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AMBIENT GROUND WATER QUALITY MONITORING COST ANALYSIS

Ambient Ground Water Quality Monitoring Cost Analysis

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Executive Summary

This paper outlines the costs incurred when implementing an ambient ground water quality monitoring program. Following a brief description of the major components of an ambient monitoring program, representative budgets for eight state programs, and well installation and laboratory analysis component costs are described. This paper also provides an algorithm for estimating the costs associated with new or expanded ambient ground water quality monitoring efforts and concludes with a discussion of those factors that could further reduce monitoring program costs.

This study found that at least eight states have amassed sufficient experience with ambient ground water quality monitoring to generate representative program cost information. Based on estimates provided by those states, well installers, and analytical laboratories, the report summarizes the following monitoring program development and operating costs:

Development

(1) Monitoring program design;
(2) Monitoring network installation;

Operation

(3) Monitoring network maintenance;
(4) Ground water sampling;
(5) Ground water sample analysis;
(6) Ground water analyte data management;
(7) Ground water analyte data interpretation;
(8) Communication of ground water monitoring results; and
(9) Monitoring program evaluation and redesign.

To provide a basis for estimating the costs associated with new or expanded state monitoring efforts, a monitoring program scenario was created including the following components:

- 100 wells sampled annually;
- 185 analytes sampled; and
- ongoing network maintenance, data analysis, data management, and communication.

Based on the assumptions outlined in this report, operating such a monitoring program would cost approximately $267,000 annually (excluding well-installation costs). The one-time cost for installing a 100 well-monitoring network would total approximately $200,000. However, most states instituting a monitoring effort would not incur this total cost because states commonly use a combination of new and existing wells when creating an ambient monitoring network.

The estimated costs for implementing this scenario exceed the budgets reported for several similar state monitoring programs due to several factors. First, state programs almost exclusively use State analysis laboratories. As these laboratories are typically subsidized by the state government, their analysis costs are significantly less than private laboratories. Second, state programs, despite larger monitoring networks, monitor on a more infrequent schedule, often sampling wells once every two or three years. State programs also tend to monitor fewer analytes than the monitoring program scenario.

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1.0 Introduction

The U.S. Environmental Protection Agency (EPA) encourages the collection of ambient ground-water quality monitoring data to support ground water protection and management. The objectives of such monitoring programs have recently been outlined in the recommendations of the Intergovernmental Task Force on Monitoring Water Quality (ITFM)[1] and the 1996 Guidelines for the Clean Water Act Section 305(b) State Ground Water Quality Reports.

This paper outlines the U.S. EPA's findings to date regarding existing state ground-water quality monitoring activities. First, the major components of an ambient monitoring program are described. Second, data representing eight state ambient ground water-quality monitoring program budgets, and well installation and laboratory analysis component costs are summarized. Third, to assist state and local programs in evaluating monitoring costs, this paper describes an algorithm for estimating the costs associated with new or expanded ambient ground water quality monitoring programs. Finally, the paper concludes with a discussion of those factors that could further reduce the costs associated with ambient ground water quality monitoring. These findings are not intended to provide a firm estimate of ambient ground water-quality monitoring costs for budgeting purposes. Instead, these data are provided to give federal, state, and local programs guidance on the likely range of costs associated with existing and expanded ambient ground water-quality monitoring programs.

2.0 Ground Water Quality Monitoring Program Components

This section outlines the nine main components of an ambient ground water quality monitoring program that most influence program costs. These components were identified primarily based upon an analysis of state ambient monitoring programs; however, these components should apply equally to federal and local ground water-quality monitoring efforts.

Monitoring program costs can be classified into two categories: (1) development costs and (2) operating costs. Program development costs encompass activities involved in designing and initiating a water quality monitoring program and a monitoring network. For example, determining the number and location of monitoring wells and installing monitoring wells, if needed. Program operating costs extend over the period of one monitoring cycle, which is typically one year. These operating costs include all activities needed to collect, analyze, and report data characterizing ambient ground water-quality conditions within a study area.

Under the development and operating categories, this study identified nine key components:

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[1] January 1996. "The Strategy for Improving Water-Quality Monitoring in the United States: Final Report of the Intergovernmental Task Force on Monitoring Water Quality."

Development

(1) Monitoring program design;
(2) Monitoring network installation;

Operation

(3) Monitoring network maintenance;
(4) Ground water sampling;
(5) Ground water sample analysis;
(6) Ground water analyte data management;
(7) Ground water analyte data interpretation;
(8) Communication of ground water monitoring results; and
(9) Monitoring program evaluation and redesign.

Each of these components is addressed briefly below. A more detailed description of the components and the costs associated with them is provided in Sections 3.0 and 4.0.

2.1 Monitoring Program Development Components

Development costs occur during the process of defining, establishing, and installing an ambient ground water-quality monitoring program. Monitoring program development costs are not always concluded prior to initial operation of a monitoring program, and can extend beyond the initial monitoring cycle.

Monitoring program design

Monitoring program design addresses the geographic area covered by the program, the number of wells needed to characterize ambient conditions accurately, the number or frequency of wells sampled annually, and the water-quality constituents to be analyzed. In determining the program design, a critical issue affecting program costs is the decision whether to use pre-existing wells or to install new monitoring wells. Pre-existing wells may be found in the area to be monitored in the form of community water supply or residential drinking water wells, irrigation wells, or wells used for compliance monitoring or other ambient monitoring activities. Existing wells may be adequate to support the monitoring program if they are finished within the aquifer of concern, screened at an appropriate sampling depth, and cased properly so as not to interfere with the sampled analytes.

Three critical factors affect ambient ground water monitoring program design: (1) the hydrogeologic characteristics of the aquifer or ground water region being monitored; (2) the nature and extent of the contaminant sources affecting the monitored region; and (3) the goal of the monitoring program (e.g., determining long-term water quality trends or identifying localized contamination incidents). For a more detailed discussion of monitoring program design considerations, see "The Strategy for Improving Water-Quality Monitoring in the United States: Final Report of the Intergovernmental Task Force on Monitoring Water Quality, Appendix L: Ground-Water Monitoring."

In addition to designing the sampling network, the number of water-quality analyses within a sampling cycle (e.g., annually) can be determined based on the number of analytes, the number of wells,

and the sampling frequency (e.g., quarterly vs. annually). Once this is determined the monitoring program can negotiate and contract with an analytical laboratory. Finally, the monitoring program design should also make provision for establishing monitoring data management and interpretation methods and conducting communication and outreach activities.

These program design activities establish the basis for conducting and executing all other components of a ground water monitoring program.

Monitoring network installation

Monitoring network installation costs can include well site procurement (if any), well installation (e.g., the labor and materials costs of drilling a well bore, inserting a well casing, and sealing/priming the final well), or well refitting (i.e., renovation or improvement of an existing well). These costs can encompass a significant portion of a monitoring program's initial budget if existing wells are not adequate. However, monitoring programs can choose to "phase-in" these costs by expanding the scope of the monitoring effort and installing new monitoring wells over time.

Key factors influencing the number of wells in a monitoring program design include the geographic size of the monitored region and the hydrogeologic complexity of the ground water system. For example, heterogeneous aquifer systems or systems with rapid ground water velocities may require a greater number of wells than more homogeneous, slow-moving groundwater systems to characterize local contamination events.

2.2 Monitoring Program Operating Components

Operating costs are incurred to support ongoing implementation of the ambient monitoring program. These costs may vary from year to year, as the number of wells sampled, the number of analytes assessed, or the level of resources devoted to data management and reporting may change. Nonetheless, these costs are characterized by the following seven components.

Monitoring network maintenance

Monitoring network maintenance costs consist of well integrity inspections and repairs to correct well anomalies. The extent of well repairs ranges from regrouting a single well to closure of an active monitoring well and the installation of a replacement well.

Ground water sampling

The ground water sampling component incorporates the costs of labor, materials, and expenses for collecting monitoring samples and transporting them to a laboratory for analysis.[2] For example, the cost of sample collection jars, field instruments (such as pH meters), and ground water extraction tools (such as well pumps and hoses) are identified as program development costs (i.e., capital costs) under most state monitoring program budgets.

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[2] In Section 3.0, several states include the cost of certain materials used in ground-water sampling as program development costs.

Ground water sample analysis

This monitoring program component entails the cost of laboratory analysis of ground water samples for a set of constituent elements. As discussed in Section 3.2, these costs may vary significantly as different analytical methods are considered and different groups of analytes are assessed. The analytical results are generally returned to the monitoring program's managing authority in tabular format.

Ground water analyte data management

The ground water data management component entails collecting ground water analysis results, compiling the results into a database, and processing analyte data into a format appropriate for data analysis and interpretation.

Ground water analyte data interpretation

Data interpretation involves examining analyte concentrations to assess the general ground water quality throughout the program study-area. This can involve generating a model of program-wide analyte levels from monitoring well data to identify areas of poor ground water quality. The data interpretation component generally culminates in a report documenting ground water quality patterns across the monitored region.

Communication of ground water monitoring results

Data communication is a significant component of an ambient ground water monitoring program. Several communication methods are used, including: publishing a ground water quality status report, presenting a ground water quality seminar, or making monitoring results available for online access. The goal of program communication is to inform the public about the status of ground water quality and the effects of contamination.

Program evaluation and redesign

Monitoring program evaluation assesses effectiveness and deficiencies after comparison of program results and program goals. This assessment is used to determine monitoring program needs, and forms a basis for program redesign and modification, if present goals are not currently being met.

3.0 Representative Ground Water Quality Monitoring Cost Data

Several state ground water programs have experience with the ambient monitoring program components summarized above. This chapter presents the costs associated with eight ambient ground water quality monitoring programs operated in the states of Arizona, Arkansas, Florida, Idaho, Kansas, Maryland, Minnesota, and North Dakota. These states were identified for this analysis based on their ability to provide budgetary information relating specifically to the cost components. In addition, this chapter presents representative data for monitoring well installation and laboratory analysis costs. These cost data were derived by contacting private well contractors and private and public analytical laboratories located throughout the United States.

3.1 Representative State Ambient Ground Water Quality Monitoring Program Costs

The eight state ground water programs were contacted to gather data on the characteristics of the programs (i.e., number and frequency of wells sampled, number of analytes assessed, and geographic scope of the monitoring program) and the costs associated with each of the monitoring program components outlined above. These data are representative only and do not necessarily predict the costs associated with other, similar ground water quality monitoring efforts. The factors influencing monitoring program costs are further summarized in Section 4.0. The analytes included under each of the state ambient monitoring programs are listed in Appendix A.

3.1.1 Ambient Ground Water Quality Monitoring Program Characteristics

Arizona

Arizona initiated ambient ground water monitoring efforts in 1987 to assist ground water quality protection programs. The purpose of the program is to provide current ground water quality data and observe the movement of contaminants through ground water resources. These programs are funded exclusively by the State of Arizona.

Arizona operates a statewide monitoring network of about 500 wells. Approximately 300 wells are sampled annually for a series of analytes selected on a site-specific basis. These analytes are selected from ions, nutrients, metals, general water quality parameters, volatile organic compounds, pesticides, radionuclides, and microbiological constituents.

Arkansas

Arkansas' ambient ground water monitoring program was developed in 1985 in conjunction with the USGS. The program is designed to collect and disseminate background ground-water quality data for several aquifers across the state. Arkansas' monitoring program is funded entirely by EPA Clean Water Act, Section 106 grants.

The program maintains a monitoring network consisting of 107 existing wells and 10 springs, located within seven "prototype" monitoring systems across the State. Each prototype system targets regions of concern and monitors for analytes based on the social (i.e., contaminant sources) and hydrogeological conditions of the prototype location. The monitoring program samples the monitoring network on a three year cycle.

Florida

The Florida ambient ground water monitoring program was developed in 1984 under the Florida Water Quality Assurance Act, to detect and predict contamination of state ground-water resources. The program characterizes the ground water quality in the major aquifers, identifies trends in individual aquifers, locates areas with water quality problems, and disseminates information back to local drinking water suppliers. The program is entirely funded by the State of Florida.

Florida operates a statewide monitoring network of approximately 2300 existing wells, which are monitored on a three year cycle. In addition, a small subset of Florida's monitoring network is sampled quarterly, for a reduced set of analytes. Florida also maintains a Very Intensive Study Area (VISA) program, which monitors wells in selected areas/aquifers for a more detailed set of analytes tied to contaminant sources in the area.

Idaho

Idaho developed its ambient ground water monitoring program in conjunction with the USGS in 1990. Idaho's program is designed to characterize ground water quality in major aquifers, identify trends in individual aquifers, and locate areas with water quality problems. Idaho also operates the program in association with USGS, and receives partial funding from USGS grants.

Idaho is devising a statewide monitoring network of 1600 existing wells, and plans to monitor each well on a four year cycle. Wells within regions of water quality concern will be sampled more frequently. Idaho plans to use an Environmental Data Management System (EDMS) to store federal, state, and other ground-water quality data.

Kansas

The Kansas ambient ground water monitoring program was developed in conjunction with the USGS in 1976. Its purpose is to characterize Kansas' ground-water quality in major aquifers, identify trends in individual aquifers, and locate areas with water quality problems. Kansas funds the entirety of monitoring program costs.

Kansas maintains a monitoring network that consists of 250 existing public and private wells. The monitoring network is sampled on a two year monitoring cycle, where each well is analyzed for pesticides and inorganic chemistry, and every year 25 private wells are analyzed for VOCs and radionuclides.

Maryland

The Maryland Geological Survey, with USGS, implemented an ambient ground water monitoring program in 1987 to establish baseline chemical conditions for selected aquifers across the State of Maryland. The program is funded by EPA Clean Water Act, Section 106 grants and by the Maryland Department of the Environment.

Maryland's monitoring network is slowly being developed and presently consists of 52 wells and springs, which are sampled annually. The program operates in four segments, conforming to the different physiographic regions of Maryland. The program was initially designed to monitor 100 wells and springs statewide; however, this design was not implemented due to budgetary constraints.

Minnesota

Minnesota's ambient ground water monitoring program was developed by USGS in 1977, to characterize the general ground water quality of Minnesota's aquifers. In 1990, the program's goals were expanded to develop a statewide baseline of ground water quality for all of the state's major aquifers. The

program goals also consist of developing trend analyses for sensitive regions, however this portion is presently unfunded. The program is funded entirely by Minnesota, but operations support is provided by county and local governments at a substantial savings.

The program currently maintains a monitoring network of approximately 600 single-aquifer, cased, and grouted wells. The network will eventually include approximately 1200 wells and cover the state's 14 major aquifers, when complete. At present, about 200 wells a year are sampled and the location verified (using a Global Positioning System) prior to addition to the baseline network.

North Dakota

The North Dakota ambient ground water monitoring program was developed in 1992 to establish a baseline description of aquifer ground water quality. The monitoring program supports a statewide ground water protection program, which assesses aquifer resource quality impacts from agricultural chemicals. The program is jointly funded by the North Dakota Environment and Rangeland Protection Fund and EPA Section 319 grants.

North Dakota targets monitoring efforts based on an aquifer vulnerability score generated by a DRASTIC ground water vulnerability model, and the highest priority aquifers are sampled each year. North Dakota currently maintains a monitoring network consisting of 403 existing public and private wells. The statewide monitoring network is being developed at a rate of approximately 155 wells per year.

3.1.2 Representative State Monitoring Program Costs

Exhibit 1 presents the monitoring program characteristics and costs reported by each state. In completing this analysis, each state was asked to apportion annual program costs into the nine cost components. For those states with established monitoring programs, limited program development costs were reported (i.e., for monitoring program design or monitoring network installation).

Specific analytes monitored by representative state programs are listed in Appendix A. For each state, the analytes monitored are cataloged by analyte group to facilitate the ground-water analysis cost estimate (e.g., metals, non-metals, or volatile organic compounds.)

Portions of the Arizona and Maryland program cost estimates are listed as "Other Undefined Costs". These are costs which cannot be classified within the program components and are therefore listed separately. In Arizona, several agencies conduct ground water quality monitoring activities. Undefined costs represent an estimate of total costs incurred by agencies that perform limited ambient ground water monitoring. Maryland's undefined program costs are generated from "common services" within the Maryland Department of Natural Resources.

States contacted for monitoring program cost estimates were provided with descriptions of monitoring program components, and asked to use the component descriptions to verify program cost estimates. Several of the contacted states were unable to separate certain program component costs. For example, Florida's program merges data management and data interpretation costs together. Idaho has entered into an agreement with USGS to perform ground water sample collection and analysis, and does not separate these cost components.

EXHIBIT 1

Estimated State Ambient Ground Water Monitoring Program Costs

Program Development Costs

Development Components	Arizona[1]	Arkansas	Florida	Idaho[1]	Kansas[1]	Maryland	Minnesota	North Dakota[1]
Monitoring Program Design	$0	$30,750	$5,100,000	$0	$0	$0	$196,000	$0
Monitoring Program Implementation	$0	$500	$0	$0	$0	$23,000	$108,000	$0
Total:	$0	$31,250	$5,100,000	$0	$0	$23,000	$304,000	$0

Program Operating Costs[3]

Operation Components	Arizona[4]	Arkansas[5]	Florida[6]	Idaho[7]	Kansas[8]	Maryland	Minnesota	North Dakota
Monitoring Network Maintenance	$0	$0	$108,000	$0	$0	$0	$0	$0
Ground Water Sampling	$110,000	$6,180	$330,000	$0	$22,000	$31,300	$50,000	$92,000
Ground Water Analysis	$250,000	$30,155	$500,000	$572,500	$55,000	$39,350	$75,000	$55,000
Analytical Data Management	$50,000	$1,800	$0	$103,000	$10,000	$16,150	$10,000	$18,000
Analytical Data Interpretation	$80,000	$11,760	$216,000	$75,000	$10,000	$10,450	$10,000	$30,000
Communicating Results	$50,000	$2,500	$70,000	$9,000	$3,000	$2,650	$3,000	$5,000
Monitoring Program Evaluation	$70,000	$3,360	$200,000	$20,000	$0	$0	$2,000	$0
Other Undefined Costs	$190,000	$0	$0	$0	$0	$67,900	$0	$0
Total:	$800,000	$55,755	$1,424,000	$779,500	$100,000	$167,800	$150,000	$200,000

Program Scope

Scope Elements	Arizona	Arkansas[9]	Florida	Idaho	Kansas[10]	Maryland	Minnesota[11]	North Dakota[12]
Number of Wells	500	117	2,300	1,600	250	52	600	403
Number of Wells Sampled Annually	300	39	767	400	125	52	206	155
Number of Analytes	NA	91	65	98	104	73	125	66

Notes:

All Reported costs are based on estimates provided by the contacted States.

1 No data were provided by these States to complete these categories.

2 Florida's initial program development cost was $1.7M/year for three years. Program implementation costs are included in program design costs.

3 Unless otherwise stated, monitoring programs maintain a one year monitoring cycle.

4 Ground water monitoring costs include ambient and compliance ground water monitoring.

5 Total cost of Arkansas ambient ground water monitoring program. Arkansas maintains a three year monitoring cycle.

6 Annual cost of Florida ambient ground water monitoring program. Florida maintains a three year monitoring cycle.

7 Annual cost of Idaho ambient ground water monitoring program. Idaho maintains a four year monitoring cycle. Cost includes $235,000 of USGS grant funding. Program design, network maintenance, well sampling, and sample analysis costs are included within ground water analysis component.

8 Annual cost of Kansas ambient ground water monitoring program. Kansas maintains a two year monitoring cycle.

9 Arkansas ambient ground water monitoring network consists of 107 wells and 10 springs. The number of analytes represents the total number of analytes monitored throughout the entire monitoring program. The actual number of analytes monitored varies by well location.

10 The number of analytes represents the total number of analytes monitored throughout the entire monitoring program. The actual number of analytes monitored varies by well location.

11 Minnesota's ambient ground water monitoring program samples approximately 206 wells annually. The number of wells within the monitoring network reflects the total number of wells sampled to date.

12 North Dakota's ambient ground water monitoring program samples approximately 155 wells annually. The number of wells within the monitoring network reflects the total number of wells sampled to date.

3.1.3 Effects of Program Scope on State Program Costs

This analysis sought to identify relationships between state program scope elements (number of wells and number of analytes monitored) and state monitoring program costs. Figure 1 depicts the relationship between the monitoring program cost and the number of wells sampled. In general, monitoring program costs increase with the number of wells sampled. In Maryland, however, the relatively high program costs in relation to the small number of wells monitored may be a function of higher labor costs in the state and the costs per analyte sampled.

Figure 2 presents the relationship between monitoring program costs and the number of analytes assessed. The number of analytes included in the monitoring program appears to be a poor predictor of program cost. For example, although Kansas assesses a large set of analytes under its program, because of the reduced emphasis the state places on data management and interpretation, overall monitoring program costs are low.

3.2 Representative Ground Water Quality Parameter - Analysis Costs

Seven public and private laboratories were contacted to gather cost estimates for conducting analyses of a broad range of ground water quality analytes. The analytes were selected based on a review of water quality parameters used by existing ground water quality monitoring programs, including the U.S. Geological Survey NAWQA program. The laboratories provided quotes both for single parameter analyses and for analyses of sets of water quality parameters (e.g., GC/MS scans for volatile organic compounds). The cost estimates provided by the laboratories are listed in Appendix B. For each analyte, either the cost of a single unit analysis or the "schedule" under which the analyte would be included is listed. Costs for multiple parameter analyses are also provided. For laboratories that do not perform analyses for certain parameters, no cost data are provided.

Making cost comparisons among analytical laboratories is often difficult. Analytical procedures differ and the experience and level of precision provided by the laboratory and the particular procedure may vary. Therefore, choosing the laboratory that offers the lowest cost for a particular analyte may not always be appropriate. The decision should also be based on the specified analytical procedure, quality assurance and turn-around times offered by the laboratory, and past experience with the vendor.

3.3 Representative Monitoring Well Installation Costs

Nine private well drilling companies were contacted to gather cost estimates for monitoring well installation. Four Representative Well Types (RWTs) were developed to ensure that the quotes reflect similar well designs. The RWT characteristics (listed in Table 1) were designed to account for the diverse nature of hydrogeological conditions across the United States. The companies were also asked to estimate the costs of installing each type of RWT in several soil scenarios: sand, glacial till, and bedrock.

Figure 1.

Annual Cost of Ambient Ground Water Monitoring Programs by Number of Sites Sampled

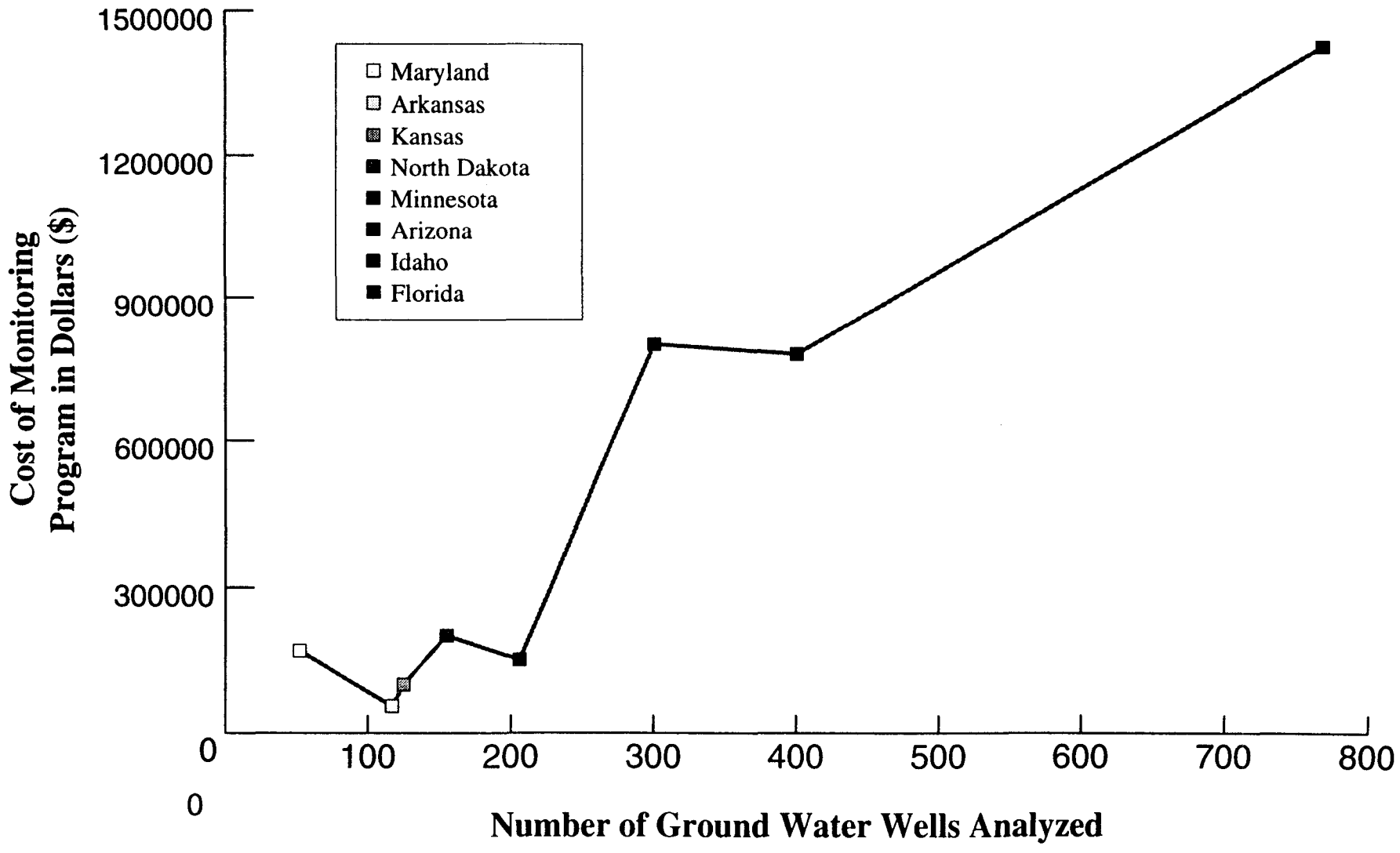

Figure 2.

Annual Cost of Ambient Ground Water Monitoring Program by Number of Analytes

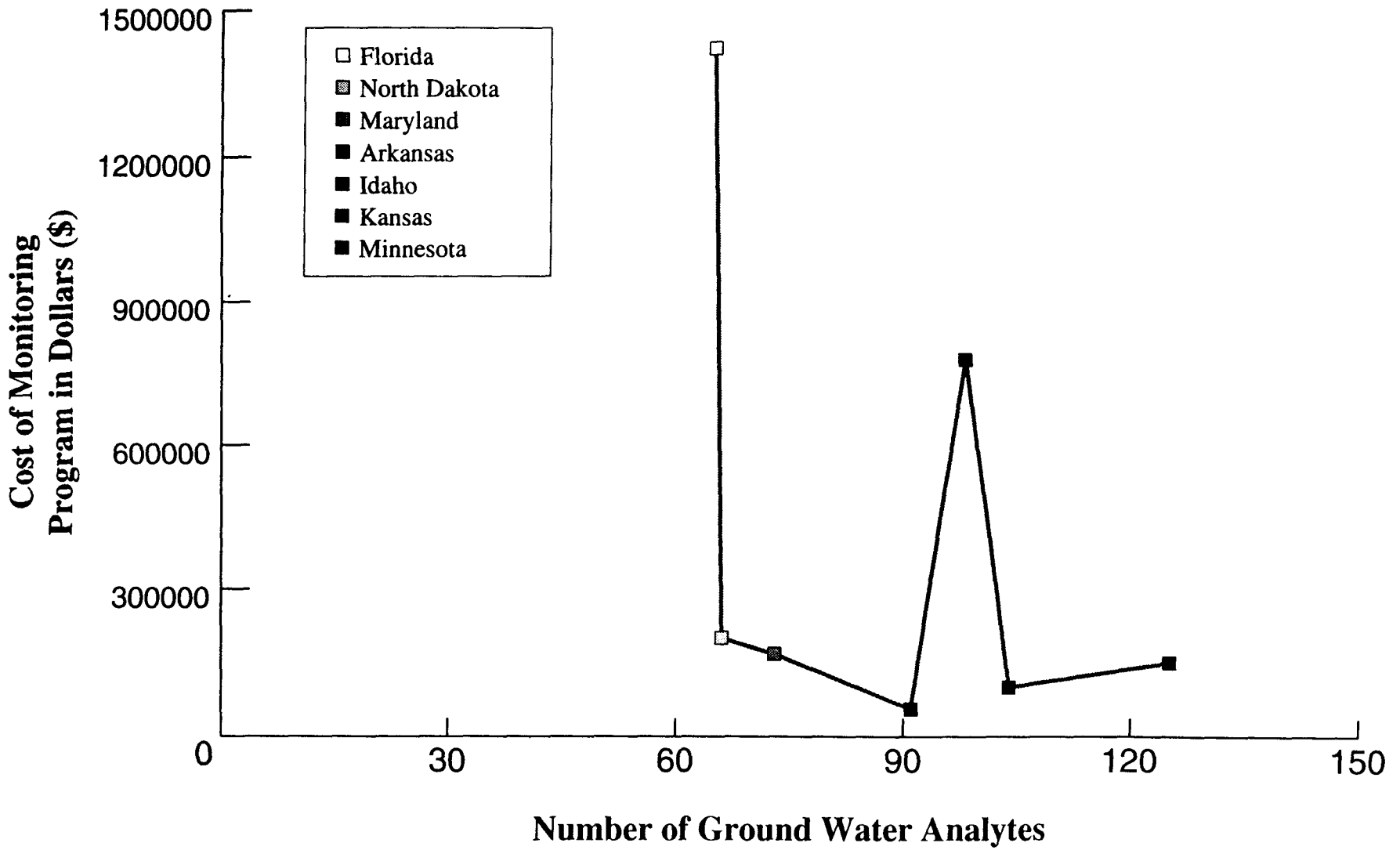

Table 1: Representative Well Type Characteristics

	Well 1	Well 2	Well 3	Well 4
Depth	50'	100'	100'	200'
Width	2"	2"	2"	4"
Screen and casing materials	PVC screen (2" x 10') and casing.	PVC screen (2" x 10') and casing.	Stainless steel screen (2" x 10') and casing.	Stainless steel screen (4" x 10') and casing.
Packing	Sand and gravel packing.	Sand and gravel packing.	Sand and gravel packing.	Sand and gravel packing.
Seal	Bentonite.	Bentonite.	Bentonite.	Bentonite.
Grout	Grout from seal to Ground Surface.	Grout from seal to Ground Surface.	Grout from seal from Ground Surface.	Grout from 10' depth to Ground Surface.
Protective Well Stack Casing	No.	Yes. Steel.	Yes. Steel.	No.
Protective Posts	No.	No.	No.	Yes.
Locking Caps	Yes.	Yes.	Yes.	Yes.

The cost estimates provided by the drilling companies are listed in Appendix C, by RWT and soil scenario. The mean well cost estimate and median well cost estimate are also shown for each RWT and soil scenario. Cost per foot of well depth, calculated from the total cost estimates, is presented on page C-2 of the appendix. Cost data are not available for drilling companies that do not install certain representative well types (i.e., 200' deep wells or wells drilled through bedrock.)

4.0 Estimating Ambient Ground Water Monitoring Program Costs

While representative state program, laboratory, and well driller data provide examples of existing monitoring program costs, these data do not provide sufficient information to estimate the total programmatic costs associated with creating or expanding ambient ground water quality monitoring activities. The following section is intended to provide states and localities with data to assist in estimating the costs associated with ground water quality monitoring programs of varying size and scope. Specifically, this section presents a scenario which illustrates the costs associated with a program that may meet the objectives identified by states participating in the ITFM/Ground Water Focus Group

(GWFG) and the 1996 305(b) Guidelines, including providing sufficient data to achieve the following[3]:

- assess ambient ground-water quality conditions;
- comply with statutory and regulatory mandates;
- determine changes (or lack of change) in ground-water quality conditions over time to: (1) define existing and emerging problems, (2) guide monitoring and management priorities, and (3) evaluate effectiveness of land and water management practices and programs; and
- improve understanding of the natural and human induced factors (for example, land use activities) affecting ground-water quality.

To meet these objectives, this analysis used the following parameters to define an ambient ground water quality monitoring program:

- 100 wells sampled annually;
- 185 analytes sampled (as summarized below in Table 2); and
- ongoing network maintenance, data analysis, data management, and communication activities.

This section presents the assumptions and costs associated with an ambient ground water quality monitoring program that meets these parameters. The section concludes with an estimate of the costs incurred when expanding state monitoring efforts to meet these objectives, involving both new monitoring well installation and the use of existing wells (see Exhibit 8, page 28).

4.1 Estimating Component Costs: Representative Ambient Ground Water Quality Monitoring Program Scenario

The monitoring program scenario, including the program design and program component assumptions, are detailed below. These assumptions are also outlined in Exhibits 3 through 7.

4.1.1 Monitoring Program Development Costs

Monitoring network design

The ambient ground water monitoring program scenario uses a series of algorithms to estimate the cost of installing and operating an ambient ground water monitoring program. The program design uses a generic state concept to support assumptions about well locations and distances between wells for modeling cost estimates.[4]

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[3] "The Strategy for Improving Water-Quality Monitoring in the United States: Final Report of the Intergovernmental Task Force on Monitoring Water Quality, Appendix L: Ground Water Monitoring, " p.2.

[4] The concept of the generic state assumes each state has an equal area of 70,737.1 mi^2, approximately one-fiftieth the total of the United States. For a 100-well monitoring program, the state area is divided into 100 squares, each 707.37 in mi^2 area, with a well at the center of each square. To account for the lack of direct travel routes between wells, the cost algorithm estimates that the ratio of physical travel distance to actual linear distance is approximately 1.35 to 1. According to the generic state grid, the center-to-center distance between wells, of 26.6

The monitoring program scenario is designed to operate at the statewide level and to monitor for 185 analytes, which are listed in Table 2. The list is intended to represent a comprehensive set of analytes that would provide a comprehensive assessment of ambient ground water quality. Analytes currently included in representative state ambient ground water quality monitoring programs are listed in Appendix A.

The scenario uses a monitoring network consisting of newly constructed wells to provide monitoring data. Wells are located within a framework defined by the generic state grid.

Under this scenario, the program's entire monitoring network is sampled annually (a one year monitoring cycle), and all samples are analyzed at a single laboratory. Analytical results are entered into a computerized database, for ease of management, and incorporated into a Geographic Information System (GIS) for analysis and interpretation. A ground water quality status report is published annually, to document the results of the ambient monitoring program. The report is complemented by an annual seminar conducted to clarify the details of the report.

Program design cost is not covered within this estimate because monitoring program design costs are generally case specific and vary considerably between program situations. This variance directly conflicts with the general nature of the cost model.

Monitoring network installation

The monitoring program scenario assumes that ground water is found less than 50 feet below the surface and the soil consists of large particles and unconsolidated materials (i.e., glacial tills and rocky soils). The estimate also assumes that the monitoring wells are located on public property and that no added costs from private land usage contracts are incurred.

Monitoring wells are assumed to be installed by private well installation contractors. All monitoring wells are constructed using a 2" polyvinylchloride (PVC) pipe casing with a 5-foot PVC screen. The annular space around the well casing is packed with sand and gravel, and sealed with bentonite pellets and grout. A locking steel cap is installed to protect the top of the well stack from external contamination.

The cost of installing the ground water monitoring network (as shown in Exhibit 2) is a product of the number of monitoring wells and the average installation cost per well. The estimated monitoring network installation cost does not include drilling crew travel time or per diem expenses.

4.1.2 Monitoring Program Operating Costs

Ground water sampling

The ground water sampling scenario assumes that two field technicians will travel to each well to collect ground water samples. Sample collection entails flushing a minimum of one well volume of water from each monitoring well, withdrawing a refreshed well water sample, recording field conditions (e.g.,

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miles, is multiplied by 1.35 resulting in a physical travel distance between wells of 35.91 miles.

Table 2: Ambient Ground Water Monitoring Program Analytes

METALS:	PESTICIDES/PCB's:
Aluminum	Aldicarb
Antimony	Aldicarb sulfone
Arsenic	Aldicarb sulfoxide
Barium	Azinphos-methyl
Beryllium	Benfluralin
Cadmium	Alpha-BHC
Calcium	Gamma-BHC
Chromium	Carbaryl
Cobalt	Carbofuran
Copper	Chlorothalonil
Iron	Chlorpyrifos
Lead	4,4'-DDE
Magnesium	Dacthl-Mono-Acid
Manganese	Diazinon
Molybdenum	Diazinon D10
Nickel	Dichlorprop
Potassium	Dieldrin
Selenium	Diethylanaline
Silver	Dimethoate
Sodium	Disulfoton
Zinc	DNOC
	Esfenvalerate
NON-METALS:	Ethoprop
Bromide	Fenuron
Chloride	Fonofos
Fluoride	Malathion
Silica	Methiocarb
Sulfate	Methomyl
	Methyl parathion
GENERAL WATER QUALITY:	Napthol 1
pH	Neburon
Specific Conductance	Oxamyl
TDS	Parathion
Total Alkalinity	Cis-Permethrin
	Phorate
NUTRIENTS:	Prometon
Ammonia, report as nitrogen	Pronamide
Nitrate, report as nitrogen	Propargite
Nitrite, nitrate, report as nitrogen	Propoxur
Orthophosporus, report as phosphorus	Terbufos
Phosphorus, report as phosphorus	Terbuthylazine
BASE/NEUTRAL HYDROCARBONS:	RADIONUCLIDES:
Hexachlorobutadiene	Gross Alpha
Naphthalene	Gross Beta
1,2,4-trichlorobenzene	Gross Alpha/Beta

Table 2: Ambient Ground Water Monitoring Program Analytes

HERBICIDES:

Acifluorfen
Alachlor
Atrazine
Atrazine desethyl
Bentazon
Bromacil
Bromoxynil
Bytylate
Chloramben
Clopyralid
Cyanazine
DCPA
Dicamba
Dichlobenil
2,4-dichlorophenoxyacetic acid
2,4-DB
Dinoseb
Diuron
EPTC
Ethalfluralin
Fluometuron
Linuron
MCPA
MCPB
Metolachlor
Metribuzin
Molinate
Napropamide
Norflurazon
Oryzalin
Pebulate
Pendimethalin
Picloram
Propachlor
Propanil
Propham
Silvex (2,4,5-TP)
Simazine
Tebuthiuron
Terbacil
Thiobencarb
Triallate
Triclopyr
Trifluralin
2,4,5-T

VOLATILE ORGANIC COMPOUNDS:

Acetonitrile
Acrolein
Acrylonitrile
Benzene
Bromobenzene
Bromochloromethane
Bromodichloromethane
Bromoform
Bromomethane
n-butylbenzene
sec-butylbenzene
tert-butylbenzene
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-chloroethyl vinyl ether
Chloroform
Chloromethane
ortho(2)-chlorotoluene
para(4)-chlorotoluene
Dibromochloromethane
1,2-dibromo-3-chloropropane
1,2-dibromoethane
Dibromomethane
1,3-dichlorobenzene
1,2-dichlorobenzene
1,4-dichlorobenzene
Dichlorodifluoromethane
1,1 dichloroethane
1,2-dichloroethane
1,1-dichloroethylene
Dichloromethane
1,1-dichloropropene
1,2-dichloropropane
1,3-dichloropropane
2,2-dichloropropane
Cis-1,3-dichloropropene
trans-1,3-dichloropropene
Ethyl benzene
Isopropylbenzene
p-isopropyltoluene
Methyl tert-Butyl Ether
n-propylbenzene
Styrene
1,1,1,2-tetrachloroethane
1,1,2,2-tetrachloroethane
Tetrachloroethylene
Toluene
1,1,1-trichloroethane
1,1,2-trichloroethane
Trichloroethylene
Trichlorofluoromethane
1,2,3,-trichloropropane
Trichlorotriflouroethane
1,2,4-trimethylbenzene
1,3,5-trimethylbenzene
Vinyl chloride
Total xylenes

EXHIBIT 2
Cost Summary for Ground Water Monitoring Network Installation

Activity:
Drill well bore through soil material; install well casing; seal and grout around well casing; and install protective well cover for ground water monitoring wells.

Assumptions:
Soil conditions are large particle, unconsolidated materials (glacial till and rocky soils).
Ground water depth is less than 50 feet below the surface.
Wells are installed by private well construction contractors.
Wells are constructed from 2" PVC casing with a 5' length of Teflon screen, packed with sand and gravel, grouted with a bentonite seal, and covered by a locking steel cap.

Cost of Installing a Ground Water Monitoring Network

Mean Cost of Well Installation[1]	Total Number of Wells	Total Cost for Monitoring Network Installation[2]
$2,005.13	50	$100,256.50
$2,005.13	75	$150,384.75
$2,005.13	100	$200,513.00
$2,005.13	125	$250,641.25
$2,005.13	150	$300,769.50

Notes:
[1] Cost of installing a single well of Representative Well Type #1 in Glacial Till (from Appendix C: Cost of Monitoring Well Installation). The characteristics of Representative Well Type #1 can be found in Table 1.
[2] Includes only the costs to install wells, and does not include well rig mobilization costs or drilling crew per diem rates. It is assumed that drilling crew per diem costs can add an additional 5% to 20% of the total cost of ground water monitoring well installation. Installation cost does not include costs necessary to acquire or use the property where the well is located.

depth to water table, water temperature, etc.), conducting a well maintenance inspection, logging well information (e.g. well number, date, and well inspection status), and decontaminating all ground water extraction tools with distilled water. Sampling technicians spend four days out of each week collecting samples from the field. The remaining day is spent arranging for transportation of the samples to the analytical laboratory, organizing future sampling routes, and completing paperwork.

Ground water sampling costs, detailed in Exhibit 3, include the estimated food and lodging expenses incurred by the technicians. Sampling costs also include materials such as ground water pumps and hoses, sample collection vessels, distilled water (for extraction tool decontamination), ice, and heavy-duty coolers (to store ground water samples).

Ground water analysis

The scenario assumes that one laboratory will perform analyses for all ground water analytes within the monitoring program. The average sample analysis cost is the sum of mean analysis costs for each of the analyte groups. Exhibit 4 presents the cost of analyzing ground water samples as the product of the number of ground water samples and the average sample analysis cost for the 185 analytes listed in Table 2.

Alternatively, some ambient ground water monitoring programs have chosen to focus on a base set of parameters for their initial monitoring efforts. These base parameters include the metals, non-metals, general-water quality, and nutrients listed in Table 2. As a means of comparison, analysis costs for this base set are presented in Exhibit 4a.

Analyte data management

Data management costs are based on estimates of the time a data technician needs to process, compile and input, verify, and output analyte data results from one monitoring well. The scenario assumes that 25 minutes are required to process analyte data results, 70 minutes to compile analyte data results, 40 minutes to verify analyte data results, and 2 hours to manipulate and output analyte data. Model data management costs are illustrated in Exhibit 5.

Analyte data processing associates well information (well number, location, and site owner) with analyte data results and generates an archival copy of analyte data. Data compilation involves entering analyte data results and well information into a digital database format to simplify data handling and manipulation efforts. Analyte data verification involves checking each well's data record for improperly entered information and making corrections. Data manipulation and output involves performing statistical analyses of analyte levels, identifying analyte concentrations in excess of MCLs, and generating data in a format suitable for use in data interpretation activities.

Analyte data interpretation

The monitoring program scenario for data interpretation will generate data layers for a GIS to investigate program-wide analyte concentration levels. This analysis method identifies areas with analyte concentrations in excess of MCLs faster and more accurately than manual methods. The GIS uses well analyte concentration levels as spot heights within a surface model to interpolate analyte concentrations across the monitoring program area. Interpolated analyte concentration levels can also be overlain with

EXHIBIT 3
Cost Summary for Ground Water Sample Collection

Activity:
Collect 100 ambient ground water monitoring samples for analysis.

Assumptions:
Two technicians, in a properly equipped vehicle, can access and collect 2 samples per day spent in the field.[1]
Technicians will spend one day each week away from the field, completing paperwork and arranging for laboratory analysis of collected ground water monitoring samples[2].
The average travel distance between wells will be 35.91 miles.[3]
Each well is purged of one full well volume (minimum) prior to sample collection.[4]
Clean (uncontaminated) ground water extraction tools (pumps and hoses) are used at each well.[5]
Ground water samples are filtered in the laboratory.
Ground water samples are collected in glass jars sealed with a Teflon coated cap.[6]
Ground water samples are cold stored at temperatures of 4° C.[7]
Ground water samples are transported under EPA chain–of–custody procedures.[8]

Cost of Ground Water Sample Collection

Labor Costs

Daily Labor Cost for One Ground Water Sample Technician[9]:	$228.27
Technician Days to Collect and Process 100 Ambient Ground Water Samples:	126
Total Cost of Labor to Collect Ambient Ground Water Monitoring Samples:	$28,762.02

Travel, Lodging, and Meal Expenses

Average Travel Distance between Wells (in Miles):	35.91
Number of Ground Water Monitoring Wells:	150
Total Travel Distance to Collect Ground Water Monitoring Wells:	3591
Cost per Mile Travel Expense[10]:	$0.40
Travel Costs to Collect Ambient Ground Water Monitoring Samples:	$1,436.40
Nightly Lodging Required for Ground Water Sampling Technicians[11]:	74
Cost per Night of Lodging[12]:	$56.00
Lodging Costs to Collect Ambient Ground Water Monitoring Samples:	$4,144.00
Days of Meals Required for Ground Water Sampling Technicians[13]:	100
Cost per Day for Meals[14]:	$31.00
Technician's Meals Costs to Collect Ambient Ground Water Monitoring Samples:	$3,100.00
Total Cost of Travel, Lodging, and Meal Expenses to Collect Ambient Ground Water Monitoring Samples:	$8,680.40

Equipment Costs[15]

Ground Water Pump:	$350.00
5 Hoses 50' Long:	$45.00
500 Gallons of Distilled Water[16]:	$550.00
100 Glass Ground Water Sample Collection Bottles with Teflon Caps:	$360.00
Five Heavy Duty Coolers for Ground Water Sample Storage[17]:	$200.00
2000 lbs. of Ice[18]:	$400.00
Total Cost of Equipment Necessary to Collect Ambient Ground Water Monitoring Samples:	$1,905.00
TOTAL:	$39,347.42

Notes:

[1] Based on personal communication with state ground water sample collection supervisors and supervisors of a private firm that collects ground water samples.

[2] Ibid.

[3] Assumes that every state has an equal area of 70,737.10 mi^2 (one–fiftieth of the total area of the United States), each well will occupy the center of a 707.37 mi^2 square, with a center–to–center distance between wells of 26.60 miles. To calculate the road distance between wells, the center–to–center distance was multiplied by 1.35 to account for the lack of direct routes. Research has identified 1.35 as the approximate ratio between actual distance and ground travel distance.

[4] Standing water inside a well stratifies and biases ground water samples. Removing a minimum of one volume of water in the well casing is recommended for a representative water sample (*Compendium of ERT Groundwater Sampling Procedures*, U.S. EPA, Office of Solid Waste and Emergency Response, Washington, DC, 1991, p. 6).

[5] To reduce the risk of collecting a nonrepresentative sample, laboratory–cleaned (washed with detergent, rinsed with distilled water, and oven–baked at 105° C) sample collection devices must be used (Lawrence H. Keith, *Compilation of EPA's Sampling and Analysis Methods*, Lewis Publishers, Inc., Boca Raton, Florida, 1991, p.51).

[6] Certain organic and inorganic trace elements have a tendency to leach into and out of handling materials. Handling material choices should be limited to glass, stainless steel, and Teflon (Lawrence H. Keith, *Compilation of EPA's Sampling and Analysis Methods*, Lewis Publishers, Inc., Boca Raton, Florida, 1991, p.48, and *Compendium of ERT Groundwater Sampling Procedures*, U.S. EPA, Office of Solid Waste and Emergency Response, Washington, DC, 1991, p. 6).

[7] Temperature at which water is most dense. Storage at this temperature limits volatilization and or breakdown of trace elements within the sample (Lawrence H. Keith, *Compilation of EPA's Sampling and Analysis Methods*, Lewis Publishers, Inc., Boca Raton, Florida, 1991, p.48, and *Compendium of ERT Groundwater Sampling Procedures*, U.S. EPA, Office of Solid Waste and Emergency Response, Washington, DC, 1991, p. 5).

[8] Chain–of–custody procedures require that forms listing the date, time, and sampling location be completed and signed when ground water samples are collected or shipped.

[9] Daily labor cost was calculated by averaging the hourly rate paid by Maryland, Minnesota, Arkansas, and North Dakota to ground water sample collection technicians. The average hourly rate of $12.97 was multiplied by eight hours to calculate the average daily labor rate. The daily labor cost was calculated by multiplying the average daily labor rate by 2.2 to include benefits and associated overhead costs.

[10] Estimated cost per mile to operate and maintain a ground water sampling vehicle. Vehicle costs include fuel, lubricants, coolants, mechanical parts and labor, and depreciation costs.

[11] While performing field sampling, technicians will be lodged in the region where they are working. This is to facilitate access to ground water monitoring wells. Lodging will not exceed four nights a week.

[12] Nightly lodging cost was calculated by averaging the government lodging per diem rate (Federal Register, December 22, 1993) for selected municipalities across the nation. The municipalities used for this cost comparison were Phoenix, AZ, Jackson, MS, Durham, NC, Utica, NY, Jefferson City, MO, Duluth, MN, Billings, MT, and Eugene, OR.

[13] While performing field sampling, technicians' meal expenses will be covered while they are operating in the field. Only three and half days of meal expenses per week will be covered in this manner.

[14] Daily meals cost was calculated by averaging the government meals and incurred expenses per diem rate (Federal Register, December 22, 1993) for selected municipalities across the nation. The municipalities used for this cost comparison were Phoenix, AZ, Jackson, MS, Durham, NC, Utica, NY, Jefferson City, MO, Duluth, MN, Billings, MT, and Eugene, OR.

[15] The majority of equipment costs are capital costs, and have been included for start–up cost purposes. These costs will not be included in subsequent annual ambient ground water monitoring program operating costs.

[16] Distilled water is used to rinse and clean ground water extraction tools.

[17] These are required to cold store collected ground water samples and transport samples to a laboratory for analyses.

[18] Water ice is used to keep ground water samples at approximately 4° C.

EXHIBIT 4
Cost Summary for Analysis of Ground Water Samples

Activity:
Conduct analyses on ambient ground water samples for analytes listed in Table 2.

Assumptions:
Samples are laboratory filtered.
Samples are collected in glass jars sealed with a Teflon coated septum.
Samples are transported to laboratory under EPA chain-of-custody procedures.[1]

Mean Cost of Ground Water Sample Analysis[2]

Mean Cost of Analysis for Metals:	$260.35
Mean Cost of Analysis for Non-Metals:	$84.76
Mean Cost of Analysis for General Water Quality:	$43.11
Mean Cost of Analysis for Nutrients in Water:	$76.26
Mean Cost of Analysis for Radionuclides in Water:	$106.67
Mean Cost of Analysis for Acid and Base/Neutral Hydrocarbons:	$313.28
Mean Cost of Analysis for Herbicides:	$356.68
Mean Cost of Analysis for Pesticides:	$381.40
Mean Cost of Analysis for Volatile Organic Compounds:	$380.00
TOTAL:	**$2,002.51**

Cost of Ground Water Sample Analysis[2]

Mean Cost of Individual Sample Analysis[3]	Total Number of Wells	Total Cost of Ground Water Sample Analysis
$2,002.51	50	$100,125.50
$2,002.51	75	$150,188.25
$2,002.51	100	$200,251.00
$2,002.51	125	$250,313.75
$2,002.51	150	$300,376.50

Notes:
[1] Chain-of-custody procedures require that forms listing the date, time, and sampling location be completed and signed when ground water samples are collected or shipped.
[2] Mean ground water sample analysis costs represent an average of the total cost for all analytes within an analyte group. Costs were compiled from several private and state laboratories that perform water quality analyses.
[3] Represents the cost of analyzing one ground water sample for analytes listed in Table 2. It does not include other laboratory fees or discounts associated with the total number of samples.

EXHIBIT 4a
Cost Summary for Analysis of Base Set Parameters

Activity:
Conduct analyses on ambient ground water samples for metals, non–metals, general water quality, and nutrient parameters listed in Table 2.

Assumptions:
Samples are laboratory filtered.
Samples are collected in glass jars sealed with a Teflon coated septum.
Samples are transported to laboratory under EPA chain–of–custody procedures.[1]

Mean Cost of Ground Water Sample Analysis[2]

Mean Cost of Analysis for Major Ions and Dissolved Solids:	$113.86
Mean Cost of Analysis for Nutrients in Water:	$63.65
TOTAL:	**$177.51**

Cost of Ground Water Sample Analysis[2]

Mean Cost of Individ Sample An:	Total Number of Wells	Total Cost of Ground Water Sample Analysis
$177.51	50	$8,875.50
$177.51	75	$13,313.25
$177.51	100	$17,751.00
$177.51	125	$22,188.75
$177.51	150	$26,626.50

Notes:
[1] Chain–of–custody procedures require that forms listing the date, time, and sampling location be completed and signed when ground water samples are collected or shipped.
[2] Mean ground water sample analysis costs represent an average of the total cost for all analytes within an analyte group. Costs were compiled from several private and state laboratories that perform water quality analyses.
[3] Represents the cost of analyzing one ground water sample for analytes listed in Table 2. It does not include other laboratory fees or discounts associated with the total number of samples.

EXHIBIT 5
Cost Summary for Ambient Ground Water Monitoring Data Management

Activity:
Collect, enter, verify, and output Ambient Ground Water Monitoring Analysis results.

Assumptions:
Laboratory analysis results (analyte concentrations) are returned in tabular form on paper.
Analyte concentration data are entered into a digital database for purposes of data management.
Each data record consists of fields listing: well number, well owner, well location, and a concentration for each of the 185 analytes listed in Table 2.

Cost of Ambient Ground Water Monitoring Data Management

Data Collection and Processing Costs

Hourly Cost for Ground Water Data Technician[1]:	$13.20
Time (minutes) per Record to Process Ground Water Analysis Results[2]:	25
Total Number of Data Records to Enter:	100
Cost to Collect and Process Ground Water Analysis Results:	$550.00

Data Entry Costs

Hourly Cost for Ground Water Data Technician:	$13.20
Time (minutes) per Record to Perform Data Entry[3]:	70
Total Number of Data Records to Enter:	100
Cost to Enter Ground Water Analysis Data:	$1,540.00

Data Review and Correction Costs

Hourly Cost for Ground Water Data Technician:	$13.20
Time (minutes) per Record to Perform Ground Water Analysis Data Review[4]:	40
Total Number of Data Records to Enter:	100
Cost to Review Ground Water Data Entry:	$880.00

Data Manipulation and Reporting Costs

Hourly Cost for Ground Water Data Technician:	$13.20
Time (hours) Required to Manipulate and Output Ground Water Analysis Data[5]:	200
Cost to Output Ground Water Analysis Data:	$2,640.00
TOTAL:	$5,610.00

Notes:

[1] Estimated hourly rate for Ground Water Data Technician. Hourly rate includes all associated overhead costs.

[2] Data Processing of ground water analysis results consists of recording well information (number, owner, location, etc.), dating when analytical results were received, and generating an archive copy of the analytical results.

[3] Data Entry of ground water analysis results consists of entering well location and analysis results into fields within a database to assist data interpretation.

[4] Analytical Data Review consists of verifying actual analytical data results with analytical data existing within the database. Data review also includes data correction where necessary.

[5] Data Manipulation and Output consists of developing general or specific reports listing the results of Ground Water Analyses. Data Manipulation and Output also includes producing copies of the analytical data for review by Data Review Technicians and Program Supervisors.

drinking water well locations to identify possible contaminated drinking water supplies.

Estimated data interpretation scenarios (as shown in Exhibit 6) also include producing a ground water quality status report addressing analyte level implications as well as the ramifications of ground water contamination. The ground water quality status report includes tables of analyte data and maps showing analyte concentration levels across the monitoring program area.

Communication of results

Under this scenario, the results of the model monitoring program will be communicated by publishing 200 copies of the ground water quality status report generated under the analyte data interpretation component of the monitoring program. This report will be sent on request via first class mail. A one-day seminar will be conducted by ground water analysts, to clarify aspects of the ground water quality status report and the ambient ground water monitoring program.

The cost of communicating monitoring program results includes labor to ship ground water quality reports and the cost of labor to prepare and organize the seminar on the results of the ambient monitoring program. These costs are described in Exhibit 7.

Monitoring program evaluation and redesign

This scenario does not cover the cost of monitoring program evaluation and redesign. These are post-operation program costs and cannot be estimated without an actual ambient ground water monitoring program to evaluate. In addition, of the eight states contacted for this study, only Florida reports devoting a significant portion (i.e., greater than ten percent) of their operating costs to program evaluation.

4.2 Estimating Operating Costs

Based on the assumptions outlined above, the cost of operating a 100 well ground water monitoring program is estimated at approximately $267,884 a year. This estimate is derived from the sum of program component cost estimates. Because program components are discrete elements, each program operating component scenario (listed in Exhibits 3 through 7) documents all pertinent assumptions affecting cost estimates. The exhibit also presents the first-year costs for operating a 100 well network when well installation costs are included.

The operating cost estimates have certain limitations. The number and selection of analytes monitored will differ from program to program. Also, the estimate does not include economies for multiple sample analyses. Labor estimates for technicians and analysts to handle and process water quality data are approximate and may vary considerably from state to state. Furthermore, most states use a combination of existing and new wells when establishing a monitoring program. As a result, few states would incur the total cost for installing a new monitoring well network in the first year of the program.

4.3 Comparing Cost Estimates to Existing State Programs

The program cost estimates presented in Section 4.2 are approximately 2 to 4 times higher than the existing state monitoring program costs reported by the eight states, on a per well basis. This

EXHIBIT 6
Cost Summary for Ambient Ground Water Monitoring Data Interpretation

Activity:
Examine ground water analyte concentration levels for sample from 100 monitoring wells. Establish ground water chemical compound trends and determine areas of ground water contamination.

Assumptions:
Geographic Information Systems (GIS) are used to follow trends and to map ground water analyte concentration levels.
The ambient ground water monitoring program generates an annual report summarizing the results of the year's ground water analyses and identifying areas of concern.

Cost of Ambient Ground Water Monitoring Data Interpretation

Ground Water GIS Data Development Costs

Hourly Cost of Ground Water Analyst[1]:	$27.00
Number of Ground Water Analytes[2]:	185
Time Required (hours) to Develop Ground Water Analyte Specific Databases:	100
Time Required (hours) to Develop Maps of Ground Water Analyte Concentration Levels[3]:	740
Cost to Develop Ground Water Analyte Concentration GIS:	$22,680.00

Ground Water GIS Data Interpretation Costs

Hourly Cost of Ground Water Analyst:	$27.00
Time Required (hours) to Interpret Ground Water Analyte Concentration Level Maps for Ground Water Quality Trends[4]:	370
Time Required (hours) to Generate Ground Water Trend Report[5]:	500
Cost to Generate Ground Water Trend Summary Report:	$23,490.00
TOTAL:	**$46,170.00**

Notes:
[1] Estimated hourly rate for Ground Water Analyst. Hourly rate includes all benefits and associated overhead costs.
[2] Maps of ground water analyte concentrations will be generated by interpolating isolines from data points established from ground water well sample analyses.
[3] Total number of analytes listed in Table 2.
[4] Estimated time to identify wells and regional areas with critical concentration levels of ground water analytes, and compare recent analysis results to previous analysis results, or develop baseline results.
[5] Estimated time to draft a report documenting the results of ambient ground water monitoring activites.

EXHIBIT 7
Cost Summary for Communicating the Results of Ambient Ground Water Monitoring

Activity:
Publish Annual Ambient Ground Water Monitoring Report and deliver copies to requesters. Give one seminar explaining the results of Ambient Ground Water Monitoring.

Assumptions:
200 copies of an Ambient Ground Water Monitoring Report are published for distribution to the public.
An ambient ground water monitoring seminar is conducted annually to present the results and data interpretations of ambient ground water monitoring, and to forecast trends in ground water quality.

Cost of Communicating the Results of Ambient Ground Water Monitoring

Annual Ground Water Monitoring Report Publishing Cost

Estimated Publishing Cost per Copy of Annual Ambient Ground Water Monitoring Report[1]:	$23.50
Number of Copies of Ambient Ground Water Monitoring Report Published:	200
Total Cost to Publish Annual Ambient Ground Water Monitoring Reports:	$4,700.00

Ground Water Monitoring Report Delivery Cost

Hourly Cost for Ground Water Data Technician[2]:	$13.20
Ground Water Data Technician Time (hours) Required to Package and Ship Ambient Ground Water Monitoring Reports[3]:	30
Estimated Postage Cost to Ship Annual Ground Water Monitoring Report[4]:	$5.00
Number of Annual Ground Water Monitoring Reports Being Delivered[5]:	200
Total Cost to Process and Send Ambient Ground Water Monitoring Report:	$1,396.00

Ambient Ground Water Monitoring Results Seminar Cost

Hourly Cost for Ground Water Analyst[6]:	$27.00
Ground Water Analyst Time (hours) Required to Prepare and Present Ambient Ground Water Monitoring Results Seminar[7]:	80
Total Cost to Present Seminar of Ambient Ground Water Monitoring Results:	$2,160.00
TOTAL:	$8,256.00

Notes:

[1] Estimated cost to print and bind one copy of a 450 page Ambient Ground Water Monitoring Report.

[2] Estimated hourly rate for Ground Water Data Technician. Hourly rate includes all associated overhead costs.

[3] Estimated time required to assemble 200 Ambient Ground Water Monitoring Report packages and prepare them for delivery.

[4] Assumes that an Ambient Ground Water Monitoring Report package weighs in excess of 3 pounds.

[5] Assumes that all Ambient Ground Water Monitoring Reports will be mailed to the recipients.

[6] Estimated hourly rate for Ground Water Analyst. Hourly rate includes all benefits and associated overhead costs.

[7] Total time required to prepare and present the Ambient Ground Water Monitoring Seminar, which would consist of a one-day series of presentations. The seminar should ideally be chaired by two Ground Water Analysts.

disparity in operating costs appears to be due to several factors. First, state programs almost exclusively use state analysis laboratories. As these laboratories are typically subsidized by the state government, their analysis costs are significantly less than private laboratories. Furthermore, all of the state monitoring programs report monitoring for fewer than 185 analytes. The number of analytes reported by the programs varies from 66 for North Dakota to 125 for Minnesota.

Second, state programs typically monitor on a more infrequent schedule, often sampling wells once every two or three years. Finally, most state programs currently do not have the resources or GIS facilities to conduct extensive data interpretation. At most, a report summarizing the status and general quality of the state's ground water can be generated, however, most states do not actively identify trends in water quality or predict contamination.

4.4 Incremental Costs to Modify Existing Ambient Monitoring Programs

The incremental cost of refitting an existing monitoring program to meet the scenario is illustrated in Exhibit 9. The State of Kansas was chosen to illustrate cost increases incurred while expanding an existing monitoring program because its existing program annually monitors 125 wells, and in-state laboratory cost information was available to estimate the increased analytical costs.

When refit to meet the ambient ground water monitoring scenario, the annual operating cost of Kansas' ambient ground water monitoring program would increase from $100,000 a year to slightly over $300,000 a year. Ninety percent of this increase is due to the increase in analysis costs. Presently, Kansas biannually monitors 250 wells for pesticides and inorganic constituents (i.e., metals and non-metals). Each year, a subset of 25 wells are also monitored for volatile organic compounds and radionuclides.

The remaining cost increases result from labor involved in handling and processing the expanded volume of water quality data. The scope of Kansas' existing monitoring program, in terms of the amount of data collected, would increase by a factor of approximately 180 percent. This factor was used to estimate the cost increases of the data management, data interpretation, and results communication components.

It should also be noted that Kansas' current monitoring program does not possess GIS facilities to perform data interpretation. The cost of developing a GIS varies depending on its design and implementation. Because these costs will have significant effects on monitoring program refitting costs and are typically borne by several state programs, they have been omitted from this estimate.

5.0 Factors Reducing Costs Associated with Ambient Ground Water Quality Monitoring Programs

The cost estimates presented above represent available cost information and data from existing monitoring programs, analytical laboratories, and well installation contractors. However, they do not reflect specific opportunities for cost savings that ground water quality monitoring programs can adopt.

These cost saving opportunities include the following:

(1) Use existing ground water wells. Monitoring programs can choose to incorporate existing municipal or residential drinking water wells, irrigation wells, or

EXHIBIT 8
GWFG Ambient Ground Water Monitoring Program
Cost Estimate Summaries by Monitoring Program Scope

Program Implementation Cost

	Program Scope (Number of Wells)				
Program Components	50	75	100	125	150
Monitoring Network Design1	$0	$0	$0	$0	$0
Monitoring Network Installation	$100,257	$150,385	$200,513	$250,641	$300,770
Ground Water Sampling	$21,517	$30,747	$39,347	$48,578	$57,178
Ground Water Analysis	$100,125	$150,186	$200,251	$250,314	$300,377
Analytical Data Management	$1,782	$2,673	$3,564	$4,455	$5,346
Analytical Data Interpretation	$17,766	$18,441	$19,116	$19,791	$20,466
Communicating Results	$5,606	$5,606	$5,606	$5,606	$5,606
Evaluating the Monitoring Program2	$0	$0	$0	$0	$0
Total:	$247,052	$358,038	$468,397	$579,385	$689,743
Average Cost Per Well:	$4,941	$4,774	$4,684	$4,635	$4,598

Program Operating Cost

	Program Scope (Number of Wells)				
Program Components	50	75	100	125	150
Monitoring Network Maintenance3	$0	$0	$0	$0	$0
Ground Water Sampling	$20,562	$29,792	$38,392	$47,623	$56,223
Ground Water Analysis	$100,125	$150,188	$200,251	$250,314	$300,377
Analytical Data Management	$1,782	$2,673	$3,564	$4,455	$5,346
Analytical Data Interpretation	$17,766	$18,441	$19,116	$19,791	$20,466
Communicating Results	$5,606	$5,606	$5,606	$5,606	$5,606
Evaluating the Monitoring Program2	$0	$0	$0	$0	$0
Total:	$145,841	$206,700	$266,929	$327,789	$388,018
Average Cost Per Well:	$2,917	$2,756	$2,669	$2,622	$2,587

Notes:

1 Monitoring Network Design costs are program specific, and cannot be generally estimated.

2 Monitoring Program Evaluation costs are program specific, and cannot be generally estimated.

3 Well inspection costs are included in the Ground Water Sampling component. Other Monitoring Network Maintenance costs are assumed to be negligible.

EXHIBIT 9
Estimated Cost of Retrofitting an Existing Ambient Ground Water Monitoring Program

Operating Cost Component	Kansas[1]	Kansas (Expanded Program)[2]	Modeled Program Scenario[3]
Monitoring Network Maintenance	$0	$0	$0
Ground Water Sampling	$22,000	$22,000	$38,504
Ground Water Analysis	$55,000	$237,000	$250,314
Analytical Data Management	$10,000	$18,000	$7,013
Analytical Data Interpretation	$10,000	$18,000	$46,845
Communicating Results	$3,000	$5,400	$8,506
Monitoring Program Evaluation	$0	$0	$0
Total	$100,000	$300,400	$351,182
Program Scope			
# wells monitored annually:	125	125	125
# of analytes monitored:	104	185	185

Notes:

[1] From Exhibit 1, State Ambient Ground Water Monitoring Program Costs. Kansas was chosen because it annually monitors 125 wells and and laboratory cost information was readily available.

[2] Kansas (expanded program) estimates the costs of expanding Kansas' existing monitoring program to reflect the scenario described in Section 4.1.

[3] From Exhibit 8, Modeled Ambient Ground Water Monitoring Program Cost Summaries by Monitoring Program Scope.

compliance monitoring wells into a monitoring network. For example, Florida has identified and incorporated a number of drinking water wells into its monitoring network.

(2) Sample for fewer ground water analytes. In Table 2 above, a set of recommended constituents for inclusion in monitoring programs is identified. The precise set of constituents adopted by a monitoring program must depend on (1) the hydrogeologic characteristics of the aquifer or ground water region being monitored; (2) the nature and extent of the contaminant sources affecting the monitored region; and (3) the goal of the monitoring program (e.g., determining long-term water quality trends or identifying localized contamination incidents). Some monitoring programs have chosen to use "indicator" constituents, such as nitrates or leachable pesticides, to identify the impacts of specific land uses on ground water quality. By using ground water quality indicators, these programs have reduced the number of analytes monitored and the associated costs.

(3) Limit sampling frequency. As noted in Section 4.9, many states do not sample all wells within their monitoring networks annually. Instead, schedules are developed to sample individual wells on two, three, or even five-year cycles.

(4) Bulk sample analysis costs. The analytical cost analysis presented in Section 4.2 did not account for discounts that laboratories often provide for multiple samples requiring the same analysis or multi-year/multi-sample contracts. For example, the laboratories contacted for this report, typically offer a 10 percent discount for five or more samples requiring the same analysis. Monitoring programs can anticipate negotiating for even greater discounts for large, multiple sample orders. This will result in a lower mean cost per sample.

(5) Account for variability in labor and overhead costs. Costs associated with labor and overhead typically vary from state to state. States and localities should use their own labor and overhead rates to more accurately estimate program costs.

6.0 Conclusions

This paper outlines the key components of an ambient ground water quality monitoring program and the costs associated with existing and expanded monitoring efforts.

This study found that sufficient experience has been developed by existing state ambient ground water quality monitoring programs to support cost estimates for new or expanded ground water quality monitoring activities. Based on the assumptions outlined in this report, the cost of operating a 100 well ground water monitoring program is estimated at approximately $300,000 a year. This estimate is derived from the sum of program component cost estimates summarized above.

Estimating the costs associated with refitting an existing monitoring program to meet the goals of the ITFM/GWFG is more problematic, because the precise design of an ambient ground water monitoring program is likely to vary from state to state. This analysis used the State of Kansas to illustrate cost increases incurred while expanding an existing monitoring program.

When expanded, it was estimated that the annual operating cost of Kansas' ambient ground water monitoring program would triple, increasing from $100,000 a year to slightly over $300,000 a year. Ninety percent of this increase is due to the increase in analysis costs. Presently, Kansas biannually monitors 250 wells for pesticides and inorganic constituents (i.e., metals and non-metals). Each year, a subset of 25 wells are also monitored for volatile organic compounds and radionuclides. As a result of meeting an expanded monitoring program scope, the modeled scenario assumed that every well sampled will be monitored for inorganic constituents, pesticides, herbicides, volatile organic compounds, and radionuclides. The remaining cost increases result from labor involved in handling and processing the expanded volume of water quality data.

These estimates are provided as illustrations only. The actual costs for each state or local program must be estimated based upon local hydrogeologic conditions; an understanding of local ground water quality and contaminant characteristics; and local labor, analytical laboratory, and overhead costs.

7.0 References

Specific references are cited within Exhibits 1 through 7. In addition, the following references or contact persons provided general information:

Arkansas Department of Pollution Control and Ecology. *Arkansas Prototype Monitoring Program Status Report.*

Bryan Bain, Kansas Department of Health and Environment

Paul Castelin, Idaho Department of Water Resources

Thomas Clark, Minnesota Pollution Control Agency

Rick Copeland, Florida Department of Environmental Protection

L. David Glatt, North Dakota Department of Health, Division of Water

Harry Hansen, Maryland Department of Natural Resources

Wayne Hood, Arizona Department of Environmental Quality

G. L. Maddox, et.al. 1992. *Florida's Ground Water Quality Monitoring Program Background Hydrogeochemistry.* Florida Geological Survey, Tallahassee, FL.

Ed Van Schaik, Arkansas Department of Pollution Control and Ecology

Appendix A

Ground Water Analytes Assessed by Representative State Ambient Monitoring Programs

Arkansas

General Water Quality
Total Alkalinity
Total Hardness
Total Dissolved Solids
Total Organic Compounds

Metals
Calcium
Sodium
Potassium
Magnesium
Barium
Cadmium
Chromium
Copper
Iron
Lead
Zinc
Manganese
Nickel
Vanadium
Mercury
Selenium
Arsenic

Nutrients
Orthophosphorus, as phosphorus
Total Phosphorus, as phosphorus
Ammonia/Ammonium, as nitrogen
Nitrites/Nitrates, as nitrogen

Non-metals
Chloride
Sulfate

Volatile Organic Compounds
Methyl chloride
Trichlorofluoromethane
1,1-dichloroethene
1,1-dichloroethane
1,2-trans-dichloroethene
Chloroform
1,2-dichloroethane
1,1,1-trichloroethane
Carbon tetrachloride
Bromodichloromethane
1,2-dichloropropane
cis-1,3-dichloropropene
Trichloroethylene
Benzene
Dibromochloromethane

Volatile Organic Compounds (cont.)
trans-1,3-dichloropropene
1,1,2-trichloroethane
Bromoform
Tetrachloroethylene
1,1,2,2-tetrachloroethane
Toluene
Chlorobenzene
Ethyl benzene
1,2-dichloroethane-D4
Toluene-D8
4-Bromofluorobenzene-D4

Pesticides
Propachlor
Alpha-BHC
Beta-BHC
Gamma BHC
Delta BHC
Prometon
Atrazine
Terbuthylazine
Fonofos
Methyl Parathion
Cyprazine
Ametryn
Heptachlor
Malathion
Chlorpyrifos
Aldrin
Heptachlor Epoxide
P-P' DDD
P-P' DDE
P-P' DDT
Endrin
Hexazinone
Trifluralin
Atraton
Simazine
Propazine
Diazinon
Metribuzin
Alachlor
Prometryn
Terbutryn
Dipropetryn
Cyanazine
Pendimethalin
Endosulfan
Dieldrin
Endosulfan II
Methoxychlor

Florida

General Water Quality
Alkalinity
Digestion (HCl in water)
Silica
Specific Conductance
Turbidity

Metals
Calcium
Magnesium
Sodium (Dissolved)
Potassium
Aluminum
Arsenic
Barium
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Nickel
Silver
Strontium
Zinc

Non-Metals
Chloride
Fluoride
Sulfate

Nutrients
Ammonium, as nitrogen
Ammonium/Organic nitrogen, as nitrogen

Nutrients (cont.)
Nitrite/Nitrate, as nitrogen
Phosphorus

Volatile Organic Compounds
Benzene
Ethylbenzene
Toluene
Xylenes
Bromodichloromethane
Bromoform
Chloromethane
Chloroform
Bromomethane
Dibromochloromethane
Carbon Tetrachloride
Chloroethane
2-Chloroethylvinyl Ether
1,2-Dichlorobenzene
Chlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
trans 1,2-Dichloroethane
1,2-Dichloropropane
cis 1,3-Dichloropropene
trans 1,3-Dichloropropene
Methylene Chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethane
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichlorothene
Vinyl Chloride

Idaho

General Water Quality
Specific Conductance
pH
Silica
Alkalinity
Hardness
Total Dissolved Solids
Carbonate
Bicarbonate
Fecal coliform

Metals
Calcium
Magnesium
Sodium
Potassium
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Zinc
Arsenic
Selenium

Non-metals
Sulfate
Chloride
Fluoride
Cyanide

Nutrients
Nitrite/Nitrate, as nitrogen
Ammonia, as nitrogen
Phosphorus

Radioactivity
Gross Alpha
Gross Beta
Radon

Pesticides
Aldicarb
Alachlor
Atrazine
2,4-D compounds

Volatile Organic Compounds
Bromodichloromethane
Bromoform

Volatile Organic Compounds (cont.)
1,1-dichloroethene
1,1,1-trichloroethane
Carbon tetrachloride
Benzene
1,2-dichloroethane
Trichloroethylene
1,4-dichlorobenzene
Bromobenzene
Bromochloromethane
Bromomethane
N-butylbenzene
sec-butylbenzene
tert-butylbenzene
Chlorobenzene
Chloroethane
Chloromethane
2-chlorotoluene
4-chlorotoluene
1,2-dibromo-3-chloropropane (DCBP)
Ethylene dibromide (EDB)
Dibromomethane
1,2-dichlorobenzene
1,3-dichlorobenzene
dichlorodifluoromethane
1,1-dichloroethane
cis-1,2-dichloroethene
trans-1,2-dichloroethene
1,2-dichloropropane
1,3-dichloropropane
2,2-dichloropropane
1,1-dichloropropene
cis-1,2-dichloropropene
trans-1,3-dichloropropene
Ethylbenzene
Hexachlorobutadiene
Isopropylbenzene
P-isopropyltoluene
Methylene chloride
Naphthalene
N-propylbenzene
Styrene
1,1,1,2-tetrachloroethane
1,1,2,2-tetrachloroethane
Tetrachloroethene
Toluene
1,2,3-trichlorobenzene
1,2,4-trichlorobenzene
1,1,2-trichloroethane
Trichlorofluoromethane
1,2,3-trichloropropane
1,2,4-trimethylbenzene

Chloroform
Dibromochloromethane
Vinyl chloride
1,3,5-trimethylbenzene
Xylenes

Kansas

General Water Quality
pH
Specific Conductance
Silica
Total Hardness
Total Alkalinity
Total Dissolved Solids

Metals
Calcium
Magnesium
Sodium
Potassium
Aluminum
Antimony
Barium
Beryllium
Cadmium
Chromium
Cobalt
Copper
Iron
Lead
Manganese
Mercury
Molybdenum
Nickel
Arsenic
Selenium
Silver
Thallium
Vanadium
Zinc

Non-metals
Chloride
Sulfate
Fluoride
Boron

Nutrients
Nitrate, as nitrogen
Total phosphorus
Ammonia, as nitrogen

Volatile Organic Compounds
Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Dichloromethane
1,1-dichloroethylene

Volatile Organic Compounds (cont.)
Bromodichloromethane
1,2-dichloropropane
trans-1,3-dichloropropene
Trichloroethylene
Benzene
Dibromochloromethane
cis-1,3-dichloropropene
1,1,2-trichloroethane
Bromoform
1,1,2,2-tetrachloroethane
Tetrachloroethene
Toluene
Chlorobenzene
Ethylbenzene
Xylene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene

Pesticides
Alachlor
Aldrin
Atrazine
Butachlor
Chlordane
Cyanazine (Bladex)
DCPA (Dacthal)
Dieldrin
Endrin
Gamma BHC (Lindane)
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene
Methoxychlor
Metolachlor (Dual)
Metribuzin (Sencor)
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
Propachlor (Ramrod0
Propazine (Milgard)
Simazine
Toxaphene
2,4-D as acid
Silvex as acid (2,4,5-TP)
2,4,5-TP as acid
Picloram (Tordon)

1,1-dichloroethane
trans-1,2-dichloroethylene
cis-1,2-dichloroethylene
Trichloromethane
1,2-dichloroethane
1,1,1-trichloroethane
Tetrachloromethane

Radionuclides

Gross Alpha
Gross Uranium
Radium-226
Radium-228
Radon-222

Minnesota

General Water Quality
Specific Conductance
Total Dissolved Solids
Suspended Solids
Phenol
Silica

Metals
Antimony
Aluminum
Arsenic
Beryllium
Barium
Cadmium
Calcium
Cobalt
Chromium
Copper
Lead
Iron
Magnesium
Lithium
Mercury
Manganese
Nickel
Molybdenum
Rubidium
Potassium
Sodium
Silver
Titanium
Selenium
Strontium
Vanadium
Thallium
Zinc

Non-metals
Boron
Bromide
Chloride
Fluoride
Sulfate
Sulfur

Nutrients
Nitrite, as nitrogen
Nitrate, as nitrogen
Phosphorus

Volatile Organic Compounds
Dichlorodifluoromethane

Volatile Organic Compounds (cont.)
1,1-dichloroethene
Allyl chloride
Methylene chloride
trans-1,2-dichloroethene
1,1-dichloroethane
2,2-dichloropropane
cis-1,2-dichloroethene
Chloroform
Bromochloromethane
1,1,1-trichloroethane
1,1-dichloropropene
Carabon tetrachloride
1,2-dichloroethane
Trichloroethene
1,2-dichloropropane
Bromodichloromethane
Dibromomethane
cis-1,3-dichloropropene
trans-1,2-dichloropropene
1,1,2-trichloroethane
1,3-dichloropropane
Tetrachloroethene
Chlorodibromomethane
1,2-dibromoethane
Chlorobenzene
1,1,1,2-tetrachloroethane
Bromoform
1,1,2,2-tetrachloroethane
1,2,3-trichloropropane
Bromobenzene
2-chlorotoluene
4-chlorotouene
1,3-dichlorobenzene
1,4-dichlorobenzene
1,2-dichlorobenzene
1,2-dibromo-3-chloropropane
1,2,4-trichlorobenzene
Ethyl ether
Acetone
Methyl tertiary-butyl ether
Methyl ethyl ketone
Tetrhydrofuran
Benzene
Methyl isobutyl ketone
Toluene
Ethyl benzene
M+P-xylene
O-xylene
Styrene
Isopropyl benzene
N-propyl benzene

Chloromethane
Vinyl Chloride
Bromomethane
Chloroethane
Dichlorofuloromethane
Trichlorotrifluoroethane

1,3,5–trimethylbenzene
Sec–butylbenzene
P–isopropyltoluene
N–butylbenzene
Naphthalene

North Dakota

General Water Quality
Bicarbonate
Carbonate
Total Alkalinity
Total Hardness
Total Dissolved Solids
Specific Conductivity
pH
Hydroxide
Turbidity
Percent Sodium
Sodium Adsorption Ratio

Metals
Sodium
Magnesium
Potassium
Calcium
Manganese
Iron

Non–metals
Chloride
Fluoride
Sulfate

Nutrients
Nitrite, as nitrogen
Nitrate, as nitrogen

Pesticides
Aldrin
Alpha BHC
Beta BHC
Lindane
Chlordane
DDD (or TDE)
DDE
DDT
Dieldrin
Endosulfan I

Pesticides (cont.)
Endosulfan II
Endosulfan Sulfate
Endrin
Heptachlor
Heptachlor Epoxide
Methoxychlor
Diclofop (Hoslon)
Monachlor
Alachlor
Malathion
Ethyl parathion
Methyl parathion
Fenvalerate
Cyamizine
Triallate
Trifluralin (Traflan)
Simazine
Atrazine
Pendimethalin (Prowl)
Metribuzin
Metolachlor
2,4–D
Dicamba
Dinoseb
HCP
Picloran (Tordan)
2,4,6–T
2,4,5–TP (Silvex)
Aldicarb
Aldicarb Sulfoxide
Aldicarb Sulfone
Dalapan
Broxynil
Oxamyl
Carbofuran
3–Hydroxy carbofuran
Methomyl
Carbaryl
Bentazon
Propoxur (Baygon)

Appendix B

Laboratory Analysis Costs

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
INORGANICS							
METALS:							
Aluminum	SCH 2703	$16.00	$13.00	$12.00	$22.70	$12.00	$6.50
Antimony	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$7.50/CHM
Arsenic	SCH 2703	$16.00	$13.00	$22.00	$26.20	$12.00	$7.50/CHM
Barium	SCH 2703	$16.00	$13.00	$12.00	$22.70	$12.00	$6.50/CHM
Beryllium	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$6.50/CHM
Cadmium	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$7.50/CHM
Calcium	SCH 2750	$16.00	$13.00	$12.00	$13.50	$12.00	$6.50/CHM
Chromium	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$6.50/CHM
Chromium, Hexavalent	NA	$16.00	$25.00	$25.00	$13.00	NA	$10.00
Cobalt	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$6.50
Copper	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$6.50/CHM
Iron	SCH 2750	$16.00	$13.00	$12.00	$13.00	$12.00	$6.50/CHM
Lead	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$7.50/CHM
Magnesium	SCH 2750	$16.00	$13.00	$12.00	$13.50	$12.00	$6.50/CCA
Manganese	SCH 2750	$16.00	$13.00	$12.00	$13.00	$12.00	$6.50/CHM
Molybdenum	SCH 2703	$16.00	$13.00	$12.00	NA	$12.00	$6.50
Mercury	NA	$16.00	$13.00	$30.00	$34.80	$20.00	$10.50/CHM
Nickel	SCH 2703	$16.00	$13.00	$12.00	$13.00	$12.00	$6.50/CHM
Potassium	SCH 2750	$16.00	$13.00	$12.00	$13.50	$12.00	$6.50/CCA
Selenium	SCH 2703	$16.00	$13.00	$22.00	$26.20	$12.00	$7.50/CHM
Silver	SCH 2703	$16.00	$13.00	$12.00	$13.80	$12.00	$6.50
Sodium	SCH 2750	$16.00	$13.00	$12.00	$13.50	$12.00	$6.50/CCA
Strontium	NA	$16.00	$13.00	$12.00	$13.50	$12.00	$6.50
Thallium	NA	$16.00	$13.00	$12.00	$13.80	$12.00	$7.50/CHM
Tin	NA	$16.00	$13.00	$12.00	$22.00	$12.00	$6.50
Titanium	NA	$16.00	$13.00	$12.00	$22.70	$12.00	$6.50
Vanadium	NA	$16.00	$13.00	$12.00	NA	$12.00	$6.50
Zinc	SCH 2703	$16.00	$13.00	$12.00	$13.00	$12.00	$6.50/CHM
NON-METALS:							
Boron	NA	$16.00	NA	$20.00	$19.80	$15.00	NA
Bromide	SCH 2750	$35.00	$30.00	$15.00	$21.20	NA	$4.50
Chloride	SCH 2750	$15.00	$15.00	$35.00	$5.70	$8.00	$4.50/CCA

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Cyanide	NA	$35.00	$35.00	$20.00	$95.00	$31.50	$12.5/CHM
Fluoride	SCH 2750	$40.00	$30.00	$12.00	$13.60	$32.50	$4.50/CCA
Silica	SCH 2750	$40.00	NA	$15.00	NA	$16.00	$6.50/CCA
Sulfate	SCH 2750	$35.00	$20.00	$15.00	$27.10	$9.00	$4.50/CCA
Sulfide	NA	$35.00	$20.00	$12.00	$29.40	NA	NA
GENERAL:							
Acidity	NA	$15.00	$15.00	$15.00	$16.30	NA	NA
pH	SCH 2750	$8.00	$10.00	$10.00	$9.00	$5.00	$4.00/CCA
Specific Conductance	SCH 2750	$15.00	$10.00	$10.00	$11.40	$6.50	$4.00/CCA
Specific Gravity	NA	$15.00	$10.00	$15.00	NA	NA	NA
TDS	SCH 2750	$15.00	$15.00	$15.00	$10.80	$16.50	$15.00/CCA
TSS	NA	$15.00	$15.00	$15.00	$10.80	$10.00	$5.50
Total Alkalinity	SCH 2750	$15.00	$15.00	$15.00	$17.50	$10.00	$4.50/CCA
Total Hardness	NA	$15.00	$18.00	NA	$9.30	$9.00	$13.00/CCA
Turbidity	NA	$15.00	$12.00	$10.00	$10.80	$8.00	$4.00/CCA
NUTRIENTS							
Ammonia, report as nitrogen	SCH 2752	$25.00	$20.00	$20.00	$31.70	NA	$4.50/CCA
Kjeldhal nitrogen (TKN)	NA	$30.00	$35.00	$35.00	$38.60	$15.50	$10.00
Nitrate, report as nitrogen	SCH 2752	$25.00	$25.00	$20.00	$20.70	$12.50	$4.50/CCA
Nitrite, report as nitrogen	NA	$25.00	$20.00	$15.00	NA	$9.00	$6.50
Nitrite, nitrate, report as nitrogen	SCH 2752	NA	$25.00	NA	$20.70	NA	NA
Orthophosporus, report as phosphorus	SCH 2752	$25.00	$25.00	$20.00	$31.90	$5.00	$4.50
Phosphorus, report as phosphorus	SCH 2752	$25.00	$30.00	$25.00	$38.60	NA	$5.50/CCA
RADIONUCLIDES							
Gross Alpha	SCH 609	$70.00	NA	$125.00	NA	NA	NA
Gross Beta	SCH 609	$70.00	NA	$125.00	NA	NA	NA
Gross Alpha/Beta	NA	NA	NA	$150.00	NA	$25.00	$45.00
Gross Gamma (Photon Activity)	NA	NA	NA	$300.00	NA	NA	NA
Iodine-131	NA	NA	NA	$150.00	NA	NA	NA
Lead-210	$121.00	$100.00	NA	NA	NA	NA	NA
Nickel-63	NA	NA	NA	$90.00	NA	NA	NA
Polonium-210	$137.00	$100.00	NA	NA	NA	NA	NA

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Radium-226	$168.00	$125.00	NA	$190.00	NA	NA	NA
Radium-228	$136.00	$125.00	NA	$190.00	NA	NA	NA
Radon-222	$111.00	$80.00	NA	$50.00	NA	NA	NA
Stontium-89	NA	NA	NA	$140.00	NA	NA	NA
Strontium-90	$133.00	$100.00	NA	$170.00	NA	NA	NA
Thorium-230	SCH 1139	$100.00	NA	NA	NA	NA	NA
Thorium-232	SCH 1139	$100.00	NA	NA	NA	NA	NA
Total Radium	NA	NA	NA	$125.00	NA	NA	NA
Tritium	$286.00	$80.00	NA	$90.00	NA	NA	NA
Uranium-ICPMS	SCH 2703	$40.00	NA	$150.00	NA	NA	NA
Uranium-234	SCH 1130	$100.00	NA	NA	NA	NA	NA
Uranium-235	SCH 1130	$100.00	NA	NA	NA	NA	NA
Uranium-238	SCH 1130	$100.00	NA	NA	NA	NA	NA
ORGANICS							
ACID COMPOUNDS:							
Benzoic acid	NA		PP/TCL A&BN	NA			EPA 8270
2-sec-butyl-4,6-dinitrophenol	NA		Appendix IX	NA			NA
p-chloro-m-cresol	NA		PP/TCL A&BN	NA			EPA 8270
o-chlorophenol	NA		NA	NA			EPA 8270
2-chlorophenol	NA		PP/TCL A&BN	NA			NA
Meta-cresol	NA		Appendix IX	NA			NA
Ortho-cresol	NA		PP/TCL A&BN	NA			EPA 8270
Para-cresol	NA		PP/TCL A&BN	NA			EPA 8270
2,4-dichlorophenol	NA		PP/TCL A&BN	NA			EPA 8270
2,6-dichlorophenol	NA		NA	NA			NA
2,4-dimethylphenol	NA		PP/TCL A&BN	NA			EPA 8270
4,6-dinitro-o-cresol	NA		PP/TCL A&BN	NA			EPA 8270
2,4-dinitrophenol	NA		PP/TCL A&BN	NA			EPA 8270
2-nitrophenol	NA		PP/TCL A&BN	NA			EPA 8270
4-nitrophenol	NA		PP/TCL A&BN	NA			EPA 8270
Pentachlorophenol	NA		PP/TCL A&BN	NA			EPA 8270
Phenol	NA		PP/TCL A&BN	NA			EPA 8270
2,3,4,6-tetrachlorophenol	NA		Appendix IX	NA			NA
2,4,5-trichlorophenol	NA		PP/TCL A&BN	NA			EPA 8270

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
2,4,6-trichlorophenol	NA		PP/TCL A&BN	NA			EPA 8270
BASE/NEUTRAL COMPOUNDS:							
Acenaphthene	NA		PP/TCL A&BN	NA			EPA 625
Acenaphthylene	NA		PP/TCL A&BN	NA			EPA 525.2
Acetophenone	NA		Appendix IX	NA			NA
2-acetylaminofluorene	NA		Appendix IX	NA			NA
4-aminobiphenyl	NA		Appendix IX	NA			NA
Aniline	NA		Appendix IX	NA			NA
Anthracene	NA		PP/TCL A&BN	NA			EPA 525.2
Aramite	NA		Appendix IX	NA			NA
Benzidine	NA		PP/TCL A&BN	NA			NA
Benzo(a)anthracene	NA		PP/TCL A&BN	NA			EPA 525.2
Benzo(b)fluoranthene	NA		PP/TCL A&BN	NA			EPA 525.2
Benzo(k)fluoranthene	NA		PP/TCL A&BN	NA			EPA 625
Benzo(g,h,i)perylene	NA		PP/TCL A&BN	NA			EPA 525.2
Benzo(a)pyrene	NA		PP/TCL A&BN	NA			EPA 525.2
Benzyl alcohol	NA		PP/TCL A&BN	NA			NA
Bis(2-chloroethoxy)methane	NA		PP/TCL A&BN	NA			EPA 625
Bis(2-chloroethyl)ether	NA		PP/TCL A&BN	NA			EPA 625
Bis(2-chloroisopropyl)ether	NA		PP/TCL A&BN	NA			EPA 625
Bis(2-ethylhexyl)adipate	NA		NA	NA			EPA 525.2
Bis(2-ethylhexyl)phthalate	NA		PP/TCL A&BN	NA			EPA 525.2
4-bromophenyl phenyl ether	NA		PP/TCL A&BN	NA			EPA 625
Butyl benzyl phthalate	NA		PP/TCL A&BN	NA			EPA 525.2
p-chloroaniline	NA		PP/TCL A&BN	NA			NA
2-chloronaphthalene	NA		PP/TCL A&BN	NA			EPA 625
4-chlorophenyl phenyl ether	NA		PP/TCL A&BN	NA			EPA 625
Chrysene	NA		PP/TCL A&BN	NA			EPA 525.2
Dibenzo(a,h)anthracene	NA		PP/TCL A&BN	NA			EPA 525.2
Dibenzofuran	NA		PP/TCL A&BN	NA			NA
1,2-dibromo-3-chloropropane	NA		Appendix IX	NA			NA
Di-n-butyl phthalate	NA		PP/TCL A&BN	NA			EPA 525.2
m-dichlorobenzene	NA		PP/TCL A&BN	NA			NA
o-dichlorobenzene	NA		PP/TCL A&BN	NA			NA

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
p-dichlorobenzene	NA		PP/TCL A&BN	NA			NA
3,3'-dichlorobenzidine	NA		PP/TCL A&BN	NA			NA
Diethyl phthalate	NA		PP/TCL A&BN	NA			EPA 625
O,O-diethyl-O-2-purazinylphosphorothioate	NA		Appendix IX	NA			NA
p-dimethylaminoazobenzene	NA		Appendix IX	NA			NA
7,12-dimethylbenz(a)anthracene	NA		Appendix IX	NA			NA
3,3'-dimethylbenzidine	NA		Appendix IX	NA			NA
Alpha. alpha-dimethyphenethylamine	NA		Appendix IX	NA			NA
Dimethyl phthalate	NA		PP/TCL A&BN	NA			EPA 525.2
m-dinitrobenzene	NA		Appendix IX	NA			NA
2,4-dinitrotoluene	NA		PP/TCL A&BN	NA			EPA 625
2,6-dinitrotoluene	NA		PP/TCL A&BN	NA			EPA 625
Di-n-octyl phthalate	NA		PP/TCL A&BN	NA			EPA 625
Diphenylamine	NA		Appendix IX	NA			NA
1,2-diphenylhydrazine	NA		PP/TCL A&BN	NA			NA
Di-n-propylnitrosamine	NA		PP/TCL A&BN	NA			NA
Ethyl methanesulfonate	NA		Appendix IX	NA			NA
Fluoranthene	NA		PP/TCL A&BN	NA			EPA 625
Fluorene	NA		PP/TCL A&BN	NA			EPA 525.2
Hexachlorobenzene	NA		PP/TCL A&BN	NA			EPA 625
Hexachlorobutadiene	SCH 2090		PP/TCL A&BN	NA			EPA 625
Hexachlorocyclopentadiene	NA		PP/TCL A&BN	NA			EPA 525.2
Hexchlorodibenzo-p-dioxins	NA		Appendix IX	NA			NA
Hexachlorodibenzofurans	NA		Appendix IX	NA			NA
Hexachloroethane	NA		PP/TCL A&BN	NA			EPA 625
Hexachlorophene	NA		Appendix IX	NA			NA
Hexachloropropene	NA		Appendix IX	NA			NA
Indeno(1,2,3-c,d)pyrene	NA		PP/TCL A&BN	NA			EPA 525.2
Isophorone	NA		PP/TCL A&BN	NA			EPA 625
Isosafrole	NA		Appendix IX	NA			NA
Methapyrilene	NA		Appendix IX	NA			NA
3-methylcholanthrene	NA		Appendix IX	NA			NA
Methyl methanesulfonate	NA		Appendix IX	NA			NA
2-methylnaphthalene	NA		PP/TCL A&BN	NA			NA
Naphthalene	SCH 2090		PP/TCL A&BN	NA			EPA 625

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
1,4-naphthoquinone	NA		Appendix IX	NA			NA
1-naphthylamine	NA		Appendix IX	NA			NA
2-naphthylamine	NA		Appendix IX	NA			NA
m-nitroaniline	NA		PP/TCL A&BN	NA			NA
o-nitroaniline	NA		PP/TCL A&BN	NA			NA
p-nitroaniline	NA		PP/TCL A&BN	NA			NA
Nitrobenzene	NA		PP/TCL A&BN	NA			EPA 625
4-nitroquinoline 1-oxide	NA		Appendix IX	NA			NA
N-nitrosodi-n-butylamine	NA		Appendix IX	NA			NA
N-nitrosodi-n-propylamine	NA		NA	NA			EPA 625
N-nitrosodiethylamine	NA		Appendix IX	NA			NA
N-nitrosodimethylamine	NA		PP/TCL A&BN	NA			NA
N-nitrosdiphenylamine	NA		PP/TCL A&BN	NA			NA
N-nitrosomethylethylamine	NA		Appendix IX	NA			NA
N-nitrosomorpholine	NA		Appendix IX	NA			NA
N-nitrosopiperidine	NA		Appendix IX	NA			NA
N-nitrosopyrrolidine	NA		Appendix IX	NA			NA
5-nitro-o-toluidine	NA		Appendix IX	NA			NA
Pentachlorobenzene	NA		Appendix IX	NA			NA
Pentachlorodibenzo-p-dioxins	NA		Appendix IX	NA			NA
Pentachlorodibenzofurans	NA		Appendix IX	NA			NA
Phenacetin	NA		Appendix IX	NA			NA
Phenanthrene	NA		PP/TCL A&BN	NA			EPA 524.2
p-phenylenediamine	NA		Appendix IX	NA			NA
2-picoline	NA		Appendix IX	NA			NA
Pyrene	NA		PP/TCL A&BN	NA			EPA 524.2
Pyridine	NA		Appendix IX	NA			NA
Safrole	NA		Appendix IX	NA			NA
1,2,4,5-terachlorobenzene	NA		Appendix IX	NA			NA
2,3,7,8-tetrachlorodibenzo-p-dioxins	NA		PP/TCL A&BN	NA			NA
Tetrachlorodibenzo-p-dioxins	NA		Appendix IX	NA			NA
Tetrachlorodibenzofurans	NA		Appendix IX	NA			NA
o-toluidene	NA		Appendix IX	NA			NA
1,2,4-trichlorobenzene	SCH 2090		PP/TCL A&BN	NA			EPA 524.2
O,O,O-triethylphosphorothioate	NA		Appendix IX	NA			NA

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Sym-trinitrobenzene	NA		Appendix IX	NA			NA
HERBICIDES:							
Acifluorfen	SCH 2050		NA	NA			NA
Alachlor	SCH 2001		NA	NA			EPA 507/8
Atrazine	SCH 2001		NA	NA			EPA 507/8
Atrazine desethyl	SCH 2001		NA	NA			NA
Bentazon	SCH 2050		NA	NA			NA
Bromacil	SCH 2050		NA	NA			NA
Bromoxynil	SCH 2050		NA	NA			NA
Bytylate	SCH 2001		NA	NA			NA
Chloramben	SCH 2050		NA	NA			NA
Clopyralid	SCH 2050		NA	NA			NA
Cyanazine	SCH 2001		NA	NA			NA
Dalapon	NA		NA	NA			EPA 515.1
DCPA	SCH 2001		NA	NA			NA
Dicamba	SCH 2050		NA	NA			EPA 515.1
Dichlobenil	SCH 2050		NA	NA			NA
2,4-dichlorophenoxyacetic acid	SCH 2050		Appendix IX	NA			EPA 515.1
2,4-DB	SCH 2050		NA	NA			NA
Dinoseb	SCH 2050		NA	NA			EPA 515.1
Diuron	SCH 2050		NA	NA			NA
EPTC	SCH 2001		NA	NA			NA
Ethalfluralin	SCH 2001		NA	NA			NA
Fluometuron	SCH 2050		NA	NA			NA
Linuron	SCH 2001		NA	NA			NA
MCPA	SCH 2050		NA	NA			NA
MCPB	SCH 2050		NA	NA			NA
Metolachlor	SCH 2001		NA	NA			EPA 507/8
Metribuzin	SCH 2001		NA	NA			EPA 507/8
Molinate	SCH 2001		NA	NA			NA
Napropamide	SCH 2001		NA	NA			NA
Norflurazon	SCH 2050		NA	NA			NA
Oryzalin	SCH 2050		NA	NA			NA
Pebulate	SCH 2001		NA	NA			NA

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Pendimethalin	SCH 2001		NA	NA			NA
Pentachlorophenol	NA		NA	NA	EPA 515.1		EPA 515.1
Picloram	SCH 2050		NA	NA	EPA 515.1		EPA 515.1
Propachlor	SCH 2001		NA	NA			EPA 507/8
Propanil	SCH 2001		NA	NA			NA
Propham	SCH 2050		NA	NA			NA
Silvex (2,4,5-TP)	SCH 2050		Appendix IX	NA	EPA 515.1		EPA 515.1
Simazine	SCH 2001		NA	NA			EPA 507/8
Tebuthiuron	SCH 2001		NA	NA			NA
Terbacil	SCH 2001		NA	NA			NA
Thiobencarb	SCH 2001		NA	NA			NA
Triallate	SCH 2001		NA	NA			NA
Triclopyr	SCH 2050		NA	NA			NA
Trifluralin	SCH 2001		NA	NA			NA
2,4,5-T	SCH 2050		Appendix IX	NA			NA
PESTICIDES/PCB's:							
Aldicarb	SCH 2050		NA	NA	EPA 531.1		EPA 531.1
Aldicarb sulfone	SCH 2050		NA	NA	EPA 531.1		EPA 531.1
Aldicarb sulfoxide	SCH 2050		NA	NA	EPA 531.1		EPA 531.1
Aldrin	NA		PP/TCL PCB	NA			EPA 507/8
Aroclor (PCB) 1016	NA		PP/TCL PCB	NA			EPA 608
Aroclor (PCB) 1221	NA		PP/TCL PCB	NA			EPA 608
Aroclor (PCB) 1232	NA		PP/TCL PCB	NA			EPA 608
Aroclor (PCB) 1242	NA		PP/TCL PCB	NA			EPA 608
Aroclor (PCB) 1248	NA		PP/TCL PCB	NA			EPA 608
Aroclor (PCB) 1254	NA		PP/TCL PCB	NA			EPA 608
Aroclor (PCB) 1260	NA		PP/TCL PCB	NA			EPA 608
Azinphos-methyl	SCH 2001		NA	NA			NA
Benfluralin	SCH 2001		NA	NA			NA
Alpha-BHC	SCH 2001		PP/TCL PCB	NA			EPA 608
Beta-BHC	NA		PP/TCL PCB	NA			EPA 608
Delta-BHC	NA		PP/TCL PCB	NA			EPA 608
Gamma-BHC	SCH 2001		PP/TCL PCB	NA			EPA 608
Butachlor	NA		NA	NA			EPA 507/8

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Carbaryl	SCH 2001		NA	NA	EPA 531.1		EPA 531.1
Carbofuran	SCH 2001		NA	NA	EPA 531.1		EPA 531.1
Chlordane	NA		PP/TCL PCB	NA			EPA 507/8
Chlorobenzilate	NA		Appendix IX	NA			NA
Chlorothalonil	SCH 2050		NA	NA			NA
Chlorpyrifos	SCH 2001		NA	NA			NA
4,4'-DDD	NA		PP/TCL PCB	NA			EPA 608
4,4'-DDE	SCH 2001		PP/TCL PCB	NA			EPA 608
4,4'-DDT	NA		PP/TCL PCB	NA			EPA 608
Dacthl-Mono-Acid	SCH 2050		NA	NA			NA
Diallate	NA		Appendix IX	NA			NA
Diazinon	SCH 2001		NA	NA			NA
Diazinon D10	SCH 2001		NA	NA			NA
Dichlorprop	SCH 2050		NA	NA			NA
Dieldrin	SCH 2001		PP/TCL PCB	NA			EPA 507/8
Diethylanaline	SCH 2001		NA	NA			NA
Dimethoate	SCH 2001		Appendix IX	NA			NA
Disulfoton	SCH 2001		Appendix IX	NA			NA
Di-2(ethylhexyl)adipate	NA		NA	NA			NA
Di-2(ethylhexyl)phthalate	NA		NA	NA			NA
DNOC	SCH 2050		NA	NA			NA
Endosulfan sulfate	NA		PP/TCL PCB	NA			EPA 608
Endosulfan I (alpha)	NA		PP/TCL PCB	NA			EPA 608
Endosulfan II (beta)	NA		PP/TCL PCB	NA			EPA 608
Endrin	NA		PP/TCL PCB	NA			EPA 507/8
Endrin aldehyde	NA		PP/TCL PCB	NA			NA
Endrin ketone	NA		PP/TCL PCB	NA			NA
Esfenvalerate	SCH 2050		NA	NA			NA
Ethoprop	SCH 2001		NA	NA			NA
Famphur	NA		Appendix IX	NA			NA
Fenuron	SCH 2050		NA	NA			NA
Fonofos	SCH 2001		NA	NA			NA
Heptachlor	NA		PP/TCL PCB	NA			EPA 507/8
Heptachlor epoxide	NA		PP/TCL PCB	NA			EPA 507/8
Hexachlorobenzene	NA		NA	NA			EPA 507/8

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
3-hydroxycarbofuran	NA		NA	NA	EPA 531.1		EPA 531.1
Isodrin	NA		Appendix IX	NA			NA
Kepone	NA		Appendix IX	NA			NA
Lindane	NA		NA	NA			NA
Malathion	SCH 2001		NA	NA			NA
Methiocarb	SCH 2050		NA	NA			NA
Methomyl	SCH 2050		NA	NA	EPA 531.1		EPA 531.1
Methoxychlor	NA		PP/TCL PCB	NA			EPA 507/8
Methyl parathion	SCH 2001		Appendix IX	NA			NA
Napthol 1	SCH 2050		NA	NA			NA
Neburon	SCH 2050		NA	NA			NA
Oxamyl	SCH 2050		NA	NA	EPA 531.1		EPA 531.1
Parathion	SCH 2001		Appendix IX	NA			NA
Pentachloronitrobenzene	NA		Appendix IX	NA			NA
Permethrin-Cis	SCH 2001		NA	NA			NA
Phorate	SCH 2001		Appendix IX	NA			NA
Prometon	SCH 2001		NA	NA			NA
Pronamide	SCH 2001		Appendix IX	NA			NA
Propargite	SCH 2001		NA	NA			NA
Propoxur	SCH 2050		NA	NA			NA
Terbufos	SCH 2001		NA	NA			NA
Terbuthylazine	SCH 2001		NA	NA			NA
Tetraethyldithiopyrophosphate	NA		Appendix IX	NA			NA
Toxaphene	NA		PP/TCL PCB	NA			EPA 507/8
VOLATILE ORGANIC COMPOUNDS:							
Acetone	NA		PP/TCL VOC	NA			NA
Acetonitrile	SCH 2090		Appendix IX	NA			NA
Acrolein	SCH 2090		PP/TCL VOC	NA			NA
Acrylonitrile	SCH 2090		PP/TCL VOC	NA			NA
Benzene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Bromobenzene	SCH 2090		NA	NA			EPA 524.2
Bromochloromethane	SCH 2090		NA	NA			NA
Bromodichloromethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Bromoform	SCH 2090		NA	NA			EPA 524.2

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Bromomethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
n-butylbenzene	SCH 2090		NA	NA			NA
sec-butylbenzene	SCH 2090		NA	NA			NA
tert-butylbenzene	SCH 2090		NA	NA			NA
Carbon disulfide	NA		PP/TCL VOC	NA			NA
Carbon tetrachloride	SCH 2090		PP/TCL VOC	NA			EPA 624
Chlorobenzene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
2-chloro-1,3-butadiene	NA		Appendix IX	NA			NA
Chlorodibromomethane	NA		PP/TCL VOC	NA			NA
Chloroethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
2-chloroethyl vinyl ether	SCH 2090		PP/TCL VOC	NA			NA
Chloroform	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Chloromethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
3-chloropropene	NA		Appendix IX	NA			NA
ortho-chlorotoluene	SCH 2090		NA	NA			EPA 524.2
para-chlorotoluene	SCH 2090		NA	NA			EPA 524.2
Dibromochloromethane	SCH 2090		NA	NA			EPA 524.2
1,2-dibromo-3-chloropropane	SCH 2090		NA	NA			EPA 524.2
1,2-dibromoethane	SCH 2090		Appendix IX	NA			EPA 524.2
Dibromomethane	SCH 2090		Appendix IX	NA			EPA 524.2
1,3-dichlorobenzene	SCH 2090		NA	NA			EPA 524.2
1,2-dichlorobenzene	SCH 2090		NA	NA			EPA 524.2
1,4-dichlorobenzene	SCH 2090		NA	NA			EPA 524.2
Trans-1,4-dichloro-2-butene	NA		Appendix IX	NA			NA
Dichlorodifluoromethane	SCH 2090		Appendix IX	NA			NA
1,1 dichloroethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,2-dichloroethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,1-dichloroethylene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
cis 1,2-dichloroethylene	NA		NA	NA			EPA 524.2
Trans-1,2-dichloroethylene	NA		PP/TCL VOC	NA			EPA 524.2
Dichloromethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,1-dichloropropene	SCH 2090		NA	NA			EPA 524.2
1,2-dichloropropane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,3-dichloropropane	SCH 2090		NA	NA			EPA 524.2
2,2-dichloropropane	SCH 2090		NA	NA			EPA 524.2

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
Cis-1,3-dichloropropene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
trans-1,3-dichloropropene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,4 dioxane	NA		Appendix IX	NA			NA
Ethyl benzene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Ethyl cyanide	NA		Appendix IX	NA			NA
Ethyl methacrylate	NA		Appendix IX	NA			NA
2-hexanone	NA		PP/TCL VOC	NA			NA
Iodomethane	NA		Appendix IX	NA			NA
Isobutyl alcohol	NA		Appendix IX	NA			NA
Isopropylbenzene	SCH 2090		NA	NA			NA
p-isopropyltoluene	SCH 2090		NA	NA			NA
Methacrylonitrile	NA		Appendix IX	NA			NA
Methyl ethyl ketone	NA		PP/TCL VOC	NA			NA
Methyl methacrylate	NA		Appendix IX	NA			NA
Methyl tert-Butyl Ether	SCH 2090		NA	NA			NA
4-methyl-2-pentanone	NA		PP/TCL VOC	NA			NA
n-propylbenzene	SCH 2090		NA	NA			NA
Pentachloroethane	NA		Appendix IX	NA			NA
Styrene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,1,1,2-tetrachloroethane	SCH 2090		Appendix IX	NA			EPA 524.2
1,1,2,2-tetrachloroethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Tetrachloroethylene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Toluene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Tribromomethane	NA		PP/TCL VOC	NA			NA
1,1,1-trichloroethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
1,1,2-trichloroethane	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Trichloroethylene	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Trichlorofluoromethane	SCH 2090		Appendix IX	NA			NA
1,2,3,-trichloropropane	SCH 2090		Appendix IX	NA			EPA 524.2
Trichlorotriflouroethane	SCH 2090		NA	NA			NA
1,2,4-trimethylbenzene	SCH 2090		NA	NA			NA
1,3,5-trimethylbenzene	SCH 2090		NA	NA			NA
Vinyl acetate	NA		PP/TCL VOC	NA			NA
Vinyl chloride	SCH 2090		PP/TCL VOC	NA			EPA 524.2
Total xylenes	SCH 2090		PP/TCL VOC	NA			EPA 524.2

SAMPLE ANALYTES	LABORATORY ANALYSIS COSTS						
	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
EPA STANDARD METHODS							
502.2 (Volatile Organics)	NA		NA	$150.00		$175.00	NA
503.1	NA		NA	NA		$170.00	NA
504 (Pesticides)	NA		NA	$75.00		$95.00	NA
505 (Pesticides)	NA		NA	$95.00		$125.00	NA
506	NA		NA	NA		$100.00	NA
507 (Chlorinated Hydrocarbon Pesticides)	NA		NA	NA		$160.00	NA
508 (Chlorinated Hydrocarbon Pesticides)	NA		NA	NA		$145.00	NA
508A	NA		NA	NA		$145.00	NA
507/508 (Chlorinated Hydrocarbon Pesticides)	NA		NA	NA		NA	$150.00
515.1* (Includes methods 515.1, 525.1, and 531.1)	NA		NA	$750.00		NA	NA
515.1 (Chlorophenoxy Herbicides)	NA		NA	$225.00		$150.00	$125.00
524.2 (Drinking Water Volatile Organics)	NA		NA	$170.00		NA	$100.00
525	NA		NA	NA		$215.00	NA
525.1 (Pesticides)	NA		NA	$325.00		NA	NA
525.2 (Synthetic Organic Compounds)	NA		NA	NA		NA	$250.00
531.1 (Carbamate Pesticides)	NA		NA	$200.00		$170.00	$150.00
Phase 1,2,5	NA		NA	NA		$1,235.00	NA
601 (Purgeable Halocarbons)	NA		$125.00	NA		$100.00	NA
602 (Purgeable Aromatics)	NA		$100.00	NA		$100.00	NA
601/602 (Purgeable Hydrocarbons & Aromatics)	NA		$175.00	NA		NA	NA
606	NA		NA	NA		$100.00	NA
608 (Organochlorine Pesticides/PCB's)	NA		$200.00	NA		$145.00	$75.00
610 (Polynuclear Aromatic Hydrocarbons)	NA		$200.00	NA		$125.00	NA
612	NA		NA	NA		$100.00	NA
614 (Organophosphorus Pesticides)	NA		$175.00	NA		NA	NA
615 (Chlorinated Herbicides)	NA		$200.00	NA		$160.00	NA
624 (Volatile Organics)	NA		$230.00	$170.00		NA	NA
625 (Acids)	NA		$270.00	NA		NA	NA
625 (Base/Neutrals)	NA		$300.00	NA		$500.00	$250.00
625 (Acids & Base/Neutrals)	NA		$450.00	NA		NA	NA
8010 (Volatile Organics)	NA		$125.00	$85.00		$100.00	NA
8015 (Non-Halogenated Volatile Organics)	NA		NA	$85.00		$75.00	NA

LABORATORY ANALYSIS COSTS

SAMPLE ANALYTES	USGS	IEA	Ross	Alpha	Arizona	Idaho	Kansas
8015 (Petroleum Hydrocarbons) Mod.	NA		$110.00	NA		NA	NA
8020 (Volatile Aromatics)	NA		$100.00	$85.00		$100.00	NA
8021	NA		NA	NA		$180.00	NA
8010/8020 (Volatile Organics)	NA		NA	$150.00		NA	NA
8010/8020 (Pugeable Hydrocarbons & Aromatics)	NA		$175.00	NA		NA	NA
8015/8020 (Petroleum Hydrocarbons with BTEX)	NA		$150.00	NA		NA	NA
8010/8015/8020 (Volatile Organics)	NA		NA	$170.00		NA	NA
8030 (Acrolein & Acrylonitrile Only)	NA		NA	$100.00		NA	NA
8080 (Organochlorine Pesticides/PCBs)	NA		$200.00	$125.00		NA	NA
8080/8081 (Pesticides/PCBs)	NA		NA	NA		$110.00	NA
8080/8150 (SDWA/RCRA Pesticides/Herbicides)	NA		NA	$125.00		NA	NA
8090/8120	NA		NA	NA		$225.00	NA
8100	NA		$200.00	NA		$125.00	NA
8140	NA		$175.00	NA		$150.00	NA
8150 (Chlorophenoxy Pesticides/Herbicides)	NA		$200.00	$175.00		$135.00	NA
8240 (Volatile Organics)	NA		$230.00	NA		NA	NA
8260 (HSL Volatile Organics)	NA		$230.00	$170.00		NA	NA
8270 (Acid Extractables)	NA		$270.00	$125.00		$175.00	$150.00
8270 (Base Neutral Extractables)	NA		$300.00	$275.00		NA	NA
8270 (Acids & Base Neutral Extractables)	NA		$450.00	NA		NA	NA
8270 (Polynuclear Aromatic Hydrocarbons)	NA		NA	$125.00		NA	NA
8270/8080 (HSL Acid/Base/Neutral/PCBs/Pesticides)	NA		NA	$400.00		NA	NA
8310	NA		NA	NA		NA	NA

Appendix C

Costs of Monitoring Well Installation

APPENDIX C: COSTS OF MONITORING WELL INSTALLATION

Total Cost of Monitoring Well Installation

Company	Well #1[1] Sand	Well #1 Till	Well #1 Bedrock	Well #2[2] Sand	Well #2 Till	Well #2 Bedrock	Well #3[3] Sand	Well #3 Till	Well #3 Bedrock	Well #4[4] Sand	Well #4 Till	Well #4 Bedrock
Guild[5]	$1,644.00	$2,444.00	$2,505.00	$3,280.00	$4,880.00	$5,758.00	$4,795.00	$6,395.00	$6,488.00	$7,042.00	$10,442.00	$9,070.00
Maher[6]	$2,100.00	$2,200.00	$3,800.00	$4,000.00	$4,300.00	$7,300.00	$5,400.00	$5,600.00	$8,600.00	$18,900.00	$18,900.00	$14,000.00
Red Wing	$1,210.00	$1,510.00	$2,500.00	$2,190.00	$2,990.00	$3,790.00	$4,525.00	$5,425.00	$6,035.00	$8,400.00	$9,000.00	$10,600.00
Aquadrill[7]	$1,800.00	$1,350.00	$1,550.00	$3,800.00	$3,050.00	$3,300.00	$5,700.00	$4,950.00	$5,200.00	$14,150.00	$15,100.00	$13,850.00
GME[8]	$1,477.00	$1,877.00	$5,400.00	$3,325.00	$3,995.00	NA	$4,450.00	$5,695.00	NA	NA	NA	NA
Layne	$1,385.00	$2,160.00	$1,912.00	$2,763.00	$4,808.00	$2,873.00	$4,441.00	$6,456.00	$4,533.00	$12,805.00	$13,615.00	$11,615.00
West Hazmat	$1,500.00	$2,250.00	$2,500.00	$2,800.00	$4,500.00	$5,000.00	$4,900.00	$6,600.00	$7,100.00	$14,000.00	$17,000.00	$18,000.00
Western	$1,500.00	$2,250.00	$2,000.00	$3,200.00	$5,500.00	$4,500.00	$5,500.00	$7,000.00	$6,000.00	$14,000.00	$20,000.00	$17,000.00
Mean	$1,577.00	$2,005.13	$2,770.88	$3,169.75	$4,252.88	$4,645.86	$4,963.88	$6,015.13	$6,279.43	$12,756.71	$14,865.29	$13,447.86
Median	$1,500.00	$2,180.00	$2,500.00	$3,262.50	$4,400.00	$4,500.00	$4,847.50	$6,045.00	$6,035.00	$14,000.00	$15,100.00	$13,850.00

Notes:

[1] Representative Well Type #1 is 50' deep, 2" PVC, sand and gravel pack, bentonite seal, complete grouting, locking cap, and no protective devices.

[2] Representative Well Type #2 is 100' deep, 2" PVC, sand and gravel pack, bentonite seal, complete grouting, locking cap, and protective steel well stack casing.

[3] Representative Well Type #3 is 100' deep, 2" Stainless steel, sand and gravel pack, bentonite seal, complete grouting, locking cap, and protective steel well stack casing.

[4] Representative Well Type #4 is 200' deep, 4" Stainless steel, sand and gravel pack, bentonite seal, partial grouting, locking cap, and protective steel posts.

[5] Prices do not include stratigraphic core sampling or decontamination.

[6] Costs assume Auger Methods for Sand and Glacial Till Scenarios for Wells Types #1, #2, & #3, and Air Rotary Methods for Bedrock Wells and for Well Type #4.

[7] Costs for Well Type #4 include grouting from sand gravel pack to ground surface.

[8] Does not have the capability install wells through full depth of bedrock. Does not install wells of 2 inch or greater diameter

APPENDIX C: COSTS OF MONITORING WELL INSTALLATION

Cost per Foot of Monitoring Well Installation

Company	Well #1[1] Sand	Well #1 Till	Well #1 Bedrock	Well #2[2] Sand	Well #2 Till	Well #2 Bedrock	Well #3[3] Sand	Well #3 Till	Well #3 Bedrock	Well #4[4] Sand	Well #4 Till	Well #4 Bedrock
Guild[5]	$32.88	$48.88	$50.10	$32.80	$48.80	$57.58	$47.95	$63.95	$64.88	$35.21	$52.21	$45.35
Maher[6]	$42.00	$44.00	$76.00	$40.00	$43.00	$73.00	$54.00	$56.00	$86.00	$94.50	$94.50	$70.00
Red Wing	$24.20	$30.20	$50.00	$21.90	$29.90	$37.90	$45.25	$54.25	$60.35	$42.00	$45.00	$53.00
Aquadrill[7]	$36.00	$27.00	$31.00	$38.00	$30.50	$33.00	$57.00	$49.50	$52.00	$70.75	$75.50	$69.25
GME[8]	$29.54	$37.54	$108.00	$33.25	$39.95	NA	$44.50	$56.95	NA	NA	NA	NA
Layne	$27.70	$43.20	$38.24	$27.63	$48.08	$28.73	$44.41	$64.56	$45.33	$64.03	$68.08	$58.08
West Hazmat	$30.00	$45.00	$50.00	$28.00	$45.00	$50.00	$49.00	$66.00	$71.00	$70.00	$85.00	$90.00
Western	$30.00	$45.00	$40.00	$32.00	$55.00	$45.00	$55.00	$70.00	$60.00	$70.00	$100.00	$85.00
Mean	$31.54	$40.10	$55.42	$31.70	$42.53	$46.46	$49.64	$60.15	$62.79	$63.78	$74.33	$67.24
Median	$30.00	$43.60	$50.00	$32.63	$44.00	$45.00	$48.48	$60.45	$50.35	$70.00	$75.50	$69.25

Notes:

[1] Representative Well Type #1 is 50' deep, 2" PVC, sand and gravel pack, bentonite seal, complete grouting, locking cap, and no protective devices.

[2] Representative Well Type #2 is 100' deep, 2" PVC, sand and gravel pack, bentonite seal, complete grouting, locking cap, and protective steel well stack casing.

[3] Representative Well Type #3 is 100' deep, 2" Stainless steel, sand and gravel pack, bentonite seal, complete grouting, locking cap, and protective steel well stack casing.

[4] Representative Well Type #4 is 200' deep, 4" Stainless steel, sand and gravel pack, bentonite seal, partial grouting, locking cap, and protective steel posts.

[5] Prices do not include stratigraphic core sampling or decontamination.

[6] Costs assume Auger Methods for Sand and Glacial Till Scenarios for Wells Types #1, #2, & #3, and Air Rotary Methods for Bedrock Wells and for Well Type #4.

[7] Costs for Well Type #4 include grouting from sand gravel pack to ground surface.

[8] Does not have the capability install wells through full depth of bedrock. Does not install wells of 2 inch or greater diameter