Ground-Water Quality in the Cook Inlet Basin, Alaska, 1999

By Roy L. Glass

U.S. GEOLOGICAL SURVEY

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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resources management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as study units. Collectively, these study units account for more than 60 percent of the overall water use and population served by public water supply, and they represent the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multiscale approach helps to determine if certain types of water-quality issues are isolated or pervasive and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the study-unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resources issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, nongovernment organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch

Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS and VERTICAL DATUM

Multiply	by	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon per minute (gal/min)	0.06309	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second
tritium unit (TU)	0.118	Becquerel per liter
picocurie per liter (pCi/L)	0.037	Becquerel per liter

In this report, temperature is reported in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the equation

$$°F = 1.8\ °C + 32$$

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called “Sea-Level Datum of 1929”), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

WATER-QUALITY ABBREVIATIONS

Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L), micrograms per liter (µg/L), or picograms per kilogram of water (pg/kg). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One milligram per liter is approximately equivalent to one part per million, one microgram per liter is approximately equivalent to one part per billion, and one picogram per kilogram is approximately equivalent to one part per quadrillion. Specific conductance is reported in microsiemens per centimeter at 25 degrees Celsius (µs/cm). Radioactivity is expressed in picocuries per liter (pCi/L) or tritium units (TU).

Stable isotope ratios are expressed as a departure of the ratio of two isotopes of an element in a given sample from the same ratio in an established standard; values are given in per mil (parts per thousand). Symbols and standards used to describe isotopes or their ratios are:

δD	deuterium/hydrogen ratio, referenced to Vienna Standard Mean Ocean Water
$\delta^{18}O$	oxygen-18/oxygen-16 ratio, referenced to Vienna Standard Mean Ocean Water

Unit abbreviations and related terms used in this report:

as N	quantified as measured nitrogen
as P	quantified as measured phosphorus
Mgal/d	million gallons per day
mg/L	milligram per liter
pCi/L	picocurie per liter
g/kg	gram per kilogram
pg/kg	picogram per kilogram
µg/g	microgram per gram, dry weight
µg/L	microgram per liter
µm	micrometer
µS/cm	microsiemen per centimeter at 25°C

Acronyms used in this report:

CFC	chlorofluorocarbon
DOC	dissolved organic carbon
MCL	maximum contaminant level, a health-based water-quality standard set by U.S. Environmental Protection Agency
NAWQA	National Water-Quality Assessment
NWQL	National Water Quality Laboratory
PMCL	proposed maximum contaminant level
SMCL	secondary maximum contaminant level, an unenforceable guideline regarding taste, odor, color, and certain other nonaesthetic effects of drinking water set by U.S. Environmental Protection Agency
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	volatile organic compound
VSMOW	Vienna Standard Mean Ocean Water

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By Roy L. Glass

Abstract

As part of the U.S. Geological Survey's National Water-Quality Assessment Program, ground-water samples were collected from 34 existing wells in the Cook Inlet Basin in south-central Alaska during 1999. All ground-water samples were from aquifers composed of glacial or alluvial sediments. The water samples were used to determine the occurrence and distribution of selected major ions, nutrients, trace elements, volatile organic compounds, pesticides, radioisotopes, and environmental isotopes. Of 34 samples, 29 were from wells chosen by using a grid-based random-selection process. Water samples from five major public-supply wells also were collected.

Radon-222 and arsenic concentrations exceeded drinking-water standards proposed by the U.S. Environmental Protection Agency in 39 and 18 percent of sampled wells, respectively. The highest radon concentration measured during this study was 610 picocuries per liter; 12 of 31 samples exceeded the proposed maximum contaminant level of 300 picocuries per liter. The highest arsenic concentration was 29 micrograms per liter; 6 of 34 samples exceeded the proposed maximum contaminant level of 10 micrograms per liter. Human activities may be increasing the concentration of nitrate in ground water, but nitrate concentrations in all samples were less than the maximum contaminant level of 10 milligrams per liter as nitrogen. Concentrations of nitrate were highest in Anchorage and were as great as 4.8 milligrams per liter as nitrogen. Dissolved-solids concentrations ranged from 77 to 986 milligrams per liter; only 2 of 34 wells yielded water having greater than 500 milligrams per liter. Iron and manganese concentrations exceeded secondary maximum contaminant levels in 18 and 42 percent of samples, respectively.

Concentrations of all pesticides and volatile organic compounds detected in ground-water samples were very low, less than 1 microgram per liter. No pesticide or volatile organic compounds were detected at concentrations exceeding drinking-water standards or guidelines. Water samples from one-half of the wells sampled had no detectable concentrations of pesticides or volatile organic carbons, at the parts-per-billion level.

Concentrations of stable isotopes of hydrogen and oxygen in ground-water samples were similar to concentrations expected for modern precipitation and for water that has been affected by evaporation. Tritium activities and concentrations of chlorofluorocarbons indicated that the water samples collected from most wells were recharged less than 50 years ago.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began a full-scale implementation of the National Water-Quality Assessment (NAWQA) Program to provide a consistent description of the Nation's ground- and surface-water resources. The long-term goals of the program are to (1) determine the general ground- and surface-water quality of the Nation's water resources; (2) define long-term trends (or lack of trends) in water quality; and (3) identify, describe, and explain, to the extent possible, the major natural and human factors that affect measured water-quality conditions and trends (Gilliom and others, 1995). In meeting these goals, the program provides nationally consistent information useful to policy makers, managers, and scientists concerned with the Nation's water resources.

NAWQA study-unit investigations of parts of most major river basins and aquifer systems throughout the Nation are the building blocks of the national assessment. More than 50 hydrologic systems have been studied; 20 investigations were started in 1991, 16 more in 1994, and 15 more in 1997. The Cook Inlet Basin (COOK) study-unit investigation in south-central Alaska (fig. 1) began in 1997.

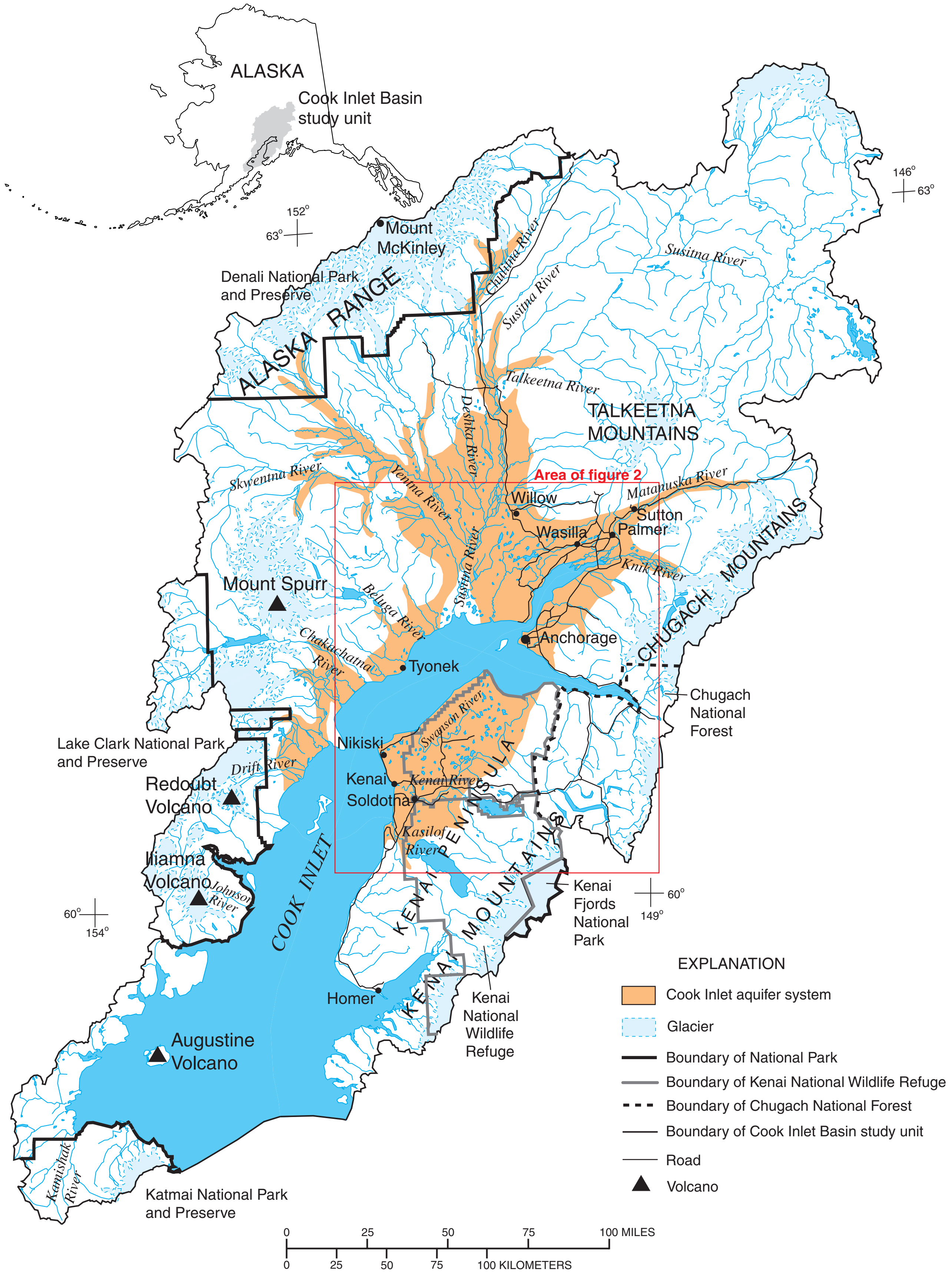
Purpose and Scope

One component of NAWQA ground-water studies focuses on water-quality conditions in major aquifers, primarily by aquifer-wide surveys (termed "subunit surveys"). The COOK "subunit" consisted of unconsolidated-deposits aquifers comprising mostly glacial and alluvial materials. These aquifers are the most important sources of present or future domestic, municipal, commercial, and industrial ground-water supplies in the Cook Inlet Basin. The geographic extent of the ground-water study was limited to developed areas within the Municipality of Anchorage and the Kenai Peninsula and Matanuska–Susitna Boroughs (fig. 2). The subunit survey consisted of sampling 29 randomly selected wells within the study area that obtained water from unconsolidated-deposits aquifers. Water samples also were collected from five of the most productive public-supply wells within the study area. Water samples from each of these 34 wells were collected once during 1999. Samples were analyzed to determine the occurrence and spatial distribution of selected physical properties, major ions, nutrients, dissolved organic carbon (DOC), trace elements, pesticides, volatile organic compounds (VOCs), and radioisotopes. Isotopes of oxygen and hydrogen, and concentrations of chlorofluorocarbons (CFCs) also were analyzed to help characterize the water and to help estimate the time that had elapsed since the water was recharged. This report includes discussions of the major water-quality issues in the COOK study unit; descriptions of the environmental setting and hydrologic conditions affecting ground-water quality and of the methods of investigation; and statistical and graphic presentations of the data. Ground-water quality in the COOK study unit is compared to drinking-water regulations and guidelines established by the U.S. Environmental Protection Agency (USEPA) and to ground water in other NAWQA study units.

Previous Investigations

Frenzel (1997) described the surface-water, ground-water, and biological studies being conducted within the COOK study unit under the NAWQA Program. Brabets and others (1999) described the environmental setting, including the physical, hydrologic, and aquatic biological characteristics of the aquifers and the major streams and rivers that flow into Cook Inlet and how these characteristics affect surface- and ground-water quality. Glass (1999) did a preliminary assessment of the quality of surface and ground water in the study unit through 1997, including statistical and graphical summaries of selected chemical constituents from about 550 wells and 31 sites on streams.

Figure 1. Location and major geographic features of Cook Inlet Basin, Alaska. Boundary of Cook Inlet aquifer system from Miller and others (1999).


ALASKA
Cook Inlet Basin study unit
152°
63°
146°
63°
Mount McKinley
Denali National Park and Preserve
ALASKA RANGE
Chulitna River
Susitna River
Susitna River
Talkeetna River
Deshka River
TALKEETNA MOUNTAINS
Skwentna River
Yentna River
Area of figure 2
Matanuska River
Willow
Sutton
Palmer
Wasilla
Knik River
Susitna River
Mount Spurr
Beluga River
CHUGACH MOUNTAINS
Anchorage
Chakachatna River
Tyonek
Chugach National Forest
Swanson River
Nikiski
Lake Clark National Park and Preserve
Drift River
Kenai
Kenai River
Soldotna
Redoubt Volcano
KENAI PENINSULA
Kasilof River
Iliamna Volcano
Johnson River
COOK INLET
KENAI MOUNTAINS
Kenai Fjords National Park
60°
149°
60°
154°
Homer
Kenai National Wildlife Refuge
Augustine Volcano
Kamishak River
Katmai National Park and Preserve
EXPLANATION
Cook Inlet aquifer system
Glacier
Boundary of National Park
Boundary of Kenai National Wildlife Refuge
Boundary of Chugach National Forest
Boundary of Cook Inlet Basin study unit
Road
Volcano
0 25 50 75 100 MILES
0 25 50 75 100 KILOMETERS

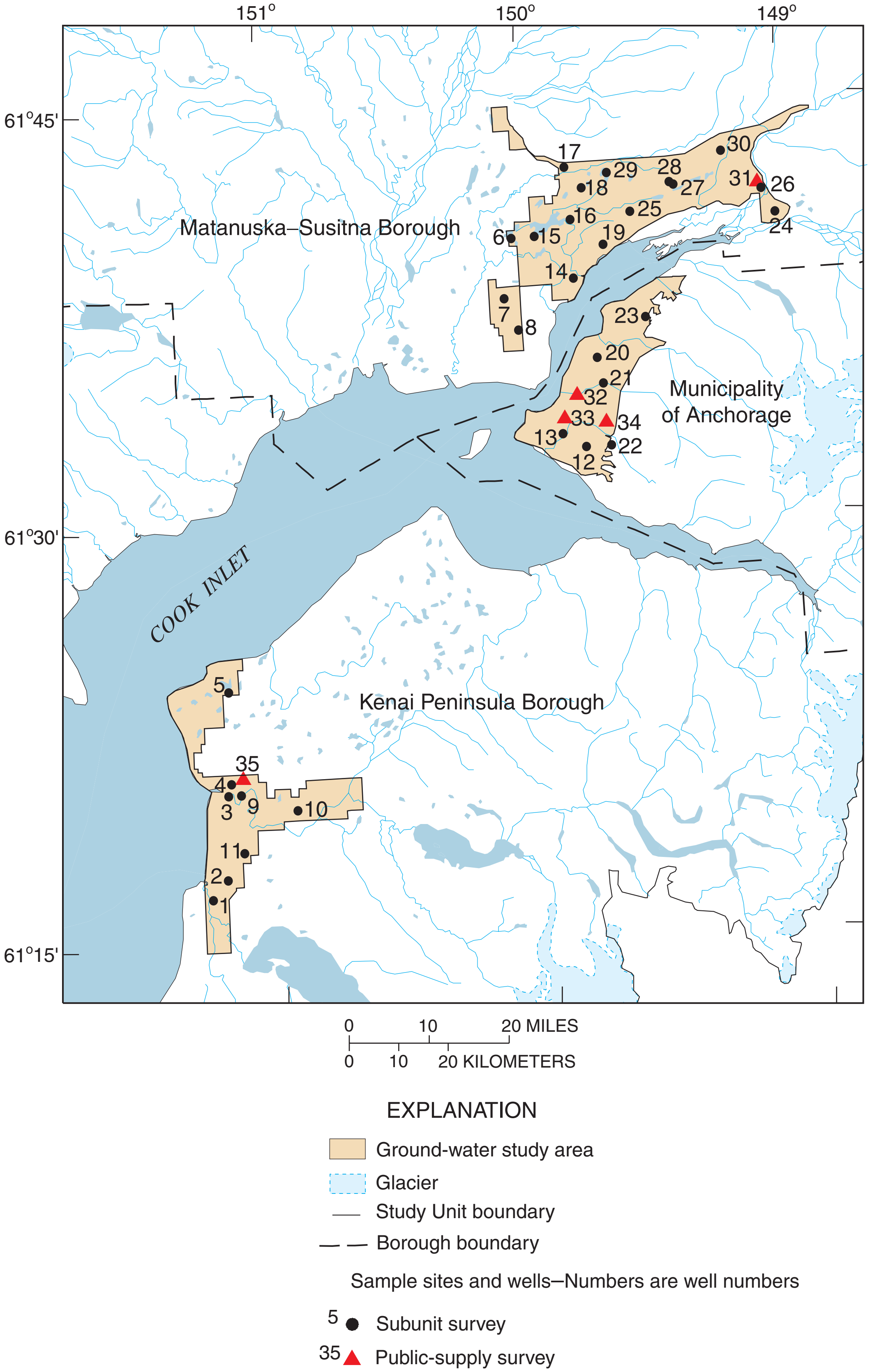


Figure 2. Locations of ground-water sampling sites, Cook Inlet Basin, 1999.

Most waters in streams and wells have small concentrations of major inorganic constituents, nutrients, trace elements, and organic compounds. However, suspended-sediment concentrations in glacier-fed streams are naturally high, and several streams and lakes in urban areas have high concentrations of fecal-coliform-bacteria. Ground water in some wells have high nitrate, iron, and arsenic concentrations. Frenzel (2000) described the occurrence of organochlorines, semivolatile organic compounds, and trace elements in streambed sediments and fish tissues at 15 sites in the basin during 1998. At most sites, semivolatile organic compounds and organochlorine compounds were either not detected or were detected at very low concentrations; however, arsenic, chromium, copper, and nickel appear to be at naturally high concentrations in the Cook Inlet Basin. Most of the analytical results for the ground-water study described in this report are tabulated in the USGS water-resources data report for water year 1999 (Bertrand and others, 2000) and are available also at URL <http://water.usgs.gov/ak/nwis/nwis>.

Water-quality data for the first 20 NAWQA study units for the period 1992–95 were summarized by Gilliom and others (1998), U.S. Geological Survey (1999b), Barbash and others (1999), Squillace and others (1999), and Nolan and Stoner (2000) and also are available at URL <http://water.usgs.gov/nawqa/data>. More than 90 ground-water studies were conducted in these 20 study units.

Acknowledgments

The author expresses his sincere thanks to the many landowners who graciously allowed access to their property and sampling of water from their wells. Numerous landowners also allowed the plumbing in their homes to be modified so that a water sample could be obtained before treatment and before a pressure tank. This study could not have been completed without their cooperation. The cities of Kenai and Palmer, the Municipality of Anchorage, and the U.S. Army provided data about their wells and allowed us to sample water from their wells.

MAJOR WATER-QUALITY ISSUES

Ground water is an important source of water for residents and businesses in the COOK study unit. About one-quarter of the public-water supply for Anchorage is from wells, and almost all water used for commercial, industrial, and domestic uses outside Anchorage is from ground water. Ground water also provides year-round discharge to surface water and potentially transports contaminants that can result in water-quality problems in streams and lakes. An understanding of the natural water quality and of the magnitude of changes in water quality caused by human activities is needed to evaluate the potential effects of contamination and to develop strategies to protect the quality of the resource.

Natural ground-water quality is determined by the mineralogy and chemical conditions of the soils and aquifer materials through which the water moves and by the length of time the water has been in contact with the soils and aquifer materials. Elevated concentrations of many naturally occurring minerals and of trace elements such as arsenic, iron, manganese, and radon may cause health or aesthetic problems and can render individual and community water supplies unusable or require that the water to be treated before use.

Human activities can influence the types and concentrations of many ground-water contaminants, such as nutrients (compounds of nitrogen and phosphorus) and organic compounds. Residential and agricultural land uses can contribute nutrients and organic compounds to ground water through leaching of fertilizers, pesticides, and petroleum products. Roadways and railroads can be the source of chloride (from applications of salt for deicing), of herbicides (applied to rights-of-way), and of VOCs (emitted to the air or spilled on the ground). Chemicals used by homeowners, such as household cleaners, paints, solvents, fuel oil, and gasoline, also can be a source of VOCs in ground water. Commercial and industrial establishments may also discharge VOCs and other substances to the atmosphere or to the ground. The Alaska Department of Environmental Conservation (1996, p. 12) stated that petroleum products constitute the primary contaminant of water in Alaska. Petroleum products commonly enter the ground through leaking of tanks and distribution lines or spilling of product on the surface.

ENVIRONMENTAL SETTING AND HYDROLOGIC CONDITIONS

Water quality is affected by natural factors such as physiography, climate, geology, and soils and by human factors such as population and land use. The lands that drain into Cook Inlet Basin extend 39,325 mi^2 and include areas of rugged mountains, glaciers, forests, and wetlands as well as the city of Anchorage and multiple surrounding suburban communities. About 366,000 people—more than half of Alaska's population—reside in the Cook Inlet Basin. Population density ranges from unpopulated remote regions to the densely populated Anchorage metropolitan area. Major roads traverse the eastern part of the basin, whereas the western part is sparsely populated and is accessed only by aircraft or boat. The 790-mi^2 ground-water study area (fig. 2) includes the populated parts of lowland areas and contains most of the residents of the Municipality of Anchorage and the Kenai Peninsula and Matanuska–Susitna Boroughs. This study area consists of about 230 mi^2 in the northwestern part of the Kenai Peninsula, about 190 mi^2 of Anchorage, and 370 mi^2 of the Matanuska–Susitna Valley. At the present time, the areas near Wasilla and Palmer in the Matanuska–Susitna Valley and Kenai and Soldotna on the Kenai Peninsula are having the greatest population growth in the basin.

Most of the ground-water study area is in a transitional zone between wet maritime and continental climates (Brabets and others, 1999). This transitional zone has cold winters and warm summers. Anchorage has an average annual temperature of 6°C and an average annual precipitation of 15 in. (Arctic Environmental Information and Climate Center, 1989). However, the amount of precipitation falling in the Talkeetna, Chugach, and Kenai Mountains that bound the study area is much greater.

These mountains consist of structurally complex and variably metamorphosed consolidated sedimentary and igneous rocks. Some formations of sedimentary rocks, which are exposed in mountains outside the ground-water study area and are present beneath the study area, contain economically significant amounts of oil, natural gas, and coal.

Glacial, glacioestuarine, and alluvial deposits underlie the lowlands of Cook Inlet Basin and make up the most productive water-supply aquifers. These unconsolidated deposits were described by Freethey and Scully (1980), Schmoll and others (1999), Miller and others (1999), and Brabets and others (1999). These deposits range in thickness from less than 50 ft along the mountain fronts to greater than 1,000 ft beneath Cook Inlet and are made up of clay, silt, sand, gravel, and boulders. Large ground-water supplies generally can be developed where aquifer materials are saturated and predominantly coarse grained.

Beneath much of the lowland area of Anchorage is an extensive layer of silt and clay that was deposited in a large body of water in Cook Inlet Basin during glacial times. Its top surface is generally less than 100 ft below land surface. This layer of fine-grained materials, as great as 200 ft thick, helps protect deeper aquifers from contamination and may create confined ground-water conditions.

Ground-water recharge occurs directly from precipitation that falls on the land surface above the aquifer and from streams, lakes, and wetlands. Ground-water flow in the aquifers is affected by topography and by the hydraulic characteristics of the aquifer system. Ground water generally flows toward Cook Inlet, but large amounts discharge to streams or are withdrawn by pumping. Brabets and others (1999, p. 44) estimated that in Anchorage, ground-water discharge from lowland aquifers into streams probably exceeds 10 Mgal/d. The highest rates of pumping occur in Anchorage, Nikiski, Kenai, and Soldotna. The average pumpage from public-supply wells in Anchorage was about 7 Mgal/d in 1998. Industrial pumpage in Nikiski is about 3.5 Mgal/d, and pumpage of public-supply wells is about 1 Mgal/d in Kenai and about 1 Mgal/d in Soldotna.

Land uses were defined by the Municipality of Anchorage (2000) for the southern two-thirds of the Anchorage ground-water study area. During 1998, about 42 percent of this part of the Anchorage study area was owned and used by the military (Elmendorf Air Force Base and the U.S. Army Fort Richardson) or by Alaska Native corporations; 20 percent was classified as residential; 12 percent was classified as park; 11 percent, as commercial, industrial, or institutional; 11 percent, as intertidal or water bodies; and 4 percent, as transportation related (such as roadways, railways, and airports). The Matanuska–Susitna and Kenai parts of the study area do not contain major military installations but have significant areas of agriculture. The main crops are hay and oats, but potatoes and carrots are also cultivated in the Matanuska–Susitna area.

METHODS OF INVESTIGATION

The design and data-collection methods used for this study are similar to other NAWQA subunit surveys to provide consistency and comparability of results. The subunit consisted of unconsolidated glacial and alluvial aquifers beneath developed areas. One set of water samples was collected from 29 randomly selected sites during July to October 1999 and was analyzed to determine the occurrence and distribution of many natural and manmade substances within the subunit. Water samples also were collected from an additional five major public-supply wells. These two groups of sample sites are referred to as the subunit survey and public-supply survey in this report.

Well Selection

To obtain an unbiased and representative sampling across the subunit's major aquifer systems, a geographic information system-based computer program (Scott, 1990) was used to divide the 790-mi^2 ground-water study area into 30 equal areas called cells, and the program randomly selected a point in each cell. Existing water-supply wells that were as near as possible to each selected point were located by using water-well data in the USGS Ground-Water Site Inventory files and by field reconnaissance. Landowners near each selected point were contacted until a suitable well was found. The well needed to have construction information (a driller's log containing depth, perforated interval, casing length, and geologic materials penetrated), be perforated or open in unconsolidated deposits, have a submersible pump, have a sampling point before any water-treatment systems and pressure tanks, and have a way to measure the depth to the water surface in the well (Lapham and others, 1995). Data from a cell in the northwestern part of the study area (well 17) are not included in this report because water-quality results indicate that at least some of the water sampled had been treated by a water softener even though water was collected before the pressure tank and water softener. The 29 remaining wells in the subunit survey range in depth from 24 to 233 ft (table 1) and have a median depth of 88 ft. All wells were drilled and have steel casings; most are 6 in. in diameter and have pitless adapters that allow water pumped from the well to be piped to a house beneath the land surface to prevent freezing.

Five of the subunit's most productive public-supply wells—one in Palmer, three in Anchorage, and one in Kenai—also were sampled. These wells generally are deeper, have longer lengths of screen, and have turbine pumps that yield water at much greater rates than the wells in the subunit survey. Although the results from five samples are too few to statistically characterize water quality and were not randomly selected, the results give a general indication of the water quality in aquifers used for public supply.

The public-supply well sampled in Palmer pumped about 261 million gallons during 2000, about 95 percent of the water distributed by the City of Palmer. The public-supply well sampled in Kenai pumped about 208 million gallons during 2000, about 55 percent of the water distributed by the City of Kenai. During 2000, the three public-supply wells sampled in Anchorage (wells 32, 33 and 34) pumped about 210 million, 503 million, and 284 million gallons, respectively, and together accounted for about 46 percent of the amount pumped by 12 wells in the Anchorage metropolitan area operated by Anchorage Water and Wastewater Utility.

Sample Collection

Water samples were collected and processed according to protocols developed by the NAWQA Program to minimize contamination during sampling and promote the collection of consistent ground-water data among NAWQA study units throughout the Nation (Koterba and others, 1995; U.S. Geological Survey, 1999a). Water samples collected for this study were collected before any water-quality treatment and may not represent the water actually used within a home or distributed for public supply. Many of the homes where water samples were collected had water-treatment equipment, such as iron and sediment filters and water softeners. Water from each of the public-supply wells has chlorine and fluoride added to it and is mixed with water from other sources during distribution.

Table 1. Identification, location, and characteristics of sampled wells in Cook Inlet Basin, 1999

[See figure 2 for geographic setting of wells. Clay or silt above well opening: Yes means open interval of well is overlain by clay, silt, or hardpan. Land use means general land use within 0.25-mile radius of well. Water level: D, value from driller's log; E, estimated on basis of water level measured in nearby well; G, pressure gage; P, well being pumped; R, well recently pumped. NAD83, North American Datum of 1983 geodetic reference system]

Well number	Station identification number	Local number	NAD83 coordinates (latitude, longitude)	Municipality or borough	Use of well water	Clay or silt above well opening	Land uses in vicinity of well	Diameter of well casing (inches)	Depth of well (feet)	Open interval (feet below land surface)	Water level (feet below land surface)	Altitude of land surface (feet above sea level)
Subunit survey												
1	602107151160901	SB00301213ADDD1 001	60°21'04.8" N., 151°16'18.2" W.	Kenai Peninsula Borough	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), general–wetland, urban–residential, urban–other	6	95	90–95	55.45	106
2	602311151123701	SB00301104BBBC1 006	60°23'09.4" N., 151°12'44.0" W.	Kenai Peninsula Borough	Domestic	Yes	Urban–residential, general–forest (coniferous–deciduous, light silviculture), general–wetland, general–water	6	177	172–177	112.45	287
3	603216151114501	SB00501110CBAD2 008	60°32'13.2" N., 151°11'52.0" W.	Kenai Peninsula Borough	Domestic	Yes	General–wetland, urban–residential, general–water, general–forest (coniferous–deciduous, light silviculture)	6	128	128	-7.30	16
4	603332151110401	SB00501103ABAB1 002	60°33'32.5" N., 151°11'04.2" W.	Kenai Peninsula Borough	Irrigation	Yes	Urban–developed land without major structures, general–forest (coniferous–deciduous, light silviculture), urban–residential, general–wetland	6	36	31–36	16.97	84
5	604328151104901	SB00701103DABC1 016	60°43'28.5" N., 151°10'48.9" W.	Kenai Peninsula Borough	Domestic	No	General–forest (coniferous–deciduous, light silviculture), general–water, urban–residential, general–wetland	6	32	32	3.60 (P)	98
6	613053150021801	SB01700432CDDA1 002	61°30'50.1" N., 150°02'25.7" W.	Matanuska–Susitna Borough	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, general–water	6	219	219	81.00	180
7	612421150044601	SB01500512ADDC1 003	61°24'20.2" N., 150°04'44.8" W.	Matanuska–Susitna Borough	Livestock	No	Agricultural (croplands), general–forest (coniferous–deciduous, light silviculture), agricultural (livestock), agricultural (farm residence and related buildings)	6	60	60	40.00	153

8	612055150014801	SB01500432ACCB1 001	61°20'52.0" N., 150°01'56.3" W.	Matanuska–Susitna Borough	Institutional	No	Agricultural (croplands), general–forest (coniferous–deciduous, light silviculture)	6	67.3	56.3–67.3	44.20	152
9	603216151085401	SB00501111DABD1 002	60°32'14.9" N., 151°08'59.3" W.	Kenai Peninsula Borough	Domestic	Yes	General–wetland, general–water, urban–residential	6	90	90	4.48	25
10	603025150564001	SB00501024DACC1 016	60°30'23.2" N., 150°56'46.9" W.	Kenai Peninsula Borough	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, urban–commercial	6	68	68	55.05	271
11	602600151084301	SB00401114CDBB1 004	60°25'59.6" N., 151°08'45.1" W.	Kenai Peninsula Borough	Domestic	Yes	Urban–residential, general–forest (coniferous–deciduous, light silviculture), agricultural (livestock)	6	110	105–110	88.60	250
12	610758149480501	SB01200315BCBC1 078	61°07'56.3" N., 149°48'13.1" W.	Municipality of Anchorage	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, urban–developed land without major structures	6	233	233	182.25	360
13	610928149530301	SB01200306CABD1 019	61°09'24.6" N., 149°53'03.8" W.	Municipality of Anchorage	Public supply	Yes	Urban–commercial, urban–residential, general–forest (coniferous–deciduous, light silviculture)	8	75	70–75	35 (D)	103
14	612606149483901	SB01600333ADCA1 001	61°26'02.3" N., 149°48'35.2" W.	Matanuska–Susitna Borough	Domestic	Yes	General–wetland, general–forest (coniferous–deciduous, light silviculture), general–water, urban–residential, urban–disturbed land	6	73.6	61–73.6	18.80	75
15	613053149565301	SB01700435CDDD1 002	61°30'48.9" N., 149°56'38.9" W.	Matanuska–Susitna Borough	Domestic	No	General–forest (coniferous–deciduous, light silviculture), general–water, urban–residential	6	24	24	12.70	250
16	613227149483501	SB01700327BBBC1 001	61°32'25.4" N., 149°48'45.9" W.	Matanuska–Susitna Borough	Domestic	Yes	Urban–residential, general–forest (coniferous–deciduous, light silviculture), urban–other	6	190	190	56.20	210
18	613550149453701	SB01700302ABDC1 006	61°35'45.9" N., 149°45'46.6" W.	Matanuska–Susitna Borough	Domestic	Yes	Urban–residential, general–forest (coniferous–deciduous, light silviculture), general–wetland	6	121	121	82.70	298
19	612939149413201	SB01600207ADBD1 006	61°29'37.3" N., 149°41'43.8" W.	Matanuska–Susitna Borough	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, urban–other, general–wetland	6	100	100	67.00	300

Table 1. Identification, location, and characteristics of sampled wells in Cook Inlet Basin, 1999—Continued

[See figure 2 for geographic setting of wells. Clay or silt above well opening: Yes means open interval of well is overlain by clay, silt, or hardpan. Land use means general land use within 0.25-mile radius of well. Water level: D, value from driller's log; E, estimated on basis of water level measured in nearby well; G, pressure gage; P, well being pumped; R, well recently pumped. NAD83, North American Datum of 1983 geodetic reference system]

Well number	Station identification number	Local number	NAD83 coordinates (latitude, longitude)	Municipality or borough	Use of well water	Clay or silt above well opening	Land uses in vicinity of well	Diameter of well casing (inches)	Depth of well (feet)	Open interval (feet below land surface)	Water level (feet below land surface)	Altitude of land surface (feet above sea level)
Subunit survey—Continued												
20	611726149442801	SB01400324BCDB1 001	61°17'27.1" N., 149°44'37.9" W.	Municipality of Anchorage	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), general–water, general–wetland, urban–developed land without major structures	6	85	75–85	18.09	100
21	611438149432301	SB01300301DACB1 003	61°14'35.4" N., 149°43'30.4" W.	Municipality of Anchorage	Public supply	Yes	Urban–disturbed land, general–water	16	152	132–152	103 (P)	251
22	610759149422301	SB01200313BCBD2 053	61°07'57.0" N., 149°44'30.0" W.	Municipality of Anchorage	Domestic	Yes	Urban–residential, general–forest (coniferous–deciduous, light silviculture)	6	211	211	202	733
23	612130149325501	SB01500225DBCD2 012	61°21'28.8" N., 149°33'04.7" W.	Municipality of Anchorage	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, general–water, urban–other	6	129	119–129	107.35	360
24	613151149015401	SA01700226DDBB1 017	61°31'49.3" N., 149°02'03.2" W.	Matanuska–Susitna Borough	Domestic	No	Urban–residential, general–forest (coniferous–deciduous, light silviculture)	6	50	50	35.34	98
25	613257149345401	SB01700223DBBA1 012	61°32'53.5" N., 149°35'02.7" W.	Matanuska–Susitna Borough	Domestic	No	Urban–residential, general–forest (coniferous–deciduous, light silviculture)	6	213	213	189.6	418
26	613428149044501	SA01700210CCAA2 018	61°34'26.3" N., 149°04'53.8" W.	Matanuska–Susitna Borough	Domestic	No	Agricultural (croplands), urban–residential, general–forest (coniferous–deciduous, light silviculture), agricultural (livestock)	6	81	81	71.90	189
27	613530149244101	SB01700102CBAD1 054	61°35'28.7" N., 149°24'49.7" W.	Matanuska–Susitna Borough	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, urban–other	6	60	60	40.70	369
28	613553149253601	SB01700103ABDA1 004	61°35'50.7" N., 149°25'44.3" W.	Matanuska–Susitna Borough	Domestic	Yes	Urban–residential, general–forest (coniferous–deciduous, light silviculture)	6	141	141	97.17	467

29	613716149394101	SB01800229DAAA3 001	61°37'15.6" N., 149°39'50.1" W.	Matanuska–Susitna Borough	Domestic	Yes	General–forest (coniferous–deciduous, light silviculture), urban–residential, general–water	6	80	80	60.25	336
30	613847149131801	SA01800114CDAA1 010	61°38'46.1" N., 149°13'28.8" W.	Matanuska–Susitna Borough	Domestic	Yes	Agricultural (croplands), general–forest (coniferous–deciduous, light silviculture), general–wetland, urban–residential, agricultural (farm residence and related buildings)	6	61	50–55	22.50	541
						Public-supply survey						
31	613509149053701	SA01700204DCDD1 012	61°35'08.8" N., 149°05'47.4" W.	Matanuska–Susitna Borough	Public supply	No	Agricultural (croplands), urban–commercial, general–forest (coniferous–deciduous, light silviculture), urban–other	12	186	151–171	106	221
32	611331149492901	SB01300309CDCD1 001	61°13'28.7" N., 149°49'38.6" W.	Municipality of Anchorage	Public supply	Yes	Urban–commercial, general–forest (coniferous–deciduous, light silviculture), urban–developed land without major structures, urban–residential, urban–disturbed land	20	329	270–322	61.9 (E)	143
33	611106149522802	SB01300330DBDD2 030	61°11'04.9" N., 149°52'34.1" W.	Municipality of Anchorage	Public supply	Yes	Urban–commercial, urban–disturbed land, general–forest (coniferous–deciduous, light silviculture)	16	268	232–268	32 (G)	110
34	611026149432002	SB01300336DABB2 009	61°10'22.5" N., 149°43'28.2" W.	Municipality of Anchorage	Public supply	Yes	General–forest (coniferous–deciduous, light silviculture), urban–disturbed land	16	89.5	70–89	31.5 (E)	398
35	603405151081201	SB00601136BCDC1 008	60°34'03.4" N., 151°08'26.2" W.	Kenai Peninsula Borough	Public supply	Yes	General–wetland, general–forest (coniferous–deciduous, light silviculture), urban–commercial	12	420	348–420	22 (R)	79

Sample Analyses

Analyses for major ions, nutrients, trace elements, radiochemicals, VOCs, and pesticides were done by the USGS National Water-Quality Laboratory (NWQL) in Denver, Colo. Analyses for CFC compounds and environmental isotopes were performed in USGS laboratories in Reston, Va. Analyses for tritium were done by Lamont–Doherty Earth Observatory of Columbia University in Palisades, N.Y. Analyses for radium were performed by Quanterra Analytical Services in Richland, Wash. The analytical methods that were used are summarized in table 2.

Samples collected for alkalinity, major ions, nutrients, trace elements, and some radioisotopes (alpha and beta activities and radium) were filtered onsite by using capsule filters that have 0.45-µm pores. Samples for dissolved organic carbon were filtered by using silver-membrane filters that have 0.45-µm pores. Pesticides samples were filtered by using 0.7-µm baked-glass-fiber filters. All other analyses were made by using unfiltered water samples. All sampling and filtering equipment was decontaminated after each use according to methods described by Koterba and others (1995).

Analytical results were evaluated in the context of minimum reporting levels and method detection limits established by each laboratory (Zaugg and

Table 2. Methods used to analyze water from wells in Cook Inlet Basin, 1999

[—, not applicable or none]

Constituent or constituent group	U.S. Geological Survey schedule or laboratory code	Method of analysis	Reference
Field determinations			
Water temperature, pH, specific conductance, dissolved oxygen, alkalinity	—	Various	U.S. Geological Survey (1999a)
Inorganic constituents			
Major ions	Schedule 2750	Various	Fishman and Friedman (1989)
Nutrients	Schedule 2752	Various	Fishman and Friedman (1989)
Metals and trace elements	Schedule 2703	Inductively coupled plasma mass spectrometry	Fishman and Friedman (1989)
Dissolved organic carbon	Schedule 2085	Ultraviolet-promoted persulfate oxidation and infrared spectrometry	Brenton and Arnett (1993)
Organic compounds			
Pesticides	Schedule 2001	Solid-phase extraction and analysis by gas chromatography–mass spectrometry with selected ion monitoring	Zaugg and others (1995)
	Laboratory code 9060	Solid-phase extraction and high-performance liquid chromatography[1]	Werner and others (1996)[1]
Volatile organic compounds	Schedule 2020	Purge-and-trap isolation and concentration; capillary-column gas chromatography–mass spectrometry	Rose and Schroeder (1995)
Chlorofluorocarbons	Schedule 1173	Purge-and-trap gas chromatography	Plummer and Busenberg (1999)
Radioisotopes and environmental isotopes			
Tritium	Laboratory code 2112	Electrolytic enrichment and liquid scintillation	Ostlund and Dorsey (1977)
Tritium–helium ratio	Schedule 1033	Electrolytic enrichment and liquid scintillation	Ostlund and Dorsey (1977)
Radon-222	Laboratory code 1369	Liquid scintillation	American Society for Testing and Materials (1996)
Deuterium–hydrogen ratio	Schedule 1173	Hydrogen equilibrium at 30°C	Coplen and others (1991)
Oxygen-18–oxygen-16 ratio	Schedule 1173	Carbon dioxide equilibrium at 25°C	Epstein and Mayeda (1953)
Gross alpha and beta radiation and radium	Schedule 1263	Gamma-ray spectrometry using high-purity germanium detector	—

[1] Analytical method was modified from that of Werner and others' (1996).

others, 1995; Childress and others, 1999). In some instances in this report, concentration values for individual compounds are lower than the method detection limits. If a constituent may be present in a sample at a concentration less than the method detection limit, the listed concentration was estimated. Estimated values indicate probable analyte detection; however, the reported concentration value was not quantifiable. Most of the analytical results were reported previously by Bertrand and others (2000), are stored in the USGS National Water Information System database, and are accessible on the Internet at URL <http://water.usgs.gov/ak/nwis/qwdata>.

Quality Control

Quality-assurance–quality-control samples were collected to evaluate the accuracy and precision of concentrations of constituents measured in ground-water samples and to determine if samples were contaminated during their collection, processing, and analysis. Blank samples, replicate samples, and spike samples were collected, preserved, and analyzed by using the same methods and equipment as those used for the environmental ground-water samples. The USGS NWQL also spiked selected samples for selected VOCs and pesticides. In general, reported concentrations of most constituents are considered accurate and precise, but the reported frequencies of detection and concentrations of ammonia, nitrate, phosphorus, copper, iron, manganese, and toluene may be higher than actual.

Field blanks consisted of waters that contained neither inorganic constituents nor organic compounds and that had been pumped through the sampling equipment and discharge lines to determine whether cleaning procedures eliminated contamination between sites and to ensure that field methods, sample shipment, and laboratory procedures had not contaminated samples. Results from three inorganic and two organic field blanks collected after sampling wells 3, 30, and 34 showed that for most constituents, chemical contaminants were not being introduced as a result of sample collection and equipment decontamination procedures. However, calcium, magnesium, silica, ammonia, nitrate, phosphorus, copper, iron, manganese, toluene, and dichloromethane were present in field blanks in small concentrations (table 3). The concentrations of ammonia, nitrate, phosphorus, copper, iron, manganese, and toluene in field blanks were similar to those measured in some ground-water samples.

Table 3. Constituents detected in quality-control samples from Cook Inlet Basin, 1999

[See table 2 regarding analytical methods used. <, less than]

Constituent	Unit	Number of quality-control samples	Number of quality-control samples having detectable concentrations	Minimum reporting level or method detection limit	Highest concentration in quality-control samples	Range of concentrations in ground-water samples
			Field Blanks			
Calcium	Milligram per liter	3	3	0.02	0.01	4.4–77
Magnesium	Milligram per liter	3	1	.001	.001	2.1–18
Silica (as SiO_2)	Milligram per liter	3	2	.05	.043	5.9–46
Ammonia plus organic nitrogen (as N)	Milligram per liter	2	2	.05	[1].05	<0.1–0.8
Nitrite plus nitrate (as N)	Milligram per liter	2	1	.05	. 15	<0.05–4.8
Phosphorus (as P)	Milligram per liter	2	1	.004	.004	<0.004–0.38
Copper	Microgram per liter	3	1	1	.22	<1–15
Iron	Microgram per liter	3	1	3	11.2	<10–18,000
Manganese	Microgram per liter	3	1	1	.13	<1–1,460
Toluene	Microgram per liter	2	2	.05	.087	<0.05–0.77
Dichloromethane (as methylene chloride)	Microgram per liter	2	1	.38	.066	<0.38
			Trip blanks			
Toluene	Microgram per liter	2	1	0.05	0.043	<0.05–0.77

[1] Estimated value.

As a result, environmental data for these constituents may be biased, and interpretations for these constituents, particularly at low levels, therefore requires caution. The presence of detectable concentrations of some constituents may be the result of one or more of the following: use of contaminated sample-preparation equipment, such as filters, sample bottles, or preservative; carryover from field or laboratory equipment; or the analytical method used.

Trip blanks consisted of sample vials filled with VOC-free water in the USGS Anchorage Field Office laboratory and transported to the field and submitted to the laboratories with environmental samples. Trip blanks, used to verify that VOC samples were not contaminated during storage, sampling, or shipment to the laboratory, were transported during the sampling of wells 5 and 24. Toluene detected in one of two trip blanks had an estimated concentration of 0.043 μg/L.

Sequential replicate samples are a second set of water samples collected and preserved immediately after an environmental sample, by the same techniques and equipment. Results from the replicate samples at wells 10, 22, and 24 indicate good agreement between measured concentrations: Most paired values were within 10 percent, although several constituents had relative differences between environmental and replicate samples of more than 10 percent (table 4). However, small concentration differences may result in large relative-percentage differences when environmental- and replicate-sample concentrations are also small.

Laboratory spiking of samples also were performed by NWQL to determine the precision and accuracy of analyte recovery in the sample matrix and to evaluate the effectiveness of the analytical methods for selected analytes. Recoveries for selected VOCs (1,2-dichloroethane, toluene, and 1,4-bromofluorobenzene) ranged from 84 to 119 percent; recoveries for selected pesticides (diazinon and alpha-HCH) ranged from 72 to 124 percent. These results of laboratory spiking indicate that matrix effects were minor, and the analytical methods were effective.

Table 4. Constituents that have relative-percentage differences greater than 10 percent in replicate samples from Cook Inlet Basin

[See table 2 regarding analytical methods used. <, less than]

Constituent	Number of replicate samples	Concentration			Relative-percentage difference[1] (percent)	Number of replicate samples that have relative-percentage differences[1] greater than 10 percent
		Environmental sample	Replicate sample	Unit		
Potassium	2	1	.9	Milligram per liter	11	1
Bromide	2	.02	.01	Milligram per liter	67	1
Aluminum	2	5	<1	Microgram per liter	133	1
Copper	2	1	2	Microgram per liter	67	1
Zinc	2	56	32	Microgram per liter	55	1
Radon-222	2	180 220	210 190	Picocurie per liter	15 15	2
Dissolved organic carbon	2	.6 .6	.7 .5	Milligram per liter	15 18	2

[1] Relative-percentage difference equals difference between concentrations of environmental and replicate samples divided by average of concentrations of environmental and replicate samples.

WATER-QUALITY STANDARDS AND GUIDELINES

The concentrations of constituents determined during this study are compared with current U.S. Environmental Protection Agency (2000, 2001) drinking-water regulations and guidelines. Drinking-water standards include the primary (MCL), secondary (SMCL), and proposed maximum contaminant levels; action levels; and health advisories. The USEPA drinking-water standards are defined as the permissible level of a contaminant in water delivered to users of a public water system. An MCL is an enforceable standard and is established on the basis of health effects, treatment feasibility, cost of treatment, and analytical detection. An SMCL is a nonenforceable guideline based on esthetics and is established for constituents that can adversely affect the odor or appearance of water and result in the discontinuation of the water's use. Action levels are considered the lowest level to which water systems can reasonably be required to control a contaminant should it occur in drinking water. Health advisories are nonregulatory levels of contaminants in drinking water that may be used for guidance in the absence of regulatory limits. They consist of estimates of the highest concentrations that would result in no known or anticipated health effects (or for carcinogens, a specified cancer risk), determined for a child or for an adult for various exposure periods. A lifetime health advisory is established for the part of an individual's lifetime exposure that is attributed to drinking water and is considered protective against noncarcinogenic adverse health effects over a lifetime exposure (70 years).

PHYSICAL PROPERTIES AND FIELD MEASUREMENTS

When possible, the depth to water in each well was measured before the pump was turned on for sampling. Water levels ranged from 7.3 ft above land surface in a well perforated in a confined aquifer near the mouth of the Kenai River to 202 ft below land surface in a well along the mountain front in Anchorage. As water was being pumped from the well, measurements of water temperature, specific conductance, dissolved oxygen, pH, and alkalinity were made to help determine some basic chemical characteristics of the water; the stabilized values for each site are summarized in table 5 and are presented in more detail in appendix 1.

Table 5. Statistical summary of physical properties and field measurements for water sampled from wells in Cook Inlet Basin, 1999

[Number in parentheses to left of property or constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. See table 2 regarding analytical methods used. SMCL, secondary maximum contaminant level. >, greater than; <, less than; —, no criteria or not applicable]

Survey network	Number of analyses	Value			Drinking-water standard[1]
		Minimum	Median	Maximum	
(72019) Water level (feet below land surface)					
Subunit	29	-7.3	56	202	—
Public supply	5	22	32	106	—
(72008) Well depth (feet below land surface)					
Subunit	29	24	90	233	—
Public supply	5	90	268	420	—
(72004) Pumpage period (minutes)					
Subunit	29	30	60	>300,000	—
Public supply	5	30	90	210	—
(00059) Flow rate (gallons per minute)					
Subunit	29	5	5	725	—
Public supply	5	650	1,200	1,800	—
(00010) Water temperature (degrees Celsius)					
Subunit	29	3.0	4.0	9.5	—
Public supply	5	2.5	4.0	5.0	—
(00400) pH (standard units)					
Subunit	29	6.7	7.9	8.3	—
Public supply	5	7.1	8.0	8.4	—
—	—	—	—	—	6.5 (SMCL) (minimum)
—	—	—	—	—	8.5 (SMCL) (maximum)
(00095) Specific conductance (microsiemens per centimeter at 25°C)					
Subunit	29	77	255	1,750	—
Public supply	5	168	201	310	—
(00300) Dissolved oxygen (milligrams per liter)					
Subunit	29	0.1	0.6	11.8	—
Public supply	5	<0.1	1.6	11	—
(39086) Alkalinity (milligrams per liter as $CaCO_3$)					
Subunit	29	34	127	384	—
Public supply	5	77	100	103	—

[1] U.S. Environmental Protection Agency (2000).

Ground water in the Cook Inlet Basin is cool: About 90 percent of the wells sampled yielded water having temperatures less than 6°C. Most wells yielded water having specific-conductance values less than 300 µS/cm, indicating low dissolved-solids contents (less than about 180 mg/L). The highest values of specific conductance (946 and 1,750 µS/cm) were from wells near the mouth of the Kenai River. Dissolved-oxygen concentrations of less than 1 mg/L indicate chemically reducing conditions and were observed in 15 of 29 wells in the subunit survey and in 1 public-supply well. Under reduced conditions, ions such as arsenic, iron, and manganese are more soluble in ground water. Observed pH values ranged from 6.7 to 8.4 units. Alkalinity, a measure of the capacity of the substances dissolved in the water to neutralize acid, ranged from 34 to 384 mg/L as $CaCO_3$ for filtered samples.

MAJOR IONS

Water samples were analyzed for the following major inorganic constituents: calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, bromide, and silica (appendix 2). Bicarbonate concentration was determined by alkalinity titration. Most ground-water samples had low to moderate dissolved-solids concentrations. However, the SMCL for dissolved solids, 500 mg/L, was exceeded in samples from two wells (3 and 9) near the mouth of the Kenai River. Summary statistics for the major constituents and USEPA drinking-water standards are listed in table 6.

The dominant positively charged compounds (cations) include calcium, magnesium, sodium, and potassium. Calcium in drinking water has no detrimental health effects but contributes to the hardness of water. Calcium and magnesium are both essential elements for plants and animals. Sodium and potassium are present in many different types of rocks, but potassium is slightly less common than sodium in igneous rock and more abundant in sedimentary rocks. Sodium tends to remain in solution once it has been dissolved, whereas potassium exhibits a strong tendency to be reincorporated; thus, the concentration of

Table 6. Statistical summary of major-ion concentrations in water sampled from wells in Cook Inlet Basin, 1999

[Number in parentheses to left of constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. MCL, maximum contaminant level; SMCL, secondary maximum contaminant level. See table 2 regarding analytical methods used. <, less than; —, none or not applicable]

Survey network	Number of analyses	Concentration in sample (milligrams per liter)			Drinking-water standard[1] (milligrams per liter)
		Minimum	Median	Maximum	
(00915) Calcium					
Subunit	29	4.4	40	77	—
Public supply	4	6.3	28	56	—
(00925) Magnesium					
Subunit	29	2.1	6.1	18	—
Public supply	4	4.1	6.5	7.7	—
(00930) Sodium					
Subunit	29	2.0	3.6	360	—
Public supply	4	3.2	5.8	34	—
(00935) Potassium					
Subunit	29	0.25	0.95	13	—
Public supply	4	.89	.95	4.2	—
(00453) Bicarbonate, as HCO_3					
Subunit	29	42	155	468	—
Public supply	5	94	122	126	—
(00945) Sulfate					
Subunit	28	<0.1	3.0	55	—
Public supply	4	.3	9.1	62	—
—	—	—	—	—	250 (SMCL)
(00940) Chloride					
Subunit	28	1.1	3.9	500	—
Public supply	4	.6	4.3	9.3	—
—	—	—	—	—	250 (SMCL)
(00950) Fluoride					
Subunit	28	<0.1	<0.1	0.2	—
Public supply	4	<.1	<.1	.3	—
—	—	—	—	—	4 (MCL)
—	—	—	—	—	2 (SMCL)
(71870) Bromide					
Subunit	28	<0.01	<0.01	0.87	—
Public supply	4	<.01	<.01	.02	—
(00955) Silica					
Subunit	29	5.9	14	44	—
Public supply	4	6.3	13	46	—
(70300) Dissolved solids, residue at 180°C					
Subunit	28	77	161	986	—
Public supply	4	119	147	213	—
—	—	—	—	—	500 (SMCL)

[1] U.S. Environmental Protection Agency (2000).

potassium in most natural water is much lower than that of sodium (Hem, 1985). Sodium concentrations were greatest in ground water near the mouth of the Kenai River. Potassium concentrations in most samples were low, generally less than 1 mg/L.

The dominant negatively charged compounds (anions) include bicarbonate, sulfate, chloride, fluoride, and bromide. Bicarbonate is produced in the soil zone from the reaction of carbon dioxide and water and from the dissolving of calcium carbonate in rocks. Bicarbonate is commonly a dominant anion in shallow, recently recharged ground water. Sulfate in ground water is derived mostly from the weathering of sedimentary and igneous rocks and from biochemical processes. Concentrations of sulfate were less than 5 mg/L in water from wells on the Kenai Peninsula and from wells in the western Matanuska–Susitna area. The highest sulfate concentrations, ranging from 52 to 62 mg/L, were in water samples from three wells (24, 26, and 31) near the Matanuska River. Wells sampled in Anchorage yielded water samples having intermediate sulfate concentrations, ranging from 7.1 to 19 mg/L. Most wells yielded water samples that had fluoride concentrations less than 0.1 mg/L.

Chloride concentrations were typically less than 5 mg/L. However, well 3 near the mouth of the Kenai River yielded water having a chloride concentration that exceeded the SMCL standard of 250 mg/L. Water samples collected for previous studies in this coastal area also had sodium and chloride concentrations greater than 250 mg/L (Glass, 1996). This brackish ground water may be remnant from the time when a larger ancestral Cook Inlet covered the area (Glass, 1999). Seawater intrusion due to withdrawals of ground water is unlikely because the altitudes of water levels in wells in this area are more than 20 ft above sea level.

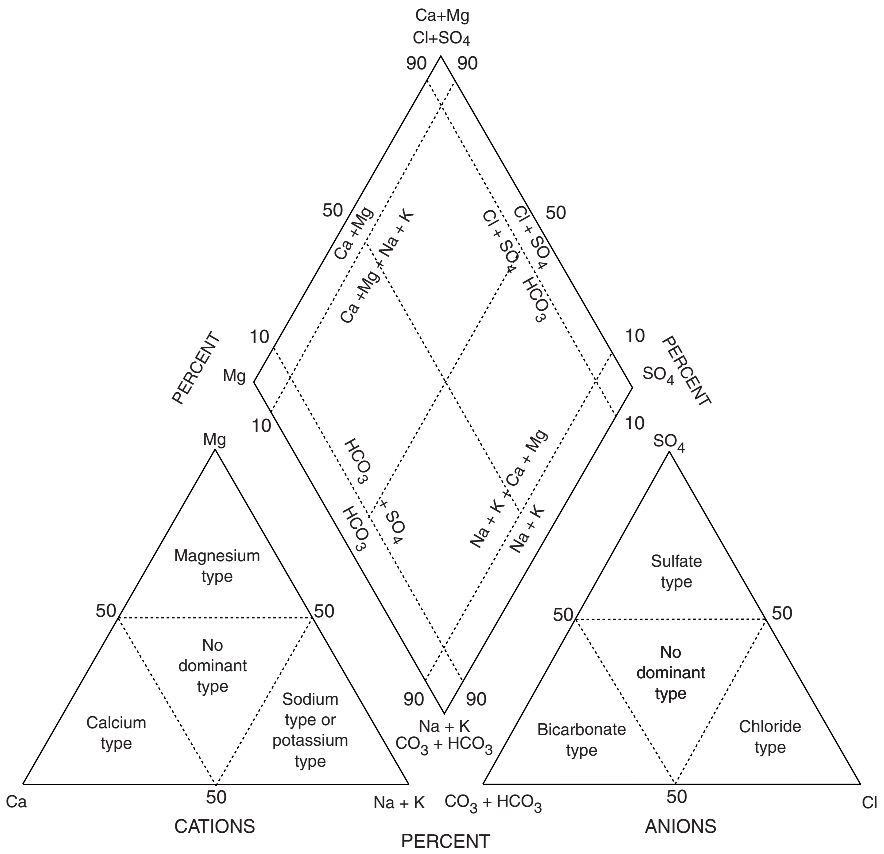
Silica concentrations in water from wells in Anchorage and the Matanuska–Susitna areas ranged from 6 to 27 mg/L. Highest values, ranging from 26 to 46 mg/L, were observed in water samples from wells on the Kenai Peninsula.

Trilinear diagrams are a means of indicating general similarities and differences in the composition of water from certain geologic units (Freeze and Cherry, 1979). Percentages of the total milliequivalents per liter (the number of moles of solute, multiplied by the valence of the solute species, in 1 liter of solution) of the dominant cations and anions in each water sample are shown in figure 3. Also shown are the combined cation and anion composition of the water, which is derived from projecting the data from the separate triangular cation and anion plots. Most water samples from wells in the Anchorage and Matanuska–Susitna areas had calcium as their dominant cation and bicarbonate as the dominant anion. Magnesium was the second-most dominant cation, commonly making up 10 to 40 percent of the positive ions. Water from some wells on the Kenai Peninsula had greater proportions of sodium and chloride. The proportion of sulfate in most samples was low; only three wells (24, 26, and 31) in the eastern Matanuska–Susitna area yielded waters having sulfate composing greater than 20 percent of the anions.

NUTRIENTS AND DISSOLVED ORGANIC CARBON

Precipitation, plant residues, and aquifer minerals generally contribute low concentrations of nitrate and phosphate to ground water. However, contributions from human sources, such as domestic and agricultural fertilizers and effluent from domestic septic systems, can increase nutrient concentrations significantly. Nutrients in sufficiently high concentrations can cause excessive algal growth in streams or, in extreme cases, be toxic to aquatic life and hazardous to human health. Nutrient concentrations in ground water sampled during 1999 did not exceed any drinking-water standard (table 7 and appendix 3) but may indicate contributions from human sources in some areas.

The solubility of nitrogen is affected by the oxidation state of the ground water or aquifer. Nitrogen in ground water containing dissolved oxygen commonly is present as nitrate, whereas nitrogen in water having no or only small amounts of dissolved oxygen might not be present as nitrate owing to conversion of nitrate to nitrogen gas, nitrite, ammonia, or ammonium. Ammonia is less common than nitrate and nitrite. Nationally, the median ammonia concentration (quantified as measured nitrogen) in ground water in major aquifers is 0.02 mg/L (Nolan and Stoner, 2000). In the Cook Inlet Basin, concentrations of ammonia were less than the minimum reporting level of 0.02 mg/L in 23 of 34 ground-water samples. The highest concentrations of ammonia observed, 0.81 and 0.80 mg/L, were from water samples from two wells (3 and 9) near the mouth of the Kenai River and were far below the 30 mg/L health advisory.


Ca+Mg
Cl+SO4
90
90
50
Ca +Mg
Ca +Mg + Na + K
Cl + SO4
Cl + SO4
HCO3
50
10
PERCENT
Mg
10
PERCENT
SO4
10
10
HCO3
+ SO4
HCO3
Na + K + Ca + Mg
Na + K
Mg
SO4
Magnesium type
Sulfate type
50
50
50
50
No dominant type
No dominant type
Calcium type
Sodium type or potassium type
90
90
Na + K
CO3 + HCO3
Bicarbonate type
Chloride type
Ca
50
Na + K
CO3 + HCO3
50
Cl
CATIONS
PERCENT
ANIONS

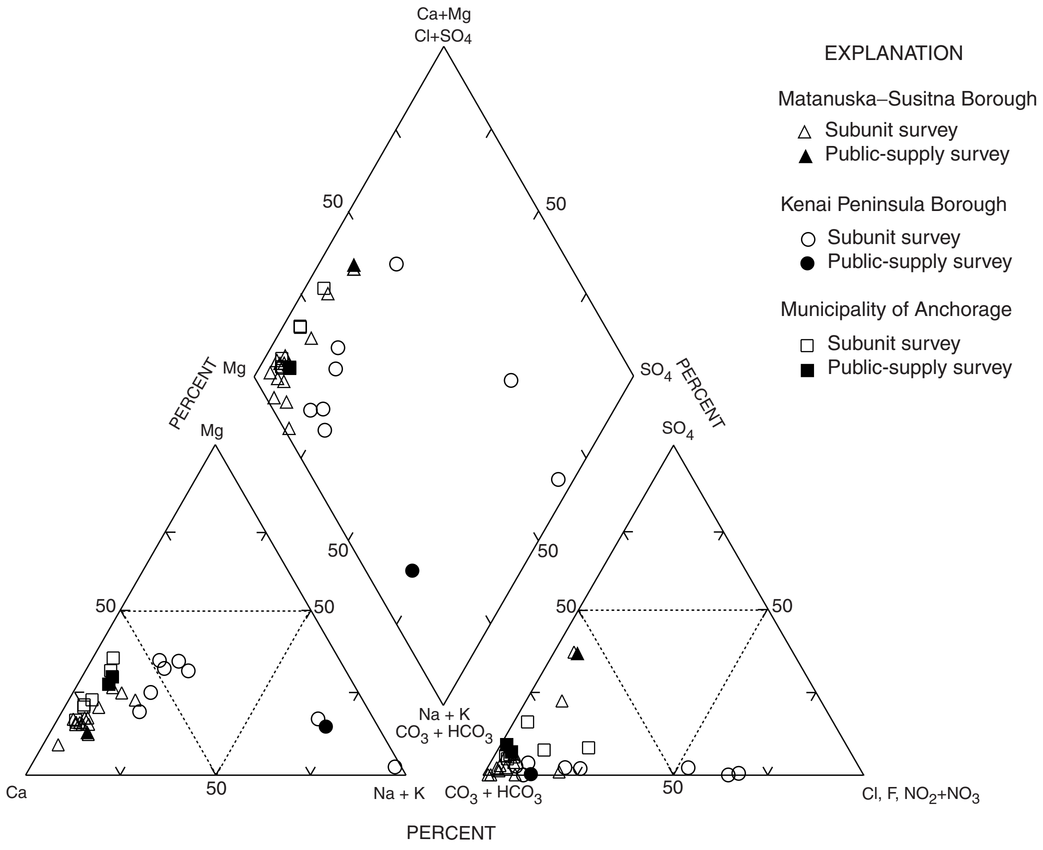

Ca+Mg
Cl+SO4
EXPLANATION
Matanuska–Susitna Borough
△ Subunit survey
▲ Public-supply survey
Kenai Peninsula Borough
○ Subunit survey
● Public-supply survey
Municipality of Anchorage
□ Subunit survey
■ Public-supply survey
50
50
PERCENT
Mg
SO4
PERCENT
Mg
SO4
50
50
50
50
50
50
Na + K
CO3 + HCO3
Ca
50
Na + K
CO3 + HCO3
50
Cl, F, NO2+NO3
PERCENT

Table 7. Statistical summary of nutrient and dissolved organic carbon concentrations in water sampled from wells in Cook Inlet Basin, 1999

[Number in parentheses to left of constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. See table 2 regarding analytical methods used. MCL, maximum contaminant level. <, less than; —, none or not applicable]

Survey network	Number of analyses		Concentration (milligrams per liter)			Criterion[1] (milligrams per liter)	
	Total	Resulting in concentrations less than minimum reporting level	Minimum	Median	Maximum	Drinking-water standard	Lifetime health advisory
(00608) Ammonia, as N							
Subunit	29	19	<0.02	<0.02	0.81	—	—
Public supply	5	4	<.02	<.02	.31	—	—
—	—	—	—	—	—	—	30
(00623) Ammonia plus organic nitrogen, as N							
Subunit	29	18	<0.1	<0.1	0.8	—	—
Public supply	5	4	<.1	<.1	.3	—	—
(00631) Nitrite plus nitrate, as N							
Subunit	29	12	<0.05	0.12	4.8	—	—
Public supply	5	1	<.05	.25	2.5	—	—
—	—	—	—	—	—	10 (MCL)	—
(00613) Nitrite, as N							
Subunit	29	27	<0.01	<0.01	0.01	—	—
Public supply	5	5	<.01	<.01	<.01	—	—
—	—	—	—	—	—	1 (MCL)	—
(00666) Phosphorus, as P							
Subunit	29	11	<0.004	0.011	0.38	—	—
Public supply	5	2	<.004	.014	.37	—	—
(00671) Orthophosphate, as P							
Subunit	29	13	<0.01	0.01	0.43	—	—
Public supply	5	3	<.01	<.01	.45	—	—
(00681) Dissolved organic carbon							
Subunit	29	0	0.3	0.9	2.1	—	—
Public supply	5	0	.3	.4	1.9	—	—

[1] U.S. Environmental Protection Agency (2000).

Figure 3. Major-ion composition of water sampled from wells in Cook Inlet Basin, 1999.

Nitrite concentrations in undeveloped areas are commonly very low, typically less than 0.2 mg/L as N, and they represent only a small fraction of the total nitrogen in the system. All nitrite concentrations in ground-water samples were at or below the minimum reporting level of 0.01 mg/L as N. The MCL for nitrite is 1.0 mg/L.

Nitrate is the primary form of nitrogen dissolved in ground water. In this report, nitrate refers to the sum of nitrite plus nitrate. The national background concentration for nitrate in shallow ground water in undeveloped areas considered to be minimally affected by agriculture, urbanization, and associated land uses is estimated to be about 2 mg/L as N (U.S. Geological Survey, 1999b, p. 34). Nitrate concentrations greater than about 3 mg/L may be indicative of human sources (Madison and Brunett, 1985). Ground-water samples from wells in the Cook Inlet Basin generally had low nitrate concentrations; 13 of 34 samples had concentrations less than 0.05 mg/L. Nitrate concentrations were highest in water from wells in the eastern part of Anchorage and were as great as 4.8 mg/L. Water from well 34, a public-supply well in a relatively undeveloped area in the eastern part of Anchorage, had a concentration of 2.5 mg/L. The MCL for dissolved nitrate is 10 mg/L as N.

To discourage excessive biotic growth in flowing water, total phosphorus concentrations (as P) should not exceed 0.1 mg/L. In the Cook Inlet Basin, phosphorus concentrations generally were low; 16 of 34 samples had concentrations of dissolved orthophosphate less than 0.01 mg/L. The highest concentrations observed, 0.43 and 0.45 mg/L, were from two wells (9 and 35) on the Kenai Peninsula. These high phosphorus concentrations are unlikely to have resulted from human activities because the openings for both wells are beneath a thick layer of clay.

DOC in ground water can result from the partial oxidation of organic matter in the soil zone or in the aquifer. Naturally occurring organic matter in water and DOC can form complexes that affect metal solubilities, participate in reduction reactions, and serve as nutrients for microorganisms that mediate chemical processes (Hem, 1985). These processes commonly decrease dissolved oxygen and sulfate concentrations but may increase the amounts of arsenic, iron, and manganese dissolved in water. Naturally occurring organic matter can also cause taste, odor, or color problems in water and serve as precursors to the formation of trihalomethane compounds, which result from chlorination in water-treatment processes. DOC was detected in water at all sites, and concentrations did not have large spatial variations throughout the study unit. Concentrations of DOC ranged from 0.3 to 2.1 mg/L. Freeze and Cherry (1979) reported that concentrations of DOC in ground water most commonly range from 0.1 to 10 mg/L.

TRACE ELEMENTS

Trace elements are inorganic chemicals commonly occurring in small amounts in natural water. In the COOK study unit, concentrations of aluminum, antimony, beryllium, cadmium, chromium, cobalt, lead, molybdenum, nickel, selenium, silver, and uranium dissolved in ground water were generally low, less than 5 µg/L (table 8 and appendix 4). Arsenic, barium, copper, iron, manganese, and zinc were present in some samples at concentrations greater than 5 µg/L. Frenzel (2000) reported that arsenic, chromium, copper, and nickel appear to be at naturally large concentrations in streambed sediments in the Cook Inlet Basin, when compared with concentrations in streambed sediments in other NAWQA studies.

Naturally occurring arsenic commonly is found in some volcanic tuffs and ash; adsorbed to and coprecipitated with metal oxides, especially iron oxides; associated with the sulfide minerals pyrite and arsenopyrite; and associated with organic carbon (Welch and others, 2000). The unconsolidated aquifer materials within the COOK study unit may contain naturally large concentrations of arsenic. Concentrations of arsenic in streambed sediments ranged from 5.2 to 44 µg/g (dry weight) at 14 sites in the basin and exceeded the median concentration at NAWQA streambed-sediment sites sampled from 1992 to 1995, 6.35 µg/g, at 13 of 14 sites (Frenzel, 2000). The chemical reduction and dissolution of iron oxide in the aquifer materials, possibly through reaction with organic matter, also may allow high arsenic concentrations in ground water in some parts of the study unit. Commonly, wells that yielded water having elevated concentrations of arsenic also yielded water having elevated concentrations of iron and manganese and low concentrations of dissolved oxygen and nitrate.

Long-term exposure to arsenic in drinking water can lead to cancer of the skin, lungs, bladder, and kidney as well as skin changes such as thickening and change in pigmentation (World Health Organization, 2001). The proposed MCL for arsenic is 10 µg/L (U.S. Environmental Protection Agency, 2001); of the 34 wells sampled, 6 (18 percent) had concentrations exceeding 10 µg/L. Glass (1999) reported that the median dissolved arsenic concentration in water from 69 wells previously sampled in the northern part of the Kenai Peninsula was 7 µg/L; the highest concentration reported was 94 µg/L. Concentrations of arsenic in water from the eight wells sampled on the Kenai Peninsula in 1999 as part of the subunit survey ranged from less than 1 to 22 µg/L and had a median value of 4.5 µg/L. Water from the sampled public-supply well (35) on the Kenai Peninsula had a concentration of 24 µg/L. Arsenic concentrations in water samples collected during 1999 were as great as 29 µg/L in the Matanuska–Susitna area and as great as 10 µg/L in Anchorage. The median dissolved arsenic concentrations were 2 µg/L for the subunit survey and less than 1 µg/L for the public-supply survey.

The median barium concentrations in water from wells in the subunit and public-supply surveys were 9 and 6 µg/L, respectively. Concentrations were greatest (106 and 133 µg/L) in water from wells 9 and 3 near the mouth of the Kenai River but were substantially below the 2,000 µg/L MCL.

Iron is dissolved from many rocks and soils and is an essential element in the metabolism of animals and plants. Iron in drinking water does not pose a health threat; however, on exposure to air, iron in water oxidizes to become a reddish-brown sediment. If present in excess quantities in water used for domestic purposes, it forms a red precipitate that stains laundry and plumbing fixtures, causes discoloration and unpleasant taste in beverages, and may promote growth of iron bacteria in pipes. An iron concentration less than 300 µg/L, the SMCL, is preferred for public supply. Most wells sampled yielded water having concentrations less than 10 µg/L, but water from 6 of 33 wells had iron concentrations greater than 300 µg/L. The highest iron content, 18,000 µg/L, was from well 18 in the western part of the Matanuska–Susitna area.

Having a chemistry similar to that of iron, manganese is undesirable in water supplies because in high concentrations it leaves black oxide stains and has an unpleasant taste. The SMCL for manganese is 50 µg/L. The median dissolved manganese concentration was 30 µg/L for the subunit survey; 14 of the 33 wells sampled yielded water having manganese concentrations greater than the SMCL. The largest concentration observed was 1,460 µg/L.

PESTICIDES

Pesticides have long been used in agricultural settings, but their use in urban and undeveloped areas has increased as well. Pesticides are used in urban settings to control weeds and insects in lawns and trees; around homes and commercial buildings; along railroad, transmission-line, and roadway rights-of-way; and in private and public gardens. When present in drinking water or streams, many pesticides have adverse effects on humans and aquatic organisms. National water-quality standards and guidelines pertaining to pesticide contaminants were summarized by Nowell and Resek (1994).

Analyses of pesticides in other NAWQA subunits have shown that pesticide contamination in ground water is not just an agricultural problem; certain contaminants commonly occur in the more populated urban areas. Nationwide, about 50 percent of the wells sampled for the first 20 NAWQA study units contained one or more pesticides; the highest detection frequencies were in shallow ground water beneath agricultural and urban areas (59 and 49 percent, respectively), and the lowest frequencies (averaging 33 percent) typically in deeper ground water from major aquifers (U.S. Geological Survey, 1999b, p. 58). Herbicides commonly found in shallow ground water were atrazine, deethylatrazine, simazine, and prometon. The most commonly detected insecticide in shallow ground water was dieldrin, which was found in about 3 percent of wells sampled nationwide.

In the Cook Inlet Basin, 24 percent of ground-water samples had very low concentrations of at least one pesticide or pesticide-degradation product (table 9 and appendix 5). Eleven pesticides or pesticide-degradation products may have been present in water samples but at concentrations too small to be quantified. None of the detected pesticides had regulated MCLs for drinking water, but three had health advisories. The largest concentration detected, 0.007 µg/L, was shared by two compounds: methylazinphos, an insecticide used to control leaf-eating insects such as aphids; and fluometuron, an herbicide used to control weeds in cotton and sugarcane, crops not grown in Alaska. All concentrations of pesticides and pesticide-degradation products were far below lifetime health advisories.

Table 8. Statistical summary of trace-element concentrations in water sampled from wells in Cook Inlet Basin, 1999

[Number in parentheses to left of constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. See table 2 regarding analytical methods used. MCL, maximum contaminant level; PMCL, proposed maximum contaminant level; SMCL, secondary maximum contaminant level. <, less than; —, none or not applicable]

Survey network	Number of analyses		Concentration (milligrams per liter)			Criterion[1] (micrograms per liter)		
	Total	Resulting in concentrations less than minimum reporting level	Minimum	Median	Maximum	Drinking-water standard	Action level	Lifetime health advisory
(01106) Aluminum								
Subunit	29	21	<1	<1	4.9	—	—	—
Public	5	2	<1	1	1.2	—	—	—
—	—	—	—	—	—	50–200 (SMCL)	—	—
(01095) Antimony								
Subunit	29	29	<1	<1	<1	—	—	—
Public	5	5	<1	<1	<1	—	—	—
(01000) Arsenic								
Subunit	29	9	<1	2	29	—	—	—
Public	5	3	<1	<1	24	—	—	—
—	—	—	—	—	—	50 (MCL)	—	—
—	—	—	—	—	—	10 (PMCL)	—	—
(01005) Barium								
Subunit	29	0	1.3	9.1	133	—	—	—
Public	5	0	2.8	5.8	52	—	—	—
—	—	—	—	—	—	2,000 (MCL)	—	
(01010) Beryllium								
Subunit	29	29	<1	<1	<1	—	—	—
Public	5	5	<1	<1	<1	—	—	—
—	—	—	—	—	—	4 (MCL)	—	—
(01025) Cadmium								
Subunit	29	29	<1	<1	<1	—	—	—
Public	5	5	<1	<1	<1	—	—	—
—	—	—	—	—	—	5 (MCL)	—	
(01030) Chromium								
Subunit	24	21	<1	<1	3	—	—	—
Public	5	4	<1	<1	1	—	—	—
—	—	—	—	—	—	100 (MCL)	—	
(01035) Cobalt								
Subunit	29	28	<1	<1	2	—	—	—
Public	5	5	<1	<1	<1	—	—	—
(01040) Copper								
Subunit	29	14	<1	<1	15	—	—	—
Public	5	4	<1	<1	2	—	—	—
—	—	—	—	—	—	—	1,300	
(01046) Iron								
Subunit	29	16	<10	<10	18,000	—	—	—
Public	4	3	<10	<10	87	—	—	—
—	—	—	—	—	—	300 (SMCL)	—	
(01049) Lead								
Subunit	29	28	<1	<1	5	—	—	—
Public	5	5	<1	<1	<1	—	—	—
—	—	—	—	—	—	—	15	

Table 8. Statistical summary of trace-element concentrations in water sampled from wells in Cook Inlet Basin, 1999—Continued

Survey network	Number of analyses		Concentration (milligrams per liter)			Criterion[1] (micrograms per liter)		
	Total	Resulting in concentrations less than minimum reporting level	Minimum	Median	Maximum	Drinking-water standard	Action level	Lifetime health advisory
(01056) Manganese								
Subunit	29	12	<1	30	1,460	—	—	—
Public	5	4	<1	<1	38	—	—	—
—	—	—	—	—	—	50 (SMCL)	—	—
(01065) Nickel								
Subunit	29	17	<1	<1	1.9	—	—	—
Public	5	4	<1	<1	1.8	—	—	—
—	—	—	—	—	—	—	—	100
(01145) Selenium								
Subunit	29	28	<1	<1	1	—	—	—
Public	5	4	<1	<1	1	—	—	—
—	—	—	—	—	—	50 (MCL)	—	—
(01075) Silver								
Subunit	29	29	<1	<1	<1	—	—	—
Public	5	5	<1	<1	<1	—	—	—
—	—	—	—	—	—	100 (SMCL)	—	—
(22703) Uranium								
Subunit	29	29	<1	<1	<1	—	—	—
Public	5	5	<1	<1	<1	—	—	—
—	—	—	—	—	—	20 (MCL)	—	—
(01090) Zinc								
Subunit	29	1	<1	12	76	—	—	—
Public	5	1	<1	1.3	2.1	—	—	—
—	—	—	—	—	—	5,000 (SMCL)	—	—

[1] U.S. Environmental Protection Agency (2000).

VOLATILE ORGANIC COMPOUNDS

VOCs are manufactured chemicals such as organic solvents, byproducts of chlorinated disinfectants, and many petroleum-based derivatives that are components of gasoline, fuel oil, and lubricants. VOCs can be important environmental contaminants because many are mobile, persistent, and toxic. Many VOCs have been the focus of national regulations, monitoring, and research during the past 10 to 20 years. These include bromodichloromethane, chlorodibromomethane, tribromomethane, and trichloromethane, all of which are associated with the chlorination of drinking water; the fumigants 1,2-dibromo-3-chloropropane and 1,2-dibromomethane (commonly referred to as DBCP and EDB, respectively); the solvents tetrachloroethylene and trichloroethene (PCE and TCE, respectively); and the gasoline aromatic hydrocarbons (commonly referred to as BTEX compounds) benzene, toluene (methyl benzene), ethyl benzene, and xylenes (dimethylbenzenes). The gasoline additive used to reduce carbon monoxide emissions from vehicles during winter, methyl *tert*-butyl ether (MTBE), also has received much attention in recent years and commonly has been found in shallow aquifers beneath urban areas. Rowe and others (1997) and Bender and others (1999) described human-health criteria, drinking-water regulations, aquatic-toxicity criteria, and other information for many of the VOCs analyzed for this study.

Table 9. Pesticides detected in water sampled from wells in Cook Inlet Basin, 1999

[See table 2 regarding analytical methods used. Well number: See table 1 and fig. 2. —, none]

Constituent	Alternative term or trade name	Number of samples analyzed	Number of detections	Well number	Method detection limit (micrograms per liter)	Maximum concentration[1] (micrograms per liter)	Lifetime health advisory[2] (micrograms per liter)
Deethylatrazine	DEA	33	1	11	0.002	0.0015	—
Methyl azinphos	Guthion or Carfene	33	1	5	.001	.007	—
p,p-DDE	*p,p*-DDT metabolite	33	3	4, 24, and 31	.006	.002	—
Propanil	—	33	1	11	.004	.002	—
Tebuthiuron	Spike or Perflan	33	1	11	.01	.004	500
Carbofuran	—	33	1	24	.057	.0008	40
3-Hydroxy-carbofuran	—	33	1	24	.062	.0013	—
Diuron	—	33	2	15 and 31	.079	.002	10
Fluometuron	—	33	1	14	.062	.007	90
Metsulfuron methyl	—	33	1	24	.114	.002	—
Neburon	—	33	2	22 and 24	.075	.0011	—

[1] Estimated values.

[2] For 70-kilogram (154-pound) adult (U.S. Environmental Protection Agency, 2000).

Nationwide, the frequency of detection of VOCs in ground water is greater in urban areas than in rural areas having fewer than 1,000 people per square mile; nearly 50 percent of wells sampled in urban areas had at least one VOC detected (minimum reporting level, 0.2 µg/L) compared with about 14 percent of wells sampled in rural areas (Squillace and others, 1999). Drinking-water criteria for at least one VOC were exceeded in water samples from 6.4 percent of all sampled wells in urban areas nationwide and 2.5 percent of urban wells used as sources of drinking water. The most commonly detected VOCs in urban areas were trichloromethane (detected in 26 percent of urban wells sampled), MTBE (in 17 percent), PCE (in 17 percent), and TCE (in 12 percent). Because their occurrence is widespread, these four VOCs commonly occur together although they are not necessarily used together. MTBE is used in gasoline, and the remaining three VOCs are classified as solvents. However, trichloromethane can form during chlorination of drinking-water supplies, and lawn irrigation or the leaking of water mains and sewers can introduce this VOC to urban ground water. That tetrachloroethylene can degrade into trichloroethene may explain in part why these two VOCs occur together.

More than 80 VOCs were analyzed for this study, but only 9 compounds were detected (table 10 and appendix 6). All concentrations were less than 1 µg/L and were below MCLs for drinking water. Toluene was detected in 22 of 33 ground-water samples at concentrations as great as 0.77 µg/L. However, toluene also was detected in the quality-control samples; thus, the concentrations and frequency of detection of toluene in environmental samples likely are overestimated. The presence of toluene in quality-control and ground-water samples may be due to the use of contaminated field or laboratory equipment or the analytical method used. The compound 1,2,4-trimethylbenzene was detected in 10 of 33 ground-water samples at concentrations as great as 0.17 µg/L. Trichlo-

Table 10. Volatile organic compounds detected in water sampled from wells in Cook Inlet Basin, 1999

[See table 2 regarding analytical methods used. Well number: See table 1 and fig. 2. MCL, maximum contaminant level; —, none or not applicable]

Constituent	Number of analyses	Number of detections	Well number	Method detection limit (micrograms per liter)	Maximum detected (micrograms per liter)	Criterion[1] (micrograms per liter)	
						Drinking-water standard	Lifetime health advisory
Toluene	33	[2]22	1, 2, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 20, 22, 24, 25, 26, 27, 29, 30, 34, and 35	0.05	[3]0.77	1,000 (MCL)	—
1,2,4-Trimethylbenzene	33	10	1, 5, 14, 15, 16, 22, 25, 26, 27, and 30	.056	.17	—	—
Trichlorofluoromethane	33	9	1, 5, 7, 14, 16, 25, 26, 28, and 30	.09	.84	—	2,000
Chloroform	33	2	15 and 32	.052	[4].023	80 (MCL)	—
1,1,1-Trichloroethane	33	2	10 and 24	.032	[4].031	200 (MCL)	—
M- and *p*-Xylene	33	2	5 and 30	.06	[4].041	10,000 (MCL)	—
Carbon disulfide	33	1	18	.37	[4].05	—	—
Chlorobenzene	33	1	16	.028	[4].007	—	—
Tetrachloroethylene	33	1	14	.1	[4].047	5 (MCL)	—

[1] U.S. Environmental Protection Agency (2000).

[2] Also detected in two field blanks and one trip blank.

[3] Detected in both environmental sample and associated blanks.

[4] Estimated values.

rofluoromethane (CFC-11 or freon-11), a refrigerant, was detected in 9 of 33 ground-water samples at concentrations as great as 0.84 µg/L. CFCs also were collected by using a sampling apparatus that allowed water collection without contact with air and were analyzed by a technique that allows detection at much lower concentrations. The substantially lower concentrations of trichlorofluoromethane determined by this technique suggest that the regular samples were contaminated by atmospheric sources of CFCs or that the field or laboratory equipment was contaminated. The highest trichlorofluoromethane concentration observed by using the lower-detection analytical procedure was 20,000 pg/kg (approximately 0.02 µg/L). Results of CFC analyses are discussed in the section “Age Dating of Ground-Water Recharge.”

When toluene is excluded, water from 15 of 33 (or 45 percent of) wells sampled for organic constituents had at least one VOC detected, and 5 of those wells (5, 14, 15, 22, and 24) had at least one pesticide and at least one VOC detected. Water samples from 16 of the 32 wells that were sampled for both pesticides and VOCs had no pesticide or VOC detected.

ENVIRONMENTAL ISOTOPES

Isotopes are atoms of the same element that differ in mass because of a difference in the number of neutrons in their nuclei. The naturally occurring elements give rise to more than 1,000 radioactive and stable isotopes, commonly referred to as “environmental isotopes.”

Radioactive Isotopes

Radioactivity is the property possessed by some elements (such as uranium and thorium) or isotopes (such as carbon-14) of spontaneously emitting energetic particles by the disintegration of their atomic nuclei. Water samples were analyzed for the general presence of radioactivity by techniques used to determine gross-alpha and gross-beta emissions (table 11 and appendix 7). Also determined were the activity concentrations of several specific radiochemical constituents, including radon-222 and radium-224, -226, and -228. Tritium, a radioactive isotope of hydrogen

Table 11. Statistical summary of radioisotopes, environmental isotopes, and chlorofluorocarbon concentrations in water sampled from wells in Cook Inlet Basin, 1999

[Number in parentheses to left of constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. See table 2 regarding analytical methods used. CFC, chlorofluorocarbon; MCL, maximum contaminant level; PMCL, proposed maximum contaminant level; VSMOW, Vienna Standard Mean Ocean Water. <, less than; —, not detected, no criteria (or no separate criteria), or not applicable]

Survey network	Number of analyses	Concentration			Drinking-water standard[1]
		Minimum	Median	Maximum	
Radioactivity (picocuries per liter)					
(04126) Alpha radioactivity as thorium-230, dissolved:					
Subunit	29	<3	<3	5.4	—
Public supply	5	<3	<3	<3	—
—	—	—	—	—	15 (MCL)
(03515) Beta radioactivity as cesium-137, dissolved:					
Subunit	29	<4	<4	10	—
Public supply	5	<4	<4	4.8	—
Radium (picocuries per liter)					
(50833) Radium-224, dissolved:					
Subunit	29	<1	<1	<1	—
Public supply	5	<1	<1	<1	—
(09503) Radium-226, dissolved:					
Subunit	29	<1	<1	<1	—
Public supply	5	<1	<1	<1	—
(81366) Radium-228, dissolved:					
Subunit	28	<1	<1	<1	—
Public supply	5	<1	<1	<1	—
(09053; 81366) Radium-226 and -228, dissolved (combined):					
—	—	—	—	—	5 (MCL)
Radon (picocuries per liter)					
(82383) Radon-222, total:					
Subunit	26	140	260	610	—
Public supply	5	140	240	580	—
—	—	—	—	—	300 (PMCL)
Hydrogen and oxygen isotope ratios (per mil relative to VSMOW)					
(82082) Hydrogen-2/hydrogen-1 ratio:					
Subunit	25	-164	-130	-89	—
Public supply	4	-162	-136	-126	—
(82085) Oxygen-18/oxygen-16 ratio:					
Subunit	25	-21.3	-16.5	-9.1	—
Public supply	5	-21.1	-17.6	-16	—
Chlorofluorocarbons (picograms per kilogram)					
(50281) CFC-11:					
Subunit	25	—	20	20,000	—
Public supply	5	—	20	2,000	—
(50282) CFC-12:					
Subunit	25	1	100	3,000	—
Public supply	4	—	60	500	—
(50283) CFC-113:					
Subunit	25	—	5	90	—
Public supply	5	—	3	100	—

[1] U.S. Environmental Protection Agency (2000).

that has been added to the atmosphere by the detonation of nuclear bombs, also was analyzed to help determine the apparent age of ground-water samples and is discussed in the section “Age Dating of Ground-Water Recharge.”

Gross-alpha and gross-beta activities of dried residues of water samples and radionuclides of radon and radium are reported in radioactivity units (picocuries per liter), as thorium-230 and cesium-137, respectively. Such measurements of particle activities and analyses of radionuclides are preliminary screening procedures for the presence of radioactivity but do not identify the contributing radionuclides. Most gross-alpha and gross-beta particle activities observed were below their laboratory detection levels, 3 and 4 pCi/L, respectively (table 11 and appendix 7). The highest gross-alpha activity observed was 5.4 pCi/L as thorium-230, and the highest gross-beta particle activity observed was 10 pCi/L as cesium-137. The MCL for gross-alpha particle activity is 15 pCi/L. The MCL for gross-beta radioactivity is an effective dose equivalent to 4 millirem per year.

Alpha-emitting substances in natural water are mainly isotopes of radium and radon. Four isotopes of radium (radium-223, -224, -226, and -228) occur naturally and are all strongly radioactive. Radium is chemically similar to calcium and collects in bone tissue where it can induce bone cancers. The current drinking-water standard established for radium (radium-226 and radium-228 combined) is 5 pCi/L (U.S. Environmental Protection Agency, 2000). The concentration of radium in most natural waters is typically less than 1 pCi/L. All water samples from wells in the Cook Inlet Basin had radium-224, -226, and -228 activities less than the method detection limit of 1 pCi/L (table 11 and appendix 7).

Radon-222 is a naturally occurring radioactive gas that is produced by the decay of uranium. Rocks and sediments commonly contain high enough concentrations of uranium to cause ground water to have significant concentrations of radon. Radon is soluble in water but readily degasses from water when exposed to air. It may be adsorbed by organic matter, especially charcoal, but apparently it is not adsorbed to any degree by most minerals (Wanty and Nordstrom, 1993). Radon has a short half-life, 3.8 days, but large quantities can occur in the gas phase below the land surface. Direct ingestion of radon from drinking water appears not to be a serious health risk. Radon poses a more serious risk in indoor air; in water supplies, it quickly degasses when the water comes into contact with the atmosphere. The health risk of airborne radon arises from inhalation of radon and its alpha-emitting daughters, all of which may deposit on lung tissue and can lead to lung cancer. Radon was present in all water sampled from wells in the Cook Inlet Basin at activities ranging from 140 to 610 pCi/L. As of this writing, the USEPA does not regulate radon in drinking water. However, activities exceeded the proposed MCL of 300 pCi/L in 12 of 31 water samples. The national median radon activities from the first 20 NAWQA study units were 450 pCi/L for drinking-water aquifers and 470 pCi/L for shallow ground water (Gilliom and others, 1998, p. 19).

Uranium is present in concentrations of 0.1 to 10 µg/L in most natural water (Hem, 1985). When ingested, uranium may cause kidney damage or induce bone cancer. The MCL for uranium is 20 µg/L. All samples of ground water from the Cook Inlet Basin that were analyzed for uranium in this study had concentrations less than the method detection limit, 1 µg/L (table 8 and appendix 4).

Stable Isotopes of Hydrogen and Oxygen

The variation in the abundance of the stable isotopes of hydrogen, carbon, nitrogen, oxygen, silicon, and sulfur in natural substances is small. Determining the differences in the relative ratios of a less abundant isotope to its more abundant isotope in ground- and surface-water samples can help provide information on the source of the water, the interactions between surface and ground water, and the hydraulic properties of an aquifer. For this study, ratios of the stable isotopes of hydrogen and oxygen were determined to help characterize water in the aquifer.

Hydrogen is most commonly present as hydrogen-1 (^1H) but is also present as deuterium (^2H) and tritium (^3H). Tritium is a radioactive isotope and is discussed in the section “Age Dating of Ground-Water

Recharge." Oxygen most commonly is in the form oxygen-16 (^{16}O) but is also naturally present in the form oxygen-18 (^{18}O). Analytical results for the isotopes of hydrogen and oxygen (table 11 and appendix 8) are reported relative to a standard as delta (δ) values in units of parts per thousand (per mil). The δ notation expresses the parts-per-thousand difference in the ratio of the heavier less abundant isotope to the more abundant isotope in a sample relative to the same ratio in a reference standard:

$$\delta_{\text{sample}} = \left[\frac{(R_{\text{sample}} - R_{\text{standard}})}{R_{\text{standard}}}\right] \times 1000$$

where R_{sample} is the isotopic ratio $^{2}H/^{1}H$ or $^{18}O/^{16}O$ in the sample and R_{standard} is the isotopic ratio $^{2}H/^{1}H$ or $^{18}O/^{16}O$ in Vienna Standard Mean Ocean Water (VSMOW) (Freeze and Cherry, 1979, p. 137). A negative δ value indicates that the sample is depleted in the heavy isotope relative to the standard. Modern ocean water at low latitudes commonly has $\delta^{2}H$ and $\delta^{18}O$ values close to 0, relative to VSMOW. When water evaporates, the water vapor produced is depleted in the heavy isotopes ^{2}H and ^{18}O. The water vapor progressively is depleted in ^{2}H and ^{18}O as an air mass moves to higher latitudes and its temperature decreases, thereby causing the heavier isotopes to be precipitated preferentially. When the water vapor falls to the ground as precipitation and percolates through the unsaturated zone, its isotopic ratios change little. However, evaporation of water in lakes and streams enriches ^{2}H and ^{18}O in the remaining water, and the water vapor is further depleted in ^{2}H and ^{18}O. Globally, the relation between $\delta^{2}H$ and $\delta^{18}O$ in meteoric water (water of recent atmospheric origin) approximates $\delta^{2}H = 8\ \delta^{18}O + 10$, but in North America, the relation approximates $\delta^{2}H = 8\ \delta^{18}O + 6$.

All wells in the Cook Inlet Basin yielded water that had $\delta^{2}H$ and $\delta^{18}O$ values below the meteoric relation (fig. 4), as was expected because of the study area's high latitude and the low temperature of its precipitation. Best-fit lines of the measured data show a divergence from VSMOW, indicating possible evaporation of some of the water before recharge. The lowest isotopic values ($\delta^{2}H$ and $\delta^{18}O$ values less than -150 and less than -20 per mil relative to VSMOW, respectively) were from wells 24, 26, and 31 in the eastern Matanuska–Susitna area. Such values indicate that the sources of water recharge for these wells may have been more mountainous, cooler, more northern, or farther inland than other water sources or that the water had been deposited in glaciers during different climatic conditions. The Matanuska River may be a large source of recharge for these wells. About 12 percent of the 2,070-mi^{2} drainage area for the Matanuska River is covered by glaciers. Water from wells 2 and 15 had the highest $\delta^{18}O$ and $\delta^{2}H$ values, indicating the samples were least depleted in heavy isotopes relative to VSMOW. Some of the ground-water recharge to these two wells may have been from lakes or wetlands containing water enriched in deuterium and oxygen-18 by evaporation.

AGE DATING OF GROUND-WATER RECHARGE

Tritium and CFCs are two substances that have been added in large quantities to the atmosphere by man within the last 50 years. In the atmosphere, tritium and CFCs dissolve in water and fall to the Earth's surface in precipitation. Water infiltrating the ground contains these substances, and they are transported through aquifers at the same rate as ground water. The presence of tritium and CFCs in ground water can help determine the time elapsed since the water became isolated from the atmosphere, help infer flow velocity and direction, and help predict contamination potential (Plummer and Friedman, 1999). Most of the urban, commercial, and residential development in the Cook Inlet Basin has occurred within the last 50 years. Because the usage and distribution of petroleum products, fertilizers, pesticides, and septic-tank effluents were minimal more than 50 years ago and because many organic contaminants break down to other compounds over time in the natural environment, few organic contaminants are expected to be present in local waters that were recharged more than 50 years ago. However, wells that yield recently recharged water have water supplies that are susceptible to anthropogenic contaminants.

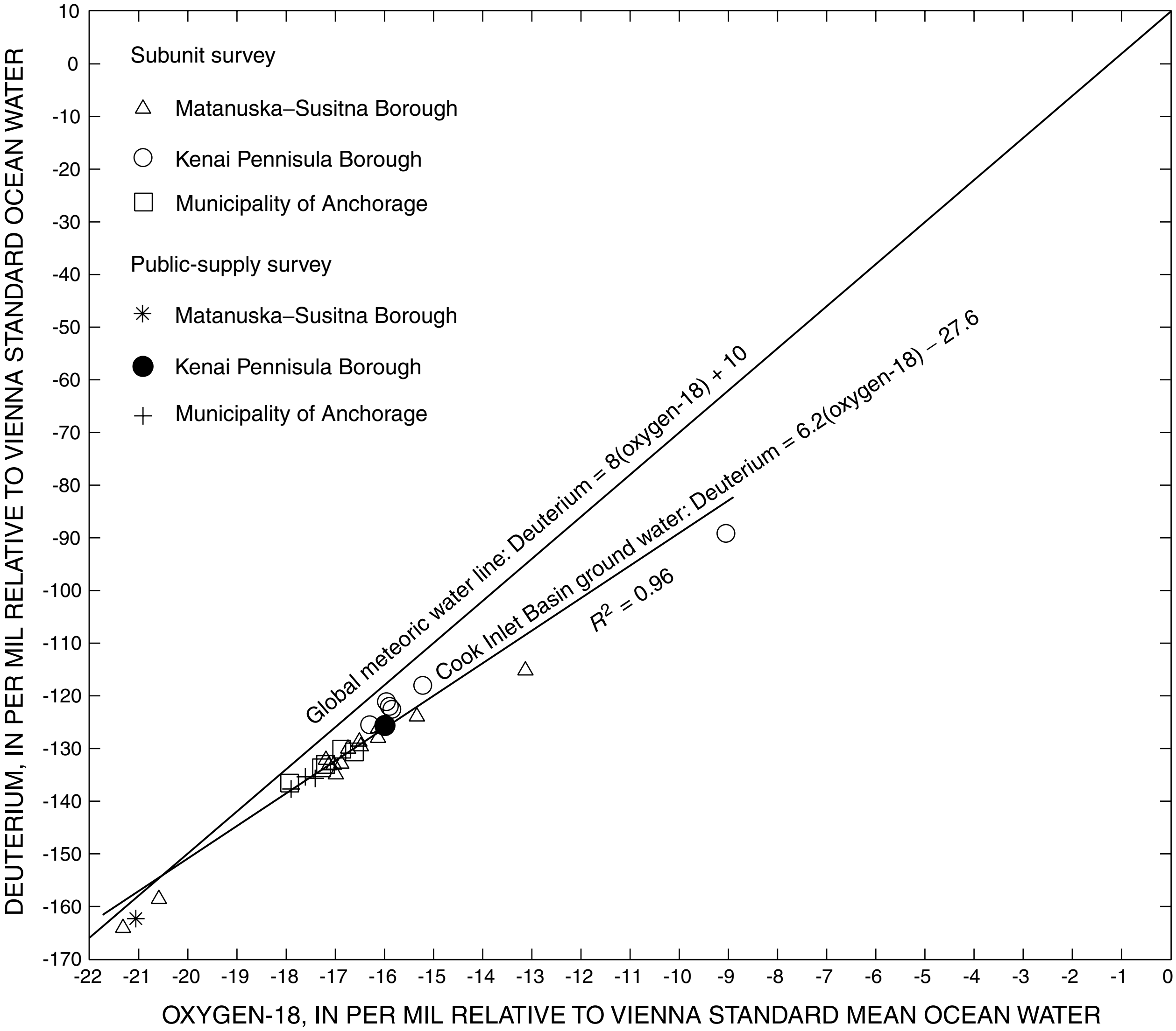


Figure 4. Isotope ratios of deuterium and oxygen-18 for water sampled from wells in Cook Inlet Basin, 1999.

Tritium

Tritium (^{3}H) is a radioactive isotope of hydrogen that has a half-life of about 12.4 years, is produced naturally, and decays to the stable isotope helium-3 (^{3}He). Prior to the initiation of atmospheric testing of nuclear weapons in 1953, the natural tritium content in precipitation was in the range of about 5 to 20 tritium units (TU) (Freeze and Cherry, 1979, p. 136). (A tritium unit is the equivalent of 1 tritium atom in 10^{18} atoms of hydrogen or an activity of 3.24 pCi/L.) During the last 50 years, the atmospheric testing of nuclear weapons has added tritium in amounts that far exceed the rate of natural production. Explosions of nuclear devices produced a maximum mean annual tritium concentration in precipitation during 1963–64 (about 8,000 TU in some parts on the northern hemisphere). Concentrations in precipitation in Anchorage (measured in monthly composite samples) had decreased to less than 100 TU as of 1975 and ranged from 4 to 17 TU during 1999 (International Atomic Energy Agency/World Meteorological Organization, 2001). Stewart and Hoffman (1966) estimated that the weighted-average tritium rainout concentration for Palmer, Alaska, had been 2,950 TU during 1963, which would have decayed to about one-eighth of this activity by 1999. Water recharged after 1963 may contain tritium at activity concentrations of 2 to 400 TU.

Water samples containing no detectable concentrations of tritium may indicate that post-1953 water is not present in significant amounts.

Measured tritium activities in ground water samples from Cook Inlet Basin during 1999 ranged from less than 1 to 35 TU and had a median value of 12 TU. Apparent ground-water ages (age since recharge) listed in appendix 9 were estimated by personnel from the Lamont–Doherty Earth Observatory (Peter Schlosser and others, written commun., 2000) by simultaneously using activities of tritium and its decay product, helium-3. This technique, described by Schlosser (1992) and Busenberg and Plummer (1992), allows a more accurate estimate of time elapsed since recharge because, together, tritium and helium-3 permit reconstruction of the initial tritium concentration before radioactive decay begins. The upper and lower estimates of ground-water recharge ages based on the tritium–helium content in the first sample analyzed for each site (recharge age ± precision estimate) are shown in figure 5. Apparent ages were estimated to range from less than 1 to greater than 50 years, and median ages, approximately 19 and 16 years for water from the subunit and public-supply surveys, respectively. However, wells yielding water having low tritium concentrations are difficult to date accurately and thus have wide ranges in their apparent ages. Of 31 wells, 8 yielded water that may have been recharged within the last than 10 years, and only 3 (wells 6, 16, and 35) yielded water that may have been recharged greater than 50 years ago and thus before nuclear testing, on the basis of their tritium activities.

Chlorofluorocarbons

CFCs are a group of stable manmade compounds containing chlorine and fluorine that have been used in numerous domestic and industrial applications since the 1930s and do not occur naturally in the environment. Atmospheric CFCs dissolve in precipitation and enter the ground-water flow systems with recharge; thus, like tritium, they provide excellent tracers and tools for dating “young” water. Because CFCs do not occur naturally in the environment, ground water containing any amount of CFC must have a component of modern recharge water.

CFCs were used as coolants in air conditioning; as propellants in aerosol cans; as blowing agents for open- and closed-cell foams, insulation, and packing materials; and as solvents. However, the manufacturing of most CFC products ended in 1996 because of concerns about CFCs depleting ozone in the stratosphere. For this study, three types of CFCs were analyzed: CFC-11 (trichlorofluoromethane or freon-11), CFC-12 (dichlorodifluoromethane), and CFC-113 (1,1,2-trichlorotrifluoroethane). CFC-11 and CFC-12 are gases at ordinary temperatures that normally volatilize when released and accumulate in the atmosphere, whereas CFC-113 is a liquid at ordinary temperatures.

Concentrations of CFCs are measured in the air at Barrow, Alaska, by the National Oceanic and Atmospheric Administration Climate Monitoring and Diagnostics Laboratory. During 1999, atmospheric concentrations of CFC-11, CFC-12, and CFC-13 were 263–267, 533–537, and 81–83 parts per trillion by volume, respectively (National Oceanic and Atmospheric Administration, 2001). However, CFC concentrations in the COOK study unit may have been greater than the concentrations at Barrow because Cook Inlet Basin is much more populated and hence the total amount of CFC used in the basin is much greater than that used in Barrow. Even though the concentration of CFC-12 was nearly twice that of CFC-11, the solubilities in water are reversed. The solubility of CFC-11 in water in equilibrium with 1999 atmosphere is approximately 1,300 pg/kg, compared with about 520 pg/kg for CFC-12 (calculated assuming a recharge temperature of 2°C).

Relative ages of ground-water recharge can be determined by using the known solubilities of CFCs in water and historical data on the concentrations of CFCs in the atmosphere (Busenberg and Plummer, 1992; Plummer and Busenberg, 1999). For this study, concentrations of CFCs were determined by techniques that allow detection at extremely low levels, about 0.3 pg/kg (equivalent to 3×10^{-13} g/kg, or 0.3 parts per quadrillion). For water recharged through relatively thin unsaturated zones, concentrations near the detection limit for CFC-11, CFC-12, and CFC-113 indicate ground-water recharge since approximately 1941, 1947, and 1955, respectively, or ground-water mixtures containing a fraction of post-1940s water. If CFCs are present in a ground-water sample, the water is considered to be “modern”; if a concentration in the sample is greater than that possible for equilibrium with the air, the sample is referred to as “contaminated.”

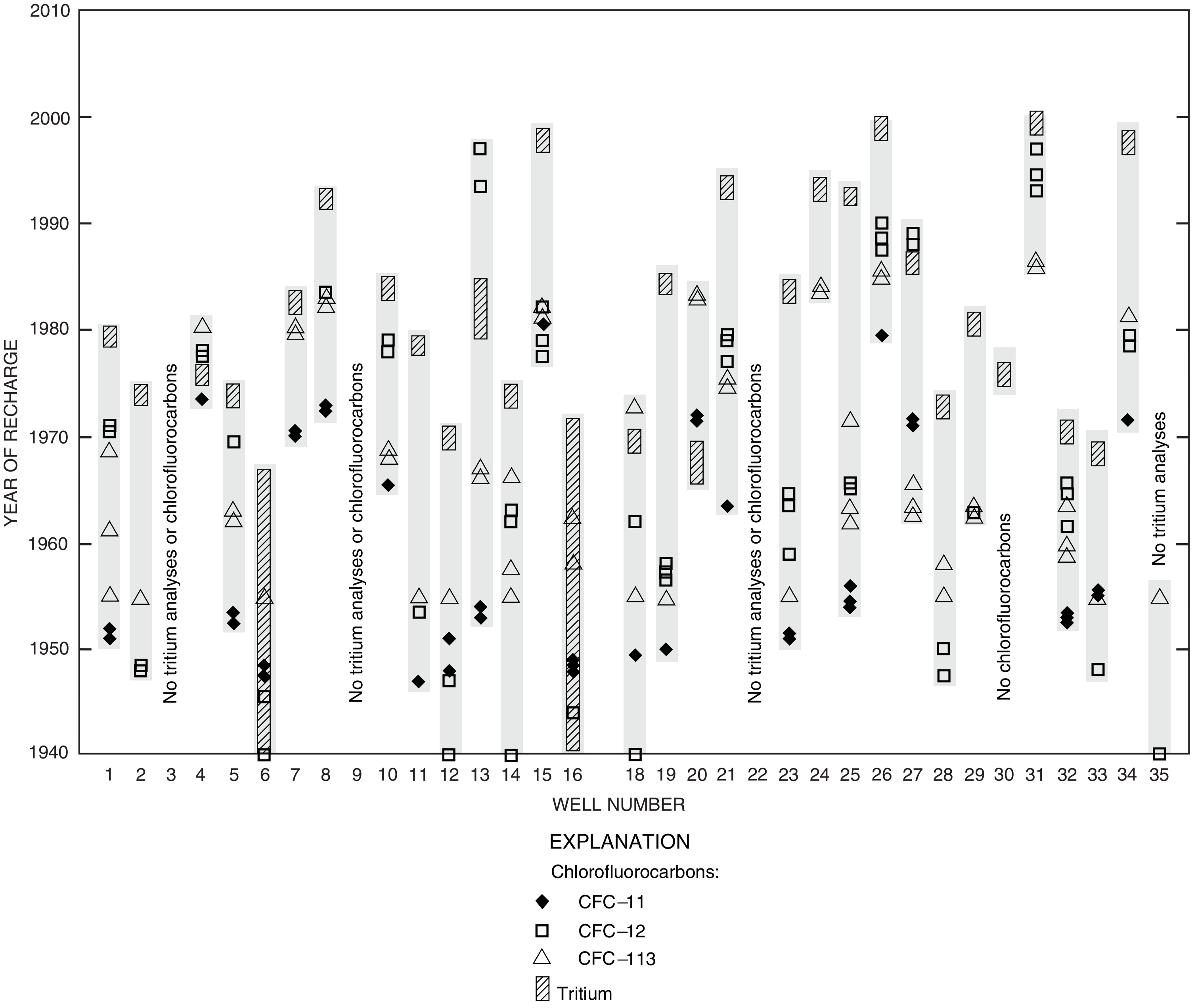


Figure 5. Dates of recharge determined by using chlorofluorocarbon and tritium analyses of water from wells in Cook Inlet Basin, 1999.

However, several processes can affect CFC concentrations and estimations of apparent age (Busenberg and Plummer, 1992; Plummer and Busenberg, 1999). Peat and other organic materials present throughout the study unit can adsorb CFCs; the resulting decrease in amounts that reach the used parts of the aquifers produces an older apparent age for recharge. Microbes can also degrade CFCs when the water in the aquifer contains little dissolved oxygen. In anoxic environments, CFC-11 degrades at the fastest rate, succeeded by CFC-113 and then by CFC-12. Under anoxic conditions, some or all the ages appear older than they actually are. CFCs also are degraded by methane. Effluent from domestic septic tanks may contain CFCs and increase CFC concentrations in recharge water and make the water appear younger. Because CFCs are present in the air, a special sampling apparatus that prevents contact of the water sample with air was used. A borosilicate ampule was flushed with ultrapure nitrogen gas and then with well water; then the ampule was flame sealed, thereby leaving a nitrogen-filled head space.

Five ampules were filled at most sites; typically water from three were analyzed by personnel from the USGS Chlorofluorocarbon Laboratory in Reston, Va. (G.C. Casile, written commun., 2000) to determine concentrations of CFC-11, CFC-12, and CFC-113 and apparent ages. Apparent ages based on the concentrations of CFCs in water from each ampule analyzed are shown in figure 5; values for the average CFC concentrations for each site are listed in appendix 10 and are stored in the USGS National Water Information System data base. Almost all wells yielded water containing detectable concentrations of CFCs. Water from well 35 had no detectable CFCs but was anoxic and chemically reduced. CFC concentrations in water samples that are greater than possible for equilibrium with modern air are referred to as “contaminated” (see appendix 10) and were not used to determine apparent age. By this definition, ground water from urban areas commonly is “contaminated” with CFCs; a likely source of CFC contamination is effluent from domestic septic tanks. However, all CFC concentrations detected were less than 0.1 µg/L and present no risk to human health. Apparent ages based on concentrations of the three types of CFCs analyzed ranged from 7 to greater than 50 years old, and the median age was about 34 years old.

Of 31 sites sampled to determine age of recharge, 29 had both CFC and tritium analyses. Of 29 samples, 24 had tritium-based apparent ages that were younger than their CFC-based ages. Differences in ages for water samples from the same well ranged from a CFC-based age that was about 15 years younger than the tritium-based age to a CFC-based age that was about 30 years older than the tritium-based age; the standard deviation between paired CFC- and tritium-based ages was 11 years. These differences suggest that CFCs were not as conservative as tritium in the Cook Inlet aquifer system’s hydrogeologic environment. CFC-12, the most conservative of the three CFCs, yielded ages closest to the tritium-based ages (fig. 5). CFC-11 and CFC-113 analyses may overestimate ground-water age owing to their greater absorption by peat, degradation by microbes, or reduction during sampling. Typically, CFC-11 is more susceptible to degradation and therefore the computed ages of recharge based on CFC-11 are most likely older than actual recharge. Accordingly, if CFC-11 ages are considered maximum ages, most wells sampled yielded water that was recharged less than 50 years ago.

SUMMARY

A regional assessment of ground-water quality in the Cook Inlet Basin in south-central Alaska during 1999 was based on analyses of water collected from 34 wells. Water from several wells screened in the unconsolidated aquifers in Cook Inlet Basin contained concentrations of radon and arsenic that exceeded proposed drinking-water standards. Of the 34 wells sampled, 39 percent yielded water having radon concentrations in excess of the USEPA proposed MCL of 300 pCi/L, and 18 percent had dissolved arsenic concentrations that exceeded the proposed MCL of 10 µg/L. The highest concentrations of radon and arsenic measured during this study were 610 pCi/L and 29 µg/L, respectively. Concentrations greater than proposed standards for both radon and arsenic were observed in ground water in the Kenai, Anchorage, and Matanuska–Susitna areas. Concentrations of manganese, iron, and dissolved solids exceeded USEPA SMCLs in water from 42, 18, and 6 percent of wells sampled, respectively. Concentrations of arsenic, radon, manganese, iron, and dissolved solids are related to the geologic materials that make up the aquifers and the chemical conditions within the aquifers.

Most wells that yielded water having elevated concentrations of arsenic also yielded water having elevated iron and manganese content but had low concentrations of oxygen, indicating chemically reduced conditions.

Ground-water samples collected in the Anchorage and Matanuska–Susitna areas typically had calcium as the dominant cation and bicarbonate as the dominant anion. Water near the Matanuska River had higher proportions of sulfate than water in other areas. Water from wells on the Kenai Peninsula typically had the highest proportions of sodium, chloride, and silica. Wells completed in a confined aquifer near the mouth of the Kenai River yielded water having the highest concentrations of dissolved solids, sodium, chloride, and barium. Concentrations of nitrate were highest in Anchorage and were as large as 4.8 mg/L as N; none exceeded the MCL of 10 mg/L as N. The presence of nitrate in water at concentrations above 3 mg/L in the eastern part of Anchorage may indicate some effects of human activities on the water quality.

Half of the wells sampled for both pesticides and VOCs had no detectable pesticides or VOCs. Of 11 pesticide compounds detected at very low concentrations, the largest concentration was estimated to be 0.007 µg/L. Nine VOCs were detected, all at concentrations of less than 1 µg/L. No pesticides or VOCs were detected at concentrations exceeding MCLs or health advisories. These low values for concentrations of pesticides and VOCs in ground water throughout the study unit indicate no widespread contamination of ground water.

Concentrations of hydrogen and oxygen isotopes in ground-water samples were similar to concentrations expected for modern precipitation and for water that has been affected by evaporation before infiltration. Water samples from most wells in the Cook Inlet Basin yielded values for tritium activities and CFC concentrations that support recharge ages of less than 50 years. Because ages based on tritium activities generally were younger than those based on CFC concentrations, CFCs may have been absorbed by organic materials in soils or aquifer materials or degraded by microbes.

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APPENDIXES

Appendix 1. Physical properties and field measurements for water sampled from wells in Cook Inlet Basin,1999

[Well number: See table 1 and fig. 2. Number in parentheses above property or constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; > greater than]

Well number	Date of sample collection	(72004) Duration of pumpage prior to sampling (minutes)	(00059) Flow rate (gallons per minute)	(00010) Water temperature (degrees Celsius)	(00400) pH (standard units)	(00300) Dissolved oxygen (milligrams per liter)	(00095) Specific conductance (microsiemens per centimeter)	(39086) Alkalinity (milligrams per liter as $CaCO_3$)
Subunit survey								
1	08/27/99	60	5	3.5	7.0	0.3	130	58
2	08/10/99	30	8	5.0	7.3	.2	77	45
3	08/27/99	30	10	5.0	8.3	.1	1,750	384
4	09/01/99	60	[1]30	4.0	6.7	6.0	84	34
5	09/21/99	60	5	6.5	6.7	.2	415	92
6	07/28/99	60	10	3.5	8.0	.1	265	150
7	08/03/99	60	5	5.0	8.1	7.6	230	111
8	08/03/99	45	5	4.0	7.7	9.4	298	173
9	08/11/99	90	5	9.5	8.0	.2	946	146
10	08/09/99	60	8	4.0	7.0	2.4	146	55
11	08/10/99	60	5	4.5	7.2	.2	118	66
12	07/27/99	105	[1]5	3.0	7.7	.1	280	142
13	07/26/99	60	500	3.5	8.0	.4	290	143
14	08/04/99	30	45	5.0	7.7	.2	401	207
15	08/06/99	60	7	8.5	6.9	1.2	117	63
16	09/13/99	60	6	4.0	8.0	.1	164	91
18	08/06/99	40	5	4.5	6.9	.1	180	97
19	08/04/99	30	8	4.5	8.2	4.6	263	128
20	08/02/99	90	10	5.5	7.8	9.6	307	151
21	07/30/99	>300,000	725	4.5	7.9	5.5	210	97
22	08/25/99	90	5	3.5	8.2	11.0	240	128
23	07/27/99	90	[1]5	5.5	8.2	1.9	255	91
24	09/29/99	60	5	4.0	7.4	9.0	450	165
25	09/15/99	30	5	3.5	8.0	8.0	225	113
26	08/31/99	30	5	4.5	7.9	11.8	300	88
27	08/30/99	35	5	4.0	7.9	7.0	260	130
28	08/16/99	60	5	4.0	8.0	.2	237	129
29	08/23/99	75	6	4.0	7.7	.6	270	145
30	10/20/99	75	10	4.0	8.3	.5	250	127
Public-supply survey								
31	08/24/99	30	1,200	4.0	7.6	11.0	310	100
32	07/26/99	90	1,400	4.0	8.0	1	209	103
33	07/21/99	210	1,800	2.5	8.4	1.6	177	90
34	07/23/99	200	1,200	4.0	7.1	9.4	168	77
35	08/11/99	>90	650	5.0	8.1	<.1	201	100

[1] Estimated values

Appendix 2. Concentrations of major ions in water sampled from wells in Cook Inlet Basin,1999

[Well number: See table 1 and fig. 2. Number in parentheses above constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. Highlighted values exceed a water-quality standard. National median concentrations for drinking-water aquifers are from Gilliom and others (1998). <, less than; —, not analyzed, unknown, or not applicable]

Well number	Concentration (milligrams per liter)										
	(00915) Calcium	(00925) Magnesium	(00930) Sodium	(00935) Potassium	(00453) Bicarbonate, as HCO_3	(00945) Sulfate	(00940) Chloride	(00950) Fluoride	(71870) Bromide	(00955) Silica	(70300) Dissolved solids, residue at 180°C
Subunit survey											
1	12	6.0	5.7	3.2	71	2.1	4.3	<.1	0.02	34	104
2	7.9	3.7	4.9	1.8	55	.16	3.3	<.1	.01	37	83
3	4.4	5.0	360	9.9	468	<.1	**500**	<.1	.87	44	**986**
4	11	2.1	3.6	1.1	42	1	6.1	<.1	<.01	29	77
5	40	11	15	3.5	113	3.2	77	<.1	.05	31	268
6	38	8.7	11	2.2	182	<.1	1.1	<.1	<.01	15	169
7	45	2.9	2.0	.52	135	<.1	2.1	<.1	<.01	12	145
8	52	6.5	6.5	.87	211	<.1	1.1	<.1	.02	14	180
9	25	18	127	13	178	.33	210	.12	.36	44	**549**
10	14	6.4	5.0	1.9	66	1.3	12	<.1	.03	26	99
11	14	5.6	5.2	2.2	81	1.7	3.5	<.1	.06	30	96
12	44	8.7	3.5	1.4	173	8.7	2.9	<.1	.02	26	184
13	41	13	4.2	1.2	174	7.3	4.0	<.1	<.01	15	163
14	72	9.4	3.6	.95	253	2.7	5.0	<.1	.04	18	218
15	19	3.4	2.6	.25	77	1.5	2.0	<.1	<.01	8.4	85
16	22	5.5	4.8	.79	111	2	1.3	.15	<.01	15	102
18	23	5.8	3.4	.91	118	.88	17	<.1	<.01	26	154
19	47	5.5	3.1	.93	156	8.8	2.8	<.1	.02	10	163
20	55	7.1	2.1	2.9	184	9.9	3.4	<.1	.02	12	184
21	36	6.1	2.4	.49	118	19	1.5	<.1	<.01	11	138
22	48	8.5	3.2	.55	156	12	4.9	<.1	.01	12	172
23	32	12	2.7	.84	111	11	10	<.1	.03	12	164
24	77	9.2	7.6	1.0	200	52	11	<.1	.02	8	275
25	38	4.7	2.4	.76	138	6.9	1.5	<.1	<.01	12	134
26	49	4.7	6.9	.87	108	55	4.3	<.1	.01	5.9	198
27	45	5.6	3.6	.83	159	5.3	3.8	<.1	<.01	12	159
28	40	5.6	3.6	.90	157	3.8	2.3	<.1	<.01	12	147
29	44	6.4	3.2	1.0	177	—	—	—	—	14	—
30	44	6.1	4.7	.75	155	7.6	5.1	<.1	<.01	11	152
Public-supply survey											
31	56	5.7	7.7	0.89	122	62	6.5	<.1	.01	6.3	213
32	30	7.7	3.8	1.0	126	11	.6	<.1	.01	12	127
33	25	7.3	3.2	.90	110	7.1	2.0	<.1	.02	13	119
34	—	—	—	—	94	—	—	—	—	—	—
35	6.3	4.1	34	4.2	122	.3	9.3	.25	<.01	46	167
National median concentration for drinking-water aquifers											
—	—	—	—	—	—	—	—	—	—	—	298

Appendix 3. Concentrations of nutrients and dissolved organic carbon in water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. Number in parentheses above property or constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. National median concentrations for major aquifers are from Nolan and Stoner (2000). <, less than; —, not applicable]

Well number	Concentrations (milligrams per liter)						
	(00608) Ammonia, as N	(00623) Ammonia + organic nitrogen, as N	(00631) Nitrite + nitrate, as N	(00613) Nitrite, as N	(00666) Phosphorus, as P	(00671) Orthophosphate, as P	(00681) Dissolved organic carbon
Subunit survey							
1	<0.02	<.1	0.12	<.01	0.057	0.055	0.8
2	.1	.14	<.05	<.01	.218	.211	.8
3	.82	.82	<.05	<.01	.115	.125	1.2
4	<.02	<.1	.07	<.01	.016	.017	1.1
5	<.02	[1].1	<.05	<.01	<.004	<.01	1.2
6	.19	.25	<.05	<.01	.117	.103	1.7
7	<.02	.11	1.9	<.01	<.004	<.01	.5
8	<.02	[1].1	.48	<.01	<.004	<.01	.8
9	.8	.73	<.05	<.01	.384	.429	1.7
10	<.02	<.1	.21	<.01	.020	.015	.6
11	<.02	<.1	<.05	<.01	.037	.032	.8
12	.12	.13	<.05	<.01	.077	.062	.8
13	.03	<.1	<.05	<.01	.031	.021	1.1
14	<.02	<.1	.12	<.01	.004	<.01	2.1
15	<.02	<.1	<.05	<.01	<.004	<.01	.7
16	.11	.17	<.05	<.01	.100	.087	.8
18	.35	.36	<.05	.01	<.004	.014	1.4
19	<.02	<.1	.81	<.01	<.004	<.01	1.0
20	<.02	<.1	.44	<.01	<.004	<.01	.9
21	<.02	<.1	.56	<.01	<.004	<.01	.3
22	<.02	.1	3.5	<.01	<.004	<.01	.6
23	<.02	[1].1	4.8	<.01	.011	.012	1.0
24	<.02	[1].1	1.8	<.01	<.006	.012	.6
25	<.02	<.1	.37	<.01	.026	.018	.8
26	<.02	<.1	.50	<.01	<.004	<.01	.9
27	<.02	<.1	.91	<.01	.006	<.01	.9
28	<.02	<.1	.15	.01	.009	<.01	.8
29	.05	.12	.17	<.01	.012	<.01	.9
30	.03	.14	<.05	<.01	.011	.01	1.0
Public-supply survey							
31	<0.02	<0.1	0.58	<0.01	<0.004	<0.01	0.4
32	<.02	<.1	.19	<.01	.014	<.01	.3
33	<.02	[1].1	.25	<.01	.014	.019	.3
34	<.02	[1].1	2.5	<.01	<.004	<.01	.6
35	.31	.31	<.05	<.01	.370	.446	1.9
National median concentration for major aquifers							
—	0.02	<0.2	0.48	<0.01	—	0.01	—

[1] Estimated values.

Appendix 4. Concentrations of trace elements in water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. Number in parentheses above constituent is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. Highlighted values exceed a drinking-water-quality standard or a proposed standard. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)																		
	(01106) Aluminum	(01095) Antimony	(01000) Arsenic	(01005) Barium	(01010) Beryllium	(01025) Cadmium	(01030) Chromium	(01035) Cobalt	(01040) Copper	(01046) Iron	(01049) Lead	(01056) Manganese[2] First method	(01056) Manganese[2] Second method	(01060) Molybdenum	(01065) Nickel	(01145) Selenium	(01075) Silver	(22703) Uranium	(01090) Zinc
Subunit survey																			
1	<1	<1	6	1.8	<1	<1	<1	<1	<1	**390**	<1	28	30	<1	1.2	<1	<1	<1	1.8
2	<1	<1	**19**	8.7	<1	<1	<1	<1	<1	**1,100**	<1	**590**	**541**	<1	<1	<1	<1	<1	56
3	1.4	<1	2	133	<1	<1	<1	<1	<1	160	<1	28	29	<1	<1	<1	<1	<1	21
4	1.4	<1	<1	3.9	<1	<1	<1	<1	1	[1]7	<1	**68**	**65**	<1	<1	<1	<1	<1	12
5	<1	<1	3	65	<1	<1	<1	<1	<1	**7,300**	<1	**290**	**295**	<1	<1	<1	<1	<1	1.0
6	2.5	<1	**15**	23	<1	<1	<1	<1	<1	[1]5	<1	**120**	**108**	2.4	<1	<1	<1	<1	39
7	<1	<1	1	6.8	<1	<1	<1	<1	15	<10	<1	<3	<1	<1	1.1	<1	<1	<1	4.8
8	<1	<1	1	9.4	<1	<1	<1	<1	1.3	<10	<1	<3	<1	<1	1.4	<1	<1	<1	16
9	<1	<1	**22**	106	<1	<1	<1	<1	<1	180	<1	**280**	**288**	<1	<1	<1	<1	<1	9.9
10	<1	<1	3	1.3	<1	<1	<1	<1	10	[1]9	<1	<3	<1	<1	<1	<1	<1	<1	1.6
11	<1	<1	6	26	<1	<1	<1	<1	<1	**1,100**	<1	**67**	**63**	<1	<1	<1	<1	<1	4.4
12	<1	<1	1	7.9	<1	<1	<1	<1	<1	110	<1	**580**	**591**	<1	<1	<1	<1	<1	76
13	<1	<1	**10**	43	<1	<1	<1	<1	<1	**330**	<1	**180**	**170**	1.5	<1	<1	<1	<1	1.5
14	<1	<1	3	21	<1	<1	—	<1	<1	[1]9	<1	**170**	**157**	<1	1.9	<1	<1	<1	5.8
15	<1	<1	<1	2.7	<1	<1	—	<1	8.3	48	<1	[1]2	3	<1	<1	<1	<1	<1	25
16	<1	<1	2	5.7	<1	<1	<1	<1	1.8	[1]7	5	**100**	**102**	1.8	<1	<1	<1	<1	18
18	<1	<1	**29**	18	<1	<1	—	1.8	<1	**18,000**	<1	**1,500**	**1,460**	<1	1.1	<1	<1	<1	9.3
19	<1	<1	<1	9.0	<1	<1	—	<1	4.1	<10	<1	<3	<1	<1	1.1	<1	<1	<1	20
20	<1	<1	<1	7.6	<1	<1	1.1	<1	1.3	<10	<1	<3	<1	<1	1.5	<1	<1	<1	23
21	<1	<1	<1	3.3	<1	<1	<1	<1	<1	<10	<1	<3	<1	<1	<1	<1	<1	<1	3.8
22	4.9	<1	<1	7.9	<1	<1	2.1	<1	3.1	<10	<1	<3	<1	<1	<1	<1	<1	<1	56
23	<1	<1	1	9.6	<1	<1	3	<1	8.8	<10	<1	<3	<1	<1	<1	<1	<1	<1	20
24	<1	<1	<2	34	<1	<1	<.8	<1	1.2	<10	<1	<2	<1	<1	1.1	<2	<1	<1	1.1
25	1.7	<1	2	3.5	<1	<1	<1	<1	12	<10	<1	<2	<1	<1	1	<1	<1	<1	48
26	1.4	<1	<1	13	<1	<1	<1	<1	3.6	[1]5	<1	<3	<1	1.5	1.3	<1	<1	<1	<1
27	<1	<1	2	9.1	<1	<1	<1	<1	14	<10	<1	<3	<1	<1	1.2	<1	<1	<1	8.1
28	1.4	<1	1	8.1	<1	<1	—	<1	3	<10	<1	**58**	**55**	<1	<1	1	<1	<1	16
29	<1	<1	<1	30	<1	<1	<1	<1	<1	63	<1	**79**	**76**	<1	1.3	<1	<1	<1	22
30	1.4	<1	7	16	<1	<1	<.8	<1	<1	85	<1	**52**	**48**	<1	<1	<2	<1	<1	10
Public-supply survey																			
31	1.2	<1	<1	19	<1	<1	<1	<1	<1	<10	<1	<3	<1	1.4	1.8	<1	<1	<1	1.3
32	<1	<1	<1	3.8	<1	<1	<1	<1	<1	<10	<1	<3	<1	<1	<1	<1	<1	<1	2.1
33	<1	<1	1	2.8	<1	<1	1	<1	<1	<10	<1	<3	<1	1.6	<1	1	<1	<1	1.0
34	1.2	<1	<1	5.8	<1	<1	<1	<1	1.6	—	<1	—	<1	<1	<1	<1	<1	<1	1.3
35	1.1	<1	**24**	52	<1	<1	<1	<1	<1	87	<1	38	38	2.1	<1	<1	<1	<1	<1

[1] Estimated values.

[2] Concentrations of manganese were determined by using two methods.

Appendix 5. Concentrations of pesticides in water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(82660) 2,6-Diethylaniline	(49260) Acetochlor	(46342) Alachlor	(39632) Atrazine	(04040) Deethylatrazine	(82686) Methyl azinphos	(82673) Benfluralin	(04028) Butylate	(82680) Carbaryl	(82674) Carbofuran	(38933) Chlorpyrifos	(04041) Cyanazine	(82682) Dacthal (DCPA)	(34653) *p,p'*-DDE	(39572) Diazinon
Subunit survey															
1	<0.003	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.003	<0.003	<0.004	<0.004	<0.002	<0.006	<0.002
2	<.003	<.002	<.002	<.001	<.002	<.02	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
3	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
4	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	[1].002	<.002
5	<.003	<.002	<.002	<.001	<.002	[1].007	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
6	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
7	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
8	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
9	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
10	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
11	<.003	<.002	<.002	<.001	[1].0015	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
12	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
13	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
14	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
15	<.003	<.002	<.002	<.074	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
16	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
18	<.003	<.002	<.002	<.001	<.002	<.02	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
19	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
20	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
23	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
24	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	[1].002	<.002
25	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
26	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
27	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
28	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
29	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
30	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
Public-supply survey															
31	<0.003	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.003	<0.003	<0.004	<0.004	<0.002	[1]0.002	<0.002
32	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
32	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
34	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002
35	<.003	<.002	<.002	<.001	<.002	<.001	<.002	<.002	<.003	<.003	<.004	<.004	<.002	<.006	<.002

Appendix 5. Concentrations of pesticides in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(39381) Dieldrin	(82677) Disulfoton	(82668) EPTC	(82663) Ethalfluralin	(82672) Ethoprophos	(04095) Fonofos	(34253) alpha-HCH	(39341) Lindane	(82666) Linuron	(39532) Malathion	(82667) Methyl parathion	(39415) Metolachlor	(82630) Metribuzin	(82671) Molinate	(82684) Naprop amide
Subunit survey															
1	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	<0.002	<0.004	<0.002	<0.005	<0.006	<0.002	<0.004	<0.004	<0.003
2	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
3	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
4	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
5	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
6	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
7	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
8	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
9	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
10	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
11	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
12	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
13	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
14	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
15	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
16	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
18	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
19	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
20	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
23	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
24	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
25	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
26	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
27	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
28	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
29	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
30	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
Public-supply survey															
31	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	<0.002	<0.004	<0.002	<0.005	<0.006	<0.002	<0.004	<0.004	<0.003
32	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
32	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
34	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003
35	<.001	<.017	<.002	<.004	<.003	<.003	<.002	<.004	<.002	<.005	<.006	<.002	<.004	<.004	<.003

Appendix 5. Concentrations of pesticides in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(39542) Parathion	(82669) Pebulate	(82683) Pendimethalin	(82687) cis-Permethrin	(82664) Phorate	(04037) Prometon	(82676) Pronamide	(04024) Propachlor	(82679) Propanil	(82685) Propargite	(04035) Simazine	(82670) Tebuthiuron	(82665) Terbacil	(82675) Terbufos	(82681) Thiobencarb
Subunit survey															
1	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003	<0.007	<0.004	<0.013	<0.005	<0.01	<0.007	<0.013	<0.002
2	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
3	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
4	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
5	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
6	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
7	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
8	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
9	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
10	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
11	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	[1].002	<.013	<.005	[1].004	<.007	<.013	<.002
12	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
13	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
14	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
15	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
16	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
18	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
19	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
20	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
23	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
24	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	--	<.005	<.01	<.007	<.013	<.002
25	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
26	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
27	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
28	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
29	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
30	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.080	<.005	<.01	<.007	<.013	<.002
Public-supply survey															
31	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003	<0.007	<0.004	<0.013	<0.005	<0.077	<0.007	<0.013	<0.002
32	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
32	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.077	<.007	<.013	<.002
34	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002
35	<.004	<.004	<.004	<.005	<.002	<.018	<.003	<.007	<.004	<.013	<.005	<.01	<.007	<.013	<.002

Appendix 5. Concentrations of pesticides in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(82678) Triallate	(82661) Trifluralin	(39732) 2,4-D	(38746) 2,4-DB	(49310) Carbaryl	(49309) Carbofuran	(49308) 3-Hydroxycarbofuran	(49315) Acifluorfen	(49312) Aldicarb	(49313) Aldicarb sulfone	(49314) Aldicarb sulfoxide	(38711) Bentazon	(61693) Methyl bensul furon	(04029) Bromacil	(49311) Bromoxynil
Subunit survey															
1	<0.001	<0.002	<0.077	<0.054	<0.063	<0.057	<0.062	<0.062	<0.082	<0.16	<0.027	<0.019	<0.048	<0.081	<0.057
2	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
3	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
4	<.001	<.002	<.077	<.054	<.063	<.057	<.062	—	<.082	<.16	<.027	<.019	<.048	<.081	<.057
5	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
6	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
7	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
8	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
9	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
10	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
11	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
12	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
13	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
14	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
15	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
16	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
18	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
19	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
20	<.001	<.002	—	—	—	—	—	—	—	—	—	—	—	—	—
21	—	—	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
22	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
23	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
24	<.001	<.002	<.077	<.054	<.063	[1].0008	[1].0013	—	<.082	<.16	<.027	<.019	<.048	<.081	<.057
25	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
26	<.001	<.002	<.077	<.054	<.063	<.057	<.062	—	<.082	<.16	<.027	<.019	<.048	<.081	<.057
27	<.001	<.002	<.077	<.054	<.063	<.057	<.062	—	<.082	<.16	<.027	<.019	<.048	<.081	<.057
28	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
29	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
30	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
Public-supply survey															
31	<0.001	<0.002	<0.077	<0.054	<0.063	<0.057	<0.062	<0.062	<0.082	<0.16	<0.027	<0.019	<0.048	<0.081	<0.057
32	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
32	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
34	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057
35	<.001	<.002	<.077	<.054	<.063	<.057	<.062	<.062	<.082	<.16	<.027	<.019	<.048	<.081	<.057

Appendix 5. Concentrations of pesticides in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(49306) Chlorothalonil	(49305) Clopyralid	(49304) Dacthal monoacid	(38442) Dicamba	(49302) Dichlorprop	(49301) Dinoseb	(49300) Diuron	(49297) Fenuron	(38811) Fluometuron	(61694) Flumetsulam	(61695) Imidacloprid	(38482) MCPA	(38487) MCPB	(38501) Methiocarb	(61696) Methomyloxime
Subunit survey															
1	<0.049	<0.041	<0.072	<0.096	<0.05	<0.043	<0.079	<0.074	<0.062	<0.087	<0.106	<0.059	<0.063	<0.08	<0.01
2	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
3	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
4	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
5	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
6	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
7	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
8	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
9	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
10	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
11	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
12	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
13	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
14	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	[1].007	<.087	<.106	<.059	<.063	<.08	<.01
15	<.049	<.041	<.072	<.096	<.05	<.043	[1].002	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
16	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
18	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
19	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
22	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
23	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
24	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
25	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
26	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
27	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
28	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
29	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
30	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
Public-supply survey															
31	<0.049	<0.041	<0.072	<0.096	<0.05	<0.043	[1]0.002	<0.074	<0.062	<0.087	<0.106	<0.059	<0.063	<0.08	<0.01
32	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
32	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
34	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01
35	<.049	<.041	<.072	<.096	<.05	<.043	<.079	<.074	<.062	<.087	<.106	<.059	<.063	<.08	<.01

Appendix 5. Concentrations of pesticides in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)										
	(49296) Methomyl	(61697) Metsulfuron methyl	(49294) Neburon	(49293) Norflur azon	(49292) Oryzalin	(38866) Oxamyl	(49291) Picloram	(49236) Propham	(38538) Propoxur	(49235) Triclopyr	(61692) 3(4-Chlorophenyl) methyl urea
Subunit survey											
1	<0.077	<0.114	<0.075	<0.077	<0.071	<0.016	<0.071	<0.072	<0.059	<0.101	<0.092
2	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
3	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
4	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
5	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
6	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
7	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
8	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
9	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
10	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
11	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
12	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
13	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
14	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
15	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
16	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
18	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
19	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
20	—	—	—	—	—	—	—	—	—	—	—
21	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
22	<.077	<.114	[1].0008	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
23	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
24	<.077	[1].002	[1].0011	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
25	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
26	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
27	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
28	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
29	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
30	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
Public-supply survey											
31	<0.077	<0.114	<0.075	<0.077	<0.071	<0.016	<0.071	<0.072	<0.059	<0.101	<0.092
32	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
32	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
34	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092
35	<.077	<.114	<.075	<.077	<.071	<.016	<.071	<.072	<.059	<.101	<.092

[1] Detected in sample; estimated value.

Appendix 6. Concentrations of volatile organic compounds in water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(34506) 1,1,1-Trichloroethane	(34511) 1,1,2-Trichloroethane	(34496) 1,1-Dichloroethane	(34501) 1,1-Dichloroethylene	(77168) 1,1-Dichloropropene	(77443) 1,2,3-Trichloropropane	(77651) 1,2-Dibromoethane	(32103) 1,2-Dichloroethane	(34541) 1,2-Dichloropropane	(34546) trans-1,2-Dichloroethylene	(77170) 2,2-Dichloropropane	(73547) trans-1,4-Dichloro-2-butene	(77103) 2-Hexanone	(81552) Acetone	(34215) Acrylo nitrile
Subunit survey															
1	<0.032	<0.064	<0.066	<0.044	<0.026	<0.16	<0.036	<0.13	<0.068	<0.032	<0.078	<0.7	<0.7	<5	<1.2
2	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
5	<.032	<.06	<.066	<.04	<.026	<.16	<.036	<.13	<.068	<.032	<.05	<.7	<.7	<7	<1.2
6	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
7	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
8	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
9	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
10	[1].031	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
11	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
12	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
13	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
14	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
15	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
16	<.032	<.06	<.066	<.04	<.026	<.16	<.036	<.13	<.068	<.032	<.05	<.7	<.7	<7	<1.2
18	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
19	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
20	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
21	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
22	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
23	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
24	[1].025	<.06	<.066	<.04	<.026	<.16	<.036	<.13	<.068	<.032	<.05	<.7	<.7	<7	<1.2
25	<.032	<.06	<.066	<.04	<.026	<.16	<.036	<.13	<.068	<.032	<.05	<.7	<.7	<7	<1.2
26	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
27	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
28	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
29	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
30	<.032	<.06	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.05	<.7	<.7	<7	<1.2
Public-supply survey															
31	<0.032	<0.064	<0.066	<0.044	<0.026	<0.16	<0.036	<0.13	<0.068	<0.032	<0.078	<0.7	<0.7	<5	<1.2
32	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
32	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
34	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2
35	<.032	<.064	<.066	<.044	<.026	<.16	<.036	<.13	<.068	<.032	<.078	<.7	<.7	<5	<1.2

Appendix 6. Concentrations of volatile organic compounds in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(77613) 1,2,3-Trichlorobenzene	(77221) 1,2,3-Trimethylbenzene	(34551) 1,2,4-Trichlorobenzene	(77222) 1,2,4-Trimethylbenzene	(77226) 1,3,5-Trimethylbenzene	(34566) 1,3-Dichlorobenzene	(34571) 1,4-Dichlorobenzene	(77223) Isopropylbenzene	(77342) Butylbenzene	(77224) n-Propylbenzene	(34536) 1,2-Dichlorobenzene	(77350) sec-Butylbenzene	(77353) tert-Butylbenzene	(34030) Benzene	(81555) Bromobenzene
Subunit survey															
1	<0.27	<0.12	<0.19	[1].038	<0.044	<0.054	<0.05	<0.032	<0.19	<0.042	<0.048	<0.048	<0.1	<0.1	<0.036
2	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
5	<.27	<.12	<.19	.17	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.032	<.06	<.035	<.036
6	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
7	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
8	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
9	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
10	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
11	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
12	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
13	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
14	<.27	<.12	<.19	[1].014	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
15	<.27	<.12	<.19	[1].019	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
16	<.27	<.12	<.19	.16	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.032	<.06	<.035	<.036
18	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
19	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
20	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
21	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
22	<.27	<.12	<.19	[1].093	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
23	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
24	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.032	<.06	<.035	<.036
25	<.27	<.12	<.19	.16	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.032	<.06	<.035	<.036
26	<.27	<.12	<.19	[1].092	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
27	<.27	<.12	<.19	[1].055	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
28	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
29	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
30	<.27	<.12	<.19	[1].035	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.032	<.06	<.035	<.036
Public-supply survey															
31	<0.27	<0.12	<0.19	<0.056	<0.044	<0.054	<0.05	<0.032	<0.19	<0.042	<0.048	<0.048	<0.1	<0.1	<0.036
32	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
32	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
34	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036
35	<.27	<.12	<.19	<.056	<.044	<.054	<.05	<.032	<.19	<.042	<.048	<.048	<.1	<.1	<.036

Appendix 6. Concentrations of volatile organic compounds in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(50002) Bromoethene	(32104) Bromoform	(77041) Carbon disulfide	(32102) Tetrachloromethane (carbon tetrachloride)	(34301) Chlorobenzene	(32105) Dibromochloromethane	(34311) Chloroethane	(32106) Chloroform	(77093) cis-1,2-Dichloroethylene	(34704) cis-1,3-Dichloropropene	(82625) 1,2-Dibromo-3-chloropropane	(30217) Dibromomethane	(32101) Bromodichloromethane	(34668) Dichlorodifluoromethane (CFC-12)	(81577) Di-isopropylether
Subunit survey															
1	<0.1	<0.1	<0.37	<0.088	<0.028	<0.18	<0.12	<0.052	<0.038	<0.09	<0.21	<0.05	<0.048	<0.14	<0.1
2	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.1
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.1
5	<.1	<.06	<.07	<.06	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.27	<.1
6	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.1
7	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.1
8	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
9	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
10	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.1
11	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
12	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
13	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
14	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
15	<.1	<.1	<.37	<.088	<.028	<.18	<.12	[1].011	<.038	<.09	<.21	<.05	<.048	<.14	<.098
16	<.1	<.06	<.07	<.06	[1].007	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.27	<.098
18	<.1	<.1	[1].05	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
19	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
20	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
21	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
22	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
23	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
24	<.1	<.06	<.07	<.06	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.27	<.1
25	<.1	<.06	<.07	<.06	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.27	<.1
26	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
27	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
28	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
29	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
30	<.1	<.06	<.07	<.06	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.27	<.1
Public-supply survey															
31	<0.1	<0.1	<0.37	<0.088	<0.028	<0.18	<0.12	<0.052	<0.038	<0.09	<0.21	<0.05	<0.048	<0.14	<0.098
32	<.1	<.1	<.37	<.088	<.028	<.18	<.12	[1].023	<.038	<.09	<.21	<.05	<.048	<.14	<.098
32	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
34	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098
35	<.1	<.1	<.37	<.088	<.028	<.18	<.12	<.052	<.038	<.09	<.21	<.05	<.048	<.14	<.098

Appendix 6. Concentrations of volatile organic compounds in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)														
	(77562) 1,1,1,2-Tetrachloroethane	(34516) 1,1,2,2-Tetrachloroethane	(34396) Hexachloroethane	(81576) Diethyl ether	(50004) Ethyl tert-butyl ether	(50005) tert-Pentyl methyl ether	(34371) Ethylbenzene	(77652) 1,1,2-Trichlorotrifluoroethane (CFC-113)	(81607) Tetrahydrofuran	(39702) Hexachlorobutadiene	(50000) 1,2,3,5-Tetramethylbenzene (isodurene)	(73570) Ethyl methacrylate	(81597) Methyl methacrylate	(81593) Methyl acrylonitrile	(77297) Bromochloromethane
Subunit survey															
1	<0.044	<0.13	<0.36	<0.17	<0.054	<0.11	<0.03	<0.032	<9	<0.14	<0.2	<0.28	<0.35	<0.57	<0.044
2	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
5	<.03	<.09	<.19	<.17	<.054	<.11	<.03	<.06	<2.2	<.14	<.2	<.18	<.35	<.6	<.044
6	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
7	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
8	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
9	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
10	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
11	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
12	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
13	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
14	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
15	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
16	<.03	<.09	<.19	<.17	<.054	<.11	<.03	<.06	<2.2	<.14	<.2	<.18	<.35	<.6	<.044
18	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
19	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
20	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
21	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
22	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
23	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
24	<.03	<.09	<.19	<.17	<.054	<.11	<.03	<.06	<2.2	<.14	<.2	<.18	<.35	<.6	<.044
25	<.03	<.09	<.19	<.17	<.054	<.11	<.03	<.06	<2.2	<.14	<.2	<.18	<.35	<.6	<.044
26	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
27	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
28	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
29	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
30	<.03	<.09	<.19	<.17	<.054	<.11	<.03	<.06	<2.2	<.14	<.2	<.18	<.35	<.6	<.044
Public-supply survey															
31	<0.044	<0.13	<0.36	<0.17	<0.054	<0.11	<0.03	<0.032	<9	<0.14	<0.2	<0.28	<0.35	<0.57	<0.044
32	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
32	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
34	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.14	<.2	<.28	<.35	<.57	<.044
35	<.044	<.13	<.36	<.17	<.054	<.11	<.03	<.032	<9	<.1	<.2	<.28	<.35	<.57	<.044

Appendix 6. Concentrations of volatile organic compounds in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)													
	(49991) Methyl acrylate	(77424) Methyl iodide	(78032) Methyl tert-butyl ether (MTBE)	(34413) Bromomethane (methyl bromide)	(34418) Chloromethane[2] (methyl chloride)	(34423) Dichloromethane (methylene chloride)	(81595) 2-Butanone (methyl ethyl ketone)	(78133) 4-Methyl-2-pentanone	(85795) meta and para Xylene	(34696) Naphthalene	(77275) 2-Chlorotoluene	(77135) o-Xylene	(77356) 4-Isopropyl-1-methyl-benzene	(49999) 1,2,3,4-Tetramethyl benzene (prehnitene)
Subunit survey														
1	<1.4	<0.21	<0.17	<0.15	<0.25	<0.38	<1.6	<0.37	<0.06	<0.25	<0.042	<0.06	<0.11	<0.23
2	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
5	<1.4	<.12	<.17	<.26	<.5	<.38	<1.6	<.37	[1].041	<.25	<.042	<.038	<.07	<.23
6	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
7	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
8	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
9	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
10	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
11	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
12	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
13	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
14	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
15	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
16	<1.4	<.12	<.17	<.26	<.5	<.38	<1.6	<.37	<.06	<.25	<.042	<.038	<.07	<.23
18	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
19	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
20	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
21	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
22	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
23	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
24	<1.4	<.12	<.17	<.26	<.5	<.38	<1.6	<.37	<.06	<.25	<.042	<.038	<.07	<.23
25	<1.4	<.12	<.17	<.26	<.5	<.38	<1.6	<.37	<.06	<.25	<.042	<.038	<.07	<.23
26	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
27	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
28	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
29	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
30	<1.4	<.12	<.17	<.26	<.5	<.38	<1.6	<.37	[1].031	<.25	<.042	<.038	<.07	<.23
Public-supply survey														
31	<1.4	<0.21	<0.17	<0.15	<0.25	<0.38	<1.6	<0.37	<0.06	<0.25	<0.042	<0.06	<0.11	<0.23
32	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
32	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
34	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23
35	<1.4	<.21	<.17	<.15	<.25	<.38	<1.6	<.37	<.06	<.25	<.042	<.06	<.11	<.23

Appendix 6. Concentrations of volatile organic compounds in water sampled from wells in Cook Inlet Basin, 1999—Continued

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. <, less than; —, not analyzed]

Well number	Concentration (micrograms per liter)										
	(77173) 1,3-Dichloropropane	(78109) 3-Chloropropene	(77128) Styrene	(34475) Tetrachloroethylene	(77220) o-Ethyl toluene	(77277) 4-Chlorotoluene	(34010) Toluene[3]	(34699) Trans-1,3-Dichloropropene	(39180) Trichloroethylene	(34488) Trichlorofluoromethane (CFC-11)	(39175) Vinyl chloride
Subunit survey											
1	<0.12	<0.2	<0.042	<0.1	<0.1	<0.056	[1]0.07	<0.13	<0.038	[1]0.06	<0.11
2	<.12	<.2	<.042	<.1	<.1	<.056	[1].01	<.13	<.038	<.09	<.11
3	—	—	—	—	—	—	—	—	—	—	—
4	<.12	<.2	<.042	<.1	<.1	<.056	[1].03	<.13	<.038	<.09	<.11
5	<.12	<.2	<.042	<.1	<.06	<.06	.77	<.09	<.038	.27	<.11
6	<.12	<.2	<.042	<.1	<.1	<.056	[1].03	<.13	<.038	<.09	<.11
7	<.12	<.2	<.042	<.1	<.1	<.056	.18	<.13	<.038	[1].04	<.11
8	<.12	<.2	<.042	<.1	<.1	<.056	[1].06	<.13	<.038	<.09	<.11
9	<.12	<.2	<.042	<.1	<.1	<.056	[1].03	<.13	<.038	<.09	<.11
10	<.12	<.2	<.042	<.1	<.1	<.056	[1].05	<.13	<.038	<.09	<.11
11	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
12	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
13	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
14	<.12	<.2	<.042	[1].05	<.1	<.056	.17	<.13	<.038	[1].1	<.11
15	<.12	<.2	<.042	<.1	<.1	<.056	[1].09	<.13	<.038	<.09	<.11
16	<.12	<.2	<.042	<.1	<.06	<.06	[1].02	<.09	<.038	.84	<.11
18	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
19	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
20	<.12	<.2	<.042	<.1	<.1	<.056	.54	<.13	<.038	<.09	<.11
21	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
22	<.12	<.2	<.042	<.1	<.1	<.056	[1].03	<.13	<.038	<.09	<.11
23	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
24	<.12	<.2	<.042	<.1	<.06	<.06	[1].01	<.09	<.038	<.09	<.11
25	<.12	<.2	<.042	<.1	<.06	<.06	[1].05	<.09	<.038	.70	<.11
26	<.12	<.2	<.042	<.1	<.1	<.056	[1].08	<.13	<.038	.44	<.11
27	<.12	<.2	<.042	<.1	<.1	<.056	[1].02	<.13	<.038	<.09	<.11
28	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	[1].03	<.11
29	<.12	<.2	<.042	<.1	<.1	<.056	[1].02	<.13	<.038	<.09	<.11
30	<.12	<.2	<.042	<.1	<.06	<.06	.19	<.09	<.038	[1].03	<.11
Public-supply survey											
31	<0.12	<0.2	<0.042	<0.1	<0.1	<0.056	<0.05	<0.13	<0.038	<0.09	<0.11
32	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
32	<.12	<.2	<.042	<.1	<.1	<.056	<.05	<.13	<.038	<.09	<.11
34	<.12	<.2	<.042	<.1	<.1	<.056	[1].01	<.13	<.038	<.09	<.11
35	<.12	<.2	<.042	<.1	<.1	<.056	[1].02	<.13	<.038	<.09	<.11

[1] Estimated value.

[2] Also detected in field blank.

[3] Also detected in field and equipment blanks.

Appendix 7. Activities of isotopes in water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. Number in parentheses is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. Highlighted values exceed a proposed water-quality standard (maximum contaminant level) for radon (U.S. Environmental Protection Agency, 2000). <, less than; —, not analyzed or not applicable]

Well number	Radioactivity (picocuries per liter)											
	(04126) Alpha, as thorium-230, dissolved	(75987) Alpha (2-sigma precision)	(03515) Gross beta, as cesium-137, dissolved	(75989) Gross beta (2-sigma precision)	(82303) Radon-222	(76002) Radon-222 (2-sigma precision)	(50833) Radium-224	(50834) Radium-224 (2-sigma precision)	(09503) Radium-226	(76001) Radium-226 (2-sigma precision)	(81366) Radium-228	(76000) Radium-228 (2-sigma precision)
Subunit survey												
1	<3	2.6	<4	4.1	190	21	<1	0.20	<1	0.09	<1	0.28
2	<3	2.6	<4	4.1	140	18	<1	.02	<1	.04	<1	.32
3	<3	4.4	<4	9.2	**390**	25	<1	.10	<1	.03	<1	.22
4	<3	2.3	<4	4.2	290	20	<1	.15	<1	.06	—	—
5	<3	2.6	6.5	4.3	260	21	<1	.10	<1	.08	<1	.34
6	<3	2.2	<4	4.3	170	18	<1	.11	<1	.03	<1	.32
7	<3	2.6	<4	4.2	200	19	<1	.90	<1	.16	<1	.33
8	<3	2.6	<4	4.2	260	21	<1	.19	<1	.04	<1	.31
9	<3	2.3	10	5.1	—	—	<1	.10	<1	.04	<1	.26
10	<3	2.4	<4	4.1	**500**	25	<1	.20	<1	.04	<1	.28
11	<3	2.5	<4	4.2	240	20	<1	.12	<1	.03	<1	.38
12	<3	2.7	<4	4.1	**610**	27	<1	.10	<1	.03	<1	.38
13	<3	2.5	4.9	4.3	150	18	<1	.11	<1	.04	<1	.40
14	<3	2.7	<4	4.4	250	29	<1	.16	<1	.04	<1	.36
15	<3	2.2	<4	3.9	**440**	30	<1	.20	<1	.13	<1	.37
16	<3	2.8	<4	4.2	290	21	<1	.15	<1	.04	<1	.33
18	5.4	3.4	5.4	4.4	**320**	24	<1	.13	<1	.04	<1	.29
19	<3	2.7	<4	4.2	**310**	31	<1	.10	<1	.02	<1	.33
20	4.1	3.5	<4	4.3	**320**	21	<1	.24	<1	.12	<1	.26
21	<3	2.8	<4	4.0	**320**	28	<1	.36	<1	.10	<1	.29
22	<3	3.4	<4	4.4	180	18	<1	.62	<1	.19	<1	.24
23	<3	2.5	5.7	4.2	**440**	24	<1	.16	<1	.03	<1	.25
24	<3	2.3	4.9	4.4	220	20	<1	.10	<1	.05	<1	.38
25	<3	3.1	<4	4.2	210	18	<1	.38	<1	.10	<1	.41
26	<3	2.8	<4	4.2	—	—	<1	.46	<1	.09	<1	.33
27	<3	2.6	<4	4.2	—	—	<1	.15	<1	.04	<1	.31
28	<3	2.5	<4	4.1	200	18	<1	.10	<1	.12	<1	.30
29	<3	2.8	<4	4.3	**450**	24	<1	.10	<1	.02	<1	.19
30	<3	2.8	<4	4.4	150	28	<1	.20	<1	.07	<1	.47
Public-supply survey												
31	<3	3.0	<4	4.4	140	18	<1	0.10	<1	0.03	<1	0.19
32	<3	2.7	4.8	4.1	**580**	27	<1	.11	<1	.04	<1	.37
32	<3	2.8	<4	3.9	**380**	37	<1	.50	<1	.09	<1	.30
34	<3	2.1	<4	3.9	240	27	<1	.22	<1	.08	<1	.37
35	<3	2.5	<4	4.1	200	19	<1	.10	<1	.02	<1	.22
National median concentration for drinking-water aquifers[1]												
—	—	—	—	—	450	—	—	—	—	—	—	—

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[1] Gilliom and others (1998).

Appendix 8. Environmental isotopes of hydrogen and oxygen in water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. See table 2 regarding analytical methods used. Number in parentheses above ratio is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. —, not determined]

Well number	Isotopic ratios (per mil relative to Vienna Standard Mean Ocean Water)	
	(82082) Hydrogen-2 / Hydrogen-1	(82085) Oxygen-18 / Oxygen-16
Subunit survey		
1	-121	-16.0
2	-89	-9.1
3	—	—
4	-122	-15.9
5	-118	-15.2
6	-133	-17.0
7	-132	-17.2
8	-135	-17.0
9	—	—
10	-126	-16.3
11	-123	-15.9
12	-133	-17.2
13	-134	-17.3
14	-130	-16.5
15	-115	-13.1
16	-133	-16.9
18	-124	-15.3
19	-130	-16.7
20	-130	-16.9
21	-137	-17.9
22	—	—
23	-131	-16.6
24	-159	-20.6
25	-128	-16.1
26	-164	-21.3
27	-126	-16.1
28	-125	-15.5
29	-129	-16.5
30	—	—
Public-supply survey		
31	-162	-21.1
32	-138	-17.9
33	-135	-17.6
34	-136	-17.4
35	-126	-16.0

Appendix 9. Tritium analyses of water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. —, not determined]

Well number	Sample date		Apparent age[1] (years)		Probable date of recharge based on tritium analyses (range of years, in decimal format)
	(mm/dd/yy format)	(decimal format)	Estimate	Error	
			Subunit survey		
1	08/27/99	1999.65	20.2	0.3	1979.2–1979.8
2	08/10/99	1999.61	25.6	.3	1973.7–1974.3
3	08/27/99	1999.65	—	—	—
4	09/01/99	1999.67	23.9	.4	1975.4–1976.2
5	09/21/99	1999.72	25.9	.5	1973.3–1974.3
6	07/28/99	1999.57	55.3	22.1	1922.2–1966.4
7	08/03/99	1999.59	17.0	.6	1982.0–1983.2
8	08/03/99	1999.59	7.3	.4	1991.9–1992.7
9	08/11/99	1999.61	—	—	—
10	08/09/99	1999.60	15.7	.6	1983.3–1984.5
11	08/10/99	1999.61	21.0	.3	1978.3–1978.9
12	07/27/99	1999.57	29.7	.5	1969.4–1970.4
13	07/26/99	1999.56	17.6	2.2	1979.8–1984.2
14	08/04/99	1999.59	25.8	.4	1973.4–1974.2
15	08/06/99	1999.59	1.8	.6	1997.2–1998.4
16	09/13/99	1999.70	58.0	29.3	1912.4–1971.0
18	08/06/99	1999.59	30.1	.4	1969.1–1969.9
19	08/04/99	1999.59	15.2	.3	1984.1–1984.7
20	08/02/99	1999.58	32.0	1.4	1966.2–1969.0
21	07/30/99	1999.58	6.3	.6	1992.7–1993.9
22	08/25/99	1999.65	—	—	—
23	07/27/99	1999.57	16.0	.4	1983.2–1984.0
24	09/29/99	1999.74	6.5	.4	1992.8–1993.6
25	09/15/99	1999.70	7.1	.2	1992.4–1992.8
26	08/31/99	1999.66	.8	.5	1998.4–1999.4
27	08/30/99	1999.66	13.4	.3	1986.0–1986.6
28	08/16/99	1999.62	26.9	.4	1972.3–1973.1
29	08/23/99	1999.64	19.1	.4	1980.1–1980.9
30	10/20/99	1999.80	23.4	.4	1976.0–1976.8
			Public-supply survey		
31	08/24/99	1999.64	0.3	0.5	1998.8–1999.8
32	07/26/99	1999.56	29.1	0.5	1970.0–1971.0
33	07/21/99	1999.55	31.2	0.5	1967.9–1968.9
34	07/23/99	1999.56	2.0	0.6	1997.0–1998.2
35	08/11/99	1999.61	—	—	—

[1] Estimated by Peter Schlosser and others, Lamont–Doherty Earth Observatory, written commun., 2000).

Appendix 10. Chlorofluorocarbon analyses of water sampled from wells in Cook Inlet Basin, 1999

[Well number: See table 1 and fig. 2. Number in parentheses above chlorofluorocarbon is number used by both U.S. Environmental Protection Agency and U.S. Geological Survey to identify parameter in computerized data bases. Highlighted values are concentrations greater than possible for equilibrium with modern air. —, no data]

Well number	Sample date	Chlorofluorocarbons (picograms per kilogram)			Probable date of recharge[1] based on concentrations of chlorofluorocarbons	Remarks
		(50281) CFC-11	(50282) CFC-12	(50283) CFC-113		
			Subunit survey			
1	08/27/99	5	100	5	About 1970	
2	08/10/99	—	5	—	Late 1940s	CFC-11 and CFC-113 not detected
3	08/27/99	—	—	—	—	Sample not analyzed for CFCs
4	09/01/99	500	300	50	Late 1970s to about 1980	
5	09/21/99	10	100	4	About 1970	
6	07/28/99	1	1	—	Mid-1940s	CFC-113 not detected
7	08/03/99	300	**3,000**	50	About 1970	
8	08/03/99	400	400	70	Early to mid-1980s	
9	08/11/99	—	—	—	—	Sample not analyzed for CFCs
10	08/09/99	100	300	10	Late 1970s	
11	08/10/99	1	10	—	Early 1950s	CFC-113 not detected
12	07/27/99	3	1	—	Late 1940s or earlier	CFC-113 not detected
13	07/26/99	10	500	7	Mid-1960s(?)	
14	08/04/99	**9,000**	30	3	Mid-1960s	
15	08/06/99	900	300	60	About 1980	
16	09/13/99	1	1	4	Early 1940s	
18	08/06/99	1	20	6	Probably pre-1940	
19	08/04/99	3	20	—	Late 1950s	CFC-113 not detected
20	08/02/99	400	**2,000**	70	Early 1980s	
21	07/30/99	90	300	20	Late 1970s	
22	08/25/99	—	—	—	—	Sample not analyzed for CFCs
23	07/27/99	4	50	—	About 1960	CFC-113 not detected
24	09/29/99	**20,000**	**3,000**	80	Early to mid-1980s	
25	09/15/99	20	70	8	Mid-1960s	
26	08/31/99	800	500	90	Late 1980s to 1990	
27	08/30/99	300	500	5	Late 1980s or older	
28	08/16/99	—	6	1	About 1950	
29	08/23/99	80	**3,000**	4	Early 1960s	
30	10/20/99	—	—	—	—	Sample not analyzed for CFCs
			Public-supply survey			
31	08/24/99	**2,000**	500	100	Early 1990s to present	
32	07/26/99	9	60	3	Early to mid-1960s	
32	07/21/99	20	5	—	Late 1940s	CFC-113 not detected
34	07/23/99	300	300	60	About 1980	
35	08/11/99	—	—	—	Probably pre-1940	No CFCs detected

[1] Estimated by G.C. Casile (U.S. Geological Survey, written commun., 2000).