Characterizing Surface Water/ Ground-Water Interactions in the Muck Creek Watershed Pierce County, Washington

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Quality Assurance Project Plan

by
Kirk Sinclair

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Approvals:

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Project Description

Muck Creek, in southwestern Pierce County (Figure 1), supports runs of Chum, Coho, and Steelhead salmon in addition to resident and sea-run cutthroat trout (Walter, 1999). Numerous efforts are underway to enhance and/or protect instream habitat and Salmonid populations within the watershed (Crawford, 1999; Sturtevant, 1999). Many of the watershed streams commonly go dry throughout portions of their length during late summer and fall (Dorner, 1999). Understanding the distribution, timing, and causes of these intermittent flow conditions is crucial for the successful implementation of habitat restoration efforts.

The purpose of this study is to determine if the intermittent nature of these creeks originates from natural factors, or whether recent human activities, such as streambed disturbances or water withdrawals, have caused or exacerbated the condition. Developing a better understanding of the watershed hydrology will help assure the success of ongoing and future habitat enhancement efforts.

Study Area Description

The Muck Creek watershed covers an area of approximately 96 square miles within southwestern Pierce County, WA. The watershed encompasses portions of the Fort Lewis Military Reservation and the communities of Roy and Graham (Figure 1). The predominant land use consists of deciduous and coniferous forests, grassland prairies, and low-density residential development.

Land surface elevations within the watershed range from approximately 960 above mean sea level near Graham to less than 140 feet at Muck Creek's confluence with the Nisqually River. The watershed precipitation averages approximately 35 inches annually (Miller, et al, 1973). Roughly 85 percent of the annual precipitation falls as rain during the September to April time period (Walters and Kimmel, 1968).

Streamflow

The Muck Creek watershed is drained by Muck Creek and its primary tributaries South Creek and Lacamas Creek. Muck Creek discharges to the Nisqually River approximately 4 miles west of the town of Roy (Figure 1). All of the watershed streams are maintained by local precipitation that enters the streams as surface runoff following storm events, or through natural ground water discharge to springs and seeps.

Seasonal intermittent flow is a common condition for these streams, particularly for South Creek and the lower reach of Muck Creek. The USGS maintained a gage on Muck Creek at Roy (USGS 12090200) from 1956 to 1971 (Figure 2). During this period the creek ceased to flow approximately 9.1% of the time (Engle, 1997). Flow in all three streams is typically lowest, between August and November, when ground-water levels are at seasonal lows and precipitation is minimal.

Hydrogeology

Muck Creek is typical of many Puget Sound watersheds in having been shaped by repeated glacial advances and retreats over the past few million years. Deposits from the most recent glacial episode, the Vashon Stade of the Frasier Glaciation, blanket the area and exert the greatest influence on the watershed hydrogeology. These surficial deposits consist largely of glacial till and undifferentiated outwash.

Till underlies much of the South Creek drainage and the upper portion of Lacamas Creek (Walsh et al, 1987). Till is typically a compact poorly sorted assemblage of clay and silt-bound sand and gravel that serves as a confining or perching unit. Where the till contains lenses of sand or gravel sufficient water may be present to supply the domestic needs of a household (Walters and Kimmel, 1968).

Undifferentiated drift underlies much of Muck Creek proper and the lower reaches of South Creek and Lacamas Creek (Walsh et al, 1987). This unit is composed mostly of recessional and proglacial-stratified sand and gravel with local accumulations of clay and silt. The primary aquifers in the watershed are contained within this unit.

Project Organization and Responsibility

Clients: *Peter Moulton*, Ecology watershed lead (360) 407-6783: Responsible for coordinating with other agency staff, securing the necessary permits for instream piezometer installation, reviewing drafts of the QAPP and project report, and for coordinating Ecology's implementation of the report recommendations.

Jeanette Dorner, Muck Creek Council (425) 227-4299: Responsible for coordinating council activities related to this project, public outreach, reviewing the draft QAPP and project report and for coordinating local implementation of the report recommendations.

Project Lead: *Kirk Sinclair*, Ecology (360) 459-7469: Responsible for managing the project, preparing the project Quality Assurance Project Plan (QAPP), coordinating and completing field activities, analyzing project data, and preparing the draft and final report. Serves at the principal public contact for the technical aspects of the study.

Project Assistants: *Katina Kapantais*, Ecology (360) 407-6458: Responsible for assisting with field activities and subsequent data reduction.

Laboratory Services: Not applicable

Project Budget

Laboratory costs: None
Estimated Infrastructure Costs:

Construction Materials for Manometer Board and Piezometers: $600

Note: Piezometers will be hand driven by project personnel

Project Schedule

August 1999 to February 2001 (see Table 1)

Project Objectives

The broad objectives of this study are 1) to quantify the timing and volume of surface water/ground water interaction within the Muck Creek watershed, and 2) to determine (data permitting) whether the intermittent flow of the watershed creeks is natural or whether it is caused or exacerbated by human activities. This evaluation will concentrate specifically on the mainstem of Muck Creek, South Creek, and Lacamas Creek with emphasis on that area lying outside of the Fort Lewis Military Reservation. Fort Lewis personnel will be overseeing a similar but separate study on fort property (Crawford, 1999). This project is designed to avoid duplicating the efforts of that study. The results of both studies will be used to affect changes in critical area ordinances and related land use guidelines, as appropriate.

Specific objectives of this study include the following:

- Estimate the longitudinal distribution of flow (both direction and volume) between the major surface-water drainages within the Muck Creek watershed (Muck Creek, South Creek, and Lacamas Creek) and area ground water.

- Compile the study data and interpretive results and develop a conceptual model of surface water/ground-water interaction within the watershed. This information will be used to target habitat restoration and enhancement efforts toward those portions of the watershed most amenable to such efforts.

- Prepare geologic cross sections, from on-file water well reports, to illustrate the vertical and horizontal relationships between the watersheds principal aquifers and confining units.

- Prepare a ground-water head map (from historic water-level data) to delineate regional ground-water gradients and principal flow directions within the watershed.

- Measure present water levels in selected wells (historic USGS observation wells) to determine if ground-water levels within the watershed have changed over time.

Study Approach (Data Collection)

The objectives of this study will be met through a combination of fieldwork and in-office interpretations of historic streamflow, ground-water level, and geologic/well report information. Each of the study's field components is described below.

Piezometer Survey

Piezometers will be installed at selected bridge crossings of Muck, South, and Lacamas creeks to define the vertical hydraulic gradient between the creek and the underlying water-table aquifer (Figure 3). The piezometers consist of a seven foot length of ½ inch diameter galvanized pipe, one end of which is crimped and slotted. The piezometers will be hand driven into the stream bed to a depth of approximately five feet.

A manometer board – which enables simultaneous head measurements of the piezometer and creek – will be used during monthly measurements of the piezometers. The head difference between the internal piezometer water level and the external creek stage, provides an indication of the vertical hydraulic gradient and the direction of flow between the creek and ground water. When the piezometer head exceeds the creek stage, ground water discharge into the creek can be inferred. Similarly, when creek stage exceeds the head in the piezometer, loss of water from the creek to ground water storage can be inferred.

Seepage Assessments

Surface-water seepage assessments will be conducted in conjunction with the monthly piezometer surveys to verify the manometer board readings and to quantify the flux of water between area streams and ground water. To conduct a seepage assessment, one establishes a series of measurement sites at selected points along a stream and then measures the discharge at all sites over a short period of time (usually a day or less). The relative increase or decrease in discharge between stations that is not accounted for through physical diversion or tributary input, is the volume of water exchanged between the stream and groundwater storage.

Seepage assessments will be conducted along the perennial segment of Muck Creek between June and November, 2000. Addition assessments may be conducted for the remaining segments of Muck, South, and Lacamas creeks between November, 1999 and May, 2000 conditions permitting (i.e. if the creeks have flow, are safely waded, and weather conditions are stable). Seepage runs will be completed in one day in conjunction with the monthly piezometer surveys. Weather conditions should be dry and stable (no measurable rain) for at least two days preceding the assessment and should not change during the assessment period.

Two discharge measurements will be made at each measurement site. A minimum of 25 observation points (verticals) will be used to define the measurement cross section. The discharge at each vertical will be determined by taking a 40-second average of the instantaneous velocity readings obtained using a calibrated current meter (Swoffer Model 2100) and wading rod. The average of the two discharge measurements will be used to compute the discharge at each measurement site.

Ground-Water Level Monitoring

Ground-water levels will be measured monthly in selected long-term USGS observation wells within the watershed. Proposed monitoring locations are shown on Figure 3. The final number and distribution of wells we monitor will be based on our ability to locate previously measured wells (both USGS and others) and to obtain the current owners permission to access the well. Water level measurements will be made using a calibrated electric well probe or steel tape in accordance with standard USGS methodology (Stallman, 1983).

Field Water Quality Monitoring

Surface/ground-water temperature and conductivity will be measured during each of the monthly piezometer surveys. In addition, these parameters will be measured as part of the monthly water-level monitoring of selected historic USGS observation wells within the watershed. Ground-water temperature and conductivity will be used as an additional check to verify surface water ground water interactions. Stream reaches with significant ground-water input (especially during low flow periods) should have similar water chemistry to area ground water. Measurements will be made with properly maintained and calibrated meters in accordance with standard USGS methodology.

Field Data Quality Objectives

Accuracy

To limit sources of bias, standard USGS protocols for streamflow and ground water level data collection will be followed throughout this study (Rantz, 1982, Stallman, 1983). Measurement precision will be estimated through duplicate ground-water level measurements and two separate discharge measurements at each seepage site. Measurement accuracy will be optimized through the use of properly maintained and calibrated field equipment including: current meters (Swoffer model 2100), temperature and specific conductance meters, steel tapes, and calibrated e-tapes. All meters will be maintained and calibrated in accordance with the manufacturers instructions.

When conducting seepage assessments the difference between the two successive streamflow measurements (which will be averaged to define the flow at each measurement site) should not exceed 10 percent of their mean. The difference between successive ground-water level measurements at each well should not exceed 0.01 feet. Water temperature will be measured to the nearest 0.1 degree centigrade.

Representativeness

The sampling design is intended to ensure the data are representative. Seepage assessments will be done only when prior weather conditions have been dry (<0.01 inches of precipitation) for the preceding two days.

Completeness

To maximize the amount of usable data collected during this study, we will follow accepted USGS protocols for stream flow and ground-water level data acquisition. Only appropriately calibrated and maintained field equipment will be used.

Comparability

Data comparability between this study and others will be assured by following standard USGS protocols for stream flow and ground-water level data acquisition.

Quality Control Procedures

The following procedures will be followed to assure that the data collected during this study is of sufficient quality and quantity to accomplish the study objectives. All streamflow and ground-water level data will be collected and recorded in accordance with standard USGS protocols (Rantz and others, 1982; and Stallman, 1983 respectively).

Wading stream flow measurements

The current meters used to conduct the seepage assessments will be inspected and calibrated prior to the start of each assessment to assure they are working properly. The meters will be inspected and calibrated in accordance with the manufacturers directions. The relative percent difference between the two successive measurements conducted at each seepage site should not exceed 10% of their mean.

Ground-water level measurements

The equipment used to measure ground-water levels (electric tape or steel tape) will be inspected prior to use to verify that it is working properly. Steel tapes will be checked for bends or twists that might result in inaccurate readings. Electric tapes will be checked to confirm they have fresh batteries and will be calibrated prior to initial use. Measurements will be made to the nearest 0.01 foot with two successive measurements being made at each well. The difference between measurements should not exceed 0.01 feet.

Water quality monitoring

All meters used to monitor water temperature and conductivity will be checked and calibrated against known standards at the start of each sampling day in accordance with the manufacturer directions.

Data Reduction, Review, and Reporting

At the completion of data collection (approximately 12 months) all field data will be compiled and formatted for subsequent analysis. A draft report will be furnished to the client within three months of completing data collection. The final report should be ready for publication within one month of receiving review comments. Interim products such as streamflow and ground-water level data will be furnished to the project clients as they become available.

Table 1

Project Timeline (by Task)

TASK	1999 SOND	2000 JFMAMJJASOND	2001 JFM
Project Planning	SO		
Write QAPP	D		
Potentiometer Survey	D	JFMAMJJASOND	
Ground-Water Levels	D	JFMAMJJASOND	
Seepage Runs	S **	*******JJASON	
Analyze Historic Data ^	OND	JFMAM	
Compile and Analyze Project Data		OND	
Write Draft Report		D	J
Incorporate Review Comments and Finalize Report			FM

* Seepage assessments will be conducted during these months – conditions permitting.
^ This task includes a number of products that will be incorporated into the final report including:

A ground water head map,
Geologic cross sections,
Ground-water level hydrographs, and
Historic stream-flow hydrographs.

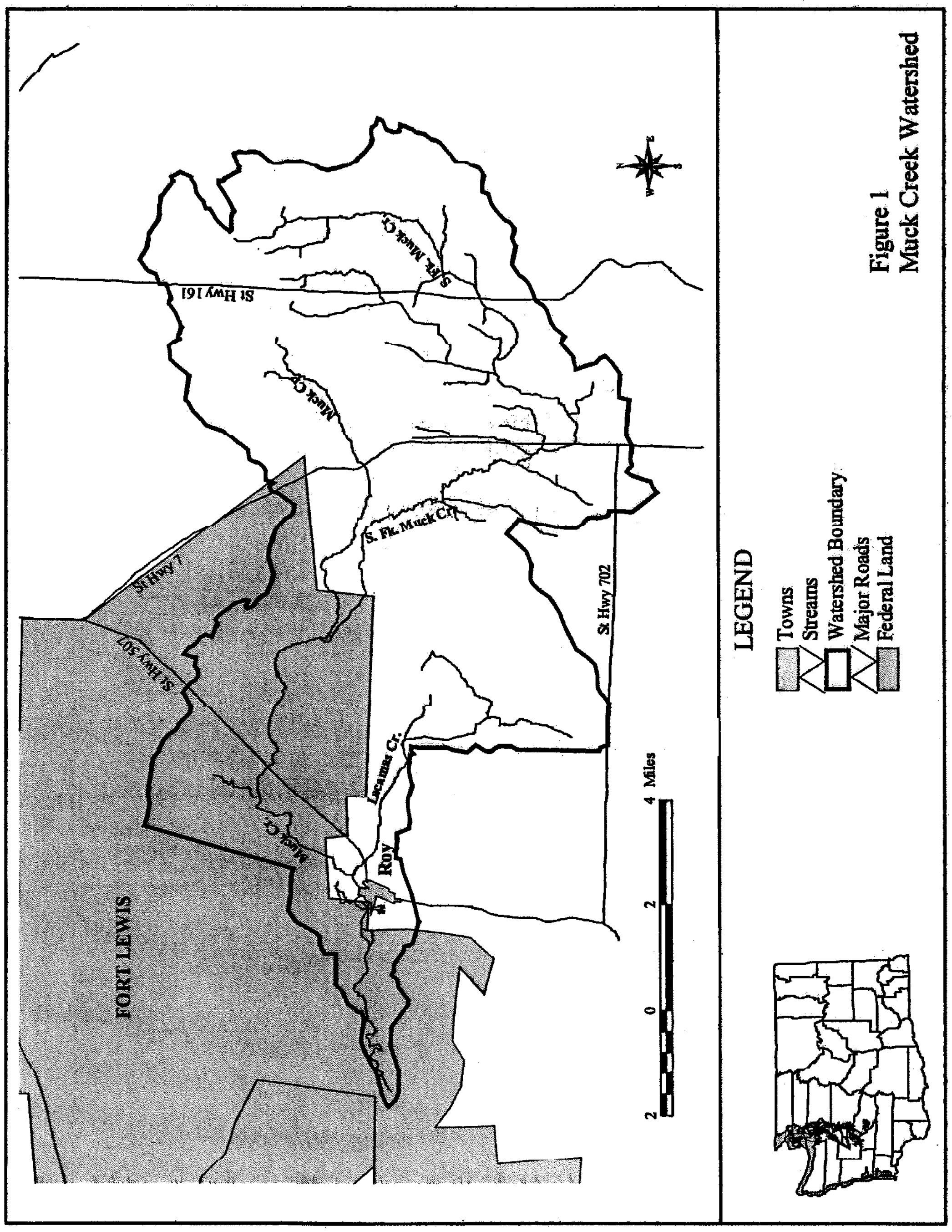
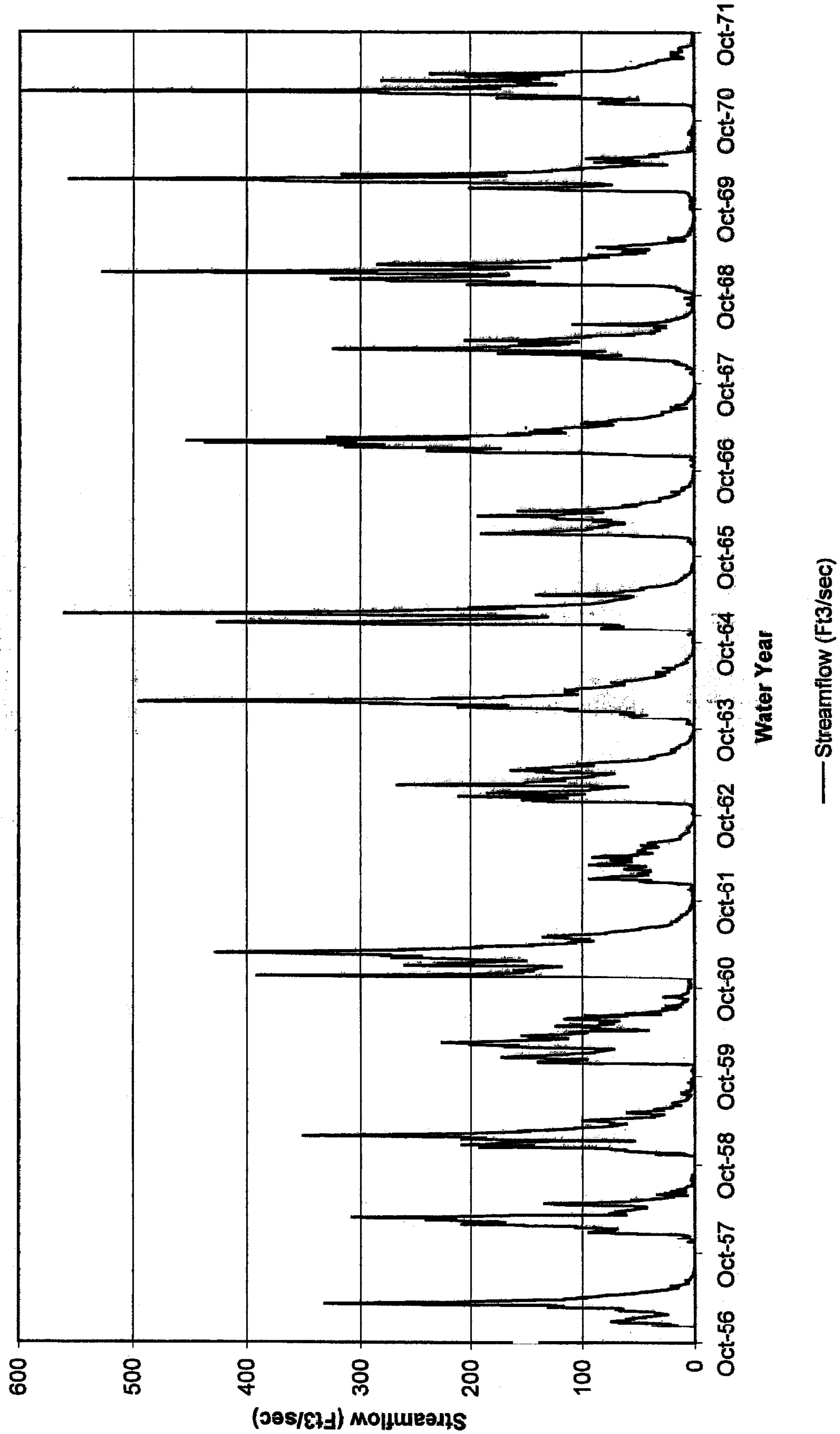


Figure 1
Muck Creek Watershed

Figure 2
Daily Mean Streamflow for Muck Cr. Near Roy
USGS (12090200)
Water Years 1957-71



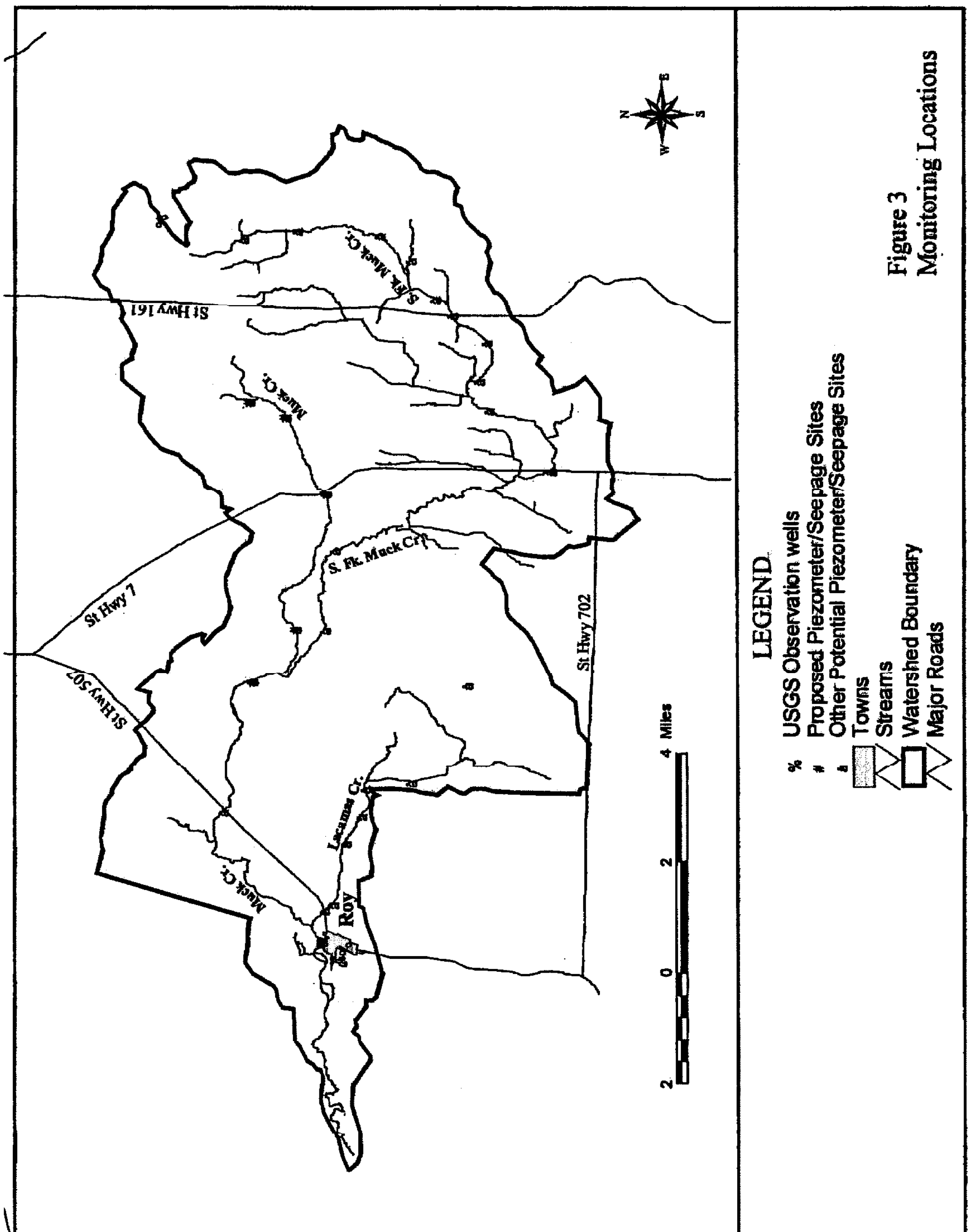


Figure 3
Monitoring Locations

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