Workplan for U.S. Geological Survey Hydrologic Data-Collection and Support Activities on Fort Wainwright, Alaska, 1994-97

By David V. Claar and Michael R. Lilly

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.304	meter
mile (mi)	1.609	kilometer
	Area	
acre	0.407	hectare
square foot (ft^2)	0.0929	square meter
square mile (mi^2)	2.590	square kilometer
	Pressure	
pound per square inch (lb/in^2)	6.895	kilopascal
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day
foot per day (ft/d)	0.00035	centimeter per second
	Conductance	
foot squared per day (ft^2/d)	0.0929	meter squared per day

Physical and Chemical Water-Quality Units:

Temperature: Water and air temperature are given in degrees Celsius (°C) and in degrees Fahrenheit (°F). Degrees Celsius can be converted to degrees Fahrenheit by use of the following equation:
°F = 1.8(°C) + 32

Specific electrical conductance (conductivity): Conductivity of water is expressed in microsiemens per centimeter at 25°C (µS/cm). This unit is equivalent to micromhos per centimeter at 25°C.

Milligrams per liter (mg/L) or micrograms per liter (µg/L): Milligrams per liter is a unit of measurement indicating the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

Millivolt (mv): A unit of electromotive force equal to one thousandth of a volt.

Vertical Datum: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929), a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929. For all recent and current hydrologic investigations in the Fort Wainwright and Fairbanks areas, the USGS uses the U.S. Coast and Geodetic Survey (1966) data.

Horizontal Datum: The horizontal datum for all locations in this report is the North American Datum of 1927. The U.S. Army typically uses local coordinate systems for each installation. These coordinates are converted to state-plane coordinates and latitude and longitude.

Abbreviations, Acronyms, and Symbols Used in this Report:

AEC	U.S. Army Environmental Center
ASTM	American Society for Testing and Materials
atm	atmospheres
BTEX	benzene, toluene, ethylbenzene, xylenes
C	chemistry data
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COE	U.S. Army Corps of Engineers, Alaska District
CRREL	Cold Regions Research and Engineering Laboratory
DMM	digital voltage multi-meter
DODEC	Department of Defense Environmental Conservation Program
DPW	Department of Public Works
e-tape	electric tape
GWSI	Ground-Water Site Inventory
IDW	investigation-derived waste
NWIS	National Water Information System
OU	Operable Unit
P	partial pressure of gas
ppm	parts per million
PVC	polyvinylchloride
Q	discharge
QA	quality assurance
Qd	daily discharge
Qm	miscellaneous discharge
QWDATA	Quality of Water Data database
ROD	Record of Decision
R	resistance
S	stage
SARA	Superfund Amendments and Reauthorization Act
SS	stainless steel
T	temperature
USARAK	U.S. Army Alaska
USGS	U.S. Geological Survey
UAF	University of Alaska Fairbanks
V	volume
WWW	World Wide Web

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Abstract

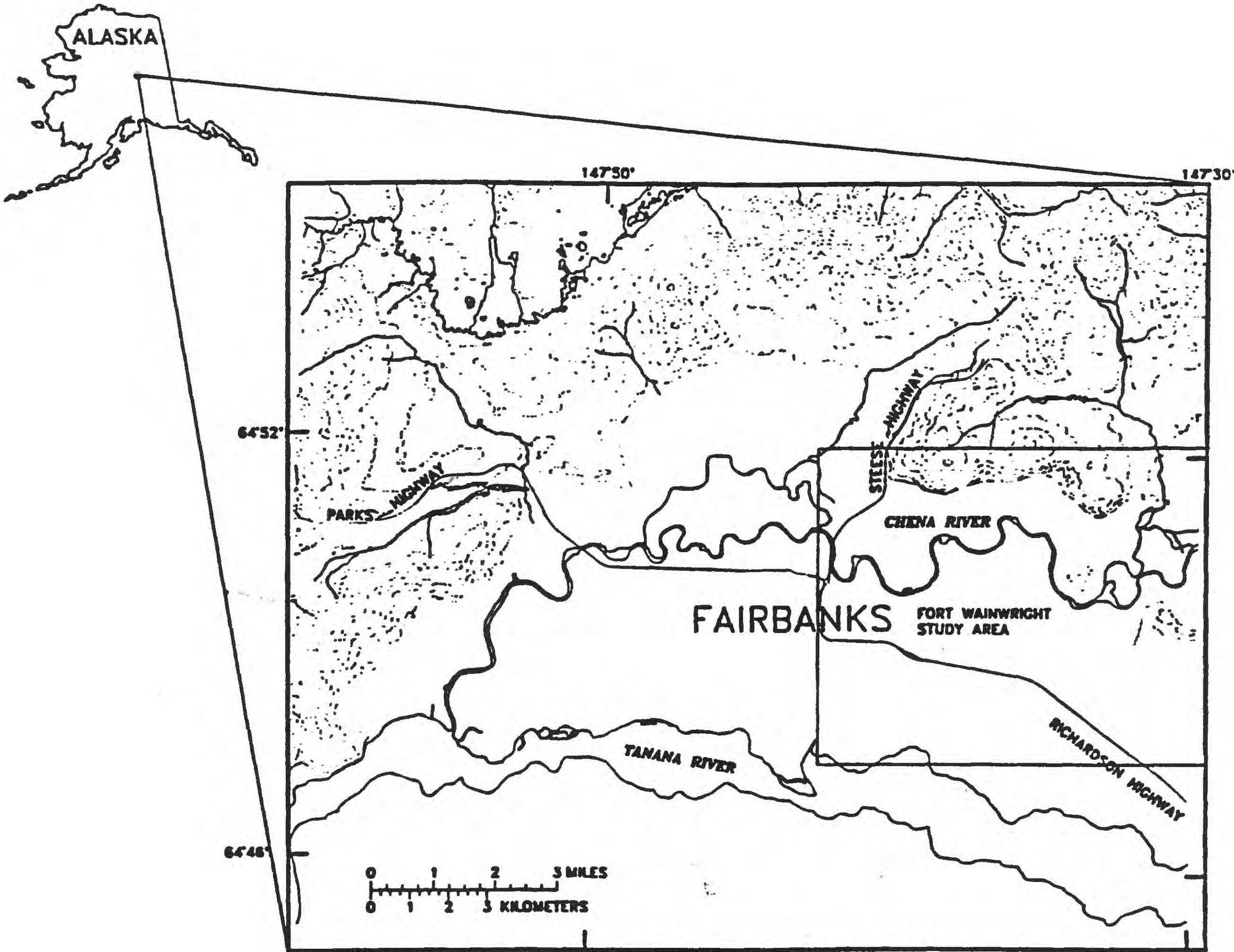
The U.S. Army Alaska is responsible for environmental activities on Fort Wainwright near Fairbanks, Alaska. In order to better meet the needs of environmental investigations, the Army requires geohydrologic information about the Fort Wainwright area. Since 1994, the U.S. Geological Survey has been working in cooperation with the U.S. Army Alaska and the U.S. Army Corps of Engineers to investigate the geohydrology of the Fort Wainwright area. The primary objectives of the study are to collect basic ground-water and surface-water data and to support ongoing environmental investigations by other agencies. This report is the workplan describing the technical methods used by the USGS to meet these objectives. It includes details on field procedures, data collection, and analyses of water samples.

INTRODUCTION

Workplans have become a common requirement for most hydrologic investigations. This is especially true for investigations related to environmental water-resource programs. Current quality-assurance (QA) practices for U.S. Geological Survey (USGS) ground-water projects are reported by Brunett and others (1997). The incorporation of workplans in general hydrologic investigations is outlined by Schroder and Shampine (1992) and Shampine and others (1992). Most of the historical hydrologic methods of the USGS are reported in Techniques of Water-Resources Investigation reports and in individual interpretive reports.

The USGS has been studying the hydrology of the Fairbanks area since 1907 (Prindle, 1908). Cederstrom first described ground-water conditions in 1950 and again in 1963 (Cederstrom, 1952, 1963). Ground-water conditions in permafrost areas are described by Cederstrom and others (1953). Anderson (1970) wrote the only geohydrologic report on the Tanana Basin. Nelson (1978), Krumhardt (1982), and Downey and Sinton (1990) reported additional geohydrologic investigations. The overall history of USGS investigations, data-collection methods, and archiving provide a foundation for quality hydrologic interpretations and for meeting the needs of current environmental projects.

The U.S. Army Alaska (USARAK) command is responsible for the environmental activities on Fort Wainwright, Alaska (fig. 1). The U.S. Army Corps of Engineers, Alaska District (COE), is the primary logistical agency for USARAK. The USGS has been working in cooperation with USARAK and COE since 1994, investigating the geohydrology of the post-wide area. The primary data-collection objectives have been the support of smaller scale environmental investigations on Fort Wainwright by environmental contractors, various Federal agencies, and the University of Alaska. The USGS objectives on Fort Wainwright have also included data collection and studies coordinated with other USGS projects.



Base from U.S. Geological Survey, Fairbanks D-2 (NE, NW, SW, SE), Alaska, 1:25,000, 1992.

Figure 1. Location of Fairbanks, Alaska, and the Fort Wainwright study area.

Objectives and Scope of Work

The primary objectives of this project are (1) collection of basic ground-water and surface-water data, (2) evaluation of the geohydrology underlying the Fort Wainwright main post area, and (3) support of ongoing environmental investigations by other State and Federal agencies, universities, and private contractors as directed by USARAK and COE.

The primary purpose of this report is to describe the technical methods used, schedules followed, and deliverables produced by the USGS to meet the project objectives. Selected information and data pertinent to current investigations on Fort Wainwright are also included.

Project Location and Background

Fort Wainwright is located in interior Alaska, approximately 100 mi (160 km) south of the Arctic Circle. The main post area is adjacent to and east of the City of Fairbanks (fig. 1) and within the Fairbanks D-2 SE quadrangle. Fort Wainwright includes a main post area and adjacent, or nearby, training areas. The USGS investigations are focused on the main post area. This area is bounded on the north by Birch Hill, on the south by the Tanana River, and on the west by the Steese Highway.

Ladd Army Air Field was the original name of the installation when it was first established as a cold-weather testing facility in 1938 (Ecology and Environment Inc., 1993). It expanded at the outbreak of World War II and was the pickup point for transferring aircraft to Russia during the Lend-Lease Program. The name of the installation was changed to Ladd Air Force Base in 1947. The installation expanded again after World War II during the cold war. The installation was renamed in 1961 to Fort Wainwright and currently serves as a major training facility for the Army.

The U.S. Environmental Protection Agency (USEPA) placed Fort Wainwright on the Superfund National Priorities List (NPL) on August 30, 1990 (Ecology and Environment Inc., 1993). Environmental Superfund programs are covered under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Various environmental sites are covered by the Superfund Amendments and Reauthorization Act (SARA). The data-collection and interpretive efforts of this project are prioritized to directly benefit Fort Wainwright's environmental programs.

GEOHYDROLOGY OF THE FAIRBANKS AREA

Geology

The western and central Tanana Basin is bounded on the north by the Yukon-Tanana Upland, and on the south by the Alaska Range. Fort Wainwright is located at the southern edge of the upland. Anderson (1970) described various geohydrologic map units for the Tanana Basin and defined the basin fill near the Tanana River as a flood-plain alluvium unit. Péwé and others (1976) describe this unit as the Chena Alluvium formation in the Fairbanks and Fort Wainwright areas. The Chena Alluvium is composed of alternating sands and gravel deposited by the Tanana River. The sedimentary facies of the Chena Alluvium are laterally and vertically discontinuous, as are typical of braided rivers (Rust, 1978).

The alluvial plain deposits have been reported to be more than 600 ft thick (183 m) by Glass and others (1996). Péwé (1958) reported a depth to bedrock of 675 ft (206 m) south of Fairbanks. Andreasen and others (1964) estimated a 2,000-ft (610-m) bedrock depth south of Fairbanks, on the basis of aeromagnetic surveys. Little is known about the surface of the underlying contact between bedrock and alluvium. Numerous intrusives and hills made up of schist and other Yukon-Tanana terrane units project out of the alluvial deposits (Newberry and others, 1996; Péwé, 1958; Robinson and others, 1990). These structural features of the basin indicate that the interface between bedrock and alluvium is not a simple boundary. It is possible that some bedrock highs are not exposed above the alluvial land surface.

The occurrence of permafrost in the Fairbanks area has been described by Péwé and Bell (1975), and in selected areas of Fort Wainwright by Lawson and others (1993, 1994). The permafrost at depth in the Chena Alluvium in the Fort Wainwright area has not been described in enough detail to define its post-wide occurrence.

Geohydrology

Recent studies by Claar and Lilly (1995, 1997), Kriegler and Lilly (1995), and Jackson and Lilly (1996) have coordinated geohydrologic data collection in the Fairbanks area across investigation boundaries. The data help better understand the overall geohydrologic system, including the geohydrology of the Fort Wainwright study area. An understanding of the large-scale hydrologic system is important when describing the processes affecting site-scale ground-water contamination and transport (Lilly and others, 1996). Factors such as the vertical gradients are important for understanding the transport of ground-water solutes from a source area. Data from the Fairbanks Railroad Industrial Area indicate that the vertical gradients are upward near the Chena River, except during rapid stage changes.

Aquifer properties for the Chena Alluvium have been reported by a variety of different sources. The results of a recent aquifer analysis (Nakanishi and Lilly, 1998) are shown in table 1. This analysis provided results at a scale that can be applied to the Fort Wainwright area.

Table 1. Reported values of geohydrologic parameters for the aquifer
[Data from Nakanishi and Lilly, 1998; ft/d, foot per day; ft^2/d, foot squared per day; m/d, meter per day; m^2/d, meter squared per day]

Parameter	Estimated value corrected for river geometry effects	
	Inch-pound unit	SI unit
Riverbed conductance	350 ft^2/d	33 m^2/d
Chena Alluvium		
Vertical hydraulic conductivity (K_v)	20 ft/d	6 m/d
Horizontal hydraulic conductivity (K_h)	400 ft/d	122 m/d
Anisotropy (K_v/K_h)	1:20	1:20
Specific yield (S_y)	[a]0.25	[a]0.25
Specific storage (S_s)	[a]1×10^{-6}	[a]1×10^{-6}
Diffusivity (K_h/S_y)	2,400 ft/d	732 m/d
Bedrock		
Vertical hydraulic conductivity (K_v)	[a]0.005 ft/d	[a]0.002 m/d
Horizontal hydraulic conductivity (K_h)	[a]0.10 ft/d	[a]0.03 m/d
Specific storage (S_s)	[a]1×10^{-7}	[a]1×10^{-7}

[a]assumed value, not estimated by calibration

Hydrology

The Tanana Basin, upstream from Fairbanks, has a drainage area of about 20,000 mi^2 (51,800 km^2) (Glass and others, 1996). The average annual precipitation for the period of record from 1961 to 1994 is 10.95 in. (27.8 cm) of water equivalent (Plumb and Lilly, 1996). The quantity of water equivalent in the snowpack varies because of differences in vegetation, slope aspect, and elevation. Plumb and Lilly (1996) reported water equivalents for the Fairbanks and Fort Wainwright areas for the spring of 1995. The water equivalence of the snowpack available for recharge at the beginning of snowmelt ranges from 4.5 in. (11.4 cm) to 5.9 in. (15.0 cm) of water, or about half of the average annual precipitation.

Ground-water flow directions follow the land-surface slope in most of the alluvial plain (fig. 2). Exceptions occur where the Chena and Tanana Rivers intersect the ground-water system. During periods of rapidly rising river levels in the Chena River, such as during spring thaw and periods of high rainfall (fig. 3), ground-water flow directions are reversed and water flows from the Chena River into the ground-water system. In contrast to that of the Chena, the stage of the Tanana River rises primarily during mid-summer, when glacial melt and high elevation snowmelt is at a maximum (Glass and others, 1996). Stage changes in the Chena River are typically more transient than those in the Tanana River. A simulation of a 1995 storm hydrograph (fig. 4) illustrates how ground-water flux directions are reversed as the Chena River stage changes. Once the surface-water stage starts to decline, ground-water levels decline near the river bank, but continue to rise at greater distances from the bank (fig. 5).

PROJECT APPROACH

The project approach has been the collection and archiving of information on geohydrologic sites, and interpretation of the post-wide geohydrology to support environmental investigations. Monitoring wells were installed in the study area as part of previous and ongoing investigations by environmental programs. Selected wells and stage-measurement stations were chosen to measure the ground-water and surface-water levels in the area. Surface-water discharge-measurement stations have also been established to help investigate the interactions between the Chena and Tanana Rivers and the ground-water system in the alluvial plain. The information collected is available in the USGS offices in Fairbanks and Anchorage, and selected information is also available on the USGS World Wide Web (WWW) pages at *http://ak.water.usgs.gov/.*

Environmental and Geohydrologic Reports

Environmental reports and miscellaneous geohydrologic information are collected and archived at the USGS offices in Fairbanks. The reports are provided by COE and are assigned a report number when received. The archived reports contain information related to geohydrologic investigations, such as initial workplans, and interim and final interpretive reports. The report numbers do not indicate any association of author, type of report, or content, but only the order in which the reports are received and processed.

The general location of the area described in the report is plotted on a map (Appendix A, fig. A1). A numerical listing helps locate a report from the number (Appendix A, fig. A1). The alphabetical listing helps locate reports by author or organization. Project staff are required to be familiar

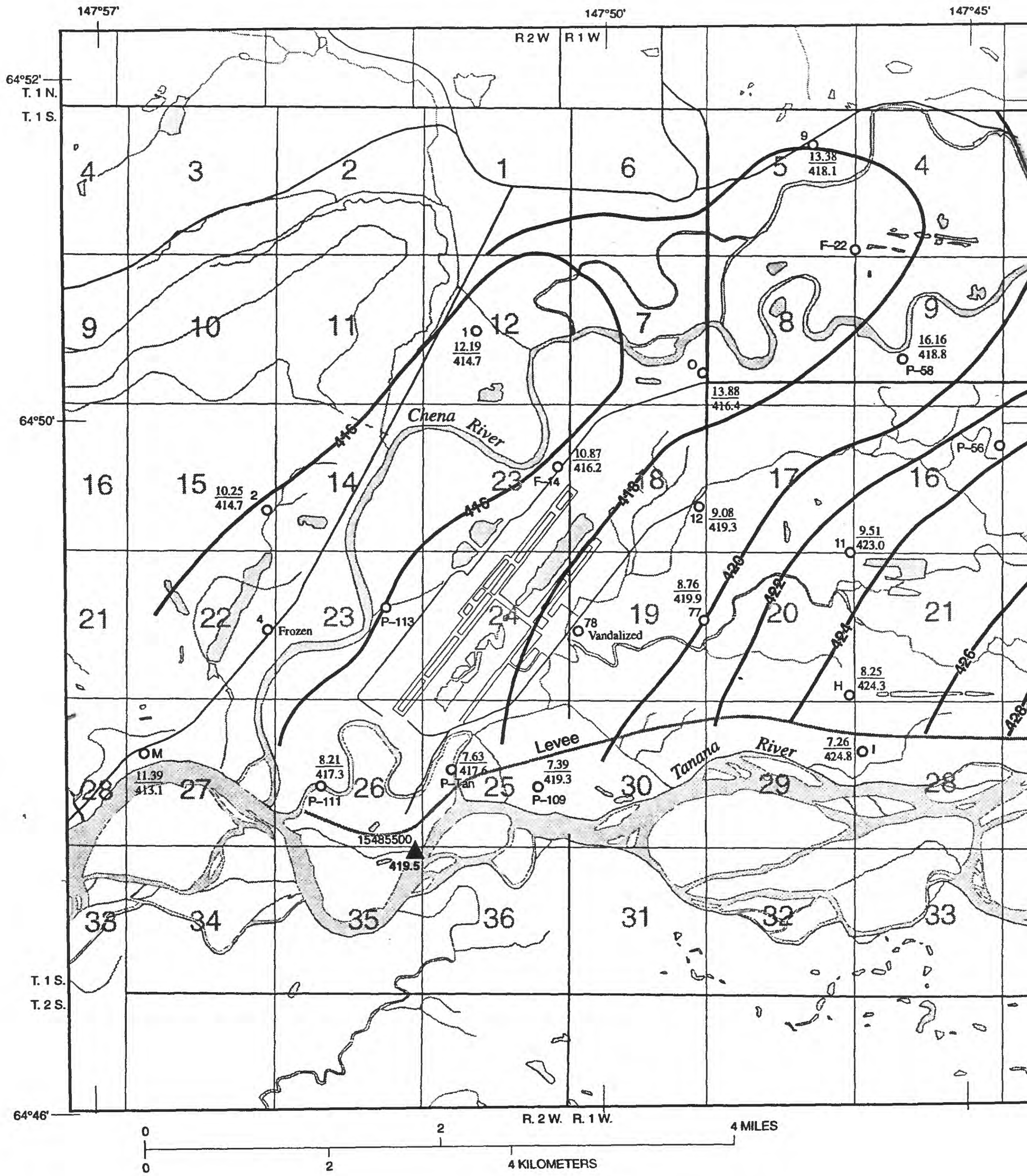
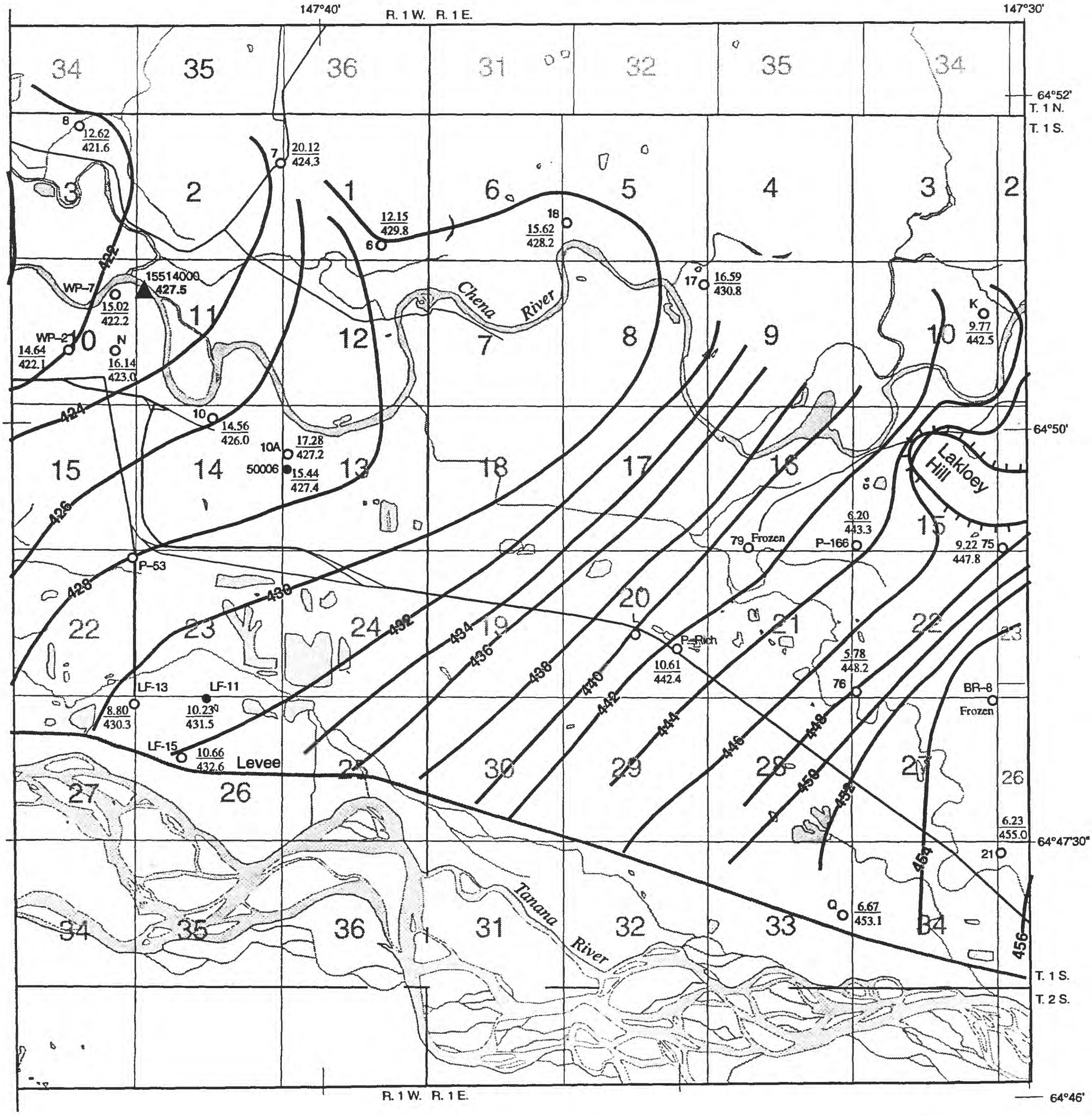


Figure 2. Water-table map for the Fairbanks and Fort Wainwright areas, showing ground-water levels during a period of low stage in the Chena and Tanana Rivers near Fairbanks, Alaska (from Glass and others, 1996).



EXPLANATION

—438— **Water-table contour**—Shows altitude of water table. Contour is 2 feet. Datum is sea level

▲ 15485500 / 419.5 **Stream-gaging station and number**—Number with decimal is Stage, in feet above sea level

○ LF-13 **Water-level monitoring well and field identifier**

● LF-11 **Water-level monitoring well equipped with a continuous recorder and field identifier**

10.66 / 432.6 **Top number is water level, in feet below land surface; negative if water level was above land surface. Bottom number is water level, in feet above sea level**

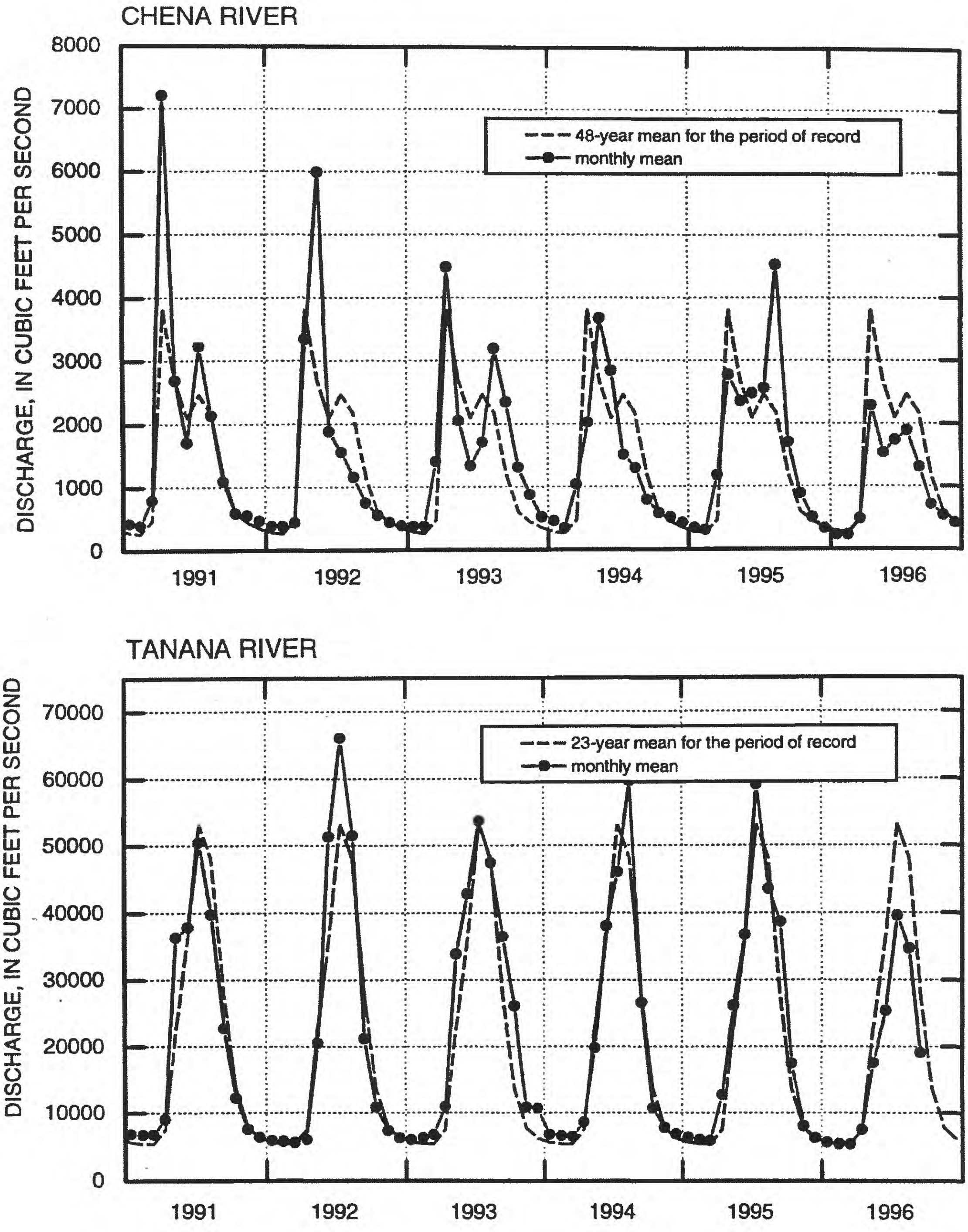


Figure 3. Monthly mean discharges for the study period and mean monthly discharges for the period of record for the Chena and Tanana Rivers. Period-of-record statistics are for water years (October through September)

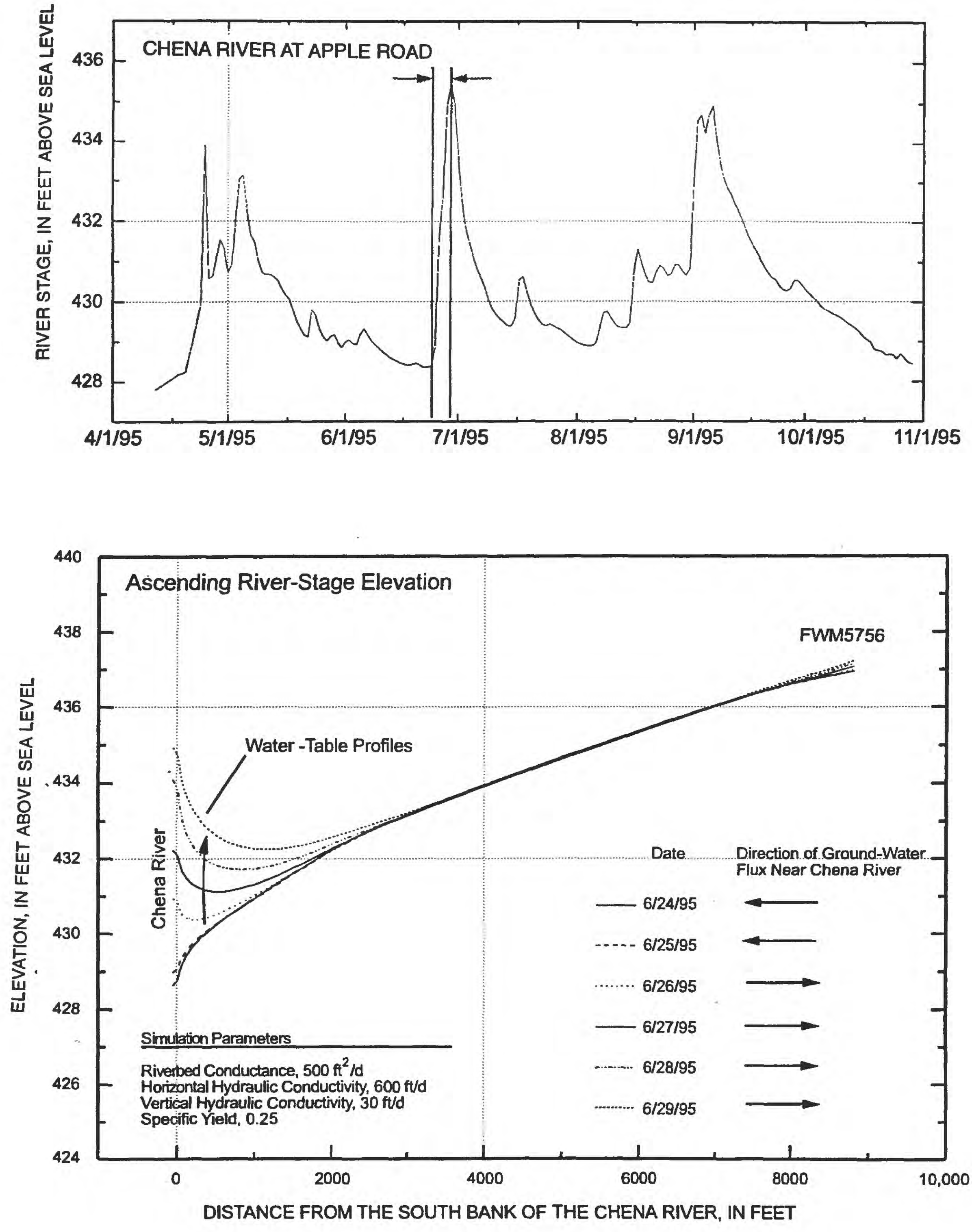


Figure 4. Simulated water-table profiles for June 24 to 29, 1995.

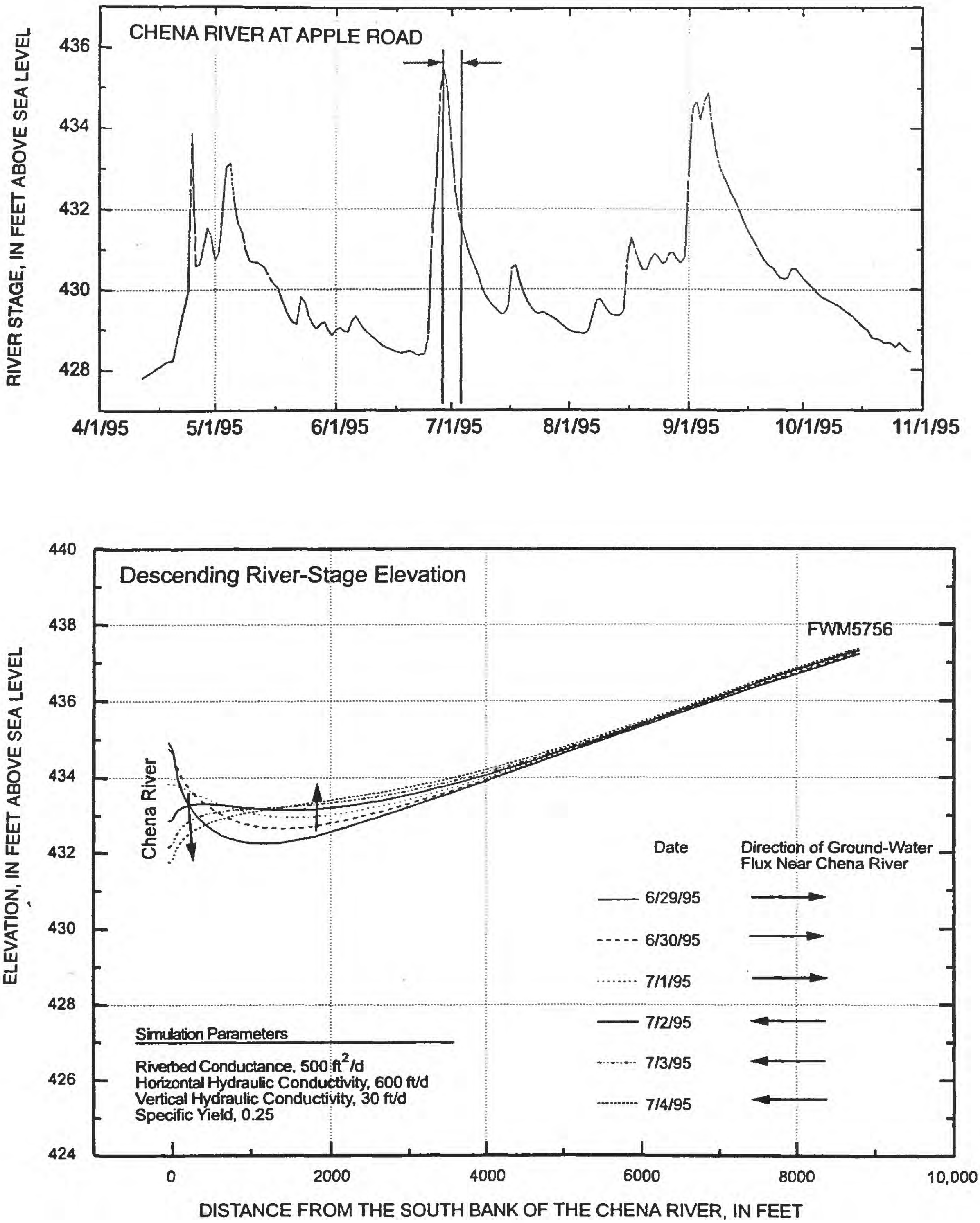


Figure 5. Simulated water-table profiles for June 29 to July 4, 1995.

with the general nature of environmental and geohydrologic reports and the environmental programs on Fort Wainwright. Project staff must also be familiar with Fort Wainwright and have visited the installation to help locate reports properly. The minimum grade level for staff in this position is GS-5 (Appendix B). A listing of the reports, ordered numerically and alphabetically, is provided in Appendix C. The index in Appendix C lists 225 reports. A listing of the reports and various other technical references is also maintained on the project WWW site: *http://ak.water.usgs.gov/*. If the operable unit number is known, the report is assigned to that operable unit (OU). If there is no clear environmental program established in the report title, the closest OU number is used.

Data Archiving

The USGS maintains a distributed National Water Information System (NWIS) data base to hold hydrologic information from data-collection programs and interpretive investigations. Three of the main components of the NWIS system are the Ground-Water Site Inventory (GWSI) data base, the Automatic Data Acquisition and Processing (ADAPS) data base, and the Quality of Water (QWDATA) data base.

The GWSI data base mainly contains information about wells, seeps, and ponds or lakes. Information on the local numbering system used by the USGS in Alaska, and a list of selected codes for data entry specific to Fort Wainwright, are presented in Appendix D. A component list for all of the available fields in GWSI is given by Luckey and Rogers (1989), and also appears in Lilly and others (1995) and Claar and Lilly (1997). The distribution of standard monitoring wells, driven wells, and pumping wells in GWSI as of June 1997 is shown in Appendix A, fig. A2 and its insets A-H. The distribution of soil borings in GWSI as of June 1997 is shown in Appendix A, fig. A3. The sites shown in these illustrations represent the number of sites in the GWSI data base for this project. The type of data input for each site varies and depends on the priorities and data requests set by USARAK and COE. The number of sites does not represent all geohydrologic sites on Fort Wainwright. The ongoing drilling and investigations are continuously adding more sites, and the past record is incomplete with respect to all of the various types of sites that exist on Fort Wainwright.

The USGS site-naming convention was adopted from the COE well-naming system with some modifications. All sites on Fort Wainwright that are standard monitoring wells, driven wells, pumping wells, or soil borings begin with FW. The third letter in the site name indicates the type of site: M indicates monitoring well, P indicates pumping well, D indicates driven well, and B indicates a soil boring. For many years, the COE has used a naming convention based on the type of drilling method, in which AP indicates power-auger drilling and AH indicates hand-augered sites. Following the AP or AH term is a sequential number indicating the order that the site was assigned a name. For example, FWM6070 (AP6070) is a monitoring well that is the 6070th power-auger site given a name on Fort Wainwright (table 2). The sequential numbers are equivalent in both the USGS and COE naming conventions. Driven wells did not have a pre-established uniform naming convention, so sequential numbers were assigned for those sites that were input into GWSI. Many of the water-supply wells on Fort Wainwright also were named in various formats, so the FWP term was added to the number used for the water-supply well for the wells that were processed. The minimum number of data elements needed to establish the site in GWSI is indicated in table 2 along with some of the more common fields used for data entry by this project.

Table 2. Selected ground-water data components in GWSI, with example entries

[See Appendix D for more information]

Component number	Description	Example input
C1[a]	Site ID (station number)	645118147400701
C2	Type of site	W
C3	Record classification	C
C4[a]	Reporting agency	USGS
C5	Project number	FTWW1 ASH
C6[a]	District code	02
C7[a]	State code	02
C8	County code	090
C9[a]	Latitude	645118
C10[a]	Longitude	1474007
C12[a]	Local well number	FC00100102DADD2
C14	Name of location map	FAIRBANKS D-2SE
C15	Scale of location map	1:25,000
C23	Primary use of site	O
C190	Other identifier	MW22
C191	Assignor of other identifier	Hughes
C190	Other identifier	AP6070
C191	Assignor of other identifier	COE
C190	Other identifier	FWM6070
C191	Assignor of other identifier	USGS
C802[a]	Station type	NNNNNYN
C803[a]	Agency use of site	A
C185	Remarks-misc.	OU3
C185	Remarks-misc.	Section A

[a]Indicates minimum data fields needed to have site in data base

ADAPS primarily contains continuous data for surface-water and ground-water sites. QWDATA primarily contains water-quality data collected by the USGS for ground water and surface water. Information from these data bases may be obtained from USGS offices in Anchorage and Fairbanks, in addition to the USARAK Department of Public Works Environmental Office at Fort Wainwright and the COE Environmental Section Office in Anchorage.

Geohydrologic Assessment

The geohydrology of the Fort Wainwright area depends on three basin-wide components of the hydrologic system:

1. The spatial and temporal distribution of recharge and evapotranspiration
2. The Chena and Tanana Rivers and associated sloughs
3. The ground-water and aquifer characteristics

The meteorological data needed for this study are primarily obtained from the ongoing data-collection network maintained by the National Weather Service and various other State and Federal agencies. Links to climate forecasts and meteorological information can be found on the USGS WWW pages.

Characteristics of Surface-Water Conditions

Various USGS investigations have studied the characteristics of the Chena and Tanana Rivers. Locations of data-collection stations for the two rivers are shown in Appendix A, fig. A4. The type of surface-water data available for the stations is listed in table 3. Stage levels and discharge measurements have been collected for this project. The surface-water data are needed for the interpretation of interactions between ground water and surface water for many of the environmental projects on Fort Wainwright

Discharge measurements were made to determine the relative amounts of inflow to and outflow from the alluvial aquifer, from the east side of Fort Wainwright to the west side. The flow variation across Fort Wainwright is important in constraining the interpretation of ground-water and surface-water interactions for mass-inflow calculations, ground-water modeling calibration, and movement of ground water near the rivers.

Stage measurements of the Chena and Tanana Rivers are important for understanding the differences in ground-water levels caused by stage changes in the rivers. Sufficient stage measurements were made to generate regression relations between selected stations on the Chena and Tanana Rivers in the Fort Wainwright area, the Chena River at Fairbanks, and the Tanana River at Fairbanks gaging stations, respectively. The use of these regression equations allows the estimation of a continuous stage record for various locations in the Fort Wainwright area. These data and estimates are of use to many Fort Wainwright environmental investigations.

Characteristics of Ground Water and Ground-Water Levels

Ground-water characteristics across Fort Wainwright are monitored by making individual ground-water and surface-water measurements. Some wells are equipped with pressure transducers for continuous measurements. The distribution of ground-water data-collection sites in the Fort

Table 3. Surface-water data collection sites in downstream order, Fort Wainwright, Alaska, study area

[C, chemistry data; S, stage data, Sed, sediment data; Qd, daily discharge data; Qi, instantaneous discharge data]

USGS site name[a]	Site location	USGS station number	Type of data
Chena River at Lowood Road Near North Pole	Chena River at north end of Lowood Road	15512150	Qi
Chena River at Lakloey Hill	Chena River at north end of Dennis Road	15512200	S, Qi
Chena River at Bailey Bridge	Chena River at Kinny Road and golf course	15512700	S
Chena River at Apple Road #2	Chena River at Apple Road, northwest of Building 1070	15512790	S, C
Chena River at Apple Road	Chena River at Apple Road	15512800	S
Chena River at Trainer Road	Chena River at Trainer Gate railroad bridge	15512900	S
Chena River at River Road	Chena River at River Road bridge	15513100	S, Qi
Chena River at Lagoon	Chena River at boat ramp north of hospital	15513200	S, C
Chena River at Fort Wainwright	Chena River at Fort Wainwright	645000147343000	C
Chena River at Fairbanks	Chena River at Steese bridge, downstream from bridge	15514000	S, Qd
Chena River at Wendell Street	Chena River at Wendell Street bridge	15514001	S
Chena River below MUS	Chena River below MUS	15514003	S, Qi
Chena River at Peger Road	Chena River at Peger Road bridge	15514004	S, Qi, C
Chena River at University Avenue	Chena River at University Avenue bridge	15514016	S, Qi
Chena River at Parks Highway	Chena River at Parks Highway bridge	15514018	S, Qi
Chena River at Pike's Landing	Chena River at Pike's Landing	15514020	S, Qi
Chena River at Anderson Road below Pump House	Chena River at Anderson Road below Pump House	15514020	S, Qi
Chena River at Mouth	Chena River at mouth	15514060	S
Tanana River at Chena Pump Campground	Tanana River at Chena Pump Road Campground	15514470	S
Tanana River at Byers Island	Tanana River at Byers Island	644752147564800	Sed
Tanana River at T1	Tanana River at T1, near current Tanana River at Fairbanks site	644730147523400	Sed
Tanana River at Fairbanks	Tanana River south of Fairbanks International Airport	15485500	S, Qd, C, Sed
Tanana River at Peger Road	Tanana River at south end of Peger Road	15485495[b]	S, Qd, Qi
Tanana River at T3	Tanana River on south side of Goose Island	15485475	C, Sed
Tanana River at T4	Tanana River T4[c]	15485455	Sed
Tanana River at T5	Tanana River T5[c]	15485445	Sed
Tanana River at T6	Tanana River T6[c]	15485430	Sed

[a]"At Fairbanks, Alaska" is dropped from the site names
[b]Stage and discharge data at station 15485495 were reported as station 15485500 before 1991
[c]For location, see Appendix A, figure A4

Wainwright area is shown in Appendix A, fig. A5. Monthly ground-water levels in the continuously recorded wells are also measured manually to verify transducer measurements. Individual measurements at these sites may be delayed by winter snow conditions or other access problems. Monthly ground-water levels at selected wells were measured in 1994 and 1995. Ground-water level measurements were limited during 1996 to the continuous data-collection sites. Miscellaneous measurements are made at selected wells to address USARAK or COE data requests or USGS project objectives.

Ground-water levels will be measured in reference to a measurement point at the top of the well (see section "Ground-Water Level Measurements"). The well-measuring points will be tied into vertical and horizontal surveys established by the COE. Vertical surveys will be repeated in the summer of 1997 or as needed, to evaluate well movement caused by frost jacking and other problems related to well movement.

FIELD PROCEDURES, DATA COLLECTION, AND ANALYSES

The procedures for installing monitoring wells, collecting and analyzing ground-water and surface-water data, installing continuous water-level recorders, and documenting field work are described in the following sections. Quality-assurance objectives and procedures are integrated throughout the sections below.

Installation of Monitoring Wells

Monitoring wells will be installed with standard augering techniques as described in American Society of Testing and Material (ASTM) Standards D5092-90 (ASTM, 1997a) and D1452-80 (ASTM, 1997b). Where these methods do not apply, reports on the drilling activities will include methods specific to each site.

Hydrologic Data Collection and Analyses

Hydrologic data have been collected for USGS project objectives, in addition to supporting other agency and contractor objectives defined by USARAK and COE. The frequency of hydrologic data collection has fluctuated as specific questions concerning operable units were addressed. Monthly measurements were made across Fort Wainwright during the first two years of the project to gain an initial understanding of the installation-scale geohydrology. Current hydrologic data-collection efforts have become more focussed on the collection of continuous ground-water level measurements at key index sites being used by multiple environmental projects on Fort Wainwright. The procedures for the collection and analysis of hydrologic data are described in the following sections.

Ground-Water Sites Field Inventory

Ground-water sites have been located in the field to determine the geohydrologic characteristics of the area. Information obtained from the field inventory is archived in USGS data bases. Field measurements at each site inventoried describe the location of the site and characteristics about the site construction. If well and construction logs are available and match the site characteristics, they are referenced for information. Project personnel who inventory sites must be familiar with general ground-water monitoring-well characteristics, construction methods, and the environmental programs in the respective field areas. Project staff will record all written information on the site, such as temporary well-driller's identification numbers, in bound field notebooks. Sites that have not been located in the field, but may have been destroyed at an earlier date, are input into the GWSI data base with a field indication that they have not been field checked. Sites found in an unusable condition are reported as destroyed. Well identification numbers (for example, FWM606, AP6060) are affixed to the site if the wells are not labeled. The minimum experience level for this activity is a GS-5 (Appendix B).

Ground-Water Level Measurements

Water levels have been measured monthly at Fort Wainwright beginning in 1994. All wells are measured within a three-day period during the winter and within a one- or two-day period in the summer. The measurement dates were coordinated between USGS and CRREL so that all measurements are made at approximately the same time each month. The collection of post-wide monthly measurements was reduced in 1996 and only continuously recorded sites and miscellaneous measurements to address specific USARAK or COE requests have been made since. The procedure for making these measurements is discussed in the following sections.

Collection

The general techniques as described in ASTM Standard D4750-87 (ASTM, 1997c) are used for measuring ground-water levels. The Fort Wainwright sites are classified as Hazard Level D, according to USEPA specifications. Members of the field crew wear rubber gloves while working at sites that have unknown water quality and at sites that reportedly are contaminated. A piezometer is unlocked and opened and a clean electric tape (e-tape) is turned on and set to a sensitivity of 3 or 4 on a scale of 10. All wells are marked on the outer rim to indicate the measurement points. The e-tape is lowered into the well until a "beep" is heard, indicating that the probe is submerged in water, or until the bottom of a dry well is reached. The depth to water is determined by reading the value off the e-tape cable at the measuring point. It is important to measure depths accurately and consistently; readings are therefore consistently recorded at the initial sound of the beep. Measurements are repeated until consecutive readings are within 0.01 ft (~3 mm). All measurements are recorded in a field book and on a field-measurement and sampling form (Appendix E, fig. E1), along with the sequential stop number, date, time, crew members, and site identification. After completing the measurement, the well is closed and locked.

Water levels at some wells may be measured with a weighted steel measuring tape and chalk. This method is generally used in areas with no record of ground-water contamination or for a site whose geochemical parameters will not be affected by small amounts of chalk material. Weighted steel tapes are also used to calibrate electric measuring tapes. Chalk is applied to the lower 2 to 3 ft (~0.7 to 0.9 m) of the steel tape. The steel tape is then lowered into the well until the lower section of the weighted tape is under water and part of the chalked section is wet. The tape is held to the measuring point for the well and a "hold" reading is recorded. The tape is then withdrawn back to the surface and the wetted limit indicated on the tape by the chalk, the "cut" mark, is recorded. This "cut" measurement is then subtracted from the "hold' measurement to give the depth to water below the reference mark. Equipment required for this work is listed in table 4.

Table 4. Field equipment and supplies required for ground-water level measurements

Tools and other materials	Decontamination kit
Tools	Tap water for rinse 1
Flathead screwdriver	Detergent/distilled water mixture for rinse 2
Channel lock pliers	Deionized water for rinse 3
Hammer	Methanol for rinse 4
Flush-mount well-cover wrench	Deionized water for rinse 5
Crescent wrench	Paper towels
Other materials	Trash bags
Field books	Rubber gloves
Location maps	Waste water container
e-tape	Waste methanol container
Steel tape, for calibration of e-tape	Extra methanol container
Keys to open wells	
Tubing, 15-20 ft (~4.6-6.1 m), that will fit down a well[a]	

[a]optional; may be used to free e-tape if caught down a well

After each water level is measured, including individual measurements within piezometer nests, the part of the e-tape or steel tape exposed to ground water will be decontaminated as follows:

1. Immerse and swirl in a container of tap water
2. Immerse and swirl in a solution of detergent and distilled water
3. Rinse in distilled water
4. Rinse in a container of methanol
5. Rinse in deionized water and dry with a paper towel
6. Dispose of the paper towel in a plastic garbage bag
7. Change the water and methanol at the end of each monthly measurement, or more often as necessary

Processing

Project staff transfer the individual water-level measurements from bound field notebooks to computer spreadsheets in the office. An example of a spreadsheet is shown in Appendix E (fig. E2). The project spreadsheets for individual sites are also being placed on the USGS WWW pages (*http://ak.water.usgs.gov/*) as an ongoing task throughout the project. The spreadsheets will not be maintained, however, past the end of the project. The spreadsheets contain information on the depth of the well and screened intervals, if available, and elevation information for the measuring point used and land surface. The data are compared with the field notebooks once the data are input into the spreadsheets. The staff requirements for data entry require experience in making field measurements and general training about the characteristics of ground-water sites. The minimum experience level is a GS-5.

Analysis

Project staff transfer the individual water-level measurements from the spreadsheets to computer graphics programs for visual analysis of the data. The nature of the data changes and anomalous readings are recorded and any unusual changes in the data are brought to the attention of the project chief. This would include high or low values outside of the known range for the well in question or adjacent wells that have similar hydrologic trends. The staff requirements for data analysis require experience in making field measurements, general training about the characteristics of ground-water sites, and computer spreadsheets and graphical plotting programs. The minimum experience level is a GS-5.

Quality-Assurance Methods

Project staff compare water-level data with data from nearby sites and with the past record to look for potential data problems. The density of the overall field data-collection network should allow for cross comparisons between nearby sites. Any potential problems are brought to the attention of the project chief to determine the quality of the data and what corrective actions can be taken. When possible, additional field measurements are made to verify any data that are not within the expected ranges and types of hydrologic changes. Data are not eliminated completely unless an adequate reason for the error or anomaly can be determined. The staff requirements for data quality-assurance methods require experience in making field measurements, general training about the characteristics of ground-water sites, ground-water hydrology, and basic quality-assurance methods. The minimum experience level is a GS-5.

Continuous Ground-Water Level Measurements

Continuous ground-water levels have been measured at Fort Wainwright at various sites since 1994. The distribution of continuous sites from 1994 to 1997 is shown in Appendix A, fig. A5. The locations of currently monitored sites are indicated on the map. The procedure for making these measurements is discussed in the following sections.

Data Loggers

Data that are automatically collected will be stored on CR-10 data loggers (Campbell Scientific, Inc., Logan, Utah). The CR-10 data loggers have an accuracy for resistance measurements of 0.015 percent of full scale bridge output and a voltage output range of 2.5 volts with a resolution of 0.67 millivolts. The input and output voltage accuracy is 0.2 percent of full scale range at -25 to 50 °C and 0.1 percent of full scale range at 0 to 40 °C. SM192 storage modules are used in combination with the data loggers. The SM192 has its own internal battery to store data in the event of a power failure in the main data logger. It also extends the data-storage capabilities of the data-logger setup.

The data loggers may have from one to four pressure transducers attached to the system. The programs used for the various configurations are listed in Appendix E, as well as a listing of the wiring-connection standards to be used with the standard pressure transducers on Fort Wainwright. Project staff must be familiar with basic electrical measurements and trained on the use of all data-logger systems. This includes installation, maintenance, testing, and data retrieval. The minimum experience level is a GS-5.

Pressure Transducers

The pressure transducers used for the project are manufactured by Microswitch and are generally a 5 lb/in^2 (~34.5 kPa) range sensor. The transducers used by the project are differential-gage sensors that require a vent tube to the surface and give a measure of the direct height of water over the sensor. The transducer housing was designed and built for this project and is used with the other coordinated geohydrologic projects in the Fairbanks area. A molding form is used to form the housing made from an injection-molding rubber. A piece of "red copper" pipe is used to help give more weight to the transducer housing, which aids in keeping the transducer cable straight when installed in a well. A 6-conductor cable, with a central vent tube is used with the transducers to connect the transducer, submerged in the well, with the data logger that is commonly installed above ground surface.

The transducers are tested before molding to make sure there are no breaks in the full-bridge readings on the pin connectors. The pin connectors of the transducer are then soldered to the cable wiring, or a pin-connector adapter is used. A steady soldering temperature is maintained and a clamp is placed across the transducer pins to act as a heat sink when directly soldering to the pins. The cable is hooked up to the pins if the pin connector is used and the cable vent tube is inserted into the correct end of the pressure-transducer housing. The connection is sealed with a silicon-rubber compound to prevent any leakage of the molding rubber, or water, between the vent tube and the transducer case.

Collection

Instrumentation of all continuously measured ground-water wells consists of an electronic data logger and a pressure transducer. Individual water-level measurements are also made at these wells to help calibrate and provide QA measures for the sites. Water-level measurements used to adjust the pressure-transducer readings are called calibration measurements. Individual measurements not used for calibration are used as check measurements to QA the continuous data. An example of a hydrograph from a continuously monitored well, with calibration and QA measurements, is shown in figure 6. Data are collected at a site using the following procedure:

1. Open well and measure two equivalent ground-water levels as described in the above sections
2. Note the condition of the battery, data logger date and time, and check instrumentation setup and wiring connections

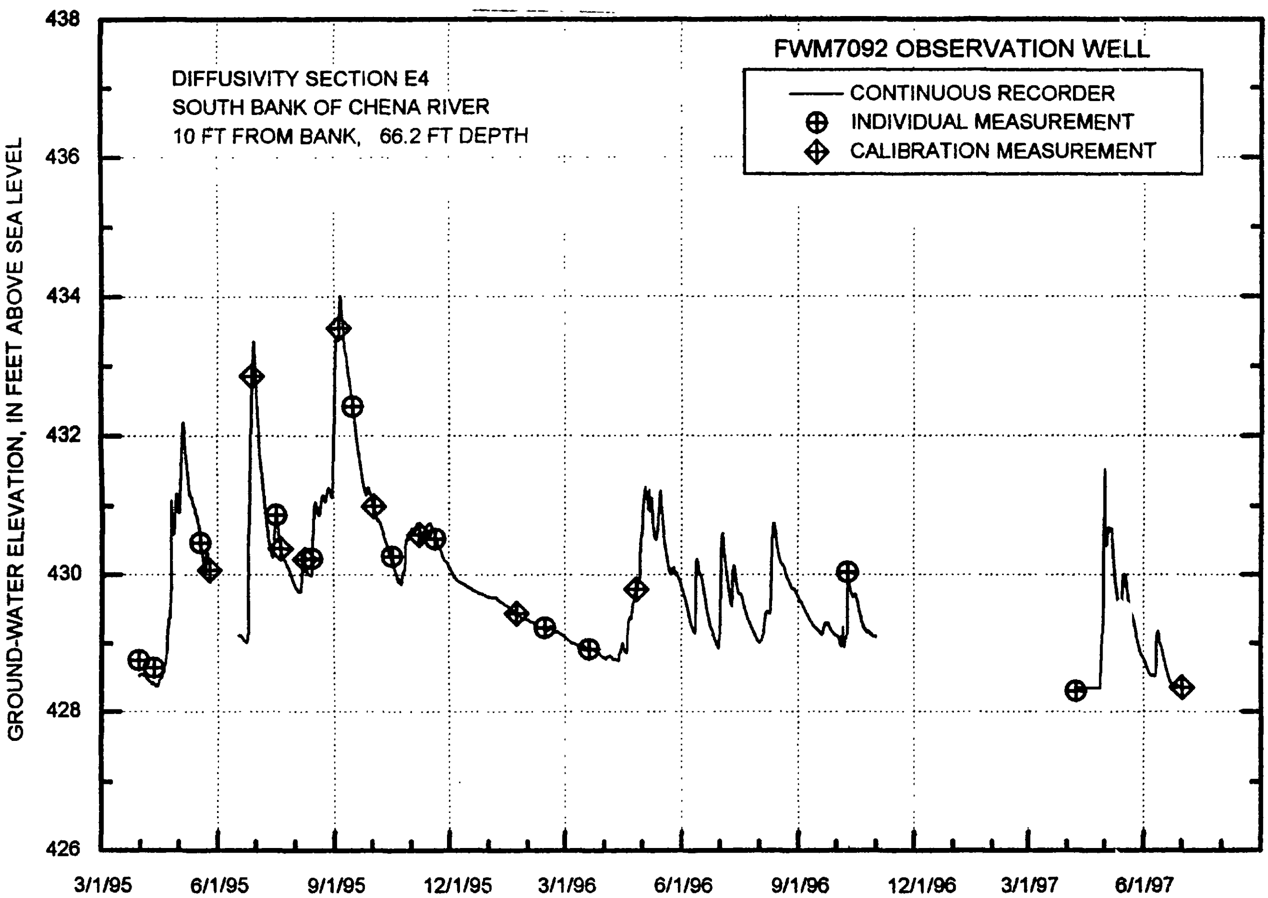


Figure 6. Example of a hydrograph from a continuously measured ground-water well.

3. Record the intermediate-storage values from the data logger (Appendix E) from a key pad or field computer
4. Transfer ("download") the data from the data logger to a field computer
5. Compare current voltage readings and water-level measurements to determine if instrumentation is working properly at time of site visit
6. Replace battery if voltage is below 12.0 volts
7. Reset data logger to recording mode
8. Save data from field computer to computer disk for backup
9. Secure site before leaving

Processing

Project staff transfer the individual water-level measurements from bound field notebooks to computer spreadsheets in the office. An example of a spreadsheet is shown in Appendix E (fig. E2). Continuously recorded data are transferred from field computers to office computers and readings are converted from voltages to ground-water elevations. For the duration of the project, selected data can be found on the USGS WWW pages (*http://ak.water.usgs.gov/*), by following the links to projects. The spreadsheets contain information on the depth of the well and screened intervals, if available, elevation information for the measuring point used, and land-surface elevation. Continuous data are provided in separate spreadsheets, or other data-file formats, because of the file sizes involved.

The individual water-level measurements are compared with those in the field notebooks once the data are input into the spreadsheet. The individual water-level measurements are then plotted with the continuously collected water-level measurements for comparison. The staff requirements for data processing require experience in making field measurements, basic electronics and data-logger operations, and general hydrology, and a review of the characteristics of ground-water changes in the Fort Wainwright area. The minimum experience level is a GS-5.

Analysis

Project staff transfer the individual water-level measurements from the spreadsheets to computer graphics programs for visual analysis of the data. The nature of the data changes and anomalous readings are recorded and any unusual changes in the data are brought to the attention of the project chief or other project staff at a GS-7 grade or higher. This would include high or low values outside of the known range for the well in question or adjacent wells that have similar hydrologic trends. Data that indicate diurnal fluctuations, rapid changes in water levels, or unchanging water levels would require further processing and review. The staff requirements for data analysis are experience in making field measurements, basic electronics and data-logger operations, general hydrology, and review of characteristics of ground-water changes in the Fort Wainwright area. The minimum experience level is a GS-5.

Quality-Assurance Methods

Project staff compare water-level data with data from nearby sites and with the past record to look for potential data problems. The density of the overall field data-collection network should allow for cross comparisons between nearby sites. Any potential problems are brought to the attention of the project chief, or project staff at a GS-7 or higher grade, to determine the quality of the data and what corrective actions can be taken. All corrections are brought to the attention of the project chief for final review. When possible, additional field measurements are made to verify any data that are not within the expected ranges and types of hydrologic variation observed in other sites. Data are not eliminated unless an adequate reason for the error or anomaly can be determined. Some data that may not be good for other purposes may be kept to show a general trend, or seasonal fluctuation. These data sets will have notations made in the electronic files to warn data users of potential usage problems. The staff requirements for quality assurance are experience in making field measurements, basic electronics and data-logger operations, and general hydrology, and a review of characteristics of ground-water changes in the Fort Wainwright area. The minimum experience level is a GS-5 with oversight by a GS-7 or higher hydrologist.

Surface-Water Discharge and Level Measurements

Surface-water discharge measurements were made following standard USGS methods described by Rantz and others (1982a,b). Discharge measurements are reported in the USGS annual data reports (U.S. Geological Survey, 1991-97) for Alaska and on the WWW at *http://ak.water.usgs.gov/*. General information and locations for the surface-water gaging stations are also available at this website.

Collection

Surface-water stations used in the Fort Wainwright area are shown in Appendix A, fig. A4. The data-collection stations on the Chena River include several different types of stage-measurement stations. The type of station, station number, and type of data collected are shown in table 3. Most of the stations used temporary measurement points from which water levels have been measured with a tape, folding rule, or by leveling methods. Standard stage readings are repeated until two consecutive measurements are made within the target QA range of 0.02 ft (6 mm). If wave action or other conditions prohibit meeting the QA range, an estimate of the error is made and reported with the recorded readings.

Some sites are equipped with a wire-weight gage. The horizontal "check bar" is the main reference point for the wire-weight gage. A weight is attached by a metal braided cable to a reel. The reel has a counter that can be adjusted to a set reading. The counter is set to a predetermined number once the check bar is surveyed. The weight is lowered to the check bar to record a reading from the reference point. This is repeated until the measurements are consistent. The weight is then lowered to the river surface and a distance is again measured. The difference between the surveyed elevation of the check bar and distance to the river is the stage height. This measurement is repeated until the QA goals stated above are met. Care should be taken to watch for boaters going under bridges while making these measurements.

Processing

The data are transferred from bound field notebooks to the appropriate electronic computer files. ADAPS is used for the calculations of discharge from the original field notes. The methods for this analysis are described in detail by Rantz and others (1982a,b). Stage measurements have been recorded in Excel spreadsheets and later archived in ADAPS as miscellaneous measurements. The spreadsheets contain information on the location of temporary measuring points and reference marks, and benchmark data. The data are compared with those in the field notebooks once the data are input into electronic files. The staff requirements for data processing require experience in making field measurements, general surface-water hydrology, computer data-base training, and general training about the characteristics of surface-water sites on Fort Wainwright. The minimum experience level is a GS-5.

Analysis

The data are plotted and checked against past measurements. The range of stage change is compared with that at other similar surface-water sites. Relations such as the gradients between closest upstream and downstream sites are checked. Data that do not fall within the expected ranges are brought to the attention of higher grade project staff to determine if a data QA problem exists. The analysis of data for surface-water discharge computations is described by Rantz and others (1982a,b). The staff requirements for surface-water data analysis are experience in making field measurements, general surface-water hydrology, computer data-base training, and general training about the characteristics of surface-water sites on Fort Wainwright. The minimum experience level is a GS-5.

Quality-Assurance Methods

Project staff compare water-level data with data from nearby sites and with the past record to look for potential data problems. Data above or below historical ranges are re-verified. Any potential problems are brought to the attention of the project chief to determine the quality of the data and what corrective actions can be taken. When possible, additional field measurements are made to verify any data that are not within the expected ranges and types of hydrologic changes. Data are not eliminated unless an adequate reason for the error or anomaly can be determined. Data that are suspect but may be valid are flagged for potential data users. The staff requirements for surface-water data analysis are experience in making field measurements, general surface-water hydrology, computer data-base training, surface-water quality-assurance methods, and general training about the characteristics of surface-water sites on Fort Wainwright. The minimum experience level is a GS-5 for initial quality-assurance tests; final approval is usually done by a GS-7 or higher hydrologist.

Survey Methods and Analysis

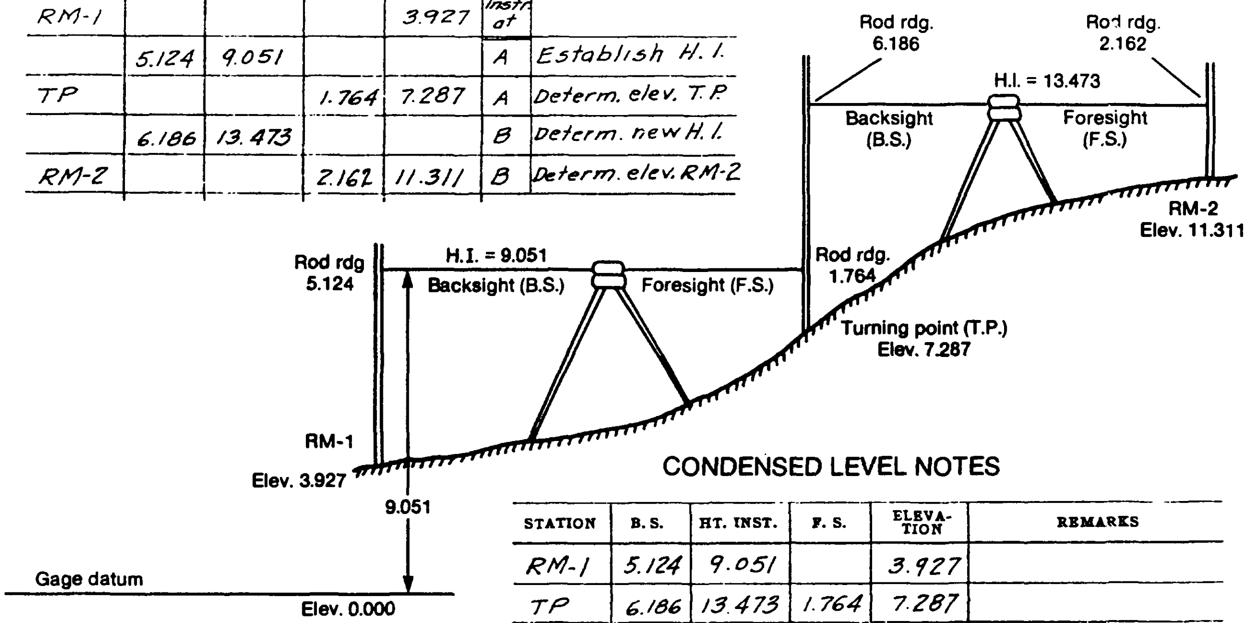
The USGS makes field surveys to determine elevations and location of various hydrologic features and to recheck well measuring-point elevations to meet project goals and timetables. The vertical datum used for the project objectives is the geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929. All elevations in this project are referenced to the 1966 Fairbanks area benchmark survey by the U.S. Coast and Geodetic Survey (1966).

Collection

Elevations of measuring or reference points at wells and at surface-water level measuring sites are needed to determine water-level elevations at different sites. Elevations of measuring and reference points shall be determined by leveling at a frequency sufficient to account for changes in elevations of the points caused by frost jacking. These elevations shall be determined by second-order leveling during which all readings are made to the nearest 0.005 ft (~1.5 mm). Two different techniques of level surveying are used for meeting project objectives. Differential level-line surveys (fig. 7) are used to determine the elevation of a desired measurement or second reference point from a known reference point using multiple instrument setups over a distance usually greater than 300 ft. A second technique of level survey is the differential level radial survey. This method is

EXPANDED LEVEL NOTES

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS	
RM-1				3.927	Instr. at	
	5.124	9.051			A	Establish H. I.
TP			1.764	7.287	A	Determ. elev. T.P.
	6.186	13.473			B	Determ. new H. I.
RM-2			2.162	11.311	B	Determ. elev. RM-2



CONDENSED LEVEL NOTES

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
RM-1	5.124	9.051		3.927	
TP	6.186	13.473	1.764	7.287	
RM-2			2.162	11.311	

Figure 7. Example of a differential-level line survey (from Kennedy, 1990).

used when measurement and reference points are in close proximity and the level instrument can be set up in a central location with all survey locations visible.

In a differential level-line survey, the allowable closure between two measuring or reference points is calculated by multiplying 0.01 ft (~3 mm) by the square root of D/100, where D is the horizontal distance, in feet, between the two points. All reference and measurement locations will be in level lines as turning points that begin and end on points whose elevations are known to an accuracy of 0.03 ft (~9 mm). The distances between all shots are balanced (that is, nearly equal distances between the foresight and back-sight distances) and less than 200 ft (~61 m) in length. Variations in these methods will be reported with the actual surveying data. Additional information on procedures to be followed during leveling is in Kennedy (1990).

In a differential level radial survey, the closure of shall be less than or equal to 0.007 ft (~2.1 mm) multiplied by the square root of the number of turning points in the line. The initial and starting points are the same and at least one turning point is used by re-surveying all of the locations in the same order in which they were initially surveyed.

Three standard points are surveyed on a well: top of outer locking cover, casing water-level measuring-point elevation, and ground surface. An example of a typical monitoring well is shown in figure 8. The surveying crew will mark with a permanent marker the surveyed locations of the

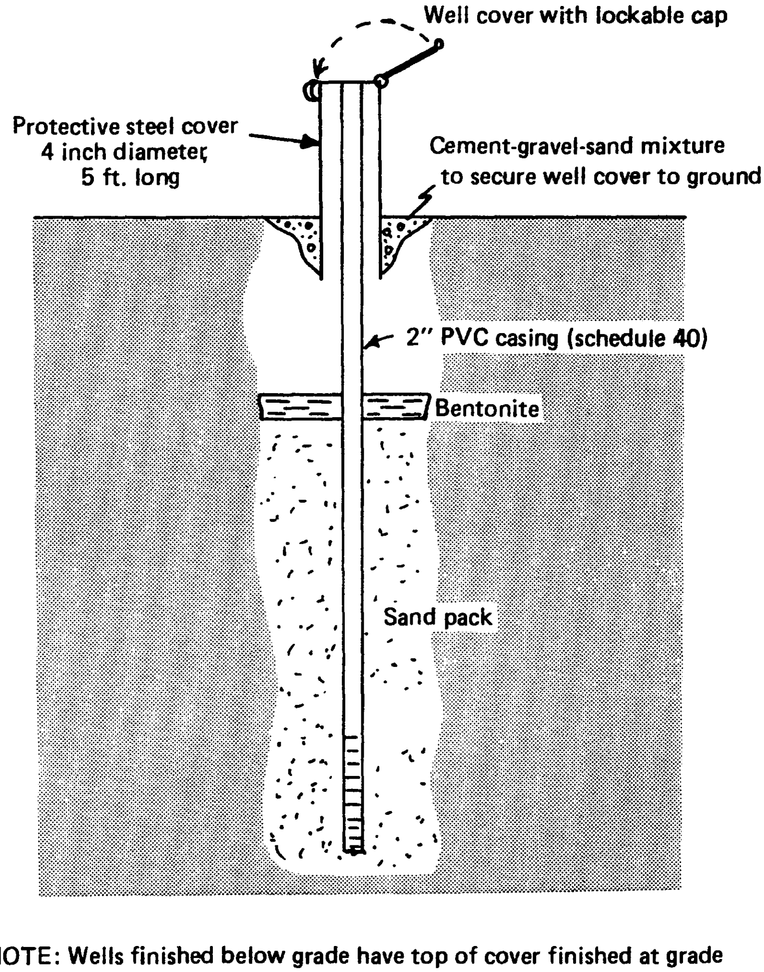


Figure 8. Diagram of a typical ground-water monitoring well.

top of locking cover and the water-level measuring point. The surveyed ground-surface location should be generally representative of the ground elevation surrounding the site. The water-level measuring point is commonly the highest point of the casing for the monitoring well. The point should be well labeled and its location noted in the survey field notebooks for later quality-assurance verification. The distance, measured to the nearest 0.01 ft (~3 mm), between the top of the outer locking cover (most often steel) and the inner well casing (most often PVC) should be measured at the two labeled points. The point on the inner casing should be the water-level measuring point. Frost jacking of wells would seldom cause equal effects on both the outer locking cover and well casing. Once a difference from previous values is noted in the field, a new survey of the water-level measuring point and outer locking cover elevations should be planned. In the Fairbanks area, many of the frost-jacking effects are observed after snowmelt and during infiltration and re-freezing in the active layer.

The staff requirements for survey-data collection require experience in making field survey measurements, survey instrumentation and instrument maintenance, and review of the COE surveying requirements for the Fort Wainwright area. The minimum experience level is a GS-5.

Processing

Field notes will be checked after each survey while in the field. After the level survey is completed, the field level notes will be entered into computer spreadsheets. The purpose of the spreadsheets is to check on the surveying data using the closures in the QA procedures outlined in the above section. The processed forms are then sent to the COE Surveying section for final QA review. Any elevation changes to measuring or reference points for monitoring wells will be input into GWSI data bases after surveying data are finalized. The staff requirements for survey-data processing are experience in making field survey measurements, survey instrumentation and instrument maintenance, and review of the COE surveying requirement for the Fort Wainwright area. The minimum experience level is a GS-5 with oversight by a GS-7 or higher hydrologist.

Quality-Assurance Methods

Project staff compare elevation data with those from past records to look for potential survey-data problems. Data above or below typical ranges of well movement are re-verified. The data are also rechecked to see if the above mentioned QA goals have been met. Survey errors commonly will be obvious when a ground-water or surface-water site has a water-level elevation that does not coincide with nearby measurements and known hydrologic conditions.

Any potential problems are brought to the attention of the project chief to determine the quality of the data and what corrective actions can be taken. When possible, additional field measurements are made to verify any data that are not within the QA range. The staff requirements for survey-data QA are experience in making field survey measurements, survey instrumentation and instrument maintenance, and QA practices, and a review of the COE surveying requirement for the Fort Wainwright area. The minimum experience level is a GS-5 with oversight by a GS-7 or higher hydrologist.

Field Notebooks

During all field activities, bound field notebooks will be used to keep detailed records. All pages of each notebook will be sequentially numbered. Information recorded in field notebooks will include:

- Site location; procedure/measurement performed; method used; date and time; names of those involved; all measurement results
- Date, time, battery voltage, and serial numbers of memory modules installed in or removed from data loggers

- Current field conditions, such as general weather, air temperature, stream stage, and other relevant ambient or antecedent conditions which may affect environmental variables or measurement of those variables
- Conditions measured on data logger or chart record
- Contacts with members of the public or military personnel while conducting field work; especially those contacts that relate to project activities, such as inquiries about what type of investigation is taking place

Equipment Calibration

- Calibrate electronic tapes used to measure water levels bimonthly with a steel tape
- Calibrate pressure transducers when they are functioning outside of their QA range using steel tape or e-tape measurements for comparison
- Record all calibration results in the bound field notebooks and/or bound instrument notebooks

Data Validation, Reduction, and Reporting

The data from the data loggers will be retrieved approximately monthly throughout the year. The data-collection retrieval interval may be longer during winter months when access to some sites is limited. Data will then be plotted to determine if they are reasonable. Ground-water levels will be compared to periodic manual measurements for verification. All reduced and compiled data will be checked by a second person. After review, data will be archived in USGS NWIS data bases.

PROJECT ORGANIZATION AND RESPONSIBILITY

The project staffing has varied each year according to the project objectives. Selected project staff information, including the technical qualifications for various positions, is available in Appendix B. The following staff was available for project objectives between October 1996 and September 1997:

Michael R. Lilly[1], USGS, Project Chief: Responsible for project management and project coordination with COE and USARAK.

Stanley A. Leake, USGS, Research Hydrologist: Responsible for ground-water modeling and geohydrologic analysis.

David V. Claar, USGS, Hydrologist: Responsible for installing hydrologic instrumentation, collecting basic hydrologic field data, and archiving the hydrologic data base; analyses and interpretation; ground-water modeling support.

[1]Robert L. Burrows assumed the duties of Project Chief for this project as of December 5, 1997.

DELIVERABLES

The primary products from this work will be hydrologic data, reference information, and reports and technical papers describing the geohydrology of the Fort Wainwright area. Additional deliverables will include the following:

- Copies of all field notebooks will be turned in annually, or as requested by USARAK or COE
- Project updates will be submitted as described in the "Schedule" section
- Available data will be provided for specific areas on Fort Wainwright at the request of USARAK and COE
- Ground-water level information, technical reference lists, and associated data will be maintained on the WWW at *http://ak.water.usgs.gov* until the project is completed or terminated.

Reports, meeting presentations, and submissions to scientific and engineering journals will receive USARAK approval before publication or presentation. In addition, the USGS will respond to informal requests for information as needed. The priorities of data reporting and exchange will be coordinated through USARAK and COE.

SCHEDULE

This project began in February 1994, and has incorporated multiple project objectives each year. Project priorities during each year were set by USARAK or COE. Interim reports and technical presentations explaining the progress and status of the project will be submitted periodically at project meetings with the USARAK and COE. Selected project objectives and activities are outlined below to help give a history and current outline of project activities:

February 1994 to September 1996:

- Collection and archiving of environmental reports, well logs, and geotechnical information for Fort Wainwright for support of USGS technical objectives and USARAK contractors
- Maintenance of and data collection from individual ground-water sites
- Maintenance of and data collection from continuously monitored ground-water sites
- Vertical level surveying of ground-water monitoring wells
- Development of a three-dimensional ground-water flow model including the main post area of Fort Wainwright, as part of the sub-regional ground-water model. This will be published as a USGS report
- Technical presentations, electronic correspondence, and telephone conferences with USARAK, COE, and USARAK contractors

- Multiple presentations given at meetings at State professional associations attended by many of the contractors working on Fort Wainwright
- Drilling of water-level measurement wells to meet the objectives of the USGS sub-regional investigation
- Aquifer-analysis studies and associated draft reports reviewed by USARAK and COE. These studies were coordinated with USARAK in OU3 and OU5

October 1996 to September 1997:

- Maintenance of and data collection from continuous ground-water data sites. Data sites will be visited monthly, except during winter months when site visits may be spaced up to three months apart
- Vertical leveling surveys of ground-water data-collection sites maintained by the USGS as needed to meet USGS project objectives or at the request of USARAK or COE. Surveying will be done within five working days from the request. The surveying requirements have been estimated to be 22 staff days. Surveying for USGS data-collection sites will be done without notification to USARAK, or COE, as required by ongoing field work
- Support of USARAK environmental projects as directed by USARAK and COE, with a focus on ground-water modeling. Support requirements have been estimated at 24 staff days. Information preparation and exchanges will include basic data and help with interpretive efforts. This task will include technical meetings, electronic correspondence, and telephone conferences. The project hydrologists responding to these requests will have a minimum grade level of GS-11 for interpretive topics. Basic data questions and data transfer may be made by GS-5 to GS-9 hydrologists under the supervision of higher grade project staff
- Archiving and distribution of geohydrologic data collected by the USGS during 1996 and past years to USARAK and COE environmental contractors. Paper archives such as report references, graphical well logs, and site folders will be archived at the Fairbanks USGS offices. Electronic data and reports will be archived on USGS District computer systems located in Anchorage, Alaska. All continuous ground-water data through August 1997, will be archived at the end of the project.
- Project updates will be provided orally at meetings with USARAK or COE, or written when requested by USARAK or COE

DEVIATIONS FROM WORKPLAN

Any deviations from this workplan, or from the methods described will be presented in interim reports or in final data or interpretive reports as needed. If procedural changes occur in the field, they will be recorded in the appropriate field notebook.

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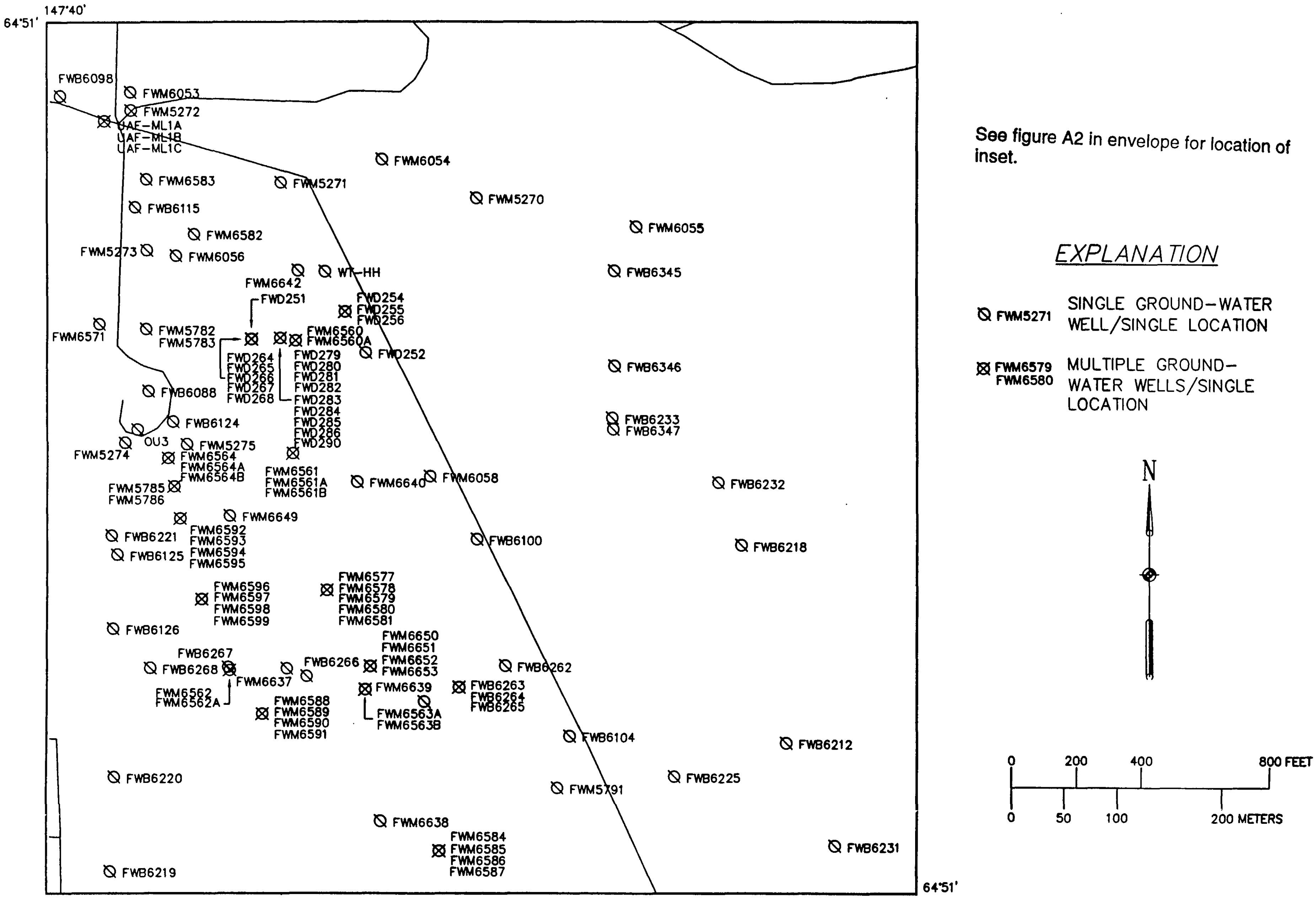
APPENDIX A

MAPS OF THE STUDY AREA

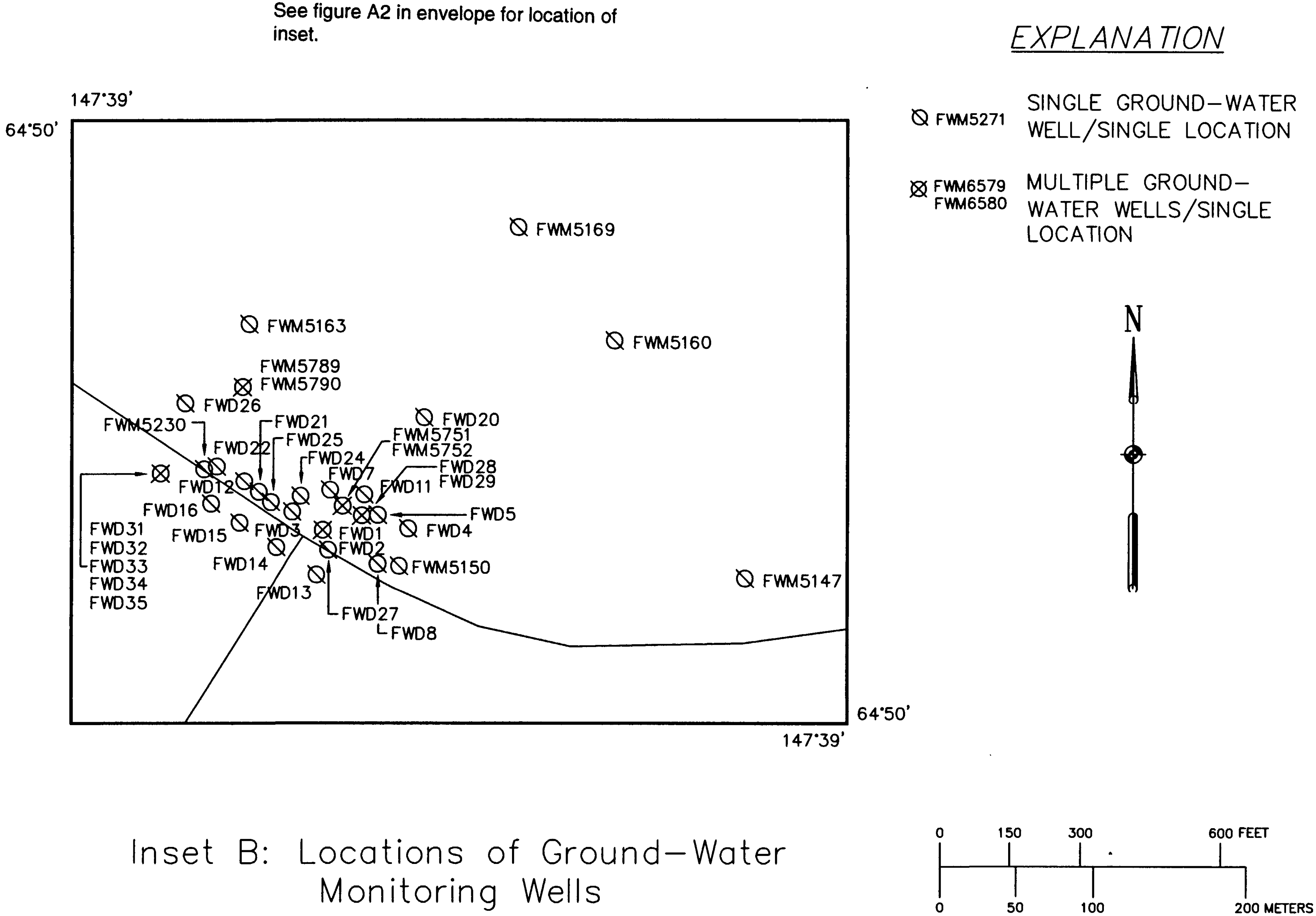
NOTE

Figures A1 through A5 are in the envelope at the back of this report. Insets A-H for figure A2 are on the following pages.

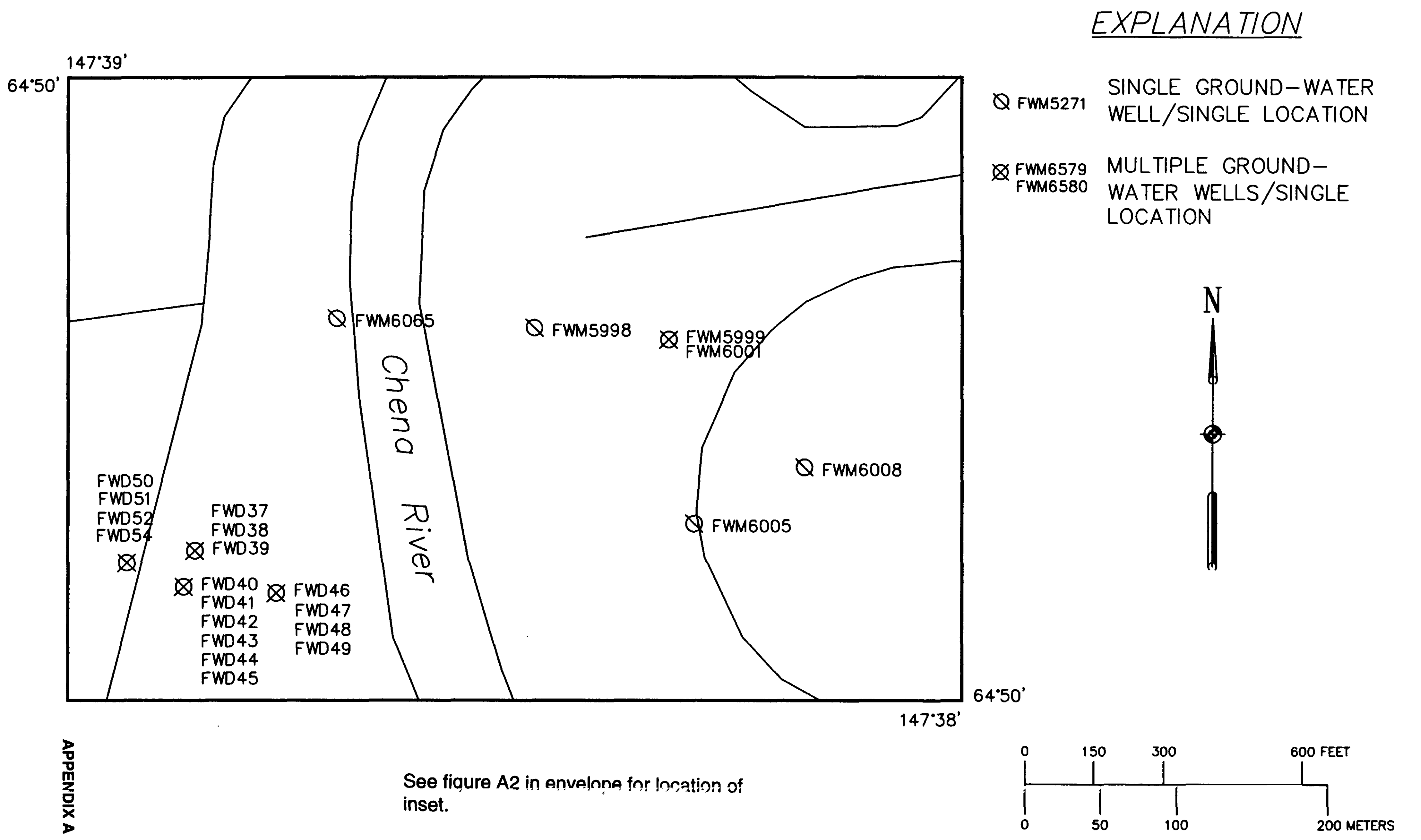


Inset A: Locations of Ground-Water Monitoring Wells

See figure A2 in envelope for location of inset.

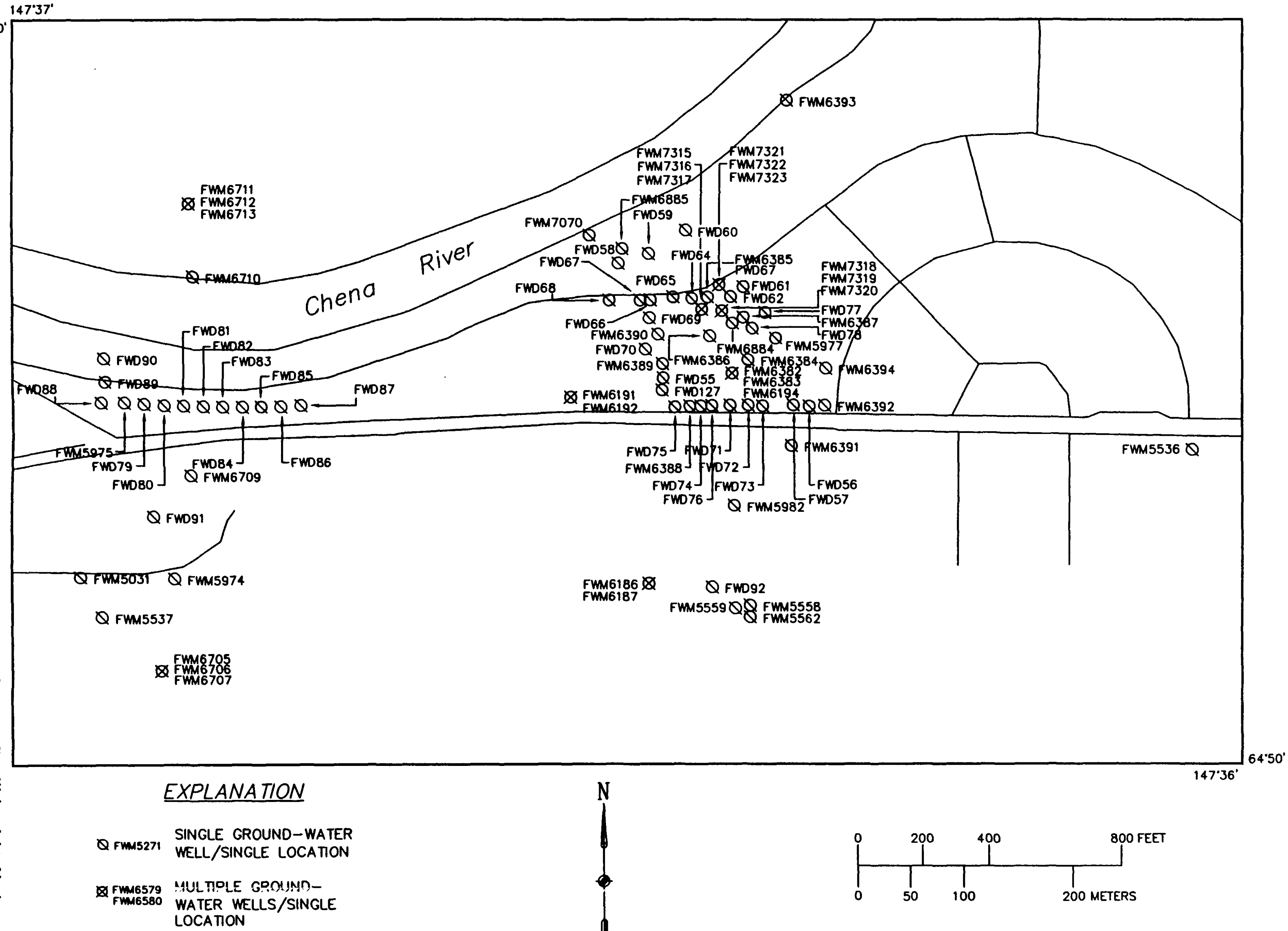


Inset B: Locations of Ground-Water Monitoring Wells



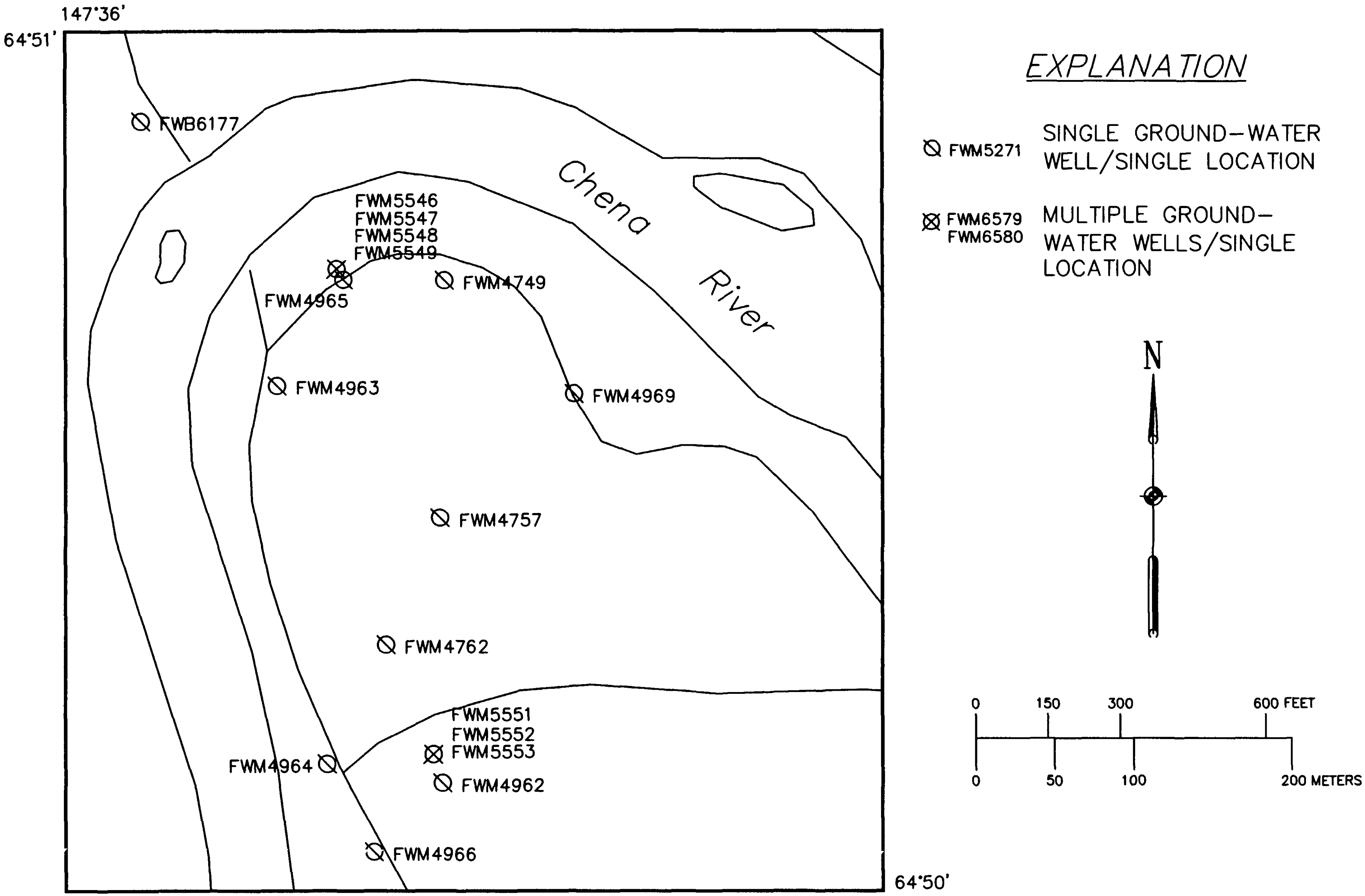
See figure A2 in envelope for location of inset.

Inset C: Locations of Ground-Water Monitoring Wells



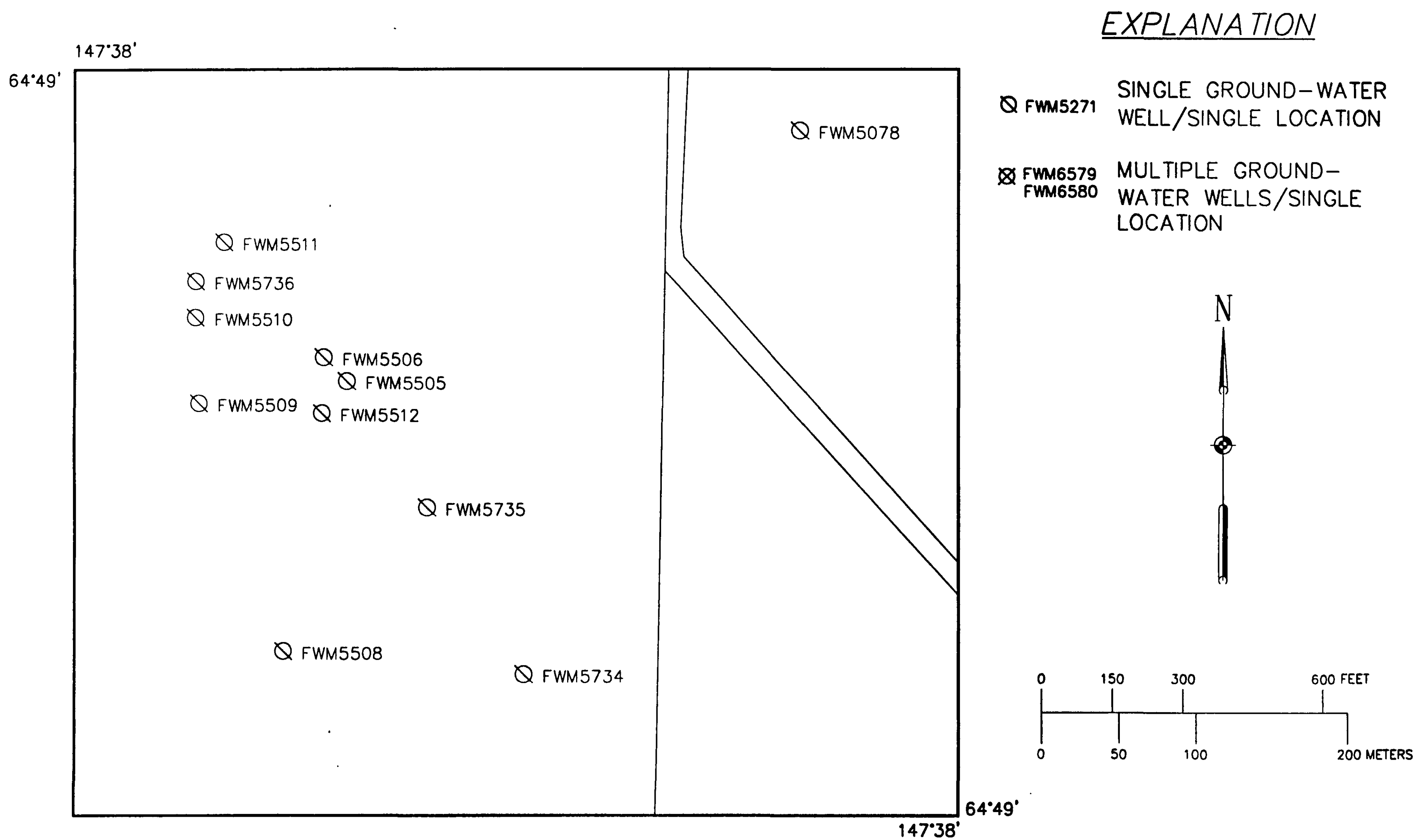
See figure A2 in envelope for location of inset.

Inset D: Locations of Ground-Water Monitoring Wells



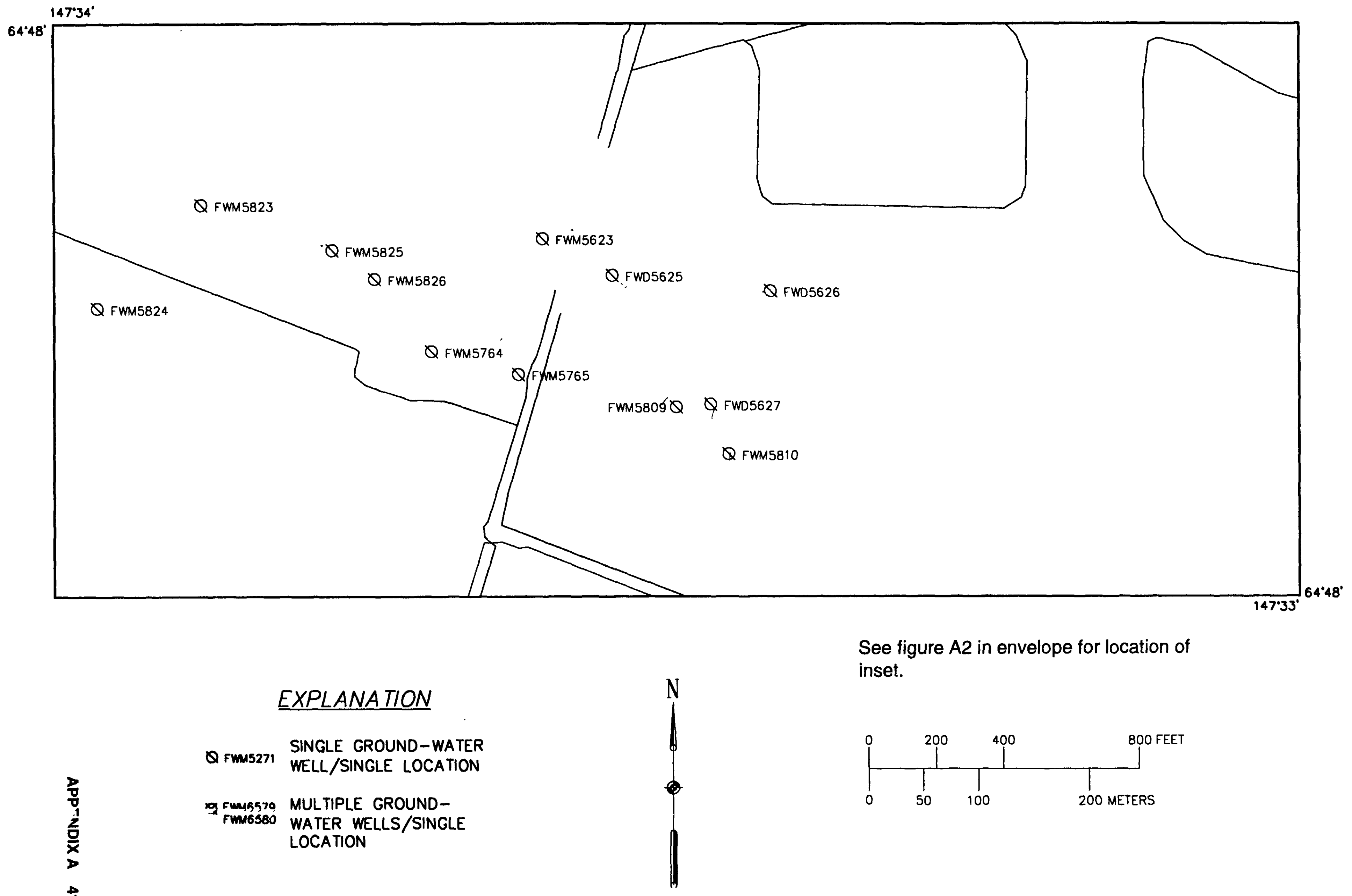
Inset E: Locations of Ground–Water Monitoring Wells

See figure A2 in envelope for location of inset.



See figure A2 in envelope for location of inset.

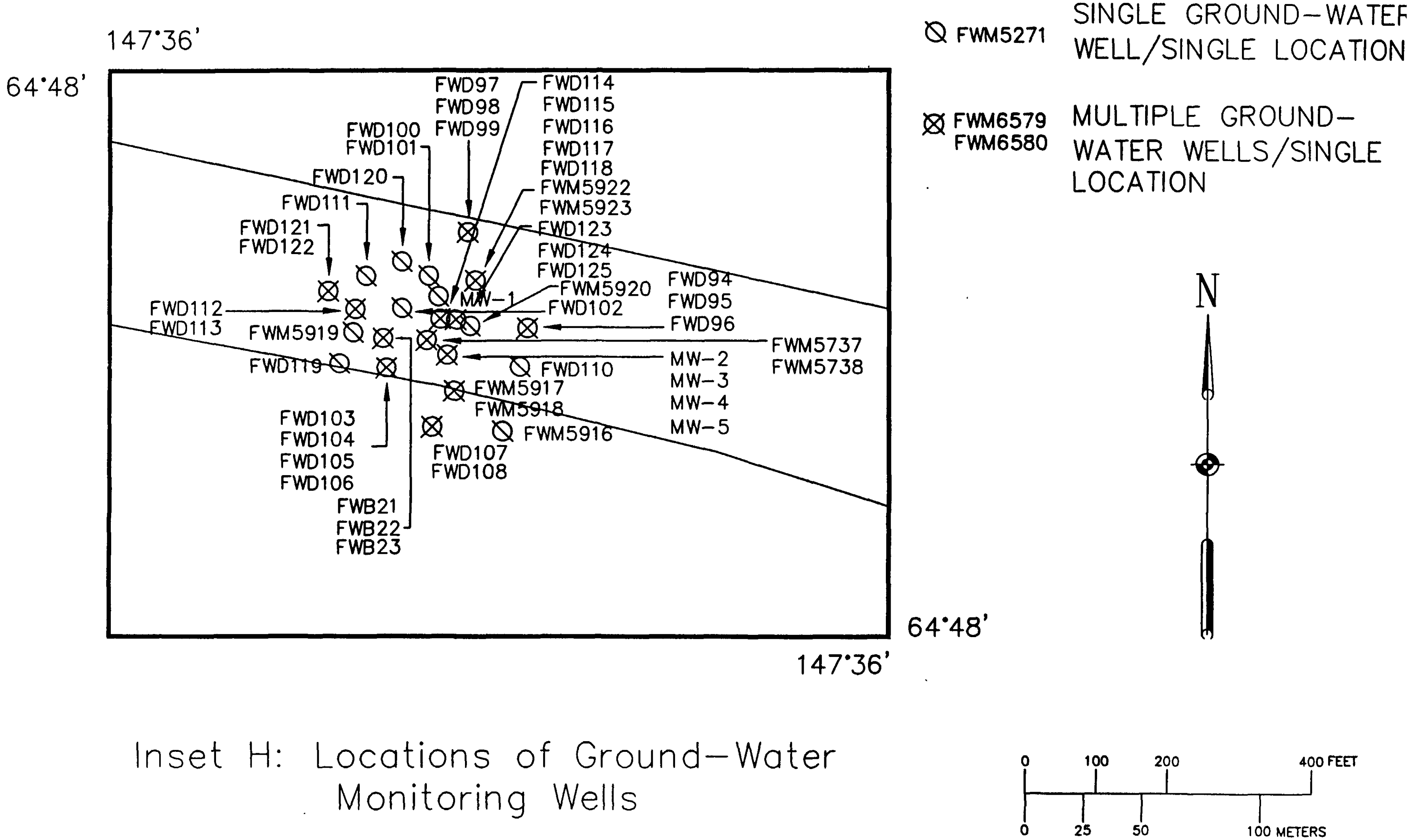
Inset F: Locations of Ground-Water Monitoring Wells



Inset G: Locations of Ground-Water Monitoring Wells

See figure A2 in envelope for location of inset.

EXPLANATION



Inset H: Locations of Ground-Water Monitoring Wells

APPENDIX B

PROJECT STAFF DESCRIPTIONS

AND

U.S. GEOLOGICAL SURVEY POSITION DESCRIPTIONS

Michael R. Lilly, USGS, Project Chief. Employed with USGS since February 1990. Highest Degree earned: University of Alaska Fairbanks, M.S. in Hydrogeology.

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David V. Claar, USGS, Hydrologist. Employed with USGS since May 1993. Highest Degree earned: University of Alaska Fairbanks, M.S. in Geological Engineering.

Selected References:

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U.S. GEOLOGICAL SURVEY POSITION DESCRIPTIONS

Hydrologist, GS-5-1315 (plan-grade-code)

A. Major Duties:

The incumbent, as an entry level trainee Hydrologist, is assigned duties directed towards providing practical experience in hydrologic data collection and analysis and training for the development of professional competence in the scientific areas of and related to hydrology. Typical assignments may include:

- Uses a variety of methods and equipment to: collect hydrologic data including stage records for streams, lakes, and wells; collect and preserve water samples for the analysis of chemical, sediment or biological characteristics; make discharge measurements; run levels to gages and wells.
- Checks discharge measurements computation; computes mean daily gage heights or prepares digital recorder tapes for computer processing; develops rating curves depicting the relationship between stage and discharge; and computes and compiles daily discharge values.
- Assists higher grade hydrologists on project work by performing duties such as: 1. measuring flood peaks indirectly by using transits or levels; 2. collecting and logging geologic samples at well sites; observing well drilling operations, or, performing pump tests; 3. preparing graphic representation of hydrologic data by way of maps, charts, hydrographs, and frequency curves; 4. determining the chemical or biological components of water for QW studies; and 5. preparing changes to standard computer programs or spot checking printouts to detect sources of errors.
- Writes reports on non-complex hydrologic studies or writes selected sections of broader, complex investigative reports.
- Operates a government vehicle as an incidental driver.

B. Factors

1. Knowledge Required by the Position

- Knowledge of theories, principles, practices and techniques of hydrology, hydraulics, geology, and/or engineering (as would be obtained through a Bachelor's Degree) to aid in the proper interpretation of scientific and technical data.
- Knowledge of Survey principles, methods, and practices in order to collect, adjust, correlate and interpret hydrologic data by Survey standards.
- Skill in using hydrologic-data collection and analysis equipment in the field and in the office.
- Skill in writing clear presentations of scientific data.

2. Supervisory Controls

- Supervisor clearly assigns work orally or in writing; exercises direct control over work; determines objectives, priorities and deadlines; and instructs on new, unusual, or difficult procedures.

- Routine assignments may be performed independently. New assignments or work situations are discussed with the supervisor.
- Thorough review of work is made in progress and upon completion.

3. Guidelines

- Survey policies, regulations, and standard practices generally dictate procedures to be followed. USGS TWRI Handbooks provide specific guidelines for data collection and analysis activities. Previous hydrologic studies and records may also serve as guides.
- Specific instructions from supervisor and USGS policy and procedures limit the interpretation of available guides. Supervisors are consulted when unclear or conflicting guidelines exist. However, in the field, situations will arise that will require the adaptation of normally standard methods of hydrologic data collection.

4. Complexity

- Work assignments provide a variety of experience and training to extend knowledge and to develop an understanding of hydrology and the complex interrelations of hydrologic systems.
- Incumbent determines methodology for routine assignments that are well-defined and which require the use of the a few sequential procedures to accomplish work.

5. Scope and Effect

- The purpose of the work is to provide unbiased hydrologic data for inclusion in the annual report and/or a hydrologic study.
- The work contributes to hydrologic information that serves as a basis for the responsible management of water resources by local, state, and other Federal agencies.

6. Personal Contacts

- Personal contacts are typically limited to co-workers in the District except, while in the field, the incumbent may be required to deal with the general public.

7. Purpose of Contacts

- Purpose of contacts within the organization is to obtain or exchange information on assignments; and, in the field, to obtain from landowners access to hydrologic data collection sites.

8. Physical Demands

- The position requires moderate periods of standing and sitting while in the office. While in the field, considerable walking, lifting, bending, climbing and stream wading is necessary to collect data.

9. Work Environment

- Office conditions are normal; field conditions may include extreme heat or cold, rain or snow, and hazardous conditions such as ice or flooding.

Hydrologist, GS-7-1315 (plan-grade-code)

A. Major Duties

As an advanced level trainee Hydrologist, the incumbent is assigned duties and provided training which contribute to the continuing professional development in the area of Hydrology and other related sciences. Typical assignments may include:

- Assists higher level hydrologists in conducting hydrologic studies by collecting hydrologic data in the field, recording, analyzing, and interpreting hydrologic data, researching records, and compiling statistical data, and preparing and editing portions of the hydrologic report.
- Collects hydrologic data using a variety of methods and equipment, such as: 1. measures the discharge of streams having a variety of depth and flow conditions; 2. collects and analyzes geologic samples to delineate and correlate aquifer systems and describe water-bearing characteristics; 3. measures water levels in observation wells, collects pumpage records and other geohydrologic data; and 4. collects water samples for the analysis of sediment concentration or chemical quality.
- Writes portions of interpretive reports of hydrologic studies and prepares hydrologic information in the form of maps, charts, or graphs for inclusion in reports.
- Computes, analyzes and interprets records of streamflow, water levels, pumpage, sediment quantities, or biological and chemical quality to assist in the scientific evaluation of hydrologic phenomena.
- Operates a government vehicle as an incidental driver.

B. Factors

1. Knowledge Required by the Position

- Knowledge of the theories, principles, practices, and techniques of hydrology, hydraulics, geology, and engineering as would typically be obtained through a Bachelor's degree to aid in the interpretation of scientific and technical data.
- Knowledge of Survey principles, methods, and practices in order to collect, adjust, correlate, and interpret hydrologic data by Survey standards.
- Skill in the use of hydrologic-data collection and analysis equipment in the field and in the office.
- Basic knowledge of computer applications for the compilation, analysis, representation, and evaluation of hydrologic information.

2. Supervisory Controls

- Supervisor assigns work in detail and fully reviews work in progress. This review is typically maintained through spot checks to monitor progress and conformance to instructions.
- Recurring work assignments covered by explicit procedures and guidelines are performed independently.
- Completed work is reviewed for compliance with instructions and to assure the quality of the work.

3. Guidelines

- Survey policies, regulations, and standard practices or instructions (such as TWRI Handbooks, Survey Manuals) provide guidelines to be followed.
- Supervisor may indicate source of instruction or available guidelines but incumbent will generally determine the appropriate guides to use.
- Deviations from guides or incomplete instructions are referred to the supervisor. However, in the field, standard guides or practices may be modified or adapted to meet unusual work situations.

4. Complexity

- Work assignments contribute to further development of professional hydrologic knowledges and experiences.
- Work assignments may require incorporation of a variety of standard procedures and methods to complete a series of sequential and specific phases of a broad hydrologic study.

5. Scope and Effect

- The scope of projects at this level typically provides unbiased, basic hydrologic information that meets the scientific standards of the Geological Survey. The effect of this work contributes to the basic understanding of hydrologic systems that serves, in part, as a basis for responsible and beneficial management of water resources by local, state, or other Federal authorities.

6. Personal Contacts

- Personal contacts are normally with other hydrologists or technicians in the organization, but occasionally, as directed by the supervisor or Project Chief, with cooperators or general public.

7. Purpose of Contacts

- Purpose of contacts within the organization is to gain or exchange information.
- Contacts external to the organization are limited to obtaining or exchanging information of a factual nature.
- Occasional contacts with the general public are to accomplish data collection, to communicate with observers, or to talk with property owners.

8. Physical Demands

- The position requires moderate periods of standing and sitting while in the office. While in the field, considerable walking, lifting, bending, climbing, and stream wading is necessary to collect data.

9. Work Environment

- Office conditions are normal; field conditions may include extreme heat or cold, rain or snow, and hazardous conditions such as ice or flooding.

Hydrologist, GS-9-1315 (plan-grade-code)

A. Major Duties

The incumbent of this position is a hydrologist with responsibility for participating on hydrologic studies of considerable scope and complexity, or serving as a Project Chief for studies which are more conventional or limited in nature. Project activity typically involves surface-water, ground-water, and /or geochemical studies. [insertion of terms needs approval]

- Plans, conducts, and reports on assigned parts of hydrologic interpretive studies which typically adhere to established techniques and conventional methods of investigation.
- Collects and analyzes hydrologic data relating to one or more of the three disciplinary fields (ground-water, surface-water, quality-water), determining apparent reasons for data anomalies, and correlating the wide variety of factors that affect the information presented.
- Maintains an awareness and understanding of the latest state-of-the-art techniques, instrumentation, and technology applicable to the conduct of hydrologic studies and data collection/analysis activities. Conceives new approaches or modifies existing methods of collecting, analyzing, and interpreting hydrologic information.
- Prepares reports of findings for assigned parts of interpretative studies summarizing the results of hydrologic investigations.
- Participates with higher level project hydrologists in the development of project proposals or descriptions which summarize critical information relating to the objective, approach, funding, and expected results of proposed investigations.
- Contacts either government, State, or local agencies to obtain data and information necessary for the conduct of hydrologic studies, or private citizens to obtain landholder permission for access to study sites.
- Directs the work of technicians and lower grade scientists serving as members of project teams in the collection and analysis of hydrologic information collected.
- Operates a motor vehicle as an incidental driver.

B. Factors

1. Knowledge Required by the Position

- A professional knowledge of scientific hydrologic principles and concepts and a practical knowledge of conventional hydrologic data collection methods, techniques, and field/lab equipment, sufficient to undertake routine hydrologic investigative projects involving water resource occurrence, use, and development.
- Knowledge sufficient to interpret the effect and impact of any change in the level or use of water resources for geographic areas under study.
- A limited knowledge of hydrology-related disciplines such as civil engineering, geology, biology, chemistry, and soil science sufficient to recognize how they relate to water management issues and to recognize when specialized advice is needed.

- Knowledge of USGS and WRD publications requirements and skill in the preparation of reports which clearly present scientific findings, interpretations, conclusions, and recommendations.

2. Supervisory Controls

- The supervisor outlines program objectives and the material, money, and personnel available for conducting project studies. the hydrologist, supervisor, and other staff scientists or project team members consult on coordination of work plans, objectives, and accomplishments, as required.
- The hydrologist independently plans the steps and techniques necessary to complete the assignments in accordance with established hydrologic practices and techniques. Where unusual or unconventional study conditions are encountered, or where problems require modification of established methods or procedures, the hydrologist generally discusses the action he/she plans to take beforehand with the supervisor or project chief, as appropriate.
- Completed work is reviewed for technical adequacy and soundness, as well as accomplishment of overall objectives for assigned project responsibilities.

3. Guidelines

- Guidelines are usually applicable and include policy, procedural, and technical manuals and handbooks, standard professional practices, published research results and related scientific reports, annual work plans, and oral instruction from the supervisor or project chief. The guides do not always address specific sets of problems or circumstances encountered, therefore, requiring periodic departure from standardized procedures or conventional study approach for completion of assignments.
- The hydrologist, in view of the considerations listed above, must select from alternative methods or procedures which appear appropriate to the existing situation, and make or recommend compromises required by technical considerations.

4. Complexity

- Primary assignments relate to the collection, analysis, and interpretation of hydrologic information collected in field studies and to the preparation of reports which summarize study findings.
- Complicating features encountered in conducting water resources studies typically include: seasonally varied hydrologic conditions and use of water resources, difficulty in accurately assessing hydrologic anomalies, a need to vary study approaches to provide for existing environmental or field conditions, and a lack of adequate and reliable hydrologic data on which to base interpretive findings and conclusions.
- Problems associated with project assignments carried out by the hydrologist are typically addressed in precedent studies and are generally amenable to the application of standard techniques and practices.

5. Scope and Effect

- The purpose of the work is to investigate and analyze any of a variety of hydrologic problems and to provide or recommend alternatives for water resources planning, management, and decision-making.
- Results of the work can affect potentially the quantity or quality of water available for use in local areas and the socio-economic well-being of dependent communities and industries. Study procedures, techniques, or results may also serve as a basis for similar hydrologic assignments or studies carried out by other hydrologists.

6. Personal Contacts

- Contacts are primarily with technicians and other hydrologists in the immediate office and with specialists at higher levels within the organization. Some contacts are with state agency scientists and local officials as well as with landowners, the general public, and contract personnel.

7. Purpose of Contacts

- Contacts are for the purpose of planning and coordinating work efforts with co-workers; to provide and obtain advice regarding study problems; to ensure correctness of study methodology employed; for compliance with cooperative agreements; and to reconcile conflicting technical viewpoints and ideas.

8. Physical Demands

- The work requires frequent physical exertion while conducting field portions of project work and with inspection of ongoing operations, including walking over rough, rocky, or uneven terrain; lifting and carrying equipment and supplies; and wading in streams in all types of weather.

9. Work Environment

- The work involves some degree of risk when conducting on-the-ground assessment of operations as well as exposure to moderate discomfort from such extremes as heat, cold, and inclement weather.

Hydrologist, GS-11-1315 (plan-grade-code)

A. Major Duties

The incumbent of this position is a hydrologist with responsibility for participating on hydrologic studies of considerable scope and complexity, or serving as a Project Chief for studies which are more conventional or limited in nature. Project activities typically involves surface-water, groundwater, and /or geochemical studies. [insertion of terms needs approval]

- Serves as a Project Chief or senior project member for complete hydrologic investigations by planning, conducting, and reporting on interpretative studies that typically require modification of established techniques or procedures and extensive collection, interpretation, analysis, and evaluation of hydrologic data.
- Develops approaches, standards, methods, guides, and procedures for conducting the interpretative study and provides advice, interpretation, and training to other professionals in the application or modification of established standards, methods, and procedures to ensure adequate treatment and thorough consideration of anomalous study conditions or situations.

- Coordinates immediate and long-term study objectives and plans, and the scheduling and establishment of priorities to ensure that they do not conflict with the overall water resources management program.
- Discusses agreements, study methods, approach, techniques, and desired results with management and representatives of cooperative agencies to implement hydrologic studies. Reconciles differences in approach or scope of study objectives in order to develop a comprehensive and scientifically sound report which can be used for comprehensive water resource management decision making.
- Maintain a high level of competence in his/her discipline specialty, a working competence in other technical disciplines, and an awareness of new technological developments in hydrology; develops methods for applying techniques and modifying such, as required, in the study of local hydrologic or related water resource problems and demonstrates or utilizes new or modified techniques in the comprehensive study of water resources for specific geographic areas of investigation.
- Prepares reports of findings for complete hydrologic interpretive studies summarizing the results of hydrologic investigations and technically reviews parts of reports prepared by project team members.
- Develops project proposals or descriptions which summarize critical information relating to the objectives, approach, funding, and expected results of proposed investigations, and defends recommendations for initiation of new projects to higher level management.
- Maintains liaison with employees of Federal and State Governments, local officials, and private organizations who are affected by, or otherwise have a shared interest in, water resource management practices and problems in the regional area; provides technical advice and information on water resource problems of mutual concern.
- Operates a motor vehicle as an incidental driver.

C. Factors

1. Knowledge Required by the Position

Knowledge of water management practices and procedures as well as broad and varied hydrologic study techniques sufficient to analyze and interpret hydrologic data and information, to analyze the existence and feasibility of water resource management alternatives, and to prepare data and interpretive findings in support of study conclusions for publication.

Familiarity with related fields such as hydraulics, engineering, geology, geochemistry, biology, and soil sciences sufficient to incorporate considerations from these disciplines in the review and study of water management problems, plans, and activities.

Knowledge of administrative procedures sufficient to develop work plans and budgetary requirements for the personnel, equipment, and study of water management problems, plans, and activities.

Knowledge of USGS and WRD publications requirements and skill in the preparation of reports which clearly present scientific findings, interpretations, conclusions, and recommendations.

2. Supervisory Controls

- The supervisor sets the overall objectives and program emphasis and works with the employee in developing project priorities. The hydrologist is responsible for independently planning own work, coordinating this work with other hydrologists or resources specialists, resolving technical problems, deciding on the necessity for and kind of technical compromise required for particular financial, manpower, or instrumentation constraints, and finalizing all assignments. The hydrologist keeps the supervisor informed of possible adverse reactions, publicity, or cooperator interest that might arise from study findings or conclusions. The individual's analysis, recommendations, and conclusions are relied upon as being technically correct. Completed work is reviewed for adherence to overall program policies and attainment of study objectives and deadlines.

3. Guidelines

- The guidelines are primarily Water Resource Division policies, operating program guidelines, and scientific reference literature. Precedent studies often provide procedural guides or methodology, but studies typically require development of a "tailor-made" approach, due to differences in study objectives, the geology or hydrology of a given study area, the depth of investigation, or the techniques available for data collection or model simulation of the hydrologic system. The hydrologist independently adapts or extends the guidelines of chooses from among alternative study procedures in attempting to achieve optimum information on which to base hydrologic interpretations. The individual uses judgement and ingenuity in developing and implementing project plans as well as directing and overseeing project investigations.

4. Complexity

- Assignments involve the development of techniques, methods, and procedures for the study of local or regional hydrologic conditions.
- The work is complicated by interrelating factors which must be considered simultaneously, such as: (1) multidisciplinary aspects of a study; (2) the varied nature of surface water velocities, ground water flow direction, storage capacity, flow boundaries, recharge characteristics, and water chemistry; (3) complex aspects of model calibration when used as a predictive study tool; (4) varied surface and subsurface geology; (5) varied land use conditions such as spatial and temporal variation in urbanization and nonuniform water supply development practices.
- The work requires the hydrologist to isolate specific variables to be considered in the study in order to describe conditions impinging on the storage, movement, and use of ground and surface water within varied surficial and subsurface geologic environments, to evaluate natural and man-induced water quality conditions in hydrologic systems; and to draw scientifically correct conclusions from the evaluation of collected data. The hydrologist must be versatile and innovative in approach and be able to adopt or extend established techniques or methods to overcome existing study problems.

5. Scope and Effect

- The purpose of the work is to investigate and analyze any of a variety of hydrologic problems and to provide or recommend alternatives for water resources planning management, and decision-making.

- Results of the work can potentially affect the quantity or quality of water available for use in local areas and the socio-economic well-being of dependent communities and industries. Study procedures, techniques, or results may also serve as a basis for similar hydrologic assignments or studies carried out by other hydrologists.

6. Personal Contacts

- Establishes and maintains contact with a technical staff of cooperators; scientists and community planners in other Federal, state, or local agencies; as well as hydrologists and support personnel in the immediate organization. Contacts are also made with consultant hydrologists and engineers as well as landowners, the general public, and contract personnel.

7. Purpose of Contacts

- Contacts are for the purpose of coordinating operational aspects of cooperative projects and study methods; to exchange information and resolve operational problems; to determine the applicability of state-of-the-art technology and existing study techniques to current project assignments; to develop new ideas and interpret methods and procedures; to reconcile conflicting viewpoints; to obtain information from cooperating agencies or other sources as required; and to provide advice and expertise in hydrologic principles for the solution of problems.
- Contacts are also to gain acceptance for use of different study techniques and methodologies; persuade reluctant landowners to provide access to study areas; and to provide information to individuals and organizations interested in the study findings, conclusions, and recommendations.

8. Physical Demands

- The work requires frequent physical exertion while conducting field portions of project work and with inspection of ongoing operations, including walking over rough, rocky, or uneven terrain; lifting and carrying equipment and supplies; and wading in streams in all types of weather.

9. Work Environment

- The work involves some degree of risk when conducting on-the-ground assessment from operations as well as exposure to moderate discomfort from such extremes as heat, cold, and inclement weather.

APPENDIX C

FORT WAINWRIGHT ENVIRONMENTAL REFERENCES

A total of 225 environmental reports are listed in this annotated bibliography. Following the alphabetical listing is a numerical listing of reports, included for ease of cross-referencing reports for locations shown on figure A1. Environmental contractor reports are filed by report number and available at the Fairbanks office of the U.S. Geological Survey.

Environmental Reports--Alphabetical Order

209 AGRA Earth & Environmental, Inc., 1995, Building 3015 release investigation, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-94-D-0011, delivery order no. 0008].

134 AGRA Earth & Environmental, Inc., 1995, Fort Wainwright drilling, sampling, and well installation: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-94-D-0011, delivery order no. 0001].

116 AGRA Earth a& Environmental, Inc., 1995, Fort Wainwright drilling, sampling, and well installation--Draft, February, 1995: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-94-D-0011, delivery order no. 0001].

30 America North/EMCON Inc., 1993, Final quarterly groundwater monitoring report, June 1993, sampling event picket wells, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Engineer District, Alaska, variously paged [contract no. DACA85-91-D-0002, delivery order no. 0013].

34 America North/EMCON Inc., 1993, Trip report--December [1992], sample collection, picket wells, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [with attached memoranda and field log, contract no. DACA85-91-D-0002, delivery order no. 0013].

31 America North/EMCON Inc., 1993, Trip report--March [1993], sample collection, picket wells, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [with attached memorandum and field log, delivery order no. 0013, contract no. DACA85-91-D-0002].

33 America North/EMCON Inc., 1993, Trip report--September [1993], sample collection, picket wells, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [with attached memorandum and field log, contract no. DACA85-91-D-0002, delivery order no. 0013].

171 Arcone, S.A., Lawson, D.E., Delaney, A.J., Strasser, J.D., 1995, Geophysical investigations of subsurface hydrogeologic conditions of the OU2 DRMO site, southeastern cantonment area, Fort Wainwright, Alaska--Preliminary interim draft report, August, 1995: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, variously paged.

66 Ballestero, T.P., and French, S.C., 1993 (sic; should be 1994), Final report on microwell investigations at Fort Wainwright, Alaska, Summer, 1993--Draft, January, 1993 (sic): Hanover, New Hampshire, University of New Hampshire Environmental Research Group, prepared for U.S. Army CRREL, v. II of II (first volume is report no. 65, though title and authors are not the same), 90 p. (plus 2 appendixes).

68 CH2M HILL, 1993, Draft preliminary assessment, Wainwright--September, 1993: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0007].

71 CH2M HILL, 1993, Site release investigation plan, delivery order 2, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

19 CH2M HILL, 1993, Site release investigation plan, delivery order 2, Fort Wainwright, Alaska--Draft, May, 1993: Anchorage, Alaska, prepared for U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

52 CH2M HILL, 1993, Site release investigation report, delivery order 2, Fort Wainwright, Alaska--Draft, December, 1993: Anchorage, Alaska, v. 1 (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

53 CH2M HILL, 1993, Site release investigation report, delivery order 2, Fort Wainwright, Alaska--Draft, December, 1993: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

80 CH2M HILL, 1993, Site release investigation plan, delivery order 3, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

55 CH2M HILL, 1993, Site release investigation report, delivery order 3, Fort Wainwright, Alaska--Draft, December, 1993: Anchorage, Alaska, v. 1, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

56 CH2M HILL, 1993, Site release investigation report, delivery order 3, Fort Wainwright, Alaska--Draft, December, 1993: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

20 CH2M HILL, 1993, Site release investigation plan, delivery order 3, Fort Wainwright, Alaska--Draft, May, 1993: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, same report as no. 45].

21 CH2M HILL, 1993, Site release investigation plan, delivery order 4, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for U.S. Army Engineer District, Alaska, variously paged [contract no. DACA85-92-D-0007, same report as no. 81].

46 CH2M HILL, 1993, Site release investigation report, delivery order 4, Fort Wainwright, Alaska--Draft, December, 1993: Anchorage, Alaska, v. 1 (text, tables, and figures--v. 2 is no. 51), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0004].

51 CH2M HILL, 1993, Site release investigation report, delivery order 4, Fort Wainwright, Alaska--Draft, December, 1993: Anchorage, Alaska, v. 2 (appendixes--v. 1 is no. 46), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

70 CH2M HILL, 1993, Technical memorandum, preliminary release investigation report, delivery order 3: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, 16 p. (plus 14 figures).

78 CH2M HILL, 1994, Appendix-microwell evaluation [Fort Wainwright, Alaska]: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [this is an appendix to reports no. 65 & no. 66].

176 CH2M HILL, 1994, Building 1060, treatability study interim report, delivery order 10, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0010].

85 CH2M HILL, 1994, Building 1060, treatability study plan, delivery order 10, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0010].

204 CH2M HILL, 1994, Corrective action plan, delivery order 2, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0002].

108 CH2M HILL, 1994, Corrective action plan, delivery order 3, Fort Wainwright, Alaska--Draft, June, 1994: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0003].

107 CH2M HILL, 1994, Corrective action plan, delivery order 4, Fort Wainwright, Alaska--Draft, July, 1994: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0004].

43 CH2M HILL, 1994, Fort Wainwright underground storage tank sites investigation, delivery order 9--Draft, February, 1994: Anchorage, Alaska, v. 1 (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, same report as no. 62].

44 CH2M HILL, 1994, Fort Wainwright underground storage tank sites investigation, delivery order 9--Draft, February, 1994: Anchorage, Alaska, v. 2 (appendixes A through I), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-000, same report as no. 63].

128 CH2M HILL, 1994, Groundwater sampling for storage tank sites, report of findings, delivery order 16, Fort Wainwright, Alaska--Draft, December, 1994: Anchorage, Alaska, v. 1 (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

129 CH2M HILL, 1994, Groundwater sampling for storage tank sites, report of findings, delivery order 16, Fort Wainwright, Alaska--Draft, December, 1994: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

167 CH2M HILL, 1994, PX service station, treatability study plan, delivery order 11, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0011].

203 CH2M HILL, 1994, Site release investigation, delivery order 2, building 2111, vessel integrity evaluation, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0002, modification no. 3].

202 CH2M HILL, 1994, Site release investigation plan, delivery order 2, building 2111, vessel integrity evaluation, Fort Wainwright, Alaska: Anchorage, Alaska, prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0002, modification no. 3].

99 CH2M HILL, 1994, Site release investigation report, delivery order 2, Fort Wainwright, Alaska: Anchorage, Alaska, v. 1 (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0002].

100 CH2M HILL, 1994, Site release investigation report, delivery order 2, Fort Wainwright, Alaska: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0002].

89 CH2M HILL, 1994, Site release investigation report, delivery order 3, Fort Wainwright, Alaska: Anchorage, Alaska, v. 1 (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, same as report no. 105].

90 CH2M HILL, 1994, Site release investigation report, delivery order 3, Fort Wainwright, Alaska: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, same as report no. 106].

91 CH2M HILL, 1994, Site release investigation report, delivery order 4, Fort Wainwright, Alaska: Anchorage, Alaska, v. 1 (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

92 CH2M HILL, 1994, Site release investigation report, delivery order 4, Fort Wainwright, Alaska: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007].

165 CH2M HILL, 1995, Groundwater samplings for storage tank sites, report of findings, delivery order 16, Fort Wainwright, Alaska: Anchorage, Alaska, v. 1, (text, tables, and figures), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0016].

166 CH2M HILL, 1995, Groundwater samplings for storage tank sites, report of findings, delivery order 16, Fort Wainwright, Alaska: Anchorage, Alaska, v. 2 (appendixes), prepared for the U.S. Army Corps of Engineers, Alaska District, variously paged [contract no. DACA85-92-D-0007, delivery order no. 0016].

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APPENDIX D

GROUND-WATER SITE INVENTORY FIELD LISTING

Derivation of Local Number

The local number, which is assigned to well and spring sites, is derived in part from the rectangular subdivision of public lands (fig. D1) and is used in Alaska as the site name. The first two letters indicate the principal meridian and the quadrant formed by the intersection of the base line and the principal meridian. The first three digits indicate the township in which the well or spring is located, the next three digits the range, and the last two digits the section. The letters following the section number indicate the quarter section, the quarter-quarter section, and so forth to the fourth order subdivision. Each of these subdivisions is lettered counter-clockwise, from the northeast corner. Each site within the smallest order of subdivision is then given a sequential number. Finally, each well within a section is assigned a sequential map number indicated by the last three digits. Thus, FD00200310CDAD1 001 denotes the Fairbanks meridian (F), the southeast quadrant (D), township 2 south, range 3 east, section 10; and the site is in the SE1/4 of NE1/4 of the SE1/4 of the SW1/4 (CDAD) of the section. It was the first site in the 2.5 acre "D" subdivision assigned a sequential number (1). The next space is left blank. The next three digits, 001, indicate the sequence in which a site was located on a map. Thus, 001 indicates the first site plotted in the one-square-mile section.

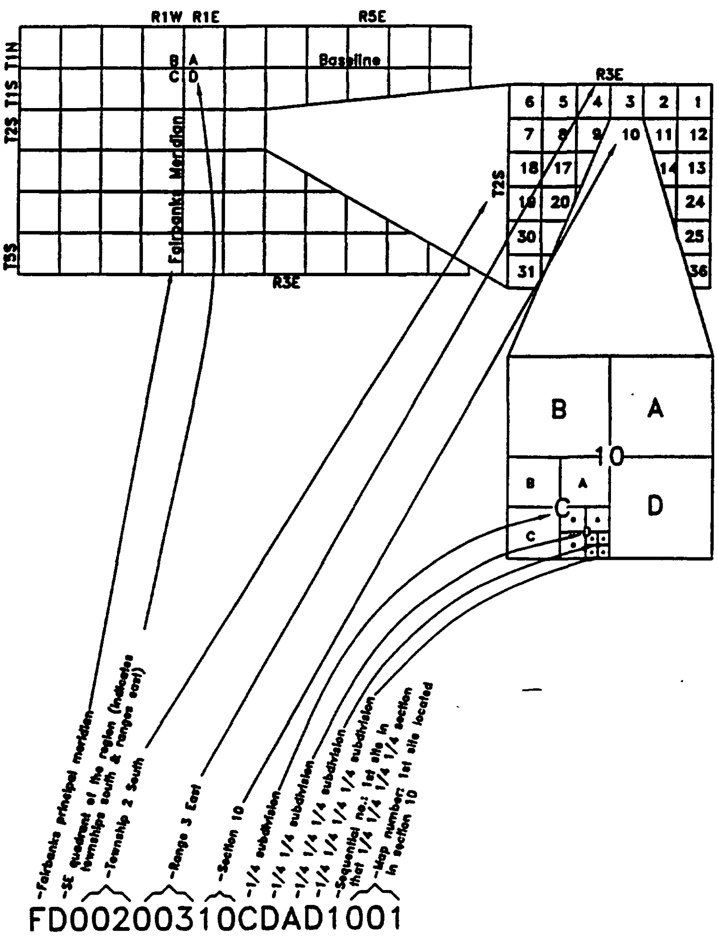


Figure D1. Derivation of local number from the official rectangular subdivision of public lands.

GWSI Data Input Outline for Fort Wainwright

The information below is to be used as a guide when entering primary site information into GWSI. All new sites entered into the data base must include this minimum amount of information. Please make sure spelling and the sequence of Other Identifiers and Remarks are in the correct order. **Bold** denotes actual format of information to be entered into the data base.

C1	Site ID:	combination of the lat/long plus sequence no. (e.g. **645032147365401**)
C5	Project number:	input FTWW1 followed by a space and then the initials of the person inputting the initial file (e.g. **FTWW1 EWP**). For sites already in GWSI, just input FTWW1 in C5.
C12	Local number:	local number (station name) needs to include all quarter section info (e.g. **FD00100107DABC2**). Do not bother entering the map number at this time, this will be done in blocks when all sites for an area have been input.
C16	Altitude:	land surface altitude from well logs or report information.
C17	Altitude method:	usually by levels (**L**)
C18	Altitude accuracy:	**.01** feet if surveyed by levels, otherwise evaluate each site on its own data.
C803	Agency use:	**A** (active data collection site) **I** (inactive or discontinued data collection site) **O** (inventory data site only)
C27	Hole depth:	depth of hole to .01.
C28	Well depth:	depth of well to .01.
C190	Other identifier:	this includes the names of wells or borings which have or will be called (e.g. FWM5650, AP-5650, MW10), always use capital letters, do not use any leading zeros. These names are placed in GWSI in the following order: USGS identifier COE identifier Contractor ID Field Marking
C191	Assignor of C190	this includes the assignors of other id's. Use the following inputs: **USGS FIELD ID** **COE SITE ID** <contractor's name> **FIELD MARKING**
C188	Name of person:	name of person who visited site (e.g. **PLUMB E**)
C187	Date of visit:	enter date of visit (e.g. **06121994**)
C185	Remarks data:	input nearest Bldg. # or Bldg. # referenced in reports, all OU#'s in vicinity of site, under-ground storage tank #'s (UST#) associated with site, for sites with no UST# input the nearest feature associated with purpose of well (e.g. Birch Hill Tank Farm, Land Fill, Canol Road Pipeline, etc.), input section site is located in, general description of site location, input who and what type of water levels are collected

at site (e.g. USGSPM, USGSMM, USGSCM, CRRELMM, UAFPM). Place remarks into GWSI in the following order:

BLDG####
OU#, OU#
UST ###,###,###
SECTION C
<site description>
USGSMM, USGSPM

C252 Misc. value-2 enter 7 digit northing for site (e.g. **3961970**).

C253 Misc. value-3 enter 6 digit easting for site (e.g. **251570**).

GWSI INPUT REMARKS:

Feature Associated With Site:

BIRCH HILL TANK FARM
CANOL ROAD PIPELINE
LAND FILL
801 DUMP SITE

Type of Water Level Collected:

CRREL1MM	< Brian Taras Mass Measurement
CRREL1PM	< Brian Taras Partial Measurement
CRREL1CM	< Brian Taras Continuous Measurement
CRREL2MM	< Dan Lawson Mass Measurement
CRREL2PM	< Dan Lawson Partial Measurement
CRREL2CM	< Dan Lawson Continuous Measurement
UAFMM	< UAF Mass Measurement
UAFPM	< UAF Partial Measurement
UAFCM	< UAF Continuous Measurement
USGSMM	< USGS Mass Measurement
USGSPM	< USGS Partial Measurement
USGSCM	< USGS Continuous Measurement

APPENDIX E

USGS HYDROLOGIC FIELD AND ANALYSIS FORMS

AND CR10 DATALOGGER PROGRAMS

FORT WAINWRIGHT, ALASKA
ENVIRONMENTAL ACTIVITIES TRACKING SYSTEM
GROUND-WATER AND SURFACE-WATER LEVELS

PURPOSE:

The purpose of this form is to allow tracking of ground-water and surface-water level measurement activities on Fort Wainwright Facilities. All measurements should be to the nearest 0.01 foot. This form is to be completed and turned in to the Fort Wainwright Environmental office within two days of water-level measurements. Contact Joseph Malen, 353-6160, for additional information.

MAIN TECHNICAL CONTRACTOR INFORMATION:

Business name: ______________________ Phone: ____________
Project manager contact: ____________________
Contract number: ____________________
Project Title: ____________________________ Project # ____________

WATER-LEVEL INFORMATION:

Field Crew	Site ID	Date	Time	Method	Est. Error (feet)	MP to WL (feet)	MP Elev. (feet)	WL Elev. (feet)

Note: Write down final measurements from duplicates recorded in field notes
MP = measuring point WL = water level
Method = s (steel tape), e (electric tape), o (other, write in)

DO NOT FILL OUT THIS SECTION:

Data form checked:
Agency: ________ Name: _________ Date: _________

Tracking Form # FWWL1A

Figure E1. Example of a field-measurement and sampling form.

FWM-6194 GROUND-WATER OBSERVATION WELL

Site ID: 645029147364002
Local Number: FD00100107DABA7

All measurements in feet	Feet	Elevation
Depth to bottom of well from MP :	52.3	399.3
Depth from TOCP to top of SI :	41.8	409.8
Depth from TOCP to bottom of SI :	52.3	399.3
Land Surface Datum (c16):	--	448.8

Datum corrections, reference survey notes in site folders

Date	MP Elevation (feet above sea level)
09-04-93	451.58

MM, mass measurement
MP, measuring point
N/A, not available
SI, screened interval
TOC, top of casing
WS, water surface

Date	Time	Method	MP to WS	Error	LS to WS	WS elevation	Remarks
06-15-94	1639	Steel Tape	21.11	0.01	18.33	430.47	MM
07-15-94	1122	Steel Tape	19.23	0.01	16.45	432.35	MM
08-15-94	1455	E-tape	20.53	0.01	17.75	431.05	MM
09-15-94	1115	E-tape	20.78	0.02	18.00	430.80	MM
10-18-94	1140	E-tape	20.79	0.03	18.01	430.79	MM
11-17-94	1107	E-tape	20.87	0.02	18.09	430.71	MM
12-22-94	1306	E-tape	21.05	0.02	18.27	430.53	MM
01-17-95	1218	E-tape	21.22	0.02	18.44	430.36	MM
02-15-95	1318	E-tape	21.34	0.02	18.56	430.24	MM
03-15-95	1051	E-tape	21.44	0.02	18.66	430.14	MM
04-14-95	1437	E-tape	21.34	0.02	18.56	430.24	MM
05-15-95	1130	E-tape	19.43	0.02	16.65	432.15	MM
06-14-95	1130	E-tape	20.74	0.02	17.96	430.84	MM
07-17-95	1629	E-tape	19.63	0.01	16.85	431.95	MM
08-15-95	1308	E-tape	20.18	0.01	17.40	431.40	MM
10-17-95	1253	E-tape	19.93	0.01	17.15	431.65	MM
11-20-95	1447	E-tape	19.90	0.01	17.12	431.68	MM
02-15-96	1135	E-tape	20.92	0.01	18.14	430.66	MM

Figure E2. Example of a water-level spreadsheet.

Campell Scientific CR10 Datalogger Programs

The purpose of this program is to make five consecutive measurements of a 4-wire full-bridge pressure transducer and then store the average, battery voltage, and panel temperature into final storage. The storage device is the SM192 as well as the CR10.

```
*1 enter programming mode
0.0000                  xxxx        sampling interval in seconds

01: P 87      Beginning of Loop
                   01:     0        delay
                   02:     5        loop count

02: P 06      Full Bridge Reading
                   01:   01reps
                   02:   2325 mV, 60 Hz rejection
                   03:   02input channel
                   04:   01excitation channel
                   05: 2500mV excitation
                   06:   01--        temp. storage location, hit "C" after 1
                                     to index input locations
                   07:   01multiplier
                   08:   00offset

03: P 95      End Loop

04: P 10      Battery Voltage
                   01:   06temp. storage location

05: P 11           Temperature Reference Junction
                   01:   01reps
                   02:   01input channel
                   03:   03excitation channel
                   04: 0007          temp. storage location
                   05:   1.0multiplier
                   06:    0offset

06: P51            Average
                   01:   05# reps
                   02:   01starting input location #
                   03:   01final average input location

07: P 86      DO command
                   01:   10starts data recording, set flag 0

08: P 77      Record Real Time
                   01:   110         Day, hour, min

09: P 70      Sample records data          Store averaged transducer voltage
                   01:   01# reps             from location 1
                   02:   01temporary location

10: P 70           Sample records data          Store battery voltage and panel
                   01:   02# reps             temperature from locations 6& 7
                   02:   06temporary location

11: P 96         Serial output to SM192
               01:   71        Storage module adress
```

Wiring of data logger and pressure transducer for voltage and temperature recording.
(program on page 1)

Transducer wiring		Temperature Block wiring	
Black-	2H	Red- 1H	
White-	2L	Black-	E3
Red-	E1	Clear-	AG
Blue-	AG		

TO DISPLAY DATE:

*7

#

Enter storage location number

Note # will tell you the final location number.

Enter #300, #600, etc, to obtain approximately 25 hr intervals (for 30 min sample interval).

Special note:

*0 resumes logging!!

The purpose of this program is to make five consecutive measurements of a 4-wire full-bridge pressure trarsducer and then store the average and the battery voltage into final storage. The primary storage device is a SM192 storage module set to Fill & Stop mode.

```
0.0000                    xxxx       sampling interval in seconds

01: P 87        Beginning of Loop
                      01:     0      delay
                      02:     5      loop count

02: P 06        Full Bridge Reading
                      01:   01reps
                      02:   2325 mV, 60 Hz rejection
                      03:   01input channel
                      04:   01excitation channel
                      05: 2500mV excitation
                      06:   01--       temp. storage location, hit "C" after 1
                                       to index input locations
                      07:   01multiplier
                      08:   00offset

03: P 95        End Loop

04: P 10        Battery Voltage
                      01:   06temp. storage location

05: P51               Average
                      01:   05# reps
                      02:   01starting input location #
                      03:   01final average input location

06: P 86        DO command
                      01:   10starts data recording, set flag 0

07: P 77        Record Real Time
                      01:   110        Day, hour, min

08: P 70        Sample records data
                      01:   01# reps
                      02:   01temp. location

09:  P 70             Sample records data
                      01:   01# reps
                      02:   06temp. location
10: P 96        Serial output to SM192
                      01:   71storage module address
```

The purpose of this program is to make single measurements of a 4-wire full-bridge pressure transducer and then store the measurement and the battery voltage in final storage. The primary storage device is a SM192 storage module set to Fill & Stop mode.

```
0.0000                 xxxx      sampling interval in seconds

01: P 06       Full Bridge Reading
                    01:   01reps
                    02:   2325 mV, 60 Hz rejection
                    03:   01input channel
                    04:   01excitation channel
                    05: 2500mV excitation
                    06:   01temp. storage location
                    07:   01multiplier
                    08:   00offset

02: P 10       Battery Voltage
                    01:   02temp. storage location

03: P 86       DO command
                    01:   10starts data recording, set flag 0

04: P 77       Record Real Time
                    01:  110        Day, hour, min

05: P 70       Sample records data
                    01:   02# reps
                    02:   01--       starting temp. location, hit "C" after 1

06: P 96       Serial output to SM192
                    01:   71storage module address
```

Wiring of Data Logger to Pressure Transducer

Black-	**1H**	Red-	**E1**
White-	**1L**	Blue/Green-	**AG**

Values In Final Storage Locations

01	?
02	Julian day
03	hour-minute
04	transducer reading
05	battery voltage

The purpose of this program is to make thermocouple reference and water temperatures in degrees Celciu~ five consecutive measurements of a 4-wire full-bridge pressure transducer, and battery voltage, and then store the temperature values, pressure transducer average and the battery voltage into final storage. The primary storage device is a SM192 storage module set to Fill & Stop mode.

```
0.0000              xxxx        sampling interval in seconds

01: P 11            Temperature Reference Junction
                    01:  01reps
                    02:  01input channel
                    03:  03excitation channel
                    04: 0001        temp. storage location
                    05:  1.0multiplier
                    06:    0        offset

02: P14        Temperature - TC Difference
                    01:  01reps
                    02:  2260 Hz rejection +/- 7.5 mv
                    03:  04input channel
                    04:  01thermocouple type
                    05: 0001reference memory location
                    06: 0002temp. storage location
                    07:  1.0multiplier
                    08:    0        offset

03: P 87       Beginning of Loop
                    01:    0        delay
                    02:    5        loop count

04: P 06       Full Bridge Reading
                    01:  01reps
                    02:  2325 mV, 60 Hz rejection
                    03:  02input channel
                    04:  01excitation channel
                    05: 2500mV excitation
                    06:  03--       temp. storage location, hit "C" after 3
                                    to index input locations
                    07:  1.0multiplier
                    08:   0offset

05: P 95       End Loop

06: P51        Average
                    01:  05# reps
                    02:  03starting input location #
                    03:  03final average input location

07: P 10       Battery Voltage
                    01:  04temp. storage location

08: P 86       DO command
                    01:  10starts data recording, set flag 0

09: P 77       Record Real Time
```

01: 110 Day, hour-min

10: P 70 Sample records data
01: 04# reps
02: 01-- temp. storage location, <u>hit "C" after 1</u>

11: P 96 Serial output to SM192
01: 71storage module address

10TCRT Thermocouple Reference Wiring

Red- **1H**
Black- **E3**
Clear- **AG**

Type 1 Thermocouple Wiring

Copper- **4H**
Silver- **4L**

Wiring of Data Logger to Pressure Transducer

Black- **2H**
White- **2L**
Red- **E1**
Blue/Green- **AG**

Values In Final Storage Locations

01	?
02	Julian day
03	hour-minute
04	reference temperature
05	water temperature
06	transducer reading
07	battery voltage

The purpose of this program is to make five consecutive measurements for each of two 4-wire full-bridge pressure transducers and then store the average and the battery voltage into final storage locations. The primary storage device is a SM192 storage module set to Fill & Stop mode.

```
0.0000                  xxxx      sampling interval in seconds

01: P 87      Beginning of Loop
                   01:     0      delay
                   02:     5      loop count

02: P 06      Full Bridge Reading
                   01:  01reps
                   02:  2325 mV, 60 Hz rejection
                   03:  01input channel
                   04:  01excitation channel
                   05: 2500mV excitation
                   06:  01--      temp. storage location, hit "C" after 1
                                  to index input locations
                   07:  01multiplier
                   08:  00offset

03: P 06      Full Bridge Reading
                   01:  01reps
                   02:  2325 mV, 60 Hz rejection
                   03:  02input channel
                   04:  02excitation channel
                   05: 2500mV excitation
                   06:  06--      temp. storage location, hit "C" after 6
                                  to index input locations
                   07:  01multiplier
                   08:  00offset

04: P 95      End Loop

05: P51            Average
                   01:  05# reps
                   02:  01starting input location #
                   03:  01final average input location

06: P51            Average
                   01:  05# reps
                   02:  06starting input location #
                   03:  02final average input location

07: P 10      Battery Voltage
                   01:  03temp. storage location

08: P 86      DO command
                   01:  10starts data recording, set flag 0

09: P 77      Record Real Time
                   01:  110       Day, hour, min

10: P 70      Sample records data
                   01:  03# reps
```

02: 01 temp. location

11: P 96 Serial output to SM192
01: 71 storage module address

Wiring of Data Logger to Pressure Transducer 1

Black-	**1H**
White-	**1L**
Red-	**E1**
Blue/Green-	**AG**

Wiring of Data Logger to Pressure Transducer 2

Black-	**2H**
White-	**2L**
Red-	**E2**
Blue/Green-	**AG**

The purpose of this program is to make five consecutive measurements for each of three 4-wire full-bridge pressure transducers and then store the average and the battery voltage into final storage locations. The primary storage device is a SM192 storage module set to Fill & Stop mode.

```
0.0000                  xxxx        sampling interval in seconds

01: P 87      Beginning of Loop
                   01:     0        delay
                   02:     5        loop count

02: P 06      Full Bridge Reading
                   01:   01reps
                   02:   2325 mV, 60 Hz rejection
                   03:   01input channel
                   04:   01excitation channel
                   05: 2500mV excitation
                   06:   01--       temp. storage location, hit "C" after 1
                                    to index input locations
                   07:   01multiplier
                   08:   00offset

03: P 06      Full Bridge Reading
                   01:   01reps
                   02:   2325 mV, 60 Hz rejection
                   03:   02input channel
                   04:   02excitation channel
                   05: 2500mV excitation
                   06:   06--       temp. storage location, hit "C" after 6
                                    to index input locations
                   07:   01multiplier
                   08:   00offset

04: P 06      Full Bridge Reading
                   01:   01reps
                   02:   2325 mV, 60 Hz rejection
                   03:   03input channel
                   04:   03excitation channel
                   05: 2500mV excitation
                   06:   11--       temp. storage location, hit "C" after 11
                                    to index input locations
                   07:   01multiplier
                   08:   00offset

05: P 95      End Loop

06: P51            Average
                   01:   05# reps
                   02:   01starting input location #
                   03:   01final average input location

07: P51            Average
                   01:   05# reps
                   02:   06starting input location #
                   03:   02final average input location

08: P51            Average
```

01: 05# reps
02: 11starting input location #
03: 03final average input location

09: P 10 Battery Voltage
01: 04temp. storage location

10: P 86 DO command
01: 10starts data recording, set flag 0

11: P 77 Record Real Time
01: 110 Day, hour, min

12: P 70 Sample records data
01: 04# reps
02: 01temp. location

13: P 96 Serial output to SM192
01: 71storage module address

Wiring of Data Logger to Pressure Transducer 1

Black-	**1H**	Red-	**E1**
White-	**1L**	Blue/Green-	**AG**

Wiring of Data Logger to Pressure Transducer 2

Black-	**2H**	Red-	**E2**
White-	**2L**	Blue/Green-	**AG**

Wiring of Data Logger to Pressure Transducer 3

Black-	**3H**	Red-	**E3**
White-	**3L**	Blue/Green-	**AG**

The purpose of this program is to make five consecutive measurements for each of four 4-wire full-bridge pressure transducers and then store the average and the battery voltage into final storage locations. The primary storage device is a SM192 storage module set to Fill & Stop mode.

```
0.0000          xxxx      sampling interval in seconds

01: P 87        Beginning of Loop
                01:    0        delay
                02:    5        loop count

02: P 06        Full Bridge Reading
                01:   01reps
                02:   2325 mV, 60 Hz rejection
                03:   01input channel
                04:   01excitation channel
                05: 2500mV excitation
                06:   01--      temp. storage location, hit "C" after 1
                                to index input locations
                07:   01multiplier
                08:   00offset

03: P 06        Full Bridge Reading
                01:   01reps
                02:   2325 mV, 60 Hz rejection
                03:   02input channel
                04:   02excitation channel
                05: 2500mV excitation
                06:   06--      temp. storage location, hit "C" after 6
                                to index input locations
                07:   01multiplier
                08:   00offset

04: P 06        Full Bridge Reading
                01:   01reps
                02:   2325 mV, 60 Hz rejection
                03:   03input channel
                04:   03excitation channel
                05: 2500mV excitation
                06:   11--      temp. storage location, hit "C" after 11
                                to index input locations
                07:   01multiplier
                08:   00offset

05: P 06        Full Bridge Reading
                01:   01reps
                02:   2325 mV, 60 Hz rejection
                03:   04input channel
                04:   03excitation channel
                05: 2500mV excitation
                06:   16--      temp. storage location, hit "C" after 11
                                to index input locations
                07:   01multiplier
                08:   00offset

06: P 95        End Loop
```

07: P51 Average
01: 05 # reps
02: 01 starting input location #
03: 01 final average input location

08: P51 Average
01: 05 # reps
02: 06 starting input location #
03: 02 final average input location

09: P51 Average
01: 05 # reps
02: 11 starting input location #
03: 03 final average input location

10: P51 Average
01: 05 # reps
02: 16 starting input location #
03: 04 final average input location

11: P 10 Battery Voltage
01: 05 temp. storage location

06: P 86 DO command
01: 10 starts data recording, set flag 0

07: P 77 Record Real Time
01: 110 Day, hour, min

08: P 70 Sample records data
01: 05 # reps
02: 01 temp. location

10: P 96 Serial output to SM192
01: 71 storage module address

Wiring of Data Logger to Pressure Transducer 1

Black-	**1H**
White-	**1L**
Red-	**E1**
Blue/Green-	**AG**

Wiring of Data Logger to Pressure Transducer 2

Black-	**2H**
White-	**2L**
Red-	**E2**
Blue/Green-	**AG**

Wiring of Data Logger to Pressure Transducer 3

Black-	**3H**
White-	**3L**
Red-	**E3**

Blue/Green- **AG**

Wiring of Data Logger to Pressure Transducer 4

Black-	**4H**
White-	**4L**
Red-	**E3**
Blue/Green-	**AG**

SM192 Storage Module Commands

*9 Executes the storage module control subroutine and prompts for the address of the storage module to control. The default "1" is initially present and the "A" may be hit to enter the *9 programming mode.

91:01 A subroutine for the *9 mode to control storage module memory. An input of "248" will reset the storage module memory. This operation will take a few minutes to complete before returning to the *9 command prompt "91:00"

91:04 A subroutine to set the type a data storage mode on the SM192. An input of "1" will place the SM192 in Fill & Stop mode. An input of "0" will place the SM192 in Ring mode.

Typical sequence to set memory to fill-and-stop: *91A4A1A*0 (*0 returns the CR10 to Log mode)
Typical sequence to reset the memory: *91A1A248A*0

CR10 Commands

*A Executes the CR10 memory configuration subroutine. This subroutine can be executed before programming to give maximum memory efficiency. It can also be used after the program is present for resetting the memory. There are five parameters which can be set. For this program, the subroutine might be set up as follows.

01: 0050	input storage
02: 0000	intermediate storage
03: 00000	final memory storage area 2
04: 30036	final memory storage area 1
05: 1986	program memory remaining

Alter memory configuration **before** programming if reconfiguring of memory is desired. Otherwise, note number in final memory storage area 1, as it is the input number necessary for resetting final memory.

Typical sequence to reset final memory: *AAAA30036A*0 (30036 is number for area 1)
Typical sequence to erase program memory: *AAAAA1986A*0

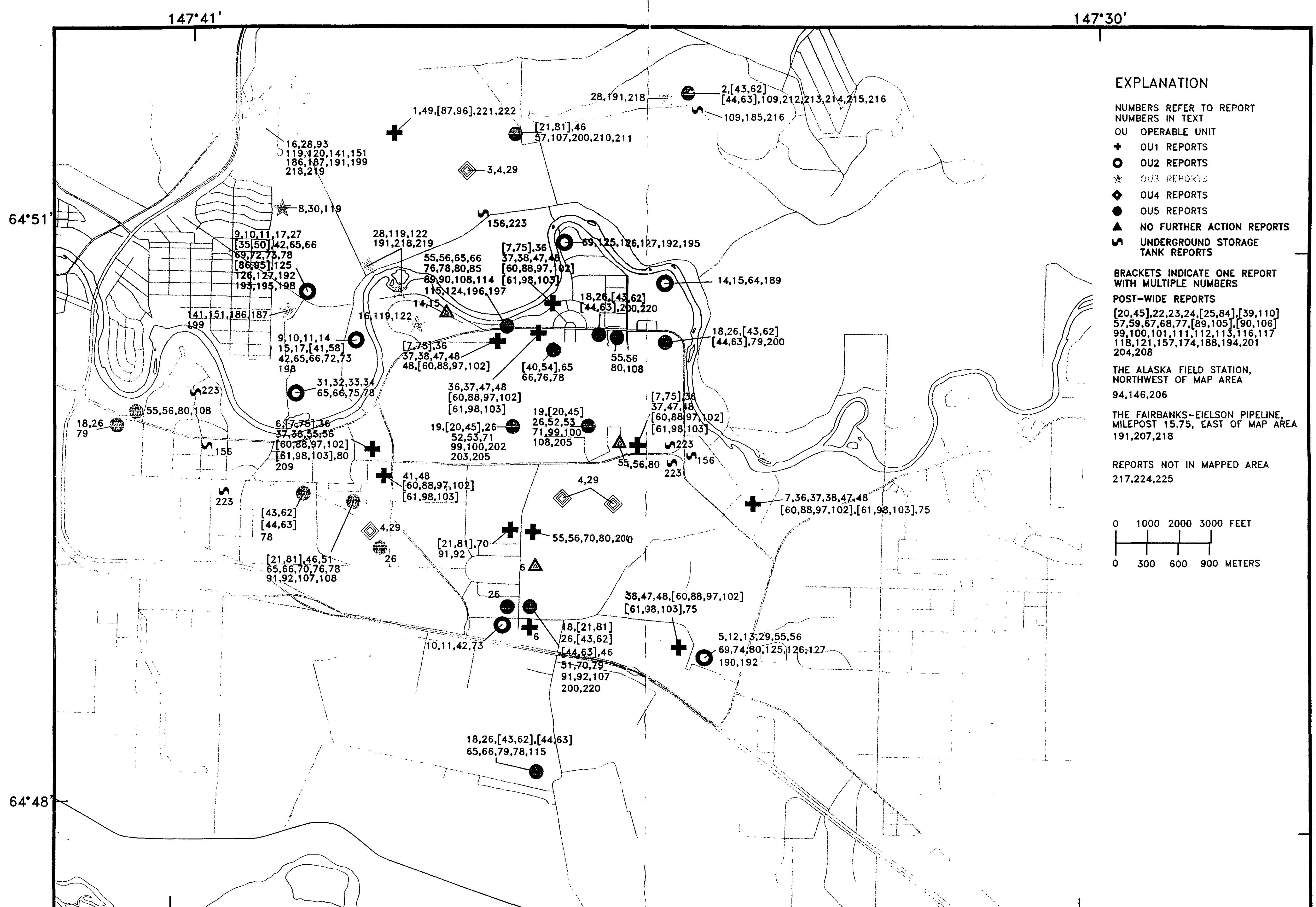


Figure A1. Distribution of environmental report locations, Fort Wainwright, June 1997.

Base from U.S. Geological Survey Fairbanks
D-2 SW, D-2 NW, D-2 NE, D-2 SE 1:25,000, 1992

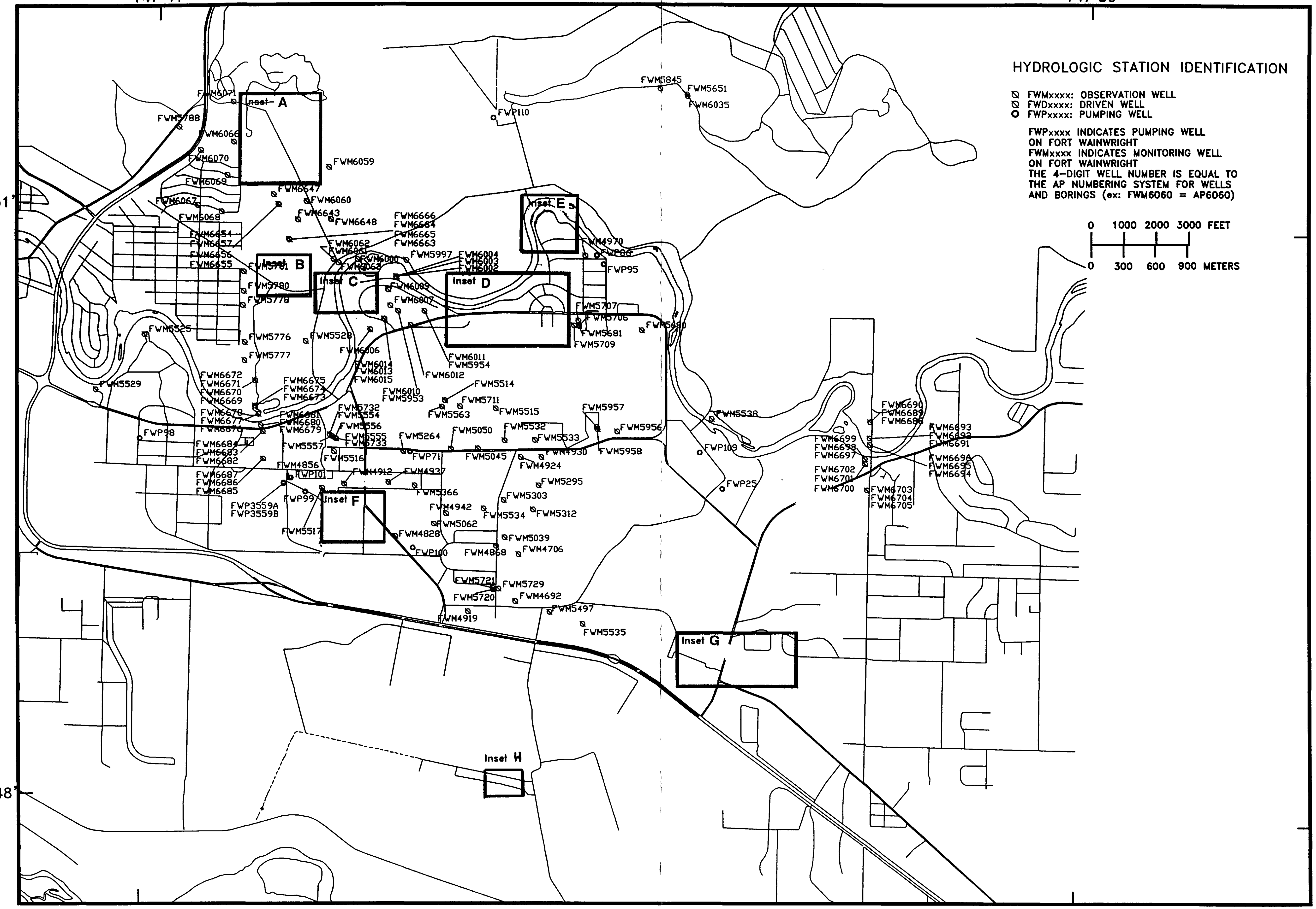


Figure A2. Locations of monitoring wells, driven wells, and pumping wells in the Ground-Water Site Inventory data base for the Fort Wainwright vicinity, June 1997. See pages 35-42 for insets A through H.

Base from U.S. Geological Survey Fairbanks D-2 SW, D-2 NW, D-2 NE, D-2 SE 1:25,000, 1992

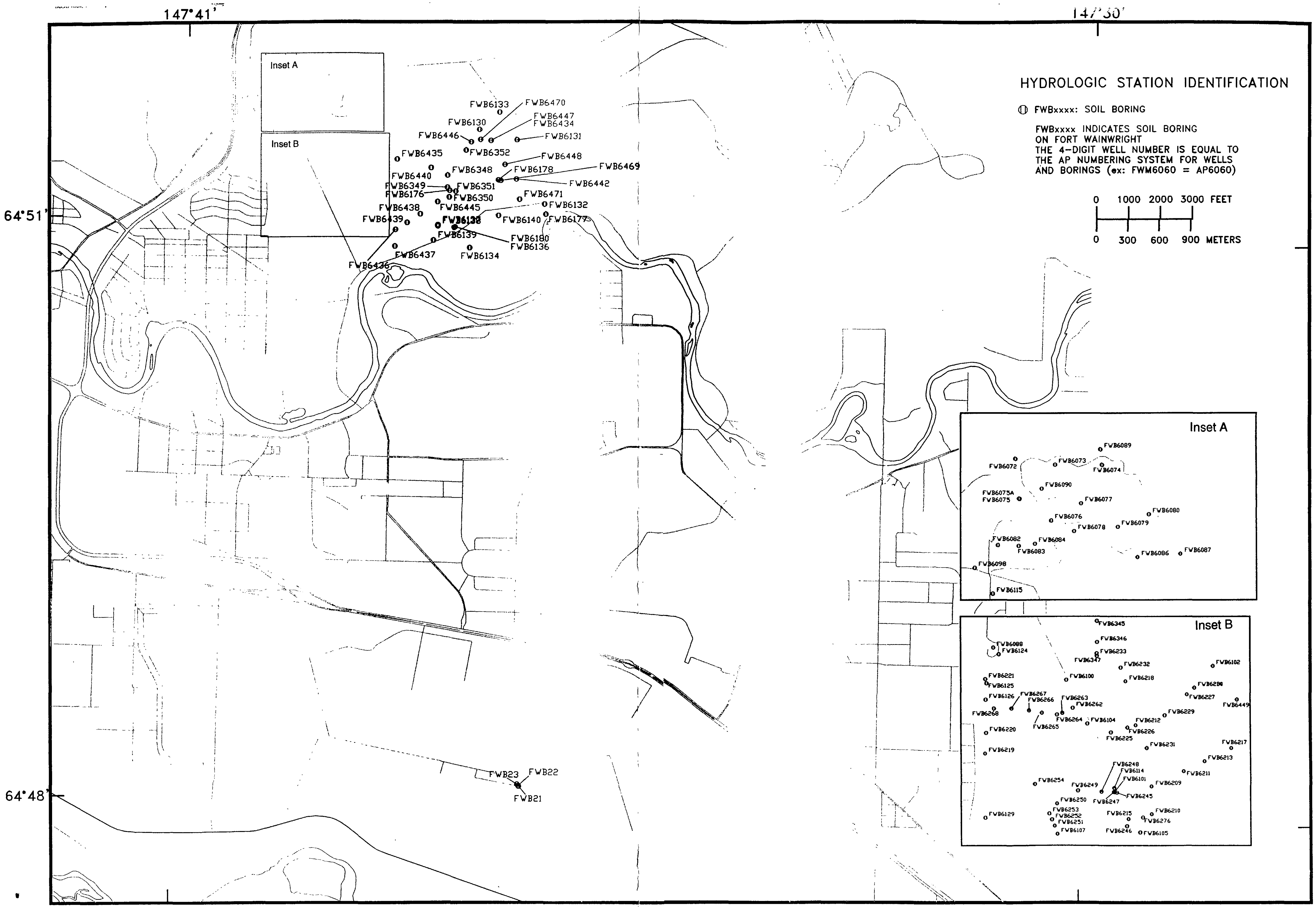


Figure A3. Locations of soil borings in the Ground-Water Site Inventory data base for the Fort Wainwright vicinity, June 1997.

Base from U.S. Geological Survey Fairbanks
D-2 SW, D-2 NW, D-2 NE, D-2 SE 1:25,000, 1992

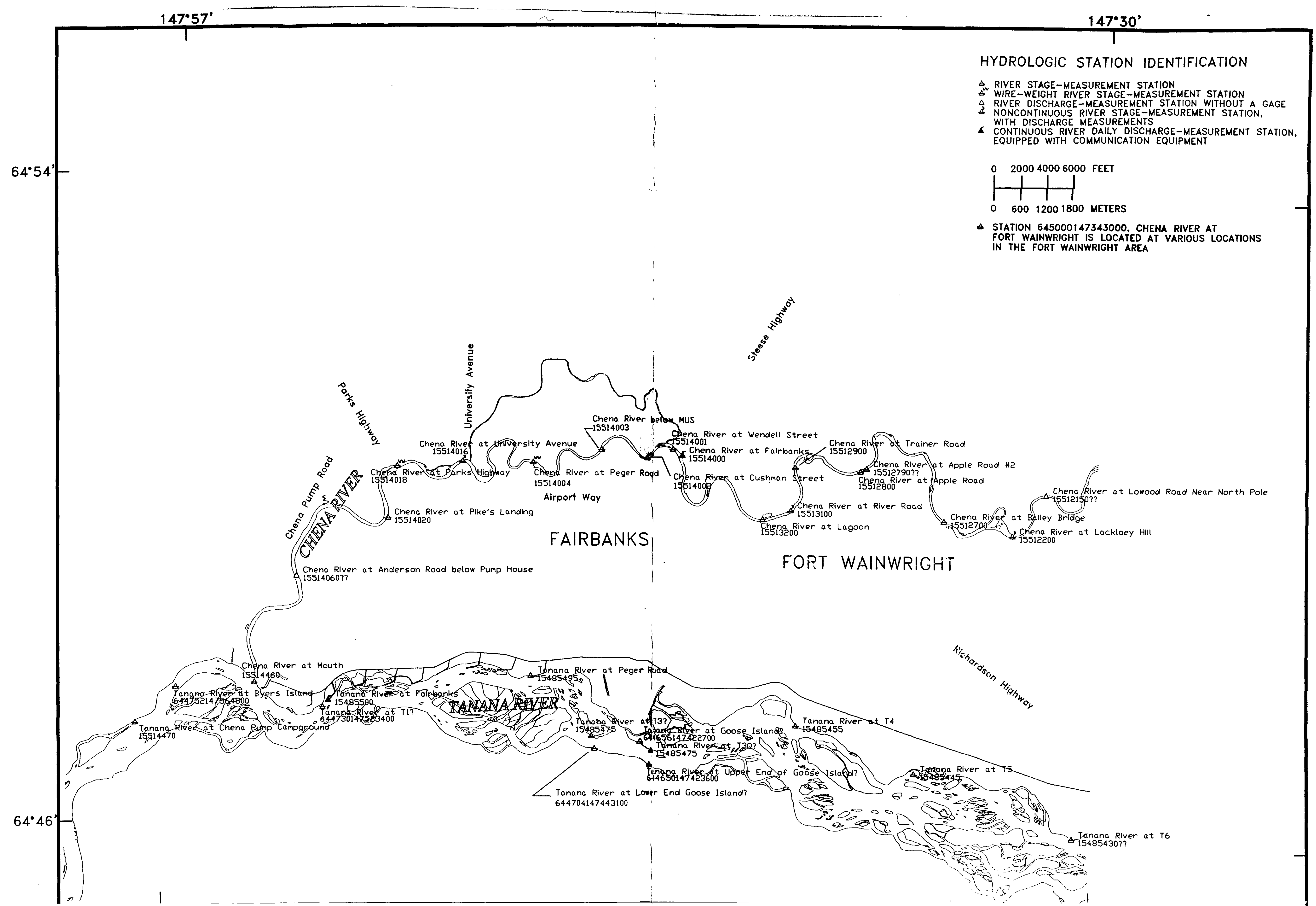
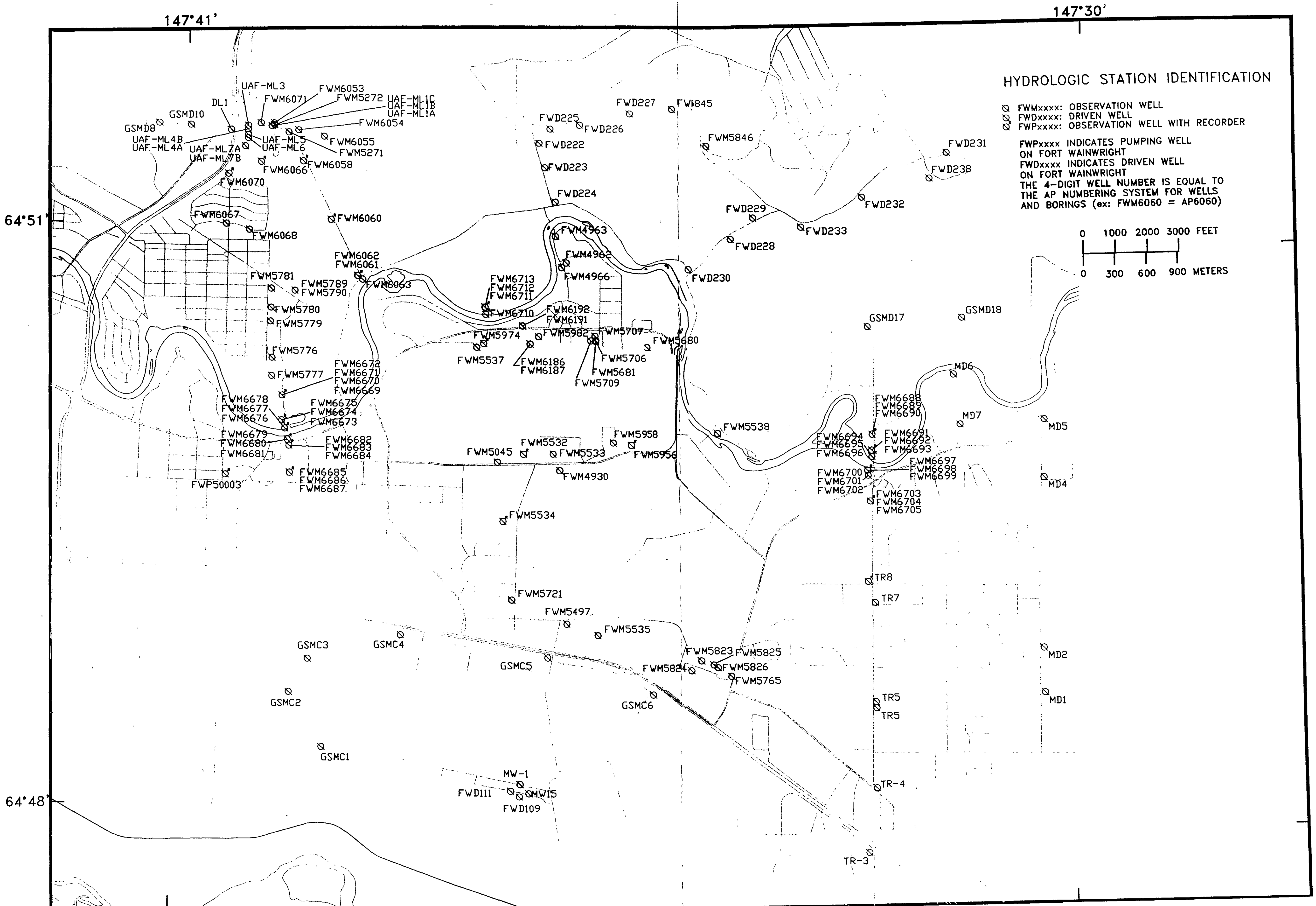


Figure A4. Locations of USGS surface-water data-collection stations for the Fairbanks and Fort Wainwright vicinity.

Base from U.S. Geological Survey Fairbanks
D-2 SW, D-2 NW, D-2 NE, D-2 SE 1:25,000, 1992



Base from U.S. Geological Survey Fairbanks
D-2 SW, D-2 NW, D-2 NE, D-2 SE 1:25,000, 1992

Figure A5. Locations of USGS geohydrologic data-collection stations for the Fort Wainwright vicinity.