STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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Report of Investigations 88-12

AN EVALUATION OF GROUND-WATER QUALITY MONITORING IN ALASKA

in cooperation with the
Department of Environmental Conservation

by
Danita L. Maynard

ERRATA

RI 88-12

Please make the following changes to Figures 3 and 4:

Figure 3. 4. Houston landfill should read:

- 4a. Houston landfill
- 4b. Big Lake landfill

8. Anchorage landfills should read:

- 8a. MOA Peters Creek landfill
- 8b. MOA Regional landfill

9. Municipality of Anchorage landfills should read:

- 9a. Ft. Richardson landfill
- 9b. Elmendorf AFB landfill
- 9c. MOA Merrill Field landfill
- 9d. MOA International Airport landfill

Figure 4. 3. Pt. MacKenzie dairy farms should read:

3. Pt. MacKenzie dairy farms (4 sites)

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AN EVALUATION OF GROUND-WATER QUALITY MONITORING IN ALASKA

by
Danita L. Maynard[1]

ABSTRACT

Current monitoring of Alaska's ground-water quality is limited. An evaluation of monitoring in Alaska and a review of ground-water monitoring networks in other, selected states, supports the conclusion that ground-water quality monitoring in Alaska is limited in scope and will require improvement to fulfill its statewide monitoring objectives. Alaska's current monitoring program includes ambient-trend monitoring, site monitoring, and public water system (PWS) monitoring. Objectives of monitoring are to assess trends in ground-water quality and ground-water contamination, effectiveness of remediation programs, and PWS potability. Ambient-trend monitoring is inadequate to assess trends in ground-water quality; site monitoring occurs at only a small number of sites where ground-water contamination may be significant; and PWS monitoring is not designed to detect organic contamination. Because quality control measures are often undocumented, data quality is often uncertain and data are often inaccessible within nonautomated, archived files.

Alaska's statewide monitoring efforts can be improved by incorporating the suggested changes in system design, data quality, and data management.

INTRODUCTION

Because 70 percent of Alaska's population depends on ground-water sources for its water supply (Madison and others, 1987), ground-water quality is especially important. Nationally, contamination of ground water is one of the most significant environmental issues of the 1980s. Federal and state legislative responses to this issue have indicated a need for ground-water data to effectively protect and manage the nation's valuable ground-water resources (Loftis and others, 1986). The National Groundwater Policy Forum (1985) has listed "monitoring, data collection, and data analysis" among 10 components vital to the development of a comprehensive ground-water protection strategy. Ground-water quality monitoring is encouraged by the U.S. Environmental Protection Agency (USEPA) Ground-water Protection Strategy (USEPA, 1984).

The collection of ground-water quality data in Alaska, by several federal, state, and local agencies through a variety of programs, represents a large expenditure of effort and funds dedicated not only to securing reliable data but to managing it in a way that enhances its usefulness. Ideally, this should provide an adequate and accessible database to support informed decisionmaking by multiple users. However, unreliable or inaccessible data not only constitute a significant economic waste but could

[1] Alaska Division of Geological & Geophysical Surveys, P.O. Box 772116, Eagle River, Alaska 99577.

contribute to the adoption of environmental policies based on erroneous or limited information.

This report evaluates current and recent ground-water quality monitoring in Alaska, compares it with monitoring programs adopted by other states, assesses Alaska's areal extent of monitoring and its suitability for achieving various objectives in data quality and data management, and suggests methods of improvement. Other recent work (Munter, 1986; Munter and Maynard, 1987a,b; and Alaska Department of Environmental Conservation, 1988a,b) has dealt with ground-water monitoring data sources, aquifer contamination, and ground-water protection programs, all of which have been used in the preparation of a statewide Groundwater Quality Protection Strategy by the Alaska Department of Environmental Conservation. The monitoring sites referred to in this report are described more completely in Maynard (1988).

MONITORING OBJECTIVES AND METHODS

The objectives of a monitoring program vary according to the needs of the agency administering the program. The following objectives are implied by federal monitoring requirements (Loftis and others, 1986):

1) determine background ground-water quality;
2) determine permit compliance;
3) detect ground-water contamination; and
4) assess the effectiveness of corrective action.

The National Research Council Committee on Ground Water Quality Protection (1986) has proposed the following objectives for state or local ground-water quality monitoring programs:

1) assess ambient water quality and trends;
2) locate and identify potential contamination sources and their impact;
3) assess impacts attributable to land and water use;
4) establish or modify standards and permits;
5) assess regulatory compliance; and
6) collect data to evaluate effectiveness of implemented programs.

In contrast to these generalized objectives, Showalter (1985) cited 17 highly specialized objectives of the monitoring program for the Salinas River (California) drainage basin, designed to satisfy the data requirements of two county agencies, regional and state water-quality control boards, and the U.S. Geological Survey (USGS). Some specific goals of the monitoring program were tracking movement of a saltwater wedge, assessing the effect of recent vineyard cultivation, and quantifying local arsenic levels.

Ground-water quality is monitored by repeated sampling either of a single station such as a well or spring (a monitoring point) or a cluster of stations (a monitoring network). In this report, sites must be sampled at least three times to be included as monitoring sites. Monitoring points provide data for a single station. Monitoring networks provide data from several monitoring points which, taken together, are intended to characterize the ground-water quality conditions of the area or aquifer bounded by the network stations. Monitoring networks supply data about regional ground-water quality (ambient-trend monitoring) or site-specific ground-water quality (site monitoring). Public water supply (PWS) monitoring consists of single stations that are regularly sampled to assure potability of the water supply. These three broad categories are discussed below.

Ambient-trend Monitoring

Ambient-trend monitoring is designed to detect temporal or spatial trends in the ground-water quality of an area (Canter and others, 1987) and is useful in defining the natural geochemistry of aquifers. Ambient water quality has been designated as a separate monitoring category by USEPA (Everett, 1980). Miller (1981) defines ambient-trend monitoring as "monitoring for statistical analysis," to determine the long-term impact of pollution from nonpoint sources. Ambient-trend monitoring typically targets actual or potential water-supply aquifers and often makes use of existing wells. Sampling may occur infrequently, from annually to once or twice a decade, with the goal of accumulating data indefinitely. Analysis parameters vary widely--depending on the perceived importance of the aquifer, the size of the population using the water, contaminants thought to occur in the area, and funds available--but usually include those parameters which define general water quality and identify indicators of suspected contamination (table 1).

Table 1. Typical water-chemistry parameters for ambient-trend monitoring.

General indicators	Major constituents[a]	Minor constituents[b]
temperature	bicarbonate	boron
pH	calcium	carbonate
specific conductance	chloride	fluoride
dissolved oxygen	magnesium	iron
total dissolved solids	silicon	nitrate
alkalinity-acidity	sodium	potassium
hardness	sulfate	strontium

[a] Commonly present in concentrations greater than 5 mg/L (Freeze and Cherry, 1979).
[b] Commonly present in concentrations of 0.01-10.0 mg/L (Freeze and Cherry, 1979).

Nationally, most ambient-trend water-quality monitoring is done by USGS or comparable state agencies such as a state geological survey or water resource department. State programs categorized as 'statewide monitoring networks' are typically ambient-trend monitoring networks. These networks are useful in ground-water quality protection if the identification of undesirable trends results in changes in land-use or pumpage patterns before drinking-water supplies are seriously impaired. In this report, any monitoring that results in the collection of ambient ground-water data is included as ambient-trend monitoring, even if the statistical analysis necessary to establish trends is not performed. (An example of this is the inclusion of monitoring points designed to collect baseline data required for permits.) The primary consideration is whether the data collected are appropriate to use in establishing trends.

Site Monitoring

Site monitoring determines the existence and magnitude of ground-water contamination attributable to point sources. Site-monitoring objectives are to detect contamination, assess its extent, and evaluate the effectiveness of remediation efforts.

The USEPA has defined three categories of monitoring which, in this report, comprise site monitoring: source monitoring, case-preparation monitoring, and research monitoring (Everett, 1980). Miller (1981) defines an additional category of emergency-response monitoring that is also included as a type of site monitoring. Categories may overlap, causing monitoring points or networks to exhibit characteristics of more than one category. Thus, a monitoring point or network may be installed initially for source monitoring, but may be used for other purposes such as emergency-response or case-preparation monitoring. Some researchers suggest that site monitoring does not address goals of ground-water protection, because once contamination is discovered, it is too late to protect the aquifer (Loftis and others, 1986).

Source monitoring

Facilities which have the potential to release contaminants into an aquifer can be required to conduct source (or 'compliance') monitoring. Landfills, wastewater lagoons, hazardous waste sites, sewage-sludge land application sites, and injection wells are monitored in many states. Additionally, many states are beginning to monitor ground-water quality near underground petroleum storage tanks. The initial objective is to detect any contamination attributable to facility operation. If contamination is detected, the objective becomes assessment of the contamination. In instances of remediation efforts, the objective may be assessment of the effectiveness of remediation efforts.

Analysis parameters typically include general indicators of contamination plus those characteristics specific to the source being monitored (table 2). Davis (1988) suggests these parameters do not fully assess ground-water quality without also including bicarbonate, calcium, magnesium, nitrogen, oxygen, potassium, and silicic acid levels. Intervals between sampling rounds are usually expressed in months rather than years. After a specified number of years, monitoring of specific potential sources of contamination terminates.

Case-preparation Monitoring

Case-preparation (enforcement) monitoring occurs when litigation is expected. The need for legally defensible data increases monitoring costs and complexity, because additional quality-assurance or quality-control measures are required. Field procedures, record-keeping, and laboratory procedures are

Table 2. Parameters for source-monitoring programs (EPA, 1985) required for sites regulated by the Resource Conservation and Recovery Act of 1976 (RCRA).

Key indicators	Indicators of water quality	Drinking-water-suitability indicators
pH	iron	arsenic
conductivity	manganese	barium
total organic carbon	sodium	cadmium
total organic halogens	sulfate	chromium
temperature	chloride	fluoride
water level	phenols	lead
		mercury
		nitrate
		selenium
		silver

frequently subjected to stringent controls not normally required in routine monitoring. The requirements listed in tables 3 and 4 for tracking the handling of the sample until its introduction as evidence illustrate the increased responsibility on data collectors to provide reliable results. Everett (1980) cautions that the worker "must be aware that his professional competence, the procedures he has used, and the reported values may be used and challenged in court."

Table 3. Elements of chain-of-custody sample-control procedures for RCRA sites (USEPA, 1986b).

sample labels	sample-analysis request sheets
sample seals	laboratory logbook and analysis notebooks
field logbook	tamperproof or locking shipping containers
chain-of-custody record	

Research Monitoring

Research monitoring is conducted to develop information about subsurface processes and is most frequently conducted by federal and state agencies or universities; however, not all monitoring conducted by these agencies matches the research monitoring definition used in this report. Research monitoring results generally appear in journals and other publications.

Emergency-response Monitoring

Emergency-response monitoring takes place when a government agency assumes responsibility for designing, implementing, and conducting a monitoring program (Miller, 1981), under such actions as spill-response programs, investigations conducted under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), or responses to contamination of unknown origin. Emergency-response monitoring is similar in many respects to case-preparation monitoring, but not all emergency-response monitoring results in litigation.

Table 4. Entries required for chain-of-custody record (USEPA, 1986b), RCRA sites.

- Sample number
- Signature of collector
- Date and time of collection
- Sample type (groundwater, immiscible layer)
- Well identification number
- Number of containers
- Parametric analyses requested
- Signatures of persons involved in chain of possession
- Inclusive dates of possession
- Internal temperature of refrigerated shipping container at time samples were sealed into container
- Maximum temperature recorded during shipment
- Minimum temperature recorded during shipment
- Internal temperature of refrigerated container on opening in laboratory

Public Water System Monitoring

Public water system (PWS) monitoring is designed to ensure potability of public water supplies (Miller, 1981). The monitoring objective is to protect the public health, in accordance with provisions of both the Safe Drinking Water Act of 1974 (SDWA) and applicable state laws. PWS monitoring applies to both surface and ground water, and is intended to assess the quality of water leaving the distribution system. Because the concern is the quality of the processed water rather than the source water, the sample is taken at the point of use rather than the point of withdrawal. Point-of-use PWS samples may represent a blend of surface water and ground water, mixed ground water from multiple aquifers, or physically or chemically processed (treated) water. For this reason, PWS monitoring is not always representative of ground-water quality.

In contrast to other types of monitoring, information pertaining to well construction and hydrogeology is not necessary to PWS monitoring and may not be available. Historical PWS data may be of uncertain quality and may require screening to ensure reliability and completeness before it is used for other purposes (O'Hearn and Schock, 1985). PWS monitoring does generate large quantities of data. Although typical analysis parameters are limited (table 5), these data complement other types of monitoring data.

GROUND-WATER MONITORING IN OTHER STATES

Several federal statutes indicate a need for ground-water quality data (Loftis and others, 1986), but the primary responsibility for implementation of ground-water monitoring rests with state and local governments (USEPA, 1984). State monitoring programs range from relatively simple, inexpensive programs to sophisticated systems and are administered by a variety of agencies for a variety of reasons. Although regional differences based on hydrogeology, land use, and demography occur among states, differences among state monitoring programs are related more to governmental structure, avail-

Table 5. Parameters and maximum contaminant levels associated with monitoring public water system quality. (USEPA sources as referenced by Montgomery, 1985).

EPA National Primary Drinking Water Standards

Inorganic chemical contaminants	Maximum contaminant level (MCL)(mg/L)
arsenic	0.05
barium	1.0
cadmium	0.010
chromium	0.05
fluoride	1.4-2.4
lead	0.05[a]
mercury	0.002
nitrate (as nitrogen)	10.0
selenium	0.01
silver	0.05
Organic chemical constituents	
enrin	0.0002
lindane	0.004
methoxychlor	0.1
total trihalomethanes	0.10
toxaphene	0.005
2,4-D	0.1
2, 4, 5-TP Silvex	0.01
Radioactive constituents	**MCL (pCi/L)[b]**
gross alpha	15
gross beta	50
strontium-90	8
combined radium-226 and -228	5
tritium	20,000
Total coliform bacteria	**MCL**
a) membrane filter technique	1 per 100 ml
b) fermentation tube (10 ml portions)	1 per 5 samples

[a]Now being evaluated. New MCLs at the source and at the tap are expected to be in place by 1990 (Larry Worley, USEPA Region X Drinking Water Program, 1988).

[b]pCi/L = picocuries per liter--the quantity of radioactive material producing 2.22 nuclear transformations per minute.

Table 5.--Continued

EPA National Secondary Drinking Water Standards

Constituent	MCL (mg/L)
chloride	250
copper	1
foaming agents	0.5
iron	0.3
manganese	0.05
sodium	250
sulfate	250
total dissolved solids	500
zinc	5
pH	6.5 - 8.5

able funding, dependence on the resource, and perceived threat of contamination. Monitoring is most often initiated to achieve compliance with one of several state or federal statutes relating to water quality. Although 16 separate federal statutes address ground-water quality (Canter and others, 1987), most monitoring is done in response to SDWA, RCRA, or CERCLA requirements. Monitoring programs for most states incorporate the concepts of determining data requirements, establishing monitoring objectives, and designing networks to achieve the objectives. USEPA guidelines (1987) require ground-water data for "issuing permits, selecting inspection targets, identifying areas of vulnerability and contamination, pursuing enforcement actions, and planning and executing site clean-ups."

Many states have a statewide monitoring network. This usually refers only to ambient-trend monitoring. The ground-water protection strategy developed by USEPA (1984), however, suggests that the most useful network design may be a combination of ambient-trend, site, and PWS monitoring. This approach has been adopted by a few states.

Many states are concerned about problems with data quality and data management, especially sharing of data between agencies. Inconsistent quality-control measures make many agencies reluctant to rely on data collected by other agencies (USEPA, 1987). Additionally, data collected by one agency may be difficult for other data users to access, in the absence of automated data storage and retrieval capabilities. Many states are standardizing data formats and data-quality identifiers and automating various databases to improve data sharing.

The following discussion focuses on monitoring programs in Illinois, Minnesota, and California, three examples of varying scope and complexity. Illinois has developed a simple statewide ambient-trend monitoring network of 1,300 selected PWS wells and has supplemented the developing ambient-trend database with historical PWS data to define ground-water quality in the principal aquifers of the state. In Minnesota, several well-established ground-water quality data-collection programs are operating, and a major objective is enhancement of data management. In California, basin networks are used rather than a statewide network; the basin networks consist of wells chosen from preexisting subnetworks administered by various agencies.

Illinois

Illinois has designed a statewide monitoring network with the following objectives (O'Hearn and Schock, 1985):

1) identify and assess existing ground-water resource problems in the principal aquifers;
2) use the available database (when practicable) for estimating historical ground-water quality and identifying trends;
3) establish baseline data in pristine areas;
4) document current levels of priority pollutants for future comparison;
5) detect existing and developing ground-water quality and quantity problems; and
6) trigger special investigations in areas with real or potential ground-water problems.

These objectives are accomplished through a statewide monitoring network of existing PWS wells. To maximize reliability of the network, only those PWS wells are included which are considered to have the most useful historical data for untreated ground water. Of the total number of available PWS wells, about one-third is included in the monitoring program, and about one-fourth of total available historical data is considered useful. Thus, the statewide network represents the highest quality data available and contains only part of the total statewide database collected. In contrast to USEPA's encouragement to enhance multiple use of data, the Illinois State Water Survey Division discourages combining data from the statewide monitoring network with data collected through site monitoring (O'Hearn and Schock, 1985) because of the inherent differences between ambient-trend and site-monitoring data.

The Illinois monitoring network is limited to its principal water-supply aquifers. Areas most susceptible to contamination were identified, and priorities established for data collection; 1,300 of 5,000 PWS wells were chosen for study, 204 assigned highest priority. The program includes three levels of monitoring:

1) routine monitoring--a continuation of existing fixed-station monitoring, at 3- to 5-yr intervals;
2) intensive surveys--a large number of measurements taken in a particular aquifer over a short period of time and repeated periodically; and
3) special studies--investigations of short duration to study problems that may be identified during either routine or intensive monitoring.

Monitoring priorities are established on the basis of current use of aquifer for water supply, potential for future water-supply use, numbers and types of potential sources of contamination, and evidence of existing contamination (O'Hearn and Schock, 1985). The data collected are placed in the nationally operated USEPA STORET database and made accessible to other agencies.

The Illinois network design is an example of an uncomplicated method for maximizing usefulness of an existing database. Choosing ambient trend observation sites from a large number of preexisting PWS wells avoids the expense of installing a new monitoring network. Several decades of historical PWS water-quality data are also available which contain useful parameters for characterizing ground-water chemistry. However, several weaknesses are inherent in this design. First, the PWS wells are not located for monitoring purposes, and therefore, PWS wells being used as monitoring wells are not necessarily placed where monitoring wells are needed. Also, many PWS wells are deep (from 100 to 3,000 ft) and are less likely to detect contamination near the surface, where most monitoring is needed (Desmarais, 1987). Finally, the Candidate Well Selection Criteria (fig. 1) proposed by the Illinois State Water Survey Division (O'Hearn and Schock, 1985) does not address the issue of multiple screens in large production wells which may produce blended water.

Minnesota

The Minnesota Pollution Control Agency (MPCA) has operated a statewide ground-water quality monitoring program since 1978 (Sabel and Porcher, 1987). The network comprises 409 wells and springs and is designed to define spatial and temporal variation of the ground-water quality of principal aquifers, with emphasis on areas of greatest use and areas with ground-water contamination. A summary report published biennially provides ground-water quality characteristics of 13 aquifers. Data are stored in the USEPA STORET system.

The MPCA operates several other programs that collect ground-water quality data: an emergency-response program; a hazardous-waste program; a nonpoint source-pollution program; a site response program; a solid waste program; a state disposal-system permit program; and an underground storage-tank program.

Other state agencies who collect ground-water data are the Minnesota Geological Survey, the Department of Natural Resources, the Department of Health, and the Department of Agriculture. Coordination of ground-water monitoring programs is a high priority of the Minnesota Ground Water Protection Strategy (Sabel and Porcher, 1987); to this end, MPCA has developed an Integrated Ground Water Information System (IGWIS), funded by a Clean Water Act section 106 grant, for standardizing storage and retrieval of ground-water information (Minnesota State Planning Agency, 1987). IGWIS is designed to facilitate coordination between the various state database systems, to store geographic locators for data (enabling IGWIS to use the geographic information systems of the Minnesota Department of Natural Resources and USEPA), and to provide interactive capabilities with federal data sources. Statistical and graphic capabilities provide use beyond MCPA's internal structure; for example, to supply information to agencies involved in water-resource planning.

Monitoring in Minnesota is representative of ground-water quality monitoring in many states. A variety of data sources exist, and data management (including data quality and storage-retrieval) differs from program to program. Shared data and assessment of stored data are major goals. This is consistent with USEPA's conclusion that the primary need of state agencies is

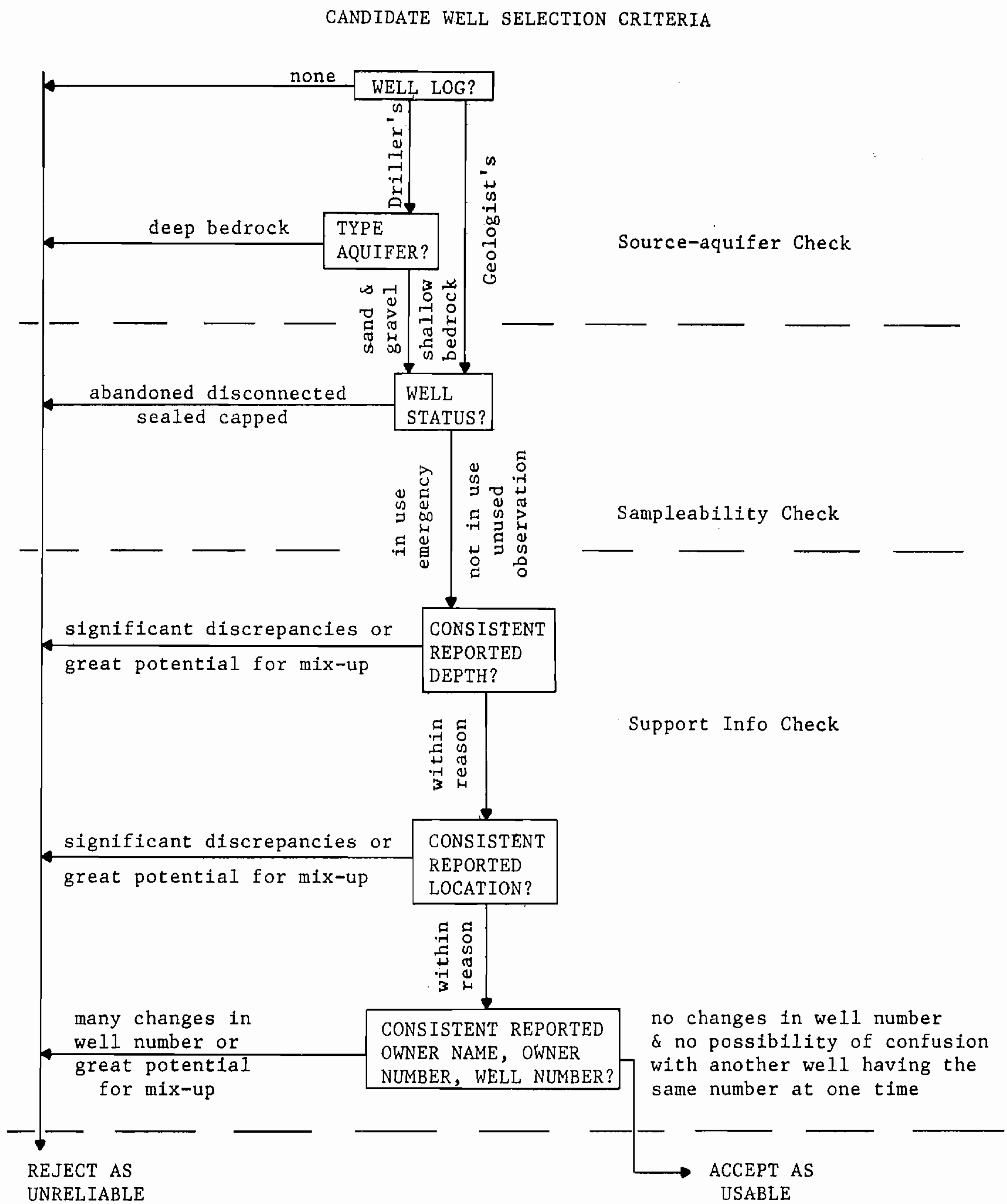

Figure 1. Screening process for pre-existing wells (O'Hearn and Schock, 1985).

improved capability for data access, retrieval, and analysis (USEPA, 1987), rather than formulation of new data-collection programs.

California

Ground-water quality monitoring in California is extensive; it has historically involved multiple agencies operating multiple monitoring networks, which resulted in duplication of effort and competition between agencies. In recent years, the California State Water Resources Control Board (WRCB), in cooperation with the California Department of Water Resources (DWR), has initiated a program of basinwide ground-water quality monitoring networks to reduce redundancy of data-collection efforts, to provide reliable data, and to eliminate the necessity of dealing with several agencies. These networks constitute subsets of the total sum of monitoring in each basin and are separate from programs requiring compliance monitoring, although data may be shared.

Goals for basin networks are to define California's ground-water basins, and to design monitoring programs for each basin to address its individual issues. Four hundred fifty ground-water basins have been identified, ranging from a few square miles to thousands of square miles (Steven Fagundes, California WRCB, oral commun., 1987). To reduce complexity and expense of such networks statewide, the Board identified 24 basins as highest priority, based on population density, availability of other water sources, and presence of operating observation sites. Monitoring programs for selected basins are designed under the following guidelines:

1. Ideal basin networks are designed in cooperation with the USGS, without regard to location of preexisting wells, based on goals specific to each basin.
2. After the ideal network is designed, preexisting wells with proper location and construction may be used as monitoring wells.
3. When possible, monitoring by other agencies may be incorporated to reduce costs and increase efficiency.
4. The California Department of Water Resources (DWR) verifies well location and suitability through field visits.
5. DWR may recommend drilling new wells at sites where wells are needed but no suitable preexisting wells are identified.

Network objectives specific to each ground-water basin may dictate the use of subnetworks with certain priorities such as ambient-trend monitoring, detection monitoring of point and nonpoint sources, or identification of areas with naturally poor ground-water quality. Table 6 lists objectives for the monitoring network in the Salinas River drainage basin network (Showalter, 1985).

Despite the significant investment of time and money in developing the basin networks, difficulties persist in collecting and managing ground-water quality data in California. Duplication of responsibilities has not been completely eliminated among the various data-collection groups such as county agencies, irrigation districts, DWR, the Department of Food and Agriculture, and the Department of Health Services. For example, DWR has initiated its own

Table 6. Objectives for ground-water monitoring in the Salinas River drainage basin, California (from Showalter, 1985).

Priority 1

- Define groundwater flow regime of basin including flow direction, flow rate, and flow across faults.
- Develop regional water-quality baseline.

Priority 2

- Monitor salt-water intrusion.
- Collect surface-water data for determining surface-water influence on ground water.

Priority 3

- Determine underflow and water quality from San Lorenzo Creek drainage (a water source known to be of poor quality).
- Determine ground-water quality in area where Estrella River and Huerhuero Creek join Salinas River.
- Determine quality and quantity of recharge from Lakes Nacimiento and San Antonio.

Priority 4

- Determine nitrate distribution and concentration in cultivated areas.
- Monitor ground-water quality downgradient from solid waste sites.

Priority 5

- Determine sources and distribution of heavy elements in ground water.

Priority 6

- Determine underflow and water quality from highly mineralized Pancho Rico Creek drainage.
- Determine effects of oil-field development.
- Monitor leakage from perched aquifers for confined aquifers in appropriate areas.

Priority 7

- Provide background information to map aquifers.
- Monitor for radioactivity in upper basin.

Priority 8

- Acquire baseline data for future assessment of impacts associated with recently initiated cultivation.

Priority 9

- Determine of arsenic levels in wells near San Juan Creek.

Priority 10

- Monitor for radioactivity in lower basin.

basinwide monitoring network program independent of the WRCB basin network program described previously (Fagundes, oral commun., 1988). There is no consistent data management policy. Some data collectors, including WRCB, forward their results to the USEPA STORET system, and others maintain inhouse databases. Neither WRCB nor DWR has routinely published results of ground-water quality monitoring, although DWR did initiate an annual report series this year (Edwin A. Ritchie, California DWR, oral commun., 1988).

The advantages of the California basin networks are (1) the initial design of an optimal network that avoids sampling biases from reliance on preexisting wells; and (2) the responsiveness of basin networks to issues of local areas as opposed to generalized statutory concepts. Optimal monitoring well locations are defined according to objective criteria rather than convenience, but practicality dictates the ultimate incorporation of existing wells when they occur within reasonable proximity to the ideal network site. The resulting working network deviates from the ideal but minimizes sampling bias. The monitoring network is limited to the principal water-supply aquifers, to provide maximum utilization of available funds.

Comparison of Programs

Illinois and Minnesota use statewide ambient-trend monitoring networks to provide data for periodic reports on ground-water quality in principal aquifers of the state, whereas California operates basinwide networks. In Minnesota, the statewide ground-water quality network is intended to supplement other monitoring programs; in Illinois, data from monitoring sites are not considered comparable with ambient-trend data. The California State Water Resources Control Board basinwide monitoring networks, composed of subnetworks with varying objectives, produce data describing general ground-water quality characteristics of principal aquifers, but reports are not published periodically. The California Department of Water Resources, which performs much of the monitoring work authorized by the State Water Resources Control Board, has also begun designing separate basinwide monitoring networks and producing an annual ground-water quality report.

An optimal ground-water quality monitoring network would incorporate existing wells and historical data when appropriate, as Illinois does; would encourage data-sharing among related programs, as in Minnesota; and would be responsive to local monitoring needs, as California's networks are. Table 7 contrasts the characteristics of ground-water quality monitoring in Illinois, Minnesota, California, and Alaska.

GROUND-WATER QUALITY MONITORING IN ALASKA

Objectives

Various agencies monitor ground-water quality in Alaska. USGS and the Municipality of Anchorage (MOA) operate regional ambient-trend monitoring networks. Some additional ambient data which could be incorporated into ambient-trend monitoring networks are collected by the Alaska Department of Fish and Game (ADF&G) and the Alaska Department of Natural Resources'

Table 7. Summary of statewide monitoring network characteristics.

Characteristic	Illinois	Minnesota	California	Alaska
Size (sq mi)	56,400	84,068	158,693	586,412
Population	11,139,000	3,957,400	21,491,300	537,800
Ground-water quality network design	Ambient data from 1,300 PWS wells statewide	Ambient data from 409 statewide wells, springs	Combination network with ambient, site, and PWS data	No statewide network currently exists
Data management	Included in STORET database	Included in STORET and coordinated with data from other MPCA programs through IGWIS	State agencies send data to STORET, local agencies may not	Most monitoring data stored in manual files. USGS and PWS data are automated
Publication of data	Raw data available on request	Biennial, aquifer-by-aquifer analysis and summary	DWR will publish annual data for about 1,200 wells. WRCB does not publish data regularily	Not regularly published
Advantages	Simple program	Established monitoring programs data-sharing high priority	Responsive to local issues; includes all types of monitoring	Minimal effort
Disadvantages	No data coordination; deep wells; no control over well placement; ambient data only	MPCA not involved with PWS monitoring. Statewide network consists of ambient data only	Involves small part of state; too many agencies involved; lack of cooperation, duplication of effort	Data limited in usefulness

Division of Mining (DOM). Site monitoring and PWS monitoring are administered primarily by DEC.

Monitoring programs in Alaska are designed to fulfill the following objectives:

1) assess ground-water quality trends;
2) detect or assess point-source contamination;
3) assess the effectiveness of remediation programs; and
4) assure public water system (PWS) potability.

Authorities and Programs

Various programs comprise current statewide ground-water quality monitoring. These programs are listed according to the agency administering them, not according to the identity of the actual data collector, which could be the administering agency, a contracting agency, a facility owner or operator, or a consultant. The areal distribution of monitoring sites is summarized in table 8. Comprehensive program descriptions, including well locations, are contained in a separate publication (Maynard, 1988).

U.S. Environmental Protection Agency

USEPA may administer several types of site monitoring programs. At present, USEPA administers one site monitoring network in Anchorage. USEPA places a high priority on ensuring data quality. Data are expected to be placed in the national USEPA STORET database.

U.S. Geological Survey

USGS operates an ambient-trend monitoring network of 11 wells in the Badger Road area near Fairbanks. To ensure data quality, USGS field-sampling personnel are tested annually for correctness of procedure, and written guidelines are followed for analyses performed in USGS laboratories. Data are stored in the USGS WATSTORE database and published annually. USGS also stores and publishes site-monitoring data collected under cooperative programs with other agencies.

U.S. Fish and Wildlife Service

USFWS may require ground-water monitoring associated with activities occurring on federal land. As of August 1987, USFWS required periodic monitoring of five well sites at the Swanson River Central Disposal Facility in the Kenai National Wildlife Refuge. Data are stored at USFWS and supplied to DEC.

U.S. Department of Defense

The Department of Defense conducts site monitoring through the Installation Restoration Program. Site monitoring currently occurs at five sites in Alaska (fig. 2). Data are contained in reports by USDOD consultants.

Table 8. Areal distribution of ground-water quality monitoring sites in Alaska.

Type of monitoring	Southcentral region	Southeastern region	Northern region
Ambient monitoring sites:			
current	48 (MOA)[a] 2 (other)	0	2
historical	-	1	20
Site monitoring:			
solid-waste disposal	25	0	2
wastewater discharge	8	0	0
case preparation-emergency response	3	0	3
PWS:			
Class A	334	44	84
Class B	716	69	304

[a]Municipality of Anchorage.

Alaska Department of Environmental Conservation

DEC is the primary statewide user of site-monitoring data. DEC administers the four programs summarized below, which generate data to determine compliance with state or federal regulations. DEC functions as a repository for data supplied for a monitored site and may also function as a data collector for special projects. DEC is developing guidelines for written Quality Assurance Project Plans to document sampling and analysis procedures for various monitoring programs. PWS data are automated; data from other programs are stored at several locations and are not yet automated.

Public Drinking Water Program - Public water systems (PWS) in Alaska are classified according to population size and type (residential or nonresidential). As of February 1988, this program included 462 Class A systems (continuously serving at least 25 people) and 1,089 Class B systems (serving at least 25 people for at least 60 days each year) that use ground water. Table 9 lists sampling frequencies and analyses required for PWS monitoring in Alaska; table 10 summarizes monitoring of Class A systems that rely on ground water sources.

Monitoring of some PWS wells may provide a useful source of long-term ground-water data which represent average aquifer conditions. These sites could be appropriate to include in an ambient-trend monitoring network. Other PWS wells would not be appropriate for inclusion: the well may be close to point sources of contamination, the water sampled may include either treated or blended water, or information about well construction, well depth, or aquifer lithology may be missing. Finally, PWS analyses are often too

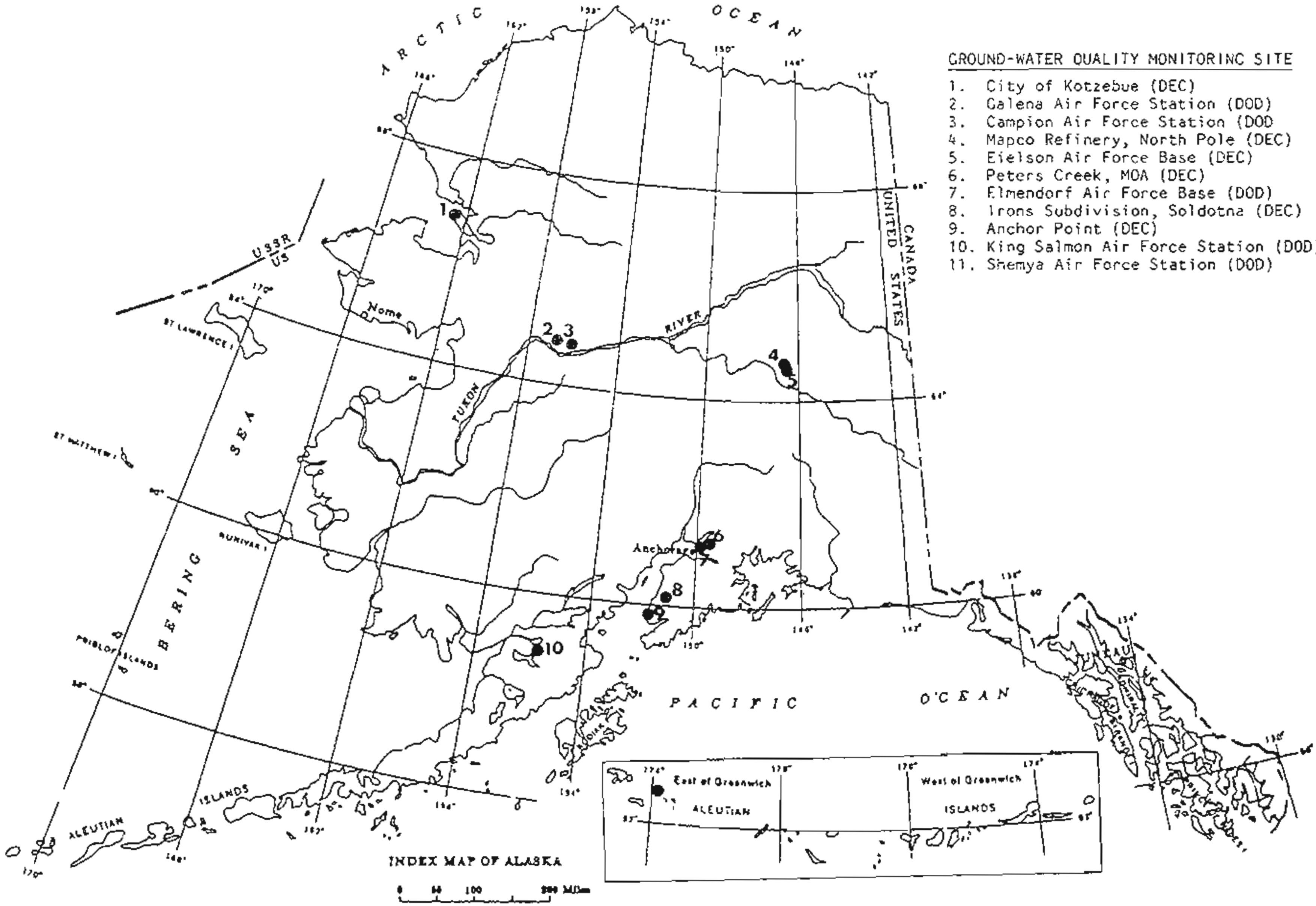

Figure 2. Map showing locations of ground-water quality monitoring at petroleum product spills.

Table 9. Routine sampling and analysis requirements for Class A and Class B public water systems using ground water (ADEC, 1982).

Parameter	Sampling interval: Class A	Sampling interval: Class B
Inorganic chemicals[a]	3 yr	-
Gross alpha	4 yr	-
Coliform	1 or more per mo	monthly
Nitrate	3 yr	3 yr

[a]Arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nitrate, selenium, silver.

incomplete to fully characterize ground-water quality. Subject to these cautions, selected PWS wells could provide an initial basis for ambient-trend monitoring networks without installation of new wells, and selected historical PWS ground-water quality data could provide the initial basis for an ambient-trend database which could be available for multiple uses.

The analyses used in Class A systems are appropriate for detecting inorganic, biological, or radiological contamination, although parameters for testing for organic contamination (for example, total organic carbon and total organic halogens) are not routinely used. Data collected from Class B systems are useful for detecting biological contamination or high levels of nitrate.

Solid Waste Management Program - Operators of solid waste sites in many states, including Alaska, must conduct source monitoring to detect any ground-water contamination attributable to facility operation. If contamination is detected, objectives of the source monitoring expand to include assessment of the extent of the contamination. In September 1987, source monitoring was required at 30 Alaska solid waste facilities, about 4 percent of the statewide total (fig. 3). The low percentage of monitoring sites is because of the geographic distribution of solid waste sites, many of which exist in areas where threat of ground-water contamination is minimal. Sampling frequencies and parameters vary according to permit conditions and reflect site-specific requirements.

Wastewater Disposal Program - Facilities regulated by the wastewater disposal program must generally perform only effluent monitoring, but certain surface impoundments and septic systems which are potential contamination sources may be responsible to monitoring ground-water quality in addition to, or instead of, effluent. Six facilities using surface impoundments and five wastewater drainfield operations presently monitor ground-water quality (fig. 4).

Oil Pollution Control Program - DEC has the authority to require monitoring in response to reported oil spills. Additionally, a state oil and hazardous substances release response fund was established in 1986 which includes provisions for ground-water quality monitoring at sites of potential

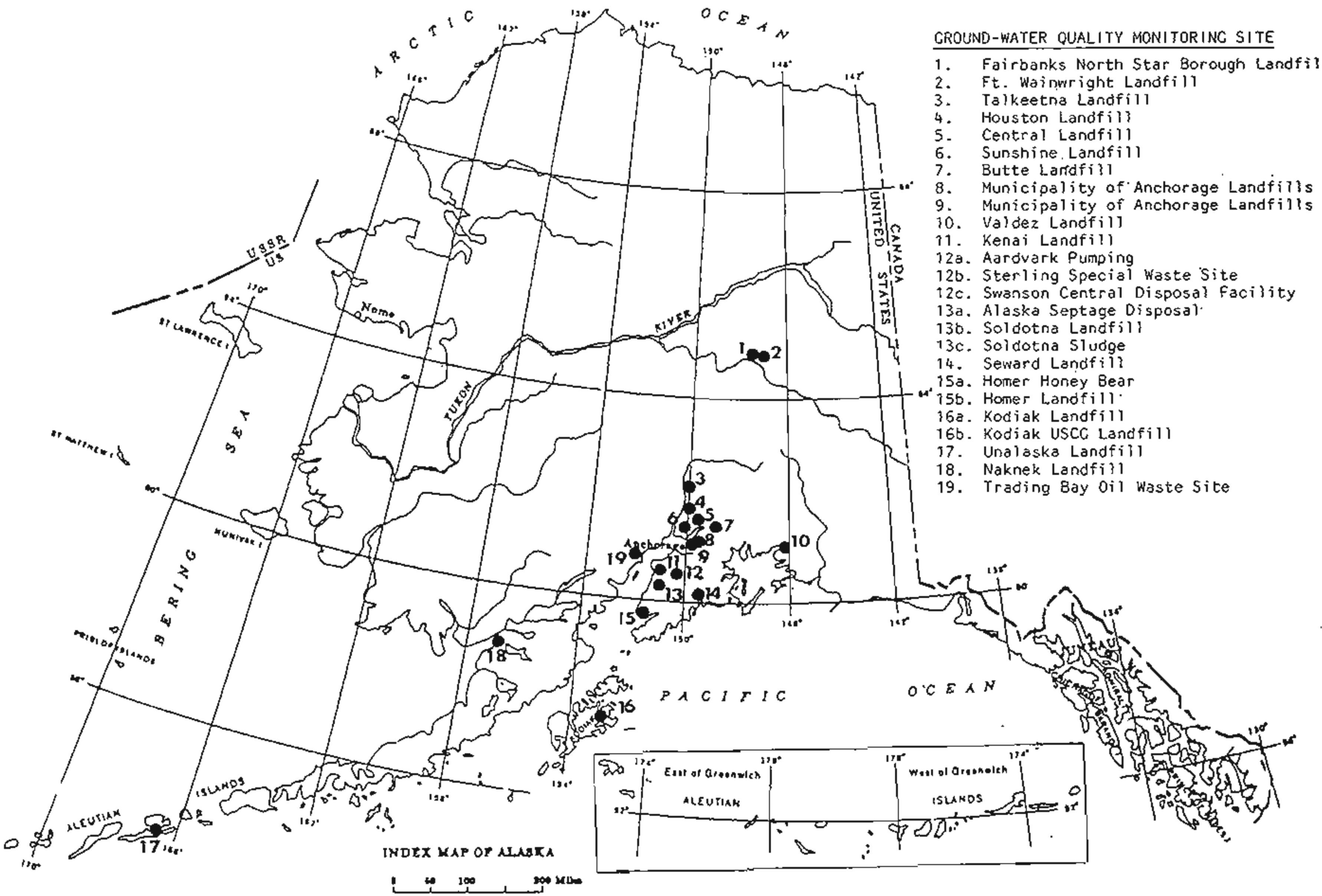

Figure 3. Map showing locations of ground-water quality monitoring at solid waste disposal sites.

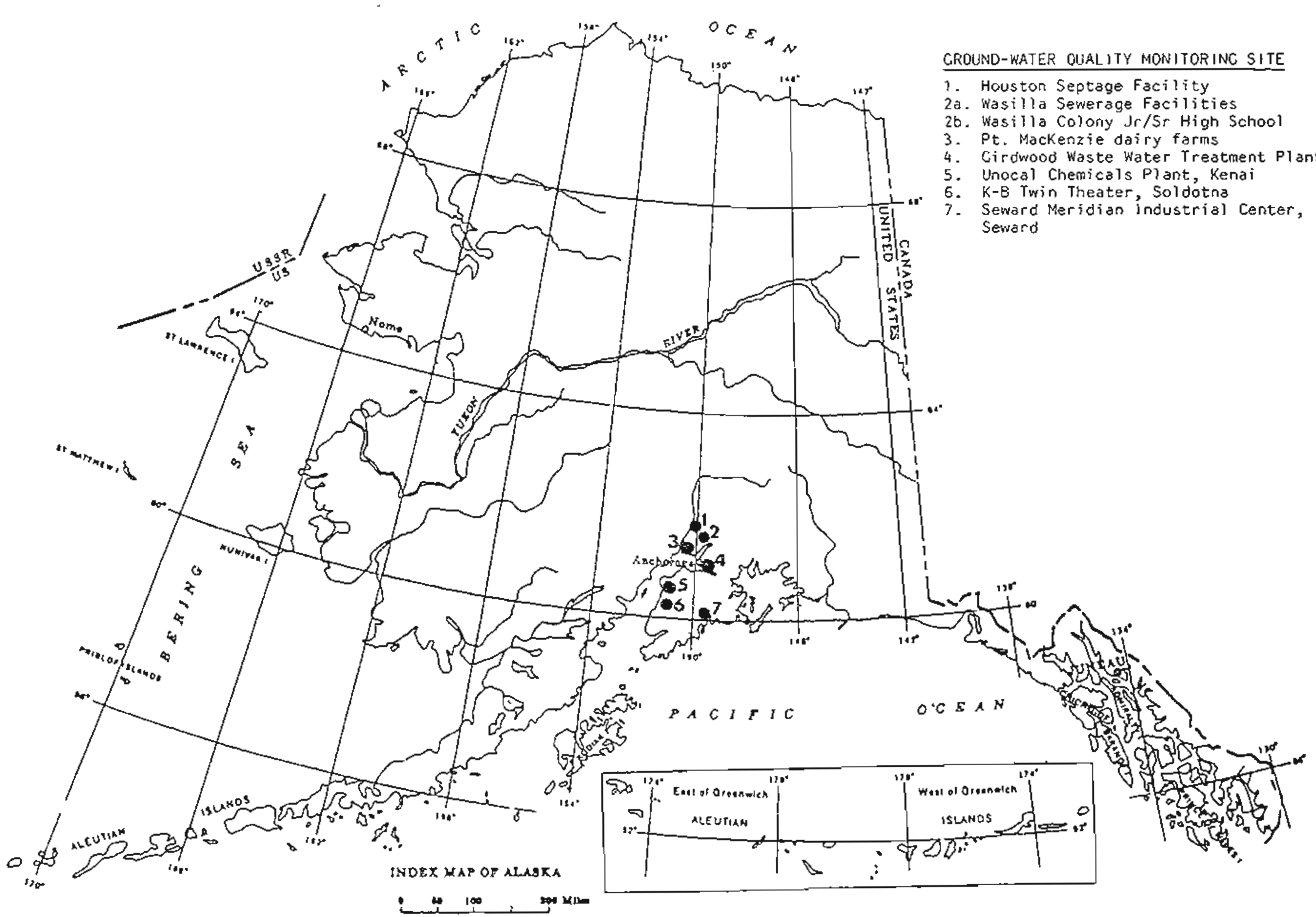

Figure 4. Map showing locations of ground-water quality monitoring at waste water disposal sites.

Table 10. Class A public drinking water systems using ground water. Number of systems per community (if more than one) shown in parentheses.

<u>Northern region</u>

Allakaket	Eagle (2)	Kiana	Rampart
Ambler	Eielson AFB	Kobuk	Ruby
Anaktuvuk Pass	Ester	Koyuk	Savoonga
Barrow	Fairbanks (23)	Koyukuk	Stevens Village
Beaver	Ft. Greeley (2)	Manley HS	Tanacross
Browerville	Ft. Wainwright	Minto	Tanana
Clear (2)	Ft. Yukon	Nenana	Tetlin
College	Galena (2)	Noatak	Tok
Council	Gulkana	Nome (2)	Unalakleet
Delta	Hughes	North Pole (6)	Venetie
Delta Junction (5)	Huslia	Northway	White Mountain
Dot Lake	Kaltag	Nulato (2)	

<u>Southcentral region</u>

Akiachak	Dillingham (4)	Marshall	Russian Mission
Akiak	Eagle River (23)	McGrath	Saint George
Aniak	Eklutna (4)	Mekoryuk	Saint Paul
Anchorage (119)	Ft. Richardson	Mountain Village	Seward (4)
Atmautluak	Girdwood	Naknek	Shageluk
Bethel (13)	Glennallen (6)	Napakiak (2)	Shemya
Big Lake (2)	Goodnews Bay	New Stuyahok	Sleetmute
Bird Creek	Holy Cross	Newhalen	Soldotna (6)
Cape Romanzof	Homer	Nightmute	South Naknek
Chefornak	Hooper Bay	Nikishka	Stony River
Chevak	Igiugig	Nikiski	Telida
Chignik Bay	Iliamna	Nondalton	Togiak
Chignik Lake	Ivanoff Bay	Nunapitchuk	Tuluksak
Chuathbaluk (2)	Kasigluk	Oscarville	Tuntutuliak
Chugiak (14)	Kenai (9)	Palmer (20)	Twin Hills
Clarks Point	King Salmon (3)	Peters Creek	Tyonek
Cold Bay	Koliganek	Pilot Station	Valdez (9)
Copper Center (5)	Kwethluk	Platinum	Wasilla (27)
Cordova	Lower Kalsag	Pt. MacKenzie	Whittier
Crooked Creek	Manokotak	Quinhagak	Willow

<u>Southeastern region</u>

Auke Bay (5)
Haines (2)
Juneau (29)
Petersburg (3)
Skagway
Wrangell
Yakutat (3)

or known contamination not under the jurisdiction of other programs. The fund is intended specifically for use when the responsible party is unknown or unwilling to participate in monitoring (ADEC, 1988a). Monitoring initiated through this 'state superfund' can include either case-preparation or emergency-response monitoring. As of November 1987, monitoring conducted under the Oil Pollution Control program included the Mapco Refinery (North Pole), the City of Kotzebue, Eielson AFB, Peters Creek (Municipality of Anchorage), Irons Subdivision (Soldotna), and Anchor Point (Kenai Peninsula).

Table 11 summarizes ground-water quality site monitoring administered by DEC through the Solid Waste Management, Wastewater Disposal, and Oil Pollution Control programs.

State of Alaska Department of Natural Resources

Ground-water quality monitoring associated with surface coal mine permit requirements is administered by DNR's Division of Mining (DOM). Baseline data are required prior to permit issuance, and monitoring is continued while the mine is active. Quarterly monitoring analyses are required under DOM permit regulations for the Diamond Alaska Coal Company in the Beluga coalfield area and the Usibelli Coal Mine near Healy.

State of Alaska Department of Fish and Game

Ground-water quality data may be collected to ensure suitability of water supply wells at fish hatcheries. Most fish hatcheries do not sample for ground-water quality data beyond an initial chemical analysis at the time of well completion, but Elmendorf Hatchery monitors oil and grease levels in a well used for hatchery waters, Clear Hatchery monitors the water chemistry of four wells used for hatchery waters, and Sikusuilaq Springs Hatchery near Kotzebue measures dissolved oxygen and hydrogen sulfide from source springs.

University of Alaska

Ground-water quality data may be collected during special, short-term study projects conducted by the university and the results are usually published. Recent research efforts have been directed towards monitoring of nitrate isotopes by the Institute of Northern Engineering, Water Research Center, University of Alaska-Fairbanks, and monitoring nitrate levels associated with leaching of dairy wastes at the UAF Agricultural and Forestry Experimental Station near Palmer. The Pt. MacKenzie data are also included as part of the DEC Wastewater Disposal Program.

Municipality of Anchorage

In 1985, the Water Quality Program of the MOA Department of Health and Human Services (DHHS) Environmental Services Division began operating a network of ambient-trend monitoring wells throughout the municipality. During the first 2 yr of operation, the wells were sampled semiannually for specific conductance, temperature, pH, alkalinity, fecal coliform, chloride, nitrate and nitrite, ammonia, and phosphorus (Keith Bandt, MOA DHHS, written commun., 1987). The goal of the network is to detect changes in shallow ground-water

Table 11. Site monitoring in Alaska administered by DEC.

Solid Waste Management Program

Northern region
- Ft. Wainwright landfill
- Fairbanks North Star Borough landfill

Southcentral region
- Aardvark Pumping (Sterling)
- Alaska Septage Disposal (Soldotna)
- Anchorage regional landfill
- Elmendorf landfill
- Ft. Richardson landfill
- Homer Honey Bear
- Homer landfill
- Houston landfill
- International Airport landfill (MOA)
- Kenai landfill
- Kodiak landfill
- Kodiak USCG landfill
- Marathon Oil waste site (Trading Bay)
- Mat-Su Borough landfills
  - Big Lake
  - Butte
  - Central
  - Sunshine
  - Talkeetna
- Merrill Field landfill (MOA)[a]
- Naknek landfill
- Peters Creek landfill (MOA)
- Seward landfill
- Soldotna landfill
- Soldotna Sludge
- Sterling special waste site
- Swanson Central Disposal Facility
- Unalaska landfill
- Valdez landfill

Wastewater Disposal Program

- Houston septage facility
- K-B Twin Theater (Soldotna)
- MOA-Girdwood treatment plant
- Pt. MacKenzie dairy farms (4 sites)
- Seward Meridian Industrial Center (Seward)
- Unocal Chemicals Division plant (Kenai)
- Wasilla Colony Jr/Sr High School
- Wasilla sewage facilities

Oil Pollution Control Program

Northern region
- Eielson AFB
- Kotzebue
- Mapco Refinery (North Pole)

Southcentral region
- Anchor Point
- Irons Subdivision (Soldotna)
- Peters Creek (MOA)

[a]Municipality of Anchorage.

quality which result from the use of on-site wastewater disposal systems. The data are collected and contained in manual files or in the USGS database. In addition, the On-site Services Program of the Environmental Services Division maintains a computerized database of over 400 nitrate analyses collected during various short-term monitoring projects.

SUITABILITY OF CURRENT MONITORING

Although ground-water quality monitoring in Alaska occurs as part of several programs within separate agencies, it is appropriate to consider all ambient-trend, site, and PWS monitoring in Alaska as a statewide monitoring system and to evaluate the adequacy of the system for achieving its objectives, using the criteria of system design, data quality, and data management.

System Design

'System design' refers to placing monitoring points and networks and selecting analytical parameters. An adequate statewide system would include (1) regional or basinwide ambient-trend networks to describe general ground-water quality and assess trends attributable to nonpoint sources of contamination; (2) site networks to define ground-water quality in the vicinity of potential point sources of contamination; and (3) PWS monitoring to ensure quality of drinking-water supplies.

In Alaska, monitoring points and networks are placed according to degree of public risk, dependence on ground-water resources (including potential for replacement of contaminated sources), and potential for contamination. These criteria tend to concentrate monitoring efforts near population centers. Consideration of these criteria sometimes result in waivers of monitoring requirements, such as site-monitoring requirements for permitted facilities in some permafrost areas.

Ambient-trend monitoring networks establish baseline data in uncontaminated aquifers and determine levels of chemical constituents in contaminated aquifers. Their primary purpose, however, is to assess degradation in ground-water quality from land-use or pumpage patterns. Ambient-trend monitoring in Alaska is limited to high-priority areas within the Municipality of Anchorage and the Fairbanks area. Therefore, undesirable trends in ground-water quality are likely to be unnoticed throughout much of the state.

The ambient-trend network administered by MOA monitors a limited group of parameters associated with degradation from septic systems. Limited chemical analysis may adequately describe important aspects of ground-water quality but is not as useful for multiple purposes as analyses that completely characterize ground-water quality. By contrast, USGS data collected in the Badger Road area of Fairbanks provide a more nearly complete analysis and are more useful for general water-quality purposes.

Both networks consist of shallow observation wells rather than water-supply wells. Shallow wells (less than 25 ft below the water table) provide data that can be used to predict changes in ground-water quality in advance of their arrival in deeper water-supply wells and may allow the opportunity to enact abatement procedures to avoid widespread aquifer contamination (Sqambat and others, 1978). A preferable design, however, would also include water-supply wells, especially in a geologically complex area such as Anchorage, where shallow wells may not be hydraulically connected to deeper wells. The recent discovery of high nitrate levels in the Debora-Schroeder Subdivision at nearby Eagle River, which were not detected by MOA's ambient-trend network, substantiates the view that deeper wells should be included in an ambient-trend monitoring network.

The lack of ambient-trend monitoring throughout the rest of the state is less significant in undeveloped areas, where land-use or pumpage patterns are unlikely to affect ground-water quality. It is a significant lack in agricultural and mining areas, areas of urban development, areas of septic system use, and in coastal communities which use ground-water supplies, because nonpoint source contamination may gradually degrade water quality or the pumpage ratio may alter natural flow patterns and result in seawater intrusion.

Ambient-trend monitoring in Alaska is not adequate to assess ground-water quality trends. To adequately assess trends, monitoring networks should be established in the Matanuska-Susitna Borough, the Kenai Peninsula Borough, the coastal communities of the Juneau Borough and those parts of the Fairbanks North Star Borough and MOA not included in existing networks. In addition, existing ambient-trend networks in geologically complex areas should be redesigned to include water-supply wells.

Site monitoring provides ground-water quality data from permitted facilities and can also be conducted at oil pollution control sites or hazardous substance release sites. The purpose of site monitoring is to detect ground-water contamination and to assess the effectiveness of remediation programs.

Site monitoring in Alaska is very limited with respect to the number of potential sources of contamination (table 12). Many potential sources of contaminants exist in Alaska, including 'petroleum-product storage and transportation facilities, historic oil spills, hazardous-waste disposal areas, wastewater discharge [sites], landfills and dumps, and coastal areas with relatively large rates of ground-water extraction' (Munter and Maynard, 1987b). Most potential sources of contamination do not monitor ground water. For example, Alaska contains an estimated 740 solid waste disposal sites, (ADEC, 1988), yet monitors ground-water quality at only 30. Although Canter and others (1987) state that 'very few sources are designed, operated, or maintained in such a manner as to contaminate ground-water formations," DEC (1988b) estimates of approximately 470 leaking underground storage tanks in Alaska suggest a significant potential for contamination. The need for site monitoring varies according to site-specific conditions, and each site requires individual evaluation.

Site monitoring of ground water is important. However, present site monitoring will not detect contamination from many potential sources that either are not regulated or are not required to monitor ground-water quality. Site monitoring which results in the identification of ground-water contamination (detection monitoring) may result in the development of assessment or

Table 12. Sources of ground-water contamination (USEPA, 1984).

- Category I--Sources designed to discharge substances
- Subsurface percolation (septic tanks and cesspools)
  - Injection wells
    - Hazardous waste
    - Nonhazardous waste (brine disposal and drainage)
    - Nonwaste (enhanced recovery, artificial re-charge, solution mining, and in-situ mining)
- Land application
    - Wastewater (spray irrigation)
    - Wastewater byproducts (sludge)
    - Hazardous waste
    - Nonhazardous waste
- Category II--Sources designed to store, treat, or dispose of substances: discharge through unplanned release
  - Landfills
    - Industrial hazardous waste
    - Industrial nonhazardous waste
    - Municipal sanitary
- Open dumps, including illegal dumping (waste)
- Residential (or local) disposal (waste)
- Surface impoundments
    - Hazardous waste
    - Nonhazardous waste
- Waste tailings
- Waste piles
    - Hazardous waste
    - Nonhazardous waste
- Materials stockpiles (nonwaste)
- Graveyards
- Animal burial
- Above-ground storage tanks
- Category III--Sources designed to retain substances during transport or transmission
- Pipelines
    - Hazardous waste
    - Nonhazardous waste
    - Nonwaste
- Materials transport and transfer operations
    - Hazardous waste
    - Nonhazardous waste
    - Nonwaste
- Category IV--Sources discharging substances as consequence of other planned activities
    - Irrigation practices (return flow)
    - Pesticide applications
    - Fertilizer applications
    - Animal feeding operations
    - De-icing (salts) applications
    - Urban runoff
    - Percolation of atmospheric pollutants
    - Mining and mine drainage
    - Surface-mine related
    - Underground-mine related
- Category V--Sources provided conduit or inducing discharge through altered flow patterns
- Production wells
    - Oil (and gas) wells
    - Geothermal and heat recovery wells
    - Water-supply wells
- Other wells (nonwaste)
    - Monitoring wells
    - Exploration wells
- Construction excavation
- Category VI--Naturally occurring sources whose discharge is created or exacerbated by human activity

Table 12.--Continued

- Hazardous waste
- Nonhazardous waste
- Nonwaste

Underground storage tanks
- Hazardous waste
- Nonhazardous waste
- Nonwaste

Containers
- Hazardous waste
- Nonhazardous waste
- Nonwaste

Open burning and detonation sites
- Radioactive disposal sites

Ground-water/surface-water interactions
- Natural leaching
- Saltwater intrusion-brackish water upconing

remediation monitoring programs. However, DEC, the agency most commonly involved in assessment or remediation programs, limits their involvement to sites of highest priority (C. Reller, DEC, oral commun., 1987), based on the degree of risk to public health or the environment. Therefore, site monitoring may confirm the presence of contamination but supply no information about areal extent and movement of the contaminated plume. Site monitoring in Alaska is valuable, but is not enough by itself to adequately fulfill the objective of detecting ground-water contamination.

PWS monitoring in Alaska differs significantly from ambient-trend or site monitoring networks because its objective of ensuring potable public water supplies may involve in-situ ground-water quality only peripherally. Data from individual PWS wells that do reflect ground-water quality are intended to describe a specific water distribution system rather than characterize an area. Nevertheless, a collection of PWS wells can function as a network with the objective of detecting contamination. PWS monitoring is more widespread than ambient-trend or site monitoring and is valuable in detecting certain types of contamination. PWS data appropriate for ambient-trend monitoring serve a dual purpose and provide particularly important information.

Data Quality

The quality of monitoring data collected in Alaska is varied because of differing levels of quality assurance between agencies. Source monitoring and PWS monitoring are the responsibility of the owner or operator, and the extent and quality of training afforded sample collectors are not documented. In instances where careful documentation of procedures is lacking, monitoring data provided by owners or operators may be considered inadequate for use by other agencies. USEPA (1986b) recommends that owners or operators involved in monitoring programs prepare written sampling and analysis plans including, at a minimum, information on sample collection, preservation, and handling; chain-of-custody control; analytical procedures; and quality-assurance and quality-control procedures for both field and laboratory. Because these sampling and analysis plans are usually lacking in Alaska's source monitoring and PWS monitoring programs, the quality of data obtained is uncertain and may be considered inadequate for multiple use.

State and local personnel who collect data are encouraged to adhere to USEPA or industry standards; however, the degree of consistency in technique may vary among agencies, or even among regional offices in the same agency. DEC is presently developing agencywide guidelines to address quality assurance. Sampling procedures are not currently included in these guidelines (W. Ashton, DEC, oral commun., 1988). These guidelines will help standardize data quality for various monitoring programs administered by DEC, but would be more useful if the sampling procedures were added.

Federal workers, including USGS and USEPA employees, follow carefully specified techniques designed to improve reliability of data collected by agency personnel. Because of these procedures, data collected by federal personnel are more standardized than data collected by state employees or private individuals. Adherence to standard, written procedures for sample collection, handling, and quality control results in reliable data that can be used for multiple-agency purposes.

Much of the data collected through ground-water quality monitoring programs in Alaska may eventually be discarded because of its uncertain quality. Montgomery Engineers (1987), in examining 500 analyses from the MOA landfill monitoring networks, considered only one analysis to be 'credible,' on the basis of internal consistency checks and available documentation. The quality of Alaskan ground-water quality monitoring data is not so poor as to render invalid the objectives of detecting contamination, assessing trends, assessing remediation programs, and assuring PWS potability. However, the lack of documented quality control creates reluctance among agencies to share data, which limits the long-term usefulness of such data.

Data Management

The emphasis in ground-water quality data management in Alaska has historically been placed on data collection rather than on data storage and retrieval, ease of transfer, analysis, or publication.

Most ground-water quality monitoring data in Alaska are generated by various programs administered by DEC. The data generally are filed manually along with other facility information at DEC region or district offices. An exception is PWS data collected through statewide drinking-water programs, which are mostly computerized and readily retrievable (Richard Farnell, DEC, oral commun., 1987). USGS maintains automated data files for ground-water quality sampling sites, including monitoring stations. These data include sampling done for other agencies through cooperative agreements and are published regularly. Retrieval capabilities for USGS ground-water quality data are limited, however (Pat Still, USGS, oral commun., 1987).

Discussions with ground-water quality data users in Alaska (private industry, University of Alaska, DNR, and DEC) reveal a need for improved accessibility of data. Accessibility is hindered by lack of information about available data sources and absence of automated data. Additionally, users are hampered by incomplete records and uncertain data quality. This situation is not unique to Alaska. USEPA (1986a) interviewed federal agencies, USEPA offices, and various state and local governments to define their ground-water data requirements, and that study identified a national need for improved capabilities in data access, retrieval, and analysis.

These results are consistent with the concept that land-use practices, facility operations, and ground-water use patterns are all long-term phenomena and require sound long-term information management to ensure appropriate decisionmaking in the future.

Statewide existing data often have not been compiled, analyzed, and interpreted. In the absence of these functions, even high-quality, verified data are of value only in the most limited sense, for comparison against published standards. Statistical analysis is important for establishing trends or for determining significance of apparent changes, and analysis of data in combination with analysis of the hydrogeology of an area is necessary to assess natural variability of ground-water quality and movement of contaminants.

SUGGESTIONS FOR IMPROVING STATEWIDE MONITORING

The following suggestions are offered as a means of improving statewide ground-water quality monitoring. For convenience, suggestions are grouped by subject. Within each subject, suggestions are ranked, with top priority given to tasks that can be easily implemented or that are important enough to merit immediate attention.

System Design

The statewide monitoring system should consist of a collection of regional or basinwide monitoring networks. These networks would document ground-water quality in different regions of the state, define trends, and detect contamination. The data will assist planning, permitting, and enforcement programs. Ground-water quality in sensitive areas or near significant potential sources of contamination should be monitored. Steps required to establish monitoring networks to fulfill these goals are outlined below.

<u>Tasks that should be immediately addressed:</u>

a. DEC, acting cooperatively with DNR, should identify areas where ground-water quality monitoring is of highest importance. This should be done either by dividing the state into a number of ground-water basins or by using USGS hydrologic-unit divisions to approximate ground-water basins and then ranking them in order. Priority should be determined by degree of public risk, dependence on ground-water supplies, and threat of contamination; a process for periodic revision should be incorporated into the identification process.

b. Clearly identify the objectives of ground-water quality monitoring in each high-priority basin. Each objective should be specific and should address major issues identified by the public, industry, and public agencies. The basinwide networks, to fulfill stated objectives, should consist of ambient-trend networks, site-monitoring networks, and a PWS network. Sites of documented contamination located within high-priority basins should be carefully considered for inclusion in the basinwide monitoring network.

c. Evaluate contaminated aquifers throughout the state which are not currently being monitored and do not occur within designated high-priority ground-water basins for special site monitoring on the basis of degree of risk to the public health or the environment.

Tasks that should be addressed as funding allows:

a. Map potential sources of contamination within high-priority basins. The resultant maps will serve as aids in designing and revising basinwide monitoring networks.

b. Map geologically sensitive areas in high-priority basins characterized by thin soils, highly permeable soils, high water tables, or shallow water-supply aquifers. Compare these maps to the potential-contamination source maps. Areas common to both maps should be considered a priority for additional monitoring.

c. Establish ambient-trend monitoring sites in areas of high-priority basins where risk of contamination resulting from land-use or pumpage patterns exists. Such areas should include (but not necessarily be limited to) areas with a high density of on-site wastewater disposal systems, areas subject to saltwater intrusion, mining areas, and agricultural areas typified by use of fertilizers or large amounts of animal waste. Ambient trends should be monitored by using existing wells where possible. Existing wells in high-priority basins should be subject to a screening process to determine if the well is a suitable site in the monitoring network. Where historical data for included wells are considered adequate, they should be added to other basinwide monitoring network ground-water quality data.

d. Candidates for additional monitoring should include sites in high-priority basins of deliberate or accidental artificial recharge such as surface impoundments, wastewater drainfields, urban runoff dry wells, or injection wells.

e. Continue current monitoring programs in lower-priority basins, with any revisions necessary to ensure adequate detection of contamination at monitored sites. Site monitoring that does not include at least one clearly identified upgradient well and two downgradient wells in each monitored aquifer is unlikely to provide adequate information about ground-water contamination and should be revised.

f. Review and modify the priority assigned to individual ground-water basins as necessary. Initiate priority review on recommendation by DEC or DNR personnel based on changes in degree of public risk, dependence on ground-water supplies, and threat of contamination. Establish networks resulting from reprioritization by the same method as the original basin networks: namely, establishing multiple goals, determining areas of risk, and screening preexisting wells for historical data.

Data Quality

If ground-water quality data are to be of value, temporal or spatial variability must reflect changes in water chemistry rather than differences in sampling or analysis techniques. The following suggestions are offered to minimize variations in technique that might mask or distort variations resulting from contamination.

Tasks that should be addressed immediately:

a. Institute standard procedures to ensure the quality of data analysis. Establish and enforce standard procedures for monitoring well construction and abandonment, sample collection and preservation, and field and lab analysis. Require a written sampling and analysis plan for monitoring, including standardized forms for use in the sampling and analysis plan that would reflect any deviation from established methods.

b. Require trained ground-water professionals to sample ambient-trend and site-monitoring networks rather than untrained or semitrained owners or operators. Persons involved in monitoring should be carefully instructed in proper sampling technique, sample preservation, and record keeping. For site monitoring, USEPA-approved methods should be used where no state methods exist.

c. Develop training materials that may include courses, seminars, handbooks, or certification programs. Training materials should adhere to federal guidelines and should be easily accessed throughout the state.

d. Amend PWS monitoring procedures to include testing for benzene, toluene, and xylene (BTX) by one of several USEPA methods. This increases the suitability of PWS wells for detecting organic contamination.

Tasks that should be addressed as funding allows:

a. Identify PWS wells in high-priority basins considered capable of yielding samples representative of ground-water quality. Analyze samples from these wells for parameters associated with ambient-trend monitoring (table 1) to provide data for ambient-trend analysis. PWS wells not capable of supplying useful ground-water quality data should continue to be monitored as currently required.

Data Management

Following the suggestion of Everett (1980), ground-water quality data should be retrievable by latitude-longitude and political jurisdiction; upgradient wells should be identified, ambient data should be distinguished from contamination data; and the database should have the capacity to provide graphic displays. USEPA (1987) distinguished four main groups of ground-water quality data that should be permanently stored and easily accessible to intraagency and interagency ground-water data users: well descriptors; hydrogeologic descriptors; water quality-sample descriptors; and related descriptors such as site identifiers. Data should be available in an easily distributed format such as computer printouts or routinely published reports.

Data-automation procedures should include verification steps, and data must be linked to accessible and permanent manual files.

<u>These tasks should be addressed immediately:</u>

a. Identify the uses for which collected sets of data are appropriate by the following method. Evaluate data for internal consistency by using common quality-control checks, as shown in the example in table 13. Combine this evaluation with an examination of the quality-control measures used in sample collection, transport, and analysis, to rate the quality of data provided by various ongoing monitoring efforts.

b. Implement standardized data coding and reporting conventions to facilitate eventual integration of data from different sources.

c. Compile and publish information about statewide monitoring in an annual index; distribute to federal, state, and local agencies and libraries. Include well location, sampling frequency, monitoring parameters, static water-level measurements, and the physical location of the water-quality data. (DGGS should assume responsibility for index compilation.) Require programs collecting ground-water data to provide annual information to DGGS, which will serve as the primary source of ground-water quality information.

d. Include well-log data for monitoring and water-supply wells in the DGGS statewide Well Log Tracking System (WELTS) and the USGS Ground Water Site Inventory (GWSI) system, to ensure documentation of well locations and construction details, and also to enhance hydrogeological data for each ground-water basin. Promote use of standard DGGS well-log forms to provide consistent data reporting.

e. Initiate a cooperative project with USGS to improve retrieval capabilities for USGS water-quality data.

<u>These tasks should be addressed as funding allows:</u>

a. Include more ambient water-quality data in Alaska's statewide ground-water quality monitoring system. This would enable the detection of changes over time and space and provide a standard for future comparison. Historical PWS data may provide data for ambient-trend analysis, and PWS data that accurately represent ground-water quality data should be included in the statewide database.

b. Collate historical water-quality data obtained from PWS wells. Discard or flag data from PWS wells which represent blended or treated water, ground water from more than one aquifer, or data of uncertain quality.

Table 13. Example of quality-control checks to evaluate water-quality data (from Montgomery, 1987).

1. For samples with pH greater than 6, bicarbonate (HCO_3) should be about 1.2 times alkalinity.

2. For samples with pH greater than 7, no acidity should be reported.

3. Chemical oxygen demand (COD) should be greater than biological oxygen demand (BOD).

4. Total chromium should be greater than hexavalent chromium.

5. Total Kjeldahl nitrogen should be greater than ammonia.

6. Nitrogen species should be clearly labeled.

7. Milliequivalents for major cations and anions should be within 5 percent.

8. Potassium should be lower than calcium, magnesium, and sodium.

9. Total dissolved solids (TDS) should be between 55 and 70 percent of conductivity. (If total volatile solids, TVS, is high, up to 90 percent is acceptable.)

10. Detections limits should be specified. Data reported as 'ND' are considered meaningless.

11. Data labeled 'provisional' or 'draft' are questionable.

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c. Institute data-management techniques to provide ease of access and versatile retrieval capabilities (for example, retrieval by location, latitude-longitude, or type of sampling). Include capabilities for statistical analyses of data, including graphic displays where appropriate.

d. Require monitoring-well records to include well location, latitude-longitude, well logs, construction details, water-use information, water-level information, site use, and water-quality information. Some sites monitored for compliance, such as certain PWS wells, may lack necessary information and should not be included in the basin monitoring networks.

e. Document sites where contamination is discovered and enter on a permanent record. PWS wells abandoned because of contamination, sites of CERCLA investigations where contamination is discovered, and sites of case-preparation or emergency-response monitoring are examples of sites which should be included in a permanent, updated database such as the DGGS Alaska Inventory of Contaminated Aquifers, described by Munter and Maynard (1987b).

f. Prepare a Network Management Report, when designing a new network or revising an existing one, that describes the following items: information expected, network design, operating procedures (including sampling and analysis plans and quality-control plans), and information reporting procedures.

Several options exist for management of ground-water quality data in Alaska:

A. Standardize format, including well descriptors, hydrogeology descriptors, water quality-sample descriptors, and site descriptors. Store data at various locations in automated databases. DGGS assumes responsibility for publishing an annual index describing data available and location of the various repositories. (Actual data would not be included in the index.)

B. Standardize data according to USEPA format and store permanently in the national STORET database. Agencies would store data on microcomputer by using programs supplied by USEPA. The data would be periodically shared with USEPA and would be publicly available from USEPA unless designated otherwise by the contributing agency. USEPA Region X would supply necessary handbooks and training under its budget for states participating in the STORET database.

C. Standardize data according to formats developed for Alaska. Data would be forwarded to a central repository and entered into a single statewide database. Necessary hardware would need to be purchased and programs would have to be written. This option could require considerable expenditure of effort and funds. Individual agencies may still maintain separate databases, resulting in the potential for duplication of effort.

D. No change. Data remain stored in various locations with no standardization of format and automation of files. This represents the minimum amount of manpower and funding, and minimizes data usefulness.

Options A, B, and C represent improvements in data management. Option A may be pursued as a precursor to options B or C, and would be the first phase in developing an integrated database.

SUMMARY AND CONCLUSIONS

Ground water in Alaska is an important natural resource and is used by nearly three-quarters of the population. Once contaminated, ground-water resources are difficult and expensive to restore. Numerous sources of potential ground-water contamination exist and are likely to remain. It is therefore important to protect ground-water resources through well-informed environmental decisionmaking. Ground-water quality monitoring is a vital source of data for ground-water resource managers, planners, and regulators. Because such data are expensive to obtain, efforts must be made to ensure that the data fulfill monitoring objectives, are of sufficient quality for multiple uses, and are permanently stored in an accessible manner.

As currently implemented, ground-water quality monitoring is not adequate for assessing trends in ground-water quality or in detecting contamination throughout much of Alaska. The lack of ambient-trend data throughout much of the state represents a significant weakness in present data collection. Some PWS wells can provide ambient-trend data; however, data from PWS wells must be examined to identify which data are appropriate for inclusion.

Site monitoring occurs primarily as source monitoring of landfills and wastewater disposal sites in southcentral Alaska. Nineteen of every 20 solid-waste sites in Alaska are not required to monitor ground water. Additionally, many unregulated potential sources of contamination exist. There are some sites for which no ground-water quality monitoring is conducted, even though known or suspected contamination is present. In short, site monitoring occurs at only a small number of locations where ground-water contamination may be significant.

Data quality varies according to individual programs. Data may lack documentation. Thus, stored data may be discarded in favor of collecting new data. Improved documentation of data quality is necessary to ensure the long-term usefulness of data. Development of personnel training and quality-control materials will improve sampling, handling, and analytical techniques.

Ground-water quality data are not effectively managed. USGS and PWS data are automated, but others are not. Emphasis has been on data collection rather than on data management and analysis. The result is that most data are not easily accessed for use in evaluating and assessing ground-water quality.

Improvements in system design, data quality, and data management would immeasurably increase the value of ground-water quality monitoring in Alaska. Initial improvements should include identification of regions considered high-priority monitoring areas, identification of known contamination sites which should be monitored, development and use of documented quality control measures, training of personnel, and establishment of a permanent, easily accessible statewide database.

The goals the statewide monitoring system will address are subject to change through time, as are federal regulations, public response, and monitoring techniques. It will be necessary to periodically reevaluate statewide monitoring priorities to maintain a database that meets the data requirements of environmental managers and decisionmakers who are responsible for management of ground-water resources in Alaska.

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