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Hydrologic Influences on Water-Level Changes in the Eastern Snake River Plain Aquifer at and near the Idaho National Laboratory, Idaho, 1949–2014

Scientific Investigations Report 2015–5085

U.S. Department of the Interior
U.S. Geological Survey

Cover: Hydrologic technician Jayson Blom, U.S. Geological Survey (USGS) taking water-level measurement at well CWP-5. (Photograph by Roy Bartholomay, USGS Idaho National Laboratory Project Office, Idaho, April 13, 2015.)

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By Roy C. Bartholomay and Brian V. Twining

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Conversion Factors

Inch/Pound to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Transmissivity	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as
°F = (1.8 × °C) + 32.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as
°C = (°F – 32) / 1.8.

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1929 (NAVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Hydrologic Influences on Water-Level Changes in the Eastern Snake River Plain Aquifer at and near the Idaho National Laboratory, Idaho, 1949–2014

By Roy C. Bartholomay and Brian V. Twining

Abstract

The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, has maintained a water-level monitoring program at the Idaho National Laboratory (INL) since 1949 to systematically measure water levels to provide long-term information on groundwater recharge, discharge, movement, and storage in the eastern Snake River Plain (ESRP) aquifer. During 2014, water levels in the ESRP aquifer reached all-time lows for the period of record, prompting this study to assess the effect that future water-level declines may have on pumps and wells. Water-level data were compared with pump-setting depth to determine the hydraulic head above the current pump setting. Additionally, geophysical logs were examined to address changes in well productivity with water-level declines. Furthermore, hydrologic factors that affect water levels in different areas of the INL were evaluated to help understand why water-level changes occur.

Review of pump intake placement and 2014 water-level data indicates that 40 wells completed within the ESRP aquifer at the INL have 20 feet (ft) or less of head above the pump. Nine of the these wells are located in the northeastern and northwestern areas of the INL where recharge is predominantly affected by irrigation, wet and dry cycles of precipitation, and flow in the Big Lost River. Water levels in northeastern and northwestern wells generally show water-level fluctuations of as much as 4.5 ft seasonally and show declines as much as 25 ft during the past 14 years.

In the southeastern area of the INL, seven wells were identified as having less than 20 ft of water remaining above the pump. Most of the wells in the southeast show less decline over the period of record compared with wells in the northeast; the smaller declines are probably attributable to less groundwater withdrawal from pumping of wells for irrigation. In addition, most of the southeastern wells show only about a 1–2 ft fluctuation seasonally because they are less influenced by groundwater withdrawals for irrigation.

In the southwestern area of the INL, 24 wells were identified as having less than 20 ft of water remaining above the pump. Wells in the southwest also only show small 1–2 ft fluctuations seasonally because of a lack of irrigation influence. Wells show larger fluctuation in water levels closer to the Big Lost River and fluctuate in response to wet and dry cycles of recharge to the Big Lost River.

Geophysical logs indicate that most of the wells evaluated will maintain their current production until the water level declines to the depth of the pump. A few of the wells may become less productive once the water level gets to within about 5 ft from the top of the pump. Wells most susceptible to future drought cycles are those in the northeastern and northwestern areas of the INL.

Introduction

The Idaho National Laboratory (INL), operated by the U.S. Department of Energy (DOE), encompasses about 890 mi^2 of the eastern Snake River Plain (ESRP) in southeastern Idaho (fig. 1). The INL was established in 1949 to develop atomic energy, nuclear safety, defense programs, environmental research, and advanced energy concepts. Wastewater disposal sites at the Test Area North (TAN), the Naval Reactors Facility (NRF), the Advanced Test Reactor Complex (ATR Complex), and the Idaho Nuclear Technology and Engineering Center (INTEC) (fig. 1) have contributed radioactive- and chemical-waste contaminants to the ESRP aquifer. These sites incorporated various wastewater disposal methods, including lined evaporation ponds, unlined percolation (infiltration) ponds and ditches, drain fields, and injection wells. Waste materials buried in shallow pits and trenches within the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) also have contributed contaminants to groundwater.

Since 1949, the U.S. Geological Survey (USGS) has worked in cooperation with the DOE at the INL to define: (1) the quality and availability of water for human consumption, (2) the usability of the water for supporting construction and cooling of facilities, and for diluting concentrated waste streams, (3) the location and movement of contaminants in the ESRP aquifer and perched groundwater zones, (4) the sources of recharge to the aquifer, (5) an early detection network for contaminants moving past the INL

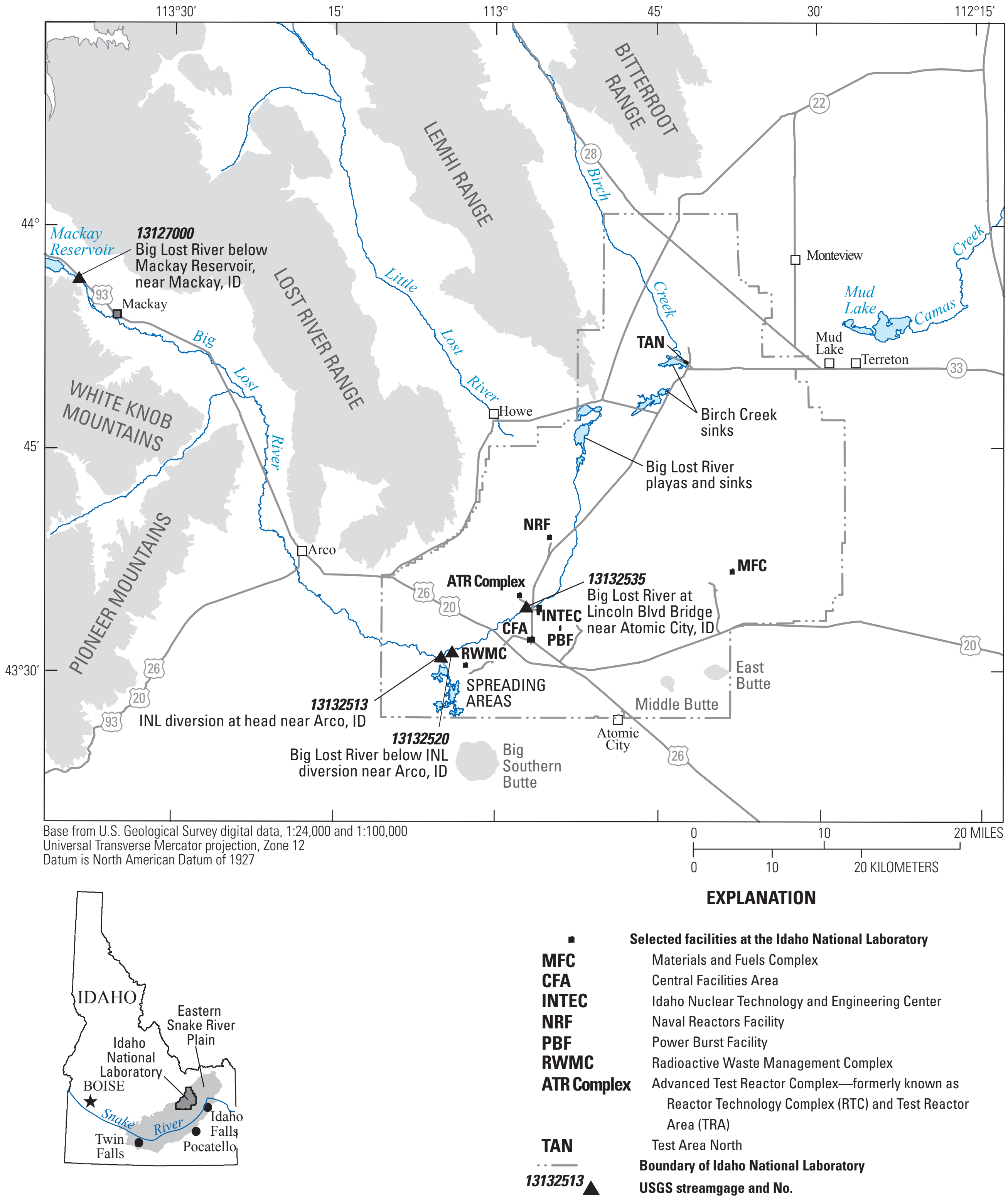

Figure 1. Location of selected facilities and inset areas for selected facilities, Idaho National Laboratory, Idaho.

boundaries, and (6) the processes controlling the origin and distribution of contaminants and naturally occurring constituents in the aquifer (Ackerman and others, 2010).

The USGS has maintained a water-level monitoring program at the INL since 1949 to systematically measure water-levels to provide long-term information on the ESRP aquifer that may affect groundwater recharge, discharge, movement, and storage. Collection of water-level data is obtained manually by use of electronic (e)-tapes and continuous data loggers. Water-levels are collected continuously, monthly, quarterly, semi-annually, or annually depending on historical data, research needs, and changes in each wells hydrograph (Bartholomay and others, 2014, appendix B).

Purpose and Scope

The purpose of this report is to evaluate water-level data for wells constructed at the INL and to assess how continued water-level declines will affect well productivity. Water levels are compared with pump depth to determine the hydraulic head above the pumps. Geophysical logs are presented for selected wells to describe expected productivity based on aquifer properties as water levels decline towards the depth of the pump. Hydrologic factors affecting water levels in different areas of the INL are discussed to provide an understanding of why water-level declines and fluctuations occur.

Geohydrologic Setting

The INL is located on the west-central part of the ESRP. The ESRP is a northeast-trending structural downwarp about 200 mi long and 50–70 mi wide (fig. 1). The basin has been filled with basaltic lava flows interbedded with terrestrial sediments. The basaltic rocks and sedimentary deposits combine to form the ESRP aquifer, which is the primary source of groundwater for the ESRP.

The ESRP aquifer is one of the most productive aquifers in the United States (U.S. Geological Survey, 1985, p. 193). Groundwater generally moves from northeast to southwest, and eventually discharges to springs along the Snake River downstream of Twin Falls, Idaho, about 100 mi southwest of the INL (fig. 1). Groundwater moves horizontally through basalt interflow zones and vertically through joints and interfingering edges of basalt flows. Infiltration of surface water, heavy pumpage, geohydrologic conditions, and seasonal fluxes of recharge and discharge locally affect the movement of groundwater (Garabedian, 1986). The ESRP aquifer is recharged primarily from infiltration of applied irrigation water, infiltration of streamflow, groundwater inflow from adjoining mountain drainage basins, and infiltration of precipitation (Ackerman and others, 2006).

At the INL, depth to water in wells completed in the ESRP aquifer ranges from about 200 ft below land surface (BLS) in the northern part of the INL to more than 900 ft BLS in the southeastern part of the INL. A significant proportion of the groundwater moves through the upper 200–800 ft of basaltic rock (Mann, 1986, p. 21). Ackerman (1991, p. 30) and Bartholomay and others (1997, table 3) reported transmissivity values for basalt in the upper part of the aquifer ranging from 1.1 to 760,000 ft^2/d. The hydraulic gradient at the INL ranges from 2 to 10 ft/mi, with an average of 4 ft/mi (Davis and others, 2013, fig. 9). Horizontal flow velocities of 2–26 ft/d have been calculated based on the movement of various constituents in different areas of the aquifer at and near the INL (Robertson and others, 1974; Mann and Beasley, 1994; Cecil and others, 2000; Plummer and others, 2000; and Busenberg and others, 2001). These flow rates equate to a travel time of about 50–700 years for water beneath the INL to travel to springs that discharge at the terminus of the ESRP groundwater-flow system near Twin Falls, Idaho. Localized tracer tests at the INL have shown that vertical- and horizontal-transport rates are as high as 60–150 ft/d (Nimmo and others, 2002; Duke and others, 2007).

Olmsted (1962), Robertson and others (1974), and Busenberg and others (2001) classified groundwater at the INL based on chemical types derived from dissolution of the rocks and minerals within the recharge source areas. Olmsted's type A water included calcium and magnesium concentrations that constituted at least 85 percent of the cations and bicarbonate that constituted at least 70 percent of the anions. Type A water is present in the northwestern and southwestern part of the INL. Type A water is attributed to seepage loss from the Big Lost River and from groundwater underflow from the Big Lost River, Little Lost River, and Birch Creek drainage basins to the west and northwest of the INL (fig. 1) that contain alluvium derived from Paleozoic carbonate rocks from the surrounding mountains.

Olmsted's type B water, which is characterized by higher equivalent fractions of sodium, potassium, fluoride, and silica than type A water, underlies much of the northeastern and southeastern part of the INL and is often referred to as regional water. The groundwater originates from the area northeast of the INL that consists of a much higher fraction of rhyolitic and andesitic volcanic rocks than mountains west and northwest of the INL that contribute to Type A water. Busenberg and others (2001) used age dating techniques of chlorofluorocarbons (CFCs), sulfur hexafluoride, and tritium/helium to further classify the regional water at the INL into two types based on the recharge type of the young fraction of groundwater. Water in the southeastern part of the INL represented a binary mixture of old (water greater than 40 and 55 years old that did not contain tritium or CFCs, respectively) regional groundwater underflow with young water derived from rapid, focused recharge, probably from precipitation infiltration. Water in the northeastern part of the INL is old, regional groundwater underflow that is mixed with local rapid, focused recharge; slow, diffuse areal recharge through the unsaturated zone; and agricultural return flow from the Mud Lake and Terreton areas (figs. 1 and 2).

Previous Investigations

Numerous previous investigations on the hydrology and geology at the INL have been done by INL contractors, state agencies, and the USGS. The USGS provides a list of references and hyperlinks to published reports from its previous INL studies at the USGS Idaho National Laboratory Project Office web site at: http://id.water.usgs.gov/INL/Pubs/index.html.

Water-level data for wells in the USGS INL Project Office water level monitoring program were published in past USGS reports. Barraclough and others (1984) published data from selected wells from 1949 through 1982, and Ott and others (1992) published data from selected wells from 1983 through 1990. Starting in the mid-1990s, USGS water-level data became more easily accessible, and tables of water-level data and presentation quality hydrographs for wells can now be accessed through USGS websites. Water-level information from wells at the INL are available at: http://maps.waterdata.usgs.gov/mapper/index.html?SiteGroups=gw,act&MapCenterX=-112.84&MapCenterY=43.58&MapZoom=10.

Water level changes at and near the INL are evaluated every 3–4 years; results of the water table altitude and changes in groundwater levels are summarized in the INL hydrologic conditions reports. Table 1 summarizes previous hydrologic condition investigations at and near the INL, specifies the periods covered by those investigations, and lists report citations. Full references for these citations are available in section, "References Cited."

Table 1. Summary of selected previous hydrologic investigations with water level information for groundwater, Idaho National Laboratory, Idaho, 1949–2011.

[**Abbreviations:** ATR Complex, Advanced Test Reactor Complex (formerly the TRA, Test Reactor Area and the RTC, Reactor Technology Complex); NRTS, National Reactor Testing Station; RWMC, Radioactive Waste Management Complex; INEL, Idaho National Engineering Laboratory; INEEL, Idaho National Engineering and Environmental Laboratory; INL, Idaho National Laboratory; INTEC, Idaho Nuclear Technology and Engineering Center (formerly the ICPP, Idaho Chemical Processing Plant); ESRP, eastern Snake River Plain]

Reference	Investigation period	Summary
Morris and others (1963, 1964, 1965)	1962–64	Hydrology of waste disposal at the NRTS.
Barraclough and others (1967a, 1967b)	1965–66	Hydrology of the NRTS.
Robertson and others (1974)		Effects of waste disposal on the geochemistry of groundwater at the NRTS.
Barraclough and others (1976)		Hydrology of the solid waste burial ground (now the RWMC).
Barracough and Jenson (1976)	1971–73	Hydrologic data for the INEL.
Barraclough and others (1981)	1974–78	Hydrologic conditions for the INEL.
Lewis and Jensen (1985)	1979–81	
Barraclough and others (1984)	1949–82	Water level data for INEL, 1949–1982.
Pittman and others (1988) http://pubs.er.usgs.gov/publication/wri894008	1982–85	Hydrologic conditions for the INEL.
Orr and Cecil (1991) http://pubs.er.usgs.gov/publication/wri914047	1986–88	Hydrologic conditions and distribution of selected chemical constituents in water at the INEL.
Bartholomay and others (1995)	1989–91	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, INEL.
Ott and others (1992)	1983–90	Water level data for INEL, 1983–1990.
Bartholomay and others (1997) http://pubs.er.usgs.gov/publication/wri974086	1992–95	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, INEL.
Bartholomay and others (2000) http://pubs.er.usgs.gov/publication/wri004192	1996–98	Hydrologic conditions and distribution of selected constituents in water, INEEL.
Davis (2006) http://pubs.er.usgs.gov/publication/sir20065088	1999–2001	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, INL.
Davis (2008) http://pubs.er.usgs.gov/publication/sir20085089	2002–05	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in groundwater and perched groundwater, INL.
Davis (2010) http://pubs.er.usgs.gov/publication/sir20105197	2006–08	
Davis and others (2013) http://pubs.er.usgs.gov/publication/sir20135214	2009–11	
Fisher (2013) http://pubs.usgs.gov/sir/2013/5120/		Optimization of water level monitoring networks in ESRP aquifer.

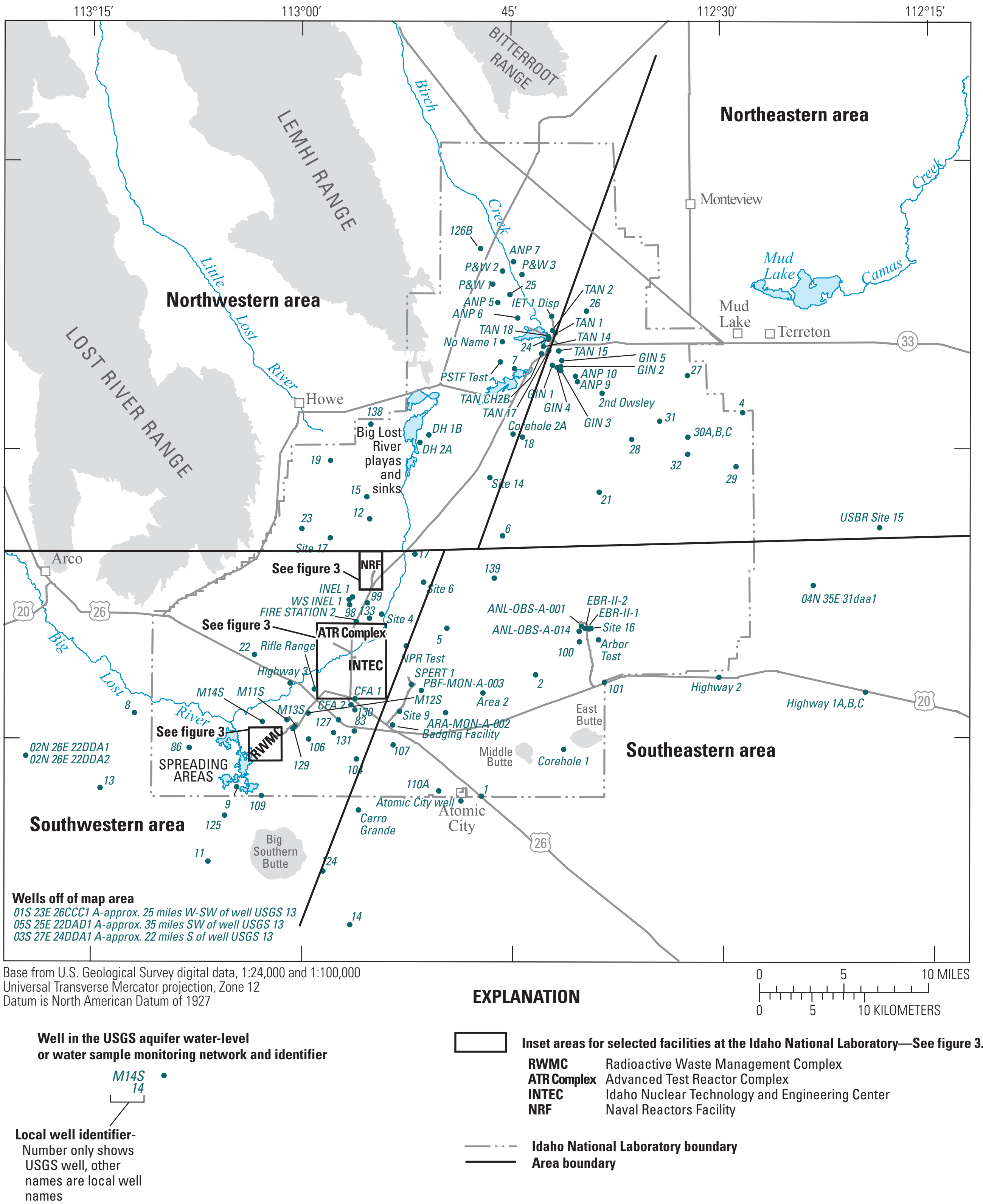

Figure 2. Location of wells used for water-level measurements at and near the Idaho National Laboratory, Idaho.

An optimization of the INL water-level monitoring network using a kriging-based genetic algorithm method was completed in 2013 to determine which set of wells, if removed, would lead to the smallest error in determining the water-table elevation (Fisher, 2013). The network design tool was applied to 171 wells at the INL. The study showed that as many as 40 wells could be removed from the INL network before the water-table map degradation accelerated.

Methods

Calibration of water-level measurement equipment and use of appropriate field procedures are crucial in assuring reliable water-level data is collected from open boreholes and data loggers. All sites are surveyed with known measuring points, and the water-level is calculated from a known land surface datum.

Calibration of Electric Tapes

The USGS INL Project Office started the use of electric (e)-tapes in 2003; prior to 2003, stainless steel tapes were used. E-tapes are calibrated against a reference steel tape, maintained in the office for calibration use only, and a calibration table is generated for each e-tape in 50-ft increments to maintain measurement consistency. Each e-tape is initially calibrated before use in the field and recalibrated annually or more frequently if the tape is used often or subjected to abnormal stress that may have caused it to stretch. Procedures used for calibration are given in Bartholomay and others (2014).

Collection Procedures for Water Levels

All water-level measurements taken with an e-tape have a calibration and measuring point correction applied to them. Several wells also have deviation corrections applied; these corrections have been calculated from geophysical deviation log files. All data are entered in the Multi Optional Network Key Entry System for electronic download and on a field sheet for back up. Collection procedures are given in Bartholomay and others (2014).

Calibration and Collection Procedures of Submersible Pressure Transducers and Data Loggers

The USGS INL Project office maintains six vented pressure transducers in observation wells for long-term continuous monitoring of water levels. These wells are scheduled for either semi-annual or quarterly visits to download the data and calibrate the transducers. The procedure for retrieving water-level measurements from pressure transducers and for maintaining the pressure transducers is given in Bartholomay and others (2014).

Results and Discussion

As of 2014, water levels from the ESRP aquifer are collected either continuously, monthly, quarterly, semi-annually, or annually at 177 wells (Bartholomay and others, 2014, appendix B) at and near the INL (figs. 2 and 3) depending on historical data, research needs, and changes in the hydrograph. Water-level data collected during 2014, submersible pump settings (if applicable), and reported well depths are given in table 2; similar information is provided for production and public supply wells in table 3. Most of the production and public supply wells do not have water-level measurement lines, so an approximate current water level from a nearby well is given to provide general information as to how much water is still above the pumps. As indicated in table 3, none of the production or public supply wells at the INL have water levels less than 20 ft above their pumps, so there is no concern of these wells pumping dry in the near future.

Figures 4 and 5 show which wells currently have less than 10 ft of water above their pump and which wells have less than 20 ft of water above their pumps. The depth of 10 ft was chosen because the last drought period from 2000 to 2005 showed about a 10-ft decline in much of the aquifer at the INL. The depth of 20 ft was chosen because wells in the northern part of the INL have declined by more than 20 ft in the past 14 years. Most of the discussion in the following sections will focus on these wells.

For discussion in this report, the INL was divided into quarters based on general hydrologic factors and water type (fig. 2). The northeastern and southeastern areas generally consist of wells composed of mostly regional recharge as defined by Busenberg and others (2001) and by Fisher and others (2012). The northwestern and southwestern areas are defined as being mostly recharged by western stream tributary and underflow recharge from the Big Lost River, Little Lost River, and Birch Creek. The boundary separating northern areas from southern areas was an arbitrary line drawn north of the NRF area (fig. 2). Wells with at least quarterly measurements that were spatially distributed were used to represent water level changes in the different areas of the aquifer.

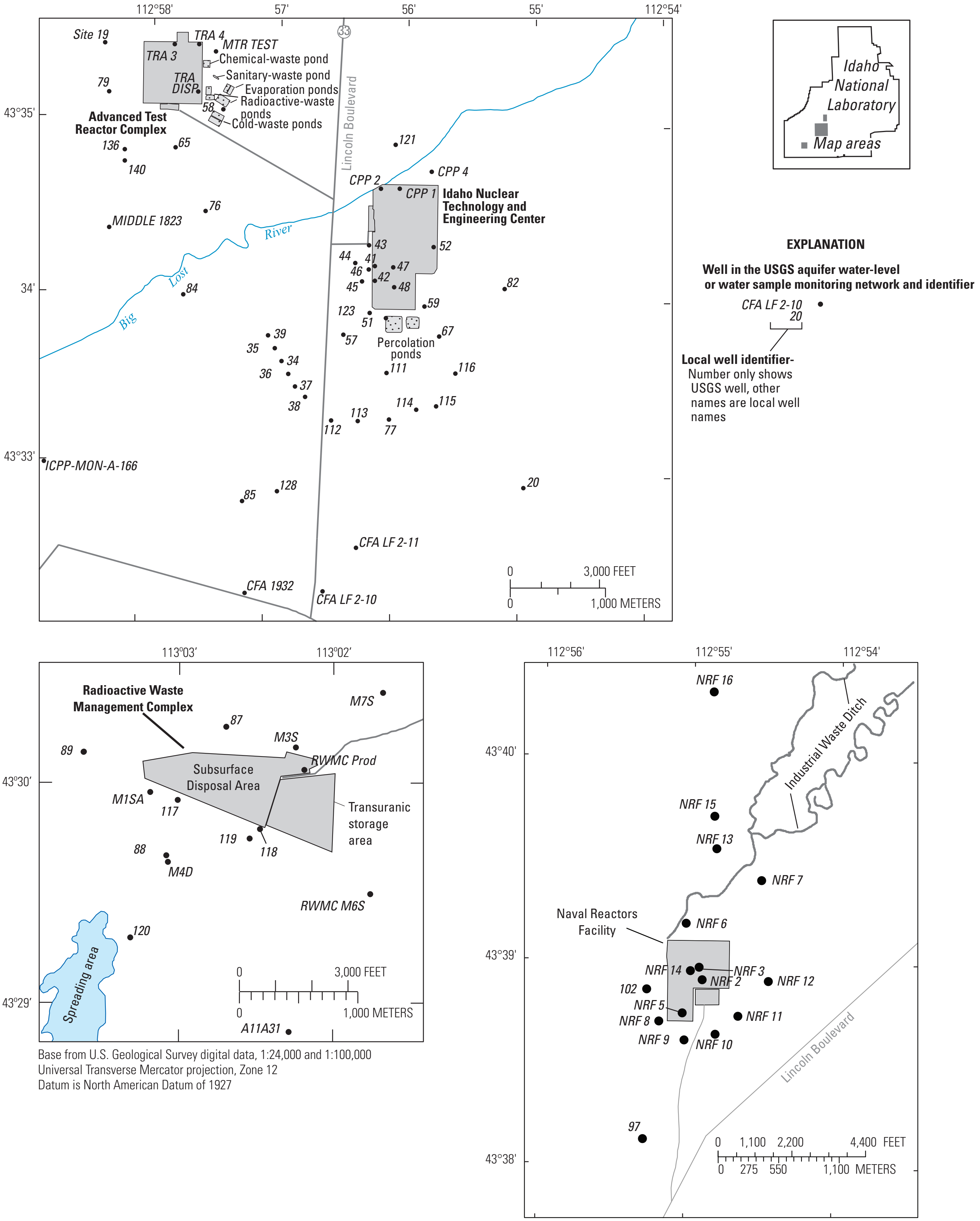

Figure 3. Location of wells used for water-level measurements near the Advanced Test Reactor Complex, the Idaho Nuclear Technology and Engineering Center, the Naval Reactors Facility, and the Radioactive Waste Management Complex, Idaho National Laboratory, Idaho.

Table 2. Monitoring well site information and water level information at and near the Idaho National Laboratory, Idaho.

[Location of wells is shown in figures 2 and 3. Water level measurements are given in feet with reference to National Geodetic Vertical Datum of 1929. **Local name** is the local well identifier used in this study. **Site identifier** is the unique numerical identifier used to access well data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis). **Pump depth** is the last known depth of pump installed in the well. **Abbreviations:** ft, feet; BLS, below land surface; NA, not applicable; unk, not available; *, well has been measured as dry since 2013]

Local name	Site identifier	Well depth (ft BLS)	Pump depth (ft BLS)	Water level date	Water level (ft)
Northeastern area wells					
2nd Owsley	434819112380501	302	NA	04-07-14	243.18
ANP 9	434856112400001	322	262	10-02-14	245.24
ANP 10	434909112400401	676	NA	04-07-14	241.02
GIN 1	434947112414301	364	NA	03-04-14	232.78
GIN 2	434949112413401	381	370	10-14-14	234.53
GIN 3	434945112413101	386	NA	03-04-14	231.81
GIN 4	434949112413601	300	NA	03-04-14	231.85
GIN 5	434953112413301	430	NA	03-04-14	231.97
Site 15	434102112180701	1,000	NA	07-29-14	432.85
TAN 15	435021112412701	252	NA	09-15-14	234.07
USGS 4	434657112282201	553	NA	10-02-14	278.93
USGS 6	434031112453701	620	461	10-06-14	426.87
USGS 18	434540112440901	329	302	10-06-14	292.48
USGS 21	434307112382601	363	NA	11-20-14	347.37
USGS 26	435212112394001	266	255	10-02-14	234.90
USGS 27	434851112321801	312	262	10-02-14	243.65
USGS 28	433334112565501	334	NA	09-15-14	249.50
USGS 29	434407112285101	426	402	10-02-14	372.17
USGS 30A	434601112315403	725	NA	09-15-14	275.71
USGS 30B	434601112315402	400	NA	09-15-14	287.71
USGS 30C	434601112315401	300	NA	09-15-14	287.72
USGS 31	434625112342101	428	284	10-02-14	268.76
USGS 32	434444112322101	392	322	10-02-14	306.85
Northwestern area wells					
ANP 5	435308112454101	383	NA	04-07-14	315.27
ANP 6	435152112443101	295	260	10-14-14	241.12
ANP 7	435522112444201	433	NA	04-07-14	373.93
Corehole 2A	434558112444801	3,000	NA	10-06-14	230.87
DH 1B	434611112504301	400	NA	09-15-14	290.36
DH 2A	434547112512801	425	NA	09-15-14	284.47
IET 1 Disposal	435153112420501	242	NA	10-02-14	236.24
Noname 1 (TAN Exploration)	435038112453401	552	266	07-16-14	230.30
PSTF Test	434941112454201	319	242	10-02-14	234.32
P&W 1	435416112460401	432	NA	10-02-14	338.31
P&W 2	435419112453101	378	362	10-02-14	337.00
P&W 3	435443112435801	406	NA	04-07-14	328.36
Site 14	434334112463101	717	326	10-20-14	290.24
Site 17	434027112575701	600	442	10-06-14	413.61
TAN CH 2B	435033112421702	1,090	NA	09-15-14	238.77
TAN 14	435039112423701	396	NA	09-15-14	228.47
TAN 17	435034112421601	340	NA	09-15-14	236.17
TAN 18	435051112421401	516	NA	09-15-14	249.73
USGS 7	434915112443901	903	242	10-02-14	237.24
USGS 12	434126112550701	563	358	10-06-14	346.52
USGS 15	434234112551701	610	358	10-06-14	337.56
USGS 19	434426112575701	399	322	10-06-14	282.77
USGS 23	434055112595901	458	442	10-22-14	416.88
USGS 24	435053112420801	326	NA	08-06-14	241.16
USGS 25	435339112444601	320	NA	08-06-14	294.47
USGS 126 B	435529112471401	472	465	10-02-14	436.97
USGS 138	434615112553501	325	NA	08-13-14	196.58

Table 2. Monitoring well site information and water level information at and near the Idaho National Laboratory, Idaho.—Continued

[Location of wells is shown in figures 2 and 3. Water level measurements are given in feet with reference to National Geodetic Vertical Datum of 1929. **Local name** is the local well identifier used in this study. **Site identifier** is the unique numerical identifier used to access well data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis). **Pump depth** is the last known depth of pump installed in the well. **Abbreviations:** ft, feet; BLS, below land surface; NA, not applicable; unk, not available; *, well has been measured as dry since 2013]

Local name	Site identifier	Well depth (ft BLS)	Pump depth (ft BLS)	Water level date	Water level (ft)
Southeastern area wells					
ANL OBS A 001	433545112394101	1,910	unk	03-10-14	646.54
ANL OBS-A 014	433537112393801	682	unk	03-10-14	645.34
ARA-MON-A-002	433054112492102	620	604	10-09-14	600.32
Arbor Test 1	433509112384801	790	720	10-01-14	691.47
Area 2	433223112470201	876	703	10-01-14	682.37
Cerro Grande	432618112555501	562	NA	12-03-13*	560.68
Corehole 1	432927112410101	2,000	NA	10-01-14	943.12
Highway 1A	433218112191603	1,147	NA	09-08-14	596.15
Highway 1B	433218112191602	982	NA	09-08-14	594.91
Highway 1C	433218112191601	800	NA	09-08-14	594.05
Highway 2	433307112300001	786	NA	09-16-14	736.32
PBF-MON-A-003	433203112514201	575	567	10-16-14	524.39
Site 16	433545112391501	758	NA	03-10-14	646.49
USGS 1	432700112470801	630	611	11-20-14	594.42
USGS 2	433320112432301	699	685	10-01-14	670.16
USGS 5	433543112493801	494	488	10-07-14	480.41
USGS 14	432019112563201	752	739	10-14-14	720.95
USGS 100	433503112400701	750	696	10-01-14	688.15
USGS 101	433255112381801	842	800	09-08-14	781.53
USGS 107	432942112532801	690	509	10-08-14	487.88
USGS 110A	432717112501502	644	612	10-01-14	571.88
USGS 124	432307112583101	800	737	10-01-14	688.23
USGS 139A	433823112460402	774	NA	10-06-14	478.63
USGS 139B	433823112460401	610	NA	10-06-14	480.81
04N 35E 31daa1	433759112225401	unk	NA	04-03-14	618.86
Southwestern area wells					
USGS 8	433121113115801	812	801	10-01-14	773.71
USGS 9	432740113044501	654	632	10-22-14	614.05
USGS 11	432336113064201	704	692	10-01-14	658.23
USGS 13	432731113143902	1,010	NA	04-08-14	993.08
USGS 17	433937112515401	498	403	10-06-14	370.43
USGS 20	433253112545901	658	518	10-07-14	472.03
USGS 22	433422113031701	657	643	10-01-14	618.80
USGS 34	433334112565501	700	518	04-07-14	482.75
USGS 35	433339112565801	579	523	10-08-14	484.71
USGS 36	433330112565201	567	521	10-08-14	484.30
USGS 37	433326112564801	572	506	10-08-14	483.99
USGS 38	433322112564301	724	522	04-07-14	483.20
USGS 39	433343112570001	492	487	07-17-14	485.66
USGS 41	433409112561301	666	502	10-09-14	471.07
USGS 42	434004112561301	678	502	04-10-14	470.39
USGS 43	433415112561501	564	522	10-06-14	470.41
USGS 44	433409112562101	650	499	04-09-14	470.88
USGS 45	433402112561801	651	502	10-06-14	473.37
USGS 46	433407112561501	651	502	04-09-14	469.72
USGS 47	433407112560301	651	486	10-12-10	469.00
USGS 48	433401112560301	750	503	10-09-14	471.55
USGS 51	433350112560601	647	501	04-09-14	470.11
USGS 52	433414112554201	602	500	10-08-14	464.17

Table 2. Monitoring well site information and water level information at and near the Idaho National Laboratory, Idaho.—Continued

[Location of wells is shown in figures 2 and 3. Water level measurements are given in feet with reference to National Geodetic Vertical Datum of 1929. **Local name** is the local well identifier used in this study. **Site identifier** is the unique numerical identifier used to access well data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis). **Pump depth** is the last known depth of pump installed in the well. **Abbreviations:** ft, feet; BLS, below land surface; NA, not applicable; unk, not available; *, well has been measured as dry since 2013]

Local name	Site identifier	Well depth (ft BLS)	Pump depth (ft BLS)	Water level date	Water level (ft)
Southwestern area wells—Continued					
USGS 57	433344112562601	582	514	10-06-14	477.84
USGS 58	433500112572502	503	483	10-08-14	472.70
USGS 59	433354112554701	587	480	10-08-14	467.74
USGS 65	433447112574501	498	489	10-08-14	476.46
USGS 67	433344112554101	694	515	10-07-14	468.50
USGS 76	433425112573201	718	502	10-08-14	484.91
USGS 77	433315112560301	586	502	10-07-14	477.12
USGS 79	433505112581901	702	522	10-08-14	485.40
USGS 82	433401112551001	693	508	10-07-14	461.51
USGS 83	433023112561501	752	606	10-08-14	506.97
USGS 84	433356112574201	505	498	10-22-14	493.00
USGS 85	433246112571201	614	514	10-08-14	494.68
USGS 86	432935113080001	691	673	10-22-14	656.49
USGS 87	433013113024201	673	610	04-17-14	595.31
USGS 88	432940113030201	663	651	10-21-14	599.72
USGS 89	433005113032801	637	635	10-08-14	608.60
USGS 97	433807112551501	510	420	10-06-14	397.16
USGS 98	433657112563601	508	440	10-14-14	425.79
USGS 99	433705112552101	440	422	10-02-14	410.18
USGS 102	433853112551601	445	422	11-24-14	389.09
USGS 104	432856112560801	700	588	10-21-14	563.31
USGS 106	432959112593101	760	612	10-20-14	594.85
USGS 109	432701113025601	800	660	10-08-14	627.21
USGS 111	433331112560501	560	506	04-08-14	475.74
USGS 112	433314112563001	507	500	10-07-14	483.14
USGS 113	433314112561801	556	504	04-08-14	478.70
USGS 114	433318112555001	560	508	10-07-14	475.84
USGS 115	433320112554101	581	507	10-07-14	474.38
USGS 116	433331112553201	572	505	10-07-14	471.32
USGS 117	432955113025901	655	635	11-25-14	591.30
USGS 118	432947113023001	608	NA	09-02-14	591.12
USGS 119	432945113023401	705	685	04-15-14	610.90
USGS 120	432919113031501	705	675	10-14-14	621.14
USGS 121	433450112560301	475	473	10-07-14	464.32
USGS 123	433352112561401	514	481	10-06-14	475.03
USGS 125	432602113052801	774	700	10-14-14	635.11
USGS 127	433058112572201	596	546	10-08-14	516.84
USGS 128	433250112565601	615	528	10-08-14	490.41
USGS 129	433036113002701	660	NA	10-08-14	605.58
USGS 130	433130112562801	636	527	10-23-14	486.09
USGS 131	433036112581601	797	NA	10-08-14	548.12
USGS 136	433447112581501	551	525	10-09-14	489.98

Table 2. Monitoring well site information and water level information at and near the Idaho National Laboratory, Idaho.—Continued

[Location of wells is shown in figures 2 and 3. Water level measurements are given in feet with reference to National Geodetic Vertical Datum of 1929. **Local name** is the local well identifier used in this study. **Site identifier** is the unique numerical identifier used to access well data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis). **Pump depth** is the last known depth of pump installed in the well. **Abbreviations:** ft, feet; BLS, below land surface; NA, not applicable; unk, not available; *, well has been measured as dry since 2013]

Local name	Site identifier	Well depth (ft BLS)	Pump depth (ft BLS)	Water level date	Water level (ft)
Southwestern area wells—Continued					
USGS 140	433441112581201	546	526	12-04-14	491.24
A11A31	432853113021701	675	NA	03-04-14	646.64
CFA 1932	433214112570101	525	NA	10-08-14	494.06
CFA LF 2-10	433216112563301	596	547	10-08-14	489.60
CFA LF 2-11	433230112561701	499	NA	03-10-14	482.77
Firestation 2	433548112562301	510	NA	09-22-14	441.69
ICPP-Mon-A-166	433300112583301	527	NA	10-08-14	511.75
INEL 1	433717112563501	10,333	NA	03-10-14	314.57
MTR TEST	433520112572601	588	486	10-08-14	470.96
NPR Test	433449112523101	600	486	10-15-14	476.04
NRF 2	433854112545401	528	unk	11-19-14	388.19
NRF 3	433858112545501	546	unk	11-19-14	389.09
NRF 5	433844112550201	1,276	NA	11-19-14	400.79
NRF 6	433910112550101	417	415	11-19-14	385.37
NRF 7	433920112543601	415	407	11-18-14	381.12
NRF 8	433843112550901	420	411	11-24-14	391.07
NRF 9	433840112550201	422	409	12-04-14	392.08
NRF 10	433841112545201	427	408	11-17-14	391.88
NRF 11	433847112544201	417	409	11-20-14	389.41
NRF 12	433855112543201	421	414	11-18-14	389.19
NRF 13	433928112545401	425	405	11-25-14	380.17
NRF 14	433856112545901	550	425	11-19-14	388.58
NRF 15-A	433942112545002	759	NA	10-06-14	379.99
NRF 15-B	433942112545001	759	NA	10-06-14	375.74
NRF 16	434018112545101	422	402	11-20-14	362.28
RWMC M1SA	432956113030901	638	633	10-15-14	591.21
RWMC M3S	433008113021801	633	631	10-15-14	595.62
RWMC M4D	432939113030101	828	819	04-07-14	602.43
RWMC M6S	432931113015001	668	663	04-07-14	645.83
RWMC M7S	433023113014801	628	621	10-15-14	583.94
RWMC M11S	433058113010401	624	612	10-15-14	571.08
RWMC M12S	433118112593401	572	560	10-02-14	542.84
RWMC M13S	433037113002701	643	633	10-23-14	605.88
RWMC M14S	433052113025001	634	633	10-23-14	610.54
Site 6	433826112510701	523	NA	03-06-14	372.38
Site 19	433522112582101	860	486	10-15-14	479.83
TRA Disposal	433506112572301	1,267	507	10-23-14	476.76
WS for INEL-1	433716112563601	490	483	10-07-14	411.66
01S 23E 26CCC1	431810113413601	1,031	NA	04-08-14	979.08
02N 26E 22DDA1	432854113201001	719	NA	04-08-14	662.25
02N 26E 22DDA2	432854113201002	1,053	NA	04-08-14	988.90
03S 27E 24DDA1	430836113143401	901	NA	04-08-14	877.49
05S 25E 22DAD1	425812113271201	581	NA	04-08-14	520.88

Table 3. Production or public supply well site information at and near the Idaho National Laboratory, Idaho.

[Location of wells is shown in figures 2 and 3. Water level measurements are given in feet with reference to National Geodetic Vertical Datum of 1929. **Local name** is the local well identifier used in this study. **Site identifier** is the unique numerical identifier used to access well data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis). **Abbreviations:** ft, feet; BLS, below land surface; unk, not available]

Local name	Site identifier	Well depth (ft BLS)	Pump depth (ft BLS)	Approximate water level (ft)	Difference (ft)	Well used for approximate water level and date	
Northwestern area wells							
NRF 2	433854112545401	528	446	387	59	NRF 2	05-12-14
NRF 3	433858112545501	546	unk	388	unk	NRF 3	05-12-14
NRF 14	433856112545901	550	425	388	37	NRF 14	05-12-14
TAN 1	435056112420001	360	287	241	46	USGS 24	08-06-14
TAN 2	435100112420701	340	279	241	38	USGS 24	08-06-14
Southwestern area wells							
BFW	433042112535101	644	unk	482	unk	Site 9	07-17-14
CFA 1	433204112562001	639	576	489	87	CFA LF 2-10	07-16-14
CFA 2	433144112563501	681	576	487	89	USGS 130	09-02-14
CPP 1	433433112560201	585	517	470	47	USGS 43	10-06-14
CPP 2	433432112560801	605	528	464	64	USGS 52	10-08-14
CPP 4	433440112554401	700	571	464	107	USGS 121	04-14-14
EBR 1	433051113002601	1,075	836	606	220	RWMC M13S	04-07-14
Highway 3	433256113002501	750	567	511	56	ICPP Mon 166	07-16-14
RIFLE RANGE	433243112591101	620	580	511	69	ICPP Mon 166	07-16-14
RWMC Production	433002113021701	685	unk	595	unk	RWMC M3S	04-07-14
Site 4	433617112542001	495	unk	410	unk	USGS 99	05-14-14
TRA 3	433522112573501	602	585	471	114	MTR Test	09-22-14
TRA 4	433521112574201	965	unk	471	unk	MTR Test	09-22-14
Southeastern area wells							
Atomic City	432638112484101	639	unk	595	unk	USGS 1	05-07-14
EBR-II-1	433546112391601	745	719	646	73	Site 16	03-10-14
EBR-II-2	433544112391301	753	719	646	73	Site 16	03-10-14
SPERT 1	433252112520301	653	554	524	30	PBF-Mon-003	03-17-14

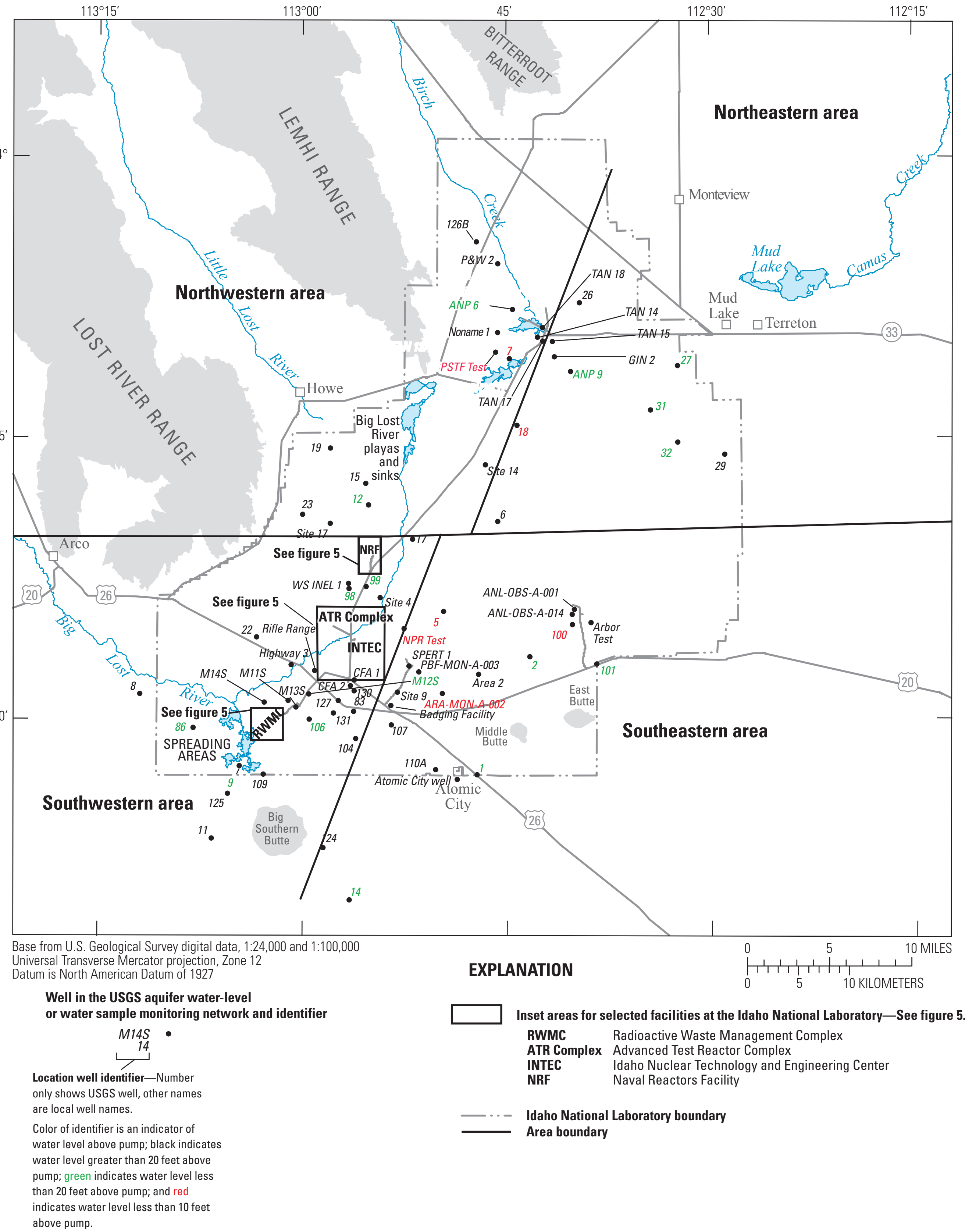

Figure 4. Water level above current pumps in wells at and near the Idaho National Laboratory, Idaho.

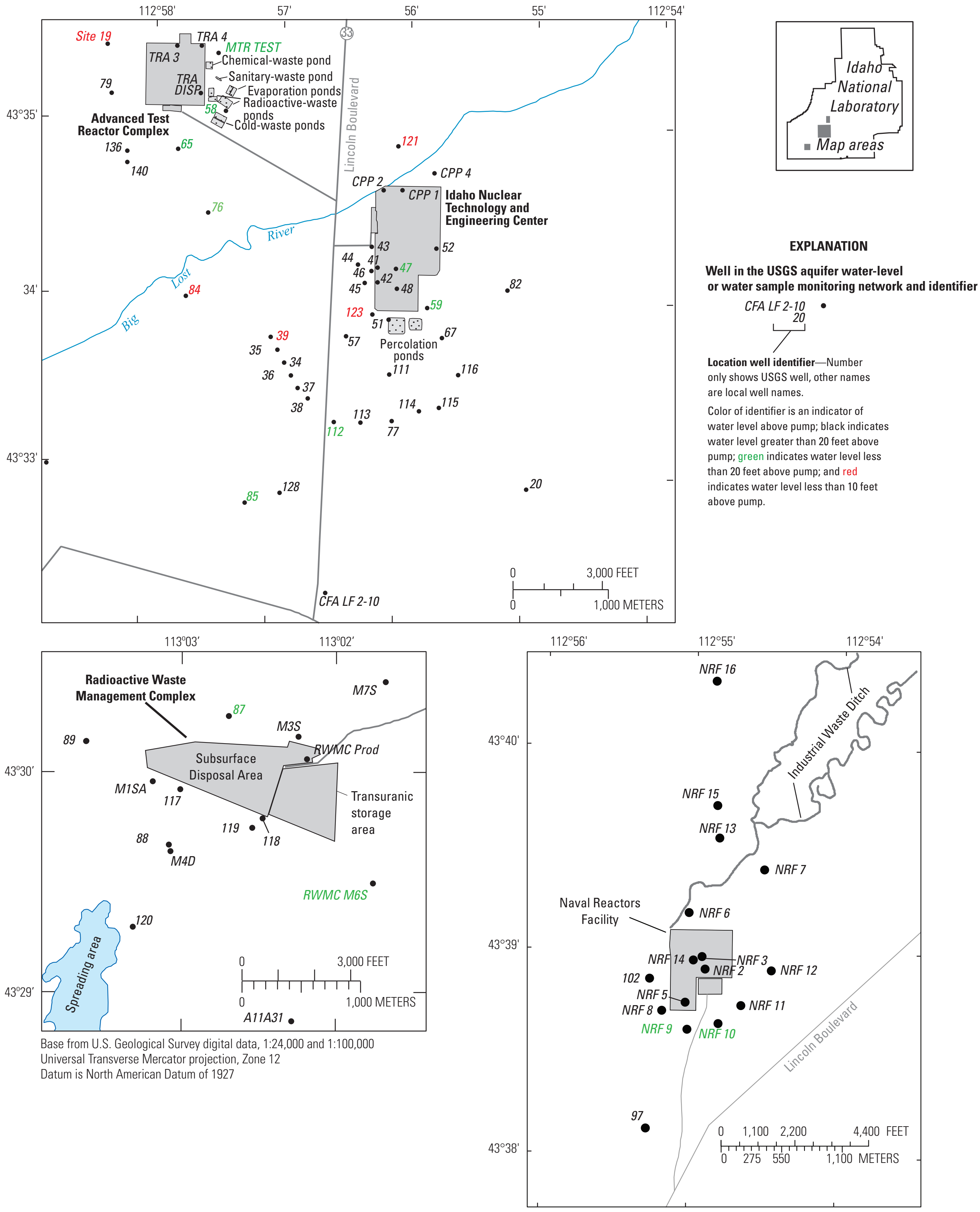

Figure 5. Water level above current pumps in wells near the Advanced Test Reactor Complex, the Idaho Nuclear Technology and Engineering Center, the Naval Reactors Facility, and the Radioactive Waste Management Complex, Idaho National Laboratory, Idaho.

Hydrologic Factors Affecting Water Levels in the Northeastern Area of the Idaho National Laboratory

Busenberg and others (2001) used age-dating techniques of CFCs, sulfur hexafluoride, and tritium/helium to classify the water in the northeastern area of the INL based on the recharge type of the young fraction of groundwater. Based on their study, groundwater in the northeastern area of the INL is older, regional groundwater underflow that is mixed with local rapid, focused recharge; slow, diffuse areal recharge through the unsaturated zone; and agricultural return flow from the Mud Lake and Terreton areas (figs. 1 and 2). Water levels in this part of the INL are thus probably influenced by groundwater pumpage, agricultural return flow, some local precipitation, and wet and dry cycles affecting the regional flow pattern of the ESRP aquifer.

Hydrographs examined for northeastern wells suggest continued water-level decline with levels ranging approximately 24 and 35 ft in wells USGS 21 and USGS 26, respectively (figs. 6*A* and 6*B*). Water-level data for wells in the northeastern area show greater declines closer to the Mud Lake and Terreton areas (fig. 2). For example, wells USGS 26 and USGS 27 show water-level declines of about 25 and 20 ft between 2000 and 2014, respectively; whereas, wells USGS 21 and USGS 32 show declines of about 18–20 ft, respectively (fig. 6). Wells to the north (USGS 26 and 27) seem to show a consistent decline since 2000, while the wells to the south (USGS 21 and 32) show declines until about 2005 and then begin to level off (except for the seasonal changes). One possible reason the northern wells show more decline as compared to the more southern wells could be related to irrigation practices upgradient of the wells. The northern wells are probably more influenced by irrigation in the Monteview/Mud Lake area, which is primarily irrigated by groundwater diversions, whereas the more southern wells are influenced more by surface water diversions (less groundwater pumping) south of the Mud Lake/Terreton area (Spinazola, 1994, fig. 24; fig. 2).

Figure 7 illustrates the seasonal variability in wells USGS 21 and 27 in the northeastern area of the INL. The water-level hydrographs show that water levels increase during the autumn and winter following the growing season when pumping stops, and begin to decrease again in late April when pumping for irrigation resumes (figs. 7*D* and 7*E*). Water levels continue to decline through September. Although seasonal changes occur in all the wells at the INL, the approximately 3–4.5 ft seasonal change in wells USGS 21 and 27 (figs. 7*D* and 7*E*), along with other wells in the northeastern area of the INL (fig. 6), also reflects the effects of irrigation that are not as prevalent at other areas at the INL. Spinazola (1994, fig. 23) showed a recharge rate as high as 1.1 million acre-ft during 1984 in the irrigated areas northeast of the INL. Drawdown from groundwater pumping for irrigation also is prevalent northeast of the INL where total withdrawals increased from 240,000 acre-ft in 1983 to about 370,000 acre-ft in 1990 (Spinazola, 1994, fig. 31).

Geophysical and construction data for wells in the northeastern area of the INL that have less than 20 ft of water above the pump intake (wells ANP 9, USGS 18, USGS 27, USGS 31, and USGS 32; table 2) are given in appendix A and figure 8. Aquifer properties are interpreted using a suite of geophysical logs. Neutron logs are generally considered good indicators of saturated formation porosity (Hodges and others, 2012) and are used in conjunction with caliper logs (which can show borehole changes and in the case of basalt, fractures), gamma logs (which show the type of rock material), and gamma gamma (density) logs (which show the bulk density of the formation). Neutron logs are not available for all of these five wells in table 2 (Bartholomay, 1990, table 1), so geophysical information from well USGS 27 (fig. 8) was used as an indicator of aquifer properties near wells in the northeastern area of the INL. USGS 27 has its pump set at 262 ft below land surface (BLS) and well logs and transmissivity for USGS 27 (fig. 8, table 4) indicate a moderately productive aquifer system, with similar density and neutron response from 240 to 285 ft BLS. The density log (Bartholomay, 1990, p. 34) for USGS 18 shows thin layers of more dense and less dense material, between 290 and 310 ft BLS, so it is believed that productivity for this well will be adequate as long as the water level is above the pump which is set at 301 ft BLS (table 2). The pump is set at 284 ft BLS in USGS 31, but no neutron or density logs are available so it is uncertain as to whether or not transmissivity will be maintained until the water level reaches the depth of the pump. The density log (Bartholomay, 1990, p. 49) for USGS 32 indicates low density material from 305 to 325 ft BLS, so it is probable that transmissivity for this well will be maintained as long as the water level is above the pump which is set at 322 ft BLS. The pump in ANP-9 is set at 262 ft BLS and the density log for ANP-9 indicates mostly dense material from 245 to 265 ft BLS (Bartholomay 1990, p. 183), so this well may not maintain the transmissivity as indicated by the aquifer test completed in 1990 (table 4) when the water level was 220 ft BLS.

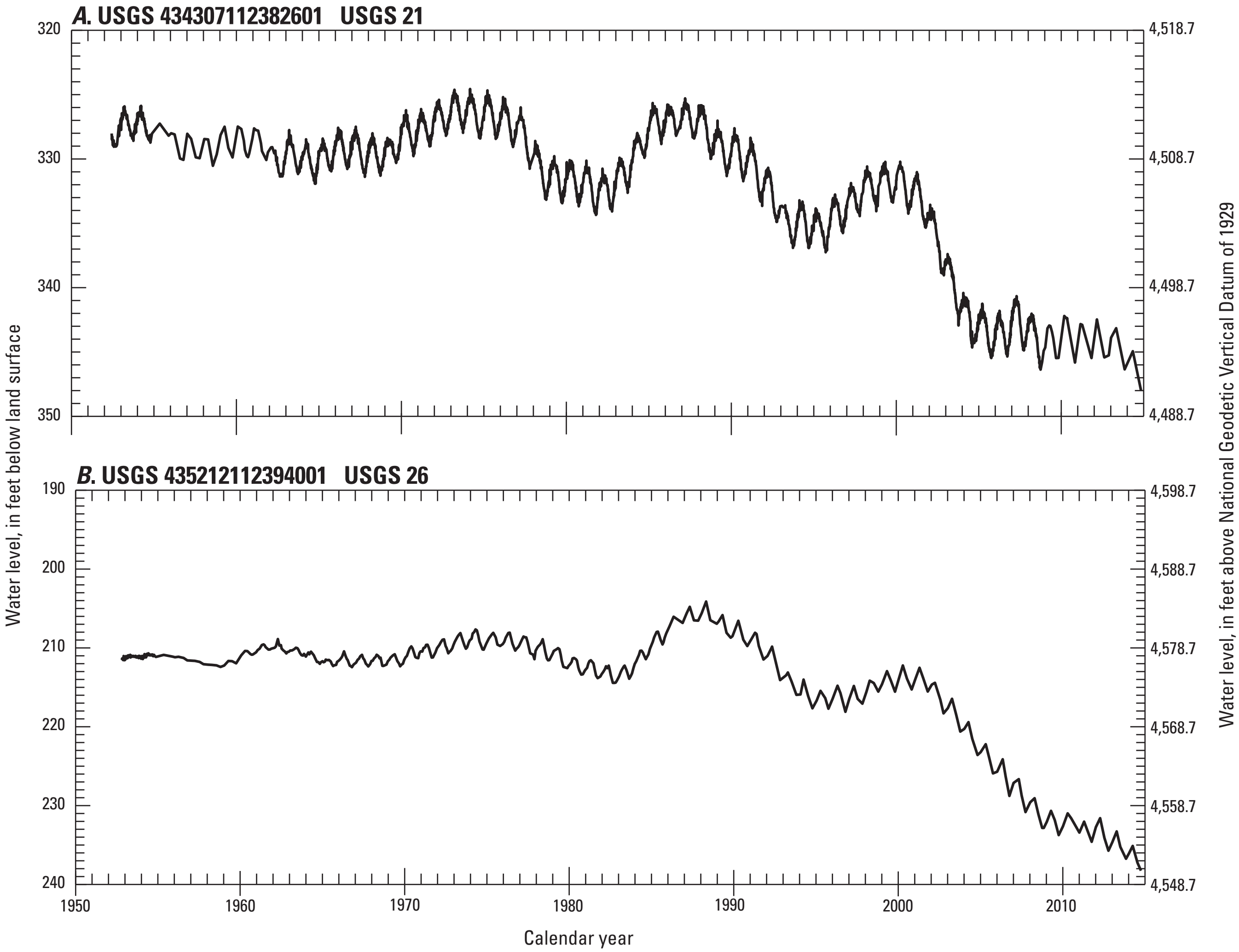

Figure 6. Water levels in wells (*A*) USGS 21, (*B*) USGS 26, (*C*) USGS 27, and (*D*) USGS 32 in the northeastern area of the Idaho National Laboratory, Idaho, 1952–2014.

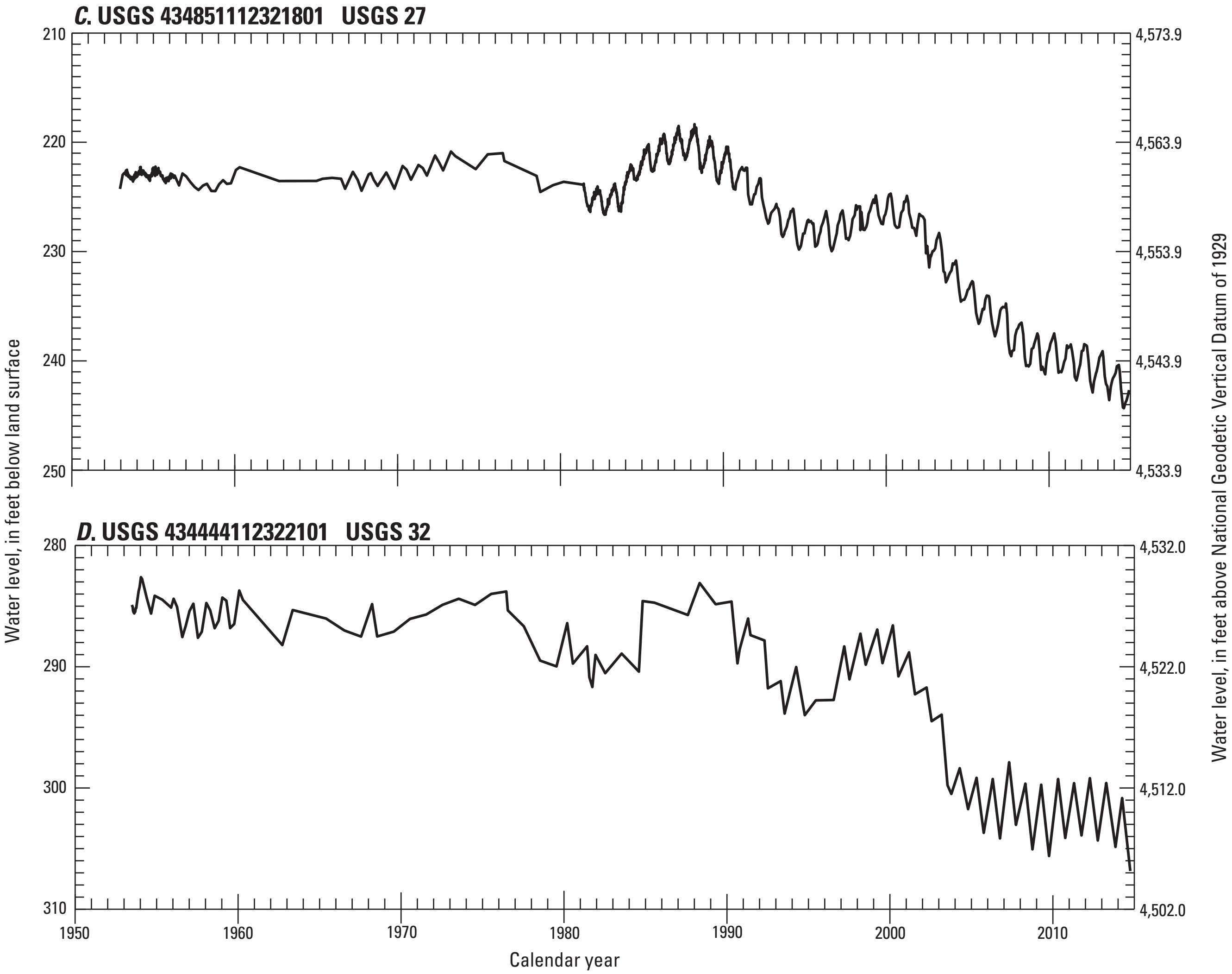

Figure 6.—Continued

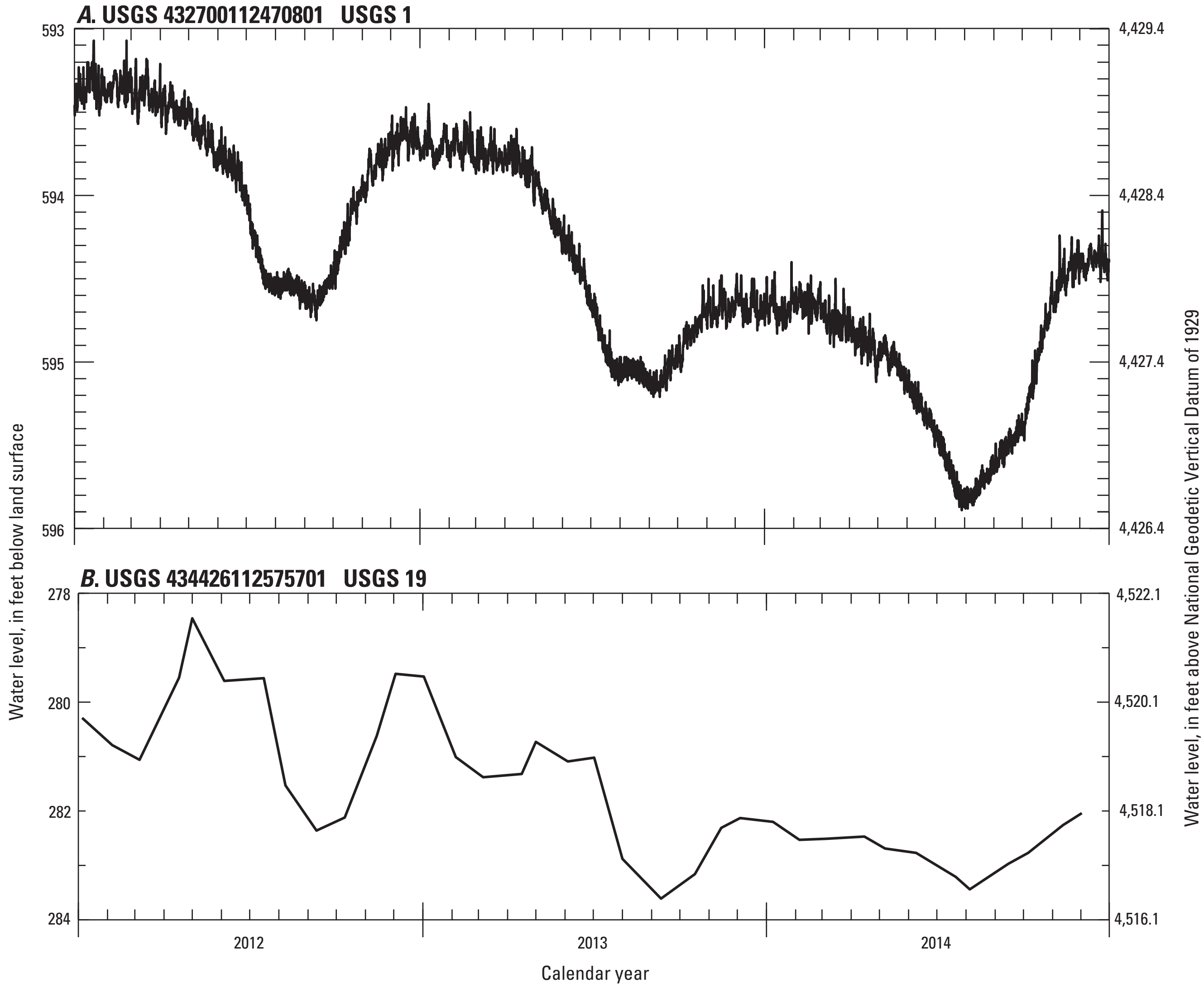

Figure 7. Water levels in wells (*A*) USGS 1, (*B*) USGS 19, (*C*) USGS 20, (*D*) USGS 21, and (*E*) USGS 27, Idaho National Laboratory, Idaho, 2012–2014.

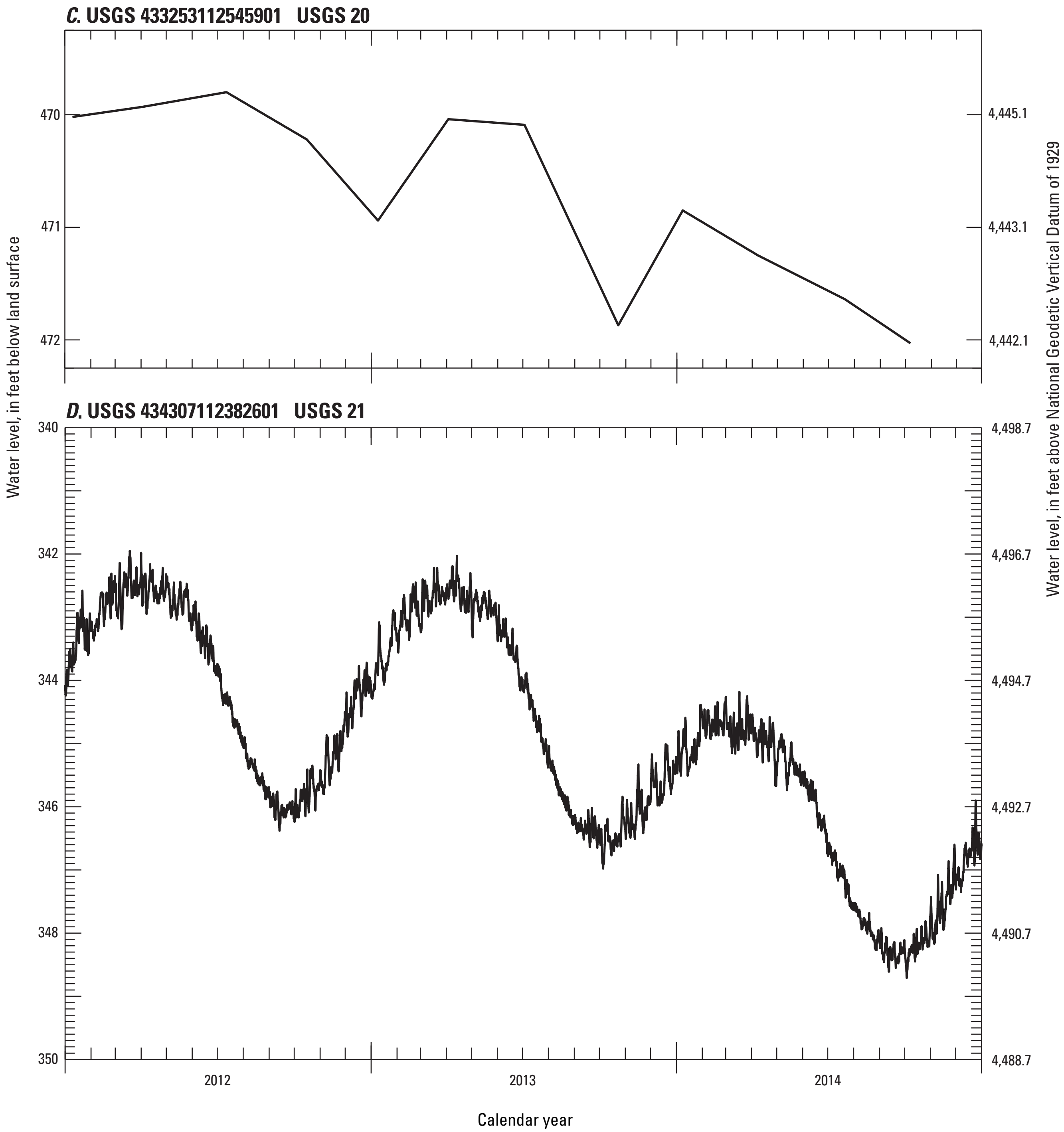

Figure 7.—Continued

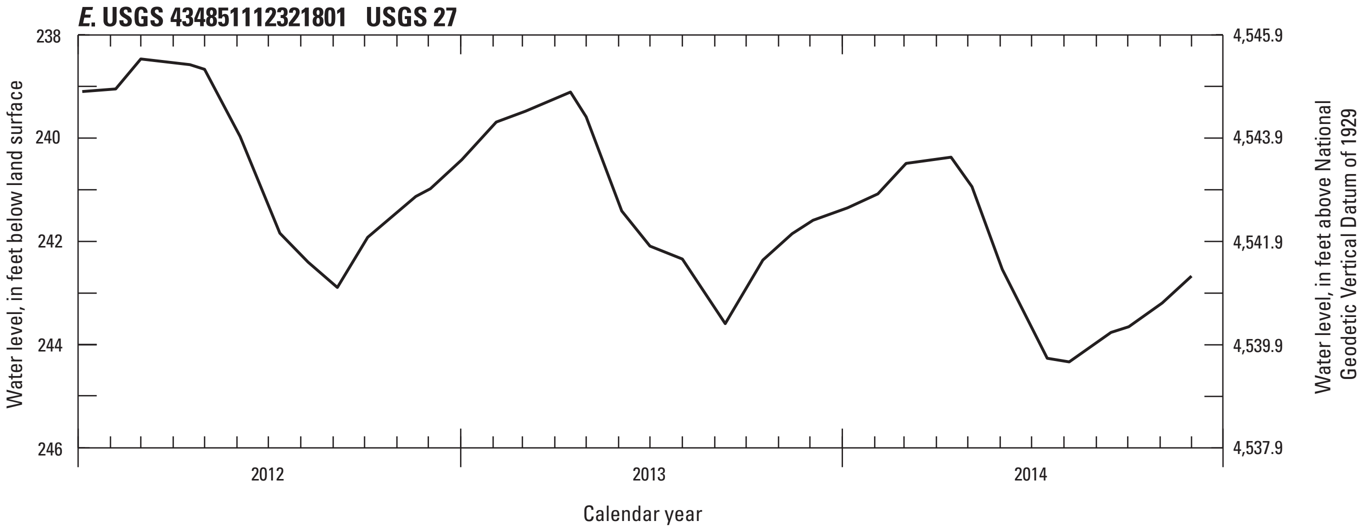

Figure 7.—Continued

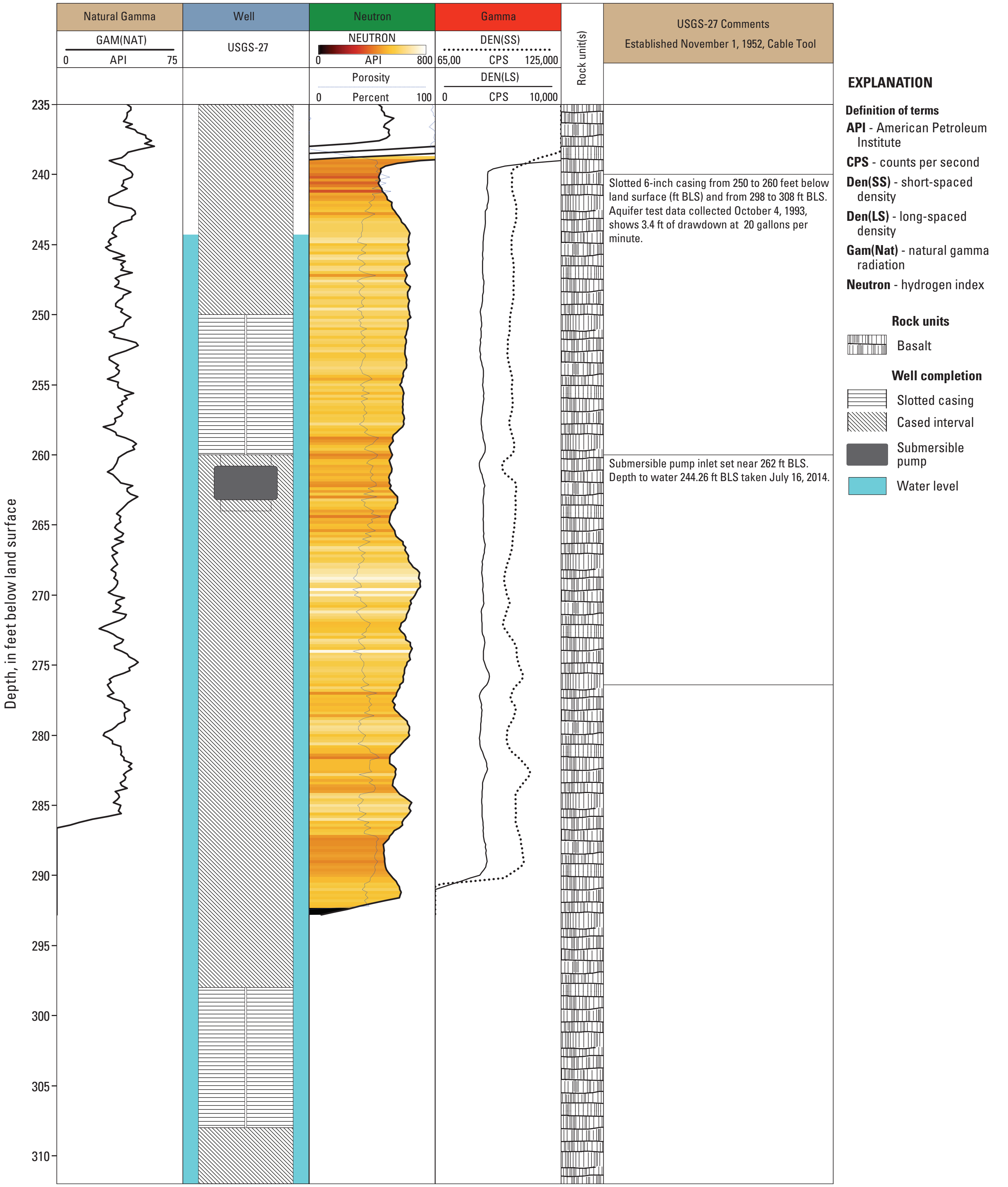

Figure 8. Geophysical logs for wells USGS 27 and ANP-6 at the Idaho National Laboratory, Idaho.

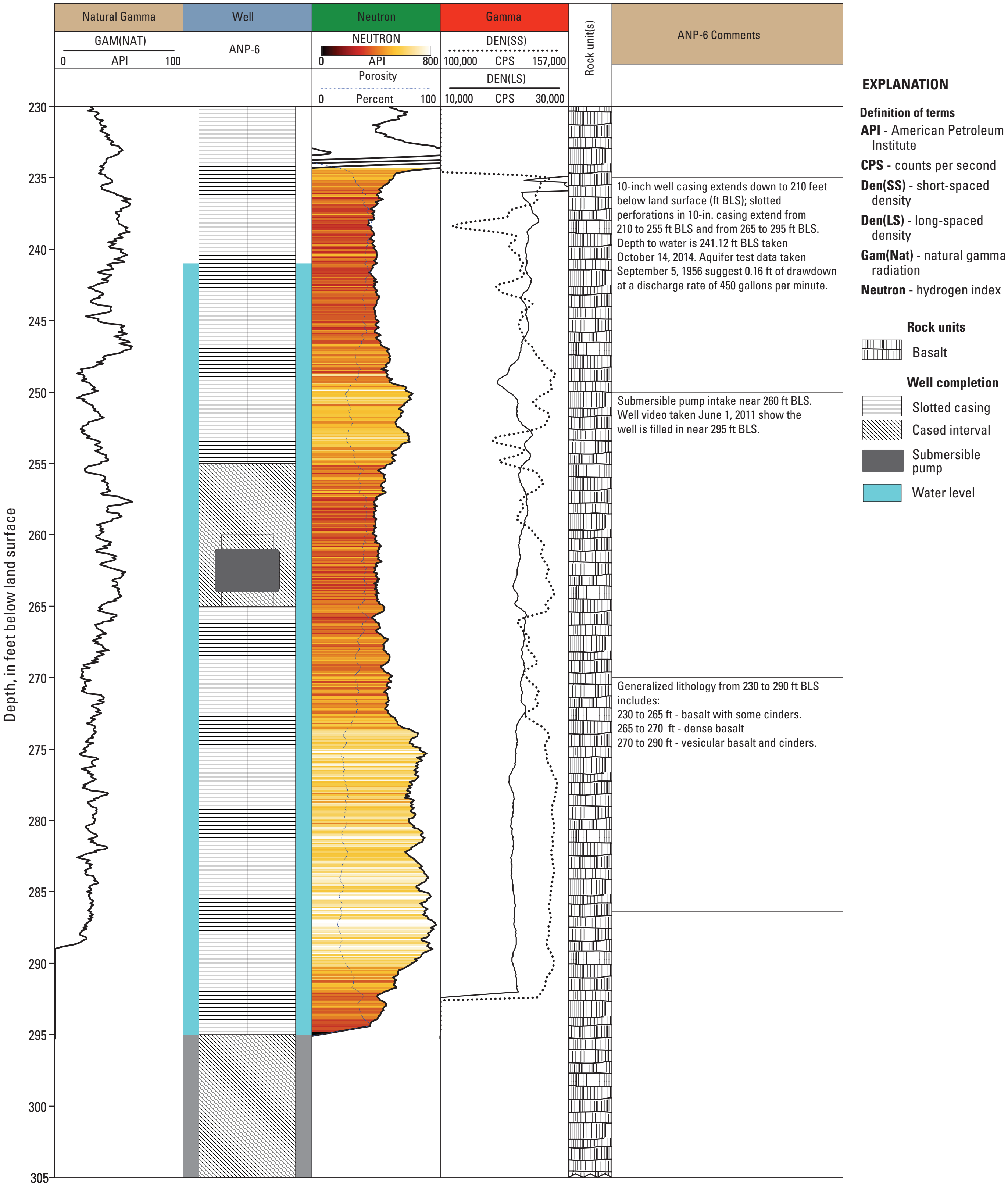

Figure 8.—Continued

Table 4. Water level information and transmissivity information for wells with less than 20 feet of water above pump at the Idaho National Laboratory, Idaho.

[Location of wells is shown in figures 2 and 3. Water level measurements are given in feet with reference to National Geodetic Vertical Datum of 1929. **Local name** is the local well identifier used in this study. **Site identifier** is the unique numerical identifier used to access well data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis). **Transmissivity** values are in foot squared per day (ft^2/d) and were taken from Ackerman (1991) or Bartholomay and others (1997). **Abbreviations:** ft, feet; NA, not available; >, greater than]

Local name	Site identifier	Transmissivity (ft^2/d)	Water level during transmissivity test (ft)	Current water level date	Current water level (ft)
		Northeastern area wells			
ANP 9	434856112400001	6.6×10^3	220	10-02-14	245.24
USGS 18	434540112440901	4.3×10^4	269	10-06-14	292.48
USGS 27	434851112321801	3.3×10^2	226	10-02-14	243.65
USGS 31	434625112342101	1.7×10^4	251	10-02-14	268.76
USGS 32	434444112322101	5.6×10^5	290	10-02-14	306.85
		Northwestern area wells			
ANP 6	435152112443101	5.0×10^5	214	10-14-14	241.12
PSTF Test	434941112454201	5.9×10^3	206	10-02-14	234.32
USGS 7	434915112443901	3.3×10^3	209	10-02-14	237.24
USGS 12	434126112550701	1.1×10^4	325	10-06-14	346.52
		Southeastern area wells			
ARA-MON-A-002	433054112492102	NA	NA	10-09-14	600.32
USGS 1	432700112470801	$>3.3 \times 10^5$	590	11-20-14	594.42
USGS 2	433320112432301	3.7×10^4	657	10-01-14	670.16
USGS 5	433543112493801	1.1×10^1	466	10-07-14	480.41
USGS 14	432019112563201	2.2×10^4	715	10-14-14	720.95
USGS 100	433503112400701	1.4×10^4	671	10-01-14	688.15
USGS 101	433255112381801	1.2×10^3	770	09-08-14	781.53
		Southwestern area wells			
NPR Test	433449112523101	8.6×10^3	456	10-15-14	476.04
USGS 9	432740113044501	5.9×10^4	604	10-22-14	614.05
USGS 39	433343112570001	3.9×10^5	475	07-17-14	485.66
USGS 47	433407112560301	NA	NA	10-12-10	469.00
USGS 58	433500112572502	3.7×10^4	453	10-08-14	472.70
USGS 59	433344112554101	NA	NA	10-08-14	467.74
USGS 65	433447112574501	9.5×10^3	464	10-08-14	476.46
USGS 76	433425112573201	1.9×10^5	466	10-08-14	484.91
USGS 84	433356112574201	$>6.4 \times 10^4$	484	10-22-14	493.00
USGS 85	433246112571201	3.9×10^5	482	10-08-14	494.68
USGS 86	432935113080001	3.0×10^2	645	10-22-14	656.49
USGS 87	433013113024201	8.5×10^2	586	04-17-14	595.31
USGS 98	433657112563601	8.1×10^4	398	10-14-14	425.79
USGS 99	433705112552101	1.1×10^5	387	10-02-14	410.18
USGS 106	432959112593101	1.0×10^5	583	10-20-14	594.85
USGS 112	433314112563001	6.4×10^4	467	10-07-14	483.14
USGS 121	433450112560301	NA	NA	10-07-14	464.32
USGS 123	433352112561401	NA	NA	10-06-14	475.03
MTR TEST	433520112572601	2.0×10^5	451	10-08-14	470.96
NRF 9	433840112550201	NA	NA	12-04-14	392.08
NRF 10	433841112545201	NA	NA	11-17-14	391.88
RWMC M6S	432931113015001	NA	NA	04-07-14	645.83
RWMC M12S	433118112593101	NA	NA	10-02-14	542.84
Site 19	433522112582101	3.1×10^4	467	10-15-14	479.83

Hydrologic Factors Affecting Water Levels in the Northwestern Area of the Idaho National Laboratory

Busenberg and others (2001) used age-dating techniques of CFCs, sulfur hexafluoride, and tritium/helium to classify the water in the northwestern area of the INL based on the recharge type of the young fraction of groundwater. Water in the northwestern area of the INL is characterized as a mixture of old and young water derived from Birch Creek, Little Lost River, and Big Lost River surface water and groundwater underflow. Wells completed in the northwest area (fig. 2) suggest water-level data is impacted by mountain front underflow, flow from the Little Lost River and Birch Creek, and episodic flow events within the Big Lost River.

Groundwater in USGS 12, near the Big Lost River, indicates water-level change that appears to be strongly influenced by flow in the Big Lost River (Bennett, 1990, p. 31; Bartholomay and others, 2012, fig. 8). Furthermore, water levels in USGS 12 have fluctuated approximately 40 ft over the period of record, peaking in the early 1970s and reaching a low during 2014. Water levels reported for USGS 12 appear to fluctuate based on the amount of flow in the Big Lost River (figs. 9*B* and 10); furthermore, the ESRP aquifer near USGS 12 appears to be directly affected by water table mounding when Big Lost River flow occurs (Ackerman and others, 2006). Water levels in USGS 19 (fig. 9*C*) show some variability similar to USGS 12 in terms of wet and dry cycles. Water levels have declined about 34 ft from a high in the early 1980s; but, given its location, the well is most likely influenced by recharge from the Little Lost River Basin. Seasonal effects influence water levels in this well, with seasonal variability (1.5–4 ft fluctuation seasonally in the past three years; fig. 7*D*) similar to wells in the northeast. Water levels in wells northwest of TAN indicate ongoing declines since about 2000, similar to patterns reported for wells USGS 26 and USGS 27 described for the northeastern area. For example, water levels in USGS 25 (fig. 9*D*) show about 26-ft decline in the past 14 years.

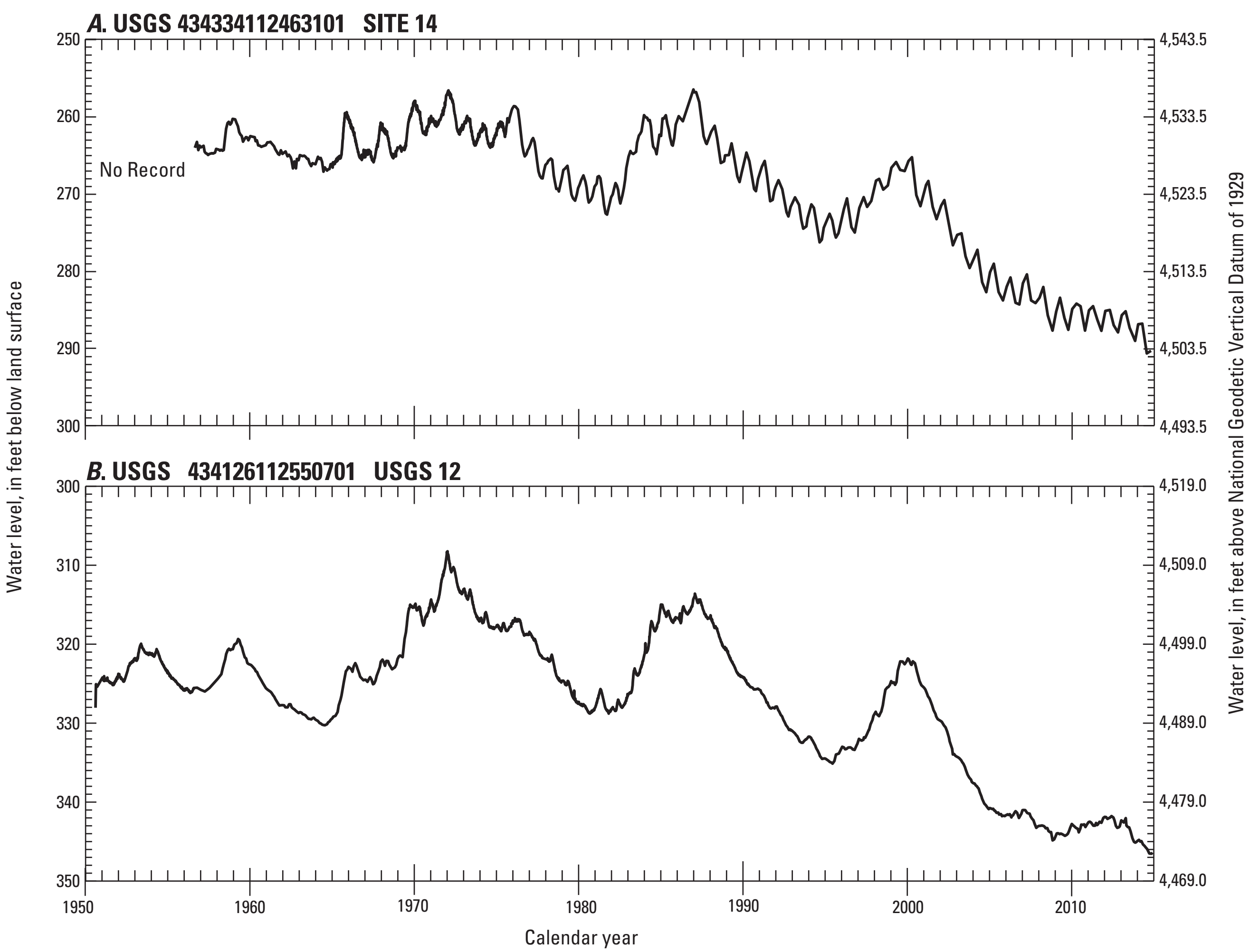

Figure 9. Water levels in wells (*A*) Site 14, (*B*) USGS 12, (*C*) USGS 19, and (*D*) USGS 25 in the northwestern part of the Idaho National Laboratory, Idaho, 1950–2014.

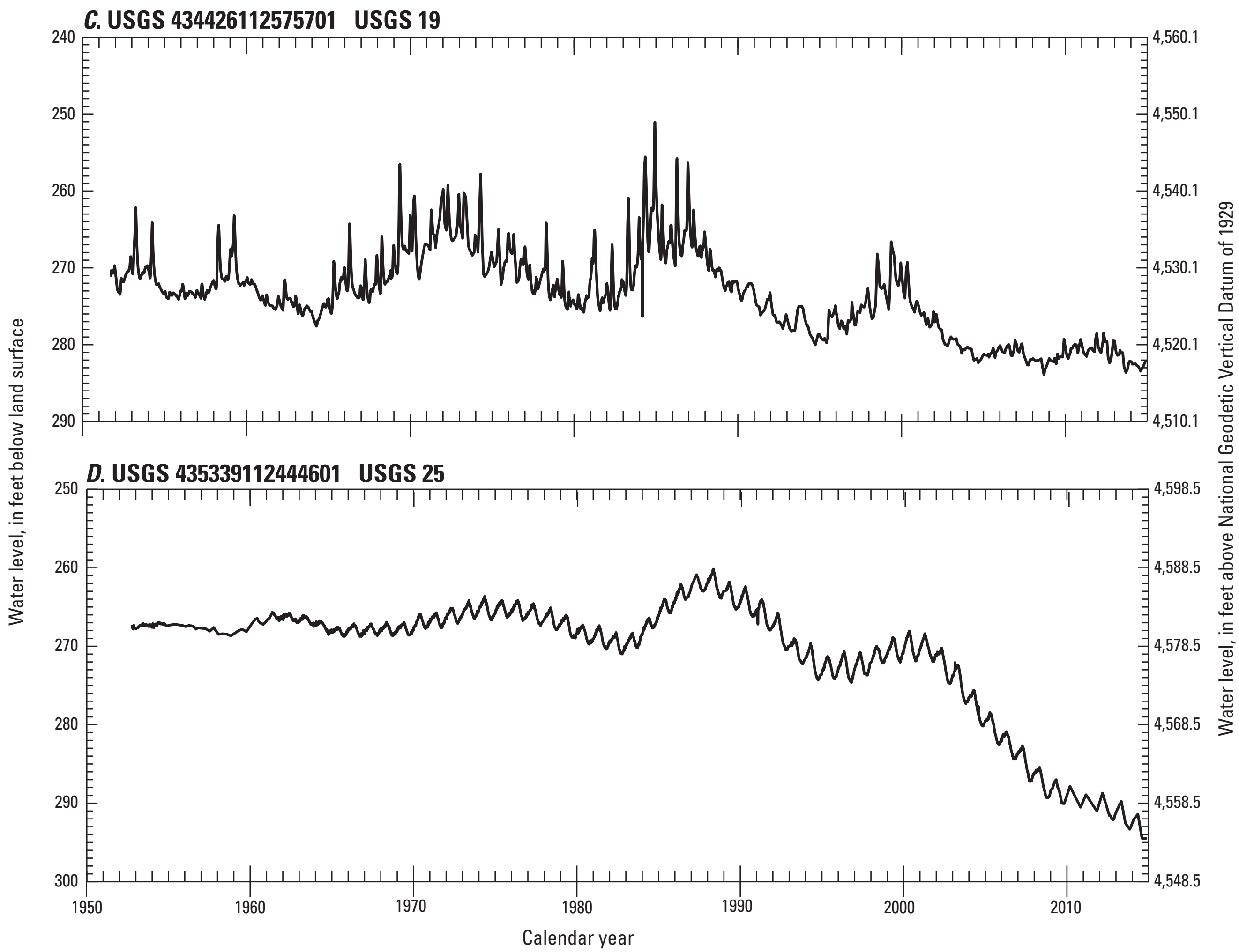

Figure 9.—Continued

Robertson and others (1974, appendix A) indicated that well USGS 25 probably represents natural conditions of the northeastern area that are not influenced by irrigation, and noted that this well may be influenced by Birch Creek flow because its water level only fluctuated by about 3 ft from 1952 to 1968. More recently, use of water coming from Birch Creek may be affecting larger water-level decline in that only about 5 percent diversion return occurs from a hydroelectric project that started in 1987 to trenches in the northern part of the INL (Swanson and others, 2003). The most recent declines in well USGS 25 also show strong seasonal effects that probably indicate irrigation influence, and the declining levels for the past 14 years probably are related to the same hydrologic factors that are affecting wells USGS 26 and 27 to the east. Well Site 14 southwest of TAN also shows this similar declining trend and seasonal fluctuations (fig. 9*A*). Water levels in the northwestern area of the INL are thus probably impacted by irrigation pumpage, wet and dry cycles, along with the lack of more recent recharge from the Big Lost River, Little Lost River, and Birch Creek (depending on the location of the well in the basin).

Geophysical and well data for wells in the northwestern area of the INL that have 20 ft or less of water above the pump include ANP 6, PSTF Test, USGS 7, and USGS 12 (table 2; fig. 8; appendix A). Not all of the four wells have neutron logs available (Bartholomay, 1990, table 1), so geophysical information from well ANP-6 (fig. 8*B*) was used to represent aquifer properties near wells in the northwestern part of the INL. Well logs for ANP-6 (fig. 8) indicate a mostly productive aquifer system, with a dense, possibly less productive zone (poorer neutron response) between about 248 and 253 ft BLS. The neutron and density response for material right above the pump, which is set at 260 ft BLS, is probably adequate for good production, so it is believed that the productivity will not change as long as the water level is above the pump.

The density log (Bartholomay, 1990, p. 296) for PSTF Test (pump setting of 242 ft BLS, table 2) indicates material with similar density from 210 to 245 ft BLS, so it is believed that the transmissivity of this well will not change much as water levels decline. The density log for USGS 7 (Bartholomay, 1990, p. 23), which has its pump set at 242 ft BLS, indicates low density material from 210 to 245 ft BLS, so it is believed that the productivity of this well will not change much as water levels decline. The density log for USGS 12 (Bartholomay, 1990, p. 27), which has the pump set at 358 ft BLS, indicates low density material from 325 to 355 ft BLS, suggesting that the productivity of this well will not change much as water levels decline.

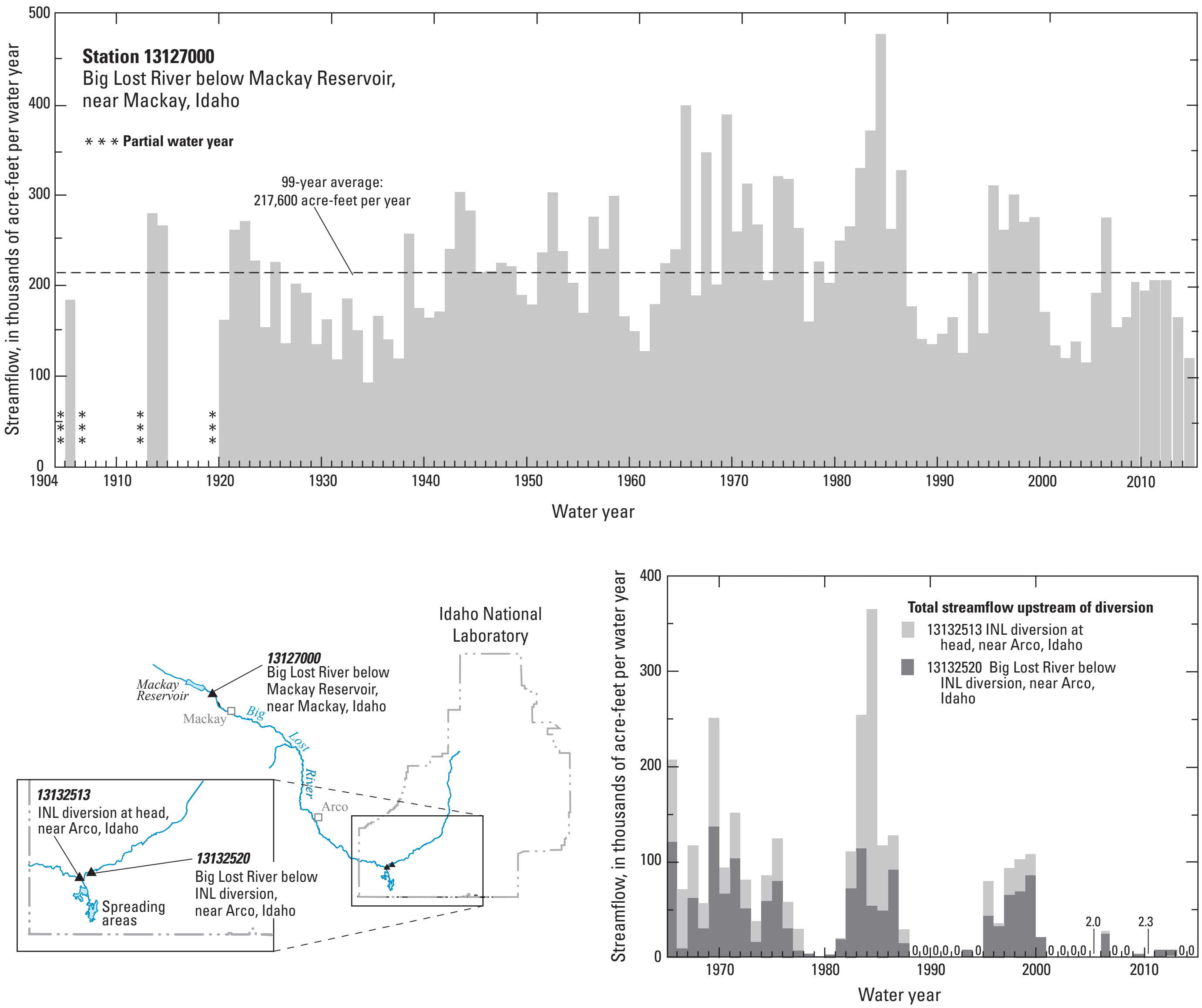

Figure 10. Streamflow at U.S. Geological Survey streamgaging stations along the Big Lost River: Big Lost River below Mackay Reservoir, near Mackay, Idaho, water years 1905, 1913–14, and 1920–2014; Big Lost River below the Idaho National Laboratory (INL) diversion, near Arco; and INL diversion at head, near Arco, Idaho, water years 1965–2014.

Hydrologic Factors Affecting Water Levels in the Southeastern Area of the Idaho National Laboratory

Busenberg and others (2001) used age dating techniques of CFCs, sulfur hexafluoride, and tritium/helium to classify the water in the southeastern area of the INL based on the recharge type of the young fraction of groundwater. Water in the southeastern area of the INL is old, regional groundwater underflow that is mixed with young water derived from local rapid, focused recharge, probably from precipitation infiltration. Water levels in this part of the INL are thus probably influenced by some local precipitation, but mostly from wet and dry cycles affecting the regional aspect of the ESRP aquifer.

Hydrographs for wells in the southeastern area (USGS 1, USGS 2, USGS 5 and Highway 2; fig. 11) show much less decline in overall water levels than in other parts of the INL. Declines from highest recorded water levels to lowest levels range from about 14 ft in USGS 1 to about 20 ft in Highway 2 (fig. 11*B* and 11*A*, respectively). Wells in the southeastern area generally show consistent changes that correspond to wet and dry climate cycles, and they all show a decline from 2000 to about 2005 and relatively stable levels since 2005. This area of the ESRP aquifer does not appear to show effects related to irrigation, with the exception of the Highway 2 well. Most of these wells also show much less seasonal variation. For example, USGS 1 only shows a maximum of about a 1.5 ft change seasonally during the past 3 years (fig. 7*A*).

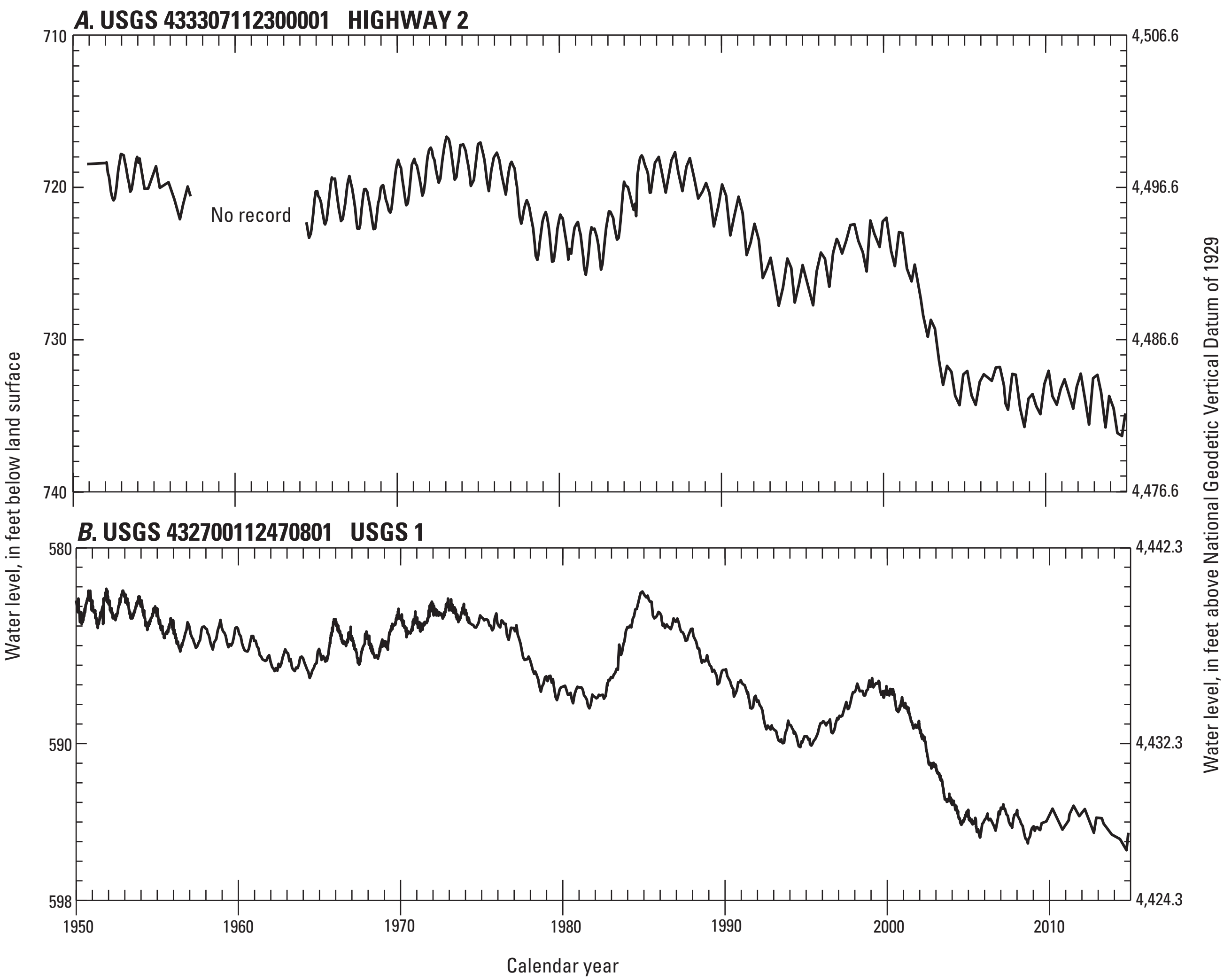

Figure 11. Water levels in wells (*A*) Highway 2, (*B*) USGS 1, (*C*) USGS 2, and (*D*) USGS 5 in the southeastern area of the Idaho National Laboratory, Idaho, 1949–2014.

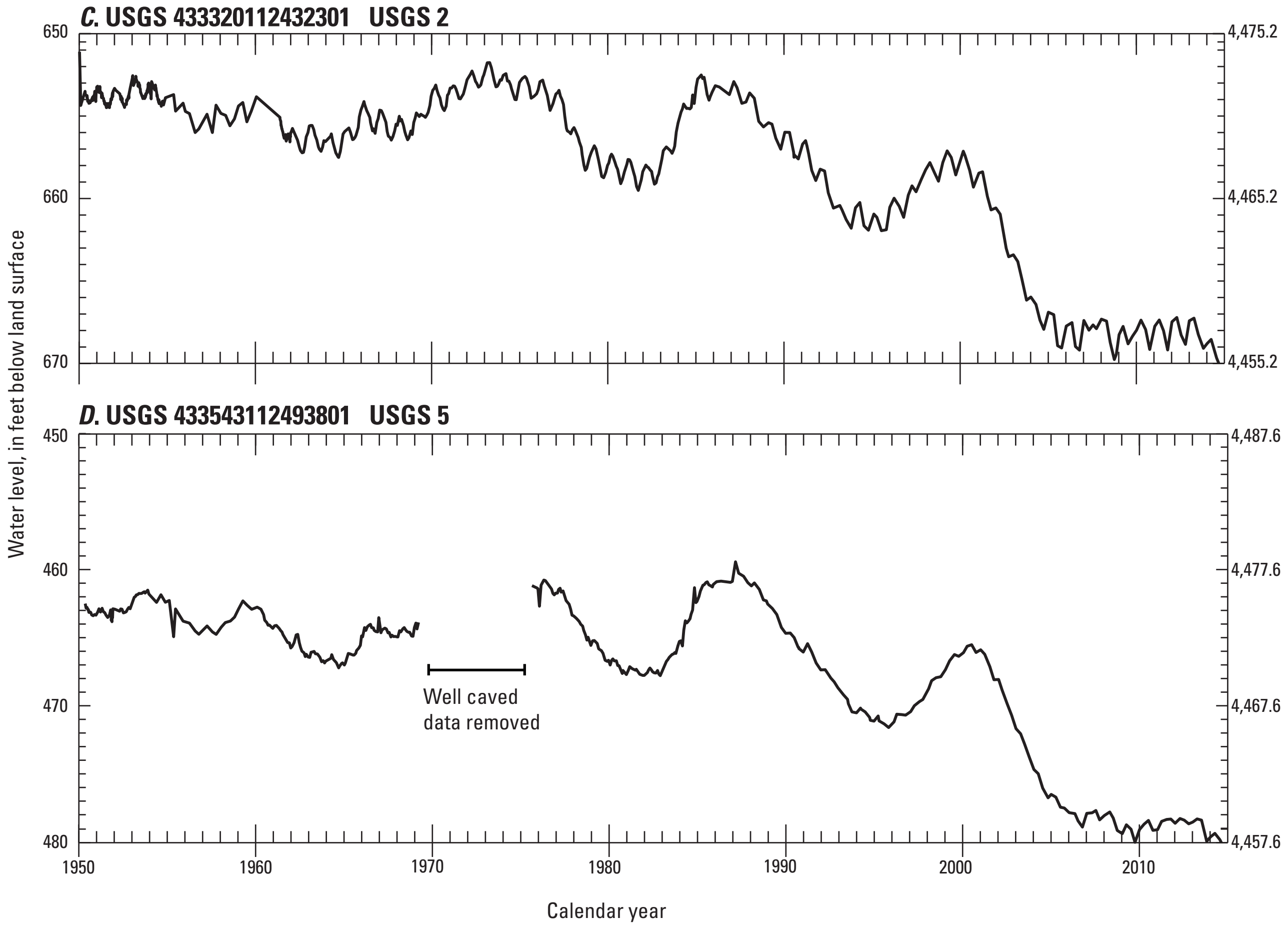

Figure 11.—Continued

Geophysical logs for wells with less than 20 ft of water above the pump (wells ARA-MON-A-002, USGS 1, USGS 2, USGS 5, USGS 14, USGS 100, and USGS 101; table 2) are given in appendix A. Neutron logs (appendix A) for ARA-MON-A-002 from about 600 to about 615 ft BLS show good productive basalt units, so this well should produce water until the water level declines below the pump that is set at 604 ft BLS. The density and neutron logs for USGS 1 (appendix A) show mostly less dense material and productive basalt between 595 and 615 ft BLS, so it is believed that productivity for this well will be adequate as long as the water level is above the pump that is set at 612 ft BLS. The neutron log for USGS 2 indicates a good productive zone from about 677 to about 682 ft BLS. The pump is set at about 685 ft BLS, and productivity could decline drastically if the water level declines below 682 ft BLS. USGS 5 is completed in dense basalt with interbedded sediment and exhibits low transmissivity, so water production will continue to be poor from this well until water levels decline below the pump. The neutron log for USGS 14 (appendix A) indicates a good productive zone between about 725 and 740 ft BLS, so this well should maintain its productivity at its current pump setting of 739 ft BLS. Neutron and density logs (Bartholomay, 1990, p. 135) for USGS 100 indicate that this well should remain productive until water levels decline below the pump. The pump in USGS 101 is set at 800 ft BLS in basalt below a sediment layer that recently has been sluffing into the well. The USGS tried to pull the pump to clean out the sediment, but sediment above the pump prevented removal. When the pump in this well eventually fails, the well may need to be abandoned.

Hydrologic Factors Affecting Water Levels in the Southwestern Area of the Idaho National Laboratory

Busenberg and others (2001) used age-dating techniques of CFCs, sulfur hexafluoride, and tritium/helium to classify the water in the southwestern area of the INL based on the recharge type of the young fraction of groundwater. Water in the southwestern area of the INL is characterized as a mixture of old and young water derived from Birch Creek, Little Lost River, and Big Lost River surface-water and groundwater underflow.

Wells constructed in the southwestern area (fig. 2) suggest that well location has a direct effect on water levels and annual fluctuations. Wells closest to the Big Lost River show more water-level change than wells located farther from the Big Lost River (Davis and others, 2013, fig. 11). For example, well MTR Test, located about 1 mi north of the Big Lost River, shows a water-level decline of about 23 ft from the 1980s to 2014 (fig. 12*A*), whereas USGS 104, located about 8 mi southeast of the Big Lost River, only shows a decline of about 14 ft for the same period (fig. 12*E*). The wells in the southwest do show similar patterns of water-level fluctuations with increases and decreases related to wet and dry cycles (fig. 12). Wells in the southwest show large declines starting in 2000 to about 2005 and show a relative leveling off since 2005 (fig. 12) similar to wells in the southeast. Additionally, wells in the southwest and southeast show less seasonal variability (about 1–2 ft change in USGS 20 and USGS 1, respectively, fig. 7) than wells to the northwest and northeast; this low variability is attributed to lack of influence from irrigation pumpage.

Well USGS 9 shows a large 13-ft increase in its water level from 1980 to 1984 (fig. 12*C*); Ackerman and others (2006) attributed this spike to flow into the spreading areas south of the RWMC (fig. 1). This spike corresponds with more than 450,000 acre-ft of discharge into the spreading areas during the 1983 and 1984 water years (fig. 10). USGS 8 shows a similar increase in the same time period (fig. 11). The rise in water level in well USGS 9 from 1994 to 2000 was 4.5 ft when about 80,000 acre-ft discharge occurred into the spreading areas (fig. 10), while the rise in wells farther north near the Big Lost River (MTR Test and USGS 97) showed water-level rises of 8 to 10 ft in the same time period. This is probably due to larger amounts of discharge along the Big Lost River (about 280,000 acre-ft total flow during 1995–99 water years) versus discharge into the spreading areas (fig. 12).

Geophysical and well data on wells in the southwestern area of the INL that have less than 20 ft of water still above the pump (wells USGS 9, USGS 39, USGS 47, USGS 58–59, USGS 65, USGS 76, USGS 84–87, USGS 98–99, USGS 106, USGS 112, USGS 121, USGS 123, MTR Test, NPR Test, NRF-9, NRF-10, RWMC M6S, RWMC M12S, and Site 19; table 2) are given in appendix A. Most of the wells have neutron and density logs available (appendix A). Wells USGS 9, USGS 47, USGS 58–59, USGS 65, USGS 84, USGS 87, USGS 99, USGS 106, USGS 112, MTR Test, and NPR Test (Bartholomay, 1990; appendix A) indicate mostly low-density material and good neutron response for the aquifer material between the current pump setting and current water level (table 2), so productivity is expected to be maintained until the water level declines below the pump. Wells 76, 85, 86, and Site 19 indicate mostly low-density aquifer material (Bartholomay, 1990) between the current pump setting and current water level, so productivity should stay about the same until the water level declines below the pump. For well USGS 39, the water level declined below the pump in 2014, and the well is caved in below the current pump setting, so this well can no longer be monitored until the water level rises again. For well USGS 98, logs indicate that the pump is set (440 ft BLS) in a sediment layer, so productivity could change when the water level declines near the current pump setting.

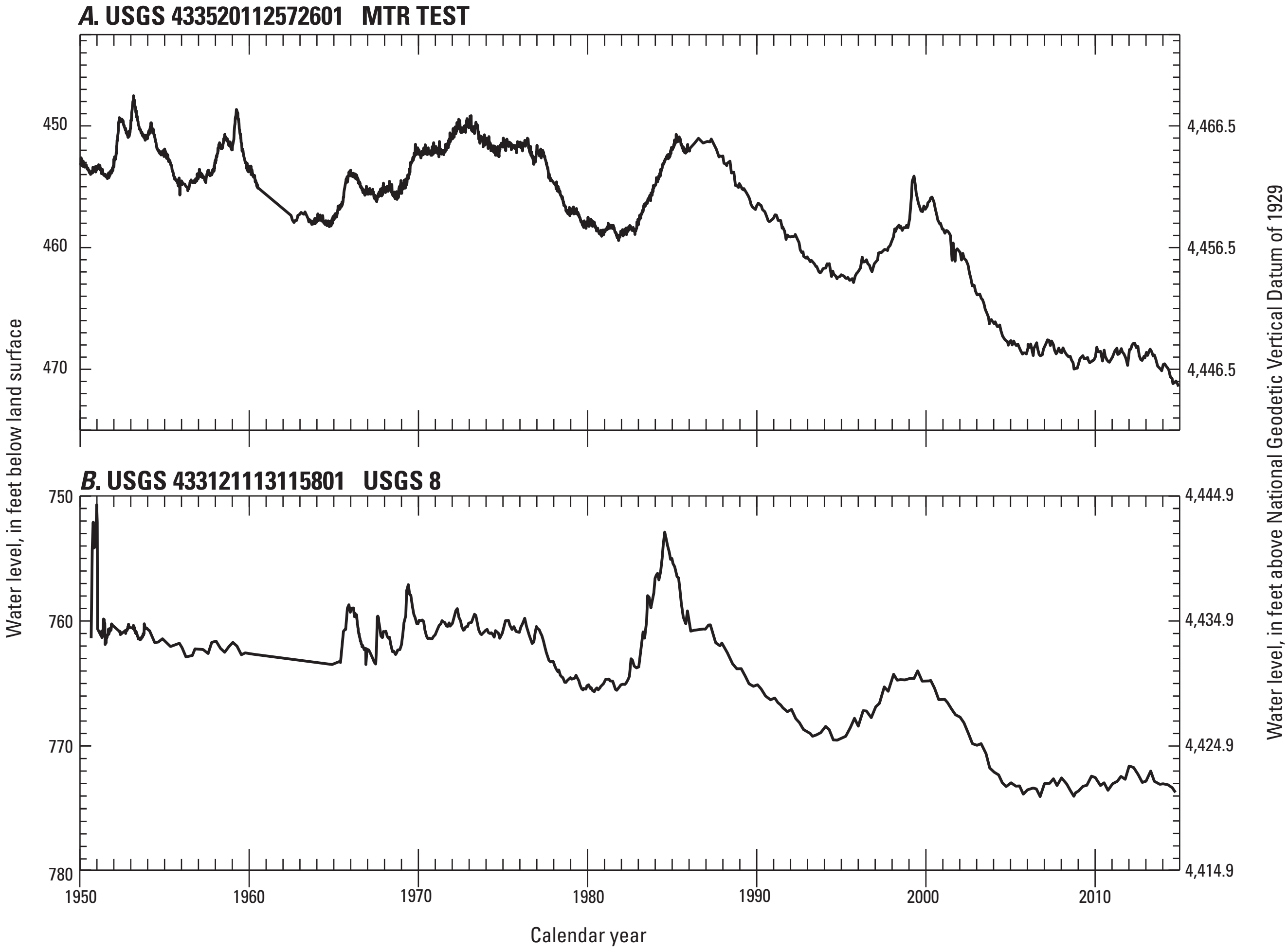

Figure 12. Water levels in wells (*A*) MTR Test, (*B*) USGS 8, (*C*) USGS 9, (*D*) USGS 20, (*E*) USGS 97, and (*F*) USGS 104 in the southwestern area of the Idaho National Laboratory, Idaho, 1949–2014.

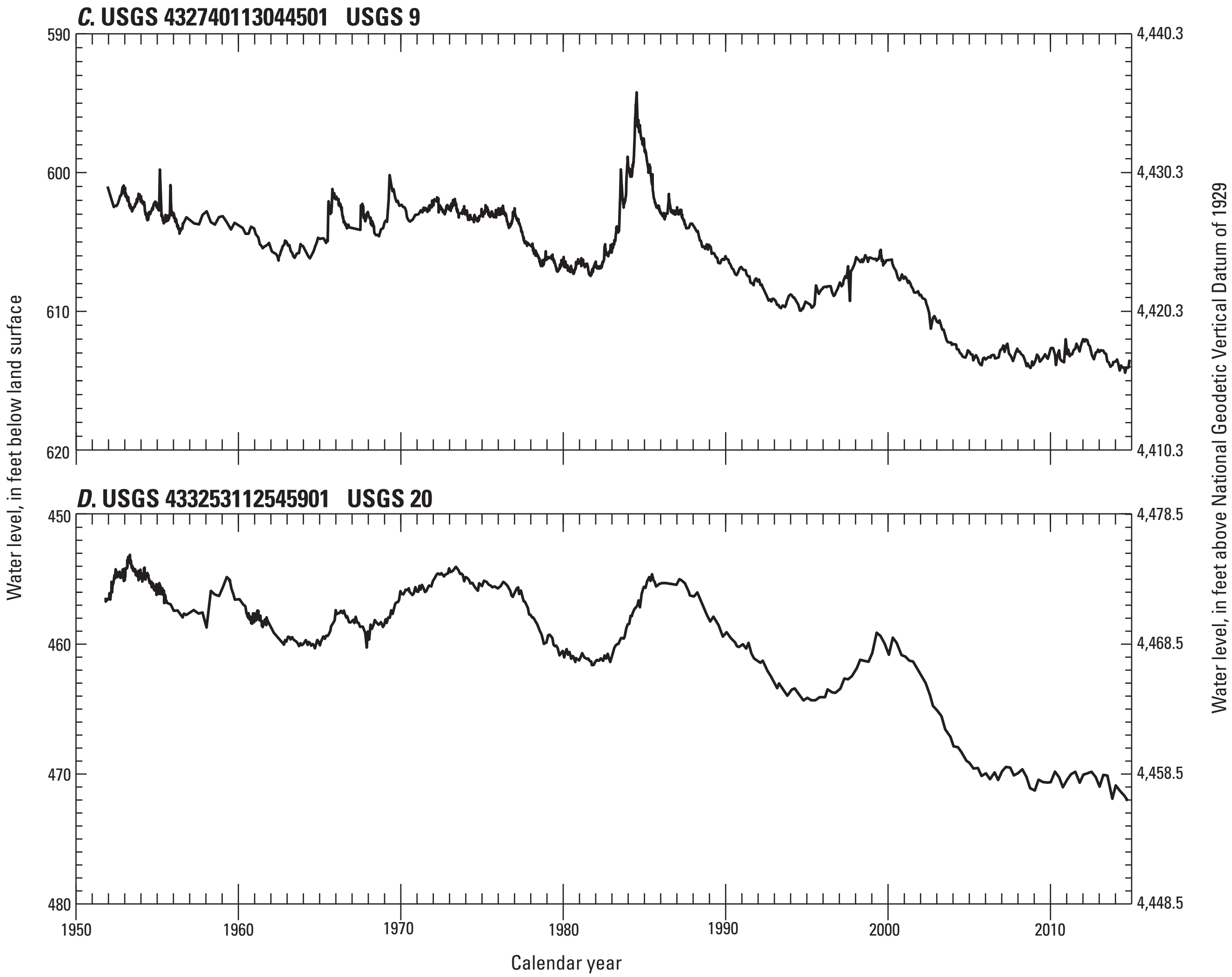

Figure 12.—Continued

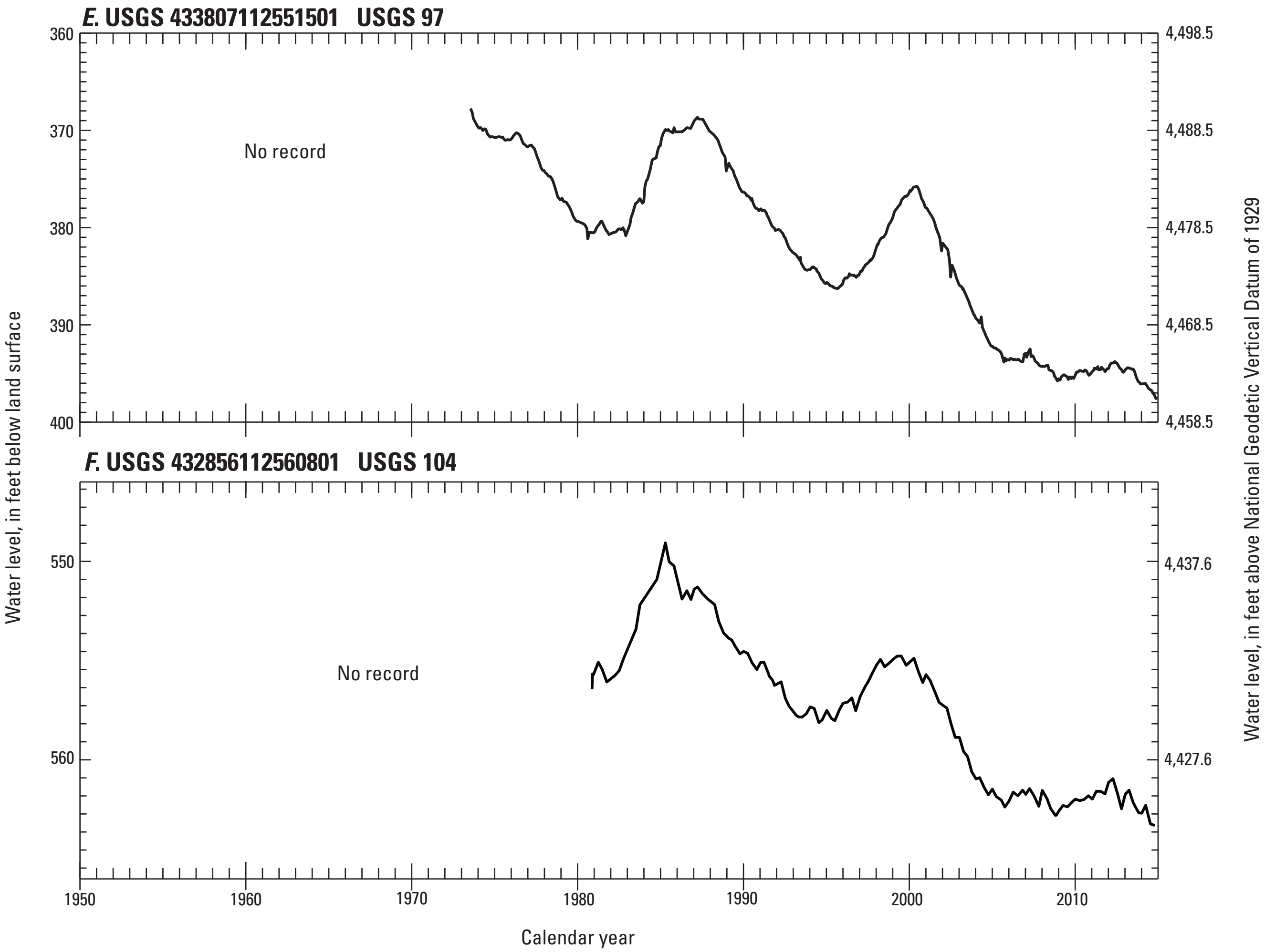

Figure 12.—Continued

Summary and Conclusions

The U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, has maintained a water-level monitoring program at the Idaho National Laboratory (INL) since 1949 to systematically measure water levels to provide long-term information on groundwater recharge, discharge, movement, and storage in the eastern Snake River Plain (ESRP) aquifer. Water levels are collected continuously, monthly, quarterly, semi-annually, or annually depending on historical data, research needs, and changes in the hydrograph.

During 2014, water levels in the ESRP aquifer at the INL reached all-time lows for the period of record. Water levels from selected wells at the INL were evaluated to assess how future water-level declines will affect well productivity. Water levels were compared with pump depth to determine the hydraulic head above the pumps. Geophysical logs were examined for selected wells to evaluate long-term productivity as water levels decline towards the depth of the pumps. Hydrologic factors affecting water levels in different areas of the INL were examined to provide an understanding of why water-level declines and fluctuations occur.

Water levels were evaluated on their geographical distribution at the INL based on northeastern, northwestern, southeastern, and southwestern areas. The eastern and western areas were divided along a line similar to water types defined as eastern regional underflow and western tributary recharge. The northern and southern areas were based on an arbitrarily defined line.

In the northeastern area, five wells were identified as having less than 20 feet (ft) of water remaining above the pump. Water levels in northeastern wells show water-level fluctuations as much as 4.5 ft seasonally and have shown declines as much as 25 ft in the past 14 years. These declines are attributed to groundwater pumping for irrigation and the lack of a wet hydrologic cycle. Water levels in the northernmost wells of the northeastern area show more consistent declines in the past 14 years compared to the southernmost wells that show declines to about 2005 and then a relatively stable hydrograph. The larger declines in the northernmost wells are attributed to more groundwater use for irrigation in the upgradient area of the aquifer.

In the northwestern area, four wells were identified as having less than 20 ft of water remaining above the current pump setting. Water levels in northwestern wells show water-level fluctuations based on the location of the well in the basin. Well USGS 12 near the Big Lost River Sinks shows consistent changes based on surface-water flow in the Big Lost River, showing increases when the Big Lost River flows and large declines when no flow occurs for several years. Well USGS 19 shows water-level fluctuations related to wet and dry cycles and shows some seasonality related to irrigation practices in the Little Lost River Basin. Wells in the northern part of the northwestern area show similar water-level changes as wells in the north-northeast area, and the recent declines are attributed to groundwater irrigation northwest of Mud Lake.

In the southeastern area, seven wells were identified as having less than 20 ft of water remaining above the pump. Most of the wells in the southeast show less decline during the period of record compared with wells to the northeast, and the smaller declines are attributed to less influence from irrigation practices. Most of the wells also show only about a 1–2 ft change seasonally because they are not influenced as much by irrigation.

In the southwestern area, 24 wells were identified as having less than 20 ft of water remaining above the pump. Wells in the southwest also only show small 1–2 ft changes seasonally because of a lack of irrigation influence. Wells show more fluctuation in water levels the closer they are to the Big Lost River, and levels fluctuate with wet and dry cycles of recharge.

Geophysical log data indicate that most of the wells will maintain their current level of water production until the water levels decline near their pump settings. A few of the wells may change from being high productivity to low productivity when the water level gets within 5 ft from the top of the pump. Areas most susceptible to another drought cycle are wells in the northeast and northwest.

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Appendix A. Geophysical Logs and Construction Information for Selected Wells at the Idaho National Laboratory, Idaho

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