General Electric Company
Albany, New York

Sampling and Analysis Plan

INVESTIGATION OF GROUNDWATER SEEPAGE IN THE THOMPSON ISLAND POOL SECTION OF THE UPPER HUDSON RIVER

February 1997

Project No: GECO0040

HydroQual, Inc.
Environmental Engineers and Scientists

General Electric Company
Albany, New York

Sampling and Analysis Plan

Investigation of Groundwater Seepage in the Thompson Island Pool Section of the Upper Hudson River

February, 1997

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1. INTRODUCTION

This sampling and Analysis Plan (SAP) has been prepared by HydroQual, in association with HSI GeoTrans, Inc. and O'Brien & Gere Engineers, Inc. on behalf of the General Electric Company (General Electric). This SAP describes the instrumentation design and installation and the sampling and analysis procedures to be used during the groundwater seepage investigation to be conducted on the Thompson Island Pool (TIP) section of the upper Hudson River. This study is being conducted to test the hypothesis that upward advective transport of groundwater through contaminated sediments can result in a significant source of PCBs to the TIP water column.

1.1 Background

An anomalous PCB load has been detected in the Thompson Island Pool (TIP) section of the Upper Hudson River since approximately 1991 (HydroQual, 1995). In recent modeling studies, the U.S. EPA has hypothesized that this PCB load may be attributed, at least in part, to advective transport of groundwater through contaminated sediments and into the water column of the pool (U.S. EPA, 1996). Advective groundwater flux can be calculated using Darcy's Law,

$$u = Ki \qquad (1)$$

where K is the hydraulic conductivity [L/T], i is the hydraulic gradient [L/L], and u is the Darcy velocity, or volumetric seepage flux [L/T]. Field measurement of these groundwater hydraulic parameters will be performed to develop estimates of the magnitude of seepage into or out of the TIP based on actual data. The estimates prepared by the EPA were based on literature values for hydraulic conductivity and land surface topography for the regional hydraulic gradient.

Local hydraulic gradients are typically estimated by measurement of water levels, and local hydraulic conductivities can be estimated from falling head tests (*e.g.*, Domenico and Schwartz, 1990). Another estimate of seepage flux can be obtained by direct measurement of the influx and/or outflux rate of seepage water, where influx refers to flow of groundwater into a surface water and outflux refers to advective flow in the opposite direction. Use of seepage meters to measure the volumetric exchange between a surface waterbody and underlying groundwater has been widely documented in the literature (*e.g.*, Lee, (1977), Lee and Cherry, (1978), and Woessner and Sullivan, (1984)). Seepage meters have been successfully employed in previous field studies to gain an understanding of the hydraulic and chemical interactions between groundwater and surface water and to examine spatial and temporal patterns of groundwater seepage. Table 1 documents a number of studies which successfully employed seepage meters to estimate advective groundwater flux.

Documented Source	Aquatic System(s)	Measured Seepage Flux ($L/m^2 \cdot hr$)
Lee, 1977	3 lakes in MN and WI	0.04 - 10
Lee, 1977	2 estuaries in NC	-0.3 - 3
Lee and Hynes, 1978	Small stream in Ontario	2 - 7
Bokuniewicz, 1979	Great South Bay, NY	0.2 - 2
Lee et al., 1980	Perch Lake, Ontario	1 - 2
Woessner and Sullivan, 1984	Lake Mead, NV	0.5 - 5
Gallagher et al., 1996	4 coastal streams in VA	0.1 - 2

Table 1. Documented range of flux rates measured with seepage meters.

Based on the range of values listed in Table 1, a flux of the magnitude hypothesized by the U.S. EPA modeling study (1.3 $L/m^2 \cdot hr$) should be detectable with a seepage meter.

1.2 Objectives

The principal objective of the groundwater seepage investigation is to test the hypothesis that groundwater flux can contribute to the observed anomaly in TIP PCB loadings. The specific objectives of the proposed study include:

- evaluate proposed seepage meter and piezometer construction designs,
- determine the most effective installation, monitoring, and sampling procedures, and
- obtain data on seepage rates and groundwater hydraulic parameters within the TIP.

1.3 Approach

The TIP groundwater seepage investigation will be implemented in two phases. Phase I will take place in the spring of 1997, and will consist of the installation and feasibility testing of two instruments:

1) seepage meters will be installed in the river bed to facilitate measurement of the groundwater influx and/or outflux rate, and

2) piezometers will be installed in the river sediments adjacent to seepage meters to allow monitoring of the local hydraulic gradient and for hydraulic conductivity measurements. Selected piezometers will be equipped with data loggers to allow monitoring of seasonal variations in hydraulic gradients following the spring high-flow period.

During Phase I, pilot tests will be performed to evaluate the usefulness of seepage meters and piezometers for measurement of seepage flux and local hydraulic conductivities and hydraulic gradients within the TIP.

Pending successful implementation and satisfactory results from Phase I, Phase II will be conducted during the summer low-flow period of 1997. Phase II will target further measurement of groundwater seepage flux and continuous monitoring of hydraulic gradients.

2. METHODOLOGY

2.1 Site Selection

Groundwater seepage within the TIP may be influenced by a number of factors, including sediment type, local topography and groundwater elevations, and by spatial differences in pool elevation due to the Thompson Island Dam. Local topography does not suggest any obvious zones of preferential groundwater discharge, and since groundwater / river hydraulic interactions often exhibit spatial variability, field measurements will be performed at multiple locations within the TIP. Selection of sites was based on historic sediment PCB concentrations, sediment textures, shoreline accessibility, and field logistics. Measurement of seepage parameters via piezometers and seepage meters will take place at the following five locations within the TIP:

1) Two seepage meters and two piezometers will be installed at a site in the H-7 area, where sediment PCB concentrations have been high (Hot Spot 5, Figure 1) and sediment textures have been characterized by historic NYSDEC sediment coring. The seclusion of this site will allow the use of a data logger in conjunction with the piezometers so that seasonal variations in hydraulic gradient can be monitored.

2) Near the eastern shore dredge spoil site (approximate Mile Point 192.7, Figure 1), two seepage meters and one piezometer will be installed in coarse sediments, as indicated by SideScan Sonar interpretation of the riverbed within the TIP (Figure 2).

3) A piezometer and two seepage meters will be installed at a site near Mile Point 191.5 (Figure 1), which was selected based on river bed sediment textures and results from the TIP float survey (HydroQual, 1996). Inspection of sediment textures from Figure 2 suggests that finer grained sediments exist along the eastern shore of the TIP, near mile point 191.5. Historically, high sediment PCB concentrations have also been observed in this region (*i.e.*, Hot Spot 8, Figure 1) and preliminary results from the TIP float survey indicate that increases in PCB concentrations were observed in eastern shore transect data near Mile Point 191.5, for both sampling events (Figure 3).

4) Two seepage meters and two piezometers with a data logger will be installed at a site

along the eastern shore across from Griffin Island, within Hot Spot 14 (approximate Mile Point 190, Figure 1).

5) The downstream study location will contain a piezometer and two seepage meters, and is located along the western shore of the TIP, near the southern tip of Griffin Island (Mile Point 189.5, Figure 1).

Measurements taken at multiple sites along the TIP may allow delineation of spatial trends in seepage and groundwater hydraulic properties. Use of duplicate seepage meters at each site will enable close examination of results for measurement biases and errors. Installation of seepage meters in both fine and coarse textured sediments may enable characterization of localized variability in volumetric groundwater flux rates. Preliminary results from this study will be used to determine whether additional sites will need to be added to characterize these variabilities more fully. A map summarizing the five TIP groundwater investigation study sites (designated S1 - S5) is provided in Figure 4. Visual descriptions of typical sediment depth profiles at these sites are also provided.

2.2 Groundwater Seepage Monitoring

2.2.1 Seepage Meter Design

Typical seepage meter construction is based on the original design outlined by Lee (1977). However, depending on the materials and experimental setup of a seepage meter, potential measurement biases may be introduced (Belanger and Montgomery, 1992). Modifications to seepage meter design and installation techniques that reduce the potential for measurement biases have been documented in the literature (e.g., Belanger and Montgomery, 1992, Shaw and Prepas, 1989).

Based on consideration of these modifications, seepage meters for the TIP groundwater seepage investigation will consist of a cylindrical stainless steel vessel equipped with two 1/4" teflon bulkhead fittings, a teflon air sampling bag equipped with a release valve, and 1/4" teflon tubing. A schematic of the seepage meter design is shown in Figure 5. A nozzle is attached to the collection valve to prevent accumulation of gasses in the collection bag and a release valve is attached to the vessel to allow air and other sediment gasses to escape. This is particularly important for deployment of seepage meters in shallow water.

2.2.2 Seepage Meter Installation and Sampling

Short duration field experiments (3-5 days) will be used during Phase I of the study to obtain preliminary estimates of TIP seepage properties. Two seepage meters will be deployed at each of the five locations depicted in Figure 4. Seepage meter installation and sampling will be as follows:

1) The stainless steel cylinders will be gently inserted into the riverbed at a slight angle to allow entrained air to escape through the air release valve.

2) Seepage meters will remain in place for an equilibration period of 2-3 days to allow for settling of the devices in sediments (Belanger and Montgomery, 1992) and for flushing of initially trapped river water from the cylinders.

3) Collection bags will be prefilled with 1 L of distilled water and attached to the teflon tubing as shown in Figure 5. Prefilling of collection bags has been recommended to allow for seepage outflux and to reduce measurement biases from bag deformation (Shaw and Prepas, 1989).

4) The teflon bags will be removed after collection of 1.5 - 3 L of water, and the volume of seepage water will be measured using a graduated cylinder.

2.3 Groundwater Hydraulic Measurements

2.3.1 Piezometer Design and Installation

Piezometers will be installed beneath the water column at each of the five study locations and will be constructed of 1.25" stainless steel standpipe and wellpoints, as depicted in Figure 6. Hand-driven installation should be sufficient since shallow clay deposits are not expected to be encountered based on the typical sediment texture depth profiles shown in Figure 4. The piezometers at study locations S1 and S4 (Figure 4) will be equipped with electronic water level data loggers during Phase I of the study and will be used to continuously monitor temporal changes in hydraulic gradients through Phase II of the study.

2.3.2 Hydraulic Gradient Measurement

The relative elevation difference between groundwater and the river will be obtained by measuring the depth to water inside and outside of piezometers. Following an initial equilibration period, observations of well point water levels and local river water elevations will be used to estimate vertical hydraulic gradients within the TIP for both phases of the investigation. At the beginning and conclusion of seepage meter deployments, gradients will be estimated with piezometer readings at sites S2, S3, and S5 (Figure 4). Data loggers in the piezometers at locations S1 and S4 (Figure 4) will continually record river water elevation and underlying groundwater hydraulic head at these locations.

2.3.3 Hydraulic Conductivity Testing

Piezometers installed in the TIP will be used to estimate local hydraulic conductivities via the slug test or constant head test method. Hydraulic conductivity tests will be performed at each of the five study locations to allow a preliminary assessment of the spatial variability of TIP groundwater interactions. Hydraulic conductivity tests will be performed following the conclusion of seepage meter experiments.

2.4 Phase II Deployment

Phase II seepage meter experiments will be performed to obtain an estimate of groundwater seepage flux during the summer low-flow period. It is during this period that the anomalous PCB load in the TIP is most prevalent (HydroQual, 1995) and largest hydraulic gradient between the river water and groundwater is expected to occur. Therefore hydraulic gradients will be continuously monitored using the piezometers equipped with data loggers (sites S1 and S4) during Phase II of the study.

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3. PROJECT ORGANIZATION, SCHEDULE, AND DELIVERABLES

3.1 Project Organization

A project organization chart is presented in Figure 7. HydroQual and HSI GeoTrans will be responsible for overall project management and the execution of field experiments for seepage flow, hydraulic gradient monitoring, and hydraulic conductivity testing. O'Brien and Gere will be responsible for fabrication of seepage meters and piezometers, and for field support throughout the installation and monitoring of these instruments.

3.2 Project Schedule

A project schedule is contained in Figure 8. The groundwater seepage investigation will begin in late March / early April of 1997, immediately following the spring high-flow event. Following a one week instrument installation and equilibration period, Phase I experiments for seepage measurement, hydraulic gradient measurement, and hydraulic conductivity tests will be performed so that an experimental protocol may be developed.

Contingent on the success of preliminary experiments, Phase II measurements of seepage flux, hydraulic gradients, and hydraulic conductivity will take place under summer low-flow conditions. Monitoring of hydraulic gradients in piezometers S1 and S4 (via data loggers) will continue through the summer, at which time a decision regarding longer-term operation will be made based upon analysis and interpretation of the data collected.

3.3 Project Deliverables

Project deliverables for the groundwater seepage investigation will include a non-interpretive data summary report containing a description of the objectives, methods, and raw data results.

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Woessner, W.W. and Sullivan, K.E., 1984. Results of Seepage Meter and Mini-Piezometer Study, Lake Mead, Nevada. *Ground Water*, 22(5), 561-568.

FIGURES

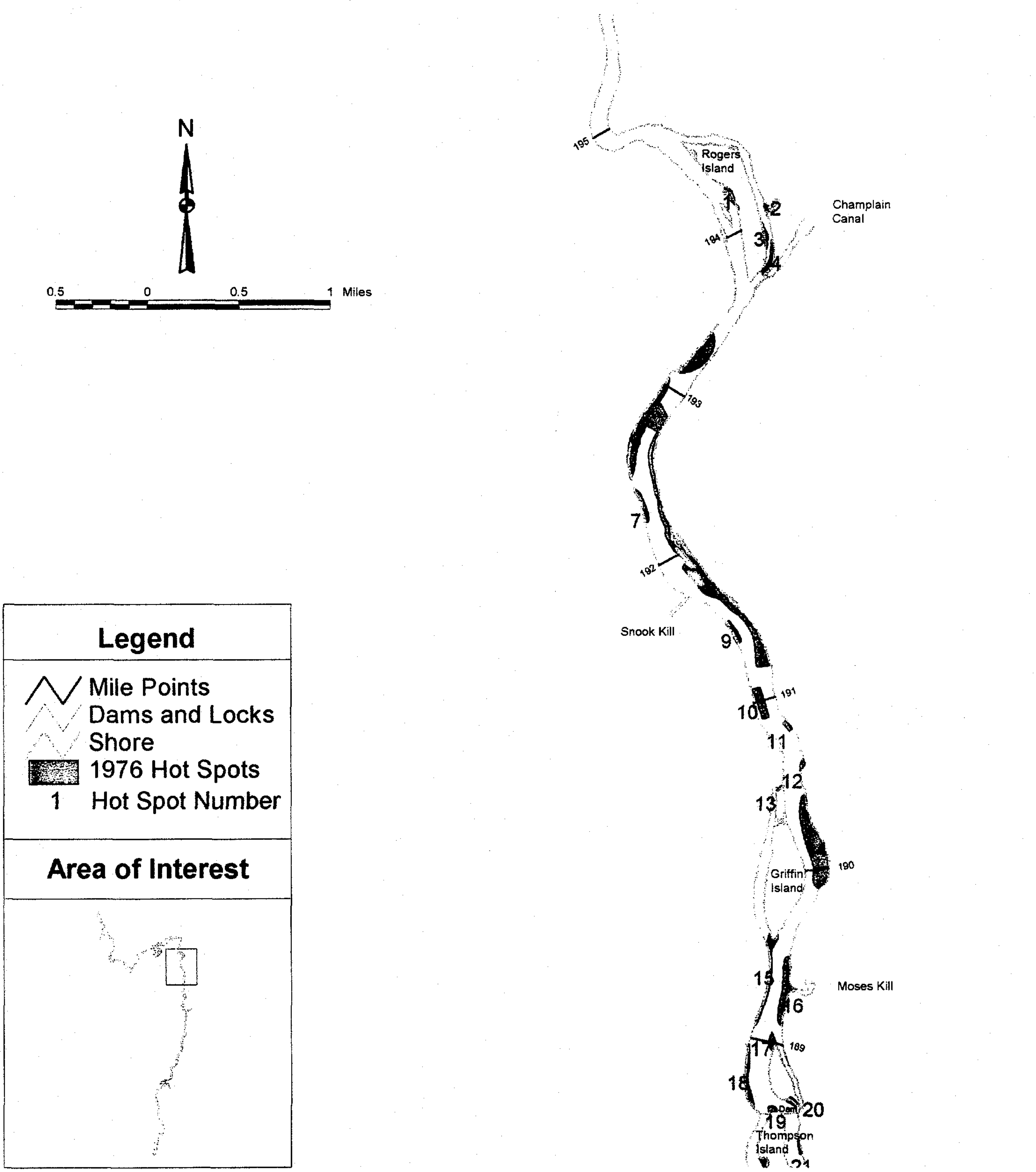

Figure 1. 1976 NYSDEC Sediment Hot Spot Locations within Thompson Island Pool

HydroQual, Inc. February, 1997

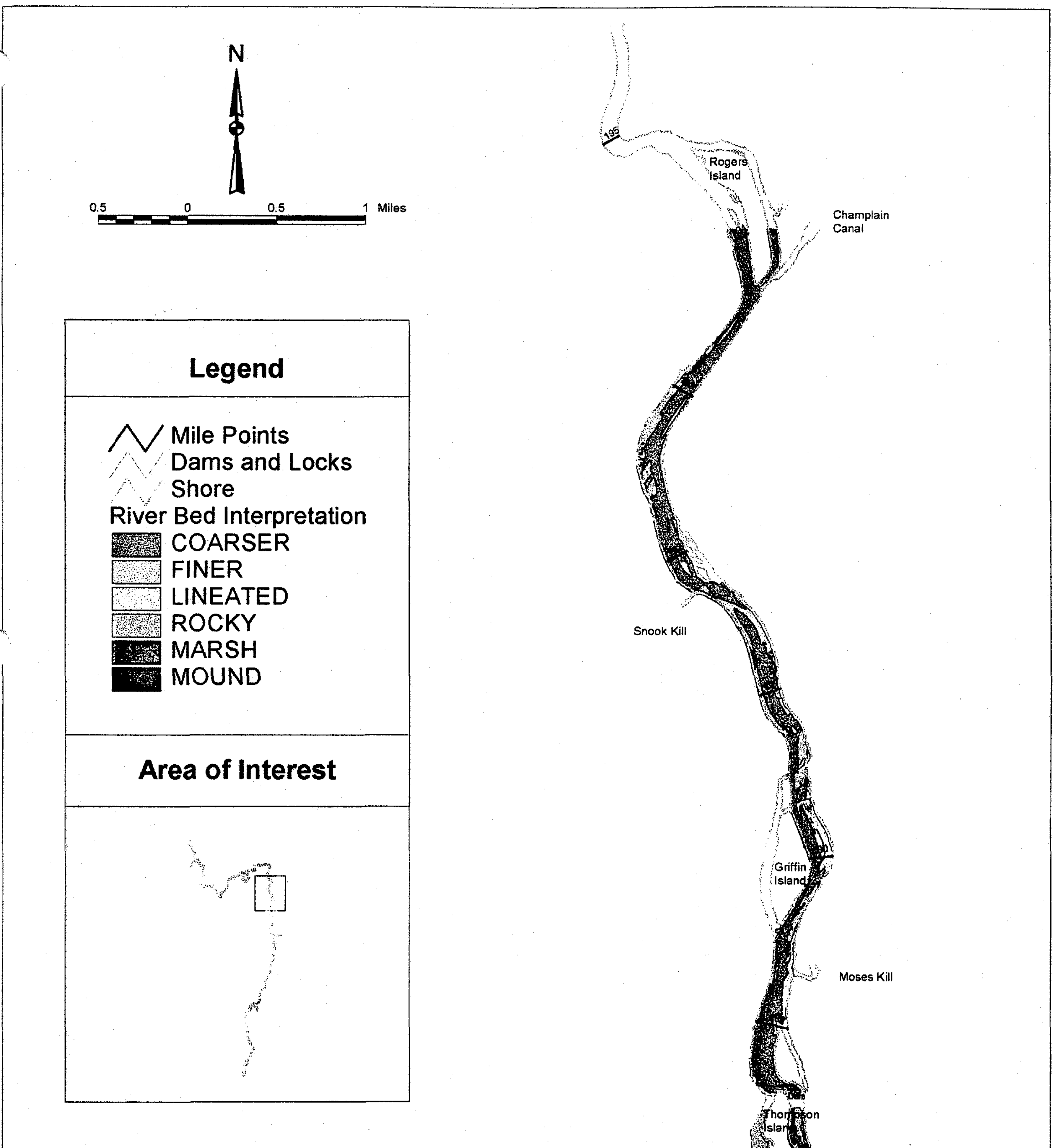

Figure 2. SideScan Sonar Interpretation of the Thompson Island Pool River Bed

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February, 1997

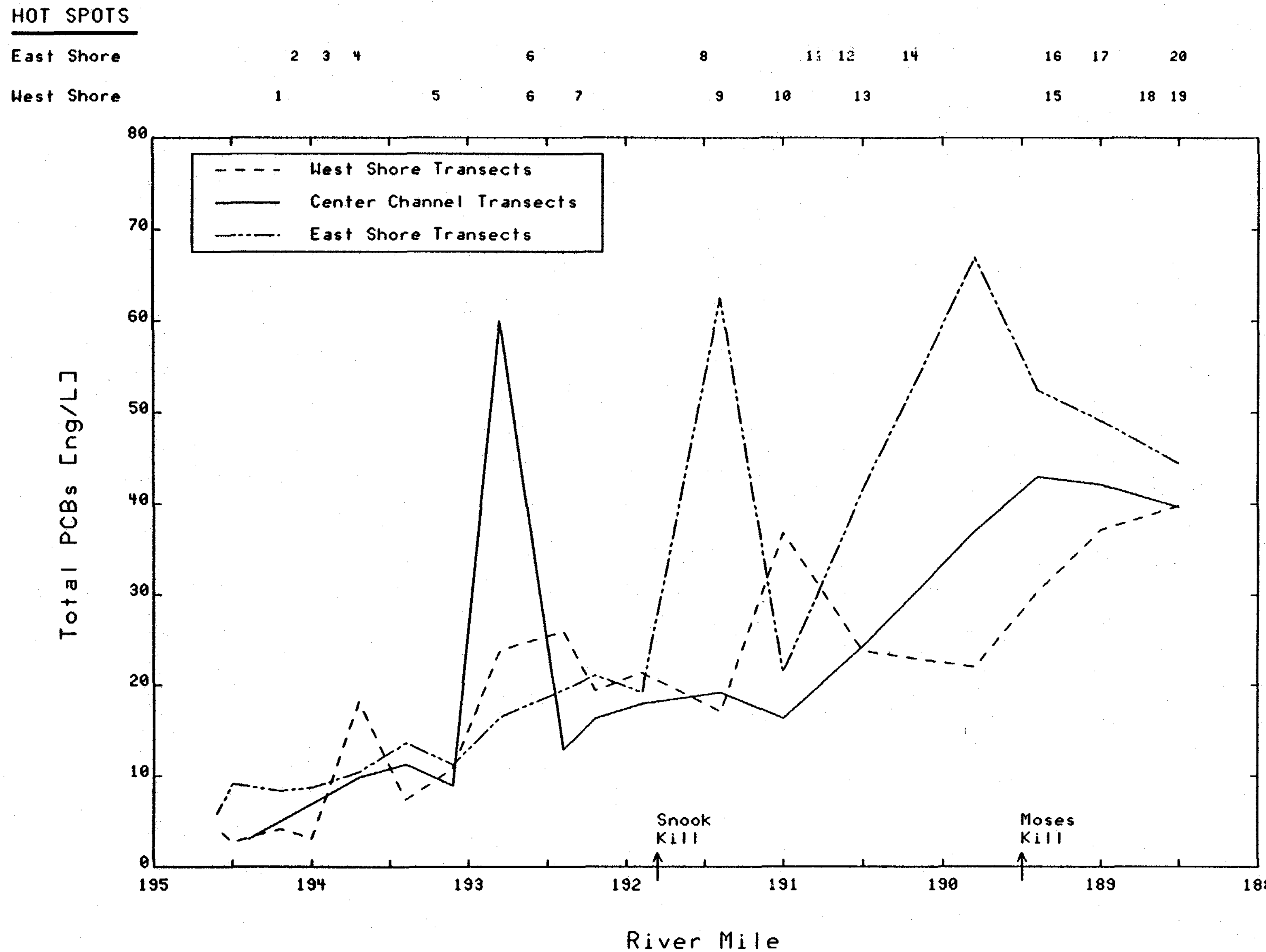

Figure 3. Spatial Profile of 1996 TIP Float Survey Data
Average from 9/24 and 9/25 Sampling Events

Mon Feb 3, 1997 16:25:43
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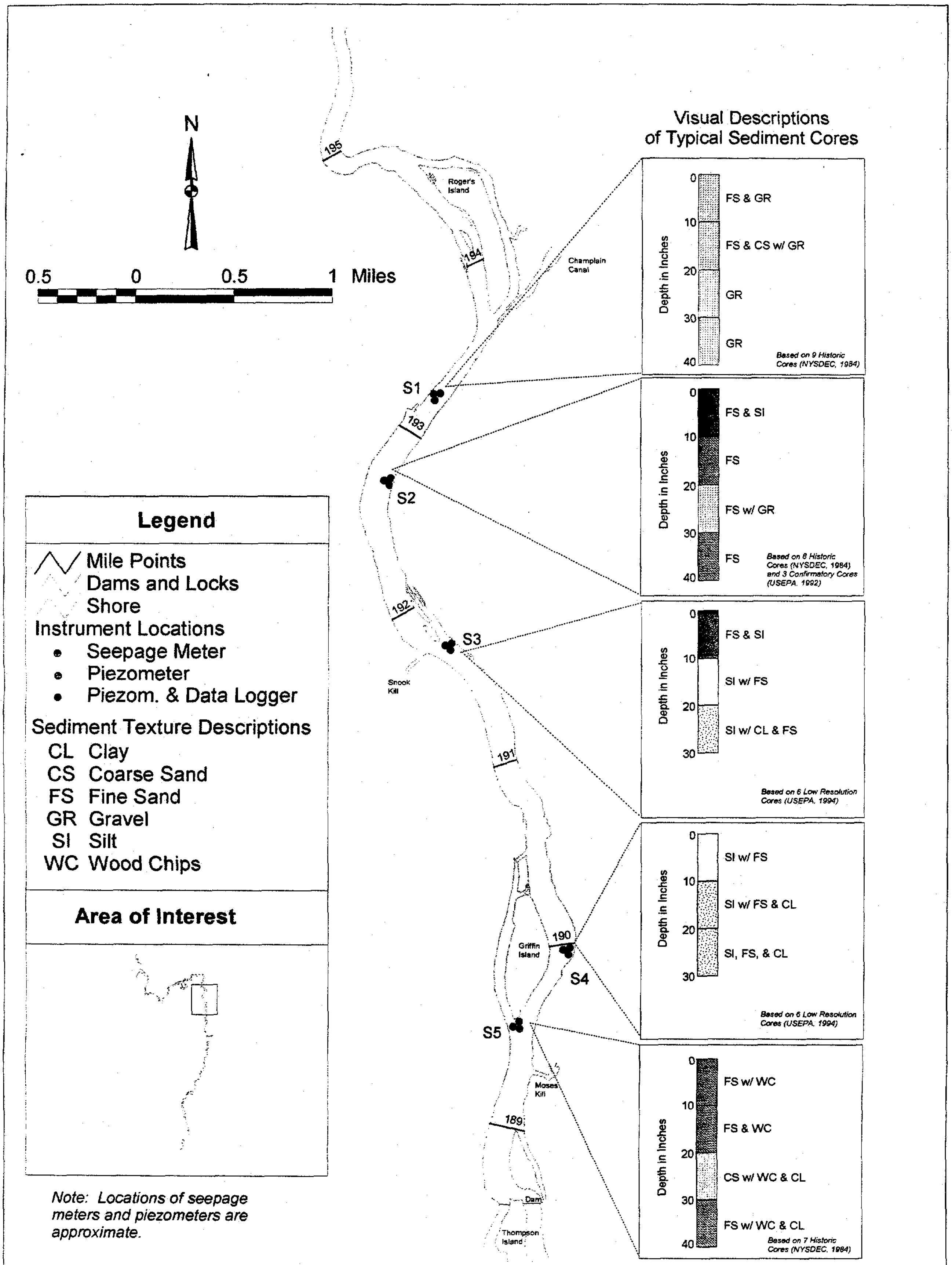

Figure 4. Groundwater Seepage Monitoring Stations and Sediment Core Visual Descriptions

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DATE: FEBRUARY 4, 1997

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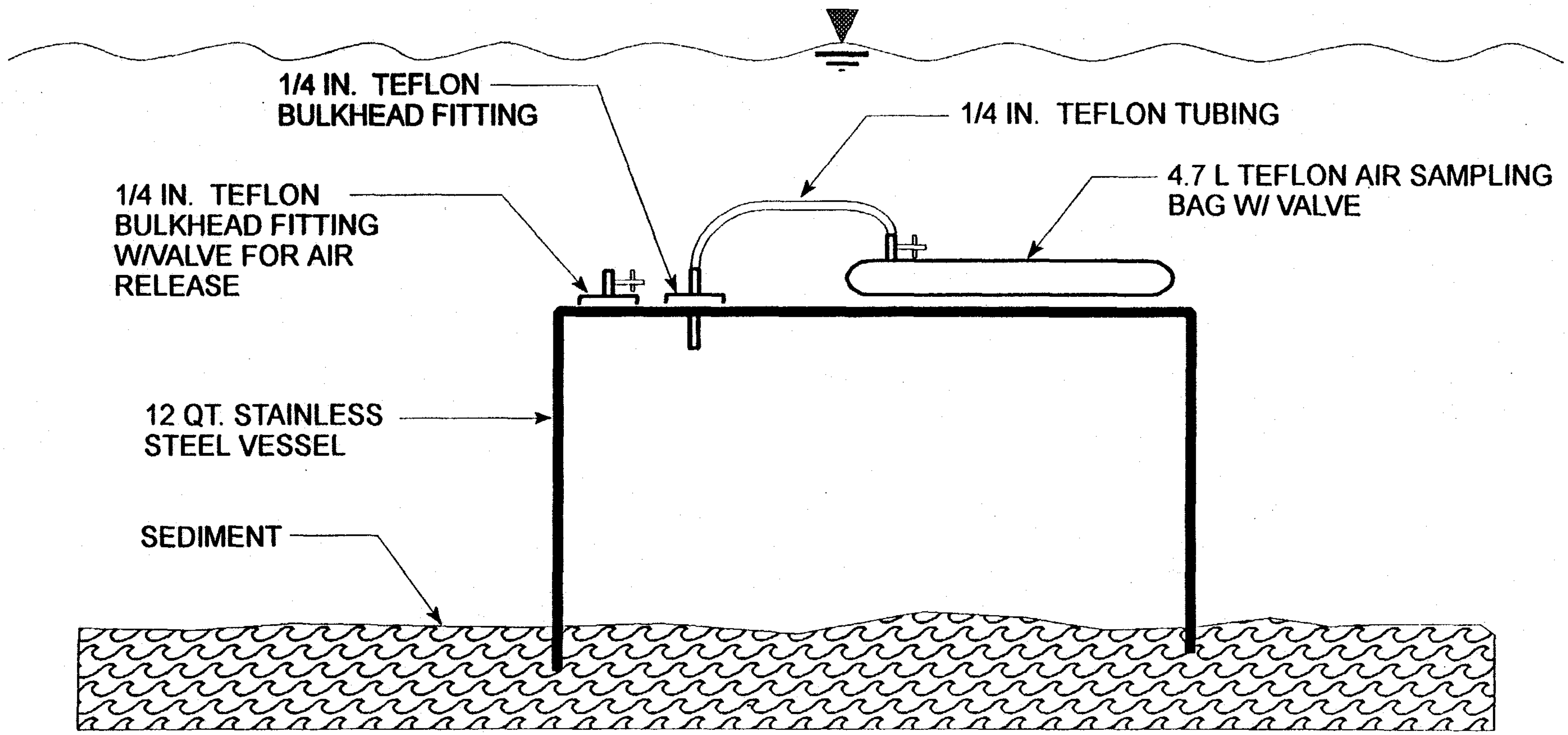

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HUDSON RIVER PROJECT

GROUND WATER SEEPAGE METER

NOT TO SCALE

FIGURE 5

O'BRIEN & GERE ENGINEERS INC.

DATE: FEBRUARY 4, 1997

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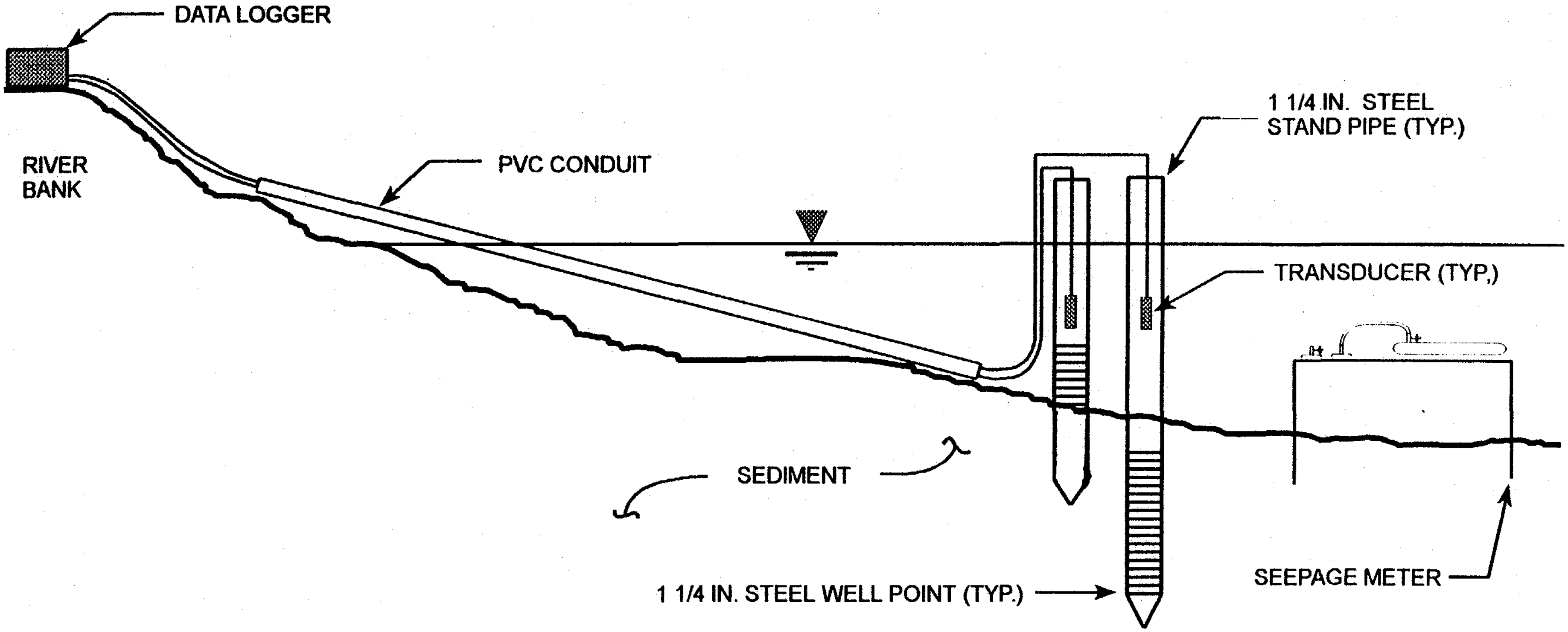

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TYPICAL PIEZOMETER/SEEPAGE METER INSTALLATION

NOT TO SCALE

FIGURE 6

O'BRIEN & GERE ENGINEERS INC.

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Figure 7.

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Hudson River Project - Groundwater Seepage Investigation
Organizational Chart

<u>Project Managers</u>
J. Guswa, (GTI)
J.R. Rhea, Ph.D., (HQI)

<u>Experimental Field Work</u>
A. Benjamin, (GTI)
K. T. Russell, (HQI)

- Seepage Meter Sampling
- Hydraulic Gradient Measurement
- Hydraulic Conductivity Testing

<u>Instrument Fabrication and Field Support</u>
M.D. LaRue, (OBG)

- Seepage Meter Fabrication
- Piezometer Fabrication
- Instrument Deployment and Sampling

Figure 8.

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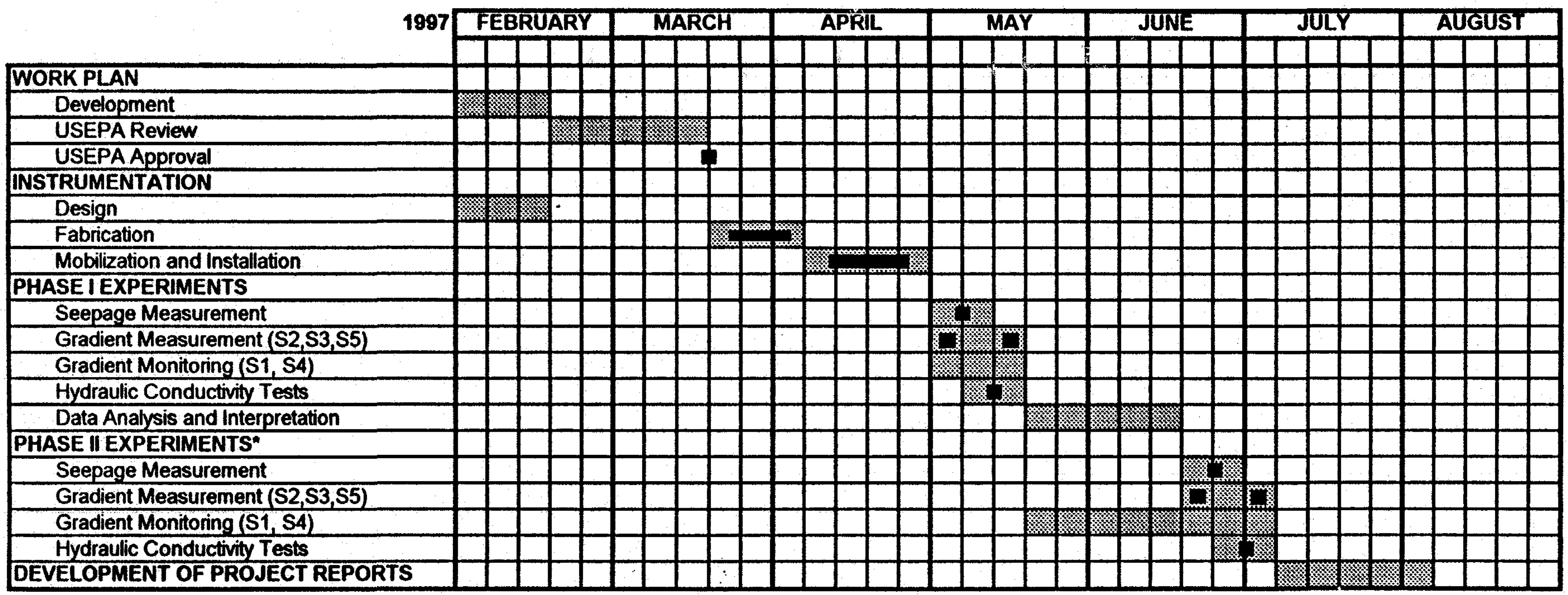
Hudson River Project - Groundwater Seepage Investigation

Project Schedule



NOTES

Mobilization and installation of seepage meters to begin immediately following spring high-flow period.

* Phase II experiments are contingent on results from Phase I data analysis and interpretation.

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ADDENDUM

HydroQual, Inc.
Environmental Engineers and Scientists

ADDENDUM No. 1

This addendum to the Sampling and Analysis Plan for the Groundwater Seepage Investigation in the Thompson Island Pool Section of the Upper Hudson River (February, 1997[1]) has been developed by HydroQual on behalf of the General Electric corporation to reflect a revised area of study.

To further examine the potential effects of advective groundwater exchange on PCB dynamics in the upper Hudson River,. an additional site has been selected for measurement of riverbed groundwater seepage properties. This additional site has been located outside of the Thompson Island Pool to allow an assessment of the impacts of groundwater seepage on other sections of the upper Hudson River.

The attached figure (Figure A-1) depicts the location of the additional groundwater seepage measurement site (to be denoted S6). This site is located downstream of the Thompson Island Dam, near Lock 6 on the eastern shore of the river (approximate mile point 185.8). Two seepage meters and a piezometer will be located within sediments historically associated with high PCB concentrations (1976 NYSDEC Hot Spot 28). The S6 site has been scheduled for hydraulic conductivity, hydraulic gradient, and groundwater seepage flux measurement in Phase II of the study (summer 1997).

[1]Work Plan entitled: Sampling and Analysis Plan. Investigation of Groundwater Seepage in the Thompson Island Pool Section of the Upper Hudson River. (HydroQual, HSI GeoTrans, Inc., and O'Brien and Gere Engineers, Inc., 2/97)

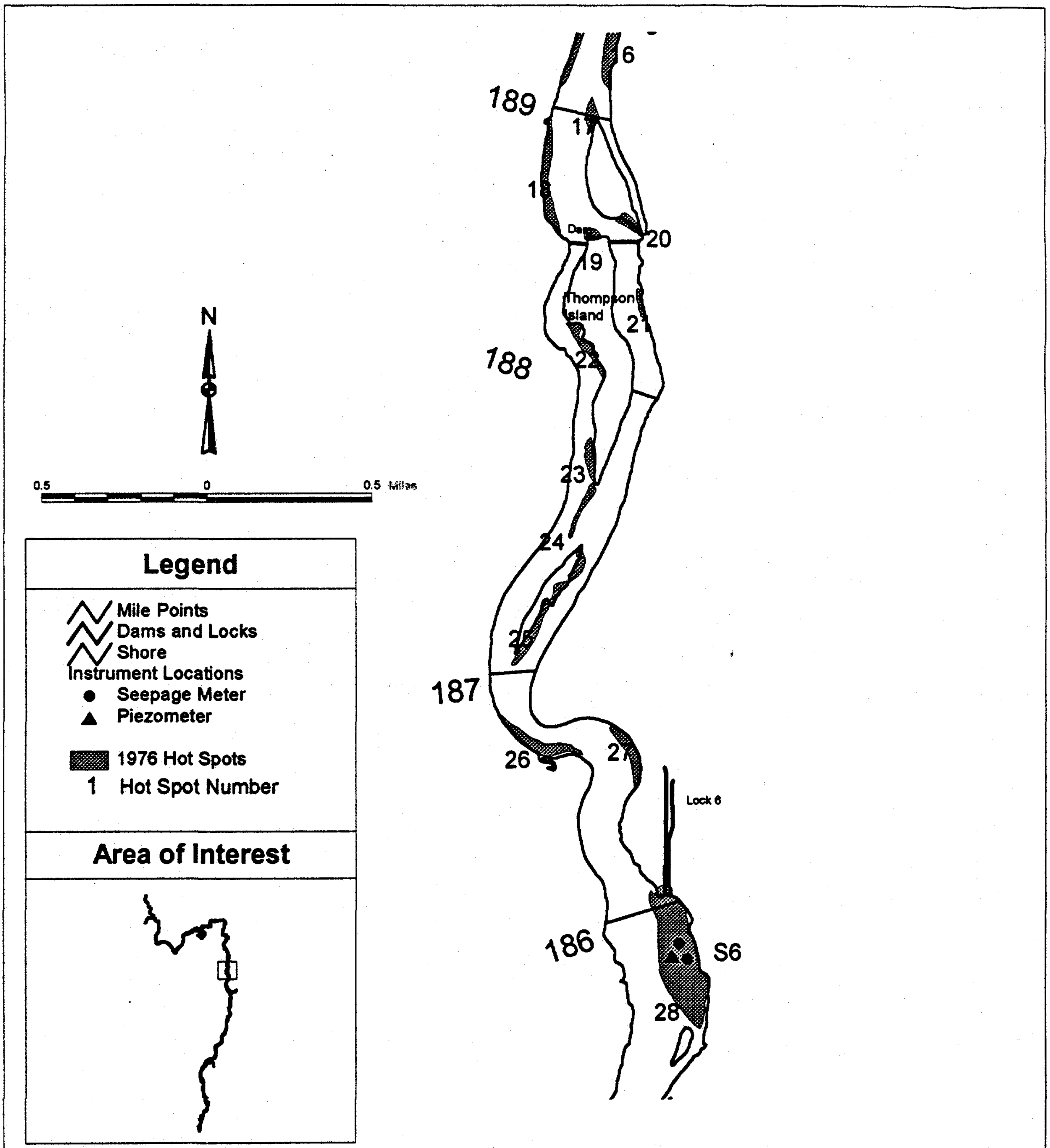

Figure A1. Additional Groundwater Seepage Monitoring Location Downstream of Thompson Island Pool

HydroQual

March, 1997