot the D.O. membrane with a soft cloth or paper towel. Secure the sonde to a ring stand (if available) and cover the cup with the top of the hard screw cap that comes with the cup (this is essential to good D.O. calibration).

An alternate calibration of D.O. can be used when barometric pressure is not available. After the temperature has stabilized, read and record the temperature. Refer to the charts on the back of the Hydrolab Analysis Sheet to calculate from elevation and stable temperature the D.O. in mg/l for the air calibration. Record the correct dissolved oxygen calibration value utilizing air and elevation. Adjust instrument to calculated value if necessary.

Specific Conductance: Select a conductivity standard that is within the range expected for the majority of water to be tested that day (i.e. 50-200 for mountain lakes, 500-1000 for a majority of Utah streams, 9000-12000 for the Great Salt Lake, etc.). Validate calibration with a conductivity reference standard.

Rinse the calibration cup and probe with distilled water or the conductivity solution to be utilized. Fill cup with solution to cover sensor. Tap cup and sonde gently to ensure sensor has no trapped air bubbles. Let instrument stabilize, and record value. If adjustment is necessary, set at solution value.

Table 13.1 Standard Reference Material for Quality Assurance

	<u>Value</u>	<u>Acceptable Limits</u>
<u>pH</u>	4.0	3.9 - 4.1 Preferred 3.8 - 4.2 Accepted
	7.4	7.3 - 7.5
	10.4	10.2 - 10.5
<u>Spec Cond</u>	363	330 - 390
	755	700 - 800
	1759	1600 - 1900

If results outside accepted limits are achieved, the calibration must be repeated. If still not successful then the buffers should be suspected. If after testing or replacing the buffers, acceptable calibration cannot be achieved, service or repair of the instrument may be required.

Sonde Configuration

Sonde units for Hydrolab and Insitu instruments may have different configurations. Currently, the units utilized for field use are configured to be able to give readings for the following parameters.

Troll 9000

Temperature, pH, D.O. (mg/l and % saturation), specific conductance (resistivity, salinity and TDS), depth (meters or feet), time, and barometric pressure.
Surveyor 4

Temperature, pH, D.O. (mg/l and % saturation), specific conductance (resistivity, salinity and TDS), depth (meters or feet), time, and barometric pressure.

Surveyor 3

Temperature, pH, D.O. (mg/l), specific conductance, redox, and depth.

Digital 4000

Temperature, pH, D.O. and specific conductance.

Notes on Hydrolab Surveyor III and IV Instruments

1. All Surveyor III units are connected to H2O transmitters and so the use of an H2O transmitter with a Surveyor III is everywhere assumed.
2. Downloading data capability from the Surveyor IV field readings is developed and on line.

Notes on Insitu Troll 9000

The Troll 9000 is connected to the Rugged Reader Display or an HP pocket PC.

Notes on Hydrolab DataSondes

Three types of DataSonde (made by Hydrolab Corp.) for continuous in situ water monitoring are in service. The majority are 2 parameter DataSonde I types with temperature and conductivity recording capabilities. Another type is the 4-parameter DataSonde I which records temperature, pH, D.O. and conductivity. The third type is a 2 parameter DataSonde III which records temperature and conductivity).

The DataSonde III has the capacity to be read in the field by a lap top computer and down loaded at the office onto the Speed II system. It also may be used as a sonde unit for a Surveyor III in place of an H2O transmitter unit.

Standard operating procedures are described in the excerpts from the operating manuals for DataSondes I and III units that follow:

13.4 Chlorine Testing

Field testing for chlorine is performed regularly onsite. The test allows a determination of the instantaneous chlorine level for the facility. The Hach Pocket Colorimeter (chlorine) is utilized.

Description of the operation.

Hach Pocket Colorimeter (DPD Method)

Fill a 10 ml cell to the 10 ml line with sample. Cap.

Note: Samples must be analyzed immediately and cannot be preserved for later analysis.

Note: Be sure the instrument is in the low range mode.

Add the contents of one DPD Total Chlorine Powder Pillow to the sample cell (the prepared sample). Cap the cell and gently shake for 20 seconds.

Note: A pink color will develop if chlorine is present.

Note: Accuracy is not affected by undissolved powder.

Note: Gently shaking the cell dissipates bubbles which may form in samples

containing dissolved gases.

Wait 3 minutes. During this period, proceed with the remaining steps.

Fill a 10 ml cell to the 10 ml line with the sample (the blank). Cap.

Remove the instrument cap.

Note: For best results, zero the instrument and read the sample under the same lighting conditions.

Place the blank in the cell holder, making sure the diamond mark faces the front of the instrument. Cover the cell with the instrument cap (flat side should face the back of the instrument). Be sure it fits tightly against the instrument.

Press: ZERO

The instrument will turn on and the display will show ---followed by 0.00.

Note: The instrument automatically shuts off after 1 minute. If this occurs, the last zero is stored in memory. Press READ to turn the instrument on and complete sample analysis.

Remove the cell from the cell holder.

Within 3 minutes after the 3 minute period, place the prepared sample in the cell holder.

Cover the cell with the instrument cap.

Press: READ

The instrument will show --- followed by the results in mg/l total chlorine.

Note: If the sample temporarily turns yellow after the reagent addition, or shows over range (flashing 2.20 in display), dilute a fresh sample and repeat the test. A slight loss of chlorine may occur because of the dilution. Multiply the result by the appropriate dilution factor. Reading is then annotated and stored in the display unit of the Hydrolab or Insitu with the corresponding field parameters at the site.

14.0 FLOW ANALYSIS

Measurement of water flow is an important tool in assessing water quality. Flow readings taken from a wide variety of situations including industry outfalls, municipal discharges, irrigation flows, and ambient stream flows help in examining such areas as pollution control, loading problems, water conservation, planning, and water allocations.

Discharge or rate of flow is defined as the volume of water that passes a particular reference section in a unit of time. The unit of discharge in general use in the irrigation practices in the west is the cubic foot per second (CFS) or second foot (sec-ft). In water supply and waste treatment, the accepted units of discharge are million gallons per day (mgd) or in some cases, gallons per minute (gpm).

All measurements used to determine flows will be recorded on lab sheets. It is essential to mark either "Estimated" or "Measured" on the lab sheet.

Flow data are generally obtained in one of five ways:

1. Figured by using fixed, open channel measuring devices i.e. weirs and flumes.
2. Continuously monitored using fixed sensors and recording devices.
3. Obtained from other agencies who have already measured the flow (such as USGS or municipal waste water treatment plants).
4. Measured in an open channel using portable measuring equipment.
5. Estimated.

14.1 Fixed Measuring Devices

Weirs

Weirs are simply obstructions built in a stream over which water flows. The weirs considered below are sharp crested weirs, that is, the edge which the water flows (the crest) is sharp edged. A properly constructed weir and a set of weir tables, will allow for an accurate flow determination. The steps are: 1. Determine the type and size of the weir, 2. Measure the height of the water backed up over the weir and 3. look the flow up in the tables. There are four basic types of weirs. They all require that the water going over them be able to fall freely to a lower level. If water below a weir is backed up enough to interfere with the water falling from the weir crest (the nappe), then the weir has become unreliable. Weirs are classified by the shape of the opening provided for water to pass through.

Rectangular Weirs Without End Contractors

This is the simplest weir and consists of a level edge from bank to bank over which the water can fall freely. A common type consists of a plate of metal inserted into a raceway or ditch. Another useable weir can be the end of a concrete raceway over which the water is able to fall free. This is the least accurate weir type.

Rectangular Weirs With End Contractors

The sides of the weir are designed to contract the flow of water to less than the channel width. As in the weir above, a plate of metal is commonly used to block the water but here a rectangular notch is cut in the top for the water to flow. A weir is created which has sides narrower than the channel width. This increases the water's velocity and turbulence which increases the aeration of the nappe. Technically a contracted weir has sides which are more than twice the distance of the maximum head from the sides of the channel. This can create a bit of a gray area between contracted and un-contracted (also called suppressed weirs) because the end contractions are "suppressed" weirs.

Cipolletti (or trapezoidal) Weirs

This weir is constructed like rectangular weirs with end contractors except that the sides of the weir incline outward at a slope of one horizontal to four vertical.

V-Notch Weirs

When flows are small, a V-notch weir permits a more accurate measurement of flow than any of the three previous weirs. A metal plate has a V-shaped notch cut into it with the sides cut to a specific angle. The most common angles are 22.5° , 45° , 60° and 90° with a few 120° in special use. It is necessary to know what the angle of the weir is to determine the flow. In cases where the angle must be determined in the field, it may be helpful to try to tilt your perspective so that the "V" becomes an "L". A proper "L" is right angled and 90° , an inclined half way would be 45° , and in between would be 60° and so forth.

Measurement

Water pooled behind a properly constructed weir will rise to a height above the weir crest which is indirect proportion to the rate of flow. This height is called the head. Since the level of water approaching the weir crest will drop as it accelerates into its fall (called a drawdown), measurement of the head should be done upstream of the weir at least four times the distance of the head. To make this possible, a staff gauge is mounted upstream with the "O" set to the elevation of the weir crest. Where the mounted staff gauge is absent, the head may be measured roughly by placing a staff gauge vertically on the weir crest, so the markings are as far upstream as possible and either sight across it to the pool upstream or read "a little high" on the mark. Though not ideal, the method will yield useable flows when the weir would be otherwise useless.

A good set of tables, such as those found in the Stevens Water Resource Data Book, is a must. Find the type of weir you have identified and look up the flow under the head feet (to 0.01') for the correct size of weir.

Flumes

Flumes are specially shaped open channel flow sections providing a restriction in area which results in an increased velocity. They are to open channels what the Venturi tube is to a pipe. The most commonly used flume, by far, is the Parshall. The Parshall flume offers several advantages over weirs. Since its velocity of flow is high, it tends to be self-cleaning and deposition of sediment or solids is practically eliminated. In addition, it can operate with a much smaller loss of head than a weir. This is a significant advantage for many irrigation and existing sewer applications where the available head is limited to the fall across the

accessible section. Another advantage is that the accuracy of the flume is not affected nearly as much as a weir by varying approach velocities. A disadvantage is that Parshall flume installations involve more expense than weir installations. The size of the flume is determined by measuring the throat width. Thus, a flume with a one foot throat is a one foot Parshall flume. The converging upstream section of the flume accelerates the entering flow which eliminates the deposition of solids that may adversely affect measurement accuracy. For free flow, the constricted throat and downwardly sloping floor causes the flow to pass through the so-called critical depth, usually near the crest of the flume. This critical depth control permits the determination of free flow discharge by a single depth measurement point, H_a , is located upstream from the throat two thirds the distance of the converging section, Figure 14.2. The discharge is found by reading the head H_a at the upstream location and determining it from a standard table.

14.2 Continuous Monitoring Devices

A continuous flow monitoring device such as the Omnidata's Datapod II is utilized to record stage heights on various streams. Both units record pressure on a sensor on the stream bed which is correlated to stage height. A discharge rating curve is generated over time by a series of actual flow measurements correlated to stage heights. This method is patterned after the USGS method.

Omni-Data Recorders

This recorder operates on the same principle as the above described unit. It is a smaller unit housed in a secured, waterproof, stainless steel box mounted to a bridge or other fixed structure. It is powered by C-cell internal batteries and the data is recorded in a (E-Prom) section of the recorder. The E-Prom is exchanged about every 6 weeks and transferred to the office and downloaded.

14.3 Cooperative Agencies Flow Data

Flow data is obtained whenever possible from existing agencies such as the United States Geological Survey, water conservative districts, water companies, and municipal wastewater treatment plants. The data from these agencies is request for the Water Year ending September 30th. Data is requested electronically whenever possible. Many DEQ sample sites correspond with USGS flow stations. Flows for WWTP's are usually requested on site. The important consideration is that the supplier be both qualified and trustworthy.

14.4 Open Channels with Portable Equipment

In this section, current instruments and common practices are described briefly.

Measuring Flow in Streams (including canals, ditches, etc)

Streams are generally waded. Measurements are recorded with a current velocity meter and a staff gauge. Measurements of depth and velocity are taken on the same vertical line at even distances across the stream in one or two foot intervals. Interval width is determined by how even and consistent the flow is across the

channel, as well as, for practical reasons, the width of the channel. A stream strewn with boulders without a uniform channel would demand closer intervals than an even channel with a sandy bottom. The .6 method is used, i.e. a single velocity measurement is taken at each position at .6 of the depth from the bottom. If the stream is fairly even in flow characteristics with a uniform channel, the velocities and depths are averaged across the transect. If the stream channel is not uniform and consistent, each subsection depth and velocity is calculated and the individual subtotals totaled. Stream width is determined with a tape measure across the transect. Flow in an even channel (CFS) = average velocity x average depth x width. CFS in uneven channels = (width x depth) section 1 + (width x depth) section 2 + so forth. Flow may be measured from a bridge using a weighted line marked in feet for the depth with the flow meter attached.

It is essential that all portable flow meters be in place long enough to get a reliable average of the velocity. Price, pigmy and the Rice electromagnetic velocity meters will be counted or observed for a minimum of 20 seconds.

The Utah DWQ SOP using the Marsh McBurney electromagnetic instrument and the .6 methods is as follows:

1. Adjust the time averaging interval with the up/down arrows until 20 seconds is displayed on the screen.
2. Measure the width of the stream leaving the tape suspended several feet above the water.
3. Beginning 6 inches from either bank, measure the depth.
4. Adjust the wading rod to the .6 tenth position.
5. Holding the rod in a steady upright position, push the START button on the meter. The movement screen will begin moving left to right measuring the 30 seconds. At the end of 20 seconds, the average velocity will appear on the screen and the display will again begin another 20 second period.
6. Record the first velocity reading, ignoring the display counting the second display period.
7. Move the wading rod 1 foot into the stream and record the depth.
8. Adjust the wading rod to the .6 tenth position.
9. Push the START button on the display. A new 20 second interval period will begin. At the end of the 20 second period, the average velocity will again appear on the screen for the immediate preceding 30 second period.
10. Record the second velocity reading, ignoring the display counting the third display period.
11. Repeat step 7-10 until you reach 6 inches from the far bank. The 6 inch reading will be your last reading
12. Add all the velocities and divide by the number of readings to get the average.
13. Add all the depths and divide by the number of readings to get the average depth.
14. Multiple the Width by the average Depth and the average Velocity to receive Cubic Feet per Second)CFS)

14.5 Pipes

Any type of circular conduit may be calculated in a unique manner. The diameter of the pipe, depth of the water and velocity (figured by the .6 or other method) is used to quickly calculate flow in CFS. Please see pages 2-1 through 2-4 of Appendix 14.3 for method of calculation and K table.

Pipes which have a low flow and some free fall may be measured using the bucket method. A bucket of known volume is allowed to fill while being timed with a stop watch.

60 seconds divided by # of seconds to fill X volume of bucket in gallons = Flow in GPM.

14.6 Portable Velocity Flow Meters

The meter currently in use is the Marsh-McBirney Flo-Mate, Model 2000 Portable Water Flometer.

Two other portable velocity meters, the Price-Type Meter and the Pygmy meter manufactured by Telydyne have historically been utilized

14.7 Estimating Flow Volumes

Flows may be estimated in situations where it may be unusually difficult or dangerous to measure the flow or is a portable meter isn't available. Estimated flows on moderately sized streams, under 100 CFS, by an experienced person is generally accurate within a 10% confidence level. The flow measurement technique is always noted on the field sheet and entered on the State computer data base as measured or estimated.

The basic idea of an estimated flow is determining width, depth, and velocity using whatever methods available. A floating stick traveling a set distance and a watch estimate velocity, a tree branch placed in the water could aid in determining depth, and a bridge could be paced to estimate the width. Site selection is critical. An uniform section of stream channel free of obstructions will increase the accuracy of the measurement. Flow estimation should be practiced on streams that are to be measured so that the estimate may be checked. Where more than one person samples a site, it is desirable to have each make an estimate as a check against making a large error.

It is critical that the field sheet is marked "Estimated" using this method.

14.8 Measuring Orifices

An orifice used as a measuring device is a well-defined, sharp-edged opening in a wall or bulkhead through which flow may occur. For true orifice flow to occur, the water surface upstream from the orifice must always be well above the top of the opening. If the upstream water surface drops below the top of the opening, the flow ceases to follow the laws of orifice discharge, and the opening performs as a weir. Usually the orifice should have a specific and standard size and shape,

and a means of measuring the head acting upon it. Orifices may be used to measure rates of flow when the size and shape of the orifices and the heads acting upon them are known, and when there is knowledge of whether the jet issuing from the orifice is discharging freely into the air or under water in submerged condition.

Orifices used for measuring irrigation water are usually either circular or rectangular in shape, and are generally placed in vertical surfaces that are perpendicular to the direction of flow. In early days of irrigation the orifices usually discharged into the air, in which case the orifices were said to be free. After weirs became more generally adopted for measuring irrigation water, free orifices were practically abandoned because their use required considerable fall and resulted in excessive loss of head.

To overcome excessive head loss, the orifices were lowered in the structures and the submerged orifice, so-called because it discharges under water, was developed. The submerged orifice conserves head and is therefore used where there is insufficient fall for a weir, and where a Parshall flume is not justified because of cost or some special field condition.

Free and submerged orifices may be either contracted or suppressed. In a contracted orifice, the perimeter of the opening is so far removed from the walls of the approach channel, or from other surfaces of a disturbing nature, that the filaments of water fully contract to form the vena contract after they pass through the orifice. A suppressed orifice is one whose perimeter partly or fully coincides with the sides of the approach channel, or with other surfaces that would eliminate or reduce contraction.

14.9 Water Stage Recorders

The major types of gauges utilized for flow measurement (instantaneous or totalizer types) will be discussed in sections to follow.

The stage of a stream, canal, or lake is the height of the water surface above an established datum. The stage, or gauge height, of the water is usually expressed in feet and hundredths of a foot. Records of stage are important in stream gauging because the rate of flow is plotted against stage in preparing discharge curves, and after a curve has been established for a stable channel, rate of flow can be directly determined from stage reading. Reliability of the stage reading is therefore of great importance. Records of gauge height may be obtained from a series of systematic readings on nonrecording gauges, or from automatic water-stage recorders. Telemetering systems may be used to transmit gauge readings from either the nonrecording or the recording gauges.

14.10 Floats and Bubble Gauges

The level of the water is sensed by a float or by a bubble gauge. The level may also be read directly from a staff gauge.

The float-type system consists of a tape or cable that passes over a pulley and has a float on one end and a counterweight on the other. The float follows the rise or fall of the water surface and the stage or level may be read from the tape and a

reference mark, or from a recorder connected to the pulley. The float usually is placed inside a stilling well to eliminate movements caused by surface waves and other transitory effects.

The bubble gauge system consists of a source of pressurized gas, a sensitive pressure control system, a tube which extends down into the water, and a manometer. The gas is fed into the tube and it bubbles freely from the open lower end which is fixed at a known level under water. The gas pressure will be essentially equal to the head of water on the tube outlet and is read on the mercury-filled manometer. The gage may be made automatic by installing a servomotor that senses the gas pressure and converts it into rotation of a shaft connected to a water-stage recorder.

14.11 Non-Recording Gauges

Two general types of nonrecording gauges are in use: (1) staff gauges, on which readings of stage are made directly, and (2) chain, wire weight, float-type, and hook gauges with which measurements are made from fixed point.

Staff gauges may be either vertical or inclined. The inclined type, especially, must be carefully graduated and accurately placed to insure correct stage readings. Most permanent gauges are enameled steel plates bolted in sections to the staff. Care must be taken to install the gauges solidly to prevent errors caused by change in elevation of the supporting structure.

A chain gauge is a substitute for the staff gauge and consists of a horizontal scale and a chain that passes over a pulley to fasten to a hanging weight. Chain gauges may be mounted on a bridge that spans the stream or overhangs it. Water stage is indicated by raising or lowering the weight until it just touches the water surface, and reading the position of the chain index mark on the horizontal scale. Chain gauges are affected by settling of the structure that supports them, changes in load on the structure, temperature changes, and changes in length as the chain links wear. Wind action may also introduce errors by blowing the weight to one side instead of allowing it to hang vertically.

The wire weight gauge is a modification of the chain gauge and uses a wire or small cable wound on a reel. The reel is graduated or a counter is used to give readings to tenths and hundredths of a foot. A check bar of known elevation is often provided so that lowering the weight onto the bar will produce a reading on the counter or reel which can be compared with the reference elevation.

14.12 Stage Recorders

Water stage recorders are instruments that produce graphic or punched paper tape recorders of water surface elevation with respect to time. Important advantages of recorders over nonrecording, attendant read, staff gauges are:

- (1) Streams with daily fluctuations, continuous records provide the most accurate means of determining the daily average gauge height.
- (2) Maximum and minimum stages are definitely recorded and the time of their occurrence can be noted.

- (3) Records can be obtained at points where observers are not always available.

Graphic Recorders

In general, graphic recorders consist of two main elements: a clock mechanism actuated by a spring, weight, or electric motor; and a gauge height element actuated by a float, cable or tape, and counter-weight. A gear reduction mechanism is usually also necessary in the height element. It is a horizontal drum recorder where the clock positions the pen along the drum axis and the gauge height element rotates the drum. In another type of recorder the drum is vertical, with the time element again operating parallel to the drum axis and the height element rotating the drum according to changes in stage. The third type of recorder also has a vertical drum, but the time and height elements have been reversed so that the clock mechanism rotates the drum, and the water stage becomes a function of displacement along the drum axis.

The above recorders are usually operated by 8-day or 30-day spring-driven clocks. Electricity could also be used if a reliable source were available nearby. The stylus, either a capillary pen or a pencil of proper hardness, must be capable of operating for the full duration without attention. To accommodate various water-stage differentials, ratios of water-stage differentials, ratios of water-stage change to recorder-chart change are procurable from 1:10 to 10:1, and must be specified at the time a recorder is ordered. In the above described recorder the standard width of recorder paper is 10 inches, and all recorders are equipped with metal ovens.

The fourth type of graphic recorder is described as follows: The time element, consisting of a compensated, balanced, weight-driven clock, drives two parallel rolls at a uniform rate and with constant tension from the supply roll to the receiving roll. Speed of travel may be adjusted from 0.3 to 9.6 inches per day on any standard instrument, and other chart speeds are available on special order. The normal chart length is 75 feet.

The float activates a pen stylus which moves parallel to the axis of the rolls so that 1 inch of travel represents a change in water stage of 1 foot. The stylus is so designed that it can be accurately set for gauge height. There is also a provision for changing the ratio of water-surface change to stylus travel to accommodate either large or small ranges in depth. The range of the recorder is limited only by the length of float cable because provision is made for stylus reversal at maximum deflection. Capacity of the ink reservoir is sufficient to make a record of 60 days or more.

Digital Recorders

The digital recorder is an electrically operated paper tape punch which records 4 digit numbers on paper tape at preselected time intervals. Electrical power is usually supplied by batteries, but alternating current can also be used if it is readily and dependably available.

Water stage is transmitted to the digital recorder by rotation of the input shaft, for example, by a float and pulley arrangement. Shaft rotation is converted by the recorder into coded punch tape records. The code consists of four groups of four punches each. In each group, the first punch represents "1", the second "2", the

third "4", and the fourth "8". Thus a combination of 1, 2, or 3 appropriate punches in a given group represents digits from 1 to 9. A blank space (no punches) represents zero. The four groups of punches represent all numbers from 1 to 9,999.

Coding is done by either one or two identical disks that have raised ridges on the faces.

If three or four digit numbers are required, two disks would be used. The right hand disk is connected directly to the input shaft and the left hand disk is driven from the first disk by a 100 to 1 worm gear reducer. Thus 100 revolutions of the input shaft and first disk results in 1 revolution of the second disk. A paper tape is moved upward through the punch assembly in the center of the instrument. The punch block contains a row of 18 pins, or punches, 16 for information and 2 for feed holes. At the selected intervals of time, the punch assembly is pivoted on a shaft at the bottom so the punch, paper, and pins are moved toward the disks. Those pins that strike raised ridges on the disks are forced through the paper, punching neat round holes. The pins that do not strike ridges do not punch holes. Thus a record is made of the position of the disks, and hence, of the water stage at the specified time intervals.

At present the mechanically punched tape is considered by many as the most practical for field use where temperature, moisture, and in many cases, power conditions are widely variable. Electronic translators are used in the office to convert the tape records into suitable input for digital computers. Future developments will undoubtedly lead to more automatic systems and to greater use of telemetry.

14.13 Float Wells or Stilling Wells

A galvanized iron culvert pipe, sealed on the lower end and with openings in the side, makes an excellent well. Tongue and groove creosote lumber can also be quite satisfactory. Lumber that is not kiln dried should never be used because of its tendency to shrink and warp. Sewer pipe of suitable size may also be used. Joints must be tightly sealed with mortar. Since the primary purpose of the stilling well is to prevent oscillations of the float caused by surging water or wave action, the structure must be well anchored to prevent movements that would introduce oscillations within the well. Surges of the outside water surface can be damped out by restricting the area of the water inlet to approximately 1/1000 of the inside horizontal cross sectional area of the well. If the stilling well is offset from the channel some distance, the inlet area may have to be increased.

Though the intake pipes on most stilling wells will require occasional cleaning, especially on streams carrying sediment, a flushing tank with pump cannot be justified on any but permanent installations. The tank is filled with a hand pump, and a sudden release of the tank water will usually flush out the intake pipe. For tightly clogged pipes, and temporary or semi permanent stilling wells not equipped with a flushing tank, sewer rod or "snakes" may provide the most satisfactory means for cleaning. The use of plugged tees instead of elbows in the piping system may allow easy insertion of the cleaning rod or "snakes."

Where large stilling wells are used, the practice is to place a staff gauge in the open water outside the well and another inside. The recorder is set to correspond

with the inside gauge since it can be read more accurately. Painted gauges are not suitable because the paint rapidly disappears at the water line. Enameled iron gauges are preferred since they resist rust and will last almost indefinitely. Gauges are available in both English and metric measurement with divisions as small as hundredths of feet or cm.

14.14 Current Meters

Current meter gauging stations are permanent or semi permanent stations along a water course where flow and topographical conditions permit the establishment of a flow rating curve based upon current meter flow measurements. After the rating curve has been established the rate of flow is determined from the curve and the measured depth of flow at the station. If the channel shape at the station becomes altered, or if the effective roughness of the channel changes, a new rating curve must be prepared.

Current meter gauging stations are often preferred over other means of water measurement when large flows are to be measured and the available fall is small. They may also be desirable for sediment laden flows even though the discharges are not large. If measurements become necessary in existing streams or canals, current meter gauging stations can be set up with relatively little effort and usually without modification to the channel. In instances where flow depths are too small for current meters and the available fall is small, Parshall flumes are probably the best alternative measuring method.

Whenever practicable, current meter gauging stations should be located in straight, uniform stretches of channel having smooth banks and beds of permanent nature. This location should be far enough from turnouts, power stations, or other installations causing flow disturbances so that the relationship of discharge to gauge height will not be appreciably affected. In many channels these conditions are difficult to find the unusual care must be taken to obtain a station that will give satisfactory results. Owing to the shifting nature of some river and canal beds, frequent current meter measurements may be necessary. Sand shifts may occur frequently, often daily. To obtain the gauge discharge relationship at stations on such streams, current meter measurements may be necessary two or three times weekly, or perhaps daily if the importance of equitable water distribution justifies such action. A rating section consisting of a short lined section in a straight stretch of channel will insure a meter station of unvarying dimensions if the sediment swivelings is not serious. A gauging station above any permanent control section, such as a drop, will usually have a constant relation between the gauge height and discharge. In small streams, it may be necessary to clean the channel of rocks and debris to insure unobstructed and constant flow.

The essential features of a current meter station are a water lever gauge, a bench mark, fixed measuring points in the channel cross section, and a stay line to hold the meter in the measuring plane or cross section when the velocity is high and the water is deep. Water stages or elevations may be obtained by systematic observations of a nonrecording gauge or by a waterstage recorder. The types of gauges most commonly used in measurement of irrigation water are the graduated enameled vertical staff gauge, the hook gauge, and the float gauge. Float gauges are often connected to automatic water stage recorders that produce charts of the water surface variations against time. The benchmark should be conveniently and permanently located, and the elevation of the datum of the gauge should be

carefully referenced to it.

The measuring points should be located in a cross section taken at right angles to the stream flow. Where the channel is shallow enough to permit wading measurements, or where cableway measurements are taken, a tagged wire should be used to establish the measuring points. When measurements are made from a bridge, permanent measuring points should be established upon the bridge. The measuring points should be permanently marked at equal intervals of from 2 to 10 feet, depending upon the size of the stream or canal. If the stream velocity is high, or if the structure from which the measurements are being made is far above the water, it may be desirable to stretch a stayline cable across the canal. The cable carries a traveling pulley that is fitted with a swivel pulley. The stayline runs from the operator, through the swiveling pulley on the stay-line cable, and down to the meter hanger. The stay line cable should be placed parallel to the measuring section and far enough so that the slope of the stay line with the water surface is less than 30° .

Streamlined weights with large tail fins, commonly called Columbus or C-type weights are used to carry the meter straight down into the flow and help hold it to the desired position when measurements are being made from a bridge or cableway. Weights are available in 15, 30, 50, 75, 100, 150, 200, 300 and 500 pound sizes. Usually weights of 75 pounds or less are adequate for canal and small stream measurements. To handle the relatively heavy current meter and weight assembly, the type A portable crane is used. This crane is mounted on three wheels designed to hold the current meter and weight in a balanced position while moving between measuring points. For stream measurement the crane is tilted to lean against the bridge rail so the boom supports the meter and weight clear of the bridge. The meter is raised and lowered by a crank and cable reel on the frame. The crane may be folded into a compact unit for ease in transportation.

A modified cableway device is used extensively on such projects as the Bureau of Reclamation's Gila project in Arizona to position current meters across canals. The head tower with the operating mechanism for the cableway and the tail tower on the opposite bank may be fixed installations, or vehicles may be used as anchors on each side of the canal. A counter is provided on the head tower reel that positions the traveling block and on the reel that raises and lowers the meter. The entire installation is relatively inexpensive and permits stream gauging to be done safely and easily from the bank.

A carriage and track system is devised by the Bureau's Yakima project personnel to handle current meters with heavy weights when working from bridges.

The standard reel and counter assembly is mounted on a carriage supported by ball bearing rollers that run on a 2 by 6 inch timber track permanently mounted on the bridge rail. This equipment allows the operator freedom of movement with great safety, facilitates obtaining accurate stream gauging data, and is easily portable from one station to another.

The essential features of conventional current meters are a wheel which rotates when immersed in flowing water and a device for determining the number of revolutions of the wheel. The relations between the velocity of the water and number of revolutions of the wheel per unit of time for various velocities are determined for each instrument by experiment at the U.S. Bureau of Standards at Washington, D.C., and are supplied in the form of an equation from which rating

table is compiled. A sample rating table for a meter with the equation $V=2.14N+0.03$ for N values less than 1.00 revolution per second, and equation $V=2.19N-0.01$ for N values greater than 1.00 revolution per second. In these equations, V is the velocity in feet per second. Each meter is calibrated for the types of suspensions with which it may be used. Two principal types of suspensions are wading rod and cables. Since its accuracy is greatly affected by dirt or injury, the instrument should be rated at least once a year and more often if inaccuracy is suspected.

Price Type Meters

Conventional meters are of two general types - the propeller type with horizontal axis, and the cup type with vertical axis. The Price meter, a cup type instrument with a vertical axis, was developed by the U.S. Geological Survey and was adopted by the Bureau of Reclamation for irrigation water measurement. This meter has the following general features: vanes to keep the wheel headed into the current, either a cable or a rod for handling the meter, weights for sinking the meter when it is suspended on a cable, an electric device for signaling the number of revolutions, and connections from the current meter to a 1 1/2-volt battery-powered headphone.

Two standard Price type meters are in general use today. These are the type AA meter with the Columbas type wrights or a wading rod, and the type BTA meter. (The pygmy meter, discussed in the following subsection, is also a modification of the standard Price meter.) The BTA meter has the same pivot, hub assembly, and shaft as the type AA meter, which alleviates maintaining two sets of repair parts. The parts for types AA and BTA meters are interchangeable except for the yoke and the contact chamber. Two sets of revolution indicating contacts are provided in the type AA and type BTA meters; one is for indicating each revolution of the bucket wheel, and the other for indicating every five revolutions. The electrical cable should be connected to the counter most appropriate for the anticipated bucket wheel speeds.

An improved contact chamber has been developed by the U.S. Geological Survey to replace the wiper contact of the type AA meter. The new chamber contains a magnetic switch that is hermetically sealed in a hydrogen atmosphere within a glass enclosure. The switch assembly attaches rigidly to the top of the meter head just above the tip of the shaft. The switch is operated by a small permanent magnet fastened to and balanced with the shaft. The switch quickly closes when the magnet is aligned with it, and promptly opens when the magnet moves away. On count per revolution is obtained.

The magnetic switch can be used on any type AA meter by replacing the shaft and the contact chamber. The rating of the meter is not altered by the change. Headphones must not be used with the new switch because arcing may weld the switch contacts. Instead, an automatic counter should be used.

Pygmy Meters

Pygmy meters are similar to Price meters in that both contain a cup-type bucket wheel mounted on a vertical shaft. The pygmy bucket wheel is 2 inches in diameter, compared with 5 inches for the conventional Price meters. The contact chamber is an integral part of the yoke, and contains a single-revolution contact only. There is no tailpiece, and no provision is made for cable suspension. The

rotational speed of the pygmy meter bucket wheel is more than twice that of the Price meters, and consequently use of the pygmy meter is limited to velocities up to 3 or 4 feet per second.

The pygmy meter was specially designed for use in shallow streams. The smaller meter was necessary because a standard Price meter does not perform with sufficient accuracy when it occupies a good share of the available stream depth. The pygmy meter may also be used in large canals where the velocity of flow is low, or near the edges of a canal to supplement data taken farther out in the channel with a Price meter.

Care of Current Meters

Current meters must receive the best of care during transportation and use to insure accurate measurements. Particular care should be taken when working near bridge piers and abutments, around floating drift or ice, and when measurements are being taken at irregular or unknown sections and the meter is suspended on a measuring line. If the cups or blades become bent or damaged, the results obtained from the rating curve for the meter will be unreliable. After completing the measurements at a rating station, the meter should be carefully cleaned, and after each day's use it should be properly lubricated.

Meter damage has occurred because of improper packing and careless handling in transportation. Meters should be transported in substantial wooden or other rigid cases with properly fitted interior supports to prevent movement and damage to the delicate parts.

General Procedures and Precautions

Accuracy of measurement may be maintained by observing the following precautions for Price meters (including the pygmy meter modification):

- (1) The conditions of the bearings may be checked in the field by a spin test. With the shaft in a vertical position and the cups protected from air currents, the cups should be given a quick turn to start them spinning. If the meter is in proper adjustment and the bearings are free from foreign particles, the cups should come to rest in not less than 3 minutes. If the length of spin is only about 1 1/2 minutes but the bucket wheel comes to rest gradually, all flows except those of very low velocities may be measured. If the length of spin is only about 1 minute but the bucket wheel comes to rest gradually, the meter may still be used to measure velocities above 1 foot per second. If the length of spin is less than 1 minute, the meter should be reconditioned. Under laboratory controlled conditions, rotation should continue for about 4 minutes. The manner in which rotation ceases should be observed because it helps indicate the condition of the meter.
- (2) The cross section of the stream should be divided vertically into 20 or more parts. Very small streams are exceptions and somewhat smaller number of segments of the stream cross section may be sufficient if the distance between vertical becomes less than 1 foot. The divisions are generally selected so that there will be not more than 10 percent, and preferably not more than 5 percent, of the discharge between any two adjacent vertical.
- (3) The stopwatch should be checked frequently and kept in good repair.

- (4) For low and irregular velocities the period of observation should be lengthened to obtain a more accurate average count.
- (5) The meter should be spin tested again after completing the measurements to insure that no damage has occurred.

Determining Flows

Method of Measurement. Depth sounding, either with a meter and rod assembly or with a special sounding line and weight, should first be made at each special sounding line and weight, should first be made at each of the permanent measuring points. These depths should be properly recorded. Next, the mean velocity at each of the measuring points should be determined with the current meter by one of the methods listed in the following section. The velocity measurements should be properly recorded.

Methods of Determining Mean Velocities. The following methods are used to determine mean velocities in a vertical line with a current meter:

- (1) Two point method.
- (2) Six tenths, depth method.
- (3) Vertical Velocity-curve method.
- (4) Subsurface method.
- (5) Integration method.
- (6) Two tenths method.
- (7) Three point methods.
- (8) One point continuous method.

The two point method consists of measuring the velocity at 0.2 and then at 0.8 of the depth from the water surface, and using the average of the two measurements. The accuracy obtainable with this method is high and its use is recommended. The method should not be used where the depth is less than 2 feet.

The six tenths depth method consists of measuring the velocity at 0.6 of the depth from the water surface, and is generally used for shallow flows where the two point method is not applicable. The method gives fairly satisfactory results.

The vertical velocity curve method consists of measuring the velocities at equal vertical intervals of 0.5 foot or more and calculating their arithmetical mean, or finding the mean value from a curve obtained by plotting the measurements on cross section paper. The method is very accurate, but is time consuming and costly.

The subsurface method involves measuring the velocity near the water surface and then multiplying it by a coefficient ranging from 0.85 to 0.95, depending on the depth of water, the velocity, and the nature of the stream or canal bed. The difficulty of determining the exact coefficient limits the usefulness and accuracy of this method.

The integration method is performed by observing the velocity along a vertical line by slowly and uniformly lowering and raising the meter throughout the range of water depth two or more times. The method is not accurate and should be used only from comparisons or quick rough checks.

The two tenths, three point, and one point continuous methods are special

procedures based on a relationship previously established for the section between the true discharge and the velocities observed by these methods. These methods are generally reliable for sections which undergo no serious changes because of erosion, sedimentation, or other deformation. They are discussed in detail in the U.S. Geological Survey papers previously referred to (1) (2). Of the methods cited in this section, the two point method and the six tenths depth method are most used in canal work.

Formulas for Computing Discharge. Two methods for computing discharges from measurements made by current meters are approved; namely, the midsection method and Simpson's parabolic rule. Both are based on the summation of discharges of elementary areas.

In the midsection method the depth and mean velocity are measured for each of a number of vertical along the cross section. The depth at each vertical is applied to a sectional width which extends halfway to the preceding vertical and halfway to the following vertical to develop a cross-sectional area. The product of the mean velocity at a vertical and the corresponding cross-sectional area gives the discharge for the elementary area. A summation of all elementary discharges gives the total discharge. If the two-point method of determining mean velocities is used, the formula for computing the discharge of an elementary area by the midsection method is:

$$q = \frac{V_1 + V_2}{2} \times \frac{(L_2 - L_1) + (L_3 - L_2)}{2} \times d_2$$

where:

L_1, L_2 and L_3	=	distances in feet from the initial point, for any three consecutive vertical,
d_2	=	water depth in feet at vertical L_2 .
V_1 and V_2	=	velocities in feet per second at 0.2 and 0.8 of the water depth, respectively, at vertical L_2 , and
q	=	discharge in second-feet through section of average depth d_2 .

The midsection method is well suited to computing discharges in canals that conform in cross section to their original trapezoidal or rectangular dimensions.

Typical discharge computations are obtained by the midsection method formula.

Velocities were taken from the current-meter rating table of figure 52.

In Simpson's parabolic rule method, the discharge is computed for consecutive pairs of elementary areas on the assumption that the mean velocities and the water depths for three consecutive vertical lie on the area of a parabola. The formula for computing the discharge for each pair of elementary areas is:

$$q' = \frac{V_a + 4V_b + V_c}{3} \times \frac{a + 4b + c}{3} \times L$$

where:

$a, b,$ and c	=	the water depths in feet at three consecutive vertical,
$V_a, V_b,$ and V_c	=	the respective mean velocities in feet per second at these vertical,
L	=	the distance in feet between the consecutive vertical, and
q'	=	the discharge in second-feet for the pair of elementary areas.

Simpson's parabolic rule method is particularly applicable to river channels and old canals that have cross sections conforming in a general way to the arc of a parabola or to a series of arcs of different parabolas.

14.15 Other Open Channel Measurements

These measurements involve a wide variety of devices and methods. No attempt

will be made to explain them, but they will be listed with a reference for interested persons. The list includes floats, Pitot tubes, salt velocity and solution methods, color velocity and dilution methods, radio isotope methods, acoustic flow meters, slope area methods, computation of discharge over dams, meter gates, deflection meters, weir sticks, and propeller meters.

15.0 CHAIN OF CUSTODY

Sample custody is part of any good laboratory or field operation. Enforcement sampling is performed by qualified personnel of the Division of Water Quality. Sampling that may involve litigation must be done using chain of custody procedures that ensure sample integrity from the time the sample is taken until results are reported.

15.1 Procedures

The objective for chain of custody procedures is to provide legally defensible sampling results. This is accomplished through physical control of the sample, and sealed sample containers. Tags are no longer required by EPA. The steps outlined below must be followed.

Label Bottle

- a. Storet Number
- b. Site Description
- c. Date
- d. Time
- e. Sampler

Sampling

- a. Seal immediately after sampling, secure seal (Figure 15.1) that contains the following information in permanent ink.
 - 1) Sample No.
 - 2) Date
 - 3) Collector Signature

Chain of Custody Form

- a. Sample number and/or STORET number unique to the sampling site
- b. Time of collection on a 24 hour clock
- c. Date of collection
- d. Site Description
- e. Type of sample container (chemical, BOD, nutrient, etc.).
- f. Preservative.
- g. Name of person sampling, and signature for enforcement samples.
- h. Witness name, and signature for enforcement samples.

Chain of custody seals are checked out from the Division and are tracked in a logbook. When a monitor takes seals, he/she must sign them out in the logbook and check in any unused seals.

1. A chain of Custody Form will be filled out on site for routine samples. The information recorded includes the date, time, location, STORET number, Parameter bottle type and bottle number. The sample is packed in ice in a shipping container and sealed for delivery to the laboratory. When samples are transferred via common carrier, names of the shipper, receiver, and at least the initials of the transportation company's representative should appear on the shipping bill. Litigation samples are also individually sealed, and tagged with the chain of custody tag which includes the above information plus the custody transfer record.
2. After labeling, the samples will be placed:
 - a. Where they are in a person's actual physical possession, or
 - b. In view after being in a person's actual physical possession, or
 - c. Located or sealed in a tamper-proof storage area until shipped or delivered to the laboratory.
3. The samples will be properly packed in a shipping container and sealed for delivery to the laboratory where the custody transfer will be made. When samples are transferred via common carrier, names of shipper, receiver, and at least the initials of the transportation company's receiver must appear on the shipping bill. Both shipper's and receiver's copies of the shipping bill will be retained in a safe place as part of the chain-of-custody evidence.

The smallest number of persons shall handle the sample. Each change of possession must be documented on the chain of custody tag. This documentation is in the form of the transferee signing, dating and recording the time of transfer. Signatures are also required from the individual assuming the custody of the sample. This procedure is necessary each time a change in custody is made.

Chain of Custody Form:

Figure 15.2 Chain of Custody Record

Field to LAB Custody OR Legal Custody

CHAIN OF CUSTODY RECORD

Project #		Project Name				Cost Code		State of Utah Department of Health Utah Public Health Laboratory 46 North Medical Drive Salt Lake City, UT 84017 Telephone: (801)584-8400 FAX: (801)584-8586									
Sampler Name						Sampler Signature											
Data Owner (Person to Address Report / Questions To)																	
Agency:																	
Mailing Address:																	
City, St, Zip:				Phone													
DoH LAB USE ONLY																	
						Tampers Evident Seal Intact (Y or N)		Comments		LAB Sample Number							
Field ID#	Date Sample	Time (M)	Type	Depth	Location												

Use this space for comments:

IMPORTANT Use signatures below this point

Dispatched BY:	Date	Time	Courier company Name	Invoice / Airbill #	
Relinquished By:	Date	Time	Received By:	Date	Time
Relinquished to LAB by:	Date	Time	Received for LAB By:	Date	Time

15.2 Definitions

1. Sample Custodian: The laboratory chain of custody officer is the Chief of the Laboratory Improvement Section, or his designated alternates; the Quality Assurance Microbiologist and the Quality Assurance Chemist. If unavailable, samples can be received by the Environmental Monitoring Section.
2. Sample Storage Area: Samples are processed immediately, but should temporary holding be necessary, samples will be locked in the walk-in refrigerator in room 235 of the State Health Lab.
3. Transferor: Any officially designated custodian of official samples who relinquishes those samples to a receiver.
4. Receiver: Any officially designated custodian that is given possession of official samples.

15.3 Laboratory Custody Procedures

1. Samples shall be received by the sample custodian or his/her alternate.
2. The samples will be accepted if they are determined to be satisfactory. The receiver and transferor will date and sign the custody record.
3. The Chain of Custody form will be completed for those samples received.
4. Laboratory analysis will be done immediately by the analysts designated by the custodian and/or the alternate.
5. Standard methods of laboratory analyses shall be used as described in the laboratory Quality Assurance Project Plan.
6. Testing will be followed to completion by the analyst designated by custodian or alternate in the presence of a witness.
7. Results will be recorded on the report form and entered in the laboratory information management system.
8. Results will be interpreted by the analyst and verified by the laboratory reviewer.
9. When testing is completed, all identifying seals, notes, worksheets, Chain of Custody forms, report forms and information pertaining to the samples are returned to the laboratory quality assurance officer.

15.4 Chain of Custody Seal

<p>UTAH STATE DEPARTMENT OF ENVIRONMENTAL QUALITY SAMPLE SEAL</p>		SAMPLE NO. _____ DATE _____ COLLECTED BY _____ (Signature)
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16.0 Data Processing and Reduction

The Division of Water Quality (DWQ) currently processes data on an Oracle platform with STORET as the primary data warehouse. Several supporting tables and custom reporting functions have been built to accommodate unique DWQ requirements. The monitoring section provides interpretation and summaries of data for the Division with comparisons to water quality standards as well as trend data throughout the State. The software has also been programmed to download data into formats acceptable for import into other software (e.g. SAS, QUATRO, Excel, etc.) for use by Division personnel and other agencies.

16.1 Data Selection and Data Gathering

Data processing begins with sampling requests from various division sections. The annual monitoring guide is produced to keep track of each program's sampling requests. Monitoring runs are built that include all stations where multiple visits per year are requested based upon the guide. Monitoring runs are organized by major hydro basin and/or geographical areas. The objective of this strategy is to fulfill all sampling requests in a given area of the State on a monitoring run. Annual or special sampling requests are handled on a case by case basis.

The requested sites, their associated project, parameter request, and any comments are entered into custom software designed and developed by the Utah DEQ. The contents of this file essentially represent the site analysis plan. Monitoring runs are built from these site specific analysis requests. The runs are logically organized so that sites are visited in the most efficient use of time and resources.

16.2 Field Data Collection Processing and Reduction

All water quality data is processed using a design similar to field data. Figure 16.1 shows the processing steps for field data. Figure 16.2 shows the general steps of data processing. Field data is collected electronically by hand entering site and sample information into field instrumentation.

Figure 16.1 Field data example of Data processing flow chart.

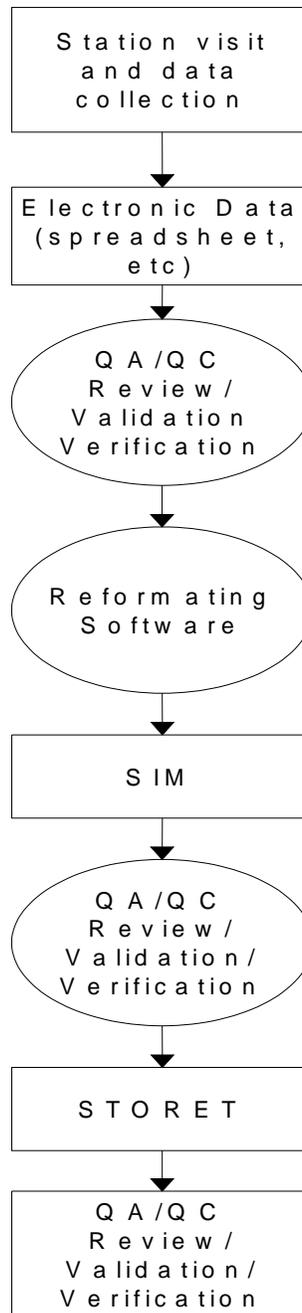
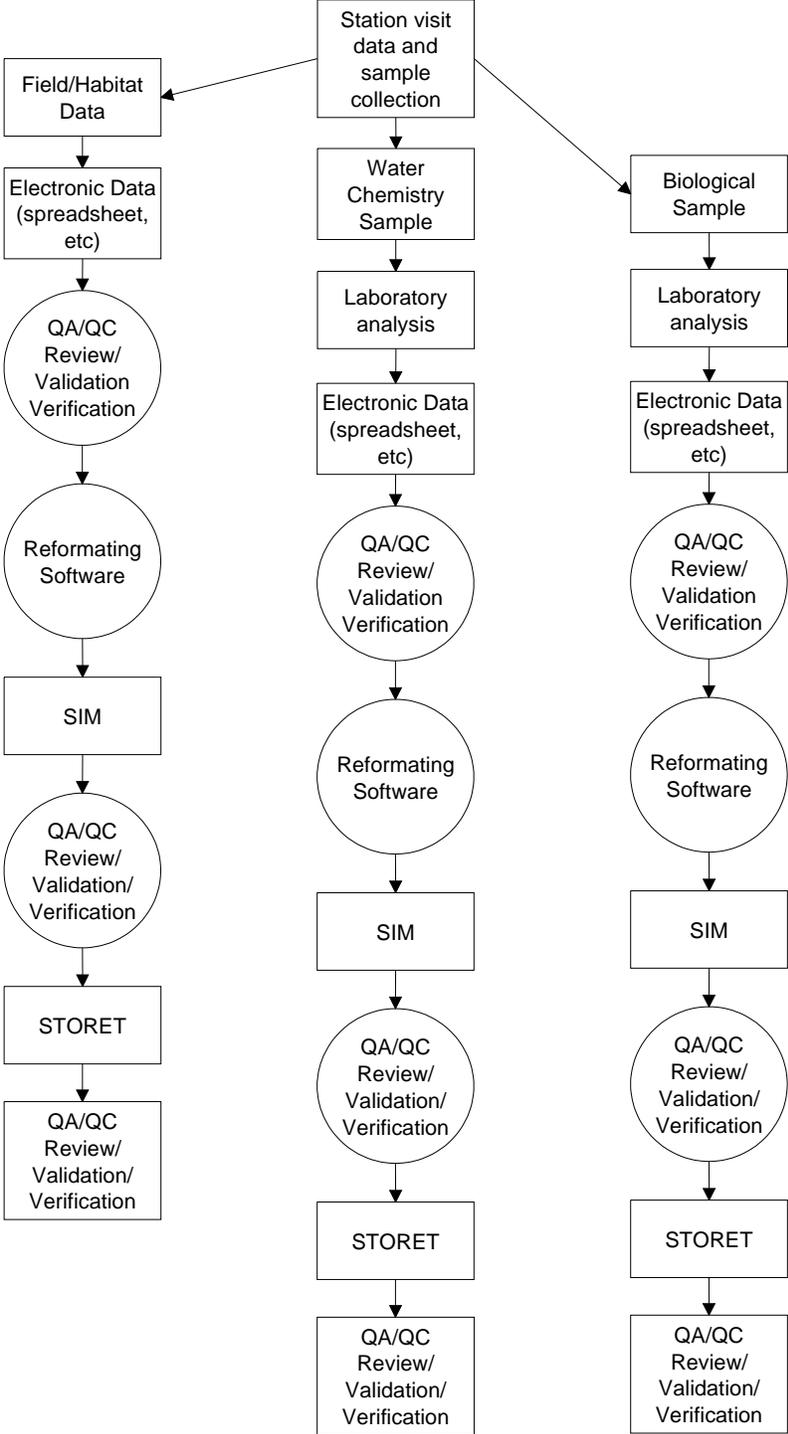


Figure 16.2 Data Processing design.



Standard Operating Procedure Collection of Field Data From Streams with a Hydrolab

Standard Operating Procedure For the collection of Field Measurements and Observations at all Sites other than Lakes Using a Hydrolab Surveyor 3 or 4a

1. Before leaving for the sampling trip, all data from last trip has been downloaded and erased from the hydrolab units going to the field. Make sure the instrument has been calibrated before using. See Section 13.1.2
2. The surveyor 4: create **one** file using the trip id for the file name. Create the file by selecting files from the initial screen menu. Select create from the next menu. Chose the corresponding alpha and numeric characters that represent the trip ID. Select DONE from when finished. Select DONE again. Do not change the default settings for the file. For the surveyor 3, use the manual file for all data storage.
3. Arriving at the sampling location, determine the flow measurement, residual chlorine value, and make weather and field observations.
- 4a. The surveyor 4: annotate with data about the station visit by selecting FILE from the main menu. Select ANNOTATE from the next menu. Surveyor 3: press the ANNOTATE button. Annotate by entering the appropriate alpha and numeric characters as follows: ,storet number,program code,sample type,organization code,weather code,weather code,weather code,weather code,weather code,field condition,field condition,field condition,field condition,samplers comments in free form text,
PLEASE NOTE: there are no spaces before or after commas.
- 4b STORE this annotation.
- 5a. ANNOTATE the hydrolab again (this time with station data) following the same procedure. The annotation consists of a ,Flow Value, Flow units,Flow Measurement type,Velocity in ft/sec,Velocity Measurement type,Chlorine Residual,. The annotation should look like: ,flow value,units,type,velocity,type,chlorine residual,
PLEASE NOTE: there are no spaces before or after commas.

Do this for **all sites** except blanks

In particular do this for:

Sample type	Code
Grab	04
8 hr composite	08
24 hr composite	09
No flows	10
No access	11
Duplicates:	04
Field data only	20

- 5b. STORE this annotation.
6. Make a mental note that DO and other parameters are stable and appear appropriate.
7. Store data under the manual file in the surveyor 3, or the only file in the surveyor 4 by pressing the STORE selection from the menu. The Surveyor 4 requires you to reaffirm the appropriate file by selecting the file.

8. Wait a few moments as necessary for the screen to return to original values. Wait another few moments for the instrument to finish storing the data.
9. Collect the appropriate water samples according to DWQ SOP/s for the type of sample you are collecting.
10. When finished with the monitoring run download the instrument using Hyperlink software.

Standard Operating Procedure Collection of Field Data From Lakes with a Hydrolab

Standard Operating Procedure For the collection of Field Measurements and Observations at Lakes Using a Hydrolab Surveyor 3 or 4a

1. Before leaving for the sampling trip, make sure all data from the last trip has been downloaded and erased from the hydrolab units going to the field. Make sure the instrument has been calibrated before using. See Section 13.1.2.
2. Surveyor 4: create **one** file with the using the trip id for the file name. Create the file by selecting files from the initial screen menu. Select CREATE from the next menu. Chose the corresponding alpha and numeric characters that represent the trip ID. Select DONE from when finished. Select DONE again. Do not change the default settings for the file. Surveyor 3: use the manual file for all data storage.
3. After arriving at the sampling location, collect secchi measurement along with weather and field observations.
4. Surveyor 4: annotate with data about the station visit by selecting FILE from the main menu. Select ANNOTATE from the next menu. Surveyor 3: press the ANNOTATE button. Annotate by entering the appropriate alpha and numeric characters as follows for lakes:
,storet number,program code,21,orginization code,weather code,weather code,weather code,weather code,weather code,field condition,field condition,field condition,field condition,samplers comments in free form text. PLEASE NOTE: no spaces before or after commas. Press the STORE button
- 4b. Store this annotation
- 5a. Annotate again (this time with station data) following the same procedure, but the actual annotation consists of the secchi depth. The annotation should look like:
,”Secchi Value”, press the store button
- PLEASE NOTE: there are no spaces before or after commas.
- 5b. STORE this annotation.
6. Do a lake profile. Starting with step 7.
7. Make a mental note that DO, Depth, and other parameters are stable and appear appropriate.
8. Store data under the manual file in the surveyor 3, or the only file in the surveyor 4 by pressing the STORE selection from the menu. The surveyor 4 requires you to reaffirm the appropriate file by selecting the file.
9. Wait a few moments as necessary for the surveyor’s screen to return to original values. Wait another few moments for the hydrolab to finish storing the data.
10. Lower the sonde 1 meter and return to step 7.
11. Repeat 7 through 10 until the bottom is reached.
11. Collect the appropriate water samples according to the DWQ SOP’s for collection of lake samples.

12. Annotate the instrument by following the above procedures at the depths where the instrument readings were observed using the depths in the profile files. The annotation should look as follows if four depths were sampled. ,”depth of 21”,”depth of 23”,”depth of 27”,”depth of 29”,
If only two depths were sampled the annotation should look as follows.
,”depth of 21”,”depth of 29,

13. When finished with the monitoring run download the instrument using the hyperlink software according to the following flow chart.

Downloading Hydrolab Surveyor 3 and Data Sonde 3
Field Data to the DWQ Database

File Download

Double click on Hyperterminal shortcut
↓
Connect computer to surveyor unit
↓
Spacebar for menu
↓
Logging
↓
Dump
↓
Powerdown Probes (Y,N)
↓
Select File
↓
Spreadsheet Importable
↓
F
↓
Transfer
↓
Receive File
↓
c:\hydrolab
↓
Receive
↓
give file a name
↓
Return

File Transfer

Double click on PC Anywhere icon
↓
click on DEQ icon
↓
user ID and password
↓
Return
↓
Load file transfer (4th button on top)
↓
hydrolab file
↓
click on up arrow (subdirectory)
↓
Monitors
↓
highlight file
↓
arrow to F drive
↓
send
↓
OK

When the data is dumped from the instrument, the lake file as a comma separated variable file in note pad will look like this:

```
"Annotation at 051200 123731 : ,492516,848,04,01,10,,,,01,,,,It was windy and cold,
"Annotation at 051200 123821 : ,2,2,
051100,123855,,,,12.74,,,,6.92,,,,688.7,,,,.35,,,,101.8,,,,9.22,,,,0.1,,,,7.4,,,,619.1,,,,
051100,123948,,,,12.48,,,,6.77,,,,689.4,,,,.36,,,,105.3,,,,9.59,,,,9,,,,7.4,,,,618.8,,,,
051100,124038,,,,12.35,,,,6.65,,,,689.2,,,,.36,,,,102.4,,,,9.35,,,,2,,,,7.4,,,,619,,,,
051100,124200,,,,12.23,,,,6.52,,,,689.4,,,,.36,,,,101.2,,,,9.27,,,,3,,,,7.4,,,,618.9,,,,
051100,124224,,,,12.22,,,,6.49,,,,689.7,,,,.36,,,,104,,,,9.53,,,,4,,,,7.4,,,,618.8,,,,
051100,124246,,,,12.16,,,,6.46,,,,689.5,,,,.36,,,,103.4,,,,9.48,,,,5,,,,7.4,,,,618.9,,,,
051100,124307,,,,12.08,,,,6.42,,,,689.9,,,,.36,,,,103.9,,,,9.55,,,,6,,,,7.4,,,,618.8,,,,
051100,124400,,,,10.72,,,,5.64,,,,696.1,,,,.36,,,,91.2,,,,8.64,,,,6.9,,,,7.4,,,,617.6,,,,
051100,124431,,,,10.01,,,,5.17,,,,697.6,,,,.36,,,,92.6,,,,8.93,,,,8,,,,7.4,,,,617.6,,,,
051100,124515,,,,9.2,,,,4.47,,,,699.1,,,,.36,,,,84,,,,8.27,,,,8.9,,,,7.4,,,,618.8,,,,
051100,124543,,,,8.4,,,,3.97,,,,699.5,,,,.36,,,,80.5,,,,8.01,,,,10.1,,,,7.4,,,,618.7,,,,
051100,124639,,,,7.26,,,,2.83,,,,703.2,,,,.36,,,,76.8,,,,7.91,,,,11.1,,,,7.4,,,,618.8,,,,
051100,124717,,,,6.5,,,,2.09,,,,706.8,,,,.36,,,,74.6,,,,7.83,,,,12.0,,,,7.4,,,,618.1,,,,
051100,125012,,,,6.1,,,,.57,,,,708.3,,,,.37,,,,71.9,,,,7.56,,,,13.8,,,,7.4,,,,618.9,,,,
051100,125033,,,,5.65,,,,.3,,,,708.8,,,,.37,,,,70.2,,,,7.53,,,,13.9,,,,7.4,,,,618.4,,,,
051100,125102,,,,5.24,,,,0,,,,712,,,,.37,,,,68.8,,,,7.46,,,,15,,,,7.4,,,,617.7,,,,
051100,125133,,,,5.13,,,,0,,,,711.9,,,,.37,,,,67.1,,,,7.28,,,,17,,,,7.4,,,,617.5,,,,
051100,125227,,,,4.92,,,,0,,,,714.9,,,,.37,,,,67.8,,,,7.41,,,,18.1,,,,7.4,,,,618.9,,,,
051100,125302,,,,4.83,,,,0,,,,716.6,,,,.37,,,,66.1,,,,7.24,,,,19.1,,,,7.4,,,,617.7,,,,
051100,125329,,,,4.72,,,,0,,,,718.8,,,,.37,,,,65.7,,,,7.22,,,,20.2,,,,7.4,,,,618.9,,,,
051100,125409,,,,4.71,,,,0,,,,719.8,,,,.37,,,,64.2,,,,7.06,,,,21.9,,,,7.4,,,,618.7,,,,
051100,125438,,,,4.53,,,,0,,,,723.8,,,,.37,,,,62.8,,,,6.94,,,,23.1,,,,7.4,,,,619.1,,,,
051100,125514,,,,4.5,,,,0,,,,25.3,,,,.37,,,,60.4,,,,6.67,,,,24,,,,7.4,,,,617.9,,,,
051100,125547,,,,4.44,,,,0,,,,727.6,,,,.38,,,,58.3,,,,6.45,,,,25.0,,,,.4,,,,619.2,,,,
051100,125618,,,,4.43,,,,0,,,,727.9,,,,.38,,,,58.6,,,,6.48,,,,26.1,,,,7.4,,,,618.6,,,,
051100,125645,,,,4.39,,,,0,,,,729.5,,,,.38,,,,57.7,,,,6.39,,,,27.1,,,,7.4,,,,619.2,,,,
051100,125727,,,,4.32,,,,0,,,,732.7,,,,.38,,,,54.6,,,,6.06,,,,28,,,,7.4,,,,619.3,,,,
051100,125758,,,,4.26,,,,0,,,,735.2,,,,.38,,,,52.3,,,,5.82,,,,29.2,,,,7.4,,,,618.5,,,,
051100,135826,,,,4.16,,,,.24,,,,743,,,,.38,,,,47.8,,,,5.3,,,,31,,,,7.4,,,,617.2,,,,
051100,135911,,,,4.01,,,,0,,,,752,,,,.39,,,,43.5,,,,4.87,,,,32.1,,,,7.4,,,,615.8,,,,
051100,135945,,,,3.97,,,,0,,,,753,,,,.39,,,,42,,,,4.7,,,,34.1,,,,7.4,,,,617.4,,,,
051100,140024,,,,3.96,,,,0,,,,754,,,,.39,,,,40.4,,,,4.53,,,,34.1,,,,7.4,,,,617.4,,,,
051100,140042,,,,3.96,,,,0,,,,754,,,,.39,,,,40.1,,,,4.5,,,,35.1,,,,7.4,,,,617.5,,,,
051100,140153,,,,3.95,,,,0,,,,755,,,,.39,,,,38.3,,,,4.29,,,,36.1,,,,7.4,,,,617.4,,,,
051100,140218,,,,3.94,,,,0,,,,755,,,,.39,,,,38.1,,,,4.27,,,,37.1,,,,7.4,,,,615.5,,,,
051100,140353,,,,4.02,,,,0,,,,752,,,,.39,,,,1.3,,,,.14,,,,37.7,,,,7.4,,,,616.7,,,,
"Annotation at 051200 123821 : ,0.1,12.0,25.0,37.7,
```

The codes refer to the following

```
"Annotation at 121099 113549 : ,stationid,program code,21,organization code,weather condition,weather condition,weather condition,weather condition,field condition,field condition,field condition,field condition,samplers comments in free form text,"
```

```
"Annotation at 121099 113551 : ,secchi depth,"
```

Last Annotation is the 21, 23, 27, 29 sampling depths

16.3 Field Data Processing and Reduction

After the instrument is downloaded to a personal computer, the data is reviewed by the staff member and corrected if necessary. It is slightly modified in a form such that all the data for one sample is on one line. Data is run through DWQ

reformatting software (called Hydrolab reformat) that reformats the data so that only one field measurement or observation is on each line. The reformatting software is interactive and requires providing a “trip id”, sampler identification, and appropriate time zone. The software also interprets the codes in the original file and replaces them with appropriate verbiage default values or other data necessary for data transfer to the STORET interface module (SIM). The data from the entire trip is loaded into SIM and the SIM software compares the elements in the file to valid data elements in the STORET tables. The SIM software also checks the elements for referential integrity. If all the rows in the file do not contain any errors, the data is migrated to STORET. The quality assurance processes indicated in Figure 16.1 are discussed in Section 17.

16.4 Water Chemistry Data Processing and Reduction

Sample data processing begins with entering appropriate information on a preprogrammed field sheet (Fig. 12.1) and the electronic field instrument (Sec 16.1). This is done by field personnel during sample collection. The field sheets accompany samples to the laboratory. Each sample or set of samples is given an identification number and parameter request. A set of samples such as chemical, nutrient, and metals bottles collected at the same location, date, and time by a sampler is considered as a single sample and each sample bottle receives the same identification number. A "master environmental chemistry log" of samples checked into the laboratory for analyses is generated to help track samples.

Data processing at the laboratory is summarized in Section 11 of the Division of Epidemiology and Laboratory Services Bureau of Chemical and Environmental Services Quality Assurance Program Plan. After all the requested analyses are completed, the results are reviewed by the manager of each appropriate laboratory section and released for electronic transfer. Files are transferred via e-mail to appropriate personnel in DWQ.

The laboratory generates an electronic file of completed and reviewed samples that have not already been transferred on a bi-weekly basis. The data flow for water chemistry samples is presented in Figure 16.2. As with field data, SIM validates station id's and other sample meta-data. The software prevents migration of samples that fail validation to STORET. When all the samples are validated by SIM, the data is migrated to STORET.

Samples not designated for permanent data storage are managed in a separate file. The log of samples not stored in the permanent file are stored in a “miscellaneous” file that can be electronically searched by laboratory number, site name, or collecting agency. The data from these samples is stored on hard copy and filed by lab number.

Station descriptions are entered by division personnel directly to the STORET system before data is transferred. The station information must be on STORET to

allow entry of appropriate data.

After the chemical analytical data files have been transferred to STORET, the ambient site data is compared against appropriate acute and chronic water quality standards and violations are reported (Figure 16.3) to the Water Quality Management and TMDL Section. Utah Pollution Discharge Elimination System site data is reported to the responsible Permitting Section by a compliance letter (Figure 16.4) for review. The compliance is reviewed by the specific permit staff, and sent to the permittee. The letter states “ DWQ monitored your discharge on a particular date and these are the results”. Action by the Permit Section for exceedances or violations of the permits limitations may be initiated.

Department of Environmental Quality Division of Water Quality Acute Water Quality Standards Compliance Report For Selected Stations for the Period of 6/1/1992 through 9/1/1992 3/10/2006						
Station Id:		4926350	Station Visit Date:		6/9/1992	
Station Name:		CHALK CK AT US189 XING	Sample Type:		4	
Sample Source:		River/Stream	Water Temperature:		11.3 deg C	
Flow:		38 cfs	Hardness Value:			
Ph Value:		7.8 None				
Depth to Activity:						
Use	Characteristic	Results	Standard		Detect/Quant Limits	
			Min.	Max.		
2B	Phosphorus as P	mg/l Total 0.19		0.05		
3A	Phosphorus as P	mg/l Total 0.19		0.05		
<hr/>						
Station Id:		4926350	Station Visit Date:		6/24/1992	
Station Name:		CHALK CK AT US189 XING	Sample Type:		4	
Sample Source:		River/Stream	Water Temperature:		15.7 deg C	
Flow:		20 cfs	Hardness Value:		293.2 mg/l	
Ph Value:		7.7 None				
Depth to Activity:						
<hr/>						
Station Id:		4926350	Station Visit Date:		7/14/1992	
Station Name:		CHALK CK AT US189 XING	Sample Type:		4	
Sample Source:		River/Stream	Water Temperature:		11.9 deg C	
Flow:		18 cfs	Hardness Value:			
Ph Value:		7.7 None				
Depth to Activity:						
<hr/>						
Station Id:		4926350	Station Visit Date:		8/6/1992	
Station Name:		CHALK CK AT US189 XING	Sample Type:		4	
Sample Source:		River/Stream	Water Temperature:		16.8 deg C	
Flow:		17 cfs	Hardness Value:		322.3 mg/l	
Ph Value:		7.7 None				
Depth to Activity:						
Use	Characteristic	Results	Standard		Detect/Quant Limits	
			Min.	Max.		
2B	Phosphorus as P	mg/l Total 0.062		0.05		
3A	Phosphorus as P	mg/l Total 0.062		0.05		

Figure 16.3: Example of Water Quality Standard Violations Report



JON M. HUNTSMAN, JR.
Governor
GARY HERBERT
Lieutenant Governor

State of Utah

Department of Environmental Quality
Division of Water Quality

Dianne R. Nielson, Ph.D. Walter L. Baker, P.E.
Executive Director *Director*

Generic Permittee
Mine Corp
P. O. Box XYZ
Anywhere UT 84000

RE: Compliance Monitoring - UT0000000
3/13/2006

The Utah Division of Water Quality grab sampled your wastewater discharge, Storet No. 4930470 (MINE 001 SED POND OUTFALL) on 1/19/2005 and obtained the following results.

	<u>Value</u>	<u>UOM</u>	<u>Fraction</u>	<u>Limit</u>	<u>UOM</u>
Field Tests					
Dissolved oxygen (DO)	9.45	mg/l	Total	()	()
Dissolved oxygen saturation	98.2	%	Total	()	()
Flow	91.1	g/min		()	()
Salinity	6.81	ppth	Total	()	()
Specific conductance	11647	umhol/cm		()	()
Temperature, water	3.43	deg C		()	()
pH	7.43	None	Total	()	()
Laboratory Analysis					
Iron	0.17	mg/l	Total	()	()
Solids, Dissolved	6526	mg/l		()	()
Solids, Total Suspended (TSS)	11.6	mg/l		()	()

For your information the values for those parameters checked (X) appear to exceed your permit limits

Sincerely,

Permit Writer
Environmental Scientist
Permits & Compliance Section
Division of Water Quality

288 North 1460 West; PO Box 144870, Salt Lake City, UT 84114-4870
Telephone (801) 538-6146* facsimile (801) 538-6016 * www.deq.utah.gov

Figure 16.4: Example of Form Letter

16.5 Biological Data

Biological data is also processed through electronic mediums and interface modules that verify referential integrity and data elements. Spreadsheet type files are imported into the STORET interface module and migrated to STORET after validation.

Biological Data Reporting

Macro invertebrate samples are submitted to laboratories in batches after the end of the collection season. Periphyton and phytoplankton samples are submitted to the consultant weekly. A list of samples and the appropriate meta-data for those samples is submitted concurrently. The results are reported in an excel type spreadsheet. DWQ personnel review the spreadsheet for correctness and completeness during the data processing. Relevant meta-data is added to the file and the data is imported into the STORET interface module for validation. The data is migrated to STORET after migration. Currently DWQ does not have any specific software to retrieve biological data. The “canned” reports on the national STORET website are used for data retrieval.

16.6 Physical Habitat Data

Physical habitat data is collected by field personnel at Utah Complete Assessment of Stream Ecosystems (UCASE) sites as per EMAP protocols. Currently, the data is hand entered onto forms in the field. The forms are sent to an EPA facility in Corvallis that scans the documents and converts them to a spreadsheet electronic format. The data will be returned to DWQ, imported into the STORET interface module, validated, and migrated to STORET. Currently DWQ does not have any specific software to retrieve physical habitat data. The “canned” reports on the national STORET website could be for data retrieval.

16.7. Flow Measurement

Instantaneous Flow Measurement

Instantaneous flow measurements collected with water quality samples by the DWQ are processed with other field measurements collected during the site visit. Continuous flow monitoring stations provide an alternative source of data that DWQ can incorporate into our program. A variety of agencies including DWQ establishes and maintains flow stations. Flow data from other agencies that can be associated with a discrete sampling event is hand entered into STORET data base with the appropriate station visit.

Continuous Flow Measurement

Depth measurements are recorded every hour using instruments and operating procedures detailed in Section 14 of this manual. The data is down loaded to a computer file. Regression analyses are used to correlate depth versus flow using instantaneous measurements of flow and depth performed in the field. Generally a linear relationship provides a large correlation coefficient. The depth data is processed with site specific mathematical equations which convert the depth to flow. Flow averages for the day and month are calculated and printed for each month.

16.8 Salinity Monitoring

Data Sondes (recorders, see section 13.2) collect conductivity measurements every other hour. Data Sonde calibration and operating procedures are detailed in Section 13 of this manual. Data is down loaded to computer files. The data is adjusted to compensate for instrument drift during deployment using computer programming done in SAS. Regression analyses are used to correlate conductivity versus total dissolved solids using measurements of conductivity and total dissolved solids. The total dissolved solids are calculated from this conductivity with programming done in SAS. Total dissolved solids averages for each day and month are calculated and printed for each month. The continuous flow data determined by the Division or acquired from the USGS is combined with the total dissolved solids data to determine loading. Daily and monthly total loading values are printed for each month.

16.9 Diurnal Dissolved Oxygen Monitoring

Continuous dissolved oxygen monitoring is conducted DWQ. Data collection parameters are determined as needed. Data Sondes are deployed and serviced on a weekly basis. Instruments are calibrated using the hydrolab calibration forms in Section 12.3. Sondes are programmed to collect a reading every hour. Data is downloaded with the hydrolab protocol as presented in Section 16.2.2. Data is reviewed, validated and verified by appropriate DWQ personnel. Currently these files are not entered into a central database.

16.10 Data Retrieval

Several data retrieval software programs have been built to “download” data and other information. Output programs or data retrievals are run as requested. A request is presented in memo, e-mail, or letter form to to begin the Information Technology approval process. Several export file types are available to accommodate data user needs.

Transfer of appropriate data to the national instance of STORET is initiated quarterly. Transfer of data is accomplished by generating an exportable zip file and standard ftp protocol

17.0 Division of Water Quality – Quality Assurance Program Plan, Revised April, 2006

17.1 Quality Assurance Program Plan Identification

Document Title: The Quality Assurance Program Plan for the Division of Water Quality

Organization Title: Division of Water Quality

Address: Department of Environmental Quality
Division of Water Quality
288 North 1460 West
Salt Lake City, Utah 84114-4870

Responsible Official: Walter L. Baker
Phone: (801) 538-6146

Quality Assurance Officer: Richard L. Denton
Phone: (801) 538-6055

Quality Assurance Coordinator: Arne Hultquist
Phone: (801) 538-6068

Plan Coverage: This is a document describing the State of Utah's Division of Water Quality Assurance Program Plan. The plan covers all water sampling done by the Division of Water Quality.

Approval for Agency: Name: Walter L. Baker
Title: Director
Division of Water Quality

_____ Signature _____ Date:

17.2 Introduction

EPA policy requires participation in a centrally managed quality assurance program by all agencies whose monitoring and measurement efforts are supported or mandated through contracts, grants, regulations, or other formalized agreements with the EPA. To implement EPA policy, the Division of Water Quality has prepared a Quality Assurance Program Plan Covering all stream water sampling which generates and processes environmental data for the Division of Water Quality.

The Division of Water Quality laboratory work is confined to field analyses for a limited number of parameters; therefore, this document does not address the internal Quality Assurance program of laboratories doing the analysis. The State of Utah, Public Health Laboratory Quality Assurance Program Plan is available from the State Laboratory. This document will be confined to the quality assurance of sampling, sample handling, field techniques, field analyses, and data treatment from the time samples are collected until the samples are submitted to the laboratory and after the results are reported until they are permanently stored.

17.3 Program Descriptions

Stream Assessment Program

Objective

The objective of the stream assessment program is to provide water quality and biological data for stream assessment in support of the 305(b) report. The program is also be used to determine the current and long term water quality trends for Utah's rivers and streams.

Purpose

The purpose of the stream assessment program is to obtain stream water quality data to characterize the water quality of streams and rivers in the State, and document known or probable water quality issues that should be addressed by the State. Under section 305(b) of the Clean Water Act, the State is required to assess and report the water quality status of its rivers and streams and under section 303(d) the State is required to identify those rivers and streams or segments of rivers and streams that are not currently achieving or are not expected to achieve state water quality standards. The program should also identify specific needs for additional information, provide data to evaluate use support designation of streams and determine what stream uses are impaired or threatened. The program should also

provide guidance for planning and setting priorities for subsequent water quality assessments, mitigation activities, and resource management projects.

Data Utilization

Data is used to determine support of a stream's classifications by comparing data against State standards, evaluate long term trends in water quality, and update the State's 303(d) list. It can provide management with a priority list of those streams which show the greatest use impairment. For further information on the program see Section 5 and 6.

Lake Assessment Program

Objective

The objective of the lake assessment program is to provide essential lake water and biological data in support of the State Water Quality 305(b) report, and the Federal Clean Lakes Program (section 314). The program is also used to determine long term water quality trends for Utah's lakes and reservoirs.

Purpose

The purpose of the program is to obtain productivity data for Utah's lakes and reservoirs. Under section 305(b) of the CWA guidelines the state is required to assess and report the water quality status of its lakes and reservoirs. Under section 314 of the CWA, a priority listing of Utah's lakes and reservoirs will be maintained to direct restoration efforts under various programs. The focus of this program is to determine general lake water quality with focus on lake transparency values, total phosphorus concentrations and chlorophyll-a concentrations. Other data will be obtained to facilitate in the overall evaluation of each lake or reservoir.

Data Utilization

Data from the program is utilized to determine an overall Carlson Trophic State Index (TSI) value for each lake or reservoir. This will provide the basis for assessing and tracking water quality changes of Utah's lakes and reservoirs. Data will be used for 305(b) assessments, and assessment and evaluation of lake water quality under the Clean Water Act Section 314 Clean Lake guidelines. For further information about the program see Section 9.

Nonpoint Source Program

Objectives

- *Determine problem parameters
- *Develop background water quality data
- *Determine trends of problem parameters
- *Determine the effectiveness of Best Management Practices

Purpose

The Non-Point monitoring programs purpose is to provide water quality and biological data to be utilized by agencies associated with watershed improvement activities. The program should provide documentation of nonpoint source pollution contributions to a waterbody. The monitoring program also develops criteria for monitoring BMP effectiveness through a feed-back process. The program establishes background information and determines improvement in water quality. The monitoring program is mandatory under EPA for the 319 programA coordinated resource management planning process documents improvement practices implemented in a watershed.

Data Utilization

Data from the program is utilized to document progress in achieving improved water quality conditions. Non-point source control programs coordinators implemented, document, and review effectiveness of best management practices (BMP's). For more information on the program see Section 8.

Permits and Compliance Program

Objectives

Discharging municipalities and industries in the State are under permit to the State of Utah to meet certain pollution limits established by the State of Utah, Department of Environmental Quality. To establish if these permittees are within their UPDES permit limits, programs of oversight and inspection have been developed.

Purpose

The purpose of the permits and compliance oversight monitoring program is to document compliance of permitties by a responsible independent agency. The program also determines point source pollution contributions to a waterbody. The oversite monitoring program also maintains the State's presence which enforces self compliance and monitoring by the permittee.

Data Utilization

The data consists of sample collection, data interpretation, Notice of Violations, and onsite evaluations. Data is utilized for compliance inspections, waste load allocation programs, and the TMDL program. For further information about the program see Section 7.0.

Ground Water Program

Objectives

Utah's ground water quality protection regulations are designed and developed to protect groundwater resources. Similar to the point source permits and compliance section the groundwater program has an oversight monitoring program. The objectives are to insure compliance with permits through inspections and oversight monitoring. The groundwater program also has an aquifer classification program that involves synoptic monitoring of an aquifer and subsequent classification of that aquifer as protected for drinking water if it qualifies. Both responsibilities have the same overall objective of documenting current groundwater quality and protecting it from degradation. The oversight monitoring program also maintains the State's presence which enforces self compliance and monitoring by the permittee.

Purpose

The purpose of the program is to:

1. Emphasize the prevention of ground water contamination.
2. Utilize widely accepted scientifically based standards as a basis for measurement of water quality.
3. Afford greater protection for quality ground water.
4. Provide an early warning mechanism such that ground water is not substantially degraded before corrective measures are initiated.
5. Not duplicate other regulatory programs, but should provide a common basis for measurement of performance.
6. Allow prioritization of effort so as to focus state resources on significant ground water problems.
7. Provide methods for achieving and maintaining compliance by the regulated community.

Data Utilization

The data from oversight monitoring of permitted wells is utilized for independent assurance of permit compliance. The data from aquifer studies is used to classify aquifers, and track aquifer water quality trends. For further information about the program see Section 10.0

Total Maximum Daily Load Program

Objectives

The objective of the total maximum daily load (TMDL) program is to develop waterbody specific strategy that will enable the waterbody to attain its water quality standards and support its beneficial uses.

Purpose

Under section 303(d) of the Clean Water Act, each state is required to identify and submit a list of these waterbodies to the U.S. Environmental Protection Agency (EPA) every five years. Waterbodies from that list are then selected to have a TMDL assessment made. The TMDL determines the sources and amounts of pollution that are entering a waterbody. Calculations can then be made to determine how much the input from each source would have to be reduced so that the waterbody meets state water quality standards and to support its beneficial uses.

Data Utilization

The data generated from the TMDL program is used to determine beneficial use support, track trends, and evaluate best management practices. A successful TMDL project results removal of a stream from the 303(d) listing based upon a waterbody meeting its water quality standards.

Waste Load Allocation Program

Objectives

The objective of the waste load allocation program (WLAP) is to prevent assessment units from violating their water quality standards as a result of a point source discharge.

Purpose

Before point source permits are issued or renewed, applications must go through the waste load analysis. A waste load allocation (WLA) is calculated to determine the level, if any, of a water parameter that can be discharged to a assessment units without violating water quality standards or impacting its beneficial uses. Receiving water is monitored for characteristics in the effluent to determine current pollutant levels. Industrial and municipal facilities are monitored to ensure that they are meeting their discharge permit limitations.

Data Utilization

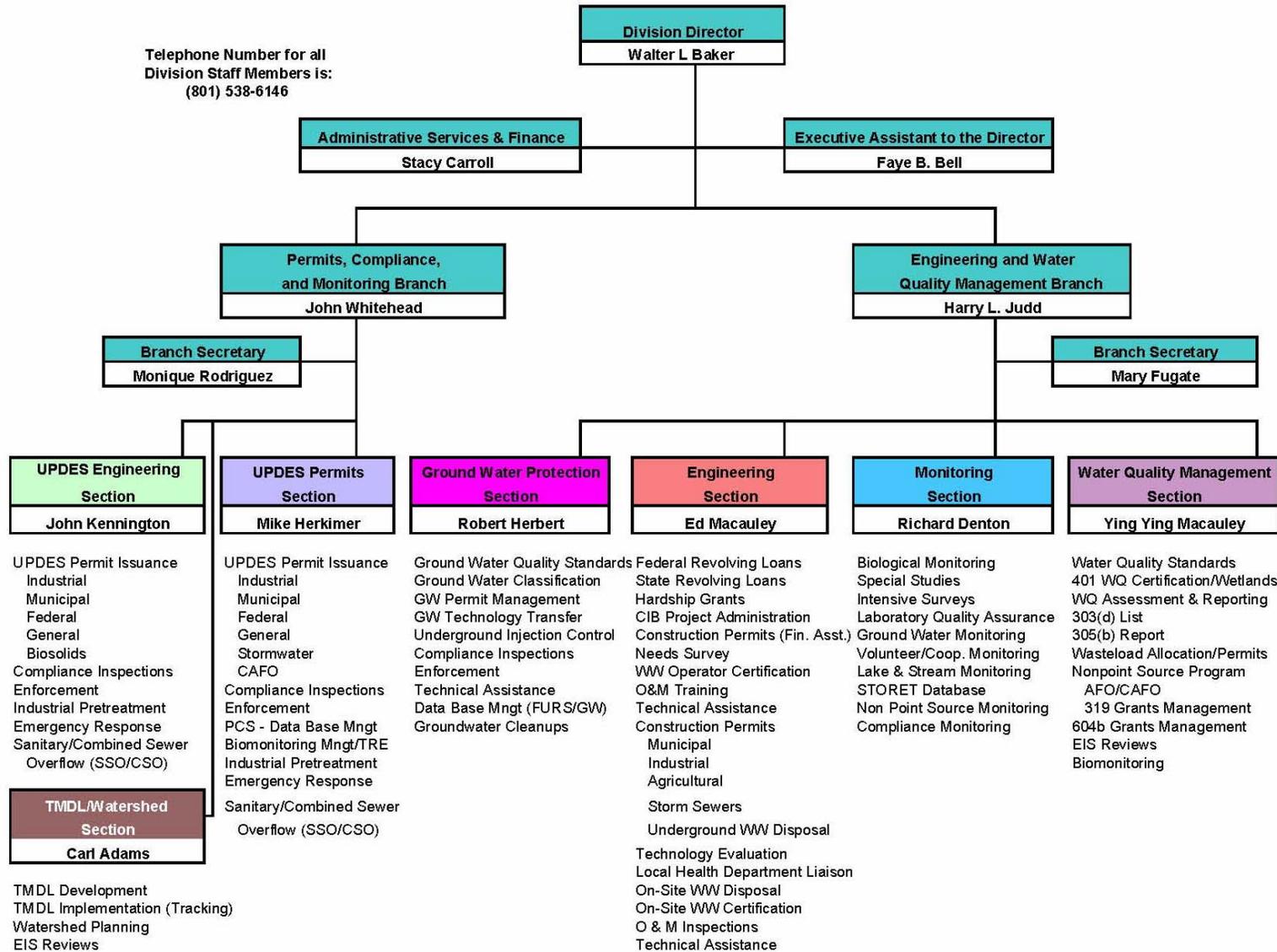
The data is utilized both prior to and after permit issuance. Prior to permitting the waste load allocation determines what contaminant level will be allowed in the permit and can drive the application of specific technology required to meet those levels. After the permit is issued the data from waste load allocation sites is used to determine the receiving assessment units continued support of its beneficial uses and determination of allowable loads during permit renewal.

17.4 Organization and Responsibility

The following flow chart (Figure 17.1) is a functional organization chart for the State of Utah DEQ Division of Water Quality.

**Department of Environmental Quality
Division of Water Quality
FUNCTIONAL ORGANIZATIONAL CHART**

Telephone Number for all
Division Staff Members is:
(801) 538-6146



17.5 Quality Assurance Objectives for Measurement Data in Terms of Precision and Accuracy

The measurement data should provide adequate precision and accuracy for each program objective. All data generated will be reported in units consistent with data generated by other organizations reporting similar analyses to allow comparability of data among organizations. Specific data quality objectives for accuracy precision and completeness for laboratory analyses are discussed in the Division of Laboratory Services Quality Assurance Program Plan (QAPP). Specific data quality objectives for accuracy and precision of sampling are for measurements to fall within a 95% confidence interval around the true value. The confidence interval for each parameter except total suspended solids (TSS), phosphorus and turbidity determinations is based on prior knowledge of the measurement system and is generated from the EPA publication "Estimation of Generic Acceptance Limits For Quality Control Limits For Use In A Water Pollution Laboratory" May, 1991. If statistics are not available in the document, the EPA document entitled "Estimation of Generic Acceptance Limits for Quality Control purposes in a Drinking Water Laboratory will be used. For parameters not listed in either EPA document, the data quality objectives will be the same as those listed in the Division of Laboratory Services QAPP. The EPA documents are in appendix 14 and the Division of Laboratory Services QAPP is in appendix 13 of the Quality Assurance and Standard Operating Procedures Manual. The data quality objectives for TSS and phosphorus determinations are also based on prior knowledge of the measurement systems. TSS has a requirement of +/- 20 % for precision and accuracy. Phosphorus determinations for both total and dissolved total phosphorus have a two-tiered requirement. Determinations of phosphorus greater than .1 mg/l have a precision and accuracy requirement of +/- 20 %. Phosphorus determinations of less than .1mg/l have precision and accuracy requirement of +/- .02 mg/l. Turbidity determinations also have a two tiered requirement. Determinations of turbidity greater than 10 NTU have precision and accuracy requirement of +/- 20 %. Turbidity determinations of less than 10 NTU have a precision and accuracy requirement of 2 NTU.

17.6 Sampling Procedures

Sampling Collection and Preservation

Water sample collection and preservation techniques for chemical analyses are presented in Section 4 of the Quality Assurance and Standard Operating Procedures Manual, and Section 7 the Division of Laboratory Services QAPP. Standard procedures and practices for the collection and preservation of chemical samples are detailed in those documents. The preservation techniques will conform to EPA Rules and Regulations listed in Federal Register VOL 49, No. 209.

Field Measurements for Chemical Parameters

Field measurement methods for chemical parameters are presented in Section 13. Standard procedures for the calibration and use of instruments used in field analyses are detailed in that section.

Field Measurements for Flow and Other Physical Parameters

Field measurement methods for physical parameters are presented in Section 14 and 19. Standard procedures for the collection of physical measurements are detailed in that document.

Sampling Methods and Procedures for Benthic Analyses

Benthic sample collection techniques are presented in Section 11 of the Quality Assurance and Standard Operating Procedures Manual and the National Aquatic Monitoring Center Standard Operating Procedures and Quality Control documentation

Sampling Methods and Procedures for Phytoplankton and Periphyton Analyses

Phytoplankton and periphyton sample collection techniques are presented in Section 9 and Section 20 of the Quality Assurance and Standard Operating Procedures Manual. Standard procedures and practices for the collection and preservation of phytoplankton samples are detailed in that document.

Sampling Methods and Procedures for Fish Analyses

Fish sample collection methods are presented in Section 21 of the Quality Assurance and Standard Operating Procedures Manual.

17.7 Sample Custody and Form Identification

17.8.1 Sample Custody and Form Identification for Routine Analyses

For routine analyses (those not involved in possible litigation) the forms and codes used are presented in Section 12 of the Utah Water Monitoring Quality Assurance Manual. Samplers will adhere to documentation techniques presented in Section 12. Samplers will prepare and complete all forms before samples will be delivered to the laboratory.

Sample Custody and Form Identification

For samples that could possibly be involved in litigation procedures, chain of custody procedures will be followed in addition to procedures for routine sampling. Chain of custody procedures are presented in Section 15.

17.8 Analytical Methods Requirements

Analytical Methods for Laboratory Chemical Analyses

Analytical methods that are used for laboratory chemical analyses are listed in the Division of Laboratory Services Quality Assurance Program Plan (QAPP), appendix 13 of the Quality Assurance and Standard Operating Procedures Manual. The analytical methods in used generally are the same as listed in 40 CFR Part 136. Any deviation in analytical methodologies will be described in detail in the site-specific sampling and analysis plans.

Analytical Methods for Field Chemical Analyses

Analytical methods that are used for field chemical analyses are listed in Section 13 of the Quality Assurance and Standard Operating Procedures Manual.

Analytical Methods for Field Measurements of Flow and Other Physical Parameters

Analytical methods that are used for physical parameters are presented in Section 14 and 19 of the Quality Assurance and Standard Operating Procedures Manual.

Analytical Methods for Benthic Analyses

The National Aquatic Monitoring Center at Utah State University is currently performing the benthic sample analyses. Analytical methods that are used for benthic analyses are listed in Section 9 of the Quality Assurance and Standard Operating Procedures Manual and the National Aquatic Monitoring Center documentation,

Analytical Methods for Phytoplankton and Periphyton Analyses

Analytical methods that are used for phytoplankton and periphyton analyses are listed in Section 9 and Section 19 of the Quality Assurance and Standard Operating Procedures Manual and Dr Rushforth's documentation is appendix 20 of the Quality Assurance and Standard Operating Procedures Manual.

Analytical Methods for Fish Analyses

Analytical Methods used for pesticide and heavy metal analysis in fish tissue follow *Standard Methods* and our outlined in the Division of Laboratory Services

Quality Assurance Program Plan (QAPP), appendix 13 of the Quality Assurance and Standard Operating Procedures Manual.

17.9 Data Reduction, Validation and Reporting

Data reduction and reporting is presented in Section 16 of the Utah Water Monitoring Quality Assurance Manual. Data processing procedures, flow charts and examples of reports are detailed in that document.

17.10 Performance and System Quality Control Checks and Audits

Quality Control Checks and Audits for Laboratory Chemical Analyses

Performance Evaluation Audits

The quality assurance officer or his designee will submit quality control samples and blind audit samples quarterly for routinely analyzed parameters to the Division of Laboratory Services. A "blank" sample will also be submitted quarterly.

Performance Evaluation Duplicate Sampling

Duplicate samples will be collected at a frequency rate of 4 % frequency rate or greater. Most surveys will have a minimum of one duplicate. A volume of water will be collected in a container to allow filling of two sets of sample containers simultaneously. Both laboratory known duplicate and blind duplicate sampling will be performed. Dummy sites with storet numbers will be used to submit blind duplicated samples to the laboratory. Sites will be chosen to insure duplication of all parameters being analyzed for that survey.

Performance Evaluating Field Blanks

Field blanks will be submitted to the laboratory at a frequency rate 1% or greater. Most surveys will have a minimum of one field blank. Deionized water will be taken from the laboratory with the monitoring team and handled in the same manner as other routine samples. During the survey the blank water will be placed in the sample bottles required for submission to the laboratory. Filtering will take place at that time if necessary. All parameters being monitored during that survey will be analyzed.

Quality Control Checks and Audits for Field Chemical Analyses

Comparing instrument results for water with known values achieves performance evaluation of field chemical analyses. Either standard reference material of known quality, or alternative analysis methodologies are used to determine the known values. Details of field instrument quality control checks are presented in Section 13 of the Quality Assurance and Standard Operating Procedures Manual.

Quality Control Checks and Audits for Field Measurements of Physical Parameters

Field personnel and the quality assurance officer perform quality control checks on field measurements of physical parameters. Field personnel check all forms and results for completeness and accuracy by before submittal to the quality assurance officer. The quality assurance officer also reviews all physical data before transfer to the database.

Quality Control Checks and Audits for Benthic Analyses

The National Aquatic Monitoring Center at Utah State University is currently performing the benthic sample analyses. The quality assurance officer at the laboratory performing the benthic analyses performs numerous quality control checks and audits on all results before they are reported. Procedures performed at the benthic laboratory are outlined in Section 9 of the Quality Assurance and Standard Operating Procedures Manual and detailed in the National Aquatic Monitoring Center's benthic laboratory documentation.

Quality Control Checks and Audits for Phytoplankton and Periphyton Analyses

Under development.

Quality Control Checks and Audits for Fish Analyses

Under development. Will be similar to EMAP

17.11 Instrument Calibration and Frequency

Calibration Frequency and Procedures for Laboratory Chemical Analyses

Analytical instrumentation calibration and frequency procedures used by the Division of Laboratory Services are detailed in the Division of Laboratory Services QAPP. Division of Laboratory Services QAPP is in Appendix 13 of the Quality Assurance and Standard Operating Procedures Manual.

Calibration Frequency and Procedures for Field Chemical Analyses

Calibration standards for field measurements parameters will be prepared in

accordance with the approved EPA methodology. These standards will be verified by comparison with standard reference materials provided by the quality assurance officer. Standards that do not provide standard reference materials measurement values within the 95% confidence interval for the parameter will not be used for calibration. Data from prepared standards will be documented on calibration forms. Standard protocol for instrument calibrations varies between instruments. At a minimum manufactures recommended calibration frequency and procedures will be used. All instruments will be calibrated before deployment in the field and will be calibrated every day they are used in the field. Calibration procedures of field instruments for chemical parameters are presented in Section 10 of the Quality Assurance and Standard Operating procedures Manual. The manufacturers specifications are also included in the appendices of that document.

Calibration Frequency and Procedures for Field Measurements and Physical Parameters

At a minimum manufactures recommended calibration frequency for portable current measuring instruments will be used. Manufactures specifications and procedures will be used to calibrate portable current measuring instruments. At a minimum manufactures recommended calibration frequency for other instruments use for measuring physical parameters will be used. The manufacturers specifications are included in the appendices of the. Quality Assurance and Standard Operating Procedures Manual.

Calibration Frequency and Procedures for Benthic, Phytoplankton, Periphyton, and Fish Analyses

Calibration procedures of analytical instrumentation used by laboratories performing benthic, phytoplankton, periphyton, and fish analyses are detailed in Quality Assurance Project Plans of each laboratory performing biological analyses

17.12 Specific Routine Procedures Used to Asses Data Precision, Accuracy and Completeness.

Field Data

Field data will be assessed continuously. If a dissolved oxygen values greater than the 100% saturation level is measured an immediate calibration of the instrument will be required and the site reanalyzed. If a pH value less than 6.5 or greater than 9.0 is measured an immediate calibration of the instrument will be required and the site reanalyzed. If a specific conductance value greater than 10 times or less than 1/10 the standard is measured, an immediate calibration of the instrument with a

standard of proper magnitude will be required and the site reanalyzed. Field data for an entire trip will be assessed on a weekly basis by the quality assurance coordinator and quality assurance officer.

Routine Laboratory Data

After results from ambient site samples are received from the laboratory, all samples from sites with use classifications are run through a program that compares the measured values to water quality standards. This report is reviewed by the quality assurance officer and quality assurance coordinator for accuracy and completeness before submittal to the water quality management section. After results are received from the laboratory, all samples from permitted discharges are run through a program that creates form letters. These letters are reviewed by the quality assurance officer for accuracy and completeness before submittal to the Permits and Compliance Section. All other laboratory reports are reviewed by the quality assurance officer for accuracy and completeness.

Duplicate Sample Data

After all duplicate sample data is received from the laboratory; the duplicate measurements will be compared to a 95% confidence interval generated around the original site value except total suspended solids (TSS), phosphorus, and turbidity. The 95% confidence interval is generated from regression equations published in the EPA document "Estimation of Generic Quality Control Limits For Use In A Water Pollution Laboratory". If statistics are not available in the document, the document from the EPA entitled "Estimation Of Generic Acceptance Limits for Quality Control Purposes In A Drinking Water Laboratory" will be used. If statistics are not available in either document, the Division of Laboratory Services Quality Assurance Project Plan quality assurance goals will be used. In any case the most current documentation available will be used. The data quality objectives for TSS and phosphorus determinations are also based on prior knowledge of the measurement systems. TSS has a requirement of +/- 20 % for precision and accuracy. Phosphorus determinations for both total and dissolved total phosphorus have a two-tiered requirement. Determinations of phosphorus greater than .1 mg/l have a precision and accuracy requirement of +/- 20 %. Phosphorus determinations of less than .1mg/l have precision and accuracy requirement of +/- .02 mg/l. Determinations of turbidity greater than 10 NTU have precision and accuracy requirement of +/- 20 %. Turbidity determinations of less than 10 NTU have a precision and accuracy requirement of 2 NTU. The data will be evaluated with every duplicate sample as it is received from the laboratory. The data will be collected from every laboratory electronic file and immediately evaluated and reported to the quality assurance officer and appropriate laboratory personnel in writing.

Performance Evaluation Audits

After all quality control sample data are received from the laboratory, the sample measurements will be compared to a 95% confidence interval generated around the true value. The 95% confidence interval is generated from regression equations provided with the audit series. If statistics are not available with the audit series, the EPA publication "Estimation Of Generic Quality Control Limits For Use In A Water Pollution Laboratory" will be used. In all cases the most current documentation will be used. The samples will be submitted quarterly. They will be evaluated and reported to the quality assurance coordinator in writing before the end of the following quarter.

Performance Evaluation of Field Blank Samples

The data from every field blank sample is collected from every laboratory electronic file and immediately evaluated and reported to the quality assurance officer and appropriate laboratory personnel in writing.

Performance Evaluation of Physical Assessment Data

Procedures used to assess physical data are contained in Section 19 of the Quality Assurance and Standard Operating Procedures Manual. Standard assessment tools detailed in each physical measurement method will be used.

Performance Evaluation of Benthic, Phytoplankton, Periphyton, and Fish Samples

Procedures used to assess data from biological sampling are contained in Section 11, Section 20, and Section 21 of the Quality Assurance and Standard Operating Procedures Manual. Standard assessment tools detailed in each biological analyses method will be used.

17.13 Corrective Actions

Corrective actions will be initiated as a result of the following quality assurance activities:

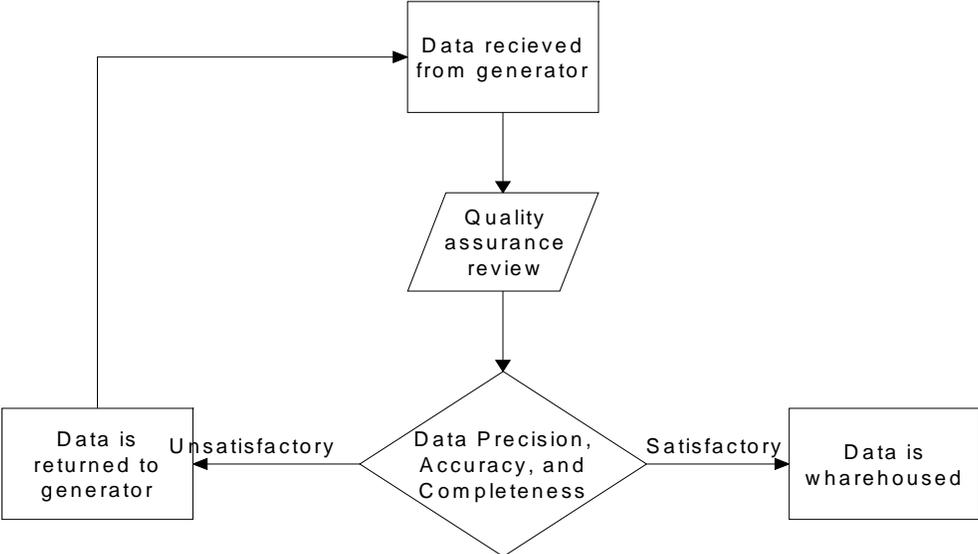
1. Daily field data assessment found to be beyond control limits.
2. Unacceptable results on performance evaluation audits.
3. Unacceptable performance found in system audits.
4. Previously reported results found to be in error.

It is imperative that early and effective corrective action be taken when control data fall outside of acceptable limits. Since the samplers and laboratory are responsible for recording all quality assurance data on forms daily, they will be the first to determine that a method is out of control and will initiate the appropriate immediate corrective measures necessary to bring data within control limits. Any corrective

action by the samplers will be documented and completed forms will be maintained by the quality assurance office.

Corrective action taken as a result of unacceptable performance on audits will be initiated by the quality assurance officer, and if appropriate, in cooperation with the Division of Laboratory Services quality assurance officer.

Figure 17.2 Quality Assurance and Feedback Channel



18.0 HEALTH SAFETY PLAN

18.1 Entering Manholes

Employees should avoid entering manholes whenever possible due to the potential hazards. Only in extreme circumstances should this be done, and then only by following all appropriate safety measures. The main hazards of manhole entry are asphyxiation due to oxygen shortage and exposure to toxic gases. Pretesting for oxygen content and toxic gases should be done before entering manholes. Continuous ventilation should be provided. Employees also should never enter a manhole without at least one other person at ground surface and available to offer assistance when needed. Employees entering manholes should wear at a minimum hard hat, safety glasses and protective clothing. The work should be interrupted **IMMEDIATELY** whenever the inspector experiences the nonspecific symptoms of exposure, including but not limited to the following: headache, eye or nose irritation, nausea, dizziness, drowsiness, vomiting, loss of coordination, chest pains, or shortness of breath. The inspector should proceed to a well ventilated area and reevaluate the potential inhalation hazards.

18.2 Entering Rooms Containing Chlorine or Sulfur Dioxide Supplies

Before employees may enter rooms where chlorine or sulfur dioxide in any amount is being stored or dispensed he or she must ensure proper breathing apparatus are stored and ready for instant use at a convenient location outside the room containing the gas. Employees should make sure rooms containing chlorine or sulfur liquid are provided with some means of ventilation. Vents or exhaust fans should be provided at floor level or combination blower on roof with floor vent to allow escape of chlorine gas. Always allow the ventilation system to operate several minutes before entering such a room, and always enter rooms containing chlorine or sulfur dioxide supplies cautiously. If you smell chlorine or sulfur dioxide when opening the door, immediately exit, and then close the door and seek assistance. Never enter an area containing chlorine or sulfur dioxide supplies alone.

18.3 Entering Confined or Enclosed Spaces

Employees should avoid entering confined and enclosed spaces, due to the potential hazards involved. The same precautions must be taken prior to entering chlorine or sulfur dioxide rooms and manholes. Only in extreme circumstances should these areas be entered. "Confined or enclosed space" means any space having a limited means of egress, which is subject to the accumulation of toxic or flammable contaminants or may have an oxygen deficient atmosphere. Confined or enclosed spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, tunnels, pipelines and open top spaces more than 4 feet in depth such as pits, tubs, vaults, and vessels. All employees required to enter into confined or enclosed spaces shall be instructed as to the nature of the hazards involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required. Never enter enclosed or confined spaces without someone outside and available to offer assistance.

18.4 Working Near or in Trenches

Employees should never enter them unless it is absolutely necessary for close-up inspection of an item. Please keep in mind more deaths occur from trench collapse each year than any other construction related hazards. In all excavations, employees exposed to danger from moving ground shall be protected by a shoring system, sloping of the ground, or some other equivalent means. All trenches over 5 feet deep in either hard and compact or soft and unstable soil must be sloped, shored, sheeted, braced or otherwise supported and that trenches less than 5 feet in depth also be effectively protected when hazardous ground movement may be expected. In excavations, which employees may be required to enter, excavated or other material shall be effectively stored and retained at least 2 feet or more from the edge of the excavation or use of effective barriers or other effective retaining devices in lieu thereof in order to prevent excavated or other materials from falling into the excavation. In case of emergency, employees must be able to leave the trench quickly. When employees are required to be in trenches 4 feet deep or more, adequate means of exit, such as a ladder or steps, must be provided and located so as to require no more than 25 feet of lateral travel. Where employees are required to cross over excavations, walkways or bridges with standard guardrails shall be provided.

18.5 Entering Tunnels and Mines

Employees should avoid entering underground tunnels and mines. If it is necessary to enter such facilities the safety requirement of the company shall be requested and adhered to. A preinspection phone conversation is required with the company safety officer. Each employee going into mines or tunnels shall have a check-in and check-out system that will provide positive identification of every employee underground. An accurate record and location of the employee shall be kept on the surface. Protective clothing and equipment shall be available as needed. Evacuation plans and procedures developed shall be made known to the employee. Instruments shall be provided to test the atmosphere for carbon monoxide, nitrogen dioxide, flammable or toxic gases, dusts, mists and fumes that occur in a tunnel or mine. Tests shall be conducted as frequently as necessary to assure that the required quality and quantity of air is maintained.

18.6 Climbing Vertical Steps

Except where either permanent or temporary stairways or suitable ramps or runways are provided, ladders shall be used to give safe access to all elevations. The use of ladders with broken or missing rungs or steps, broken or split side rails or other faulty or defective construction is prohibited. When climbing ladders, the horizontal rungs should be grasped. Both hands must be free for climbing, and equipment must not be carried in either hand.

18.7 Employees Working On or Near Water

Prior to working on ice, take ice depth samples to determine the stability. Whenever aboard a boat, life jackets, buoyant work vests, and all other necessary safety equipment shall be available. All outdoor activity should be terminated

whenever the wind chill factor is below -20°F.

18.8 Exposure to Caustic or Toxic Chemicals

Only employees who have been properly trained and certified to work near toxic chemicals are authorized to participate in such activities. Only in extreme circumstances should this be necessary. The Department of Health should be contacted for assistance and proper equipment for monitoring. Exposure of employees to inhalation, ingestion, skin absorption or contact with any material or substance at a concentration above those specified in the "Threshold Limit" Values and Biological Exposure Indices of the American Conference of Governmental Industrial Hygienist (ACGIA) latest annual edition, shall be avoided. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reasons of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact. When no other method or combination of methods can be provided to prevent employees from becoming exposed to toxic dusts, fumes, gases, flying particles or other objects, dangerous rays or burns from heat, acid, caustic, or any other hazard of a similar nature, the employer must provide each worker with the necessary personal protection equipment, such as respirators, goggles, gas masks, certain types of protective clothing, etc. Provisions must also be made to keep all such equipment in good, sanitary working condition at all times.

18.9 General Construction Safety

Employees working in areas where there is a possible danger of head injury from impact or from falling or flying objects or from electrical shock or burns, shall be protected by using a hard hat, safety glasses, and safety shoes. These items should be obtained even when not required by plant safety policies.

Whenever it is not feasible to reduce the noise levels or duration of exposure to loud noises, ear protective devices shall be used. Hearing protection should be used whenever it is difficult to hear another person speaking in a normal tone of voice at a distance of 3 feet.

Employees shall use eye protection equipment when machines or operations present potential eye injury from physical, chemical or radiation agents. Employees whose vision requires the use of corrective lenses in spectacles, shall be protected by goggle or spectacles of one of the following types:

- 1) Spectacles whose protective lenses provide optical correction.
- 2) Goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles. Eye protection must conform with plant requirements. Persons shall not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. Approved or accepted respirators shall be used. The respirator furnished shall provide adequate respiratory protection against the particular hazard for which it is designed

in accordance with standards established. Respiratory protective equipment shall be inspected regularly and maintained in good condition. Respiratory protective equipment which has been previously used shall be cleaned and disinfected before it is reissued or used by employees.

18.10 Exposure to Wastewater

Employees who come into contact with wastewater are exposed to all types of water-borne disease. Whenever possible eye protection and protective gloves (rubber) should be worn when sampling wastewater, sludges, storm water, ground water or sampling any other unknown material. When sampling is finished always discard the gloves, or wash them thoroughly before removing them. After removing the gloves wash hands thoroughly, using a disinfectant type soap. Never collect any sample with bare hands. This is especially important if you have any broken skin areas such as cuts or scratches. Don't climb over or go beyond guardrails or chains when collecting samples if at all possible. Use sample poles, ropes and other devices as necessary to collect samples. If coveralls are worn and become contaminated, remove, place in plastic bag and have them laundered.

18.11 Driving State Vehicles

Always follow the basic rules of the Utah Drivers Handbook. Obey all traffic warning signs and adjust driving to existing weather, road and terrain conditions. When traveling to remote area always let someone know of your intended route and approximate time of return. When operating off-road vehicles (4 wheelers, snow machines) always go in pairs and let someone know of your route of travel. While driving if you become sleepy or fatigued, stop and rest or change drivers.

18.12 Basic Safety Equipment

- (1) Hard Hat
- (2) Safety Shoes
- (3) Safety Glasses or Goggles
- (4) Ear Protection
- (5) Coveralls
- (6) Rubber Gloves
- (7) Hand Wipes

18.13 Basic Training

First Aid/CPR - Department
Emergency Response - Division
Confined Spaces
Construction Safety

18.14 References Cited

"UTAH OCCUPATIONAL SAFETY AND HEALTH" General Standards.
Revision No. 3 September 1, 1985

"UTAH OCCUPATIONAL SAFETY AND HEALTH" Construction Standards
Revision No. 3 July 1, 1984

"THRESHOLD LIMIT VALUES AND BIOLOGICAL EXPOSURE INDICES"
For 1988-89

"Response Plan For Emergency Actions" Utah Department of Health Division of
Environmental Health May 1, 1989

Utah Boating Laws and rules, Utah Boating Act, Board of Parks and Recreation
Boating Rules

See our reference library for other safety information

19.0 PHYSICAL HABITAT

Utah Division of Water Quality Overview

Historically, the Division of Water Quality had not collected physical habitat data due to lack of resources and written protocols. With the initiation of the EPA Western Environmental Assessment and Monitoring Program (EMAP), a protocol was available for this data to be collected on division sites where chemical and biological data was collected. Fifty statewide sites were assessed by the EMAP from 2000 to 2003. In 2004, the division adopted the EMAP assessment procedures, and numerous sites have been assessed for physical habitat. The long term monitoring plan calls for 74 sites to be sampled each year in conjunction with chemistry, and biological monitoring.

Twenty five of the sites will be targeted toward reference site conditions. An additional thirty seven sites will be targeted toward sites needing further study in conjunction with listing on the 303d list, Total Maximum Daily Load work, Waste Load, or other DWQ programs. Twelve sites are assigned to the Non Point Source Program.

PROTOCOLS

The following introduction is copied from the Environmental Monitoring and Assessment Program (EMAP) Western Pilot Study Field Operation Manual for Wadeable Streams edited by David V Peck, James M Lazorchak, and Donald Klemm of the EPA in Corvallis, Oregon. The Physical Habitat section is authored by Philip R Kaufmann from EPA, Corvallis, Oregon. The protocols and procedures are referenced in that document. The Utah Division of Water Quality will adopt those protocols and procedures.

EMAP Guidance

In the broad sense, physical habitat in streams includes all those physical attributes that influence or provide sustenance to organisms within the stream. Stream physical habitat varies naturally, as do biological characteristics; thus, expectations differ even in the absence of anthropogenic disturbance. Within a given physiographic-climatic region, stream drainage area and overall stream gradient are likely to be strong natural determinants of many aspects of stream habitat, because of their influence on discharge, flood stage, and stream power (the product of discharge times gradient). Summarizing the habitat results of a workshop conducted by EMAP on stream monitoring design, Kaufmann (1993) identified seven general physical habitat attributes important in influencing stream ecology:

- Channel Dimensions
- Channel Gradient
- Channel Substrate Size and Type
- Habitat Complexity and Cover

- Riparian Vegetation Cover and Structure
- Anthropogenic Alterations
- Channel-Riparian Interaction

All of these attributes may be directly or indirectly altered by anthropogenic activities. Nevertheless, their expected values tend to vary systematically with stream size (drainage area) and overall gradient (as measured from topographic maps). The relationships of specific physical habitat measurements described in this section to these seven attributes are discussed by Kaufmann (1993). Aquatic macrophytes, riparian vegetation, and large woody debris are included in this and other physical habitat assessments because of their role in modifying habitat structure and light inputs, even though they are actually biological measures. The field physical habitat measurements from this field habitat characterization are used in the context of water chemistry, temperature, and other data sources (e.g., remote sensing of basin land use and land cover). The combined data analyses will more comprehensively describe additional habitat attributes and larger scales of physical habitat of human disturbance than are evaluated by the field assessment alone. A comprehensive data analysis guide (Kaufmann et al., 1999) discusses the detailed procedures used to calculate metrics related to stream reach and riparian habitat quality from field data collected using the EMAP field protocols. This guide also discusses the precision associated with these measurements and metrics.

These procedures are intended for evaluating physical habitat in wadeable streams. The EMAP field procedures are most efficiently applied during low flow conditions and during times when terrestrial vegetation is active, but may be applied during other seasons and higher flows except as limited by safety considerations. This collection of procedures is designed for monitoring applications where robust, quantitative descriptions of reach-scale habitat are desired, but time is limited. The qualitative nature of the habitat quality rank scores produced by many currently available rapid habitat assessment methods have not been demonstrated, as yet, to meet the objectives of EMAP, where more quantitative assessment is needed for site classification, trend interpretation, and analysis of possible causes of biotic impairment.

The habitat characterization protocol developed for EMAP differs from other rapid habitat assessments approaches (e.g., Plafkin et al., 1989; Rankin, 1995) by employing a randomized, systematic spatial sampling design that minimizes bias in the placement and positioning of measurements. Measures are taken over defined channel areas and these sampling areas or points are placed systematically at spacings that are proportional to baseflow channel width. This systematic sampling design scales the sampling reach length and resolution in proportion to stream size. It also allows statistical and series analyses of the data that are not possible under other designs. We strive to make the protocol objective and repeatable by using easily learned, repeatable measures of physical habitat in place of estimation techniques wherever possible. Where estimation is employed, we direct the sampling team to estimate attributes that are otherwise measurable, rather than estimating the quality of importance of the attribute to the biota or its importance as an indicator of disturbance. We have included the more traditional

visual classification of channel unit scale habitat types because they have been useful in past studies and enhance comparability with other work.

The time commitment to gain repeatability and precision is greater than that required for more qualitative methods. The additional substrate measurements (pebble count of 105 vs. 55 particles) add 20 to 30 minutes to the protocol described by Kaufmann and Robison (1998). In our field trials, two people typically complete the specified channel, riparian, and discharge measurements in about 3.5 hours of field time. However, the time required can vary considerably with channel characteristics. On streams up to about 4 meters wide with sparse woody debris, measurements can be completed in about two hours. The current protocol, requiring 21 wetted width measurements, will require less than 4.5 hours for a well-practiced crew of two, even in large (>10 m wide), complex streams with abundant woody debris and deep water.

The procedures are employed on a sampling reach length 40 times its low flow wetted width, as described in Section 4. Measurement points are systematically placed to statistically represent the entire reach. Stream depth and wetted width are measured at very tightly spaced intervals, whereas channel cross-section profiles, substrate, bank characteristics and riparian vegetation structure are measured at larger spacings. Woody debris is tallied along the full length of the sampling reach, and discharge is measured at one location (see Section 6). The tightly spaced depth and width measures allow calculation of indices of channel structural complexity, objective classification of channel units such as pools, and quantification of residual pool depth, pool volume, and total stream volume.

For EMAP-WP, there are several modifications to various procedures previously published for EMAP-SW by Kaufmann and Robison (1998). Four procedures (substrate particle size, instream fish cover, human influence, and thalweg habitat classification) are modified slightly from previous versions. The increase in the number of particles to be included in the systematic pebble count (from 55 particles to 105) increases the precision of substrate characterizations such as %fines. To obtain the additional particles, 10 “supplemental” cross-sections are located mid-way between successive “regular” transects. Procedures for locating and estimating the size of particles on each cross-section remain unchanged, for “regular” and “supplemental” cross-sections, except that only the substrate size class and the wetted width data are recorded at the 10 supplemental cross sections. Logistically, the supplemental substrate cross-section procedures are accomplished as part of the thalweg profile that is undertaken between regular transects. However, the details of the actual measurements and observations are described. Instream fish cover and human influence procedures now include additional or modified features.

In ephemeral streams, fish cover is assessed within the bankfull channel. The thalweg habitat classification now includes the tallying of presence/absence of off-channel backwater habitats, (e.g., sloughs, alcoves, backwater pools). Backwater pools are included in this tally, but if they are the dominant channel habitat classification, they are

also identified by a channel unit classification, as in previous versions of this field protocol.

Three new procedures are included for EMAP-WP. The first is added to provide additional data on the size and proximity of large, old riparian trees and on the occurrence of non-native invasive tree, shrub and grass species. The second is added to classify the general degree of geomorphic channel constraint. This is an overall assessment of reach characteristics that is done after completing the thalweg profile and other measurements at the 11 cross-section Transects. Finally, a procedure is added to identify evidence of major floods or debris torrents (lahars). This is an overall assessment for the reach as a whole, and is done after completing the other measurements. The field form and procedures for assessing debris torrent evidence have been applied in Oregon and Washington research and R-EMAP surveys since 1994.

20.0 PERIPHYTON

Periphyton are useful indicators of environmental conditions because they respond rapidly and are sensitive to a number of anthropogenic disturbances, including habitat destruction, contamination by metals, nutrients, and herbicides.

The Division of Water Quality began limited periphyton studies in 2000. In 2004, field protocols were adopted from the Western Environmental Monitoring and Assessment Program ‘Field Operations Manual for Wadeable Streams’. The following sampling procedure are from the EPA manual.

20.1 Sample Collection

The general scheme for collecting periphyton samples from the sampling reach at each stream is illustrated in Figure 20-1. The procedure for collecting periphyton samples is presented in Table 20-1. At each transect, samples are collected from an assigned sampling point (left, center, or right). **Sampling points are located 1 m downstream of each transect to avoid disturbing substrates that are enumerated and classified as part of the physical habitat characterization.** Sampling points at each transect may have been assigned when the sampling reach was laid out (Figure 20-1). If not, the sampling point at Transect ‘A’ is assigned at random using a die or other suitable means (e.g., digital watch). Once the first sampling point is determined, either an erosional or depositional sample is collected, depending on whether the dominant habitat at the sampling point is flowing water (e.g., a riffle or run) or slack water (e.g., a pool). A composite sample for the reach is prepared by combining the individual transect samples as they are collected into a single plastic bottle. The volume of the composite sample are recorded on the Sample Collection Form as shown in Figure 20-2.

Figure 20-1. Index sampling design for periphyton.

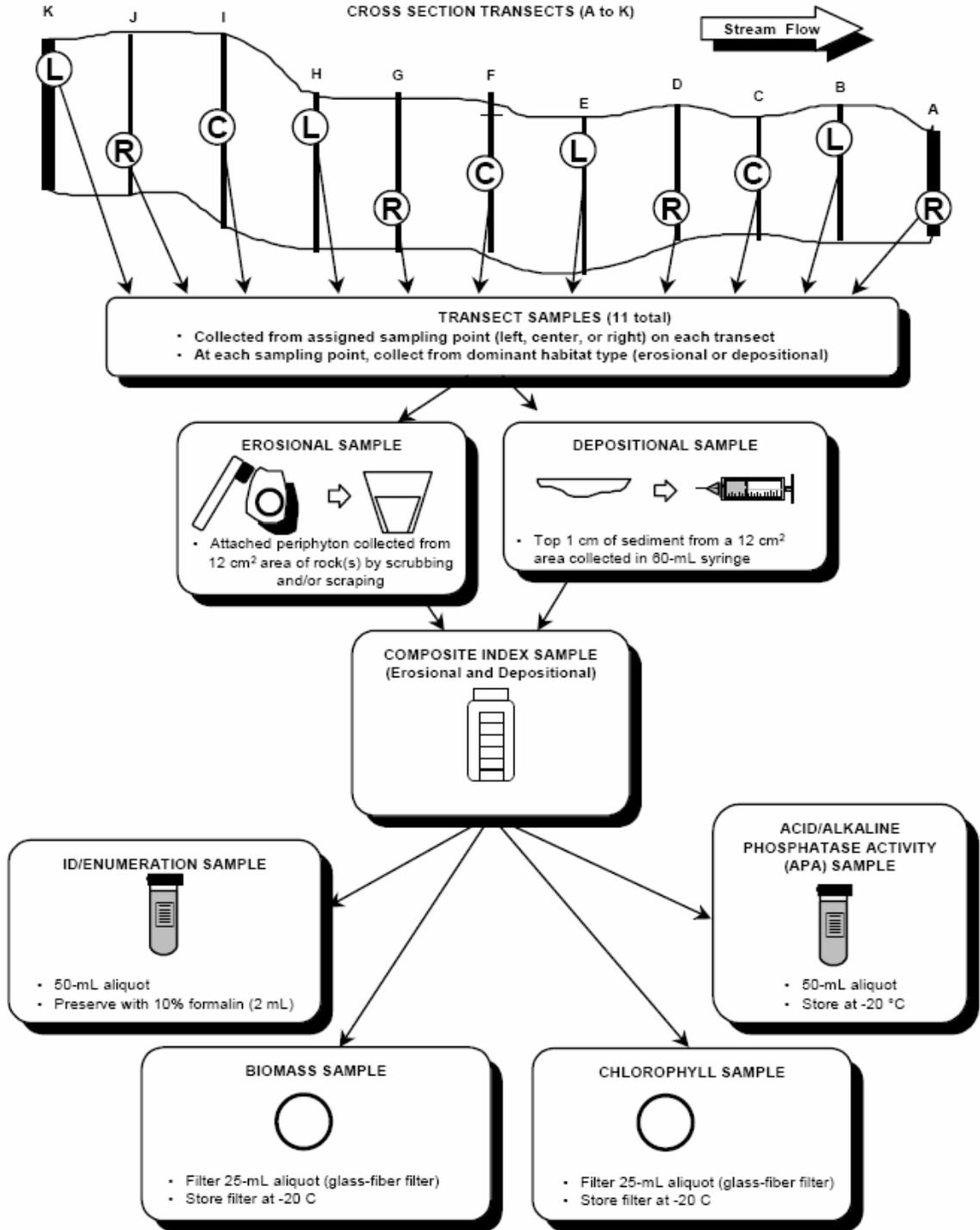


TABLE 20-1. PROCEDURE FOR COLLECTING COMPOSITE INDEX SAMPLES OF PERIPHYTON

1. Starting with Transect “A”, determine if the assigned sampling point (Left, Center, or Right) is located in an erosional (riffle) habitat or a slack water (pool) habitat. Collect a single sample at the point using the appropriate procedure in Step 2 below. **NOTE: to avoid disturbing the substrate on a transect, locate each sampling point 1 m downstream of the actual transect.**

If the sampling points were not assigned previously when laying out the sampling reach, proceed to Transect “A”. Roll a die to determine if it is a left (L), center ©, or right ® sampling point for collecting periphyton and benthic macroinvertebrate samples. A roll of 1 or 2 indicates L, 3 or 4 indicates C, and 5 or 6 indicates R (or use a digital wristwatch and glance at the last digit (1-3=L, 4-6=c, 7-9=r). Mark L, C, or R on the transect flagging. Assign sampling points at each successive transect in order as L, C, R after the first random selection.

2A. Erosional habitats:

- (1) Collect a sample of substrate (rock or wood) that is small enough (, 15 cm diameter) and can be easily removed from the stream. Place the substrate in a plastic funnel which drains into a 500-mL plastic bottle with volume graduations marked on it and labeled “PERIPHYTON.”
- (2) Use the area delimiter to define a 12-cm² area on the **upper** surface of the substrate. Dislodge attached periphyton from the substrate within the delimiter into the funnel by brushing with a stiff-bristled toothbrush for 30 seconds. **Take care to ensure that the upper surface of the substrate is the surface that is being scrubbed, and that the entire surface within the delimiter is scrubbed.**
- (3) Fill a wash bottle with stream water. Using a minimal volume of water from this bottle, wash the dislodged periphyton from the rock, delimiter, and funnel into the 500-mL bottle.

2B. Depositional habitats:

- (1) Use the area delimiter to confine a 12-cm² area of soft sediments.
 - (2) Vacuum the top 1 cm of sediments from within the delimited area into a catheter-tipped syringe (35-60-mL size).
 - (3) Empty the syringe into the 500-mL “PERIPHYTON” bottle (combining it with samples collected from erosional habitats).
3. Repeat Steps 1 and 2 for transects “B” through “K” to produce the composite index sample for the stream reach. Keep the collection bottle out of direct sunlight as much as possible to minimize degradation of chlorophyll.
 4. After samples have been collected from all eleven transects, mix the 500-mL bottle thoroughly. Record the total estimated volume of the composite sample in the periphyton section of the Sample Collection Form. Also record the number of transects at which you obtained a periphyton sample.
-
-

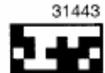
Figure 20-2 Sample Collection Form, showing data recorded for periphyton samples

SAMPLE COLLECTION FORM - STREAMS Reviewed by (initial): SW

SITE ID: WXXP99-9999 DATE: 07/01/2001

WATER CHEMISTRY																							
Sample ID		Transect		Comments																			
<u>229015</u>		<u>X</u>																					
REACH-WIDE BENTHOS SAMPLE																							
Sample ID		No. of Jars		Comment																			
<u>999001</u>		<u>2</u>		<u>FOR TRANSECT K OTHER</u>																			
TRANSECT		A		B		C		D		E		F		G		H		I		J		K	
SUBSTRATE	CHAN.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.
Fine/Sand	Pool	<input type="checkbox"/> F	<input type="checkbox"/> P	<input checked="" type="checkbox"/> F	<input type="checkbox"/> P	<input checked="" type="checkbox"/> F	<input checked="" type="checkbox"/> P	<input type="checkbox"/> F	<input type="checkbox"/> P	<input type="checkbox"/> F	<input type="checkbox"/> P	<input type="checkbox"/> F	<input type="checkbox"/> P	<input type="checkbox"/> F	<input type="checkbox"/> P	<input checked="" type="checkbox"/> F	<input type="checkbox"/> P	<input checked="" type="checkbox"/> F	<input checked="" type="checkbox"/> P	<input checked="" type="checkbox"/> F	<input checked="" type="checkbox"/> P	<input type="checkbox"/> F	<input checked="" type="checkbox"/> P
Gravel	Glide	<input checked="" type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G
Coarse	Riffle	<input type="checkbox"/> C	<input checked="" type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI	<input type="checkbox"/> C	<input checked="" type="checkbox"/> RI	<input checked="" type="checkbox"/> C	<input checked="" type="checkbox"/> RI	<input type="checkbox"/> C	<input checked="" type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI	<input type="checkbox"/> C	<input type="checkbox"/> RI
Other: Note in Comments	Rapid	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input type="checkbox"/> O	<input type="checkbox"/> RA	<input checked="" type="checkbox"/> O	<input type="checkbox"/> RA
TARGETED RIFFLE BENTHOS SAMPLE																							
Sample ID		No. of Jars		Comment																			
<u>999002</u>		<u>1</u>																					
NEAREST TRANSECT		A		A		E		E		F		F		G		G		SUBSTRATE SIZE CLASSES					
Dom. Substrate	Fine/Sand	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	<input type="checkbox"/> F/S	F/S - ladybug or smaller (<2 mm)					
	Gravel	<input checked="" type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input type="checkbox"/> G	<input checked="" type="checkbox"/> G	<input checked="" type="checkbox"/> G	G - ladybug to tennis ball (2 to 64 mm)								
	Coarse	<input type="checkbox"/> C	<input type="checkbox"/> C	<input checked="" type="checkbox"/> C	<input type="checkbox"/> C	<input checked="" type="checkbox"/> C	<input type="checkbox"/> C	<input checked="" type="checkbox"/> C	<input checked="" type="checkbox"/> C	<input type="checkbox"/> C	<input type="checkbox"/> C	<input type="checkbox"/> C	<input type="checkbox"/> C	<input type="checkbox"/> C	C - tennis ball to car sized (64 to 4000 mm)								
	Other: Note in Comments	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	<input type="checkbox"/> O	O - bedrock, hardpan, wood, etc								
Additional Benthos Comments																							
COMPOSITE PERIPLYTON SAMPLE																							
Sample ID		Composite Volume (mL)				Number of transects sampled (0-11):																	
<u>800990</u>		<u>500</u>				<u>11</u>																	
Assemblage ID (50-mL tube, preserved)				Chlorophyll (GF/F filter)				Biomass (GF/F Filter)															
Sample Vol. (mL)		Flag		Sample Vol. (mL)		Flag		Sample Vol. (mL)		Flag		Sample Vol. (mL)		Flag		Sample Vol. (mL)		Flag					
<u>50</u>				<u>25</u>				<u>25</u>				<u>25</u>				<u>25</u>							
Flag		Comments																					

Flag codes: K = Sample not collected; U = Suspect sample; F1, F2, etc. = misc. flag assigned by field crew. Explain all flags in comment sections.



20.2 Preparation of Laboratory Samples

Three different types of laboratory samples are prepared from the composite index sample: an ID/enumeration sample (to determine taxonomic composition and relative abundances), a chlorophyll sample, and a biomass sample (for ash-free dry mass). All the sample containers required for an individual stream should be sealed in plastic bags until use to avoid external sources of contamination (e.g., dust, dirt, or mud) that are present at streamside.

A set of completed periphyton sample labels is shown in Figure 20-3. All labels in a set have the same sample ID number. Circle the appropriate type of sample (chlorophyll, biomass, etc.) on each label. Attach completed labels to the appropriate containers and cover with clear tape. When attaching the completed labels, do not cover any volume graduations and markings on the container.

Species Identification Sample

Prepare the Species Identification sample as a 50-mL aliquot from the composite index sample, following the procedure presented in Table 20-2. Record the Storet number from the sample container label and the total volume of the sample (50 mL) in the appropriate fields on the Sample Collection Form as shown in Figure 20-2. Explain any deviations from the 50 mL target volume in the comments field of the collection form. Store the samples upright in a container, on ice.

Figure 20-3. Completed set of periphyton sample labels

PERIPHYTON STORET # <u>490 5001</u> <u>7</u> / <u>1</u> /2006 BIO CHLA <u>ID</u> SUBSAMPLE VOLUME: <u>50</u> mL COMPOSITE VOLUME: <u>500</u> mL 100000	PERIPHYTON STORET# <u>490 5001</u> <u>7</u> / <u>1</u> /2006 BIO <u>CHLA</u> ID SUBSAMPLE VOLUME: <u>25</u> mL COMPOSITE VOLUME: <u>500</u> mL 100000	PERIPERIPHYTON STORET# <u>490 5001</u> <u>7</u> / <u>1</u> /2006 <u>BIO</u> CHLA ID SUBSAMPLE VOLUME: <u>25</u> mL COMPOSITE VOLUME: <u>500</u> mL 100000
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Chlorophyll Sample

Prepare a chlorophyll sample by filtering a 25-mL aliquot of the composite index sample through a glass fiber filter (Whatman GF/F or equivalent). Chlorophyll

can degrade rapidly when exposed to bright light. If possible, prepare the samples in subdued light (or shade), filtering as quickly as possible after collection to minimize degradation. Filtration is described in Section 4 and 9. Keep the glass fiber filters in a dispenser inside a sealed plastic bag until use.

It is important to measure the volume of the sample being filtered accurately (± 1 mL) with a graduated cylinder. During filtration, do not exceed 7 pounds per square inch (psi) to avoid rupturing cells. If the vacuum pressure exceeds 7 psi, prepare a new sample. If the filter clogs completely before the entire sample in the chamber has been filtered, see Section 4 and 9.

After filtering the sample, fold the filter paper in half and place it in a dark film canister. Complete a sample label (Figure 20-3) and check it to ensure that all written information is complete and legible. Affix the label to the centrifuge tube and cover it completely with a strip of clear tape. Record the Storet number printed on the label on the Sample Collection Form (Figure 20-2). Make sure the volume recorded on each sample label matches the corresponding volume recorded on the Sample Collection Form. Place the sample on dry ice for shipment to the laboratory.

Biomass sample

Measure a thoroughly homogenized 25-mL aliquot of the composite index sample and pour into a centrifuge tube. As with the chlorophyll sample, it is important to measure the volume to be filtered accurately (± 1 mL).

Check the sample label to ensure that all written information is complete and legible. Affix the label to the 50-mL centrifuge tube and cover it completely with clear tape. Record the Storet number printed on the label and the volume filtered on the Sample Collection Form as shown in Figure 20-2. Make sure the information recorded on each sample label matches the corresponding values recorded on the Sample Collection Form. Record a flag and provide comments on the Sample Collection Form if there are any problems in collecting the sample or if conditions occur that may affect sample integrity. Store each labeled sample container on dry ice until delivered to the laboratory (Section 3).

20.3 Equipment and Supplies

Figure 20-4 is a checklist of equipment and supplies required to conduct periphyton sample collection and processing activities. Use this checklist to ensure that equipment and supplies are organized and available at the stream site in order to conduct the activities efficiently.

Figure 20-4. Checklist of equipment and supplies for periphyton

EQUIPMENT AND SUPPLIES FOR PERIPHYTON

QUANTITY	ITEM	
1	Large funnel (15-20 cm diameter)	
1	12-cm ² area delimiter (3.8 cm diameter PVC pipe, 3 cm tall)	
1	Stiff-bristle toothbrush with handle bent at 90° angle	
1	1-L wash bottle labeled "STREAM WATER"	
1	1-L wash bottle labeled for and containing deionized water	
1	500-mL plastic bottle (with volume markings) for composite index samples, labeled "PERIPHYTON COMPOSITE SAMPLE"	
4	50-mL screw-top centrifuge tubes	
1 box	Glass-fiber filters for chlorophyll and biomass samples	
1 pair	Forceps for filter handling	
1	25-mL or 50-mL graduated cylinder	
1	Filtration unit, including filter holder	
1	Pump and clear plastic tubing	
1	Small lightproof plastic bags for storing chlorophyll and biomass samples	
2	Self-sealing plastic bags for chlorophyll and biomass samples	
2 sets	Sample labels (3 per set) with the same Storet number	
1	Sample Collection Form for stream	
	Soft (#2) lead pencils for recording data on field forms	
	Fine-tipped indelible markers for filling out sample labels	
1 pkg.	Clear tape strips for covering labels	
1	Portable freezer, cooler with dry ice, or cooler with bags of ice to store frozen samples	
1 copy	Field operations and method manual	
1 set	Laminated sheets of procedure tables and/or quick reference guides for periphyton	

21.0 STANDARD OPERATING PROCEDURES FOR THE COLLECTION AND PROCESSING OF FISH SAMPLING FOR MERCURY ANALYSIS

21.1 Abstract

The following document presents the sample collection and preparation procedure to be implemented for the collection of fish samples for mercury analysis. Fish collection procedures can be variable depending upon the circumstances associated with sampling. Depending upon the specific water body being sampled and possible multiple purpose sample efforts undertaken, fish could be collected by electro shocking, gill netting or any other means that will provide fish in conditions required for the analysis. A minimum of five fish of each species are required for statistically significant comparison to human health criteria on stream sites. Lakes require five fish from at least two sites. After the fish are collected, measured for length, weighted, and identified by species, each are given an identification number. The whole fish (preferred method) or a filet is wrapped in aluminum foil, labeled, and placed on preferably dry ice or regular ice. The sample is placed in the freezer upon returning to the home bases until delivered to the State laboratory with the accompanying paperwork.

The physical whole fish data is electronically entered into the DWQ database. At the State Laboratory, a sub sample or plug is removed from each fish and placed in a pfd tube. Field data is electronically entered into the DWQ database and awaits the arrival of laboratory analysis data which is added to the field data set.

Results are reviewed, and an exceedence is noted, the data is given to the Utah Department of Health epidemiologist for further action.

21.2 Background and Project Description:

Fish advisories for mercury occur throughout the United States, but until the summer of 2005 they were absent from Utah. Sites were screened for potential mercury contamination using historical data associated with the EPA funded Environmental Monitoring and Assessment Program (EMAP) and the National Study of Chemical Residues in Lake Fish Tissue. Two streams and three reservoirs indicated mercury limits above the recommended value of .3. Subsequently, they were sampled again in the summer of 2005. Results from that sampling resulted in three mercury fish advisories. Based upon these events, the Division of Water Quality has determined it is in the States best interest to develop an ongoing monitoring program for mercury in fish.

Five individual tissue samples from the dominant consumable species of fish in streams is the minimum acceptable requirement for a viable analysis for comparison to human health criteria. Lakes or reservoirs require 5 individual

from at least two sites on the water body. Although the preferred sample set from a water body would include 5 individual tissue samples from each of several size categories for all consumable fish species present, resources at this time limit the optimum situation. Currently, five fish from the largest size category are collected.

Three sample types are acceptable. Whole fish are preferred, but individual fillets or plugs can be taken. Whole fish reduce the possibility of contamination while the sample is awaiting analysis at the laboratory. Fillets could be taken when the sample crew is in the field for several days and the volume of cold storage space could be problem with whole fish. Plugs will be used only on large trophy game fish, therefore, leaving them available for the sport fisherman.

21.3 Sample Design

Sample design will follow the protocols as outlined by Western EMAP. Sampling in streams requires a minimum sampling length of 40 times the wetted width. Streams less than 4 meters in width will be sample in a 150 meter length. Five fish of the largest size category are collected over the entire reach. In streams with low densities of larger fish, fish in smaller length category may be utilized to obtain the five fish sample. In extreme low fish populations, the reach may need to be extended until the five fish have been collected.

As collection begins, the dominate species will be determined. Streams with two dominate species will require 5 fish from each species.

The Utah Department of Health recommends that samples from lake or reservoirs require 5 fish from a minimum of two sites to be statically viable. Larger water bodies over 500 acres will require additional sites. A formula for number of sites on larger lakes will be developed later. Lakes with multiple dominate species should include fish from pelagic and bottom feeding fish. Lakes may have multiple pelagic species; therefore, five fish from at least two of the species should be collect.

21.4 Field Sampling Methods

Fish Collection Protocal

Fish may be obtained by a variety of methods. Utah Divisions of Water Quality and Wildlife Resources commonly utilize electro shocking on streams and gill nets on lakes and reservoirs.

Electro shocking is labor intensive requiring at least a four person crew. The shocking crew works upward through the reach utilizing a one pass method catching, identifying, measuring, weighing and transporting a small live well for storing the needed five fish. Since the objective is not to determine populations, but to determine the variety and ratio of species and obtain fish for samples, the

one pass method without blocking of the reach is not necessary. Meta data is recorded for all species, not just the target species for analysis.

Gill nets are set on lakes and reservoirs generally in conjunction with the Division of Wildlife Resources. The net is fished overnight and net pulled early in the morning. As the net is pulled, one crew member with latex gloves removes the needed fish from the net as it emerges from the water. The fish are bagged individually in plastic zip lock bags until the net is cleared. The fish are processed as described below.

Field Sample Preparation

Upon completing collection of the required number of fish, processing will begin immediately.

Care should be taken to assure quality control through the preparation. Latex gloves will be worn by all processing fish. Any equipment used in filleting should be decontaminated between each fish processed by being rinsed with regular water, then 10 % nitric acid solution, and then rinsed with distilled water. A new piece of aluminum foil will be spread on a cutting board before filleting each fish. The measuring board and scales will be rinsed with stream water between each measurement.

The species, length, and weight are recorded.

Fillets are obtained by following steps 1-9 listed below in the Sample Preparation Analysis section listed below except in step 8, the fillet should be 3 inches long.

Place the entire fish or the fillet on a clean sheet of aluminum foil, dull side toward the sample.

Wrap the fish with enough foil to somewhat seal the fish.

A plug sample will be taken in the same area as described above. The corer will be quickly inserted into the fish, twisted slightly and removed. The entire corer with the sample will be wrapped in foil as described above. Apply antiseptic to fish.

A label with the required field and identification information will be attached to the foiled sample (see example). The sample is placed in a zip lock bag with the identification code which consists of the site STORET number/species code/fish number (1-5), and immediately place preferably on dry ice. An example of the Identification Coding from a site for the five required fish is as follows:

Storet #, Species code, fish #

4905002BRT01

4905002BRT02

4905002BRT03
4905002BRT04
4905002BRT05

Samples on regular ice will be either shortly placed in the freezer near the sampling location or delivered to the laboratory on dry ice.

21.5 Sample Preparation Before Analysis

Whole Fish

The following procedure is best performed by two individuals. One person can work the sample while the other clears and decontaminates the equipment.

1. Frozen samples are removed from the freezer. Let the sample only slightly defrost.
2. Sterile 15 ml PVSC centrifuge sample tubes can be pre labeled from labels on the frozen samples.
3. Both individuals put on latex gloves. Gloves are discarded between each fish processed.
4. The decontamination person prepares a pistol and mortar plus scalpels by rinsing with a solution of 10 % nitric acid followed by a deionized water rinse.
5. On a PVSC type cutting board, place a clean sheet of aluminum foil. The foil can be replaced between processing each fish, thus reducing cross contamination. The sample is unwrapped from the aluminum foil on the board. Place the foil aside for rewrapping the specimen for future reference.
6. With a stainless steel scalpel, cut an incision from behind the head to the mid dorsal fin and slightly to one side of the back bone, cutting to the rib cage, but not into the body cavity. Cut two more incisions' from the beginning of the back bone and cut downward to the end of the rib cage. Beginning at the back bone, cut the fillet off the carcass with small scalpel strokes toward the belly. Belly meat should not be part of the fillet. Next, cut the skin and fillet off the carcass from front to back.
7. Lay the fillet on part of the cutting board with foil not used.
8. In the center of the fillet, make two cuts $\frac{1}{2}$ inch apart cross ways of the fillet to the skin. Do not cut the skin.
9. Cut the fillet of the skin between the two cross ways cuts.
10. With the scalpel, place the thin strip of fillet in the mortar.
11. Rewrap the remaining fish in the original foil and return the specimen to the freezer.
12. Second person masticates the sample thoroughly adding a small piece of dry ice. With a stainless steel scalpel, scrape the masticated sample into

the prelabeled PVSC tube. Label will include the coding as described above.

13. Place in freezer.
14. Decontamination pistol, mortar, and scalpels.
15. Remove and discard foil from cutting board
16. Discard latex glove.
17. Fill out a laboratory request form (see attached).
18. The meta data from the field must be on the laboratory request form.

Fillets

1. Skip to step 11 above

Biopsy Punches

1. See step 1-5 above
2. With the laboratory pipette bulb, quickly blow the sample into the mortar.
3. See steps 12-18 above.

21.6 Analytical Method

EPA method 7473 (thermal decomposition) requires less than 1 gram of fish tissue to produce analyses with reporting limits as low as .005 ug/kg. The methodology and quality assurance for this method and lab procedures can be obtained from the Division of Laboratory Services

21.7 Equipment and Supplies:

- _____ Fish measuring board.
- _____ Fish weigh scale.
- _____ Plastic bags.
- _____ Sterile 15 mL PVSC centrifuge sample tube.
- _____ Coolers with dry ice or regular ice.
- _____ Field data forms (Figure 1).
- _____ Sample Analysis Request forms (Figure 2).
- _____ Sample labels (Figure 3).
- _____ Latex gloves.
- _____ 8 millimeter disposable biopsy punch (Acuderm brand Acu-Punch or equivalent)
- _____ Laboratory pipette bulb.
- _____ Antibiotic salve.
- _____ Scalpel
- _____ Pistol & mortar
- _____ Water proof pen.
- _____ Heavy duty aluminum foil
- _____ Fish collection gear (nets, electro shocker etc.).
- _____ 10 percent nitric acid rinse made from ultra-pure certified trace-metal grade concentrated nitric acid.
- _____ Laboratory-grade deionized water (for rinsing cutting equipment and board between samples)

21.8 Fish Forms and Data Entry Tables

The following three forms are used for fish data entry and submittal of samples to the laboratory.

FIGURE 21.1. FIELD SAMPLING FORM

Date	Sampler Last Name	Sampler last name	Site Description	Site ID (storet #)	Length of transect fished	Fishing Duration	Gear	Water visibility
Comments								
		Fish Id = Station ID + Species ID + Sample count (2 digits)	Example Fish id 591322RBT01					
Fish Data								
Sample count	Species	Fish id	Fish length	Fish Weight				
1								
2								
3								
4							Species	Spec ID
5							Rainbow Trout	RBT
6							Brook Trout	BKT
7							Brown Trout	BRT
8							Cutthroat Trout	CTT
9							Tiger Trout	TGT
10							Lake Trout	LKT
11							Splake	SPT
12								
13							Small Mouth Bass	SMB
14							Large Mouth Bass	LMB
15							Striped Bass	STB
16							White Bass	WHB
17								
18							Yellow Perch	YLP
19							Channel Catfish	CCF
20							Black Bullhead	BBH
21							Black Crappie	BLC
22							Common Carp	CMC
23							Mountain Whitefish	MWF
24							Walleye	WLE
							Bluegill	BLG

Figure 1: Hard Copy of Fish Data Form. Electronic copy is an equivalent Excel spreadsheet.

Storet# _____ Date _____
Site Description _____
_____ Samplers _____
Fish ID _____

Figure 21.2: PVSC label for fish tissue sample.

Figure 21.3. Laboratory Analysis Request Form

UTAH STATE WATER QUALITY SYSTEM
MONITORING RUN PROGRAM

MONITORING RUN: MERCURY IN FISH

TRIP ID: ASSESSMENTA2005

RUN SEQUENCE NUMBER: 1

STORET: 0000000

LAB ID: [113]

TYPE: [4]

PROJECT: 555

DESCRIPTION: #

COLLECTOR: [OSTERMILLER] [] [] [] [] AGENCY: [] []

DATE: [] [] [] [] [] [] TIME: [] [] [] []
Y Y M M D D

WEATHER CONDITIONS: [] [] / [] [] / [] []

FIELD CONDITIONS: [] [] / [] [] / [] []

FIELD TESTS

AIR TEMP. (CELCIUS):	[] [] . []	TRANSPARENCY (METERS):	[] [] . []
TEMPERATURE (CELCIUS):	[] [] . []	CL. RESID :	[] . [] []
pH :	[] [] . []	TURBIDITY (NTU) :	[] [] . []
SP COND UMHOS/CM	[] [] [] [] []	FLOW (MGD) :	[] [] [] . []
SALINITY PPM:	[] [] [] [] . [] []	FLOW (GPM) :	[] . [] []
% D.O. SATURATION :	[] [] [] . []	FLOW (CFS) :	[] [] [] [] [] [] . []
D.O. :	[] [] . []	FLOW ESTIMATED :	[] MEASURED : []
DEPTH : (METERS)	[] [] [] . []		

METHOD: Mercury FishTissueTube : TEMP: pH: COMMENTS:

FIELD COMMENTS:

WEIR TYPE	_____	PIPE DIA	_____	BUCKET SIZE	_____
WIDTH	_____	DEPTH	_____	SECONDS	_____
DEPTH	_____	VELOCITY	_____		

STR WIDTH _____

DEPTH _____

VELOCITY _____

21.9 Bibliography

North Dakota Environmental Monitoring Quality Assurance Project Plan, Section 17.

EPA Quality Assurance Project Plan for Sample Collection Activities for a National Study of Chemical Residues in Lake Fish Tissue

EPA Method 7473 Analysis of Mercury by Thermal Decomposition

United States Department of the Interior National Irrigation Water Quality Program Information Report No. 3: Guidelines for Interpretation of the Biological Effects of Selected constituents in Biota, Water, and Sediment: Mercury.

Quality Assurance Project Plan: Screening Survey of Mercury Levels in Edible Fish Tissue from Selected Lakes and Rivers of Washington State.

Low-Level Collection Techniques and Species-specific Analytical Methods for Mercury in Water, Sediment, and Biota. USGS publication.