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EVALUATION OF THE HYDROLOGY AND GEOLOGY OF THE MOONLIGHT SPRINGS AREA, NOME, ALASKA: QUALITY ASSURANCE PROJECT PLAN

By

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Alaska Division of
Geological and Geophysical Surveys

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ERRATA

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"Evaluation of the hydrology and geology of the Moonlight Springs area, Nome, Alaska: Quality assurance project plan"

by
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Please make the following changes to page 11:

Duplicate samples should read:

Two aliquots (split from a single bottle of sample)

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Evaluation of the hydrology and geology of the
Moonlight Springs area, Nome, Alaska

Quality Assurance Project Plan

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INTRODUCTION

At the request of the City of Nome, the Division of Geological and Geophysical Surveys has been invited to design and conduct a hydrologic and geologic investigation to determine the geologic units from which water at Moonlight Springs emerges, the watershed area for Moonlight Springs, and land areas that contribute to the recharge of Moonlight Springs water. This plan has been prepared according to recently published guidelines (Alaska Department of Environmental Conservation, 1989) in order to facilitate dialog between the City of Nome and DGGS regarding detailed project objectives, methodologies, products, timelines, and costs.

History

Moonlight Springs has been used as a source of potable water for the Nome area since the early 1900's. In recent decades the City of Nome acquired ownership of the springs, and, in 1968, constructed an infiltration gallery, collection box, and piping to supply the city located about 3.5 mi to the south. Moonlight Springs is currently the only source of potable water available for the 4400 residents of Nome. Average daily use of water in 1987 was 438,000 gallons per day (0.68 cubic feet per second, or cfs) (Petrik, 1988). Out of concern for the effects of nearby gold mining activities on the spring, the City commissioned a study of the hydrology of the Springs (Ott Water Engineers, 1982). The study generally identified a recharge area for the Springs and made recommendations regarding land management practices within the recharge area in order to protect the quality and quantity of flow of Moonlight Springs. An ordinance was passed in January 1983, by the City of Nome providing for the issuance of watershed development permits within the Moonlight Springs watershed. A problem currently exists because the watershed area for Moonlight Springs has never been clearly and precisely defined. In addition, technical review of the moonlight springs hydrology report (L. Dearborn and J. Munter, DGGS, written commun., 1983) identified several significant technical problems that cast doubt on the validity of some of the conclusions and recommendations of the report. Recent legal advice to the City of Nome suggests that the report would be of minimal value in defending the City in litigation that could occur related to the watershed protection ordinance.

Principal issues regarding Moonlight Springs are focused on the protection of the quality and quantity of spring flow from the effects of

human activities. Identification of lands and waters that may influence the springs are important factors. Currently, the degree of uncertainty concerning these factors is large as a result of the limited data available and questionable practices of evaluating and interpreting these data. It is proposed that the degree of confidence in understanding these factors be increased by the collection of additional data with prescribed collection, evaluation, and interpretation methods.

An additional problem relevant to this project is whether or not the natural flows of Moonlight Springs are sufficient to supply existing and projected future demands of the City of Nome under conditions of seasonal and annual climate fluctuations. Spring flows are reported to be relatively low during late winter conditions, and a water shortage was reportedly narrowly averted in 1970 after a dry year (Leo Rasmussen, Nome, oral commun., 1989). Six miscellaneous discharge measurements made between 1960 and 1969 on file with the U.S. Geological Survey (USGS) range from 0.25 cfs to 6.7 cfs. This amount of data is inadequate to assess the adequacy of spring flows for municipal use.

Objectives

The objectives of the investigation are to:

1. Identify the quality of Moonlight Springs and nearby surface and ground waters with regard to major anions and cations, trace metals, and selected radiological components to allow comparisons and inferences regarding sources of waters;
2. Perform reconnaissance hydrogeological mapping to assess surface and ground-water flow system configurations;

3. To obtain flow measurements of Moonlight Springs and nearby surface and ground waters to assess short and long-term fluctuations of Moonlight Springs discharges and to estimate basin water budgets.

Approach

Existing historical data will be assembled and evaluated for technical validity. Continuous flow measurements will be obtained at the Moonlight Springs overflow structure and Anvil Creek near the springs with pressure transducers and digital data recording devices with periodic manual discharge measurements of surface flows. Metered water-use data will be obtained from the City Water Utility. Miscellaneous discharge measurements will be made at Specimen Gulch, Anvil Creek near Specimen Gulch, Cooper Gulch, Bear Creek, Little Creek, and an unnamed stream located a few hundred feet west of Moonlight Springs. Discharge estimates will also be made for seeps and springs visited during reconnaissance mapping activities.

Reconnaissance hydrogeologic mapping in the Anvil Mountain and surrounding areas will be initiated by examination of existing aerial photography and records searches supplemented by direct examination, measurement, plotting (on maps) and description of outcrops, vegetation patterns, soil types, water flowages, wells and excavations.

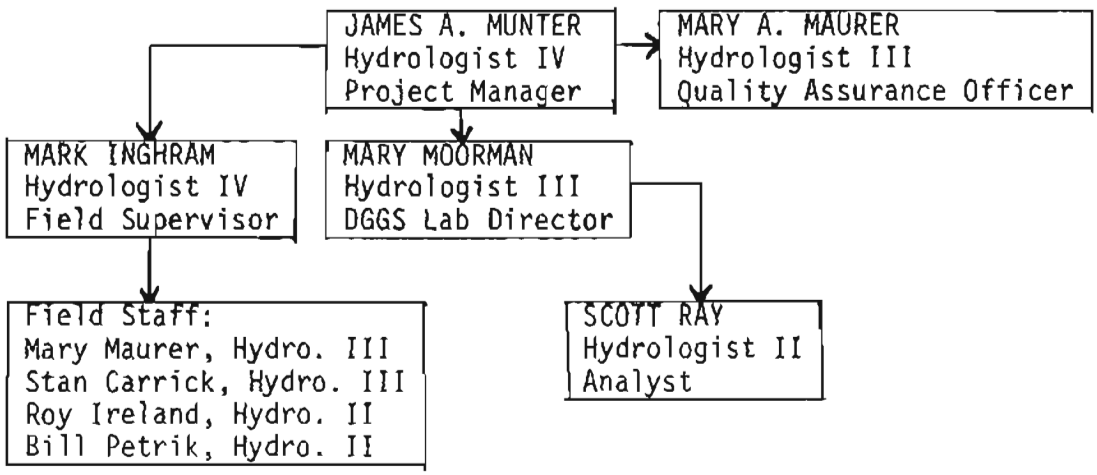
Water samples will be obtained from approximately 10 to 20 sites in the Nome area. Wells will be sampled by existing pumps or by bailers. Actual sample sites will be determined by physical access and permission-to-enter considerations. All lab analyses except for radiological parameters will be conducted at the DGGS Water Quality Laboratory on the University of Alaska

campus at Fairbanks. Radiological analyses will be conducted by commericial laboratories outside of Alaska. Core Laboratories, in Casper Wyoming, will be used for total alpha and total beta analyses and is certified by the U.S. Environmental Protection Agency for the analysis of radioactive contaminants in drinking water. The University of Miami Tritium Laboratory (1989) will be used for tritium analyses.

Project Organization and Responsibilities

Figure 1 depicts an organization chart for the Moonlight Springs project. The project manager is responsible for overall project design, performance, and reporting. He is the primary project contact person. The quality assurance officer is responsible for identifying and conducting appropriate methodologies for chemical analysis, overseeing commericial lab contracts, and reviewing field and lab results. The DGGS lab director is responsible for maintaining appropriate DGGS lab capabilities and conducting analyses as specified in this document. The field supervisor is responsible for organizing field excursions, logistics, equipment and supplies, and directing specific activities of field staff consistent with this document. Listed

Figure 1. DGGS organization chart for Moonlight Springs project.



field staff all have different specializations that include: water sampling; streamflow measurement; digital instrument installation, calibration and operation; and hydrogeologic mapping. The field supervisor will identify specific task leaders prior to each field trip.

QUALITY ASSURANCE OBJECTIVES

Data quality objectives for precision, accuracy, and optimum concentration ranges are listed in Table 1. Except for radiological parameters, these values were obtained from literature sources because the DGGS laboratory does not process a sufficient volume of samples to estimate precision and accuracy objectives. All analyses are expected to fall within the precision objectives listed, however. Because published values for accuracy are not available, calculated values for accuracy will be used only in a qualitative way, or for comparison with future data. The objective for completeness, the percentage of usable to total possible data, is 100 percent. Representativeness of data will be assured by selecting measurement and sampling stations such that principal water flows are sampled. In cases where flow is minimal or stagnant (such as a minor seep or a well), modification of the sampling site will be performed to enhance, channel or induce flows, or water will be artificially pumped or removed until general indicators of water quality (specific conductance or temperature) have stabilized to indicate that waters sampled are representative of the water body being sampled. Data comparisons will be conducted between all data collected during this study and previously collected data subsequent to an evaluation of the general quality of previously-collected data. A narrative description of the validity of data comparisons will be prepared for the final project report.

SAMPLING PROCEDURES

Surface and ground waters will be sampled according to the methods of the U.S. Geological Survey (1977) which are listed in Table 2. Containers, preservation techniques, and holding times (Table 2) are in accordance with U.S. Environmental Protection Agency Guidelines (40 CFS Part 136.3, p. 250-266, 1988) unless otherwise noted.

Stream discharge will be measured at all stream sampling locations according to U.S. Geological Survey methods (Carter and Davidian, 1968; Buchanan and Somers, 1969). A cross-sectional conductivity profile will determine whether the water is well-mixed. If conductivity fluctuates across the cross-section, depth-integrating sampling will be performed. Otherwise, a mid-depth grab sample will be taken from mid-channel.

A Hydrolab Model 4041 will be used to measure in situ water temperature, pH, and specific conductance in streams and springs. Water obtained from seeps and wells will be placed in a cup and measured immediately with the Hydrolab. Total alkalinity will be measured on site according to Method 310.1 (pp. 310.1-1 to 310.1-3) of the U.S. Environmental Protection Agency (1983). A Hach digital titrator will be used in this method. Turbidity of surface waters and Moonlight Springs will be measured on site with a Hach Model 16800 Porta Lab Turbidimeter unless serial dilutions are required in which case turbidity will be measured in the laboratory.

All sampling equipment including churn splitter, peristaltic pump tubing, filter head, bailers, depth-integrating sampling bottle, and graduated cylinders will be triple rinsed with deionized water between sampling sites.

SAMPLE CUSTODY

All sample containers will be cleaned according to U.S. Environmental Protection Agency (1982) methods. Upon departure from the lab, sample bottles will be under chain of custody (COC) procedures from that time until the final laboratory report is completed.

The field sampler is responsible for the custody of the sample containers and samples collected from the time of receipt of containers from the lab until they are shipped, at which time the sampler signs, dates, and notes time and method of shipment on the COC record. The sampler will also sign and place custody seals across the closures of the sample bottles and coolers used for shipping samples. Each laboratory receiving samples will receive a COC record. Mailed shipments are registered with return receipt requested. All sample bottles and samples not in direct possession or in view will be kept in secured locked areas until shipping.

Once samples are received by the DGGS Water Quality Lab, and recorded on the COC record and the project sample log sheet, they are considered to be in the possession of the lab. All samples, COC records, and analytical reports will be stored in a locked compartment accessible only to DGGS analysts. A ring binder lab notebook specifically for the Moonlight Springs project will be kept by the Water Quality Lab. In the front will be a log of all samples received by the lab for that project with indications of sample types and amounts. Also in front will be flow diagrams of analyses to be conducted on each sample type. The notebook will contain a data sheet for each sample locality and the "request for laboratory services/field data sample and chain of custody" form.

After the analyses are completed, any remaining samples will be stored in a locked, heated repository in the DGGS warehouse until the final analytical reports and quality assurance evaluations are completed.

The commercial laboratories that analyze radiological samples will follow COC laboratory procedures and document requirements. Documentation of laboratory operating procedures will be maintained in the project file.

CALIBRATION PROCEDURES AND STANDARDS

Field and laboratory instrument calibration frequency, standards and reference manuals are listed in Table 3.

ANALYTICAL PROCEDURES

Field and laboratory analytical procedures are listed in Table 4.

DATA REDUCTION, VALIDATION, and REPORTING

Data Reduction

Once raw data are received from analytical instrumentation readouts, final component concentrations are calculated by the analyst from computer-generated regression equations derived from multiple standard analyses. General data reduction procedures are described in Standard Methods (APHA, 1985). Specific data calculations are listed with the analytical method (see references in footnotes, Table 4).

Data Validation

The quality control and the sample analytical data will be validated by comparing the actual values obtained with the data quality objectives

described previously. Accuracy, precision, and completeness will be calculated using the formulas on pages 13-14 of this report.

The accuracy of major dissolved-constituent values will also be checked by following the procedures in Hem (1985, p. 164-165), which include calculating cation-anion balances, concentration relationships among major cations, and the relationship of conductivity to dissolved solids. A summary of these checks will be included in the final project report.

Data Reporting

An analytical report will be produced as the final product of the chemical analysis, and will include site identification, data analyzed, the concentration or value of the analyte, percent recovery, relative percent difference, estimated range of value, method code(s), digestion method (if applicable), and detection limits for each analyte. A final project report containing the results of all data collection activities and interpretations will also be prepared and published as a DGGS Report of Investigations or Professional Report.

INTERNAL QUALITY CONTROL CHECKS

Field Checks

Field Blanks One set of field blanks for each sample type will be collected to evaluate field cleaning procedures and identify possible cross-contamination between sampling sites. The field blank sample, which consists of deionized water, is processed on site through the same collection equipment and treatment procedures as all other field samples.

Duplicate samples Blind duplicate samples and identified duplicate samples will be used to assess the precision and reproducibility of field and laboratory procedures. Duplicates will represent ten percent of the total of each sample. At least one blind duplicate and one identified duplicate sample set will be taken on each sampling trip.

Laboratory Checks

The following laboratory checks will be performed by the DGGS Water Quality Lab:

Reagent blank A distilled, de-ionized water sample will be analyzed along with field samples.

Standards Standards in the concentration range of samples to be analyzed will be prepared daily from concentrated standards obtained from commercial sources which have been tested against National Institute of Standard Testing (NIST) reference standards and expiration dated.

Duplicate samples At least three aliquots (split from a single bottle of sample) will be taken from ten percent of the field samples and treated exactly the same throughout the laboratory procedures and analytical method.

Spikes Matrix spike samples and matrix spike duplicates will be used on ten percent of the field samples to evaluate the performance of analytical instrumentation.

Quality control samples Standard reference samples of known composition from the USEPA laboratory (Cincinnati, Ohio), USGS, or Environmental Research

Associates (a private firm supplying NBS certified sample) will be included in each analytical procedure during the course of this project to assure accuracy of the analytical system.

Systems Audits DGGS will submit to on-site field and laboratory systems audits by the City of Nome or its designated auditor upon request. The system auditor may evaluate field and laboratory operations and quality control procedures to assure that they are appropriate and used.

Performance Audits The DGGS Water Quality Lab participates in two quality assurance performance programs, one conducted by the USGS and one by the EPA. Both involve the analysis of blind samples distributed twice a year to participating labs. Performance evaluations for these two programs during the Moonlight Springs study will be available upon request.

The laboratory checks to be performed for tritium analyses are described in "procedures and standards" of the University of Miami Tritium Laboratory (1989). The laboratory checks to be performed for total alpha and total beta analyses are described in U.S. EPA (1980).

PREVENTATIVE MAINTENANCE

The main instruments involved in the analytical process at the DGGS Water Quality Lab are a Turner nephelometer, a Mettler analytical balance, two Perkin-Elmer atomic absorption spectrophotometers, a DIONEX ion chromatograph, and a Beckman direct current argon plasma. All of these instruments receive the routine daily maintenance outlined in their operator's manual and for most there is a modest supply of components which need routine replacement such as

columns for the DIONEX and bulbs for the nephelometer. The analytical balance receives yearly servicing by a representative of the manufacturer.

Preventive maintenance procedures for tritium instrumentation are described in University of Miami Tritium Laboratory (1989), and for total alpha and total beta instrumentation in U.S. EPA (1980).

STANDARD OPERATING PROCEDURES FOR ASSESSING DQO's

Standard operating procedures for assessing data objectives for precision are based on expected precision figures listed with methods in published references (see Table 4). Sample duplicates will allow actual precision to be calculated for major ions, metals, and radiological parameters using the following equation:

$$\text{precision} = \text{relative percent difference} = \frac{|D_2 - D_1| \times 100}{(D_1 + D_2/2)}$$

where: D_1 = first sample result

D_2 = second sample result

Matrix spiked samples will allow actual accuracy to be calculated for analytes, using the following formula:

$$\text{Accuracy} = \text{Percent recovery} = \frac{(SSR - SR) \times 100}{SA}$$

where: SSR = spiked sample result

SR = sample result

SA = amount of spike added

Completeness will be calculated after the study has been completed using the following formula:

$$\text{Completeness} = \text{percent useable data} = \frac{\text{useable data} \times 100}{\text{total possible data}}$$

The procedures that will be followed to assess sampling site representativeness are (1) actual hydrologic reconnaissance, (2) review of hydrologic records, and (3) guidelines in the USGS's "National Handbook of recommended methods for water-data acquisition", (USGS, 1977).

Data collected during the study will be compared to Alaska drinking water standards (ADEC, 1982). Data comparisons among sampling sites will be made using common statistical, graphical or analytical methods. Examples of these techniques are presented in Hem (1985, p. 162-188). Interpretations of data to clarify the likely source(s) of Moonlight Springs will be made using common hydrologic and hydrogeologic methods such as are described by Freeze and Cherry (1979), Fetter (1988), and other relevant literature sources.

CORRECTIVE ACTION PROCEDURES

Corrective actions will be implemented as soon as any measurement system is found to be out of control. Out of control situations are defined as unacceptable quality control measurements such as contamination of blanks, poor precision or low accuracy (based on data quality objectives), or improper sample storage or preservation. Corrective actions will consist of re-sampling, re-measuring, or re-analyzing all affected samples, if possible. Out of control data will either be discarded or used with appropriate

cautionary notes. The project manager will be responsible for initiating all corrective actions with the approval of the quality assurance officer.

QUALITY ASSURANCE REPORTING PROCEDURES

A quality assurance evaluation will be reported in writing to the project manager after receipt of analytical reports.

REFERENCES CITED

Alaska Department of Environmental Conservation, 1982, State of Alaska, Drinking water regulations: ADEC, Juneau, 20 p.

_____, 1989, Guidelines for preparing quality assurance project plans: unpublished report ADEC-QA-006/88, Revision No. 2, 5/19/89, 11 p.

American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985, Standard Methods for the Examination of Water and Wastewater, 16th edition: APHA, AWWA, WPCF, Washington, DC.

Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A8, 65 p.

Carter, R.W., and Davidian, Jacob, 1968, General procedures for gaging streams: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A6, 13 p.

Fetter, C.W., 1988, Applied hydrogeology; second edition: Merrill Publishing Co., Columbus, Ohio, 592 p.

Freeze, R.A., and Cherry, J.A., Groundwater: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water, Third Edition: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

National Archives and Records Administration, 1988, Code of Federal Regulations Title 40, Chapter 1 - Environmental Protection Agency (Continued) (Parts 100-149): U.S. Government Printing Office, Washington DC, 1988, 859 p.

Ott Water Engineers, Inc., 1982, Hydrology of Moonlight Springs: Unpublished report for Municipality of Nome, 12 p.

Petrik, William A., 1988, Summary of Water-Use Data in Alaska, 1987: Alaska Division of Geological and Geophysical Surveys Public Data File 88-37, 62 p.

U.S. Environmental Protection Agency, 1980, Precribed procedures for measurement of radioactivity in drinking water: U.S. Environmental Protection Agency, EPA-600/4-80-032 (1980 update), August 1980.

_____, 1982, Handbook for sampling and sample preservation of water and wastewater: U.S. Environmental Protection Agency, EPA-600/4-82-029 September 1982.

_____, 1983, Methods for chemical analysis of water and wastes: U.S. Environmental Protection Agency, EPA-600/4-79-020, 1 volume.

U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: U.S. Geological Survey Office of Water Data Coordination, Reston, VA, 3 volumes.

University of Miami Tritium Laboratory, 1989, Tritium and C14 Measurements - Price Schecule, Procedures and Standards, Advice on Sampling: Unpublished report, University of Miami, Rosenstiel School of Marine and Atmospheric Science, Tritium Laboratory, Miami, Florida, July 1989, 7 p.

Table 1. Data quality objectives for determining precision and accuracy as determined from sources listed below.

Component	Precision	Accuracy	Optimum Concentration Range
Alkalinity, as $CaCO_3$	10%	NA[1]	20-154 mg/l
Ions			
F	3.14%	NA[1]	0.48-4.84 mg/l
Cl	5.9%	NA[1]	0.76-455 mg/l
NO_3	21.5%	NA[1]	0.50-15.1 mg/l
SO_4	1.2%	NA[1]	0.51-43.7 mg/l
Na	SD^2=0.8 at 52 mg/l	NA[1]	0.03-1.0 mg/l
K	SD^2=0.2 at 1.6 mg/l	NA[1]	0.1-2 mg/l
Ca	7%	NA[1]	0.0002-500 mg/l
Mg	7%	NA[1]	.004-100,000 mg/l
Trace Metals			
As	SD^2=1.1 at 50 ug/l; 1.6 at 100 ug/l	NA[1]	5-100 ug/l
Al	30%	NA[1]	1-30,000 ug/l
Ba	RSD^3 ~ 3% throughout range	NA[1]	1-30,000 ug/l
Cd	10%	NA[1]	1-10,000 ug/l
Cu	14%	NA[1]	10-10,000 ug/l
Cr	S_T[4]=0.173 X + 2.44	NA[1]	10-55 ug/l
Fe	10%	NA[1]	3-10,000 ug/l
Fe, total	10%	NA[1]	3-10,000 ug/l
Hg	SD^2=0.39 at 0.60 ug/l	NA[1]	$\geq$ 0.5 ug/l
Mn	11%	NA[1]	1-10,000 ug/l
Pb	SD^2=1.6 at 50 ug/l	NA[1]	5-100 ug/l
Zn	4%	NA[1]	3-10,000 ug/l
Radiological			
Total alpha	20%	75-125%	
Total beta	20%	75-125%	
Tritium	±3.5%, one SD, or 6TU[5] whichever is larger	±3.5%, one SD, or 6TU[5] whichever is larger	

[1] NA = Accuracy values not available from published literature

[2] SD = Standard deviation

[3] RSD = Relative standard deviation

[4] S_T = Interlaboratory overall precision

[5] TU = Tritium units

Table 1. Continued

Sources:

"Methods for Determination of Inorganic Substances in Water and Fluvial Sediments", by M.J. Fishman and L.C. Friedman (editors), U.S. Geological Survey, Techniques of Water-Resources Investigation Book 5, Chapter A1, 1985, 709 p.

"Standard Methods for the Examination of Water and Wastewater (16th edition)", by American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, D.C., 1985.

"National Handbook of Recommended Methods for Water-data Acquisition", U.S. Geological Survey, Office of Water Data Coordination, Reston, VA, 1977.

"Prescribed Procedures for Measurement of Radioactivity in Drinking Water", EPA-600/4-80-032 (1980 update), U.S. Environmental Protection Agency, August 1980.

Tritium Laboratory Tritium and C14 Measurements, Price Schedule, Procedures and Standards, Advise on Sampling, July 1, 1989, University of Miami, Rosenstiel School of Marine and Atmospheric Science, Tritium Laboratory, 4600 Rickenbacker Causeway, Miami, FL 33149-1098.

Oral Communication, University of Miami Tritium Laboratory, (1989).

Table 2. Sampling procedures for surface and ground waters.

Parameter	Sampling method	Filtration equipment	Container	Preservation method[1]	Maximum holding time
Metals (As,Al,Ba, Cd,Cr,Cu,Fe,Mn, Pb,Zn)	Grab sample or DH-75P Depth Integrating Sampler for surface waters. Pump or bailer for ground waters. Water composited in churn splitter and split into subsamples.[2]	0.45 um membrane filter in GEOTECH backflushing filter w/MASTERFLEX peristaltic pump	250ml plastic	2ml ULTREX HNO_3	6 months
Mercury[3]	same as above	same as above	125ml glass	2ml ULTREX HNO_3, 0.01% $K_2Cr_2O_7$	28 days
Major Ions (F,Cl, NO_3,SO_4,Na,K,Ca,Mg)	same as above	same as above	500ml plastic	cool, 4°C	28 days[4]
Iron, total[5]	same as above	not applicable	250ml plastic	2ml ULTREX HNO_3	6 months
Total Suspended Sediment[6]	same as above	not applicable	250ml plastic	cool, 4°C	2 months[7]
Turbidity[6]	same as above	not applicable	250ml plastic	cool, 4°C	2 months[7]
Total alpha[8]	same as above	not applicable	1 L plastic	4ml ULTREX HNO_3	6 months
Total beta[8]	same as above	not applicable	1 L plastic	4ml ULTREX HNO_3	6 months
Tritium[8]	same as above	not applicable	1 L plastic	cool,4°C	Indefinite[2]

[1] All methods to be performed at the sampling site
[2] U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: USGS Office of Water Data Coordination, Reston, VA.
[3] Preservation method according to "Preservation of samples for dissolved mercury", by S.N. Hamlin, Water Resources Bulletin, American Water Resources Association, Volume 25, No. 2, pp. 255-262, 1989.
[4] Holding time for NO_3 exceeds EPA guidelines.
[5] Ground-water samples and Moonlight Springs only.
[6] Surface-water samples and Moonlight Springs only.
[7] Holding time exceeds EPA guidelines.
[8] Selected surface-water and ground-water samples only.

Table 3. Calibration frequency, standards, and traceability of field and laboratory instruments.

Parameter	Calibration Frequency	Instrument	Ref. Manual	Standard used[1]
Alkalinity	pH meter calibrated each titration, acid calibrated each month	Beckman pHI 11 meter	1	Na_2CO_3, Anhydrous, Suprapur
F,Cl,NO_3,SO_4	every 6 samples	DIONEX Ion Chromatograph	2	Orion NaF, NaCl, $NaNO_3$,$NaSO_4$
Na,K	every 6 samples	Perkin-Elmer Flame Atomic Absorption Spectrophotometer(AA)	3,4	NaCl in wk[2] HCl, KCl in wk HCl
As,Hg	every 10 samples	Perkin-Elmer AA, MHS-1 Mercury/Hydride System	3,5,6	As_2O_3 in $H_2SO_4H_2O$,HgO in wk HNO_3
Cd,Pb	every 5 samples	Perkin-Elmer AA 400 HGA Graphite Furnace	3,7,8	$CdCl_22H_2O$ in HCl/H_2O, $Pb(NO_3)_2$ in wk HNO_3
Al,Ba,Cu, Cr,Fe,Mn,Zn	every 6 samples	ARL DCP Plasma Spectrophotometer	9	$AlCl_36H_2O$ in HCl/H_2O, $BaCl_32H_2O$ in HCl/H_2O, Cu in wk HNO_3, $CrCl_36H_2O$ in wk HCl, $FeCl_36H_2O$ in wk HCl, $MnCl_24H_2O$ in wk HCl, $Zn(NO_3)_26H_2O$ in wk HNO_3
Water temperature, dissolved oxygen, pH, conductivity	the day before & after each field trip, biennial factory checkup	Hydrolab Model 4041	10	Temperature: compared against ERTCO precision-grade thermometer, complies with NBS. Dissolved oxygen:calibrated to water saturated air at temperature of D.O. cell. Conductivity: KCl solutions. pH: Beckman buffer solutions.
Turbidity	on-site before each measurement	Hach Portalab Turbidimeter Model 16800	11	Liquid latex secondary turbidity standard, periodically checked against formazin stock solution, APHA
pH	on-site before each measurement	Beckman pHI 11 meter	12	Beckman buffer solutions
Tritium	once weekly	low-level gas proportional counter	13	Standard water is prepared from NBS, Standard Reference Materials #4926 dead hydrogen gas, dead water, NAOH solution
Total alpha, Total beta	-	-	14	-

[1] DGGS Water Quality Lab uses commercial AA standards where possible, and the manufacturer, EM Science, reports to have tested them against NRS Reference Standards. All standards are expiration dated.

[2] wk = weak (approximately 10% by volume)

Table 3. (continued)

Reference Manuals

1 Beckman pHI 11 pH meters, instruction and maintenance; Beckman Instruments, Inc., Irvine, CA 92713.

2 DIONEX ION CHROMATOGRAPHY COOKBOOK, A Practical Guide to Quantitative Analysis by Ion Chromatography, DIONEX Corp., 1228 Titan Way, Sunnyvale, CA 94088-3603, 1987

3 Perkin-Elmer Model 4000 Atomic Absorption Spectrophotometer, Perkin-Elmer Corp., Norwalk, Connecticut, USA; Revised April 1979.

4 Analytical Methods for Atomic Absorption Spectrophotometry, Perkin-Elmer Corp., printed in West Germany, January 1982.

5 Perkin-Elmer MHS-1 Mercury/Hydride System Operator's Manual; Perkin-Elmer Corp., Printed in West Germany, August 1977.

6 Analytical Methods using the MHS Mercury/Hydride System, Perkin-Elmer Corp., printed in West Germany, revised October 1978.

7 Perkin-Elmer HGA-400 Graphite Furnace Operator's Manual, Perkin-Elmer Corp., Printed in West Germany, April 15, 1979.

8 Analytical Methods for Furnace Atomic Absorption Spectroscopy, Perkin-Elmer Corp., Printed in West Germany, Revised February 1980.

9 ARL SpectrSpan VI Rapid Scanning High Resolution Spectrophotometer Operator's Manual and Tutorial, Applied Research Laboratories, 3080 Enterprise Blvd., Brea, CA 92621, July 1987.

10 Operation and Maintenance Instructions Hydrolab Digital 4041 June 1981, Hydrolab Corporation, 12921 Burnet Road, Austin, TX 78759.

11 Instruction Manual Portalab Turbidimeter Model 16800, Hach Company, PO BOX 389, Loveland, CO 80539.

12 Instruction Manual pHI 11 meter, Beckman Instruments, Inc., Irvine, CA 92713.

13 Tritium Laboratory Tritium and C14 Measurements, Price Schedule, Procedures and Standards, Advise on Sampling, July 1, 1989, University of Miami, Rosenstiel School of Marine and Atmospheric Science, Tritium Laboratory, 4600 Rickenbacker Causeway, Miami, FL 33149-1098.

14 Prescribed Procedures for Measurement of Radioactivity in Drinking Water, "EPA-600/4-80-032 (1980 update), U.S. Environmental Protection Agency, August 1980.

Table 4. Field and analytical methods for surface water and ground-water samples.

Parameter	Method	Detection limit*
Alkalinity, as $CaCO_3$	Potentiometric titration (untreated sample, field) EPA Method 310.1[1]	
IONS		
F	Dionex ion chromatography[2]	0.01
Cl	Dionex ion chromatography[2]	0.01
NO_3	Dionex ion chromatography[2]	0.02
SO_4	Dionex ion chromatography[2]	0.01
Na	Flame atomic absorption (AA) spectrophotometry; EPA Method 273.1	0.1
K	Flame AA; EPA Method 258.1	0.01
Ca	Direct Current Plasma Emission spectrophotometry (DCP)[3]	0.001
Mg	DCP[3]	0.001
TRACE METALS		
As	AA, gaseous hydride; EPA Method 206.3[1]	0.004
Al	DCP[3]	0.002
Ba	DCP[3]	0.001
Cd	DCP[3]	0.001
Cu	DCP[3]	0.01
Cr	DCP[3]	0.001
Fe	0.1 um filter, DCP[3]	0.03
Fe, total[4]	unfiltered, HCl digestion, DCP[3]	0.03
Hg	AA, cold vapor, EPA Method 245.1[1]	0.002
Mn	DCP[3]	0.005
Pb	DCP[3]	0.03
Zn	DCP[3]	0.02
RADIOLOGICAL[5]		
Total alpha[5]	Proportional counter; EPA Method 900.0[6]	1 pCi/L
Total beta[5]	Proportional counter; EPA Method 900.0[6]	1 pCi/L
Tritium[5]	Gas proportional counting[7]	6 Tritium units or 0.02 pCi/mL

* mg/L, unless otherwise noted

Table 4. (continued)

Parameter	Method	Detection limit
OTHER DETERMINATIONS		
Total dissolved solids	Calculated from analytical data	
pH (units)	Beckman pHI meter, Model 11 (on-site)	
Specific Conductance (uS/cm)	Hydrolab Model 4041 (on-site)	
Water Temperature[8] (°C)	Hydrolab Model 4041 (on-site)	
Dissolved oxygen[8]	Hydrolab Model 4041 (on-site)	
Total suspended solids[8]	Gravimetric; EPA Method 160.2	
Turbidity (NTU)[8]	Hach turbidimeter (on-site), or Turner Nephelometer (laboratory); EPA Method 180.1	0.1 NTU

Footnotes

1 "Methods for Chemical Analysis of Water and Wastes," EPA 600/4-79-020, U.S. Environmental Protection Agency, March 1983.

2 Method 429 Determination of Anions by Ion Chromatography with Conductivity Measurement, "Standard Methods for the Examination of Water and Wastewater (16th ed.), American Public Health Association, 1985.

3 Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes, Method AES0029, 1986. Beckman Instruments, Inc., Corpus Drive at Jamboree Boulevard, Irvine, CA 98213.

4 Groundwater samples and Moonlight Springs only

5 Selected surface water and ground-water samples only

6 "Prescribed Procedures for Measurement of Radioactivity in Drinking Water", EPA-600/4-80-032 (1980 update), U.S. Environmental Protection Agency, August 1980.

7 Low Level Gas Proportional Counting. Procedures and Standards, revised June 1989. University of Miami, Tritium Laboratory, 4600 Rickenbacker Causeway, Miami, FL 33149-1098.

8 Surface water samples and Moonlight Springs only