Department of Environmental Protection
Bureau of Remediation & Waste Management
RCRA Program

Standard Operating Procedure Change Record

Title: **GROUNDWATER SAMPLING USING LOW FLOW PURGING AND SAMPLING FOR LONG-TERM MONITORING**

Identification #: **RWM-DR-003**

SOP Originator: **Brian Beneski**

Author	Revision	Description of Change	Date
Erika Bonenfant	RCRA01	Substitute MEDEP/RCRA in the place of MEDEP/DR, and Division of Oil and Hazardous Waste Facilities Regulation in the place of Division of Remediation. Section 2.0: Change first sentence to "MEDEP/RCRA is responsible for the investigation and subsequent corrective actions for RCRA facilities throughout Maine." Section 6.1 Field Procedure, 6th paragraph: Add sentence - "Preserve all samples according to guidelines in SAMPLING CRITERIA FOR METALS AND ORGANIC COMPOUNDS.	8/1/2009

Approved by:

Scott Whittier, RCRA Program Manager Date:

COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **GROUNDWATER SAMPLING USING LOW FLOW PURGING AND SAMPLING FOR LONG-TERM MONITORING**

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Standard Operating Procedure: **RWM-DR-003**
REVISION: **#04**
DATE: **March 27, 2009**
Written by: **Hank Andolsek/ Troy Smith**
Reviewed by: **Brian Beneski**

Five Year Review No Changes Needed:

Print Name:________________________ Signature:__________________________ Date:________

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1.0 PURPOSE

The purpose of this document is to describe the Maine Department of Environmental Protection, Bureau of Remediation and Waste Management, Division of Site Remediation's (MEDEP/DR) procedure for collecting groundwater samples from wells utilizing the Low Flow purging and sampling procedure. This SOP is similar to DR#002 entitled Groundwater Sample Collection for Site Investigation and Assessment Monitoring. DR#002 is intended to be used at sites where DQOs do not require long-term monitoring of concentration trends. The purpose of this SOP (DR#003) is for collecting groundwater samples from existing monitoring wells where DQOs require consistent documented procedures for collecting groundwater samples at regular intervals (quarterly, tri-annual, bi-annual, annual, etc.) to monitor data trends over time. Site specific DQOs should be reviewed to ensure the sampling methods are appropriate.

2.0 APPLICABILITY

MEDEP/DR is responsible for the investigation and remediation of hazardous substance, petroleum, and landfill sites throughout Maine. In the course of these investigations, samples must be taken to determine the geographical extent, chemical characteristics, and relative levels of contaminants at and in the vicinity of each site. This standard operating procedure (SOP) is designed to be a guideline for MEDEP/DR staff for collecting groundwater samples from monitoring wells using the low flow (minimum stress) purging and sampling procedure (LFS). This procedure is based on current research and field experience by MEDEP personnel. In addition to this SOP, it is recommended that personnel performing LFS review the published articles on this technique listed in Section 12, References, before attempting to perform the procedure for the first time.

3.0 RESPONSIBLITIES

LFS is the recommended methodology for long-term monitoring of groundwater. MEDEP staff must review the site-specific DQOs to determine whether LFS is an appropriate method to meet their data requirements. The field staff in MEDEP/DR and geological support staff in MEDEP/Technical Services (MEDEP/TS) in particular must be well versed in LFS. Their managers and supervisors are responsible for ensuring that they receive adequate training, are familiar with, and adhere to this procedure. Other staff members who may assist with LFS will receive training on an as needed basis.

4.0 INTRODUCTION

LFS is an appropriate method for long-term monitoring of groundwater at sites. The goal in any groundwater monitoring activity is to collect ground water samples that are representative of mobile organic and inorganic loads in the vicinity of the selected open well interval. Current research indicates that LFS is the best available technique for: 1) obtaining the most consistently representative samples of groundwater from the formation surrounding the screened interval of a properly installed monitoring well; 2) eliminate variability introduced by sampling technique; and 3) providing a basis for evaluating appropriateness of long-term groundwater sampling data.

LFS includes both a purge and no-purge option. The purge option for LFS involves pumping the well at a rate that minimizes dradown in a well to reduce mixing of the riser water and groundwater in the aquifer. Field parameters, such as pH and conductivity are monitored during purging until readings have stabilized; at this point, groundwater entering the pump intake represents formation water and the sample is collected.

In low permeability formations or poorly installed monitoring wells it may not be possible to collect groundwater samples using the specified purge techniques. In such instances, the no-purge option should be evaluated.

Additionally, this procedure is not designed to collect samples from wells containing light or dense nonaqueous phase liquids (LNAPLs or DNAPLS).

LFS is a skill which requires considerable experience and ongoing education and tuning on the part of those who perform it; therefore, at least one experienced person in LFS should always accompany every sampling team.

5.0 EQUIPMENT

The following list of equipment is necessary when performing LFS. Specific brand names indicate equipment owned by either MEDEP/DR and MEDEP/TS, and is available to staff for use. Deviations from this list must be indicated on the site specific sampling plan (see SOP DR#014, Development of a Sampling Plan).

> *Use of trademarked names does not imply endorsement by MEDEP/DR & /TS, only to identify the specific equipment owned by MEDEP/DR & /TS.*

5.1 PUMP

The pump selected must have capabilities of adjusting the flow rate without the use of flow restrictors. Types of acceptable pumps include: submersible, bladder and inertial pumps. The use of inertial pumps(e.g.peristaltic pumps) is permissible for most situations where the contaminants of concern have appropriate vapor pressures. Physical limitations on the use of peristaltic pumps also apply to wells with deeper water levels; wells with water levels greater than approximately 24 feet cannot be sampled with a paristaltic pump. In these instances, a submersible pump should be used.

The Department recommends the use of dedicated equipment, where possible, for long term monitoring plans.

5.2 TUBING

The goal in proper tubing selection is to maximize the tubing diameter, while minimizing the tubing length. Polyethylene is acceptable for most situations. However, site specific DQOs should be reviewed before selecting the appropriate tubing. Site with low concetrations of certain petroleum related contaminats should consider the use of tephlon lines polyethylene. One quarter (¼) inch inside diameter (ID) tubing is the standard size used in conjunction with peristalitic pumps. Three eighths (3/8) inch ID tubing is the size used with the submersible pumps.

As in the case with pumps, the use of dedicated tubing, where possible, will be used for long term monitoring programs.

5.3 POWER SUPPLY

The power supply options for the pumps include generators, deep cycle batteries, and compressed gas. If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples. If the operator of the generator has handled gasoline they should not handle the sampling equipment or sample containers.

5.4 INDICATOR PARAMETER MONITORING INSTRUMENTS

Site specific Data Quality Objectives (DQO) should be used to selct appropriate field parmeters. Field parmeter options include, but are not limited to:

- pH (EPA Methods 150.1 or 9040),
- turbidity (EPA Method 180.1),
- specific conductance (EPA Methods 120.1 or 9050),
- temperature (EPA Method 170.1),
- Oxidation Reduction(Eh), and
- dissolved oxygen (EPA Method 360.1).

A flow-through cell is required for dissolved oxygen and Eh measurements.

5.5 WATER LEVEL/FLOW MEASURING TOOLS

Water level and flow measurement are required for LFS. Several different water level meters, including Solinist® and Well Wizard®, are available to staff. A graduated cylinder and stopwatch are used for measuring flow in mL/minute.

5.6 DOCUMENTATION SUPPLIES

This includes a field notebook for taking field notes, and LFS data sheet, which can be found in attachment A.

5.7 WELL DOCUMENTATION

A well's location, well construction, previous sampling data, and the Sampling and Analysis Plan (SAP) should accompany samplers in the field.

5.8 MISCELLANEOUS SUPPLIES

Miscellaneous supplies include decontamination equipment and material, sample bottles, preservation supplies, sample tags and labels.

6.0 LFS PURGE AND SAMPLE PROCEDURE

6.1 PREPARATION

Prior to conducting a low flow sampling event, information regarding well construction, development, and water level records for each well to be sampled should be obtained and reviewed to determine the appropiate pump to be used, locating the intake, and the potential groundwater recharge rate of the well. If this information is not available, a reconnaissance should be made prior to the actual sampling event to determine well depth, water level, lenghth of screen, and an pump test to determine the recharge rate of the well. Additionally, wells that have not been sampled for two years should be redeveloped prior to conducting the actual sampling event.

6.1 FIELD PROCEDURE

1) Obtain static water level. Measure and record the depth to water (to 0.01 ft) in the well to be sampled before any disturbance to the well. Care should be taken to minimize suspension of any particulates attached to the sides or at the bottom of the well.

2) Install sampling pump or tubing. The use of dedicated sample tubing will reduce disturbance and water mixing in the well. In situations where dedicated equipment is not used, field staff will lower equipment., i.e., pump, safety cable, tubing and electrical lines, slowly into the well so that the pump intake is located at the center of the saturated screened interval to avoid sturring sediments in the bottom of the well.

3) Purge well. Flow rate and water level (drawdown) should stabilize before connecting the flow cell or obtaining any other measurements. Air or gas bubbles trapped in the sample tube can usually be removed by elevating the discharge tube and pump to allow the air to continue rising until discharged with the water. However, some groundwater have high dissolved gas levels and gas can not be completely removed from the sample tube. Check previous data sheets to assist in well set up, flow rates, and notes regarding gas presence in the sample tube.

Monitor water level and pumping rate frequently during the first five minutes of purging. If the recharge rate of the well is less than minimum capability of the pump the water level will not stabilize. If a constant water level can not be maintained at a flow rate of 80 to 100 mL/min., the no-purge option should be evaluated(see Section 9.0 No-Purge Option). Care should be used to avoid dewatering the screen or lowering the water level to the intake depth.

During well purging, monitor field indicator parameters every three to five minutes. Measurements of dissolved oxygen and Eh must be obtained using a flow-through cell. Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at three to five minute intervals).

4) Collect Samples. Collect samples in appropriate containers as indicated by laboratory conducting the analysis. Samples for laboratory analyses must be collected before the flow cell. This can be done by disconnecting the flow cell after reaching

stabilization, using a sample port before the flow cell, or by disconnecting the flow cell once parmeters have stabilized.

LFS will help reduce turbidity caused by improper purge and sampling techniques. The need for filtering water samples will be reduced by using this method. However, if turbidity values equilibrate above 30 NTUs, one should consider the need to collect both a filtered and an unfiltered sample. The use of an in-line filter is preferred. An in-line 0.2-0.45 um particulate filter should be pre-rinsed with approximately 25 - 50 mL of groundwater prior to sample collection, or as per filter manufacturers instructions. **Note that filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations representative of total mobile loads.**

After collection of the samples, any tubing used may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

7.0 PROCEDURE EVALUATION

The purpose of the LFS purge option is to sample the groundwater from the surrounding aquifer. If your well is not receiving sufficient recharge from the formation, the water level in the well will drop as pumping continues. This means that the discharge water could contain a significant percentage of stagnant water from the well casing. As the percentage of casing water increases, the representativeness of the sample decreases. If the percentage of casing water is significant, an alternative sampling technique, such as the No – Purge Option, should be considered (see Section 9). A Decision process for implementing low flow/no purge sampling can be found in Attachment A.

The second step in evaluating the viability of LFS for a potential no - purge well is to determine the volume of groundwater needed to fill the laboratory containers. Compare this volume to the volume of groundwater in the screened section of the monitoring well. If the volume of water contained in the screened zone is greater than the volume of sample required to fill the sample containers, then the no-purge option is appropriate for this well.

7.1 Calculating Formation/Stagnant Water Ratio

The following calculation will determine how much of the water being pumped is coming from the well, and how much is coming from the aquifer. This is done by comparing the total volume being purged to the drawdown volume in the well. If the equilibrium flow rate is 150 mL/min or lower for a given well, the following evaluation should be followed:

- Calculate the total volume of water discharged for a given time interval.
- Measure the total drawdown of the water level in the well during that time interval.
- Calculate the total drawn down volume in the well.(For a two inch diameter well there are ~660 mL/foot.)

Compare the total volume of water discharged to the total drawdown volume. If the drawdown volume comprises 60% or more of the discharge volume, the well construction should be evaluated.

7.2 Well Construction Evaluation

Evaluate the well construction. Was the appropriate screen slot size selected? Was the appropriate filter sand selected? If the well construction details are not appropriate for the formation then consideration should be given to installing a new, properly designed well. A poorly designed well will not yield representative samples no matter what purging procedure is utilized.

Any sampling of wells that have not been sampled for more than three years should be evaluated to determine if re-development is necessary before attempting to sample with LFS.

8.0 PROCEDURE MODIFICATIONS

The LFS procedure can be modified to meet the Data Quality Objectives for the Sampling Event. In long-term monitoring events it may be possible to reduce the field parameter list after baseline information is obtained over the first year or two. Careful consideration should be given to the purpose of each parameter used in the procedure. Each parameter has importance that extend beyond the measurement for equilibrium. If Low-Flow sampling is not appropriate for a site, the SOP for groundwater sampling (DR#002) should be used for the site.

Cold weather considerations must be factored into a low flow sampling plan.

Monitoring wells with recharge rates below 100 mL/min may not be capable of being pumped at a continuous rate. Therefore, low purge or no purge options should be considered.

9.O NO – PURGE OPTION

The theory of no-purge sampling is that the water in the screened zone is in equilibrium with the aquifer and the water in the riser portion of the well is not. The goal is to sample only the water in the screened zone and to minimize any mixing with the water in the riser.

In certain low permeability formations it may not be possible to maintain a constant drawdown at low flow rates(~80-100 mL/min.). In these formations the only option may be to obtain a groundwater sample without purging.

9.1 NO-PURGE PROCEDURE

The same principle applies to the no-purge option that apply to the purge option. Dedicated equipment is required to properly complete this procedure(to eliminate any additional mixing of the water in the riser with the water in the screen).

The pump intake must be in the screened zone, at or slightly above the midpoint of the screen.

1) Calculate the volume of water standing in the discharge line.

2) Turn on the pump at the lowest possible flow rate.

3) Purge the volume of water that was standing in the discharge line.

4) Immediately begin sample collection after the discharge line is purged.

10.0 DECONTAMINATION

Dedicated equipment will not need decontaminating. However, non dedicated equipment should be cleaned prior to field work, after each sampling location, and upon return to the office from the field, as outlined in MEDEP/DR SOP RWM-DR-017 – Decontamination procedures, with specific precedures for cleaning submersible pumps as outlined below. Non dedicated tubing should be discarded. The pump, including support cable and electrical wires which are in contact with the well will be decontaminated by one of the procedures listed below.

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is flushed out. The outside of the pump and the electrical wires must be rinsed with the decontaminating solutions as well. The procedure is as follows:

- Flush the equipment/pump with deionized or tap water. Flush pump by allowing pump to run with water for several minutes in basin filled with water.
- Flush with non-phosphate detergent solution for several minutes.
- Flush with deionized water to remove all of the detergent solution. In some instances of high levels of contamination, it may be appropriate to use isopropyl alcohol in this step. The need for this will be determined in the Site Specific Sampling and Analysis Plan (See SOP DR#014)
- Flush one final time with distilled/deionized water. If required (as determined in Site Specific Sampling and Analysis Plan), collect equipment blank after final flushing.

11.0 QUALITY ASSURANCE/ QUALITY CONTROL

Data quality objectives should be stated in the SAP. Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet your data quality objectives. The following are typical types of QA/QC samples that may be collected as part of the QA/QC program for groundwater sample collection utilizing this SOP, other QA/QC samples may be collected as stated in the SAP. For an additional discussion of QA/QC, please refer to the MEDEP/DR Quality Assurance Plan, Section 5 and Section 10. All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer.

11.1 TYPICAL QA/QC SAMPLES

11.1.1 Equipment Blanks

If using non dedicated or disposable equipment, equipment blanks should be collected at a rate of 5%, one equipment blank every twenty samples collected. The equipment blank will consist of purging de-ionized water through submersible pumps and piping, and/ or rinsing equipment with de-ionized water, and collection for appropriate sample analysis.

11.1.2 Duplicate Samples

It is recommended that duplicate samples be collected at a rate of 5% to assess sample location variability.

11.1.3 Trip Blank

A trip blank may be necessary when sampling for volatile organic compounds. The need for a trip blank will be outlined in the SAP.

11.1.4 Background Samples

The need for background groundwater samples will be outlined in the SAP.

12.0 DOCUMENTATION

All site visits, including groundwater sampling events shall be documented as described in the SOP RWM-DR-013 - Documentation of Field Notebooks and development of an SETR. A field log must be kept each time ground water monitoring activities are conducted in the field; the LFS Data Sheet in Attachment B is the approved form for use by staff. The field log should document the following:

- Well identification, condition of well
- Static water level
- Pumping rate, or flow rate including units
- Time of all measurements
- Water Level at the specified pumping rate
- Indicator parameters values
- Well sampling sequence and time of sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Name of sample collector(s).

Calibration information of meters should also be documented.

13.0 REFERENCES

Backhus, D.A., Ryan, J.N., Groher, D.M., MacFarlane, J.K., Gschwend, P.M., 1993; Sampling Colloids and Colloid- Associated Contaminats in Ground Water; Ground Water, Vol 31, No. 3, pp. 466-479.

Barcelona, M.J., Wehrmann, H.A., Varljen, M.D., 1994. Reproducible Well-Purging Procedures and VOC Stabilization Criteria for Ground-Water Sampling; Ground Water, Vol 32, No.1, pp. 12-22.

Garske, E.E., Schock, M.R., 1986. An Inexpensive Flow- Through Cell and Measurment Sysytem for Monitoring Selected Chemical Parameters in Ground Water. GWMR, Summer.

Herzog, B.L., Chou, S.J., Valkenburg, J.R., and Griffin R.A., 1988. Changes in Volatile Organic Chemical Concentrations After Purging Slowly Recovering Wells. *Groundwater Monitoring Review*, v.9, no.3, pp 93-99.

Kearl, P.M., Korte, N.E., Cronk, T.A., 1992. Suggested Modifications to Ground Water Sampling Procedures Based on Observations from Colloidal Borescope. GWMR, Spring, pp 155-161.

Powell, R.M., Puls, R.W., 1993. Passive Sampling of Groundwater Monitoring Wells Without Purging: Mulitlevel Well Chemistry and Tracer Dissappearance. Journal of Contaminant Hydrology, Volume 12, pp 51-77.

Puls, R.W., Powell, R.M., 1992. Acquisition of Representative Ground Water Quality Samples for Metals. *Groundwater Monitoring Review*, v.12, no.2, pp 167-176.

Puls, R.W., Powell, R.M., 1992. Transport of Inorganic Colloids through Natural Aquifer Material. Environmental Science Technology, Vol 26, pp614-621.

Puls, R.W., Powell, R.M., Clark, D.A., Paul, C.J., 1990. Facilitated Transport of Inorganic Contaminants in Ground Water: Part I, Sampling Considerations. Enviromental Research Brief, EPA-600-M-90-023, December

Puls, R.W., Powell, R.M., Clark, D.A., Paul, C.J., 1990. Facilitated Transport of Inorganic Contaminants in Ground Water: Part II, Colloidal Transport. Enviromental Research Brief, EPA-600-M-90-023, December

Puls, R.W., Barcelona, M.J., 1989. Ground Water Sampling for Metals Analyses. Superfund Ground Water Issue, EPA- 540-4-89-001, March.

Shanklin, D.E., Sidle, W.C., Ferguson, 1995. Micro-Purge Low-Flow Sampling of Uranium-Contaminated Ground Water at the Fernald Environmental Management Project. Groundwater Monitoring Review, Summer.

USEPA, 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance; EPA/530-R-93-001; U.S. EPA; Office of Solid Waste; Washington, D.C. PB93-139-350.

USEPA, 1993. Solid Waste Disposal Facility Criteria: Technical Manual; EPA/530-R-93-017; U.S. EPA; Office of Solid Waste; Washington, D.C. PB94-100-450.

ATTACHMENT A
DECISION PROCESS FOR IMPLEMENTING LOW FLOW/NO PURGE SAMPLING

Decision Process for Implementing LFS

1) Obtain well construction, development, and water level records for each well being sampled. Compile total depth, screened interval, water level, and available hydraulic conductivity information for field technician(s).
   Continue to 2

2) Review available equipment. Make sure the pump is capable of variable speeds and can pump water at low rates without the use of mechanical flow restrictions. Reducing flow by altering the diameter of the discharge pipe is not acceptable for purposed of LFS. Make sure the chamber being used to collect field parameters is appropriate for the parameters being measured. For Eh and DO measurements with probes, the chamber must be an enclosed chamber that does not allow water to contact the atmosphere and does not impact the water quality. Additionally, the size of the chamber should be appropriate given the expected flow rates.
   Continue to 3

3) The objectives of the sampling event should be reviewed to determine the important stabilization parameters as well as the important field parameters for geochemical analyses.
   Continue to 4

4) Is the well being used as part of a long-term plan to monitor trends in groundwater chemistry?
   Yes … Go to 5
   No … Go to 6

5) Complete Well Performance Evaluation on Well prior to first sampling event.
   Continue to 6

6) Will water level (under pumping conditions) stabilize above the top of the screen?
   Yes … Go to 11
   No … Go to 7

7) Is the static water level above the top of the screen?
   Yes … Go to 9
   No … Go to 8

8) Will the stabilized water level reduce the volume of water in the well by greater than 10%?
   Yes … Go to 12

No … Go to 11

9) Is there sufficient water in the well to purge and sample the well given the measured drawdown rate without dewatering any part of the screen?
Yes … Go to 10
No … Go to 12

10) Is the volume of water attributable to the change in water level greater than 20% of the volume of water being discharged during the same time period?
Yes … Go to 12
No … Go to 11

11) Complete the Standard Low Flow Sampling Procedure and collect groundwater samples once the selected stabilization parameters have equilibrated.

12) Evaluate the appropriate application of Reduced Purge Procedures for this well.
Continue to 13

13) Is the sampling equipment (pump or sample tube) dedicated to the well and/or has it been installed for more than 2 weeks prior to sampling?
Yes … Go to 15
No … Go to 14

14) Install the pump or tubing and purge a volume of water equal to 1.5 times the volume required to fill the laboratory containers. Purging must be completed at the lowest setting possible (must be less than 100 mL/min). Then shut-off the pump and allow the well to recharge until the water level returns to the static water level
Continue to 15

15) Set the pump rate to the lowest possible setting (must be lower than 100 mL/min) and purge a volume of water equal to the volume of water in the sample tube. Then immediately begin collection of laboratory samples at the same rate. Record the water level at the beginning of sample collection and at the end of sample collection. If field parameters are to be collected, they must be collected after laboratory samples are collected.

ATTACHMENT B
LOW FLOW DATA SHEET

INSERT LOW FLOW DATA SHEET