Table Of Contents

List of Tables

List of Figures

2.3 WATER

2.3.1 HYDROLOGY

This section describes surface water bodies and groundwater aquifers that could affect or be affected by the construction and operation of {Callaway Plant Unit 2}. The site specific and regional data on the physical and hydrologic characteristics of these water resources are summarized to provide basic data for an evaluation of impacts on water bodies, aquifers, human social and economic structures, and aquatic ecosystems of the area.

{Callaway Plant Unit 2 is located northwest of Callaway Plant Unit 1, as shown in Figure 2.3-1. The site covers an area of approximately 2,765 acres (1,119 hectares) of primarily rural land.

The Callaway Plant site is located in Callaway County, Missouri approximately 10 miles (16 km) southeast of Fulton and 80 miles (129 km) west of the St. Louis metropolitan area. The climate of the site area can be described as a humid continental moderate climate, with cool to cold winters and long hot summers.

The Missouri River flows in an easterly direction approximately 5 miles (8 km) south of the site at its closest point. The elevations ranging from 530 ft to 536 ft (162 m to 163 m) above mean sea level (msl) on the north and south sides of the river define approximately the 100-yr Missouri River floodplain, which is about 2.4 miles (3.9 km) wide in this area.}

2.3.1.1 Surface Water Resources

{The Callaway Plant site is situated in an area of gently rolling upland, once part of an old glacial till plain. Erosion and down-cutting of the Missouri River and its tributary streams have dissected the plain, leaving a nearly isolated plateau of approximately 8 sq mi (21 sq km). The Callaway Plant Unit 2 location is on this plateau, which lies north of the Missouri River, at plant grade elevation 845 ft (257.6 m) msl. At the site, near the Chamois NOAA gauging station, the Missouri River 100-yr floodplain is at about elevation 533.4 ft (162.6 m) msl (NOAA, 2007a). Thus, the site lies about 311.6 ft (95.0 m) above the 100-yr floodplain of the Missouri River. Figure 2.3-2 shows the site utilization plant layout.

The area between the plateau and the Missouri River floodplain is highly dissected. Mud Creek and its intermittent stream branches have incised deeply into the southern flank of the plateau with steep stream gradients. Topographic relief varies from about 150 ft to 325 ft (45 m to 99 m) or more.

Surface drainage to the east and southeast is to Logan Creek. Mud Creek is a major drainage from the south and southwestern side of the site. Auxvasse Creek, a major tributary to the Missouri River located about 2 miles (3.2 km) west of the site area, intercepts surface drainage from the western and northern flanks of the plateau.

There are six man-made stormwater runoff ponds that are located around the periphery of the plateau, which are designated as P-3 through P-8 on Figure 4.3-2. These ponds were created during construction of Callaway Plant Unit 1 to control sediment runoff in addition to two pre-existing ponds in the vicinity. The surface area of these ponds ranges from approximately 0.9 acres to 13.5 acres (0.4 hectares to 5.5 hectares) with depths generally 5 ft (1.5 m) or less. Runoff from the Callaway Plant site is and will continue to be diverted to these on-site stormwater runoff ponds and two new stormwater runoff ponds, thus minimizing the impacts on the surrounding streams including Logan Creek, Mud Creek, Cow Creek, and Auxvasse Creek. Because stormwater ponds P-3 through P-8 have a surface water connection to the unnamed streams which eventually flow into named streams and then the Missouri River, these stormwater ponds are considered jurisdictional waters of the United States. Pond P-1 is isolated and, thus, is not a jurisdictional water of the United States. Stormwater runoff ponds P-1, P-2, P-7, and P-8 are actively managed by the Missouri Department of Conservation (MDC).

Existing stormwater runoff pond P-4, along with three isolated ponds C3-WT-02, C3-WT-03, and C4-WT-02 will be filled during the construction of the new Laydown Area as shown on Figure 2.3-3. The two new stormwater runoff ponds, A and B, will receive discharge from the Laydown Area, as indicated on Figure 2.3-3, and will drain to the adjacent streams discharging to Cow Creek. These stormwater runoff ponds will be unlined basins with a simple earth-fill closure on the downstream end and will include a piping system that will direct any discharge to the adjacent water courses. Stormwater from the Essential Service Water Emergency Management System (ESWEMS) Pond Area will discharge through perimeter ditches to new stormwater runoff pond A. Portions of the Construction Worker Parking Area will be directed to the existing stormwater runoff pond P-1, with the balance being directed to new stormwater runoff pond A. The Callaway Plant Unit 2 powerblock and Switchyard Area will drain to the existing pond P-2 and to the new stormwater runoff pond A. All of the existing stormwater runoff ponds and future ponds are designed for the 100-yr flood.

Wetlands and streams were delineated on the Callaway Plant site in accordance with the 1987 *Corps of Engineers Wetlands Delineation Manual*. In addition, wetlands were deemed jurisdictional waters of the United States if a direct hydrologic connection could be made to a Traditional Navigable Water, such as the Missouri River, in accordance with the U.S. Supreme Court ruling in *Solid Waste Agency of Northern Cook County versus U.S. Army Corps of Engineers*. Streams were identified as jurisdictional waters of the United States based on the presence of an ordinary high water mark (OHWM), bed and bank, and the presence of a surface water connection to Traditional Navigable Waters of the United States such as the Missouri River.

Because the Callaway Plant site was sited at the highest point in the local landscape, several small drainages radiate away from the plant to the north and south. As noted earlier, these small unnamed drainages are tributaries to several named streams around the site and vicinity including Auxvasse Creek, Mud Creek, and Logan Creek, all of which are tributaries to the Missouri River. Since the small unnamed drainages and named streams are connected to the traditionally navigable waters of the Missouri River, all said drainages and streams are considered jurisdictional waters of the U.S.

In general, four wetland types were delineated at the Callaway Plant site: isolated ponds, settling ponds, Logan Creek wetlands, and big river wetlands located within the Missouri River floodplain. Further information on the wetland types is presented in ER Section 2.4.2.

2.3.1.1.1 Hydrological Characteristics

Callaway Plant Unit 2 is located on a plateau which lies about 5 miles (8 km) north of the Missouri River. The plateau sits within the Auxvasse Creek watershed which is part of the Missouri River basin. Since the plateau is the topographic high in the area, surface runoff from the site vicinity drains into small intermittent streams. These drainages are tributaries of local streams that include Logan Creek to the east, Mud Creek to the southwest, Cow Creek to the north, and Auxvasse Creek to the west. Mud Creek and Cow Creek are tributaries to Logan and Auxvasse Creek, respectively. The approximate lengths and average gradients of these creeks are presented on Table 2.3-1. The Missouri River basin and the Auxvasse Creek sub-watersheds defined by the United States Geological Survey (USGS) are illustrated on Figure 2.3-4. The USGS 14-digit hydrologic unit code (HUC) boundary delineation of the Auxvasse Creek watershed includes the area drained by Logan Creek. However, the entire drainage basin of Logan Creek is not connected to Auxvasse Creek and it drains directly into the Missouri River downstream of the confluence of the Auxvasse Creek and Missouri River. Figure 2.3-5 illustrates the sub-watersheds of Auxvasse Creek.

Two stream gauges are located in Auxvasse Creek: Big Hollow near Fulton, Missouri (06927200) and Doane Branch near Kingdom City, Missouri (06927100). The drainage area of the Big Hollow station is approximately 4.05 sq mi (10.5 sq km), and the average annual flow from USGS daily mean data, recorded from a 16-year period, 1957-1972, is 3.0 (cfs) (0.08 cms). The Doane Branch station drains a smaller area of 0.54 sq mi (1.4 sq km). Only a few data points were recorded for a period of 24 years, 1955 to 1979.

The closest gauging stations that report flow estimates for the Missouri River are USGS stations at Boonville, Missouri (06909000) and Hermann, Missouri (06934500) which are upstream and downstream of the Callaway Plant site (Figure 2.3-6), respectively.

2.3.1.1.1.1 Auxvasse Creek

Auxvasse Creek flows toward the south until it converges with the Missouri River at river mile 120.6. At its closest point, it flows within 2.5 miles (4 km) west of the site. Auxvasse collects runoff from the western and northern portions of the plant site area, which totals approximately 317 sq mi (821 sq km) not including the Cow Creek tributary. Auxvasse Creek has a difference in elevation of about 350 ft (106 m) over its entire length (AmerenUE, 2003).

2.3.1.1.1.2 Cow Creek

Cow Creek, characteristically an intermittent stream, exhibits a milder slope than the streams that drain generally in a southerly direction in the vicinity of the site. It is located about 5 miles (8 km) north and northwest of the plant site and drains about 29.7 sq mi (77 sq km). Cow Creek flows generally in a westerly direction and is a major tributary of Auxvasse Creek (AmerenUE, 2003).

2.3.1.1.1.3 Mud Creek

Mud Creek collects surface drainage in the vicinity of the south and southwest portions of the plant site, which encompasses about 8.3 sq mi (21.5 sq km). Mud Creek, which is deeply incised within narrow valley walls, is an intermittent stream that begins approximately 1.5 miles (2.4 km) south of the plant site and flows about 5 miles (8 km) until its convergence with Logan Creek at approximately 2.5 miles (4 km) south of the site. Mud Creek descends approximately 350 ft (107 m) throughout its course including a one-half mile reach in which it drops more than 200 ft (61 m) (AmerenUE, 2003).

2.3.1.1.1.4 Logan Creek

Logan Creek, deeply incised in the plateau, drains the central and eastern segments of the plant site and flows within 2 miles (3.2 km) of the plant at its nearest point. Draining about 16.7 sq mi (43.3 sq km), Logan Creek flows generally in a southerly direction about 11 miles (18 km) and joins the Missouri River at river mile 114.7. The Logan Creek floodplain is from 500 ft to 1,000 ft (152 m to 304 m) wide, and the creek slopes from an elevation of approximately 570 ft (174 m) at a point approximately 4.5 miles (7.2 km) above its confluence to 525 ft (160 m) at its confluence with the Missouri River floodplain (AmerenUE, 2003).

2.3.1.1.1.5 The Missouri River

The Missouri River is one of the longest rivers in the United States. This river, forced into its present course by the face of the Continental glacier, is formed by the joining of the Gallatin, Madison, and Jefferson rivers, near Three Forks, Montana. It flows generally in a southeasterly direction for about 2,315 river miles (3,726 km) until its confluence with the Mississippi River about 15 miles (24 km) upstream from St. Louis, Missouri (USGS, 1998).

The Missouri River drains a 529,350 sq mi (1,371,010 sq km) basin covering mountainous regions in Montana with an elevation of about 4,050 ft (1,234 m) and plains that are only 380 ft (116m) above sea level (USGS, 1998).

The Gasconade River enters the Missouri River at about Missouri River mile 104.5 (AmerenUE, 2003). The total drainage area for the Gasconade River is approximately 3,500 sq mi (9,065 sq km). The Osage River is a major tributary that joins the Missouri River at about river mile 129.9 (209 km).

The Callaway Plant site is located about 5 miles (8 km) north of the Missouri River at river mile 115. The closest gauging stations that report flow estimates for the Missouri River are USGS stations at Boonville, Missouri (06909000) and Hermann, Missouri (06934500), which are upstream and downstream of the Callaway Plant site, respectively.

At the Hermann gauging station, located downstream approximately 17 river miles (27.4 km) at Missouri River mile 97.9 (158 km), continuous streamflow records have been collected since August 1928 by the USGS (USGS, 2008b). The drainage area of the Missouri River at Hermann is approximately 522,500 sq mi (1,353,223 sq km), and the average annual flow from USGS daily mean data recorded from a 79-year period, 1928-2007, is 78,886 cfs (2,234 cms). At the Hermann Station, the daily maximum that has been recorded is 750,000 cfs (21,240 cms) and the maximum recorded flood water level is 518.53 ft (158 m); both were recorded on July 31, 1993. The minimum recorded flow was 4,200 cfs (119 cms) recorded on January 10, 1940.

Peak annual streamflow for the Hermann station is presented in Table 2.3-2. Monthly streamflows and mean, maximum and minimum daily streamflows are presented in Table 2.3-3 through Table 2.3-6. Mean streamflow discharges are also presented on Figure 2.3-7 along with maximum and minimum monthly values. Daily average temperature for the Hermann station (from 2006 to 2007) is presented on Figure 2.3-8.

At the Boonville gauging station, about 82 river miles (132 km) upstream from the site, streamflow records have been kept since October 1925 (USGS, 2008a). The drainage area of the Missouri River at Boonville is approximately 500,700 sq mi (1,293,763 sq km), and the average annual flow from USGS daily mean data, recorded from a 81-year period, 1926-2007, is 62,483 cfs (1,769 cms). At the Boonville station, the daily maximum and minimum recorded flows were taken as 755,000 cfs (21,382 cms) and 1,800 cfs (51 cms) recorded on July 29, 1993, and January 10, 1940, respectively. The daily maximum recorded flood level was recorded on July 29, 1993, at 602.52 ft (184 m).

Peak annual streamflow for Boonville station is presented in Table 2.3-7. Monthly streamflows and mean, maximum and minimum daily streamflows are presented in Table 2.3-8 through Table 2.3-11. Mean streamflow discharges are also presented on Figure 2.3-9 along with maximum and minimum monthly average values. Daily average temperature for the Boonville station (from 2006 to 2007) is presented on Figure 2.3-10.

The bathymetry of the Missouri River near the existing Callaway Plant Unit 1 intake is illustrated on Figure 2.3-11. Average depths in the vicinity of the intake structure range from 2 ft to 16 ft (1 m to 5 m). The collector well system will draw water from the Missouri River/Missouri River alluvial aquifer from approximately 100 ft (30 m) below grade (Burns & McDonnell, 2008). As a result, the bathymetry of the Missouri River will not be affected by the collector well system. ER

Section 2.3.1.2.3.4 describes the impacts of low water due to a 100-yr drought on the performance of the collector wells.

The U.S. Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map for the Callaway Plant site area (FEMA, 2005) shows that Missouri River flooding during the 100-yr and 500-yr time periods extends up to Binggeli Island as shown on the FEMA Flood Insurance Rate Map, February 18, 2005. Map Number 29027C04750 and Map Number 29027C0500D. Map Number 29027C0350D and Map Number 29027C0375D illustrate the 100-yr and 500-yr flooding impacts on Auxvasse Creek, Logan Creek and Mud Creek. Callaway Plant Unit 2 is located at an approximate elevation of 845 ft (258 m) msl. Based on the FEMA flooding maps, the highest elevation during the 100-yr and 500-yr flood is 536 ft (163 m) msl observed in the Auxvasse Creek. Thus, the Callaway Plant site is still about 309 ft (94 m) higher; therefore, it is anticipated that Missouri River flooding will not affect the plant. Similarly, the plant site is not affected by major flooding on the Auxvasse Creek, Logan Creek or Mud Creek.

2.3.1.1.2 Dams and Reservoirs

The Missouri River is the largest sub-basin in the Mississippi River Basin, covering 529,350 sq mi (1,371,010 sq km) and part of 10 states and numerous Indian tribal reservations (USEPA, 2007).

Damming and channelization has occurred on most of the Missouri River basin. Since the 1930s, the Army Corps of Engineers has built six dams in the upper basin of the Missouri River, creating Fort Peck Lake (Fort Peck Dam), Lake Sakakawea (Garrison Dam), Lake Oahe (Oahe Dam), Lake Sharpe (Big Bend Dam), Lake Francis Case (Fort Randall Dam), and Lewis & Clark Lake (Gavins Point Dam). Gavins Point Dam is located about 734 miles (1,181 km) upstream of Callaway Plant Unit 2, with the other listed dams being farther upstream in South Dakota, North Dakota, and Montana (USGS, 1998). Figure 2.3-12 shows major reservoirs within the Missouri River Basin.

These dams, their respective reservoirs and the storage capacity of their reservoirs are as follows: Fort Peck Dam and Fort Peck Lake (18.7 million acre-feet of water (2.3E+10 cu m) near Glasgow, Montana; Garrison Dam and Lake Sakakawea (23.8 million acre-feet of water (2.9E+10 cu m)) near Bismark, North Dakota; Oahe Dam and Lake (23.1 million acre-feet of water (2.8E+10 cu m)) near Pierre, South Dakota; Big Bend Dam and Sharpe Lake (1.9 million acre-feet of water (2.4E+9 cu m)) near Fort Thompson, South Dakota; Fort Randall Dam and Lake Francis Case (nearly 5.4 million acre-feet of water (3.8E+9 cu m)) near Wagner, South Dakota; and Gavins Point Dam and Louis and Clark Lake (470,000 acre-feet of water (5.8E+8 cu m)) near Yankton, South Dakota (USACE, 2007). Figure 2.3-12 depicts the locations of the six main stem dams on the Upper Missouri River Basin.

The largest dams and reservoirs closest to Callaway Plant Unit 2 are located on the Osage River: Harry S Truman Dam and Bagnell Dam. Table 2.3-12 lists detailed information about these two dams.

The Osage Hydroelectric Power Plant, operated by AmerenUE, is located on the Osage River, approximately 35 miles (56 km) southwest of Jefferson City, Missouri, and approximately 82 miles (132 km) upstream of the confluence with the Missouri River. The Osage Plant is supplied by the reservoir known as the Lake of the Ozarks, which is created by Bagnell Dam. The Osage Plant and Lake of the Ozarks are operated primarily to generate electricity during peak demand periods, but also provide recreational opportunities and flood control.

Bagnell Dam is a concrete gravity structure located on the Osage River about 80 miles (129 km) above its confluence with the Missouri River (about 97 miles (156 km)) from the Callaway Plant site. At the maximum pool elevation of 660 ft (201 m), the reservoir formed by the dam covers an area of about 1,893,670 acre-ft (2.3E+9 cu m) (RIZZO, 2006). At full reservoir capacity, the lake extends to near the toe of the Harry S Truman Dam.

Harry S Truman Dam is an earth-fill structure located upstream from the Bagnell Dam. The reservoir, also known as the Truman Lake, is located near Warsaw, Missouri, on the Osage River. The Truman Dam and reservoir, completed in October 1979, covers 55,600 acres (22,500 hectares) at normal pool, but when the pool is at the top of flood control, the surface area increases to 209,300 acres (87,700 hectares). Truman Lake has an estimated storage capacity of more than 5 million acre-feet (6.2E+9 m^3). At full reservoir capacity, the water level at the dam will be about 125 ft (38 m) above the streambed (USACE, 2008).

In addition, there are several smaller dams/reservoirs within Callaway County. Thunderbird Lakes and Upper and Lower Canyon Lakes are within the 10-mile (16 km) radius of Callaway Plant Unit 2 and are closest to the site. Thunderbird Lakes are divided into lower and upper lakes, each with a lake area of 20 acres and 19 acres (8 hectares and 7.7 hectares), respectively. Canyon Lakes are also divided into lower and upper lakes, each with an area of 40 acres and 13 acres (16 hectares and 5.3 hectares), respectively. These dams were built in the late 1960s and early 1970s and are regulated by the Missouri Department of Natural Resources. Figure 2.3-13 shows the reservoirs within the Auxvasse Creek sub-watersheds.}

2.3.1.2 Groundwater Resources

{This section provides a description of the regional and local hydrogeology relevant to the Callaway Plant site. The site-specific data from the hydrogeological field investigation are presented and utilized to evaluate the existing groundwater conditions and to identify pathways of groundwater flow toward downgradient surface water bodies and surface water and groundwater users. Groundwater flow velocities and travel times are estimated for the existing conditions. The location of the site, including regional and local surface hydrologic features, is described in Section 2.3.1.1. Section 2.3.2.2 describes the regional and local groundwater aquifer resources (including on-site use) that potentially could be affected by the construction and operation of Callaway Plant Unit 2, planned groundwater monitoring and safeguards, and potential construction and post-construction operational changes to groundwater conditions.

2.3.1.2.1 Hydrogeologic Setting

Except as otherwise noted, the information presented in this section is summarized from the United States Geological Survey (USGS) Ground Water Atlas of the United States, Segment three (USGS, 1997), which contains Kansas, Missouri, and Nebraska. Across the three-state area, there are four physiographic provinces: the Great Plains, the Central Lowland, the Ozark Plateaus, and the Coastal Plain as shown on Figure 2.3-14. In general, the land surface across the three-state area slopes gradually from west to east. In the Great Plains Physiographic Province the altitude of the relatively flat land surface is about 5,000 feet (1524 m) above mean sea level (msl) in westernmost Nebraska. By contrast, in the flat Coastal Plain Physiographic Province of eastern Missouri, the altitude is about 500 ft (152 m) msl. The land surface is gently rolling in the Central Lowland Province except where major rivers and their tributaries are deeply incised. In the Ozark Plateaus Physiographic Province, rugged topography has developed where the underlying rocks have been uplifted and deeply eroded.

According to the Figure 2.3-14, the Callaway Plant site is located in the Ozark Plateaus Physiographic Province; however, this is due to its sharing of deeper bedrock units with areas in southern Missouri. In the shallower geologic sections, the Callaway Plant site is associated with the glaciated areas of northern Missouri, which extend approximately to the Missouri River as shown on Figure 2.3-15. Glacial and subsequent alluvial erosion and deposition have left both coarse-grained and fine-grained surficial deposits across northern Missouri, which is categorized by the Missouri Department of Natural Resources (MDNR) as the Dissected Till Plains sub-province of the Central Lowland Province (MDNR, 1997).

The regional extent of glaciation determined the present-day drainage patterns across the three-state region. The major rivers that drain the three states are the Niobrara, Platte, Kansas, Arkansas, and Missouri. The Mississippi River flows along the eastern boundary of the area. These rivers supply water for many uses, but groundwater is the source of slightly more than one-half of the total water withdrawn for all uses within the three-state area (USGS, 1997). The aquifers consist of consolidated sedimentary rocks and unconsolidated deposits that range in age from the Cambrian through Quaternary periods.

Figure 2.3-16 shows the vertical sequence of aquifer systems across the three-state region. The surficial aquifer system consists of stream valley aquifers along major drainages as well as glacial drift aquifers in northern Missouri, eastern Nebraska, and northeastern Kansas. These aquifers are composed primarily of unconsolidated sand and gravel.

The High Plains aquifer consists of the Ogallala Formation in Nebraska and western Kansas and Quarternary beds in south-central Kansas. The aquifer underlies and is hydraulically connected to parts of the surficial aquifer system in Kansas and Nebraska. Beneath the High Plains aquifer is the Great Plains aquifer system.

The Mississippi embayment aquifer system directly underlies the surficial aquifer system in southeastern Missouri.

In southern Missouri, the Ozark Plateaus aquifer system is a large fresh-water system. Equivalent rocks of the Western Interior Plains aquifer system, however, contain little to no fresh-water due to high mineralization of slowly moving groundwater. The Mississippian aquifer of northern Missouri is equivalent to rocks in the upper part of the Ozark Plateaus aquifer system; however, it has little or no hydraulic connection to the Ozark system. Beneath the Mississippian aquifer in northern Missouri, the Cambrian-Ordovician aquifer is equivalent to rocks in the middle part of the Ozark Plateaus aquifer system, and these systems may be, at least in part, hydraulically connected.

Figure 2.3-17 shows a generalized aquifer section trending west (northwest) to east (southeast) across Missouri. The Ozark Plateaus aquifer system in southern Missouri (primary aquifer is the Ozark aquifer) transitions to equivalent sections in the Western Interior Plains aquifer system in Western Missouri, Kansas, and Nebraska and to equivalent sections in the Mississippian and Cambrian-Ordovician aquifers of northern Missouri. Figure 2.3-18 shows these relationships conceptually by geologic age. A key difference between the sections in northern and southern Missouri is the relatively thick confining unit and thinner Cambrian-Ordovician aquifer in northern Missouri in contrast to the relatively thin confining unit and thick Ozark aquifer in southern Missouri. Beneath these aquifers is the pre-Cambrian crystalline bedrock that serves as a basement confining unit.}

2.3.1.2.2 Regional Hydrogeologic Description

{Important aquifer systems of interest to the Missouri region are the surficial aquifer system, the Ozark Plateau aquifer system in southern Missouri, and the Mississippian and Cambrian-Ordovician aquifers in northern Missouri. Beneath the surficial aquifer system, the usability of the bedrock aquifers is defined by the freshwater-saline water transition zone as shown on Figure 2.3-19. North of this demarcation, groundwater is too highly mineralized for potable use.

2.3.1.2.2.1 Surficial Aquifer System (Missouri)

The surficial aquifer system consists of stream-valley aquifers and glacial-drift aquifers. These aquifers are hydraulically connected in some places. For example, many of the glacial-drift aquifers in northern Missouri, northeastern Kansas, and eastern Nebraska occupy ancient stream channels that have been eroded into bedrock. At locations where modern streams follow the ancient drainage patterns, the alluvial deposits of sand and gravel may lie directly on glacial outwash that also consists of sand and gravel; therefore, they may be difficult to distinguish. Most of the water in the surficial aquifer system is under unconfined conditions.

2.3.1.2.2.1.1 Stream-Valley Aquifers

The stream-valley aquifers consist of narrow bands of fluvial and alluvial sediments, which fill or partly fill the valleys of meandering to braided streams that have eroded shallow channels into glacial deposits, older unconsolidated alluvium, or bedrock. Locally, the stream-valley aquifers may be hydraulically connected to bedrock aquifers, but, in most places, they are separated from the bedrock aquifers by low permeability beds of clay or shale.

The stream-valley aquifers consist mostly of sand and gravel of Holocene age but locally include sediments of Pleistocene age. The average thickness of the aquifers is about 90 ft to 100 ft (27 m to 31 m), but locally they are as much as 160 ft (49 m) thick. The average thickness of saturated alluvial material generally ranges from 50 ft to 80 ft (15 m to 24 m).

Most of the water in the stream-valley aquifers is under unconfined conditions. Locally, where coarse-grained aquifer sediments are capped by poorly permeable silt or clay, confined (artesian) conditions exist. The stream-valley aquifers are in direct hydraulic connection with adjacent streams, and water levels in the aquifers are closely related to river levels. Aquifer and river water levels rise following precipitation events.

Recharge to a typical stream-valley aquifer is by precipitation that falls directly onto the aquifer, seepage through the beds of streams and of reservoirs and canals constructed in the stream valleys, downward percolation of applied irrigation water, and groundwater inflow from underlying, permeable bedrock. The aquifer discharges by leakage to streams and canals, pumping from wells, and evapotranspiration. A small amount of water is consumed by crops and vegetation.

The stream-valley aquifers are reliable sources of groundwater because of the coarse-grained nature and high permeability of the aquifer material. Yields that range from 100 gpm to 1,000 gpm (380 lpm to 3800 lpm) commonly are reported for wells completed in these aquifers; maximum yields of more than 2,500 gpm (9500 lpm) are reported locally in Missouri. Reported transmissivity values for these aquifers, as calculated from aquifer tests, range from 8,000 sq ft per day to 80,000 sq ft per day) (740 sq m per day to 7400 sq m per day).

The chemical quality of the water in the stream-valley aquifers generally is suitable for most uses. Typically, the water is hard and a calcium bicarbonate type. Dissolved-solids concentrations generally are less than 500 parts per million (ppm) but locally are as much as 7,000 ppm; the larger concentrations reflect an influx of water with large chloride or sulfate concentrations from underlying aquifers (north of the freshwater-saline transition zone) or from irrigation return flow. Large iron concentrations are common.

The unconsolidated sand and gravel deposits that compose the stream-valley aquifers are thicker, more widespread, and more productive in the valleys of the larger rivers than those of smaller streams. In Missouri, the stream-valley aquifers along the Missouri and the Mississippi Rivers and their tributaries are important sources of freshwater for many communities and industries.

2.3.1.2.2.1.2 Missouri River Valley Alluvial Aquifer

Alluvial deposits along the Missouri River form an important stream-valley aquifer from the Iowa-Missouri State line to the junction of the Missouri and the Mississippi Rivers. The deposits partly fill an entrenched bedrock valley that ranges from about 2 miles to 10 miles (3 km to 16 km) wide. In many places in northern Missouri, the bedrock contains slightly saline to saline water, and the stream-valley aquifers, along with aquifers in glacial drift, are the only sources of fresh groundwater.

The Missouri River stream-valley aquifer along the Missouri River between Jefferson City and St. Charles, Missouri, is shown on Figure 2.3-20. This portion of the stream-valley aquifer consists of clay, silt, sand, and gravel. Gravel and sand generally are most common in the lower parts of the aquifer. Poorly permeable silt and clay are prominent in the upper part of the aquifer and locally create confined conditions. From the Boone County line eastward, the bedrock consists of Ordovician limestone and dolomite. In upland areas north of the Missouri River, glacial deposits overlie the bedrock.

The alluvial material of the Missouri River stream-valley aquifer averages about 90 ft (27 m) in thickness but is locally as much as 160 ft (49 m) thick. The saturated thickness of the aquifer averages about 80 ft (24 m). Reported yields of wells completed in the aquifer range from less than 100 gpm to about 3,000 gpm (380 lpm to 11,400 lpm).

Recharge to the stream-valley aquifer is by infiltration of precipitation, seepage of water from the Missouri River to the aquifer during periods of high streamflow, and inflow from bedrock aquifers. Discharge from the aquifer is by evapotranspiration, withdrawals by wells, and seepage to the Missouri River during periods of low streamflow. The general direction of water movement in the stream-valley aquifer is downstream and toward the river as shown on Figure 2.3-20.

During 1990, an average of about 147 million gallons of water per day (MGD) (559 million liters per day (MLD)) was withdrawn from the Missouri River stream-valley aquifer. About 45% of this amount, or about 66 MGD (251 MLD), was used for public supply. Industrial, mining, and thermoelectric power withdrawals amounted to about 48 MGD (181 MLD), and agricultural withdrawals were about 24 MGD (91 MLD). The remainder of the water withdrawn (about 9 MGD (34 MLD)) was used for domestic and commercial purposes.

2.3.1.2.2.1.3 Glacial Drift Aquifers

The maximum southern extent of glacial ice and glacial-drift deposition was approximately the present location of the Missouri River in Missouri. Although deposits of glacial drift extend over wide areas, most were laid down directly by the ice; are fine grained, poorly sorted, or both; and, therefore, yield only small amounts of water to wells. Melt-water created an extensive stream network in front of the advancing ice, and the streams deposited gravel, sand, and finer sediments as alluvium along the courses of pre-glacial bedrock valleys.

Complex inter-bedding of fine- and coarse-grained material is characteristic of the glacial deposits. The lens-like shape of some of the beds is the result of meandering of the melt-water streams across their valley floors and of periodic changes in stream-channel locations.

However, in parts of Missouri, the glacial-drift aquifers are not complexly inter-bedded. For example, in Daviess County, Missouri, the basal part of the deposits that fill glacial stream channels is coarse grained, and the upper part generally consists of poorly permeable silt, clay, or till. Such aquifers are called buried channel or buried valley aquifers and contain water under confined or semi-confined conditions. The thickness of glacial deposits ranges from 0 ft to 50 ft (0 m to 15 m) near the Missouri River where erosion has removed the original deposits to as much as 400 ft (122 m) in northernmost areas of Missouri.

Groundwater flow directions reflect topography. Movement of water in the glacial-drift aquifers is from recharge areas to discharge areas along the streams. Some groundwater follows longer flow paths and discharges to larger streams. A small amount of the water percolates downward and enters underlying bedrock aquifers.

Yields of wells completed in the glacial-drift aquifers are highly variable and range from less than 10 gpm to about 1,000 gpm (38 lpm to 3800 lpm). Groundwater generally is obtained from sand beds that range from 20 ft to 40 ft (6 m to 12 m) in thickness. Large diameter wells that penetrate several thick, saturated, highly permeable sand beds yield the most water. Highly variable transmissivity values that range from 200 sq ft per day to 13,000 sq ft per day (19 sq m per day to 1200 sq m per day) have been reported from aquifer tests in glacial-drift aquifers in Kansas.

The chemical quality of the water in the glacial-drift aquifers generally is suitable for most uses. The water is hard and commonly is a calcium bicarbonate type although in many places in Missouri and locally in Kansas, it is a sodium sulfate type. Dissolved-solids concentrations in water from these aquifers usually are less than 500 ppm but exceed 4000 ppm in places (north of freshwater-saline transition zone). Locally, concentrations of as much as 30 ppm of iron have been reported in Missouri.

2.3.1.2.2.2 Ozark Plateaus Aquifer System (Southern Missouri)

The Ozark Plateaus aquifer system underlies most of southern Missouri and a small part of extreme southeastern Kansas, a large area in northwestern Arkansas, and a small part of northeastern Oklahoma. The water-yielding rocks in the Ozark Plateaus system are mostly comprised of limestone and dolomite, but some sandstone units are productive. Confining units within the aquifer system are typically shale or dolomite. The lithology of the individual aquifers and confining units and their hydraulic characteristics are consistent over large areas.

Groundwater in the aquifer system locally moves from topographically high recharge areas toward streams. Regional movement is northwestward, eastward, and southward from the St. Francois Mountains and other topographically high areas in southern Missouri. The water moves upward at the transition zone between the Ozark Plateaus and the Western Interior Plains aquifer systems and discharges either to streams as base flow or to shallow stream valley alluvial aquifers. Water that moves northward in the lower part of the Ozark aquifer discharges mostly to the Missouri River.

The aquifers in the Ozark Plateaus aquifer system from shallowest to deepest are the Springfield Plateau aquifer, the Ozark aquifer, and the St. Francois aquifer. Confining units in the system are named the same as the aquifers they overlie.

2.3.1.2.2.2.1 Springfield Plateau Aquifer

The Springfield Plateau aquifer is the uppermost aquifer of the Ozark Plateaus aquifer system and consists almost entirely of limestone of Mississippian-age. The thickest and most productive water-yielding geologic formations are the Keokuk and Burlington Limestone

Formations. North of the Missouri River, the Keokuk and Burlington also yield water but are considered to be a separate aquifer, the Mississippian aquifer. The thickness of the Springfield Plateau aquifer ranges from less than 200 ft to more than 400 ft (less than 60 m to more than 120 m) and averages about 200 ft (60 m). Locally, the aquifer may be discontinuous or absent.

Most of the water in the Springfield Plateau aquifer occurs in and moves through secondary openings, such as fractures and bedding planes. The slightly acidic ground water that moves through these openings has dissolved part of the limestone and has resulted in a network of solution channels. This dissolution activity is reflected at the land surface by springs, caves, and sinkholes, and by sparse surface drainage. These features are characteristic of a type of topography called karst topography, which commonly is developed in areas underlain by limestone.

Recharge to the Springfield Plateau aquifer is mostly from precipitation onto outcrop areas of the aquifer. After the recharge water percolates downward to the water table, most of it moves laterally along short flow paths to discharge as base flow to nearby streams. Some of the water follows flow paths of intermediate length and discharges to large streams, and a small part of the recharge moves laterally into deep, confined parts of the aquifer.

The chemical quality of water in the Springfield Plateau aquifer generally is suitable for most uses where the aquifer is unconfined or where the confining unit that overlies the aquifer is thin. The water commonly is a calcium bicarbonate type and is moderately hard. Dissolved-solids concentrations generally are less than 1,000 ppm but are higher where the aquifer is confined. Concentrations of sulfate generally are low except in the lead-zinc mining district of southwestern Missouri, southwestern Kansas, and northeastern Oklahoma where concentrations of more than 500 ppm are reported near some mining areas. These large concentrations result from oxidation and leaching of the sulfide minerals that contain the lead and zinc.

Most of the water withdrawn from the Springfield Plateau aquifer is used for domestic and stock-watering supplies. Yields of wells completed in the aquifer generally are less than 20 gpm (76 lpm).

2.3.1.2.2.2.2 Ozark Confining Unit

The Ozark confining unit underlies the Springfield Plateau aquifer and hydraulically separates this aquifer from the deeper Ozark aquifer. The Ozark confining unit consists mostly of shale but locally includes limestone of minimal permeability. The confining unit generally is less than 100 ft (30 m) thick except in small areas. Where the shale content of the confining unit is greater, the confining unit can more effectively retard the vertical movement of water between the Springfield Plateau and the Ozark aquifers. North of the Missouri River, rocks equivalent to the Ozark confining unit separate the Mississippian and the Cambrian-Ordovician aquifers.

2.3.1.2.2.2.3 Ozark Aquifer

The Ozark aquifer is the primary source of water in the Ozark Plateaus Physiographic Province, is the middle aquifer of the Ozark Plateaus aquifer system, and consists of numerous geologic formations that range in age from Devonian to Cambrian (Figure 2.3-18). T he rocks of the aquifer are mostly dolomite and limestone, but there are also some beds of sandstone, chert, and shale. The aquifer provides water for municipal, industrial, and domestic supplies. The main water-yielding formations in the Ozark aquifer are the Potosi Dolomite, Gasconade Dolomite, and the Roubidoux Formation. The Potosi Dolomite is the most permeable of these three formations.

The Ozark aquifer is less than 1,000 ft (300 m) thick across most of southern Missouri but thickens to more than 3,000 ft (900 m) in southeastern Missouri just north and east of the bootheel. The Ozark aquifer pinches out against the flanks of the St. Francois Mountains, and its thickness is irregular where it has been eroded in outcrop areas.

Caves, sinkholes, and other types of solution features characteristic of karst topography have developed in the carbonate-rock units, primarily where they are exposed at the land surface or are covered by a thin layer of soil. Springs are common in the Ozark and Springfield Plateau aquifers. Missouri has eight first-order springs (greater than 100 cfs (3 cms); all of which issue from the Ozark aquifer.

Groundwater is generally unconfined in the Ozark aquifer. Where the water is unconfined, water levels in the aquifer respond rapidly to changes in precipitation due to solution openings in the carbonate rocks that allow large volumes of water to enter the aquifer quickly. Recharge is mostly from precipitation at aquifer outcrop areas. Small volumes of water recharge the aquifer by downward leakage from the shallower Springfield Plateau aquifer. Groundwater flow moves from topographically high recharge areas to discharge at nearby streams.

In most places, water in the Ozark aquifer is not highly mineralized, and the chemical quality of the water is suitable for most uses. Dissolved-solids concentrations are less than 1,000 ppm except in the westernmost parts of the aquifer and locally near the Mississippi River. Groundwater generally is a calcium bicarbonate type but locally may be a sodium bicarbonate type.

Total fresh groundwater withdrawals from the Ozark Plateaus aquifer system during 1990 were 330 MGD (1254 MLD), 8 MGD (30 MLD) of which was withdrawn in Kansas. About 139 MGD (528 MLD) was withdrawn for agricultural purposes, about 88 MGD (334 MLD) was used for public supply, and about 53 MGD (201 MLD) was withdrawn for industrial, mining, and thermoelectric power uses. Withdrawals for domestic and commercial supplies were about 50 MGD (190 MLD).

2.3.1.2.2.2.4 St. Francois Confining Unit

The St. Francois confining unit underlies the Ozark aquifer and separates it from the underlying St. Francois aquifer. The confining unit consists primarily of dolomite of minimal permeability but includes limestone, shale, and siltstone. Where the confining unit contains more shale and siltstone, it more effectively retards the movement of groundwater between the two aquifers. The Davis Formation and the Derby-Doe Run Dolomite are the geologic formations that compose the St. Francois confining unit. The thickness in the eastern two-thirds of the confining unit generally is greater than 200 ft (61 m); in the western third, it is about 100 ft (30 m) thick. However, the thickness of the unit is variable.

2.3.1.2.2.2.5 St. Francois Aquifer

The St. Francois aquifer is the lowermost aquifer in the Ozark Plateaus aquifer system and is exposed at the land surface only in the St. Francois Mountains. Away from the mountains, the top of the aquifer slopes into the subsurface in all directions and becomes buried beneath the more productive Ozark aquifer. The St. Francois aquifer is accordingly used as a source of supply only in and near the St. Francois Mountains.

The St. Francois aquifer consists of the Bonneterre Dolomite and the Lamotte Sandstone and its lateral equivalent, the Reagan Sandstone, all of which are of Cambrian-age. The Lamotte Sandstone is the most productive and yields as high as 500 gpm (1,900 lpm) have been reported. Yields of wells completed in the Bonneterre Dolomite are reported to range between 10 gpm and 50 gpm (38 lpm to 190 lpm). The water-yielding capability of the Reagan

Sandstone is not well known. The Lamotte Sandstone and the Bonneterre Dolomite occur north of the Missouri River, but their water-yielding properties are not known; accordingly, no aquifer equivalent to the St. Francois aquifer is mapped there.

The thickness of the St. Francois aquifer is generally between 300 ft and 500 ft (90 m to 150 m) in south-central Missouri west of the St. Francois Mountains. The thickness of the aquifer is greater than 700 ft (213 m) in several places to the north, east, and southeast of the mountains. The aquifer thins near its western and southern limits. Water is withdrawn from the St. Francois aquifer only where the aquifer crops out or is buried to shallow depths. Sparse water-level data indicate that flow in the aquifer in and near outcrop areas primarily is controlled by topography. Water enters the aquifer as recharge from precipitation that falls on topographically high outcrop areas. Most of the water moves along short flow paths and discharges as base flow to nearby streams. A small volume of water moves along slightly longer flow paths into confined parts of the aquifer and discharges to shallower aquifers by upward leakage.

The chemical quality of the water in the St. Francois aquifer in and near the aquifer outcrop areas generally is suitable for most uses. The water is a calcium magnesium bicarbonate type with dissolved-solids concentrations reported to range between 200 and 450 ppm. Chloride concentrations in the water generally are less than 60 ppm, and sulfate concentrations are 150 ppm or less. Freshwater has been reported from the St. Francois aquifer as far west as Jasper and Pettis Counties, Missouri, which indicates a regional ground-water flow system in the aquifer.

2.3.1.2.2.3 Mississippian and Cambrian-Ordovician Aquifers (Northern Missouri)

From the three-state regional perspective, the aquifers of northern Missouri are generally described as equivalent, less significant aquifers to those in southern Missouri and therefore much less detail is reported in the USGS Ground Water Atlas. The information presented below has been supplemented by “The Ground-Water Flow System in Northern Missouri with Emphasis on the Cambrian-Ordovician Aquifer” (USGS, 1985) and “Groundwater Resources of Missouri” (MDNR, 1997). The Missouri Department of Natural Resources has divided the state into seven groundwater provinces and two sub-provinces. Information here is cited for the Northeast province (MDNR, 1997).

2.3.1.2.2.3.1 Mississippian Aquifer

The Mississippian aquifer in northern Missouri is stratigraphically equivalent though hydraulically unconnected to the Springfield Plateau aquifer in southern Missouri. The Keokuk, Burlington, Fern Glen, Sedalia, and Chouteau Limestones compose the aquifer; of these formations, the Keokuk and the Burlington are the principal water-yielding rocks and are generally considered to be one unit. Both formations consist of crystalline limestone and yield water primarily from solution cavities. In most places, typically to the north, the aquifer is overlain by a confining unit of Pennsylvanian shale and sandstone and is everywhere underlain by a confining unit of Mississippian shale.

The thickness of the Mississippian aquifer averages about 200 ft (60 m) but locally exceeds 400 ft (121 m) in northwestern Missouri. The aquifer is thickest as it extends northward into Iowa and is thinnest near the Mississippi and the Missouri Rivers where it has been dissected or removed by erosion.

The Mississippian aquifer receives recharge by vertical leakage from the overlying glacial drift aquifers. Most of the water in the Mississippian aquifer moves along flow paths toward small and large streams, into which it discharges as base flow. Groundwater flow patterns largely reflect the topography of the area. Groundwater yields are realistically 5 gpm to 15 gpm (19 lpm to 57 lpm).

The chemical quality of the water in the Mississippian aquifer varies considerably. The aquifer contains freshwater only in the eastern one-third of Missouri. Elsewhere, it contains slightly saline to very saline water. Dissolved-solids concentrations of water from the aquifer generally are greatest where the aquifer is overlain by a thick confining unit and least where it is unconfined or overlain by a thin or leaky confining unit. In southern Carroll and Chariton Counties and western Howard County, the aquifer contains water with dissolved-solids concentrations of greater than 10,000 ppm.

2.3.1.2.2.3.2 Upper Confining Unit

The Upper Confining Unit in northern Missouri is stratigraphically equivalent, much thicker than and hydraulically unconnected to the Ozark Confining Unit in southern Missouri. The Upper Confining Unit is not a single unit, but a sequence of shale and limestone formations from the Lower Mississippian to the Upper Ordovician periods. Across northern Missouri, the nomenclature and thicknesses of the formations vary, but in Callaway County, the significant formations are the Snyder Creek Formation (shale unit), Callaway Limestone, and Cotter-Jefferson City (CJC) Formation. Where these formations have thick, buried sections, they function overall as a leaky, confining aquitard that separates the overlying and underlying aquifers.

2.3.1.2.2.3.3 Cambrian-Ordovician Aquifer System (Northern Missouri)

North of the Missouri River, formations that are equivalent to the Ozark aquifer are called the Cambrian-Ordovician aquifer. Like the Ozark aquifer, the Cambrian-Ordovician aquifer consists mostly of dolomite and limestone; however, it also includes beds of sandstone and shale. Vertically, the aquifer is not continuous as it contains both permeable and semi-permeable rock units, which function as alternating intervals of aquifers and aquitards. The Potosi and Eminence Dolomites are the main water-yielding formations, but the Roubidoux Formation and Lower Gasconade Dolomite are also important due to the presence of permeable sandstone bodies. Most wells completed in the Cambrian-Ordovician aquifer are open to more than one water-yielding unit.

The thickness of the Cambrian-Ordovician aquifer averages about 1,200 ft (365 m) but is as great as 1,800 ft (550 m) in St. Charles County. Groundwater conditions are mostly confined. Groundwater is fresh across a small area in east-central Missouri but is slightly-to-moderately saline in northern and northwestern Missouri where the aquifer is more deeply buried by confining units. Groundwater divides prevent the regional saline water to the west from entering the freshwater area. Recharge to the aquifer is from precipitation at aquifer outcrop areas and to some extent from downward leakage of water from the overlying aquifers through the Upper Confining Unit. Groundwater flow directions generally reflect topography. Groundwater flows toward local streams as well as regionally toward the Missouri and Mississippi Rivers where discharge provides base-flow.

Well yields from the major units range from approximately 50 gpm to 500 gpm (190 lpm to 1900 lpm) and are used for municipal and industrial supply. Smaller yields from minor, less permeable units range from 10 gpm to 25 gpm (38 lpm to 95 lpm) are used for domestic and farm wells. Estimated values of transmissivity range from 250 sq ft per day to 1500 sq ft per day (23 sq m per day to 140 sq m per day).

Groundwater in the freshwater areas has total dissolved solids that range from 350 to 750 ppm. Groundwater to the north and west regional-flow system is saline with total dissolved solids greater than 10,000 ppm.

2.3.1.2.3 Local and Callaway Site-Specific Hydrogeology

2.3.1.2.3.1 Local Hydrogeology And Conceptual Flow Model

2.3.1.2.3.1.1 Callaway Plant Unit 1 Investigation

The field investigation for Callaway Plant Unit 2 was based on the local hydrogeological description and conceptual model developed for the Callaway Plant Unit 1 Final Safety Analysis Report (FSAR) (AmerenUE, 2003). The Callaway Plant site is located five miles (8 km) north of the Missouri River in Callaway County. The site sits on a plateau at an approximate elevation of 840 ft to 850 ft (256 m to 259 m) msl as shown on the USGS background of Figure 2.3-22. The plateau serves as the headwater area for four sub-watersheds shown to extend from the 820 ft (250 m) msl contour line toward the drainage boundaries. Unnamed tributaries drain away from the plateau toward Logan Creek, Mud Creek, Cow Creek, and Auxvasse Creek, all of which ultimately drain to the Missouri River. No one drainage pattern accurately describes the creek watersheds. Surface water moves radially from the topographic high toward the heads of tributaries that ring the plateau. The tributaries that ultimately drain to Mud Creek roughly follow a parallel drainage pattern; those to Logan Creek a trellis drainage pattern, and those to Auxvasse Creek a dendritic drainage pattern. The elevation of the Missouri River in the vicinity of the site is approximately 525 ft (160 m) msl, which indicates that the topographic relief of the area is approximately 315 ft to 325 ft (96 m to 99 m).

Figure 2.3-21 shows a section of the important hydrogeologic units and their associated formations beneath the site either identified during site investigation or expected based on the regional hydrogeology. The relevant aquifers from the regional discussion of Northern Missouri are the surficial aquifer system, the Mississippian aquifer, and the Cambrian-Ordovician aquifer. From the plateau surface to approximately 2000 ft (610 m) below ground surface (bgs), the geologic formations can be combined into three overall hydrostratigraphic units that generally are consistent with the regional scale. There is a shallow aquifer (Mississippian or stratigraphically equivalent to the Mississippian) that extends to approximately 80 ft (24 m) bgs, underlain by a leaky, confining aquitard (Upper Confining Unit) that is approximately 250 ft (76 m) thick, which in turn is underlain by a Cambrian-Ordovician confined aquifer system that is approximately 1500 ft (457 m) thick atop the Pre-Cambrian bedrock.

In the Callaway Plant Unit 1 FSAR, the shallow aquifer was described as an unconfined aquifer that consists of surface quaternary deposits such as loess, clay, and clayey glacial till underlain by the Graydon Chert conglomerate (either Pennsylvanian or Mississippian in age), and the Mississippian Burlington Limestone and Bushberg Sandstone. These units extend to approximately 80 ft (24 m) bgs, although the Bushberg Sandstone is relatively thin (0 ft to 8 ft (0 m to 2.4 m) thick across the area of study) and discontinuous. Due to the low permeability of these units, well yield was estimated as less than 1 gpm (3.8 lpm).

Recharge enters the aquifer through local precipitation. The Callaway Plant Unit 1 FSAR described the Bushberg Sandstone as a drainage conduit at the base of the shallow aquifer due to its higher hydraulic conductivity. In stream valleys, the Bushberg Sandstone may be exposed with water seeping from it into creek beds. At lower elevations, outside of the facility boundary, these units may not be present nor are they necessarily present along the major streams where they have been eroded and replaced by modern day alluvial deposits.

In the area of the Callaway Plant site, the aquitard (Upper Confining Unit) consists of the Snyder Creek Formation underlain by the Callaway Limestone, the St. Peter Sandstone, and the upper portion of the CJC Dolomite. These units extend to approximately 350 ft (107 m) bgs. Within the Callaway and upper CJC Formations, both saturated and unsaturated zones were identified. It was reported that overall the aquitard has slow vertical leakage to the saturated zones and that horizontal flow is not occurring.

The deeper, confined artesian Cambrian-Ordovician aquifer system consists of many hydrogeologic units with highly varying yields beginning with the middle to lower portion of the CJC Formation and extending approximately 1500 ft (457 m) downward to Pre-Cambrian bedrock. The Callaway Plant Unit 1 investigation penetrated the CJC but presented information about the deeper units from the regional literature. The units consist of the Middle to Lower CJC Dolomite (referred to here as the CJC aquifer), Roubidoux Sandstone, Gasconade Dolomite and Gunter Sandstone, Eminence Dolomite, Derby-Doe Run, Davis and Bonneterre Dolomites, and Lamotte Sandstone. The CJC aquifer is considered to be a minor aquifer with well yields less than 10 gpm (37.9 lpm) and is expected to crop out along stream valleys and discharge water into the alluvial material along the Missouri River. Along the smaller creeks, this formation is exposed along the streambeds.

2.3.1.2.3.1.2 Callaway Plant Unit 2 Investigation

The Callaway Plant Unit 2 field investigation was developed to support the following objectives:

- Provide an understanding of the hydrogeological characteristics of the shallow aquifer. Due to the Callaway Plant Unit 1 construction, surface materials have been removed, stormwater drainage has been constructed, and areas have been covered and paved. Additionally, an excavation pond is located between Callaway Plant Unit 1 and Callaway Plant Unit 2, and stormwater runoff ponds for Callaway Plant Unit 1 construction remain on the plateau downgradient of both the Callaway Plant Unit 1 and Callaway Plant Unit 2 facility operation areas.

- Provide an understanding of the hydrogeological characteristics of the intermediate aquitard. The Callaway Plant Unit 1 investigation found that the aquitard yielded little to no water over significant depth; however, it is important to investigate the potential interaction of the shallow and deeper aquifers and the extent of vertical versus horizontal migration of groundwater through the aquitard.

- Provide an understanding of the hydrogeological characteristics of the deeper confined aquifer, specifically the portion of the CJC aquifer that potentially discharges to local streams. On the plateau, the CJC aquifer is expected to be present approximately 350 ft to 400 ft (107 m to 122 m) bgs, whereas along the study area boundary this aquifer is expected to be present at a similar elevation but nearer to the ground surface beneath modern alluvial deposits.

- Provide an understanding of the hydrogeological characteristics of the Missouri River alluvial aquifer, because make-up water is supplied by a groundwater collector well system constructed on the Missouri River floodplain.

The data collected during the investigation were utilized to:

- Evaluate the seasonal precipitation changes on groundwater elevations across the study area;

- Evaluate the extent that shallow groundwater on the plateau is traveling radially toward downgradient streams versus leaking through the aquitard to the deeper aquifer;
- Evaluate the connection between groundwater and surface water;
- Evaluate the possible groundwater conditions for the construction and post-construction groundwater periods for Callaway Plant Unit 2;
- Evaluate potential pathways for liquid releases and provide a basis for evaluating the transport of hypothetical release scenarios; and
- Evaluate the seasonal and long-term drawdown of the horizontal well intake in the alluvial aquifer and its potential impact to other surface water and groundwater users.

The study area extends across nearly 50 sq mi (130 sq km) from the facility plateau to surface water boundaries as shown by the dashed line on Figure 2.3-22. Field locations for the hydrogeological investigation are shown on this figure and Figure 2.3-23 shows more detail on the plateau. The field work activities were as follows:

- Utilized site reconnaissance to identify formation outcrops and potential seeps along the stream drainages that originate from the plateau and lead toward the major streams.
- Utilized coring, geophysics, and packer tests in one 400-ft (122-m) deep borehole on the plateau to investigate the fracture and water-bearing characteristics and associated depths of the consolidated rocks to the Cambrian-Ordovician CJC aquifer. The purpose was also to verify the conceptual model developed for Callaway Plant Unit 1 and allow the field personnel to identify the rock and aquifer characteristics prior to proceeding with drilling at additional locations.
- Results from drilling and testing at the first borehole indicated that the shallow aquifer was located approximately 30 ft (9 m) bgs yet exhibited confined, artesian conditions; an intermediate interval in the aquitard may yield some water, and the CJC aquifer was approximately 350 ft (107 m) bgs and exhibited confined, artesian conditions. The field personnel noted dry, moist, and wet at intervals along the entire section.
- Installed 25 monitoring wells in the shallow and deep aquifers, 1 well in the aquitard, and 10 monitoring wells in the alluvial aquifer along the Missouri River floodplain.
- Installed/surveyed 28 staff gauges or permanent structures at streams, ponds, and lakes.
- Measured seasonal water levels, water quality, and surface water flow velocities.
- Monitored water levels continuously for 1 month at select shallow wells on the plateau.
- Performed slug and pumping tests.
- Analyzed soil samples for physical characteristics and adsorption properties (results of adsorption properties are presented in FSAR Section 2.4.13).

Preliminary assessment of the field data allowed for the development of an alternate conceptual model of groundwater recharge, flow, and subsequent discharge to downgradient surface water (refer to Figure 2.3-21). The primary change to the Callaway Plant Unit 1 conceptual model is that the shallow aquifer is under confined conditions within the chert to a depth of approximately 70 ft (21.3 m) bgs. During the Callaway Plant Unit 2 field investigation, field personnel identified the chert as a moderate water-bearing unit with the glacial till acting as the confining unit above the chert and the Burlington Limestone acting as the confining unit and top of the aquitard beneath the chert. It is believed that the site investigation wells during the Callaway Plant Unit 1 investigation were screened across multiple units and thus artesian water within the chert was construed as unconfined, saturated groundwater within the loess and till. The Callaway Plant Unit 2 investigation found that the loess and till as well as the deeper Burlington Limestone were dry to partially saturated to saturated and these units did not make water. These findings are consistent with the construction phase of Callaway Plant Unit 1 when minimal seepage occurred in excavations below the base of the glacial till and no de-watering was required (AmerenUE, 2003). It is believed that on-site ponds not present during the Callaway Plant Unit 1 investigation likely provide enhanced groundwater recharge and hydraulic head to the underlying materials, thus explaining the artesian conditions.

Beneath the Burlington Limestone, the Bushberg Sandstone was either not present, or very thin and dry to partially saturated. It is not likely that the Bushberg acts as the base of the shallow aquifer except in places where the Burlington is not present. Beneath these units, the Callaway Plant Unit 2 field investigation findings were consistent with the conceptual model developed during the Callaway Plant Unit 1 investigation, although the CJC aquifer was characterized as a dolomitic limestone during the Callaway Plant Unit 2 investigation.

A detailed description of the Callaway Plant Unit 2 field investigation results and evaluations to meet the regulatory objectives are provided in Section 2.3.1.2.3.2. Subsurface data from the Callaway Plant Unit 2 geotechnical investigation are summarized in FSAR Section 2.5.

2.3.1.2.3.2 Groundwater Monitoring and Subsurface Pathways

The Callaway Plant Unit 2 site hydrogeological field activities and conceptual model are introduced in Section 2.3.1.2.3.1. Figure 2.3-22 and Figure 2.3-23 show the monitoring well, pumping well, and surface water gauging locations. This section describes the analysis and results of the site-specific field investigations. The surveyed horizontal reference datum is NAD83 State Plane feet, and the surveyed vertical reference datum is NAVD88 feet.

2.3.1.2.3.2.1 Monitoring Well and Surface Water Gauging Data

Table 2.3-13 shows construction characteristics for the Callaway Plant Unit 2 monitoring wells. The wells are divided into five groups:

- Eleven (11) shallow wells on the plateau are screened within or primarily within the Graydon Chert. PW-1 and MW-18 are centrally located for Callaway Plant Unit 2; MW-8 through MW-12 are located radially outward from the central part of the plateau; and MW-2S, MW-3S, MW-5S, and MW-6S are located further radially outward near the perimeter of the plateau. At MW-2S, the well is screened above the chert due to saturated groundwater over a consistent section at this location. At MW-18, the top of the well screen is placed partially in glacial till for the same reason. A shallow well at the MW-4D location was not installed due to field conditions (refer to text later in this section for more detail).

- One (1) intermediate well as part of a cluster centrally located on the plateau is screened within the aquitard (MW-1I).

- Six (6) deep wells on the plateau are screened within the Cotter-Jefferson City (CJC) aquifer. MW-1D through MW-6D are paired with shallow wells (except a shallow well was not installed with MW-4D due to field conditions). One (1) additional well, MW-7D, is located on a separate plateau northwest of the site. This well was installed to evaluate the groundwater potential in the CJC aquifer on the western side of Auxvasse Creek.

- Seven (7) shallow wells along the study area boundary are screened within the CJC aquifer. MW-13 through MW-17, PW-2, and PW-3 are located downgradient of the plateau near surface water boundaries. There are 6 additional piezometers (3 each at the pumping wells PW-2 and PW-3) that were used as observation wells during pumping tests.

- Ten (10) wells on the Missouri River floodplain. FMW-1S and FMW-1D is a cluster, which consists of two wells screened in the alluvial and CJC aquifers, respectively. MW-5 through FMW-12 are screened in the deeper portion of the alluvial aquifer. There were 5 additional soil borings (FSB-2 through FSB-4, FSB-13, and FSB-14) logged in the floodplain.

Depth to and thickness of the identified formations are shown on Table 2.3-14 (refer to FSAR Section 2.5 for depths and thicknesses of formations from the geotechnical investigation beneath Callaway Plant Unit 2 structures). Water levels in the monitoring wells were measured to characterize groundwater elevations, hydraulic gradients, flow directions, flow velocities, and seasonal variations in these characteristics. Monitoring of these wells began in March 2007 and is reported through February 2008. Measured depths to groundwater and calculated groundwater elevations are presented in Table 2.3-15. Field parameters for water quality were measured on a seasonal basis and are presented in Table 2.3-16 for June, August, and November of 2007, and January of 2008. Additionally, 28 surface water locations were monitored for surface water elevations, flow velocities, depths, flow rates, and field water quality characteristics. These locations can be grouped as follows:

- Auxvasse Creek stream gauges (SG-A1 through SG-A5)
- Logan Creek stream gauges (SG-L1 through SG-L4)
- Mud Creek stream gauges (SG-M1 through SG-M5)
- Logan Camp Branch stream gauges (SG-LB1 and SG-LB2)
- Pond gauges (PG-1 through PG-7, PG-9, PG-10)
- Lake gauges (LG-1 through LG-3)

The streams were monitored to evaluate the interaction of surface water with the CJC aquifer groundwater along the study area boundary. Stream monitoring locations were monitored by utilizing surveyed reference points at bridge crossings. Pond gauges were installed to evaluate the interaction of surface water with the chert aquifer groundwater on the plateau. The lake gauges were installed to monitor surface water elevations in the large lakes north of the site.

PG-1 is located in a pond on private property. PG-2 through PG-7 and PG-9 are located at ponds that were constructed at the headwater of historical drainages for control of runoff and sediment during construction of Callaway Plant Unit 1. These ponds are unlined, likely situated on top of a relatively thin layer of fine-grained alluvial or glacial material, and in many cases

(PG-2 through PG-5 and PG-9) within 5 ft to 10 ft (1.5 m to 3.1 m) of the top of the chert. Carbonate rocks were emplaced around their perimeter. A gauge was planned as PG-8 in a small pond near PG-9, but it was inaccessible due to a receding water line and mucky conditions, so it was not installed. PG-10 is located in an excavation trench that was slated for a possible Callaway Plant Unit 2 that was subsequently cancelled. This pond is approximately 15 ft to 20 ft (4.6 m to 6.1 m) deep and, based on the elevation of the chert at PW-1, MW-18 and MW-9, it extends to within 10 ft (3.1 m) of the top of the chert. This pond has a rip-rap boundary surrounded by a paved ground surface.

Table 2.3-17 presents the surface water elevations that were measured in conjunction with the groundwater elevations. Average flow depths, average flow velocities, and average flow rate are provided in Table 2.3-18. Table 2.3-19 shows the field water quality data for these locations. The following aquifer groundwater characteristics, potentiometric surface trends, and groundwater-surface water interaction evaluations are based on this information.

2.3.1.2.3.2.2 Graydon Chert Aquifer

Across the plateau, the Graydon Chert is considered to be the shallow aquifer. There are localized areas where the overlying material may be a part of this aquifer, but on the whole it was found that saturated conditions are confined within the chert. The Graydon Chert lies unconformably atop the Burlington Limestone and unconformably below the glacial till so its elevation and thickness vary. Across the plateau, the depth of the Graydon Chert ranges from 15 ft to 39 ft (4.6 m to 11.9 m) below ground surface (bgs) and averages approximately 27 ft (8.2 m) bgs. Its thickness ranges from 16 ft to 61 ft (4.9 m to 18.6 m) and averages approximately 38 ft (11.6 m). At the centrally located MW-18 well (beneath the power block area), the depth to the Graydon Chert is 30 ft (9.1 m) and its thickness is 40 ft (12.2 m).

The chert itself is present in several forms, which are described in more detail in FSAR Section 2.5. Although the chert is not wholly consolidated, it is very hard and has definite intervals of consolidation. The top of the chert is a partially weathered, friable sandstone, although considered to be unconsolidated, with chert nodules. The middle section is a hard, crystalline quartz sandstone with very large chert inclusions that is mildly fractured and yields little groundwater. The lower section lying on the Burlington Limestone is also somewhat weathered likely due to groundwater flowing on top of the aquitard. Depending on the thickness and water-yielding nature of the chert at each location, in most cases the 20-ft (6.1 m) well screen extends down to the base of the chert and sits on top of the aquitard.

In the central part of the plateau, groundwater is present in fractures in the chert and is consistently confined. Due to confined groundwater conditions, groundwater elevations measured at the monitoring wells rise above the top of the chert to within approximately 7 ft to 15 ft (2.1 m to 4.6 m) of the ground surface.

Local conditions varied at MW-11. At MW-11, the well was installed across an interval that demonstrated the highest chance of monitoring shallow groundwater. However, after several months of monitoring, the water at the base of the well was determined to be stagnant, trapped in the "shoe" of the well, and not indicative of an aquifer at that location. Groundwater elevation data was recorded, but it was not utilized in the evaluations. A second borehole was then drilled to determine if shallow groundwater was present either higher or lower in the section. However, yielding groundwater was not found during the second drilling effort at this location.

Around the perimeter of the plateau, the geology and thickness of the overlying materials are more variable and the shallow groundwater is more affected by the presence and configuration of local drainages; hence, the groundwater conditions are less consistent. For example, the MW-4D location was placed along a southern extension of the plateau where no shallow well was installed due to the absence of shallow groundwater. The ground surface is relatively high, but there are steep valleys that drop to the west, east, and south; hence, runoff is high and any groundwater recharge is likely to discharge to local drainages. This is indicative of what is expected along the perimeter of the plateau where shallow groundwater is not consistently present across an area and any water that does infiltrate discharges to local drainages.

Temporal trends of groundwater elevation data for the Graydon Chert aquifer are shown on Figure 2.3-24. Precipitation data for the NOAA Columbia Regional Airport station (NOAA, 2007b) are shown on Figure 2.3-25, and surface water elevations at the plateau ponds PG-1 through PG-7, PG-9 and PG-10 are shown on Figure 2.3-26. Overall, groundwater elevations do not vary much through the year, typically by less than 1 ft to 2 ft (0.3 m to 0.6 m) across the central part of the plateau and several feet in the shallow wells around the perimeter of the plateau. The relatively larger, yet at some locations inconsistent, variations in groundwater elevations along the perimeter reflect the localized variations as discussed above. Pond elevations mostly varied by about 1 ft to 2 ft (0.3 m to 0.6 m) during the year.

The precipitation shown on Figure 2.3-25 is plotted with the total precipitation for each month. Groundwater elevations at some locations, such as at MW-2S, MW-6S, MW-9 and MW-12, fluctuate from a high in the late spring after spring rains and infiltration of water from melting snow through the month of June to a low in late summer. Groundwater elevations at locations such as MW-8 and MW-10 have a delayed response to the rain in the spring, and groundwater elevations at PW-1 have little sensitivity to seasonal fluctuations in precipitation.

In order to assess sensitivity to precipitation in the central portion of the plateau over a shorter time frame, pressure transducers monitored groundwater elevations at PW-1, MW-8, and MW-10 from late May to late June while rainfall was recorded with an on-site rain gauge. The data are shown on Figure 2.3-27. The transducers were not vented (i.e., they measured absolute pressure), so changes in groundwater elevations due to daily changes in barometric pressure were recorded. There does not appear to be a consistent correlation between a rain event and an increase in groundwater elevations; rather the data indicate that barometric pressure changes affect the groundwater elevations by approximately 1 ft (0.3 m). These short-lived oscillations are consistent with fluctuations that could be expected for confined groundwater such that as atmospheric pressure increases, groundwater potentiometric head decreases (Freeze & Cherry, 1979).

The groundwater elevation data were used to develop potentiometric surface contour maps for the Graydon Chert aquifer on a seasonal basis with four rounds of data (May, August, and November of 2007, and January of 2008). These maps are presented on Figure 2.3-28 through Figure 2.3-31, respectively. Pond elevations are shown but were not used in the contouring.

Generally, groundwater has the potential to move through the chert radially from the central portion of the plateau from an area that encompasses MW-18 and PW-1 toward the perimeter and associated drainages. It is expected that the ponds provide localized, enhanced recharge and hydraulic head to the aquifer. The groundwater potentiometric contours do not change much from one season to the next due to relatively small temporal variations in the groundwater elevations.

Field personnel looked for evidence of groundwater discharge around the perimeter of the plateau and in the upper portions of the drainages down to approximately 700 ft (213 m) msl. Drainages are consistently dry throughout the year. However, a seep was noted in a drainage to the east of the MW-2 well cluster. There are numerous small ponds in this general location just below 780 ft (238 m) msl.

Horizontal hydraulic gradients were estimated for the Graydon Chert aquifer and results for the four seasonal rounds are shown on Table 2.3-20. Horizontal gradients were estimated between upgradient and downgradient groundwater elevations of well pairs from the central part of the plateau (power block area) outward toward the perimeter (refer to Note 1 in the table for exceptions).

The horizontal hydraulic gradients do not vary much seasonally, and there does not appear to be a consistent trend seasonally in the various directions. It is expected that during drier months horizontal hydraulic gradients would be higher and this is mostly the case for gradients in the central area of the plateau but not at the periphery. Therefore, average horizontal hydraulic gradients are appropriate for further evaluation.

In the central area of the plateau, the average horizontal hydraulic gradients range from 0.00121 to 0.00419. The steepest gradients are toward the west-northwest (WNW) and south-southeast (SSE) from the MW-18 well (power block area). Toward the periphery of the plateau, the average horizontal hydraulic gradients range from 0.00325 to 0.00837. In general, these are steeper than those in the central area of the plateau.

Vertical hydraulic gradients were estimated at well clusters between the Graydon Chert aquifer and the CJC aquifer. Results are shown on Table 2.3-17. Seasonally, the vertical hydraulic gradients are very consistent. Therefore, average vertical hydraulic gradients are appropriate for further evaluation. The average vertical hydraulic gradients range from 0.815 to 0.848. Both horizontal and vertical groundwater flow will be evaluated in Section 2.3.1.2.3.4.

Groundwater quality was monitored at each well screened in the chert and surface water quality was monitored at each pond gauge location on the plateau. For groundwater, the pH ranges from 6.85 to 7.27 and is indicative of normal groundwater conditions (pH range 6-8.5). The groundwater is considered to be fresh (salinity less than 1 part per thousand (ppt)) and with a total dissolved solids (TDS) concentration that is in the majority of cases slightly higher than the 0.5 ppt indicator of acceptable aesthetic quality. The dissolved oxygen (DO) concentrations are consistent with normal values of 5 to 10 parts per million (ppm) for shallow groundwater that is recharged through infiltration. However, the temperature of the groundwater is approximately (18 degrees Fahrenheit (10 degrees Celsius) colder than the pond surface water (refer to discussion below), which indicates that recharge is relatively slow. The oxidation-reduction potential (ORP) is positive for all wells, which indicates an oxidizing environment. Seasonally, water quality changes but not consistently from one well to the next.

For surface water in the ponds, the pH ranges from 7.20 to 9.97; this is higher than the groundwater. The higher pH is attributable to a higher aeration of the surface water and contact with carbonate materials (the ponds have carbonate rocks along their perimeter that were emplaced during construction). The pond water is considered to be fresh (salinity less than 1 ppt) and with a TDS that is in most cases below the 0.5 ppt indicator of acceptable aesthetic quality. Generally, dissolved oxygen concentrations are higher than the groundwater but within the same range of 5 to 10 ppm. The temperature of the ponds is approximately (18 degrees Fahrenheit (10 degrees Celsius) warmer than the groundwater and in most cases reflects the expected seasonal changes in atmospheric temperature. The ORP is positive for all ponds, which indicates an oxidizing environment.

2.3.1.2.3.2.3 Aquitard

During the drilling of the first borehole at MW-1D, a packer test and geophysical logging were performed to assess qualitatively the fracture characteristics of the rocks found beneath the chert within the aquitard and deeper CJC aquifer. These tests resulted in the identification of a potential water-bearing zone within the aquitard at approximately 165 ft (50.3 m) bgs and extending to approximately 180 ft to 182 ft (54.9 m to 55.5 m) bgs. A monitoring well (MW-1I) with a 15 ft (4.6 m) screened section was installed across this interval from 167 ft to 182 ft (50.9 m to 55.5 m) bgs.

After the MW-1I monitoring well was installed, it was developed and it was found that the well went dry very quickly and did not readily recharge. This indicates that recharge to this zone and groundwater flow to the well are limited and that fractures that were identified in the downhole tests are not connected across an extensive area. During the drilling of the deep monitoring wells, conditions through the aquitard were monitored and the conditions were similar at the different locations. Through the aquitard, there are intervals of dry, moist, and wet conditions, with wet conditions correlating to zones of increased fracturing. However, there was no specific depth interval where water-yielding zones were consistently encountered. These findings are consistent with results from the Callaway Plant Unit 1 FSAR investigation where groundwater yield was found to be very low during a failed pumping test; the pumping well produced a yield of less than 1 gpm (3.8 lpm).

Based on the drilling of the monitoring wells across the plateau, the top of the aquitard begins with the top of the Burlington Limestone. Based on the drilling of the deep monitoring wells MW-1D through MW-7D, the aquitard extends through the Bushberg Sandstone (only identified at the MW-4 and MW-5 well locations), Snyder Creek Formation (shale), Callaway Limestone, and upper portion of the CJC Dolomitic Limestone. The demarcation between the upper CJC (aquitard) and the lower CJC (aquifer) was identified during the drilling process whenever water-yielding fractures were encountered in the lower portion of the formation.

The depth to the top of the aquitard is 60 ft (18.3 m) at MW-1D and averages 68 ft (20.7 m) across the plateau based on the other deep boreholes. It ranges in thickness from 252 ft to 289 ft (76.8 m to 88.1 m) (MW-1D, MW-3D through MW-6); however, it is only 180 ft (54.9 m) thick at MW-2D and 237 ft (72.2 m) thick at MW-7D. MW-2D is at an elevation that is approximately 65 ft (19.8 m) lower than the top of the plateau and the deeper aquifer was encountered at a shallower depth. MW-7D is located on an adjacent plateau with an elevation that is approximately 65 ft (19.8 m) lower than the Callaway Plant Unit 2 site.

Temporal trends of groundwater elevation data for the MW-1I well are shown on Figure 2.3-32. Groundwater elevations vary by less than 1 ft (0.3 m) through the year. These elevations indicate that the groundwater is within 2 ft (0.6 m) of the bottom of the well throughout the year. When compared to the groundwater elevation at the shallow well at this cluster, PW-1, the groundwater elevation in the aquitard is approximately 166 ft (50.6 m) lower throughout the year. Further evaluation of the interaction between the shallow aquifer and the aquitard is presented in Section 2.3.1.2.3.4. Groundwater quality was not monitored at this well, because when the well is purged at a low rate, it goes dry.

As discussed in the previous section, vertical gradients between the Graydon Chert aquifer and the CJC aquifer are similar at the well clusters located in the center and around the periphery of the plateau. This narrow range of gradients is generally indicative of a uniform depositional and weathering history across the area of the plateau, which translates to relatively similar recharge rates and hydrogeologic properties of the units beneath all areas of the plateau.

2.3.1.2.3.2.4 Cotter-Jefferson City Aquifer

As stated in the previous section, the demarcation between the aquitard and the CJC aquifer was identified by a zone of water yielding fractures that were found consistently in the lower portion of the CJC Formation. At monitoring well MW-1D, the aquifer was encountered at a depth of 349 ft (106.4 m) bgs. The borehole was extended to 400 ft (121.9 m) and the aquifer extended to this depth. The well screen was installed from 345 ft to 375 ft (105.2 m to 114.3 m) bgs. At the remaining locations, the borehole was extended 20 ft to 25 ft (6.1 m to 7.6 m) below the top of the aquifer and the well was installed. Yields during drilling were estimated to be 3 gpm to 5 gpm (11.4 lpm to 19 lpm), but over some intervals up to 15 gpm to 20 gpm (57 lpm to 76 lpm) was encountered.

The depth to the CJC aquifer is 349 ft (106.4 m) bgs at MW-1D and ranges from 325 ft to 345 ft (99.1 m to 105.2 m) bgs at MW-3D through MW-6D, is 260 ft (79.2 m) bgs at MW-2D, and is 315 ft (96.0 m) bgs at MW-7D (located on the adjacent plateau). Based on the well logs for the three AmerenUE industrial wells, the thickness of the CJC aquifer beneath the plateau is approximately 300 ft (91.4 m), which would extend the aquifer to a depth of approximately 650 ft (198 m) bgs at MW-1D. Regionally, the CJC aquifer is considered to be a minor aquifer and represents the top of the Cambrian-Ordovician aquifer system, which consists of intervals of minor aquifers and major aquifers with intermittent aquitards to depths up to 2000 ft (610 m) bgs.

Along the study area boundary near streams, monitoring wells were installed in the CJC aquifer, again, by the identification of water-yielding fractures (MW-13 through MW-17, PW-2, and PW-3). The ground surface elevations at these locations range from 533 ft to 570 ft (162.5 m to 173.7 m) msl, which is approximately 300 ft (91.4 m) below the top of the plateau. Stream drainages are eroded into the upper and lower portions of the CJC Formation, and erosion and fracturing make them indistinguishable. Alluvium has been deposited and re-worked in more recent geological time above the eroded surface of the CJC Formation.

A comparison of the screened interval elevations of the deep plateau wells and the study area boundary wells shows that these two sets of wells are monitoring a comparable interval of the CJC aquifer and that the top of the aquifer is relatively consistent across the study area. The well screens range from an elevation of 447 ft (136.3 m) msl at the base of MW-4D to 511 ft (155.8 m) msl at the top of MW-2D for the deep plateau wells and from 426 ft (129.8 m) msl at the base of MW-15 to 538 ft (164.0 m) msl at the top of PW-3 for the study area boundary wells.

Temporal trends of groundwater elevation data for the CJC aquifer are shown on Figure 2.3-33. Precipitation data for the NOAA Columbia Regional Airport station is shown on Figure 2.3-25 and surface water elevations at the stream and lake gauges are shown on Figure 2.3-34 and Figure 2.3-35. At the deep cluster wells, beneath the plateau, the groundwater elevations appear to respond to seasonal changes in precipitation, however, they vary only by approximately 1 ft (0.3 m) (similarly as the wells screened in the Graydon Chert aquifer). The monitoring wells along the stream boundaries also respond to seasonal changes. In some cases, groundwater elevations vary by approximately 2 ft (0.6 m) (MW-13 and PW-3), but at other locations by up to 5 ft (1.5 m) (MW-14 through MW-16) and up to 10 ft to 15 ft (3.1 m to 4.6 m) (MW-17 and PW-2). The relatively larger variations in groundwater elevations along the stream boundaries probably reflect localized conditions of increased fracturing and enhanced interaction with the streams.

The lakes, where gauged to the north of the site, have a minimal response to seasonal changes; water levels varied up to 1 ft (0.3 m) over the one year of monitoring.

For Auxvasse Creek, at the gauge location SG-A1, the surface water elevation is nearly equal throughout the year. However, there was a response recorded to a large rain event that occurred in May. Surface water elevations at the remaining downstream locations are more responsive to seasonal changes with a range of approximately 10 ft (3.1 m) at SG-A2, 15 ft (4.6 m) at SG-A3, and 25 ft (7.6 m) at SG-A4 and SG-A5. Surface water along Mud and Logan Creek also vary considerably during the year, although the upstream locations are dry through the summer months. The largest change in surface water elevation of approximately 11 ft (3.4 m) occurs at the most downstream gauging location of Logan Creek (SG-L4). These large changes at the downstream locations of Auxvasse and Logan Creek are the result of the deeper channels, flatter terrain, and influence from the Missouri River.

Along Auxvasse Creek, there is water at all gauged locations throughout the year, although its flow is likely more influenced by the larger portion of its drainage area that is north of the study area boundary. Mud, Logan, and Logan Camp Branch (a minor tributary of Mud Creek) Creeks remain dry through the summer to early fall and in some cases until January. Estimated flow velocities and discharge were highest in January at most locations, which is the one round where water was flowing at all gauged locations due to an intense rain event. Estimated flow velocities and discharge were lowest in August at most locations; August was the round when there was only pooled water and no flow in Mud, Logan, and Logan Camp Branch Creeks.

The groundwater elevation data were used to develop potentiometric surface contour maps for the CJC aquifer on a seasonal basis with four rounds (May, August, and November of 2007, and January of 2008). These maps are presented on Figure 2.3-36 through Figure 2.3-39. Surface water elevations are shown but were not included in the contouring.

Generally, groundwater moves toward Auxvasse Creek and to some extent toward the Missouri River. The relatively high groundwater elevations at MW-17 and MW-16 (which are further downstream along Logan and Mud Creeks, respectively) relative to those at MW-14 and PW-2 (which are further upstream along Auxvasse Creek) demonstrate that the fracturing, weathering and erosion along Auxvasse Creek and its tributaries have a significant impact on the directional movement and subsequent drainage of groundwater. The relatively high groundwater elevation at PW-3 is located furthest from Auxvasse Creek and there are no major drainages to the east within 20 miles (32.2 km).

Deep groundwater elevations across the plateau are relatively similar. The general shape of the groundwater contours do not change much from one season to the next. However, in the spring the higher groundwater elevation at MW-17 (higher than MW-16) creates a stronger gradient toward Auxvasse Creek, whereas in August the lower groundwater elevation at the same location (lower than MW-16) creates a gradient more toward the Missouri River.

Groundwater elevations can be compared seasonally to surface water elevations at locations where there is a well and stream monitoring gauge together. For the May round, groundwater discharges to the streams at all locations except at MW-15, SG-A5, and SG-A4 (recall that SG-A4 and SG-A5 locations are influenced by the Missouri River demonstrated by large fluctuations in water elevations). For the August round, stream flow along Auxvasse Creek (other streams were dry) has the potential to recharge groundwater. Evidence of a spring was identified in August between SG-M1 and SG-M2 where water was flowing; it disappeared below the dry stream bed and no water was apparent further south down to the mouth of Mud Creek.

Horizontal hydraulic gradients were estimated for the CJC aquifer and results for the four seasonal rounds are shown on Table 2.3-20. Hydraulic gradients were estimated from upgradient and downgradient groundwater elevations of well pairs from the deep CJC wells at the periphery of the plateau toward CJC wells near the study area boundary.

Seasonally, the horizontal hydraulic gradients do not vary much. Generally, the gradients are steeper during the drier months of August and November, but this is not true in each case. The average horizontal hydraulic gradient ranges from 0.00060 to 0.00348. The mildest gradients are to the northwest (NW) and southwest (SW) while the steepest gradient is to the west (W) (from the plateau toward PW-2 along Auxvasse Creek). Downward vertical hydraulic gradients from the Graydon Chert aquifer to the CJC aquifer are presented and described in previous text. Both horizontal and vertical groundwater flow will be evaluated in Section 2.3.1.2.3.4.

Groundwater quality was monitored at each well screened in the CJC aquifer and surface water quality was monitored at each stream gauge location. For groundwater, the pH ranges from 6.85 to 7.48 and is indicative of normal groundwater conditions (pH range 6-8.5). There is little difference between the wells beneath the plateau and those along the study boundary. The groundwater is considered to be fresh (salinity less than 1 ppt) and with TDS concentrations that are either slightly above or slightly below the 0.5 ppt indicator of acceptable aesthetic quality. DO concentrations are low with most values below 1 ppm. The ORP is slightly positive to negative, which indicates a slightly oxidizing to reducing environment. The temperature of the groundwater in the deep plateau wells ranges from 57.2 degrees to 71.6 degrees Fahrenheit (14 degrees to 22 degrees Celsius) as compared to the temperature of the groundwater along the study area boundary, which ranges from 57.2 degrees to 64.4 degrees Fahrenheit (14 degrees to 18 degrees Celsius). Stream temperatures, which range from 42.8 degrees to 87.8 degrees Fahrenheit (6 degrees to 31 degrees Celsius), are at times colder and warmer than the deep plateau and boundary area study wells, as would be expected, due to the streams contact with the atmosphere. Seasonally, water quality changes but not consistently from one well to the next.

For surface water in the streams, the pH ranges from 7.17 to 8.16; this is higher than the groundwater. The higher pH is attributable to a higher aeration of the surface water and contact with carbonate materials. The stream water is considered to be fresh (salinity less than 1 ppt) and with a TDS concentration that is in all cases below the 0.5 ppt indicator of acceptable aesthetic quality. Generally, DO concentrations are higher than the groundwater but with a relatively low range of approximately 2 to 6 ppm. The ORP is positive for all streams, which indicates an oxidizing environment. The temperature of the streams is variable from one round to the next and is likely dependent on short-term rain events and weather patterns.

2.3.1.2.3.2.5 Missouri River Alluvial Aquifer

Based on the regional understanding of the Missouri River alluvial aquifer (summarized in Section 2.3.1.2.2, it was expected that groundwater elevations within the aquifer would mimic surface water elevations along the Missouri River and the lower reach of Auxvasse Creek. When a collector well system became a consideration for the water intake of Callaway Plant Unit 2, it was determined that a more thorough investigation of the aquifer would be required. A Phase I investigation included the monitoring wells and borings shown on Figure 2.3-22. A Phase II investigation performed by Burns & McDonnell (Burns & McDonnell, 2008) included two large-scale pumping tests, which included additional installation of the test pumping wells and observation wells in the vicinity of the test wells.

For the Phase I work, the monitoring wells and borings were drilled to the top of the CJC Formation. Alluvial material was encountered in all wells and borings along the Missouri River (both north and south sides) to a depth of 91 ft to 104 ft (27.7 m to 31.7 m) bgs. At the upgradient borings and monitoring well (FSB-2, FSB-4, and FMW-5), the depth to bedrock varied (85 ft, 101 ft, and 50 ft (25.9 m, 30.8 m, and 15.2 m) bgs, respectively). This suggests that during glaciation, the bedrock surface was eroded irregularly along the edge of the original valley. Subsequent aggradation of the valley by the Missouri River has created a relatively flat floodplain surface that likely has been filled-in further over the last 100 years for agricultural purposes. Prior to those changes, the Auxvasse Creek likely had a deltaic transition that splayed into the Missouri River floodplain.

At FMW-1D, the borehole was drilled through a thin, fractured zone of a few feet into the CJC Formation to competent bedrock, and the well was set from 114 ft to 134 ft (34.7 m to 40.8 m) bgs. Based on the depth to bedrock and the depth to saturated groundwater, the thickness of the alluvial aquifer along the Missouri River is approximately 80 ft to 85 ft (24 m to 26 m) thick. However, the aquifer is expected to be thinner at locations further north of the current Missouri River channel, especially in the areas of FSB-2 (70 ft (21.3 m) thick) and FMW-5 (35 ft (10.7 m) thick).

Temporal trends of groundwater elevation data for the alluvial aquifer are shown on Figure 2.3-40. Precipitation data for the NOAA Columbia Regional Airport station is shown on Figure 2.3-25. Groundwater elevations fluctuated by approximately 2 ft to 3 ft (0.6 m to 0.8 m) from August through February. Two large-scale pumping tests were performed in mid-to-late November to investigate the feasibility of the collector well system that will be used for cooling water intake. Groundwater elevation trends indicate that the wells screened in the alluvial aquifer re-bounded prior to the December round of water levels. However, the groundwater elevation at FMW-1D was still depressed during the December round but re-bounded prior to the January round. Additional analysis will be provided in Section 2.3.1.2.3.4.

The groundwater elevation data was used to develop potentiometric surface contour maps for the Missouri River alluvial aquifer on a seasonal basis with three rounds (August and November of 2007 and January of 2008). These maps are presented on Figure 2.3-41 through Figure 2.3-43. The groundwater contours indicate that groundwater flows through the alluvial aquifer toward the Missouri River but with a downstream component as well. This is consistent with the regional contours shown at the top of Figure 2.3-20 where the groundwater contours indicate flow toward the river but with a downstream direction as well. The groundwater elevation at FMW-1D is slightly higher than at FMW-1S, which indicates a slightly upward vertical gradient and the potential for groundwater to discharge from the CJC aquifer to the alluvial aquifer.

Groundwater quality was monitored at each well. The pH for the 9 wells installed in the alluvial material along the Missouri River ranges from 6.92 to 7.10 and is indicative of normal groundwater conditions (pH range 6-8.5). At the bedrock well, the pH ranges from 7.37 to 7.40. The groundwater is considered to be fresh (salinity less than 1 ppt) and with a TDS concentration that is either slightly above or slightly below the 0.5 ppt indicator of acceptable aesthetic quality. The DO concentrations are low with most values below 1 ppm. The ORP is negative, which indicates a reducing environment. These parameters indicate that the water quality of the alluvial aquifer is similar to that of the CJC aquifer. The temperature in the alluvial aquifer is warmer than that in the CJC aquifer but colder than the surface water temperatures measured in the creeks.

2.3.1.2.3.3 Hydrogeologic Properties

Falling head slug tests were performed at all of the monitoring wells, except MW-11 and MW-1I due to their lack of water production and the dry well determination of MW-11. Two pumping tests were successfully completed at PW-2 and PW-3, which are screened in the CJC aquifer along the eastern and western boundaries of the study area. A step pumping-drawdown test was performed at PW-1, which is screened in the chert aquifer on the plateau, but the well went dry very quickly after pumping up to 1 gpm (3.75 lpm) for 7 minutes. It was determined that a pumping test would not yield viable results at PW-1 and that the chert does not recharge readily. Results of the large-scale pumping tests performed to support the collector well design are summarized in Section 2.3.1.2.3.4.

Results of the slug and pumping tests are presented in Table 2.3-21 and Table 2.3-22, respectively. The estimated hydraulic conductivity of the Graydon Chert aquifer ranges over four orders of magnitude from 7.05E-3 ft per day to 9.02 ft per day (2.49E-6 cm per sec to 3.18E-3 cm per sec). The estimated hydraulic conductivity of the CJC aquifer ranges over two orders of magnitude from 1.57E-1 ft per day to 3.09 ft per day (5.54E-5 cm per sec to 1.09E-3 cm per sec). The estimated transmissivity of the CJC aquifer averages 2.6 sq ft per day and 13.8 sq ft per day (2.79E-2 cm^2 per sec and 1.49E-1 cm^2 per sec) at PW-3 and PW-2, respectively. The estimates of transmissivity are based on the length of the screened interval and sand pack of each pumping well and not the entire aquifer. The storativity values average 1.58E-4 and 3.03E-4 at PW-3 and PW-2, respectively. The hydraulic conductivity of the alluvial aquifer along the shoreline could not be estimated from slug tests, because the wells responded too fast to obtain data. The estimated hydraulic conductivity of the upgradient well FMW-5 and the CJC bedrock well beneath the alluvium (FMW-1D) are 16.2 ft per day (5.72E-3 cm per sec) and 5.72E-2 ft per day (2.02E-5 cm per sec), respectively.

The pumping test results confirm that the CJC is a leaky, confined aquifer; the pumping test data followed the Theis Curve but delayed yield was observed as the test proceeded due to leakage from overlying alluvium or recharge from the streams (the tests were performed in the spring when water was flowing in the streams). The relatively low storativity value for the CJC aquifer is consistent with mildly fractured bedrock aquifers where the small size of fractures and lack of interconnectedness limits the amount of water in storage and the amount of water to potentially yield to a well. Given that the pumping of PW-1 was not viable, the attempted pumping test confirms its low-yielding characteristics.

Shelby-tube samples collected from the unconsolidated zone above or within the top of the Graydon Chert and from the vadose zone of the Missouri River alluvial aquifer were submitted for laboratory testing of moisture content (weight of water in the sample divided by the weight of dry solids), moist (wet) unit weight (weight of water and solids divided by the sample volume), specific gravity, total organic content, and vertical hydraulic conductivity. The moisture content, wet unit weight and specific gravity were utilized to estimate the void ratio and porosity of the sample material. These results are listed in Table 2.3-23. Additionally, grain-size analyses were performed for the Shelby tube samples collected above the chert and for separate, washed grab samples collected with depth from the alluvial aquifer. Results are shown in Table 2.3-24. A summary is as follows:

- Unconsolidated zone above and within top of Graydon Chert. The samples consisted of from 71.3% to 96.0% silt and clay; a few samples had approximately 20% fine sand. Moisture content ranges from 16% to 26%, organic content ranges from 1.3% to 2%, and estimated porosity ranges from 32% to 46%. Estimated vertical hydraulic conductivity ranges over four orders of magnitude from 1.2E-5 ft per day to 4.8E-3 ft per day (4.2E-9 cm per sec to 1.7E-6 cm per sec).

- Vadose zone of Missouri River alluvial aquifer. For three Shelby tube samples, the alluvial material consists of 80% to 90% silt and clay while for two Shelby tube samples at FMW-5 and FSB-13, the alluvial material consists of nearly 80% fine sand. This correlates to estimated vertical hydraulic conductivity values of 1.3E-4 ft per day to

2.5E-4 ft per day (4.6E-8 cm per sec to 8.7E-8 cm per sec) for the samples with high silt and clay content and 5.1E-1 ft per day to 6.0E-1 ft per day (1.8E-4 cm per sec to 2.1E-4 cm per sec) for the samples with high sand content.

- Grab samples from Missouri River alluvial aquifer. Although there is variation with depth and across the floodplain, the alluvial aquifer predominantly consists of coarse, medium, and fine-grained sand. There are some intervals at FSB-4 and FMW-1D that contain a higher percentage of coarser materials such as fine gravel and coarse sand in the lower portion of the aquifer. Field personnel noted a boulder field at these locations in the lower portion of the aquifer and air-hammered to fine, gravel-sized fragments. This was also observed in the lower portion across the river at FSB-13 and FSB-14.

Results from soil lab analyses of samples collected for the geotechnical investigation are presented in FSAR Section 2.5.

2.3.1.2.3.4 Groundwater Flow and Travel Time

The following sections present the most probable groundwater flow direction and travel time from the Callaway Plant Unit 2 power block area to nearby surface water features. Based on the evaluation summarized in the above sections, the Graydon Chert and CJC aquifers may be affected by construction and operation of the Callaway Plant Unit 2. Groundwater use associated with Callaway Plant Unit 2 operations is discussed in Section 2.3.2.2. Accidental release parameters and pathways for liquid effluents in groundwater and surface water are presented in FSAR Section 2.4.13.

The groundwater seepage velocity is defined as distance over time and is calculated as follows:

Velocity = [(hydraulic gradient) x (hydraulic conductivity)] / (effective porosity)

The travel time is defined as rate of groundwater movement for a set distance and is calculated as follows:

Travel Time = (distance) / (velocity)

2.3.1.2.3.4.1 Graydon Chert Aquifer, Aquitard, and CJC Aquifer

On the plateau, groundwater originates from precipitation recharge and enhanced recharge from shallow ponds. Groundwater flow from the Callaway Plant Unit 2 power block area will travel outward (horizontal) and downward (vertical) according to the gradients and hydraulic conductivities estimated in the previous sections. In reality, for a groundwater flow "particle" that originates in the power block area, the relationship between (relative magnitude of) the horizontal and vertical velocities will determine its flow path as it travels across the plateau, leaves the Graydon Chert aquifer, travels through the aquitard and underlying Cotter-Jefferson City aquifer until it reaches a point of discharge to a surface water drainage or stream.

If a three-dimensional model were developed and was calibrated to represent the three-dimensional flow field, then the travel time from the power block area to downgradient drainages or streams can be estimated. However, in this section, simplified calculations are performed. In many situations, it may be appropriate when vertical flow is considered to be negligible to estimate groundwater flow in the horizontal direction only. However, for the Callaway Plant site, the vertical flow component is significant and cannot be dismissed. The approach presented here is a simplified approach that, in spite of its limitations to evaluate the three-dimensional flow field, still honors both horizontal and vertical flow components.

First the horizontal and vertical flow velocities are estimated from the power block area outward and downward. At MW-18, near the center of the power block area, the Graydon Chert aquifer is 40 ft (12.2 m) thick. A groundwater particle is assumed to start at the top of the chert aquifer, travel outward and downward according to the estimated groundwater flow velocities. The travel time for the particle to leave the base of the chert aquifer is estimated. Based on this time estimate, the horizontal travel distance is estimated.

Second, it is assumed that once the groundwater particle moves into the aquitard that only downward, vertical flow occurs until the CJC aquifer is reached. The vertical groundwater flow velocity and the travel time through the aquitard (275 ft (83.8 m) thick at the MW-1D well cluster) are estimated.

Finally, horizontal flow velocities through the CJC aquifer from the deep wells along the periphery of the plateau toward CJC wells along stream boundaries are estimated. Travel times are estimated as well.

It is assumed that both horizontal and vertical flow occur in the Graydon Chert aquifer, vertical flow occurs through the aquitard and horizontal flow occurs through the CJC aquifer. There are several key conclusions from the field investigation and use of the aquifers and creeks that support why these assumptions are appropriate and conservative:

- Callaway Plant Unit 2 is located in the area of the topographic high of the plateau and the highest groundwater elevation was measured at the MW-18 well, which is located in the central portion of the power block area. Radially horizontal and vertically downward hydraulic gradients are both important.

- Drilling conditions and lithologic characteristics of the aquitard were similar in the center and around the periphery of the plateau, which indicates a uniform depositional and weathering history beneath the plateau. Downward vertical hydraulic gradients are relatively uniform in the center and around the periphery of the plateau, which indicates similar recharge rates and hydrogeologic properties of the units beneath the plateau.

- Site reconnaissance of the drainages around the periphery of the plateau indicated that these drainages remain dry except during and after rain events and snow-melt. There was no evidence to suggest that the shallow aquifer is providing significant discharge to these drainages. Given the downward vertical hydraulic gradients, it is likely that any groundwater discharge to a particular drainage is from an area that is fairly localized to the drainage.

- The shallow Graydon Chert aquifer is not used as a water supply; however, the deeper CJC aquifer is utilized by private well users in the area. The major creeks, such as Auxvasse, Mud, and Logan, are not utilized for a public or private drinking water supply, but private users could have incidental contact or use of these creeks. Therefore, the shortest travel time through the aquitard and into the CJC aquifer is estimated (vertical). Then from the CJC aquifer, the shortest travel time to the creeks is estimated (horizontal).

Because the estimates of vertical groundwater flow through the aquitard are performed through the center of the plateau and the estimates of groundwater flow through the CJC aquifer are performed from the periphery of the plateau to downgradient streams, the combined travel time estimates from the top of the aquitard to the downgradient streams are conservative.

Table 2.3-25 provides the data used to calculate groundwater flow velocities, the travel distances, and travel times associated with groundwater moving through the Graydon Chert aquifer, aquitard, and CJC aquifer. A summary of the data are as follows:

- The mean vertical or horizontal hydraulic gradient between well pairs for the May, August, November, and January rounds of water levels.
- The mean horizontal hydraulic conductivity for the Graydon Chert aquifer from slug test results.
- The mean vertical hydraulic conductivity from permeability testing of Shelby-tube samples.
- The mean horizontal hydraulic conductivity of the CJC aquifer from slug tests.
- The vertical hydraulic conductivity for the aquitard is assumed to be 10% of the mean from the Shelby tube samples, or 1.7E-5 ft per day (6.1E-9 cm per sec).
- Porosity of all materials was estimated as 5%. The chert is consolidated but has weathered intervals. The aquitard is expected to have relatively low porosity and any sustained flow is likely through fractures or weathered intervals. The CJC aquifer is expected to have relatively higher porosity (as compared to the aquitard), but again is subject to fracturing and weathering characteristics. It is believed that 5% is conservative. Increases in porosity will result in slower groundwater flow velocities and longer travel times.

Results indicate that the estimated horizontal groundwater flow velocities through the Graydon Chert aquifer from the Callaway Plant Unit 2 power block area range from 0.0027 ft per day to 0.0094 ft per day (8.2E-4 m per day to 2.9E-3 m per day), and the estimated vertical groundwater flow velocity is 0.0029 ft per day (8.3E-4 m per day). The maximum horizontal travel distance for a groundwater particle that originates in the power block area at MW-18 before it leaves the chert aquifer is 128.3 ft (39.1 m) and the travel time associated with this distance is 37.4 years. This means that groundwater does not move far in the Graydon Chert aquifer from the power block area.

The estimated vertical groundwater flow velocity through the aquitard is 0.00029 ft per day (8.8E-5 m per day), and the associated travel time is 2573 years. The estimated horizontal groundwater flow velocity through the CJC aquifer ranges from 0.0093 ft per day to 0.0534 ft per day (2.8E-3 m per day to 1.6E-2 m per day), and the minimum estimated travel time through the CJC aquifer for the evaluated well pairs is 408 years.

It should be emphasized that this analysis was performed for a groundwater particle that originates in the power block area, and is not representative of groundwater that originates around the periphery of the plateau or along the drainages that run from the periphery of the plateau.

2.3.1.2.3.4.2 Missouri River Alluvial Aquifer

Collector Well Pumping Test Results and Design Yield

As stated previously in Section 2.3.1.2.3.2, two pumping tests were performed in the alluvial aquifer at locations very close to FMW-07 and FMW-11 to investigate whether the aquifer will support the operation of collector wells at a capacity to meet cooling water intake needs for Callaway Units 1 and 2. This effort included the installation of a 12-inch (0.31-m) diameter pumping well (TW-01 at the FMW-07 location and TW-02 at the FMW-11 location) and 9 observation wells at each test location (Burns & McDonnell, 2008).

The materials identified in samples from the well boreholes were interpreted in the Burns & McDonnell report as follows. Generally, there is a coarsening-downward sequence of inter-bedded layers of fine to coarse sand. The upper 10 ft (3.05 m) of the formation is a mixture of silt, clay and sand, which transitions downward to fine-to-medium grained sand. From approximately 10 ft to 60 ft (3.05 m to 18.29 m) bgs, the formation is primarily sand with some gravel. The lower 40 ft (12.19 m) of the formation is a poorly sorted mixture of sand and gravel with some cobbles. The report states that based on visual observations and geophysical logs, clay layers were not encountered in any test boring at depths greater than 30 ft (9.14 m) bgs. Bedrock underlying the sand and gravel consists of dolomite and was encountered at depths ranging from 95 ft to 99 ft (28.96 m to 31.18 m) bgs. Groundwater elevations were measured prior to the start of pumping activities and averaged approximately 20 ft (6.10 m) bgs, and the saturated thickness of the aquifer is approximately 75 ft to 80 ft (22.86 m to 24.38 m).

An observation well was to be installed into the dolomite beneath the alluvial aquifer at each test location. At the FMW-07 location, the bedrock section of the borehole was left as an open hole during the pumping test, and data from the borehole during the pumping test was inconclusive. Later, the well was completed in a similar manner as the bedrock well at the FMW-11 location; a 20-ft (6.10-m) well screen was installed from approximately 20 ft to 40 ft (6.10 m to 12.19 m) below the top of the bedrock. Slug tests were performed on these wells. The estimated hydraulic conductivity of the bedrock wells was 0.13 ft per day (4.6E-5 cm per sec). This is similar to the value reported at FMW-1D of 0.06 ft per day (2.0E-5 cm per sec).

A step-drawdown test was performed prior to a 72-hour pumping test, and recovery was monitored for 24 hours. Constant pumping rates for TW-01 and TW-02 were 1595 gpm and 1906 gpm (6038 lpm and 7215 lpm), respectively. Drawdown at the pumping wells was not reported. At a monitoring location approximately 250 ft (76.2 m) inland (furthest from the pumping well), the drawdowns were approximately 1.6 ft and 1.8 ft (0.49 m and 0.55 m), respectively. All pumping test activities took place from November 7 through 17, 2007. Results from the Burns & McDonnell (2008) report are reproduced in the following table:

Site	TW-01	TW-02
Transmissivity	450,000 gpd/ft	400,000 gpd/ft
Distance to Line Source of Recharge	1,000 feet	825 feet
Saturated Thickness	78 feet	77 feet
Hydraulic Conductivity	5,770 gpd/sq ft	5,195 gpd/sq ft
Storativity	0.179	0.208

The test results were considered to be favorable and test site TW-01 (at the FMW-07 location) has been chosen as the area where three collector well systems will be constructed with a planned collective yield of approximately 50,000 gpm (189,300 lpm). The anticipated average cooling water intake need for Units 1 and 2 are 16,000 gpm (60,800 lpm) and 24,160 gpm (91,446 lpm), respectively. The design yield for each collector well in million gallons per day

(MGD) (million liters per day (MLD)) and gallons per minute (gpm) (liters per minute (lpm)) is as follows:

	(MGD)	(gpm)	(MLD)	(lpm)
Average summer	37	26,000	140	97,200
Test conditions	32	22,000	121	84,000
Average winter	25	17,000	95	65,700

The report states that the water supply from the collector wells could be 85% river water and 15% aquifer water during most of the year, except during winter months; with cold river water, it is expected that a larger percentage would come from the aquifer; however, no calculations in the report (Burns & McDonnell, 2008) were provided.

Kansas City Board of Utilities (BPU) System and U.S. Geological Survey (USGS) Studies

Similar collector well systems are operational at other areas along the Missouri River, and one that is of comparable size is operated by the Kansas City Board of Public Utilities (BPU). Two collector wells in Kansas City were put into operation in early 2000 (HCW-1) and 2006 (HCW-2) to withdraw water from the Missouri River alluvial aquifer. These wells were each proposed to supply at least 25 MGD (17,000 gpm) (113.6 MLD (79,000 lpm)), with design criteria selected for 30 MGD (20,800 gpm) (94.6 MLD (65,700 lpm)), (HydroGroup, 1993; Collector Wells International, 2006). These wells are located approximately 1000 ft (304.8 m) apart along the Missouri River where the depth to bedrock ranges from 140 ft to 150 ft (42.7 m to 45.7 m) bgs, the saturated aquifer thickness is estimated to be 124 ft (37.8 m), and the estimated hydraulic conductivity was approximately 825 ft per day (251.5 m per day). The lowest recommended pumping level is approximately 86 ft (26.2 m) below grade or 70 ft (21.3 m) below the top of the aquifer. A quarterly monitoring report for data collected through May 2006 (three months after the second well began operation) indicates:

- The highest reported combined rate from both wells was 37.1 MGD (140 MLD).
- The observed groundwater levels were drawn down to approximately 18 ft (5.5 m) at HCW-1 and 7 ft (2.1 m) at HCW-2 below the river level (HCW-2 was not operating to its proposed capacity).
- Drawdown at a new monitoring well located approximately 1000 ft (305 m) upgradient of HCW-1 was approximately 7 ft (2.1 m) below the river level.
- The pumping of HCW-2 interfered with HCW-1, but this interference was not indicative of a substantial loss in well efficiency.

The U.S. Geological Survey (USGS, 1996) studied and modeled contributing recharge areas of the alluvial aquifer across a study area that included many well fields in the Kansas City area. Transient groundwater flow and particle tracking results indicate that contributing recharge areas extend up-valley, but are smaller and skewed toward the river when the wells are in close proximity to the river. Calibrated horizontal hydraulic conductivities varied widely, but typical values of areas that have similar alluvial sand thickness and characteristics as those cited in the Burns & McDonnell (2008) report ranged from 328 ft per day to 1640 ft per day (100 m per day to 500 m per day). Sensitivity analyses indicated that the model results were most sensitive to changes in hydraulic conductivity (increases and decreases from the calibrated values) and less sensitive to increases in vertical conductance of the riverbed.

Information and analyses from the comparable system in Kansas City and the USGS modeling study help to provide context for the Burns & McDonnell pumping test results at the Callaway location. Several conclusions can be inferred:

- The estimates of transmissivity and hydraulic conductivity of the Burns & McDonnell test results are similar to the BPU location and are within the range estimated at a comparable area of the USGS modeling study.
- The saturated thickness of the alluvial aquifer at the Callaway location is approximately 45 ft (13.7 m) less than at the BPU location. However, drawdown at the BPU HCW-1 well is only 20 ft (6.1 m) of the approximate 125 ft (38.1 m) of saturated aquifer.
- Based on the observed interference of the two collector wells at the BPU location, there may be interference between the three collector wells at the Callaway location. The BPU wells are approximately 1000 ft (305 m) apart while the planned distance between collector wells at the Callaway location is approximately 1500 ft (457 m).
- Based on the current Callaway modeling results, it is anticipated that the contributing recharge area for the Callaway collector wells will extend inland across the floodplain and potentially beneath the Missouri River. These modeling results are similar to the USGS modeling results and BPU monitoring conducted for the BPU well field.

Groundwater Modeling and Assessment of Potential Impact

Based on the previous analyses, there is a hydraulic connection between groundwater in the CJC aquifer, the alluvial aquifer, and the surface water bodies, especially the Missouri River and Auxvasse Creek. Therefore, it was determined that groundwater modeling should be performed to evaluate the anticipated drawdown and contributing recharge areas in the alluvial and CJC aquifers. Also, evaluations are needed to assess potential impact to well users upgradient from the alluvial aquifer and also to assess the capability and impact of the collector well system during a hypothetical 100-year drought condition.

A three-dimensional steady-state groundwater flow model was developed across the entire study area. Waterloo Hydrogeologic, Inc. (WHI) supplied the software "Visual MODFLOW Premium 4.2" (WHI, 2006) that was used for the development and simulation of the model. The Visual MODFLOW Premium software package is a bundled group of software modules that were developed by various entities such as the United States Geological Survey (MODFLOW) and Battelle's Pacific Northwest Laboratory (RT3D), with a common interface that links these modules. MODFLOW-2000 was utilized for this model. Units were length (feet), time (day), hydraulic conductivity (ft per day), pumping rate (gpm), and recharge (in per year).

A map such as the one on Figure 2.3-22 was imported. Two points, one near the upper-left corner and one near the lower-right corner were used to "lock" the image to a coordinate system; hence a "world" coordinate system was utilized. The model boundaries were selected by "cropping" the image to the desired boundaries. Once this was done Visual MODFLOW defined the "model" coordinate system where (0, 0) is the lower left-hand corner of the boundaries selected. The two coordinates used for geo-referencing were identified in a GIS system where x, y, z coordinates from a digital elevation model are in NAD 83/NAVD 88 State Plane feet. The site-specific survey coordinates for monitoring wells and surface water gauging locations, which were provided in this coordinate system, were verified to be consistent with the digital elevation database. Therefore, the model is coordinate-based.

The grid was defined so that there are equally spaced cells across the model domain. There are 186 rows by 126 columns with approximate cell dimensions of 300 ft by 300 ft (91 m by 91 m) for a total area of approximately 55,800 ft by 37,800 ft (17,000 m by 11,520 m). There are four layers in the model, and they are one) Unconsolidated glacial/modern materials above the Graydon Chert, two) the Graydon Chert aquifer, three) the aquitard, except in the area of the Missouri River floodplain where layer three represents the alluvial aquifer, and four) the CJC aquifer. These layers were built from the bottom to the top. The bottom elevation of the CJC aquifer in the model is a constant 350 ft (107 m) msl. The top of the CJC aquifer, top of the aquitard, and the top of the Graydon Chert aquifer were interpolated from discrete data identified during the drilling of the geotechnical and hydrogeological borings and installation of the monitoring wells. The ground surface was interpolated from the digital elevation file previously mentioned. Inactive cells for each layer were identified and defined by assessing where the upper model layers are not present (eroded around the plateau) or outside the stream boundaries of the model (refer to Figure 2.3-44 through Figure 2.3-49). The calibrated model is continuous across the study area, such that the transition from the glacial valley wall to the floodplain is simulated.

Boundary conditions were defined across each layer of the model (refer to Figure 2.3-44 through Figure 2.3-49). River boundaries (blue) were defined in the model using linear interpolation of surface water elevations along the river segments. When this is done in Visual MODFLOW, each cell along the segment is assigned a surface water elevation in accordance with a linear interpolation between two endpoints. Drains (grey) were defined along drainages from the top of the plateau down the hillsides to connections with the river boundaries. These were also defined using linear interpolation of approximated ground surface elevations along segments. Like the river boundary condition, each cell along the segment is assigned an elevation in accordance with the linear interpolation between two endpoints. Drains were also assigned around the periphery of the plateau in layers one and two to simulate seepage or evapotranspiration at the outcrop areas.

General head boundaries (green) were assigned for the pond surface water elevations on top of the plateau. Constant head boundaries (red) were assigned along the edges of the model on the south side of the Missouri River and on the upgradient edge of the alluvial aquifer to the east of Auxvasse Creek. Conductance (seepage) between the rivers and ponds and the underlying aquifer was defined as 90 sq ft per day (8.4 sq m per day) for the ponds, 900 sq ft per day (83.6 sq m per day) for the Callaway Plant Unit 2 excavation pond, 1500 sq ft per day (139.4 sq m per day) for Auxvasse, Logan, and Mud Creeks, and 2.25E6 sq ft per day (2.09E5 sq m per day) for the Missouri River.

Recharge was set to two inches per year for the Callaway Plant Unit 1 area and the steep hillside areas, three inches per year for the remaining areas of the plateau, and four inches per year for the alluvial floodplain area. Recharge rates for relatively impermeable soils and steep hillsides will be relatively low as compared to the approximate 10% of normal precipitation that is estimated for the alluvial aquifer.

Estimated values of hydraulic conductivity from aquifer tests were imported at the different well locations at the well screen midpoint. Again, these values were associated with a specific layer in the model. These values were interpolated across the model domain for each layer and zones of hydraulic conductivity were subsequently defined from this interpolation. For horizontal hydraulic conductivity, Kx = Ky. Initial values of Kz were defined by the mean of Shelby-tube sample values. These zones of hydraulic conductivity were the starting values for the model calibration process. Through the calibration process, these zones and their values were changed to create a flow balance in the model layers such that estimates of hydraulic head were similar to actual measured values (i.e. calibration targets).

The site investigation monitoring wells were inserted into the model with survey coordinates. The monitoring elevation was set to the middle of the well screen and this screen elevation is associated with a specific layer in the model. The calibration target value at each well was estimated as the average value of those measured between March 2007 and January 2008. Initial heads were set to ground surface elevations. The default WHS solver (bi-conjugate gradient stabilized) was selected. Recharge was set to be applied to the uppermost active layer. All model layers were set to Type three, which is a confined/unconfined variable storage and transmissivity setting. Cell re-wetting was not activated.

Visual MODFLOW provides a seamless interface to the Parameter Estimation (PEST-ASP) program, which is used to optimize a model calibration and assess the predictive capability of a model. Individual property parameters, such as hydraulic conductivity, storage, or recharge, are selected and a range of values is allowed for each parameter selected. MODFLOW was run with the PEST option, such that as the model was run many times, each parameter value was changed, the calibrated hydraulic head at each observation point was compared to the measured calibration target, and the overall error in the calibrated hydraulic heads was quantified. PEST determined when the optimum value of each parameter was identified within the range specified. At the end of each model run, the calibrated hydraulic heads were compared to the measured hydraulic heads, areas where the calibration was strong versus weak were assessed, and a decision was made as to how the parameter values should be updated.

Calibrated hydraulic head for the four layers is shown on Figure 2.3-50 through Figure 2.3-54. Layer one is the glacial and post-glacial material above the Graydon Chert aquifer. This layer is modeled as a saturated unit from the water table surface to the bottom of the layer. Hydraulic head for this layer was calibrated to be slightly higher than that of Layer two in the central portion of the plateau. It is understood from the field investigation that this layer is partially saturated to saturated and near the top of the chert, acts as a confining unit to the Graydon Chert aquifer.

Layer two is the Graydon Chert aquifer. Calibrated hydraulic heads match the observed heads very closely. Potentiometric surface contours are similar to those presented in Section 2.3.1.2.3.2. for the field measured values; however, the model contours extend to the drains along the layer boundaries.

Layer three is the aquitard, except along the Auxvasse Creek and Missouri River stream boundaries where alluvium replaces the aquitard. The hydraulic conductivity for the alluvial aquifer was set at 750 ft per day (228.6 m per day), based on the Burns & McDonnell pumping test (Burns & McDonnell, 2008a). The hydraulic conductivity of the alluvium was not allowed to vary during the model calibration activities.

Layer 4 is the CJC aquifer. The model predicted potentiometric surface contours are similar to those presented in Section 2.3.1.2.3.2 for the field measured values. There is one primary difference: measured groundwater elevations at MW-5D are higher than others beneath the plateau; this anomaly was represented by a dashed line on the figures in Section 2.3.1.2.3.2; and this anomaly was not duplicated in the model because it would have required adding more zones of hydraulic conductivity and adding complexity to the model.

Once the model was calibrated, the three collector wells were added to the alluvial aquifer and a simulation was performed with the collector wells pumping at projected pumping rates of 18,000 gpm (68,130 lpm) each. Each collector well was represented by four cells: one pumping well with three pumping wells in a radial configuration skewed toward the Missouri River (to simulate the radial lateral lines toward the caisson). For each collector well, the overall pumping rate was 18,000 gpm (68,130 lpm), and this was divided as 9,000 gpm (34,065 lpm) at the caisson and 3,000 gpm (11,355 lpm) at the three radial pumping wells. This simulation is termed the baseline simulation.

Next**,** a sensitivity analysis was performed by varying hydraulic conductivity and riverbed conductance, one parameter at a time. For assessment of the 100-year drought condition, surface water boundary conditions were lowered (as discussed below). For each simulation, a parameter or condition was changed, the model was run without the wells pumping, the model-predicted steady-state hydraulic heads were saved back into the model as starting heads, and the model was then run with the wells pumping. This allowed for an evaluation of how each change in parameter values affected drawdown, both in magnitude and areal extent as compared to the baseline simulation. It should be noted that none of the simulations had an impact to areas very far upgradient of the glacial valley wall and therefore, there was no impact to other upstream areas or upper layers of the model. Therefore, the following discussion of the model inputs and subsequent results are presented with a focus on the floodplain area.

The floodplain area of the model was developed with ground surface elevations and bedrock elevations estimated from boring logs. Hydraulic conductivity of the alluvial aquifer was set to 750 ft per day (228.6 m per day), based on estimates from the Burns & McDonnell pumping tests. Horizontal hydraulic conductivity of the CJC aquifer beneath the alluvial aquifer was set to 0.06 ft per day (2.1E-5 cm per sec) based on slug test results. Vertical hydraulic conductivity of the CJC aquifer was calibrated as 0.0012 ft per day (4.5E-3 cm per sec). The Missouri River bed hydraulic conductivity was set to 250 ft per day (76.2 m per day).

For the average groundwater elevation condition, the Missouri River elevations varied from 507 ft (154.5 m) msl at the upstream end of the model to 503 ft (153.3 m) msl at the downstream end of the model. For the 100-year drought condition, the Missouri River elevations varied from 499 ft (152.1 m) msl at the upstream end of the model to 495 ft (150.9 m) msl at the downstream end of the model. The constant head boundaries along the edges of the model on the south side of the Missouri River and on the upgradient edge of the alluvial aquifer to the east of Auxvasse Creek (shown in red on Figure 2.3-46) were also decreased by 8 ft (2.4 m) to reflect this condition. A river surface elevation of 496 ft (151.2 m) msl corresponds to a river flow rate of 9000 cfs (255 cms) that the U.S. Army Corps of Engineers (USACE) will provide (assuming no tributary input) and projections for the winter with ice jam condition at the Callaway surface water intake. A flow rate of less than 9000 cfs (255 cms) is considered to have a probability of 10% (Burns & McDonnell, 2007). The 495 ft (150.88 m) msl was estimated to be the lowest probable river elevation by performing a linear regression using the median, lower quartile, and lower decile values of 499 ft, 497 ft, and 496 ft (152.1 m, 151.5 m, and 151.2 m) msl, respectively, and projecting the regression line to 1%.

Figure 2.3-55 and Figure 2.3-56 show the baseline calibrated groundwater elevations for the non-pumping conditions. Model-predicted drawdown in the alluvial and CJC aquifers during pumping conditions are presented in Figure 2.3-57 and Figure 2.3-58, respectively. The following list summarizes the model simulations and their generalized result. Drawdown was contoured at 2-ft (0.61 m) intervals; only significant changes are reported.

- Riverbed conductivity was changed to assess uncertainty and sensitivity of this parameter on the resulting drawdown and contributing recharge area. When the river bed conductivity was increased to 500 ft per day (152.4 m per day) or decreased to 125 ft per day (38.1 m per day), there was no significant change in the drawdown at the pumping wells or the drawdown and contributing recharge area across the alluvial or CJC aquifers.

- The hydraulic conductivity of the aquifer was changed to assess the impact of seasonal variations of hydraulic conductivity due to changes in aquifer temperature, viscosity, and density. Burns & McDonnell report (2008a) that aquifer temperatures will vary by approximately 10 degrees F (18 degrees C) higher and lower than the test conditions such that estimated summer and winter values of hydraulic conductivity will be approximately 900 ft per day and 660 ft per day (274 m per day and 183 m per day), respectively. In the model, when the alluvial aquifer hydraulic conductivity was increased to 900 ft per day (274 m per day), drawdown at the pumping wells decreased by approximately 2 ft (0.61 m) and there was no significant change in the drawdown in the CJC beneath the pumping wells. The contributing recharge area was broader in the alluvial aquifer and smaller in the CJC aquifer. When the alluvial aquifer conductivity was decreased to 600 ft per day (183 m per day), drawdown in the alluvial and bedrock aquifers increased around the pumping wells by approximately 2 ft (0.61 m).

- The hydraulic conductivity of the CJC aquifer was changed to assess the spatial uncertainty in the CJC aquifer beneath the alluvial aquifer. When the CJC aquifer horizontal conductivity was increased to 0.1 ft per day (3.5E-5 cm per sec), there was no significant change. When the CJC horizontal conductivity was decreased to 0.01 ft per day (3.5E-6 cm per sec), the drawdown in the CJC aquifer beneath the pumping wells increased by approximately 4 ft per day (1.22 m per day) and the contributing recharge area increased slightly in size.

- The hydraulic conductivity of the alluvial aquifer was changed to assess the spatial uncertainty of hydraulic conductivity in areas upgradient of and farther removed from the pumping test and collector well installation area. When the hydraulic conductivity of the alluvial aquifer outside of Binggeli Island area was decreased to 250 ft per day (76.2 m per day) or 100 ft per day (30.5 m per day), there was no significant change in the drawdown at the pumping wells or in the CJC aquifer beneath the pumping wells. The contributing recharge areas extended slightly wider across the floodplain but did not extend as far to the valley wall.

- When the Missouri River level and constant head boundaries were decreased to the levels described above for the 100-year drought condition, there was no significant change in the drawdown in the alluvial aquifer near the pumping wells, but the drawdown in the CJC aquifer beneath the pumping wells increased by approximately 2 ft per day (0.061 m per day). There was no significant change in the contributing recharge areas.

- The 100-year drought condition was simulated with the lower seasonal hydraulic conductivity value of 600 ft per day (183 m per day) for the alluvial aquifer to evaluate the combined effects. Drawdown in the alluvial and bedrock aquifers around the pumping wells increased by approximately 4 ft to 6 ft (1.2 m to 1.8 m). There was no significant change in the contributing recharge areas.

Zone Budget is a tool developed by the USGS (and fully implemented in Visual MODFLOW) to calculate water budgets into and out of a designated zone by tabulating flow produced by MODFLOW on a cell-by-cell basis. Zone Budget was utilized to evaluate a sub-regional water budget across a zone defined by an area that is slightly larger than and inclusive of the predicted contributing recharge areas for the alluvial and CJC aquifers (layers three and four, respectively) in the floodplain area. The zone is shown in blue on Figure 2.3-59, which also shows the predicted groundwater elevations for the alluvial aquifer when the collector wells are operational during the 100-year drought condition. The zone was defined for both layers three and four and water contributions into and out of this zone were evaluated for the baseline and 100-year drought conditions. The following table summaries the results.

	Baseline		**100-Year Drought**	
	Flow Rate (ft^3/day)	Fraction of Well Intake	Flow Rate (ft^3/day)	Fraction of Well Intake
Recharge	118,790	0.0114	117,720	0.0113
River (in-out)	9,184,200	0.8866	9,263,000	0.8913
GW (in-out)	1,076,435	0.1036	1,000,190	0.0962
Well Intake	10,393,000	NA	10,393,000	NA

These model results indicate that the Missouri River is expected to contribute nearly 90% of the water that is extracted by the collector well system and that upgradient sources of groundwater are expected to contribute nearly 10%. The remaining fraction (approximately 1.1%) is contributed by precipitation recharge.

In summary, the model simulations suggest that the groundwater capacity required for Callaway Units 1 and 2 can be met by the collector well system (three collector wells pumping 50,000 gpm (189,300 lpm)) within the parameter constraints reported from the pumping test results by Burns & McDonnell (2008). The model simulations suggest that the potential impact to the alluvial and CJC aquifers is minimal. The simulated drawdown and contributing recharge areas of the alluvial aquifer at the Callaway location are similar to the observed drawdown at the BPU well field and estimated contributing recharge areas from the USGS study. There is no anticipated impact to groundwater well users that have been identified in Section 2.3.2.2.}

2.3.1.3 References

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2.3.2 WATER USE

This section describes surface water and groundwater uses that could affect or be affected by the construction or operation of the {Callaway Plant Unit 2} and associated transmission corridor and offsite facilities. Consumptive and non-consumptive water uses are identified, and water diversions, withdrawals, consumption, and returns are quantified. In addition, this section describes statutory and legal restrictions on water use and provides the projected water use for {Callaway Plant Unit 2}.

2.3.2.1 Surface Water Use

2.3.2.1.1 Surface Water

{Callaway Plant Unit 2 is located on a plateau within the Auxvasse Creek watershed. Although the plateau on which Callaway Plant Unit 2 is located is relatively level, peripheral streams have deeply dissected its flanks in a dendritic pattern. The Auxvasse Creek watershed is the one that encompasses the plateau. Detailed information about the water bodies nearest to the plateau is provided in Section 2.3.1.1.

Since the plateau is the topographic high in the area, surface runoff drains radially into small intermittent streams. These small streams are branches of local streams that include Logan Creek to the East, Mud Creek to the Southwest, Cow Creek to the North, and Auxvasse Creek to the West. Mud Creek and Cow Creek are tributaries to Logan and Auxvasse Creek, respectively. Logan Creek and Auxvasse Creek have relatively steep channel gradients and drain directly into the Missouri River. Stinson Creek and Crows Fork Creek are tributaries of the Auxvasse Creek on the upstream west side. The drainage areas and confluence points with the Missouri River for Logan Creek and Auxvasse Creek are illustrated on Figure 2.3-5. The Auxvasse Creek watershed has a drainage area of 221,876 acres (89,790 hectares).

Several small lakes and impoundments are also located within the Auxvasse Creek watershed. Figure 2.3-5 shows the water bodies and major streams and rivers near Callaway Plant Unit 2, which could affect or be affected by Callaway Plant Unit 2.}

2.3.2.1.2 Consumptive Surface Water Use

{Surface water use data for Callaway County were obtained from the Missouri Department of Natural Resources (MDNR). There are no state laws, regulations or policies that specify the quantity of surface water that any diverter may use. “Missouri is a riparian water law state, and all landowners touching or lying above water sources have a right to a reasonable use of that water” (MDNR, 2007a).

No water use permits are required. However, since 1983, any large quantity water withdrawals (100,000 gallons per day or more, from either surface water or groundwater) are required to be reported to the MDNR Water Resources Program (Major Water Users Registration) and are labeled as Major Water users (MDNR, 2003). Figure 2.3-60 illustrates the total surface water withdrawals reported by Major Water users in Callaway County.

As per Water Resources Report No. 64 (MDNR, 2002a), the surface water use in the central region of Missouri (including Callaway County) indicates fluctuating demands. “Peak reported surface water use occurred in 1998 and lowest use occurred in 2000. Electrical power generation is the major surface water use category, averaging 99.9% of the total surface water withdrawals. Significant quantities of surface water were reported for domestic, municipal and fish and wildlife categories, even though together they represent less than 0.1% of the total. Surface water use in this central region alone represents over 56% of the total surface water used in the entire state" (MDNR, 2002a). As illustrated in Figure 2.3-60, the peak reported surface water use in Callaway County occurred in 1996 and the lowest use occurred in 1998.

In the mid-Missouri region, water withdrawals are used for industrial and residential needs, power generation, and irrigation. However, except for the Central Electric Power Cooperative Chamois Plant, there are no major municipal or industrial water users located within five miles of the Callaway Plant site (MDNR, 2007b). The nearest municipal users are at Chamois, Mokane, and Fulton but these municipal users rely on groundwater supply for their water consumption.

Table 2.3-26 identifies active surface water users within the 50-mile (80 km) radius of the location of Callaway Plant Unit 2 and their withdrawal rates (MDNR, 2007c). Table 2.3-26 indicates that withdrawals are mainly for irrigation and power generation. There are no withdrawals for public water supply within 25 miles upstream or 50 miles downstream of the Callaway Plant discharge. Figure 2.3-61 shows the locations of all reported surface water intakes within the 50-mile (80 km) radius of the location of Callaway Plant Unit 2. In the Callaway Plant site area, the predominant water withdrawal from the Missouri River is for power generation by Callaway Plant Unit 1 and the Central Electric Power Cooperative Chamois Plant. Central Electric Power Cooperative Chamois Plant is the largest water user in the area; the Callaway Plant Unit 1 is the second largest user. Local streams are presently used for irrigation and livestock watering.

Based on historical conditions in 2006, Callaway Plant Unit 1 reported an annual average withdrawal of 34.6 cfs (0.98 cms) with a maximum daily withdrawal of 52.4 cfs (1.48 cms). Most of the water withdrawn for Callaway Plant Unit 1 that is not lost to the atmosphere is returned back to the Missouri River after being circulated through the plant condensers. The monthly variation of the blowdown discharge rate from Callaway Plant Unit 1 is shown in Table 2.3-27, which represents the typical annual water use pattern by Callaway Plant Unit 1. Based on the existing intake structure, the highest 2006 monthly average withdrawal was 42.6 cfs (1.21 cms), and based on the current National Pollutant Discharge Elimination System (NPDES) Permit No. MO-009800, the highest monthly discharge rate from 2004-2007 was 11.8 cfs (0.334 cms) (MDNR, 2007d; MDNR, 2007e).

Water use projections are assessed based on population trends in a given area. Since surface water is not a common source for drinking water in Callaway County, the surface water use projection in the county cannot be calculated. Excluding the plant water use of Callaway Plant Unit 2, the future additional use of surface water will be extremely limited. The surface water use rate in the future will change with the additional withdrawal for Callaway Plant Unit 2, but there are still limited uses for water that principally comprise surface water in Callaway County.

Figure 2.3-62 illustrates surface discharge data developed from the NPDES MDNR registry for a 50-mile radius (80 km) from the Callaway Plant Unit 2 site. MDNR has issued 138 NPDES surface discharge permits in Callaway County and 967 within the 50-mile (80 km) radius of the Callaway Plant Unit 2 site (MDNR, 2006).}

2.3.2.1.3 Non-Consumptive Surface Water Use

{The major non-consumptive surface water uses in the vicinity of the site are recreation, fishing, and navigation. The recreational activities include swimming, fishing, and boating along the Missouri River.

The dikes, revetments, and levees constructed by the U.S. Army Corps of Engineers (USACE) as part of the Missouri River Navigation and Flood Control Project have transformed the once sprawling and constantly changing Missouri River into a narrower, deeper, fixed channel designed to naturally maintain a 735-mile (1,183 km) long, 9 ft (3 m) deep navigation channel. However, barge traffic has been steadily declining (USACE, 1998).

Fishing is a year-round activity in the Missouri River. Boating is an activity that is generally limited to the 9-month period from spring to fall. Swimming is an activity that occurs during the summer season.

Two public ramps for boating are located within 5 miles (8 km) of the Callaway plant property: Mokane Access and Chamois Access. Mokane Access is owned by the Missouri Department of Conservation and Chamois Access is run by the City of Chamois. There is another Missouri River access located in Portland, and it is owned by Hermann Sand and Gravel.}

2.3.2.1.4 Statutory and Legal Restrictions on Surface Water Use

{The withdrawal of water from the Missouri River to be used in the cooling systems for Callaway Plant Unit 2 is not subject to provisions mandated by the MDNR. The discharge of blowdown from cooling towers, effluent from a sewage treatment plant, and storm water runoff will be subject to the MDNR operating permit.}

2.3.2.1.5 Plant Water Use

Plant water use for {Callaway Plant Unit 2} is described in Section 3.3. There are no other station water uses other than those described in Section 3.3.

2.3.2.2 Groundwater Use

This section provides a description of the groundwater use at, and in the vicinity of, the {Callaway Plant Unit 2} site. This section also describes the regional and local groundwater resources that could be affected by the construction and operation of {Callaway Plant Unit 2}.

The objective of this section is to discuss the U.S. Environmental Protection Agency (EPA) sole source aquifers within the region and to describe groundwater use {in central Missouri, current users in Callaway and Osage Counties, current Callaway Plant Unit 1 groundwater use, expected future demands for central Missouri and Callaway and Osage Counties, and anticipated Callaway Plant Unit 2 groundwater use}, and to identify and determine impacts to the groundwater aquifers due to the operation and construction of {Callaway Plant Unit 2}.

2.3.2.2.1 Sole Source Aquifers

{The Sole Source Aquifer (SSA) Program, which is authorized by the Safe Drinking Water Act, allows for protection of an aquifer when a community is dependent on a single source of drinking water and there is no possibility of a replacement water supply to be found. The U.S. EPA defines a sole or principal source aquifer as one which supplies at least 50% of the drinking water consumed in the area overlying the aquifer (USEPA, 2007a).

The Callaway Plant site is located in EPA Region 7 (Nebraska, Iowa, Kansas, and Missouri). There are no sole source aquifers in this region.}

2.3.2.2.2 {Missouri} Regional Groundwater Use

{Groundwater is extensively used as a source of potable water across the state of Missouri. Important aquifers of Missouri are described in Section 2.3.1.2. All of the potable groundwater in storage in Missouri originated as and is recharged by relatively local precipitation. It is estimated that during normal weather cycles the volume of potable groundwater in storage is:

Aquifer Storage	Missouri - Mississippi Alluvial	Glacial (northern Missouri only)	Sand/Gravel (Missouri southeastern boot-heel area only)	Bedrock (south of transition zone only)	Total
Rounded trillion gallons	26	9	44	421	500
Rounded trillion liters	98	34	166	1,594	1,892

Reference: Groundwater Resources of Missouri (MDNR, 1997).

To assess Missouri's groundwater resources, the state has been divided into seven major groundwater provinces and two sub-provinces (MDNR, 1997). The boundaries are based on aquifer area, type of groundwater system, groundwater flow patterns, groundwater quality, and other factors. The Callaway Plant site and all of Callaway County are located within the Northeast groundwater province with aquifers as described in Section 2.3.1.2 for northern Missouri. Five miles (8 km) south of the Callaway Plant Unit 2, the Missouri River alluvial aquifer is considered to be a part of the Mississippi and Missouri River groundwater sub-province. It is planned that water will be drawn from a collector well system located in this sub-province on the Missouri River floodplain. Across from the intake area on the southern side of the Missouri River, Osage County is located within the Salem Plateau groundwater province with aquifers as described in Section 2.3.1.2 for southern Missouri.

As part of the Missouri State Water Plan, Callaway and Osage Counties are managed by the Jefferson City Regional Office of MDNR, which oversees the "Central Missouri" region (MDNR, 2002b), as shaded on Figure 2.3-19.

Estimated water usage (surface water and groundwater) for central Missouri in 1995 by use was:

Use	Domestic	Agricultural	Commercial	Industrial	Total
Billion gallons	15.3	6.3	3.2	0.3	25.1
Billion Liters	58.0	23.8	12.1	1.1	95.0

Reference: Topics in Water Use: Central Missouri (MDNR, 2002b).

Central Missouri is home to a large number of universities and Missouri state government offices. The percentage of publicly supplied water allocated to commercial and public uses (85.5%) is higher than the statewide average (65.2%). Industrial water use was less than 2% of the public water supply as compared to the state-wide average of 24.4% (MDNR, 2002b).

Three-fourths of the population in central Missouri is connected to a public water supply. Of this group, two-thirds received public water supplied by groundwater. The Missouri River and a number of small public water supply lakes supply the remaining one-third. For private supply, nearly 100% of self-supplied domestic water withdrawals come from groundwater sources, although a small percentage of users (1-2%) obtain water from surface water sources such as springs, creeks, lakes, or cisterns.

Farmers in central Missouri draw water for both irrigation and livestock. Surface water sources account for approximately 70% with the balance supplied by groundwater.

For power production, water usage by four thermoelectric power generation plants in central Missouri was approximately 31 billion gallons (117 billion liters) in 2000 (MDNR, 2002b). Callaway Plant Unit 1 in Callaway County withdraws surface water from the Missouri River and one groundwater well; the Central Electric Power Cooperative in Osage County withdraws surface water from the Missouri River and from two groundwater wells; the University of Missouri at Columbia and the City of Columbia (Columbia Power and Light) withdraw their water from groundwater wells.

MDNR divides water supply wells into classes for regulatory purposes. These are public water systems (community public water supply wells, transient non-community public water supply wells, and non-transient non-community public water supply wells), private wells (domestic and multiple-family), petroleum distribution, high yield, Grade A dairy, unconsolidated material irrigation, and bedrock irrigation (MDNR, 2007f).

The service description of public wells as quoted from the MDNR guidelines is as follows:

- Community. A public water system which serves at least 15 service connections or regularly serves an average of at least 25 residents on a year-round basis. Examples are cities, towns, and mobile home parks.
- Transient Non-community. A public water system that is not a community water system which has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days of the year. Examples are restaurants, motels, convenience stores, and campgrounds.
- Non-transient Non-community. A public water system that is not a community water system, and that regularly serves at least 25 of the same persons over six months per year. Examples are schools and factories.

The service description of private wells as quoted from the MDNR guidelines is as follows:

- Domestic. A private water supply well that is constructed to meet minimum standards and is equipped with a pump that does not have the capacity to produce more than 70 gallons of water per minute and services three or less service connections. A private domestic water supply well that produces less than 70 gallons of water per minute regardless of the use is a domestic well. This allows for 1 to 3 families.
- Multi-family. A private water supply well constructed for the purpose of serving more than three dwellings, but having less than 15 service connections and serving less than 25 individuals daily at least 60 days out of the year. This allows for multiple family and small industry (non-drinking).

All public water supply wells must be drilled by permitted well drillers and well construction is regulated by the MDNR. The MDNR Department of Environmental Quality - Public Drinking Water Program administers and must approve engineering plans and specifications for all community and non-transient non-community public water supply wells. They provide general guidelines for constructing transient non-community public water supply wells. The Division of Geology and Land Survey assists by providing casing and total depth information. Private well construction standards, as well as those for monitoring wells and heat pump wells, are published by the MDNR Division of Geology and Land Survey (DGLS) in Missouri Well Construction Rules (MDNR, 2007f). Construction of private water supply wells is administered by the MDNR Division of Geology and Land Survey. Once private wells are constructed, there are no further administrative or reporting requirements with MDNR.}

2.3.2.2.3 {Callaway and Osage Counties} Groundwater Use

{In Callaway County, it is estimated that approximately 10,000 billion gallons (37,850 billion liters) of potable groundwater are in storage. This total is estimated from several aquifers as follows:

Aquifer Storage	Mississippian	Cambrian-Ordovician	St. Francois	Missouri Alluvial	Total
Rounded billion gallons	250	9,650	0 (limited or unknown extent)	100	10,000
Rounded billion liters	945	36,530	0	375	37,850

Reference: Groundwater Resources of Missouri (MDNR, 1997).

In Osage County, it is estimated that approximately 6,400 billion gallons (24,230 billion liters) of potable groundwater are in storage. This total is estimated from several aquifers as follows:

Aquifer Storage	Springfield Plateau	Ozark	St. Francois	Missouri Alluvial	Total
Rounded billion gallons	Not present	5,700	640	60	6,400
Rounded billion liters	Not present	21,600	2,400	230	24,230

Reference: Groundwater Resources of Missouri (MDNR, 1997).

In 2000, the groundwater use in Callaway and Osage Counties by major water users was as follows:

County	Domestic	Municipal	Irrigation	Recreation	Industrial	Elec. Power	Fish and Wildlife	Total
Callaway								
Million gallons	286	959	186	0	0	151	0	1,582
Million Liters	1,082	3,630	704	0	0	572	0	5,988
Osage								
Million gallons	0	180	0	0	0	97	0	277
Million Liters	0	681	0	0	0	367	0	1,048

Reference: Major Water Use in Missouri 1996-2000 (MDNR, 2003).

Table 2.3-28 summarizes both active and closed public water systems listed in the Safe Drinking Water Information System (SDWIS) (USEPA, 2007b) for Callaway and Osage Counties. The active systems are consistent with those tracked by the MDNR. Table 2.3-29 summarizes the number of wells, population served, and usage reported for the active public water systems in Callaway and Osage Counties as reported in the 2007 Census Report (MDNR, 2007g). In some cases, the individual wells for a particular public water supply system may not be located near each other. The largest providers in Callaway County are the Callaway Public Water Supply

District (PWSD) #1, Callaway PWSD #2, and the city of Fulton, which combined serve nearly 35,000 people. The largest providers in Osage County are the Osage PWSD #1 and the city of Linn, which are the only ones to serve more than 1,000 people.

Table 2.3-30 summarizes the individual public and private water wells within the hydrogeologic study area boundary and within approximately 1 mile (1.6 km) of the boundary. The sources of the data are the MDNR drilling records of public and private wells (referenced by the DGLS number), the AmerenUE Land Use Census Report of local groundwater wells (AmerenUE, 2006a), and a request to the MDNR (MDNR, 2007h). The MDNR DGLS records for each well contain the drilling log, well depth, casing depth, and yield at time of drilling. Information from private wells identified by AmerenUE is limited to the location. Information from the MDNR request contains the well type, section/township/range location, and in some cases, information about the well depth, casing depth, and yield at time of drilling. It should be noted that there is not a common number or reference that allows these three sources of data to be cross-referenced. Therefore, the table summarizes all of the information from each source of data and is sorted by the data source. Well locations from each data source except the MDNR request are shown on Figure 2.3-63. Locations from the MDNR request were limited to section, township, and range, and therefore, they could not be placed on the figure with any reasonable accuracy.

Review of the MDNR well logs indicates that all wells in Callaway County for which the well logs are available are drilled into the Cambrian-Ordovician aquifer. In Osage County, well logs are not available, but limited information was available through personal communication (MDNR, 2007i). The depth and open length of the wells are variable and depend on the ground surface elevation at the well location, which varies by approximately 300 ft (90 m), and the yield required. Generally, private wells are shallower and end within the Cotter or Cotter-Jefferson City (CJC) formations, which have a yield of approximately 5 to 35 gpm (20 to 130 lpm). Public wells are deeper and extend to the Roubidoux, Eminence, or Derby-Doe Run formations, which have yields of approximately 200 to 600 gpm (750 to 2300 lpm). Estimated yields are based on cumulative yield over extended lengths of the well.

The distance from Callaway Plant Unit 2 to the local groundwater wells is shown on Table 2.3-30. The closest non-AmerenUE well is classified as an irrigation well (although it is believed to be used to fill sprayer tanks and for washing equipment) and is located approximately 0.8 miles (1.3 km) north (and downgradient) of Callaway Plant Unit 2. This well is 375 ft (114.3 m) deep and is likely drawing water from the Cotter-Jefferson City aquifer. Additional verification of the two wells at the Central Electric Power Station located across the Missouri River and Osage County indicate that there are two active wells that are utilized for cooling water and boiler operations, but are not used as drinking or irrigation water as indicated in the MDNR records (Central Electric Power, 2008). These wells are screened in the alluvial aquifer, are located approximately 75 ft (22.9 m) from the river, and provide approximately 75 to 100 gpm (285 to 380 lpm).}

2.3.2.2.4 {Callaway Plant Unit 1} Groundwater Use

{Callaway Plant Unit 1 does not use groundwater as the source of cooling water. The existing source of cooling water for Callaway Plant Unit 1 is a surface water intake located along the Missouri River. The water is pumped up the water line corridor, utilized by the plant, and discharged down the water line corridor to a location approximately 450 ft (135 m) downstream of the water intake. In the late 1990s a deep well was installed, it has a depth of 103 ft (31 m) below ground surface (bgs) and withdraws water from the Missouri River alluvial aquifer. Yield has been estimated at 300 gpm (1,100 lpm). Later, in the late 1990s, a deep well was installed to supply lubrication water to the intake pumps and the shallow well was maintained as a back-up well. The deeper well is cased to 350 ft (107 m) and has a total depth of 854 ft (260 m). Estimated yield is 665 gpm (2,517 lpm).

During Callaway Plant Unit 1 construction, three water supply wells were installed from approximately 1,100 ft to 1,510 ft (335 m to 460 m) below ground surface into the Cambrian-Ordovician aquifer. These wells are highlighted on Table 2.3-30. These wells are open across multiple formations from the CJC aquifer through either the Eminence Formation or deeper to the Derby-Doe Run formation. Initially, the three wells were used for potable water, a concrete batch plant, and for on-site lab services. Presently, only one well, Well #3 (DGLS # 028347), is utilized for potable water. The estimated average total groundwater use is 50 gpm (190 lpm), with a break-down as follows: potable water usage is 15 gpm (57 lpm), fire make-up water is 6 gpm (23 lpm), demineralization make-up water is 15 gpm (57 lpm), and miscellaneous water use is 10 to 15 gpm (38 to 57 lpm). Due to the small amount of water withdrawn relative to the estimated yield of the well from the drilling record (approximately 565 gpm (2,139 lpm)), there has been no MDNR reporting requirement.}

2.3.2.2.5 {Central Missouri} Groundwater Demands

{The Missouri State Water Resources Plan attempts to identify water use problems and opportunities related to drinking water, agricultural, industrial, recreational, and environmental needs. The central region has relatively abundant surface water and groundwater resources and, as a result, water use concerns are primarily focused on water quality and resource protection. These concerns include surface water and groundwater protection from non-point sources, including municipal, industrial, sewer, septic tank, and agriculture-related potential contaminant sources (MDNR, 2002b).

Central Missouri usually has enough snow and rainfall to replenish the water supply in principal aquifers but during years of drought, water levels in aquifers decline. Water conservation is common during droughts, and mandatory curtailment of water use sometimes becomes necessary in severe, persistent droughts. Mandatory curtailment of water use must be ordered by the governor, under state emergency declarations. Missouri has no statute that requires curtailment in certain circumstances. However, citizens can file suit under the “reasonable use” doctrine to curtail what is alleged to be unreasonable or excessive use (MDNR, 2002b).

The Missouri Drought Plan was first published in 1995. Beginning in the summer of 1999 through the summer of 2000, many parts of Missouri experienced drought conditions and the Plan was activated. Especially hard hit were agriculture and water supply reservoirs in north central and northwestern Missouri. The lack of precipitation was compounded by marginal water reserves in several community reservoirs that supplied drinking water. Many local water supplies imposed voluntary or mandatory restrictions on water use. Additional pipelines were laid to allow water to be drawn from local streams to meet the water demand. Through the implementation of the original Plan and subsequent revisions, rainfall, stream flow, and groundwater level monitoring and reporting were improved to near-real time (MDNR, 2002c).

Drought is defined by five categories that pertain to indicators that are important to various water users as follows: agricultural, hydrological, meteorological, land use, and socio-economic. Based on these indicators, Missouri divided the state into three regions according to drought susceptibility, as shown on Figure 2.3-64. Region A has minor surface water and groundwater supply drought susceptibility. It is a region underlain by saturated sands and gravels (alluvium). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs. Region B has moderate surface and groundwater supply drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs but due to required well depths, irrigation wells are very expensive. The topography is generally unsuitable for row-crop irrigation. Region C has severe surface and groundwater supply drought vulnerability. Surface water resources usually become inadequate during extended drought. Groundwater resources are naturally of poor quality and typically only supply enough for domestic needs. Irrigation is generally not feasible and groundwater withdrawal may affect other users. Central Missouri and Callaway and Osage Counties fall into Region B, except along the Missouri River, which falls into Region A.

The MDNR has been monitoring groundwater levels throughout Missouri since the mid-1950s. The 1950s were a time of severe regional drought. Many shallow wells were failing due to declines in water level. The initial monitoring network consisted of about 23 wells. The network is operated by the MDNR's Water Resources Center, and currently consists of more than 100 wells that vary from less than 30 ft (9 m) deep to more than 1,800 ft (550 m) deep. These wells are summarized in Table 2.3-31 (MDNR, 2007j). They monitor aquifers ranging from shallow, unconfined alluvial and glacial drift aquifers to deep confined bedrock aquifers. Some of these were constructed by the MDNR specifically for measuring groundwater levels. Most, however, began as water supply wells whose use was later discontinued.

Approximately 50 new groundwater-level monitoring wells are planned to be added to the network bringing the total number of monitoring wells to about 155. Many of these are being placed in areas of high groundwater use to help better document water-level changes caused by all types of development. Other monitoring wells will be placed in areas not currently monitored to help fill data gaps. Several of the wells are being placed in areas far from significant groundwater use to monitor the variations in groundwater levels under natural conditions (MDNR, 2002c).

Water levels for the last five years are shown on Figure 2.3-65 through Figure 2.3-67 for monitoring wells located in Audrain, Boone, Callaway, Gasconade, Montgomery, and Osage Counties (USGS, 2007). These surround Callaway County and monitor the Cambrian-Ordovician aquifer north of the Missouri River and Ozark aquifer south of the Missouri River, except for the Callaway County station in Jefferson City, which monitors the Missouri River alluvial aquifer. These wells are highlighted in Table 2.3-31.

Annual precipitation for the same period (2002 through 2007) at the Columbia Regional Airport weather station, which is located in Callaway County approximately 25 miles (40 km) from the site, was as follows (NOAA, 2007):

Year	2002	2003	2004	2005	2006	2007	Normal [1]
Precipitation inches (cm)	42.30 (107.44)	39.43 (100.15)	45.95 (116.71)	41.21 (104.67)	30.12 (76.51)	32.92 (83.62)	40.28 (102.31)

[1]normal as reported in the 2006 annual report (NOAA, 2007).

From 2002 through 2005, precipitation levels were considered to be normal to above normal. However, precipitation for 2006 and 2007 was well below normal. These below normal precipitation levels are reflected in the overall decrease in groundwater levels monitored in Audrain, Boone, and Montgomery Counties in the Cambrian-Ordovician aquifer north of the Missouri River. Within each year, groundwater levels increase from late summer through spring and then decrease from late spring through late summer. For the monitoring station at Jefferson City, the alluvial aquifer appears to be more responsive to recharge from individual flood events or series of events, such as the flood that occurred in the spring of 2007 when the groundwater levels in the aquifer re-bounded almost entirely from the low levels of 2006.}

2.3.2.2.6 {Callaway Plant Unit 2} Groundwater Use

{For Callaway Plant Unit 2, it is intended that Wells #1 and #2 (DGLS # 027975 and 028076), will be used during construction activities. Their yields are estimated as approximately 200 gpm (760 lpm) each, such that the combined yield of the three wells (refer to Section 2.3.2.2.4 for discussion of Well #3) is approximately 965 gpm (3,650 lpm). It is currently estimated that a peak water supply of up to 700 gpm (2,660 lpm) will be required during Callaway Plant Unit 2 construction activities (demands include those for the construction workforce, concrete mixing, dust control, and hydro testing and flushing). This is based on an estimate of 150 gpm (570 lpm) for normal operations of Callaway Plant Unit 1 and anticipated construction requirements for Callaway Plant Unit 2, de-mineralization plant full operation of 500 gpm (1,900 lpm), and concrete plant and miscellaneous construction of 50 gpm (190 lpm). Average construction demand would be less.

Increasing groundwater withdrawals for construction needs from the three on-site production wells is not expected to exceed the well yields. The wells are open across multiple formations of the Cambrian-Ordovician aquifer system from the casing depths of 380 ft to 405 ft (115.8 m to 123.4 m) bgs to depths of approximately 1,100 ft to 1,510 ft (335 m to 460 m) bgs. Groundwater extraction from these wells is expected to yield water from the relatively high yielding formations that are present in the lower portion of the regional aquifer system. Generally, private wells in the area are shallower and end within the CJC aquifer, a minor aquifer that is the upper-most aquifer in the Cambrian-Ordovician aquifer system. Because the deeper aquifers are expected to have higher storativity, groundwater flow to the wells will be recharged more readily by these deeper formations rather than the CJC aquifer. Therefore, it is not expected that withdrawals from the Callaway production wells will impact local private users.

Projected average needs for Callaway Plant Unit 2 operation (after construction) are 20 gpm (76 lpm) for potable water, 3 gpm (11 lpm) for fire water make-up, and 80 gpm (300 lpm) for demineralization make-up. Therefore, it is expected that the supply requirement for Callaway Plant Unit 2 operations can be met from the existing wells. Any lowered Cambrian-Ordovician aquifer water levels will rebound as post-construction groundwater needs are much less than that needed for construction activities and much less than the aquifer yield.

AmerenUE is planning to construct a collector well system along the Missouri River to supply makeup cooling water for Callaway Plant Unit 2 (and additional water for Unit 1). Collector wells have been constructed in alluvial aquifers elsewhere along the Missouri River to produce large yields of water for municipal entities such as a system serving the Kansas City area (USGS, 1996). Conceptually, each collector well would be constructed of a 20-ft (6.1-m) diameter caisson extending through the alluvial aquifer to bedrock with approximately 14 well-screen laterals extending radially to 200 ft (61 m) from the caisson. Each collector well could potentially supply 15,000 to 20,000 gpm (57,000 to 76,000 lpm). Three collector wells are being planned for the two units (Burns & McDonnell, 2008a). Average water requirements are expected to be 16,000 gpm (60,800 lpm) for Unit 1 (based on current use) and 24,160 gpm (91,446 lpm) for Callaway Plant Unit 2. Water would be pumped through a common line up the corridor and be split for usage by the two plants. The collector wells will be distributed along the edge of the Missouri River separated by approximately 1,500 ft (450 m) to limit interference of water production among wells. It is expected that 85% of the water will be derived from surface water recharge to the aquifer, while 15% will be derived from upgradient sources of groundwater (Burns & McDonnell, 2008a).

No significant hydrologic alteration of the Missouri River alluvial aquifer during construction of the collector well system is anticipated. The caisson is constructed “wet” and during projection and development of the lateral intake lines, water production to the caisson will be much less than what occurs during normal operation (Burns & McDonnell, 2008b). Operational changes to the alluvial aquifer are described in Section 2.3.1.2.}

2.3.2.2.7 {**Callaway Plant Unit 2**} Groundwater Impacts

{Groundwater impacts during construction and operation of Callaway Plant Unit 2 have been evaluated and presented in various subsections of Sections 2.3.1.2 and 2.3.2.2 as follows:

- Graydon Chert aquifer – construction and operational impacts are presented in Section 2.3.2.2.9.
- Cambrian-Ordovician aquifer (including CJC aquifer) – construction and operational impacts are presented in Section 2.3.2.2.6.
- Missouri River alluvial aquifer – construction impacts are presented in Section 2.3.2.2.6 and operational impacts are presented in 2.3.1.2.3.4.}

2.3.2.2.8 Groundwater Monitoring

{Groundwater monitoring (water level observation) of the Callaway Plant Unit 2 area is currently being implemented through the use of the groundwater monitoring wells installed in 2007 for the Callaway Plant Unit 2 site subsurface investigation and through the periodic review of water levels from selected wells in central Missouri that are monitored by the MDNR Groundwater Monitoring Network.

With respect to groundwater monitoring, the existing site Radiological Environmental Monitoring Program (REMP) for Unit 1 (AmerenUE, 2006b; AmerenUE, 2007) and NRC regulations contain no explicit requirements to routinely monitor groundwater on-site near plant facilities. By design, liquid effluents are not released to groundwater or structures that discharge to groundwater, and as such, there is no expected or intended human exposure pathway associated with groundwater for Callaway Plant Unit 2. However, recent nuclear industry initiatives by the Nuclear Energy Institute, the Electric Power Research Institute and NRC assessments (NRC, 2006) of existing nuclear reactors indicate that guidance documents covering the implementation of NRC regulation 10 CFR 20.1406 (NRC, 2007) relating to groundwater monitoring for both operating and future nuclear reactors is being developed. Groundwater monitoring near plant facilities will provide an early indication if unexpected releases through system leaks or failures have occurred and are impacting the environment beyond expected pathways. Development of these guidance documents concerning groundwater protection is being followed and future requirements will be addressed, as applicable, for inclusion in the Callaway Plant Unit 2 REMP.

Safeguards will be used to minimize the potential of adverse impacts to the groundwater by construction and operation of Callaway Plant Unit 2. These safeguards will include the use of lined containment structures around storage tanks (where appropriate), hazardous materials storage areas, emergency cleanup procedures to capture and remove surface contaminants, and other measures deemed necessary to prevent or minimize adverse impacts to groundwater beneath the Callaway Plant Unit 2 site. No groundwater wells are planned for safety-related purposes.}

2.3.2.2.9 Site Characteristics for Subsurface Hydrostatic Loading and Dewatering

{Groundwater conditions relative to the foundation stability of safety-related facilities and plans for the analysis of seepage and piping conditions during construction are discussed in Section 2.5.4.6.

A summary of the groundwater conditions is provided for assessment of hydrostatic loading and de-watering requirements. Across the plateau, the Graydon Chert Formation is considered to be the shallow aquifer. There are localized areas where the overlying material may be included in this aquifer, but on the whole it was found that saturated groundwater is confined within the chert. During the Callaway Plant Unit 2 field investigation, field personnel identified the chert as a moderate water-bearing unit, with the glacial till acting as the confining unit above the chert and the Burlington Limestone acting as the confining unit and top of the aquitard beneath the chert. The Graydon Chert lies unconformably atop the Burlington Limestone and unconformably below the glacial till so its elevation and thickness vary. Across the plateau, the depth of the Graydon Chert ranges from 15 ft to 39 ft (4.6 m to 11.9 m) below ground surface (bgs) and averages approximately 27 ft (8.2 m) bgs. Its thickness ranges from 16 ft to 61 ft (4.9 m to 18.6 m) and averages approximately 38 ft (11.6 m). At the centrally located MW-18 well (beneath the proposed power block area), the depth to the Graydon Chert is 30 ft (9.1 m) bgs and its thickness is 40 ft (12.2 m). The corresponding elevations of the top and bottom of the chert at this location are 810 ft (246.9 m) and 770 ft (234.7 m), respectively.

Due to confined groundwater conditions in the Graydon Chert aquifer, groundwater elevations measured in the monitoring wells rise above the top of the chert to within approximately 7 ft to 15 ft (2.1 m to 4.6 m) of the ground surface in the central portion of the plateau. Within the power block area at MW-18, the maximum measured groundwater elevation was 832.21 ft (253.66 m) msl. Overall, groundwater elevations did not vary much through the year, typically by less than 1 ft to 2 ft (0.3 m to 0.6 m) across the central part of the plateau and several feet at the shallow wells around the perimeter of the plateau.

Beneath the shallow aquifer, there is a leaky, confining aquitard. The depth to the top of the aquitard averages 68 ft (20.7 m) bgs across the plateau, and its thickness is approximately 290 ft (88 m) in the central portion of the plateau. Beneath the aquitard is the Cotter-Jefferson City (CJC) aquifer. The depth to the CJC aquifer is approximately 350 ft (107 m) bgs in the central portion of the plateau. Based on the well logs for the three AmerenUE industrial wells, the thickness of the CJC aquifer beneath the plateau is approximately 300 ft (92 m). Regionally, the CJC aquifer is considered to be a minor aquifer and represents the top of the Cambrian-Ordovician aquifer system, which consists of intervals of minor aquifers and major aquifers with intermittent aquitards to depths up to 2000 ft (610 m) bgs. Groundwater levels for the deeper CJC wells beneath the plateau are also confined such that measured groundwater levels rise approximately 50 ft (15.2 m) above the top of the CJC aquifer to an approximate elevation of between 550 ft and 560 ft (168 m to 171 m) mean sea level. Although groundwater elevations appear to respond to seasonal changes in precipitation, they vary only by approximately 1 ft (0.3 m).

From the Callaway Plant Unit 1 investigation, it was estimated that the well yield for the chert aquifer is less than 1 gpm (3.8 lpm) and for the CJC aquifer is approximately 5 gpm to 10 gpm (19 lpm to 38 lpm). Drilling observations and pumping test results for the Callaway Plant Unit 2 investigation confirm these estimates. Two pumping tests were performed successfully in the CJC aquifer, and the relatively low estimates of storativity are consistent with mildly fractured bedrock aquifers where the small size of fractures and low degree of interconnectedness limits the amount of water in storage and the amount of water to potentially yield to a well. A step-drawdown test at a pumping well in the chert aquifer resulted in a dry well after a short period of time, which made the pumping test unviable.

The existing ground surface elevation at MW-18 in the area of the nuclear island is approximately 840 ft (256.0 m) msl. The completed nominal surface grade for the Callaway Plant Unit 2 nuclear island will be 845 ft (257.6 m) msl. The bottom of the nuclear island building foundations will range from 36 ft to 46 ft (11.0 m to 14.0 m) bgs or 809 ft to 799 ft (246.6 m to 243.5 m) msl. The Essential Service Water (ESW) cooling towers and emergency diesel generators will have a nominal surface grade between 843 ft to 845 ft (257.0 m to 257.6 m) msl. The ESW Emergency Makeup System (ESWEMS) Pumphouse will have a nominal surface grade of 840 ft (256.0 m) msl. The ESWEMS Pumphouse intake bay will include shear keys to the nominal depth of 37 ft (11.3 m) bgs, which corresponds to an elevation of 803 ft (244.8 m) msl. The remainder of the Pumphouse structure will have a foundation depth of 4.5 ft to 9 ft (1.4 m to 2.7 m) bgs, which corresponds to an elevation of 835.5 ft to 831 ft (254.6 m to 253.3 m) msl. The proposed entry elevation of the safety structures is 6 inches to 1 ft (0.152 cm to 0.305 m) above nominal grade. The maximum design depth for construction activities is currently estimated to be 1 ft (0.3 m) beneath the foundation depths, however there could be some trenching or minor excavation up to 5 ft (1.5 m) beneath the bottom of building foundations. The maximum design depth for construction activities beneath the ESWEMS Pumphouse is estimated to be approximately 30 ft (9.1 m) below the nominal surface grade to allow placement of backfill between the chert and the foundation.

Temporary dewatering will be required for groundwater management during excavation and construction of Callaway Plant Unit 2 foundations. During Callaway Plant Unit 1 construction, the low yield of the glacial and postglacial soil deposits and older sediments allowed minimal seepage into excavations during construction. The maximum depth of excavations for Unit 1 was below the base of glacial till, extending approximately 15 ft (4.6 m) into the Graydon Chert conglomerate. Although the highest water table in the site area was about 10 ft to 15 ft (3.0 m to 4.6 m) above the top of the chert conglomerate, neither the postglacial and glacial soils nor the chert conglomerate layer required dewatering (AmerenUE, 2003).

Observations of the groundwater conditions during construction did not reveal any seepage into the excavations through the cohesive materials. Isolated saturated silt lenses at the bottom of the loess and sand lenses in the glacial till did yield seepage when exposed by excavations, but the small seepage did not hinder construction or affect construction quality. Sump pumps located in the excavations were adequate to remove seepage and any runoff occurring after periods of rainfall (AmerenUE, 2003).

Current groundwater conditions are similar to those presented in the Callaway Plant Unit 1 FSAR, so it is anticipated that seepage and subsequent control of seepage for Callaway Plant Unit 2 construction will be similar to that encountered during Callaway Plant Unit 1 construction. Groundwater associated with seepage into the excavations will be controlled through site grading and sump pumps. Water will be diverted to on-site stormwater runoff ponds that were constructed for Unit 1 construction purposes.

Temporary dewatering is required for the excavation of the ESWEMS Pumphouse and the ESWEMS Pond. During Callaway Plant Unit 1 construction, the completed Ultimate Heat Sink (UHS) Retention Pond was constructed above the Graydon Chert unit. Due to the low permeability of the glacial and postglacial materials, it was considered unnecessary to seal the pond side slopes and bottom with an impervious material. The pond side slopes and bottom were inspected during construction. Any sand or silt lenses encountered were removed and replaced with Category I Cohesive Fill. For Callaway Plant Unit 2 construction, de-watering and stability control will be designed to aid with the dewatering needs; however, some level of groundwater control is still required to maintain a relatively dry excavation during construction. At a minimum, sumps will be installed to control and/or lower the groundwater level inside the excavation.

Disruption of the current Graydon Chert aquifer recharge and discharge areas by plant construction is not a concern. The Graydon Chert aquifer is isolated on the plateau and is not used for public or private well use. The construction area is relatively flat and clear of vegetated areas. Runoff is currently directed toward stormwater runoff ponds and during construction, runoff and water from dewatering of excavations will be directed toward these ponds and two additionally planned stormwater runoff ponds. Due to low-permeability soils, groundwater recharge is minimal, and construction activities are not expected to significantly alter groundwater recharge or discharge. Any locally lowered Graydon Chert aquifer water levels would be expected to eventually recover after the dewatering and other subsurface construction activities are completed.

The U.S. EPR FSAR (Areva, 2007) requires that the maximum post-construction groundwater elevation to be at least 3.3 ft (1.0 m) below grade for the nuclear island. Based on the final grade of the nuclear island (845 ft msl), groundwater for the existing conditions is well below grade at 810 ft (246.9 m) msl for the saturated chert with a measured maximum hydraulic head of approximately 832 ft (253.6 m) msl.

The constructed configuration of Callaway Plant Unit 2 is not expected to greatly alter the Graydon Chert aquifer. Recharge to groundwater may be reduced due to the presence of structures and controlled runoff from the power-block area toward the stormwater runoff ponds. However, by assuming a reduction in recharge by 1 inch per year (2.54 cm per year) from the approximate 10% of normal precipitation of 4 inches per year (10.16 cm per year), groundwater elevations are projected to decline by less than 1 ft (0.3 m). Given that precipitation was less than normal for 2006 and 2007, recharge to groundwater may have been reduced during those years and measured groundwater levels may be lower than normal. However, by assuming an increase in recharge by 1 inch per year (2.54 cm per year), groundwater elevations are projected to increase by less than 1 ft (0.3 m). Therefore, the highest measured groundwater elevation is utilized to estimate a maximum of approximately 33 ft (10.0 m) of groundwater induced hydrostatic head loadings (799 ft to 809 ft (243.5 m to 246.6 m) msl is the range of foundation depth elevations of safety-related structures) as the design basis for the subsurface portions of all safety-related structures.

A permanent groundwater dewatering system will not be needed for the Callaway Plant Unit 2 facility. Groundwater elevations will continue to be monitored, and any observed deviations in groundwater elevations potentially impacting the current design bases will be accounted for to design a construction dewatering system, if necessary.}

2.3.2.3 References

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2.3.3 WATER QUALITY

This section describes the site-specific water quality conditions that directly impact the surface waters and groundwater aquifers within the vicinity of the {Callaway Plant} Site. {Recent} site-specific water quality data were obtained {by conducting a baseline hydrogeological site investigation of surface water and groundwater (Rizzo, 2007). Water level measurements were conducted monthly and samples for chemical analytical parameters were collected quarterly.

Detailed information about the water bodies nearest to the plateau is provided in FSAR Section 2.3.1.}

2.3.3.1 Surface Water

{The Callaway Plant site is located on a plateau and is the topographic high in the area. All water that impacts the site and does not infiltrate the ground has a potential impact on surface water receptors. As previously described in Sections 2.3.1 and 2.3.2, surface water run-off from the site drains into small intermittent streams which are tributaries of Logan Creek to the east, Mud Creek to the southwest, Cow Creek to the north, and Auxvasse Creek to the west. Mud Creek and Cow Creek are tributaries to Logan and Auxvasse Creek, respectively. They are part of the Auxvasse Creek watershed which ultimately drains into the Missouri River. Only major impacts on surface water from the Callaway Plant Unit 2 site would likely have effects upon the Missouri River because of the intervening distance and number of intermediate water bodies.

A description of the hydrological characteristics of the drainage creeks is provided in Section 2.3.1.

As described further in Section 4.2, the use of Best Management Practices (BMPs) will minimize the addition of sediment and organic debris to the local streams from clearing, grubbing, and grading. Organic debris could dam or clog existing streams, increase sediment deposition, and increase potential for future flooding. Organic debris decomposing in streams can cause dissolved oxygen and pH imbalances and subsequent releases of other organic and inorganic compounds from the stream sediments. Sediment laden waters are prone to reduced oxygen levels, algal growth, and increases in pathogens. If heavy metals or chemical compounds spill and/or wash into surface waters, there could be a direct toxicity to aquatic organisms. These potential pollutant releases could impact aquatic species and in turn affect the recreational aspects associated with fishing, boating, or swimming.

The following sections describe the site-specific work performed to support the evaluation of the baseline water quality conditions both on the plateau and across the surrounding area. This baseline study will be utilized as a reference such that water quality potential impacts due to the construction and operation of Callaway Plant Unit 2 can be assessed.

2.3.3.1.1 Sample Locations for Surface Water

Sample locations for surface water include the Missouri River, several small streams, and selected stormwater runoff ponds in the area that were originally constructed for Callaway Plant Unit 1 construction purposes, as shown in Figure 2.3-68.

The first set of sample locations are the stormwater runoff ponds PG-1 through PG-9. These pond locations are referenced to pond gauges installed and named with the “PG” prefix shown on Figure 2.3-68 and are different than the references utilized in previous investigations with the prefix “P”.

The stormwater run-off ponds receive precipitation and runoff from the site, thereby representing the closest surface water bodies potentially impacted by construction or operation. Second, two sites were chosen along the Auxvasse and Logan Creeks just west and southeasterly of the Callaway Plant site, respectively. Auxvasse Creek drains the vicinity north and west of the plant. Logan Creek drains the vicinity east of the plant.

Additionally, surface water samples were taken from the Missouri River upstream and downstream of the existing discharge from the existing Callaway Plant Unit 1 at the same locations as presently used for the Callaway Plant Unit 1 operations monitoring program.

2.3.3.1.2 Missouri River

The Missouri River is one of the longest rivers in the United States. This river, forced into its present course by the face of the Continental glacier, is formed by the joining of the Gallatin, Madison, and Jefferson rivers, near Three Forks, Montana. It flows generally in a southeasterly direction for about 2,315 river miles (4,047 km) until its confluence with the Mississippi River about 15 miles (24 km) upstream from St. Louis, Missouri (USGS, 1998). For more information on the Missouri River refer to Section 2.3.1.

2.3.3.1.3 Sampling Program

The sampling program was performed for four quarters from spring 2007 until winter of 2008, representing the four seasons. Samples were collected in May 2007, August 2007, November 2007, and February 2008.

The chemical parameters for analysis from these surface sample locations were selected to correspond to analytes recommended by the NUREG-1555 guidance document. Also, additional analytes were selected from the Missouri Water Quality Standard for Protection of Aquatic Life (AQL; 10 CSR 20-7, November, 2005). These analytes are shown on Table 2.3-34. Water quality measurements presented in Table 2.3-16 and 2.3-19 for groundwater and surface water, respectively include pH, specific conductivity, turbidity, dissolved oxygen, temperature, oxidation reduction potential, salinity, and total dissolved solids. Parameters that are contained within Callaway Plant Unit 1's current water quality monitoring program were also included.

2.3.3.1.4 Sampling Results From All Surface Water Sites

Sample results were compared to AQL guidelines (10 CSR 20-7, November, 2005). Table 2.3-32 shows the summary of results for surface water compared to the AQL guidelines for protection of aquatic life (for parameters for which AQL criteria exist). As shown in Table 2.3-32, most parameters were below the allowable limits. There were certain analytes that exceeded the guideline value one time, but the mean of all four rounds together was under the maximum allowable. The following list presents all of the results that exceeded the AQL guidelines:

- Chloride analyzed in stream samples remained under the AQL guideline. One sample from collection pond PG-9 was above the AQL for chronic toxicity and one sample was above the acute toxicity level. These results appear anecdotal and are not indicative of a continuing source of contamination.
- One stream sample and one stormwater collection pond sample exceeded the maximum temperature AQL. All mean temperatures were under the AQL minimum temperature. Higher temperatures indicative of summertime heating of shallow water bodies.
- The high aluminum results were found to be from the Missouri River. There were no detectable limits in over half of the samples taken. Aluminum is a common soil constituent.
- Total selenium, a common soil constituent, exceeded the AQL limit in every case.

Note dissolved oxygen mean levels were above 5.0 mg per L in all sample sites.

Review of these data indicates that the condition of the surface waters surrounding the site meet the overall criteria for protection of aquatic life.

2.3.3.1.5 Wastewater Treatment

2.3.3.1.5.1 Sanitary waste management

During the operations phase for Callaway Unit 2, the existing on-site sanitary wastewater treatment lagoons will manage sanitary wastes. The Callaway Plant Unit 2 wastewater collection system will collect sanitary sewage and wastewater from various site facilities (e.g. restrooms, shower, cafeteria areas, etc.), outside of radiological controlled areas and will transfer it for treatment to the existing series of sewage treatment lagoons. For more in depth details regarding the wastewater treatment, refer to Section 3.6.

2.3.3.1.5.2 Cooling tower blowdown

Blowdown from the Callaway Plant Unit 1 cooling tower is monitored in accordance with the requirements of the Missouri Operating (NPDES) permit. Table 2.3-34 presents summary information on the water quality of the cooling tower blowdown prepared from the monthly NPDES reports submitted to the Missouri Department of Natural Resources.}

2.3.3.2 Groundwater

{The existing source of cooling water for Callaway Plant Unit 1 is a surface water intake located along the Missouri River. The water is pumped to the plant through a pipeline placed in a path that is a corridor for the transmission line, plant makeup water, and discharge line. The corridor is shown in Figure 2.3-69. After the water is utilized by the plant, it is discharged down the corridor to the Missouri River. In the late 1980s a shallow well was installed in the alluvial aquifer to supply lube water to the intake pumps. In the late 1990s, a deep well was installed to supply lube water to the intake pumps and the shallow well was maintained as a back-up well.

During the Callaway Plant Unit 1 construction, three water supply wells were installed from 1100 ft to 1510 ft (335 m to 460 m) below ground surface (bgs) into the Cambrian-Ordovician aquifer. These wells are highlighted on Table 2.3-30. These wells are open across multiple formations from the Cotter-Jefferson City aquifer through either the Eminence Formation or deeper to the Derby-Doe Run Formation. During construction, the three wells were used for potable water, to support a concrete batch plant, and for on-site lab services. The current estimated total groundwater use by Callaway Plant Unit 1, which is withdrawn from Well #3 only, is 50 gpm (190 lpm) with a break-down as follows: potable water usage is 15 gpm (57 lpm), fire make-up water is 6 gpm (23 lpm), de-mineralization make-up water is 15 gpm (57 lpm), and miscellaneous water is 10 gpm to 15 gpm (38 lpm to 57 lpm) Due to the small amount of water withdrawn relative to the estimated yield of the well from the drilling record (approximately 565 gpm (2139 lpm)), there has been no MDNR reporting requirement for many years (AmerenUE, 2007).

For Callaway Unit 2, it is intended that Wells #1 and #2, will be used for construction. Their yields are estimated as approximately 200 gpm (760 lpm) each, such that the combined yield of the three wells is approximately 965 gpm (3650 lpm). It is currently estimated that a peak water supply of up to approximately 700 gpm (2,660 lpm) will be required duringCallaway Plant Unit 2construction activities (demands include those for Unit 1 operations, construction personnel, concrete manufacturing, dust control, and hydro testing and flushing). Average construction demand would be less. Projected needs for Unit 2 operation are 20 gpm (76 lpm) for potable water, 3 gpm (11 lpm) for fire water make-up, and 80 gpm (303 lpm) for demineralization make-up (AmerenUE, 2007). Therefore, it is expected that the additional supply requirements can be met.

AmerenUE investigated the feasibility of a collector well system along the Missouri River to supply makeup cooling water for Callaway Plant Unit 2 (and additionally for Unit 1). Collector wells have been constructed in alluvial aquifers along the Missouri River to produce large yields of water as described in Section 2.3.1 and 3.4.2

2.3.3.2.1 Sample Locations for Groundwater

The closest monitoring wells to the Callaway site are MW-12 and MW-1D. MW-12 is located just outside of the Callaway Plant site to the northwest, and MW-1D is located inside the Callaway plant area next to the Unit 1 cooling tower. MW-12 is a shallow monitoring well and is screened in the Graydon Chert Aquifer. MW-1D is a deep monitoring well, and is screened in the Carter-Jefferson City Aquifer. Monitoring wells MW-2S, MW-3S, MW-5S, MW-6S are all shallow monitoring wells primarily screened across the Graydon Chert Aquifer. These locations are considered to be downgradient of Callaway Unit 2. They are all located 4,000 ft to 9,000 ft (1219 m to 2743 m) from the center of the existing Callaway Plant site. MW-2S is located to the north. MW-6S is located to the northwest. MW-5S is located to the west, and MW-3S is located to the east of the plant. Also, samples were taken from Wildwood Lot Owner's Association which is a potable water source. For further description of the monitoring wells refer to Section 2.3.2.

2.3.3.2.2 Sampling Program

The sampling program is described in Section 2.3.3.1.3.

The chemical parameters for analysis from these groundwater sample locations were selected to correspond to analytes recommended by the NUREG-1555 guidance document. Analytes were compared to the ground water standards as provided for in the Missouri Code of State Regulations (CSR, 2007); table A-Criteria for Designated Uses.

2.3.3.2.3 Sampling Results From All Groundwater Sites

Sample results were compared to ground water parameters in the Missouri Code of State Regulations (CSR, 2007). Table 2.3-33 shows the summary of results compared to the guidelines for groundwater.

- Arsenic was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Samples remained under the limits set by 10 CSR 20-7 except for one sample at location MW-6S.

- Beryllium was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Samples remained under the limits set by 10 CSR 20-7 except for one sample at location MW-6S.

- Chromium was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Samples remained under the limits set by 10 CSR 20-7 except for one at location MW-6S.

- Iron was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Most samples were above limits set by 10 CSR 20-7 in the shallow aquifers, but below for the mean at the deep aquifer and potable water well.

- Lead was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Most samples were below limits set by 10 CSR 20-7. Two samples were above limits at MW-2S and MW-6S, and once at MW-12.

- Manganese was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Half of the samples were below limits set by 10 CSR 20-7. Two samples were above limits at MW-2S and MW-6S, and once at MW-12. Of the samples that exceeded the limit, most occurred in the shallow aquifer samples.

- Nickel was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Samples remained under the limits set by 10 CSR 20-7 except for two samples: one at location MW-6S and one at MW-2S.

- Strontium 90 was analyzed in shallow aquifers, a deep aquifer, and a potable water well. Samples remained under the minimum detectable limits except for one sample at MW-2S, which was detected at a value much lower than the EPA limit for drinking water of 8 picocuries per liter.

The shallow aquifer results for arsenic, beryllium, chromium, iron, lead, manganese, and nickel were found to be above the limits for 10 CSR 20-7 Table A for groundwater primarily at locations MW-2S and MW-6S. All of these metals are naturally occurring. The posted results represent a baseline condition against which to evaluate future monitoring results. The deep aquifer and the potable water well were below all the limits.}

2.3.3.3 References

{**CFR, 2006.** Title 10 Code of Federal Regulations, Part 50.75, "Reporting and Recordkeeping for Decommissioning Planning," January 2006.

CSR, 2007. Title 10 Code of State Regulations, Division 20, 7.031, Ground Water Regulation Standards, July 2007

CSR, 2003. Title 10 Code of State Regulations, Division 60, Chapter 4.070, Secondary Contaminant Levels and Monitoring Requirements, December 2003.

CSR, 2002. Title 10 Code of State Regulations, Division 60, Chapter 15.070 Monitoring Requirements for Lead and Copper in Tap Water, March 2002.

NRC, 1992. U.S. Nuclear Regulatory Commission, Decommissioning and Regulatory Issues Branch, "A Summary of NRC's Interim Radiological Cleanup Criteria and Current Dose Bases," November 1992.

Rizzo, 2007. Quality Assurance Project Plan for Baseline Study: Surface Water and Groundwater Quality, Callaway Unit 2 Environmental Report Section 2.3.3, Revision 1. August 2007.}

Table 2.3-1—{Approximate Length and Average Gradient of Creeks Located near Callaway Plant Unit 2}

#	River/Creek Name	Subwatershed Name	Length ft (m)	Average Slope %
1	Cow Creek	Auxvasse Creek Watershed	48,448 (14,767)	0.63
2	Logan Creek	Auxvasse Creek Watershed	56,811 (17,316)	0.27
3	Mud Creek	Auxvasse Creek Watershed	26,319 (8,022)	1.19
4	Auxvasse Creek	Auxvasse Creek Watershed	276,973 (84,421)	0.14

NOTE:

Length represents the entire length of each Creek. Slopes were estimated based on upstream and downstream elevations.

Table 2.3-2—{Peak Annual Streamflow for the Hermann, MO USGS Station No. 06934500}

Water Year	Date	Discharge (cfs)	Water Year	Date	Discharge (cfs)
1903	7-Jun-1903	676,000	1968	27-May-1968	187,000
1929	8-Jun-1929	407,000	1969	5-Jul-1969	330,000
1930	19-Jun-1930	164,000	1970	14-Oct-1969	360,000
1931	20-May-1931	123,000	1971	23-Feb-1971	207,000
1932	29-Nov-1931	269,000	1972	3-May-1972	179,000
1933	14-May-1933	183,000	1973	25-Apr-1973	500,000
1934	10-Mar-1934	85,000	1973	18-Oct-1973	325,000
1935	7-Jun-1935	473,000	1975	26-Apr-1975	278,000
1936	27-Feb-1936	145,000	1976	28-Apr-1976	199,000
1937	10-Jun-1937	194,000	1977	16-Sep-1977	250,000
1938	28-May-1938	231,000	1978	27-Mar-1978	348,000
1939	18-Apr-1939	247,000	1979	13-Apr-1979	289,000
1940	12-Jun-1940	111,000	1980	2-Apr-1980	201,000
1941	20-Apr-1941	256,000	1981	20-May-1981	282,000
1942	28-Jun-1942	435,000	1982	11-Jun-1982	298,900
1943	21-May-1943	550,000	1983	3-May-1983	394,600
1944	28-Apr-1944	577,000	1984	23-Apr-1984	314,000
1945	20-Apr-1945	398,000	1985	25-Feb-1985	415,000
1946	15-Aug-1946	209,000	1986	20-Nov-1985	329,000
1947	29-Jun-1947	487,000	1987	5-Oct-1986	549,000
1948	25-Jun-1948	333,000	1988	28-Dec-1987	185,000
1949	5-Jun-1949	239,000	1989	12-Sep-1989	214,000
1950	17-Aug-1950	265,000	1990	17-May-1990	381,000
1951	19-Jul-1951	618,000	1991	20-Apr-1991	164,000
1952	28-Apr-1952	368,000	1992	28-Jul-1992	249,000
1953	9-May-1953	177,000	1993	31-Jul-1993	750,000
1954	5-Jun-1954	145,000	1994	13-Apr-1994	445,000
1955	21-Feb-1955	186,000	1995	19-May-1995	579,000
1955	1-Oct-1955	144,000	1996	31-May-1996	294,000
1957	26-May-1957	196,000	1997	15-Apr-1997	303,000
1958	23-Jul-1958	339,000	1998	3-Apr-1998	297,000
1959	3-Jun-1959	190,000	1999	8-Oct-1998	357,000
1960	7-Apr-1960	330,000	2000	27-Jun-2000	147,000
1961	10-May-1961	405,000	2001	7-Jun-2001	350,000
1962	23-Mar-1962	278,000	2002	14-May-2002	348,000
1963	6-Mar-1963	139,000	2003	11-May-2003	158,000
1964	26-Jun-1964	202,000	2004	7-Mar-2004	214,000
1965	25-Sep-1965	306,000	2005	6-Jan-2005	267,000
1966	15-Jun-1966	188,000	2006	4-May-2006	145,000
1967	28-Jun-1967	372,000			

Table 2.3-3—{Monthly Mean Streamflow for Hermann, MO USGS Station No. 06934500, (1957 through 2006)}

(Page 1 of 2)

	Discharge, cubic feet per second											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1957	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	46,830	33,610	34,430
1958	24,150	32,120	103,800	73,240	73,990	71,640	179,800	127,200	76,310	52,770	43,620	24,530
1959	25,120	58,860	71,550	72,320	95,020	77,380	59,770	55,200	49,690	96,820	37,970	32,180
1960	52,950	49,020	67,740	213,500	139,000	79,970	75,720	52,670	52,690	41,400	44,580	28,970
1961	22,340	29,710	107,000	124,500	196,600	78,950	80,490	55,280	137,700	80,410	144,300	45,110
1962	46,980	121,600	132,300	104,100	60,130	107,900	75,650	51,030	55,490	60,150	43,450	24,710
1963	17,350	25,620	69,170	45,800	75,080	52,660	45,250	40,760	37,800	36,680	38,780	17,060
1964	18,130	19,250	22,810	80,920	63,250	121,000	59,690	41,070	52,240	38,170	43,770	24,730
1965	43,740	37,940	99,460	137,300	61,870	111,400	147,100	56,540	159,500	84,050	54,990	44,980
1966	44,250	64,740	56,710	77,600	71,100	73,250	52,940	50,630	43,750	41,620	42,270	27,660
1967	21,570	27,480	29,910	83,480	66,590	228,800	118,900	57,520	52,460	73,050	84,520	65,110
1968	33,740	62,470	51,330	81,930	79,480	69,590	59,450	83,270	49,890	62,390	76,420	66,380
1969	69,980	94,530	109,000	175,800	126,100	140,100	195,200	78,510	95,790	140,700	76,030	47,840
1970	31,050	41,850	55,050	119,400	137,400	137,800	53,890	59,640	109,000	99,890	78,980	50,520
1971	50,860	84,590	108,400	64,920	89,330	106,300	76,630	60,600	58,170	60,120	74,050	86,050
1972	47,780	39,320	60,610	81,510	116,400	71,540	63,350	70,380	85,200	68,060	134,000	66,550
1973	129,000	135,300	267,500	333,400	192,100	113,400	92,290	72,910	84,410	221,900	127,600	127,400
1974	114,700	115,600	129,100	87,050	143,800	132,600	55,880	53,650	64,250	51,460	104,400	54,780
1975	58,920	103,100	108,300	124,000	88,110	112,500	82,570	80,750	92,730	79,590	81,530	68,900
1976	40,190	49,540	80,480	101,100	103,800	70,000	59,470	47,250	43,760	48,190	45,640	36,060
1977	21,560	34,150	42,840	50,660	53,720	83,470	77,150	58,670	128,400	93,350	125,100	47,200
1978	32,830	26,710	169,800	173,200	145,400	88,500	90,990	79,900	89,050	67,760	77,620	54,110
1979	32,390	67,340	192,800	158,500	116,600	94,390	99,200	70,260	63,340	50,900	70,920	54,960
1980	41,550	49,360	73,320	124,500	58,970	83,450	48,860	49,910	50,700	45,260	47,030	40,750
1981	26,230	30,030	30,910	51,390	97,480	117,900	153,300	89,730	54,830	52,730	59,750	49,080
1982	37,450	136,800	111,200	76,770	124,400	223,500	135,000	100,100	103,400	72,680	80,840	178,900
1983	77,940	90,670	119,100	233,600	204,200	156,000	109,300	63,470	56,770	61,360	103,100	84,000
1984	50,600	92,710	169,500	248,400	205,500	206,700	164,100	71,990	67,410	78,200	111,300	85,940
1985	96,820	124,400	171,700	122,800	106,400	152,700	71,770	81,990	68,530	156,000	152,700	116,300
1986	61,030	91,410	88,880	107,300	155,500	99,990	132,400	76,070	107,100	286,700	149,700	133,100
1987	71,280	80,110	146,800	177,800	123,600	105,900	99,330	77,300	72,110	53,730	63,930	98,760
1988	67,450	75,410	84,420	105,800	64,740	46,150	44,010	42,790	45,280	46,660	47,280	37,250
1989	36,850	39,120	52,970	57,540	47,710	57,020	48,900	56,410	97,110	44,860	34,260	21,740

Table 2.3-3—{Monthly Mean Streamflow for Hermann, MO USGS Station No. 06934500, (1957 through 2006)}

(Page 2 of 2)

	Discharge, cubic feet per second											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1990	31,010	48,730	95,370	89,980	183,600	183,500	89,710	74,700	45,450	45,560	29,400	30,970
1991	48,930	48,920	42,310	80,810	115,900	92,640	52,840	39,540	40,720	40,810	35,130	44,960
1992	39,350	50,860	62,680	100,000	62,210	59,600	119,100	109,000	80,980	61,050	118,200	146,000
1993	108,000	96,640	149,200	197,800	194,900	176,000	376,300	306,600	243,500	169,000	127,900	91,390
1994	62,380	86,920	107,000	173,200	174,000	127,300	85,750	57,140	56,260	49,160	82,220	64,080
1995	67,750	66,510	63,900	109,400	313,000	282,300	178,000	118,900	83,030	79,190	85,280	58,130
1996	44,370	52,840	58,710	82,620	194,500	199,600	132,300	110,400	92,020	97,000	135,500	100,200
1997	61,600	126,600	146,700	193,800	154,800	155,800	107,700	90,260	91,420	93,950	96,170	103,000
1998	89,850	91,360	148,400	189,300	111,000	158,400	130,900	100,600	91,140	173,000	174,800	106,800
1999	77,160	124,000	107,100	172,200	220,400	172,800	147,200	83,940	69,700	66,650	63,820	57,860
2000	49,210	46,860	54,730	51,160	54,600	75,500	70,330	56,840	45,940	46,940	47,800	30,040
2001	32,830	84,590	123,700	118,700	116,400	206,200	97,450	61,240	59,410	57,830	44,680	43,600
2002	34,880	54,450	44,960	65,810	184,500	100,800	47,810	44,480	41,610	42,670	40,360	28,910
2003	25,540	29,000	38,130	47,170	81,730	65,030	53,390	37,920	50,850	38,500	44,660	48,240
2004	51,040	38,740	103,700	70,600	94,400	107,200	87,790	72,820	62,070	42,640	70,610	65,000
2005	119,500	102,700	47,200	65,800	73,500	128,000	56,580	57,680	55,420	49,250	26,790	28,190
2006	30,100	30,540	34,460	50,960	72,360	48,250	40,970	42,660	44,790	n/a	n/a	n/a
Mean of Monthly Discharge	**51,400**	**67,600**	**94,100**	**117,000**	**120,000**	**119,000**	**97,600**	**73,000**	**74,700**	**76,500**	**76,700**	**61,700**

Table 2.3-4—{Mean Daily Streamflow for Hermann, MO USGS Station No. 06934500,(1957 through 2006)}

	Discharge, cubic feet per second											
Day	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	59,100	62,200	79,400	110,000	119,000	122,000	109,000	92,100	68,400	79,300	70,800	71,400
2	56,400	62,700	77,400	113,000	121,000	123,000	110,000	90,100	68,300	79,300	77,000	72,500
3	53,200	64,000	77,700	116,000	117,000	121,000	110,000	86,900	69,100	78,900	83,000	75,300
4	55,200	65,200	81,100	118,000	114,000	119,000	110,000	84,900	69,500	78,200	86,500	74,200
5	59,200	64,100	85,700	118,000	114,000	119,000	107,000	84,500	68,200	78,900	86,400	72,200
6	58,900	62,600	88,200	122,000	116,000	119,000	105,000	82,500	67,900	81,000	83,300	70,900
7	55,300	61,100	89,700	121,000	118,000	122,000	106,000	79,600	66,700	80,200	80,500	69,800
8	52,100	60,000	88,900	116,000	123,000	119,000	104,000	77,300	65,800	79,200	77,900	68,800
9	50,400	59,600	89,900	111,000	128,000	119,000	103,000	74,800	66,700	77,900	74,300	66,700
10	48,200	62,700	88,900	109,000	128,000	120,000	101,000	73,300	68,400	78,600	72,800	64,700
11	46,900	62,800	88,400	111,000	126,000	118,000	97,500	72,900	68,500	80,400	71,900	64,800
12	44,300	61,300	87,400	118,000	123,000	117,000	96,200	72,500	67,300	81,800	71,400	63,100
13	44,000	61,100	87,600	119,000	121,000	117,000	97,400	72,600	66,800	84,400	71,100	60,700
14	45,200	62,000	89,900	119,000	121,000	119,000	97,400	70,300	70,300	85,100	73,200	58,500
15	45,400	62,100	93,100	121,000	123,000	123,000	98,300	71,800	74,900	84,500	74,700	58,300
16	45,000	61,600	95,800	121,000	125,000	123,000	98,300	71,700	77,100	83,000	75,400	59,600
17	45,600	61,700	97,100	119,000	126,000	123,000	93,400	70,600	79,100	81,100	76,600	60,300
18	46,600	62,800	97,600	117,000	129,000	125,000	90,300	69,400	77,100	79,000	78,100	58,800
19	49,600	63,700	96,100	117,000	128,000	122,000	90,000	68,400	77,200	77,200	78,700	57,400
20	50,800	65,900	96,700	118,000	123,000	118,000	89,300	67,100	77,400	77,000	79,300	57,300
21	51,400	68,500	101,000	119,000	117,000	115,000	90,000	65,700	75,500	75,400	80,100	58,000
22	52,500	74,200	102,000	120,000	113,000	117,000	92,100	64,600	75,200	72,900	79,700	57,500
23	52,400	81,400	100,000	121,000	112,000	118,000	95,600	64,100	78,400	70,300	79,100	56,000
24	52,900	83,300	98,500	123,000	114,000	116,000	96,700	63,800	82,500	68,300	77,100	54,200
25	51,700	84,400	99,100	123,000	114,000	116,000	93,000	64,900	85,600	68,600	75,100	54,400
26	50,000	83,700	100,000	118,000	116,000	118,000	89,400	65,600	87,500	69,800	74,100	52,700
27	51,200	83,900	103,000	111,000	118,000	116,000	90,000	66,700	88,800	69,700	75,100	52,000
28	51,500	82,400	105,000	110,000	119,000	113,000	90,700	69,200	86,100	69,200	74,100	54,800
29	51,900	55,100	110,000	113,000	120,000	111,000	90,100	69,600	84,500	67,700	72,800	54,900
30	56,400	n/a	113,000	116,000	119,000	109,000	91,200	68,600	81,700	66,800	70,400	55,900
31	61,100	n/a	110,000	n/a	119,000	n/a	92,700	67,800	n/a	67,100	n/a	57,200

Table 2.3-5—{Maximum Daily Streamflow for Hermann, MO USGS Station No. 06934500, (1957 through 2006)}

	Discharge, cubic feet per second											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	239,000	177,000	271,000	386,000	321,000	386,000	330,000	716,000	160,000	394,000	182,000	177,000
2	238,000	157,000	229,000	389,000	374,000	379,000	300,000	655,000	207,000	353,000	203,000	211,000
3	193,000	189,000	210,000	397,000	382,000	367,000	314,000	584,000	210,000	374,000	248,000	300,000
4	155,000	231,000	185,000	402,000	336,000	334,000	322,000	512,000	179,000	435,000	245,000	354,000
5	206,000	232,000	248,000	403,000	265,000	311,000	326,000	457,000	170,000	519,000	274,000	334,000
6	261,000	212,000	274,000	394,000	276,000	303,000	309,000	415,000	167,000	519,000	285,000	355,000
7	240,000	191,000	289,000	367,000	294,000	337,000	402,000	383,000	176,000	456,000	269,000	373,000
8	200,000	182,000	307,000	348,000	323,000	346,000	418,000	365,000	162,000	414,000	240,000	325,000
9	167,000	170,000	299,000	336,000	385,000	339,000	408,000	350,000	150,000	384,000	208,000	260,000
10	148,000	161,000	296,000	313,000	401,000	314,000	365,000	337,000	155,000	354,000	204,000	218,000
11	128,000	152,000	343,000	281,000	382,000	299,000	343,000	328,000	181,000	315,000	208,000	201,000
12	116,000	151,000	350,000	376,000	369,000	301,000	331,000	328,000	207,000	272,000	214,000	202,000
13	159,000	152,000	333,000	437,000	324,000	303,000	332,000	371,000	207,000	346,000	218,000	166,000
14	194,000	150,000	333,000	413,000	345,000	301,000	347,000	318,000	204,000	353,000	205,000	140,000
15	179,000	184,000	338,000	365,000	332,000	292,000	435,000	300,000	266,000	338,000	211,000	161,000
16	156,000	192,000	337,000	315,000	315,000	281,000	492,000	290,000	268,000	298,000	222,000	268,000
17	132,000	181,000	315,000	297,000	366,000	271,000	416,000	275,000	274,000	310,000	239,000	285,000
18	109,000	166,000	299,000	313,000	465,000	267,000	375,000	250,000	271,000	318,000	244,000	273,000
19	164,000	167,000	277,000	323,000	523,000	276,000	357,000	220,000	246,000	316,000	302,000	254,000
20	213,000	198,000	260,000	333,000	486,000	278,000	347,000	197,000	234,000	311,000	322,000	234,000
21	210,000	220,000	269,000	338,000	386,000	288,000	337,000	186,000	239,000	295,000	314,000	210,000
22	221,000	252,000	260,000	381,000	358,000	291,000	330,000	181,000	240,000	271,000	277,000	180,000
23	221,000	294,000	275,000	463,000	350,000	300,000	337,000	184,000	324,000	230,000	295,000	156,000
24	209,000	384,000	268,000	489,000	355,000	310,000	325,000	193,000	363,000	184,000	288,000	149,000
25	185,000	405,000	329,000	449,000	375,000	322,000	347,000	185,000	375,000	181,000	259,000	162,000
26	178,000	394,000	340,000	407,000	377,000	331,000	376,000	173,000	419,000	190,000	227,000	155,000
27	238,000	375,000	332,000	376,000	373,000	343,000	386,000	165,000	432,000	208,000	197,000	148,000
28	244,000	334,000	349,000	345,000	384,000	367,000	427,000	164,000	435,000	223,000	177,000	180,000
29	221,000	105,000	368,000	289,000	396,000	367,000	511,000	153,000	465,000	218,000	172,000	167,000
30	203,000	n/a	368,000	294,000	392,000	356,000	636,000	159,000	442,000	203,000	166,000	166,000
31	197,000	n/a	364,000	n/a	390,000	n/a	739,000	152,000	n/a	189,000	n/a	170,000

Table 2.3-6—{Minimum Daily Streamflow for Hermann, MO USGS Station No. 06934500, (1957 through 2006)}

	Discharge, cubic feet per second											
Day	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	15,400	13,400	17,400	36,500	42,000	44,600	41,000	38,600	37,200	36,300	28,800	23,300
2	17,600	13,200	17,400	35,700	41,500	44,600	40,500	38,200	37,000	35,800	28,800	23,200
3	17,200	12,800	17,200	35,700	41,000	43,700	40,600	38,600	37,800	36,000	28,400	23,100
4	16,300	14,000	16,700	36,200	40,500	43,700	39,900	37,500	37,900	36,000	28,100	23,000
5	15,000	15,000	16,900	37,700	40,000	45,200	40,400	35,800	39,600	36,000	27,600	22,300
6	12,800	13,600	17,200	38,600	39,600	47,200	44,700	35,200	39,400	36,000	28,600	22,500
7	17,200	14,400	17,400	40,700	39,700	46,600	41,400	35,600	39,400	36,000	28,000	22,400
8	14,800	15,700	17,800	43,200	41,300	44,400	39,900	35,500	38,300	35,200	26,500	21,000
9	19,100	17,000	20,100	41,500	45,800	43,500	38,700	35,000	37,800	35,200	25,900	19,400
10	18,300	17,400	23,600	39,800	44,700	43,500	37,600	34,900	37,400	35,500	25,500	19,200
11	17,600	17,800	24,700	39,800	43,000	46,000	37,500	35,100	36,200	35,700	25,300	19,200
12	13,400	18,700	27,900	40,400	41,800	46,000	37,000	35,600	35,400	35,400	25,000	19,200
13	13,000	20,100	26,900	40,700	41,000	42,200	38,600	37,000	34,900	35,700	24,700	19,200
14	14,000	19,700	24,500	40,700	40,300	38,900	41,600	37,500	34,900	36,700	23,900	20,500
15	14,400	19,700	23,600	40,400	39,200	39,500	42,300	38,000	36,600	36,800	23,700	17,900
16	13,700	19,900	22,200	39,300	38,100	40,100	42,200	38,900	36,300	36,000	23,800	16,200
17	11,000	16,000	20,800	39,700	38,000	40,400	42,800	38,100	36,300	35,700	23,500	16,700
18	10,000	15,000	19,700	40,000	38,300	40,400	43,500	37,500	36,000	35,700	25,400	9,620
19	9,500	19,700	19,200	41,000	38,600	42,500	43,600	36,900	35,800	35,700	25,300	9,430
20	9,000	19,700	19,400	40,600	39,300	41,500	42,800	36,000	35,800	36,000	24,900	7,580
21	10,000	19,700	21,300	41,300	41,900	40,100	43,200	35,500	36,300	35,000	23,900	6,720
22	11,000	19,900	22,200	41,300	41,300	39,800	41,000	38,600	38,600	33,400	23,500	6,550
23	8,000	19,900	22,200	41,900	41,600	40,700	39,700	38,600	37,100	32,800	23,000	6,210
24	7,530	19,400	22,200	40,700	41,600	42,400	38,100	35,500	36,000	32,000	21,600	7,760
25	10,000	19,000	21,700	39,500	38,000	41,300	37,700	33,000	36,500	31,900	21,400	8,670
26	11,400	19,400	22,000	38,900	38,000	42,200	38,400	33,500	36,500	31,500	23,000	8,300
27	13,000	19,700	22,400	39,800	42,200	41,600	37,900	34,600	36,000	34,100	23,800	9,430
28	14,000	18,500	26,700	41,900	46,400	41,400	37,000	37,300	37,400	32,000	23,900	10,200
29	11,000	17,600	35,700	43,000	44,100	41,400	36,400	36,900	38,000	30,600	23,800	11,800
30	11,500	n/a	38,700	42,500	42,900	41,200	36,400	34,900	37,700	29,700	23,500	13,100
31	11,000	n/a	38,600	n/a	45,000	n/a	38,500	34,000	n/a	29,100	n/a	15,600

ER Section 2.3

Table 2.3-7—{Peak Annual Streamflow for Boonville, MO, USGS Station No. 06909000}

Water Year	Date	Discharge (cfs)	Water Year	Date	Discharge (cfs)
1903	6-Jun-1903	612,000	1966	15-Jun-1966	187,000
1926	25-Sep-1926	175,000	1967	25-Jun-1967	275,000
1927	23-Apr-1927	381,000	1968	12-Aug-1968	133,000
1928	20-Jun-1928	224,000	1969	12-Jul-1969	223,000
1929	7-Jun-1929	344,000	1970	24-Sep-1970	213,000
1930	11-May-1930	150,000	1971	22-Feb-1971	158,000
1931	10-Jun-1931	79,200	1972	15-Sep-1972	137,000
1932	28-Nov-1931	221,000	1973	22-Apr-1973	334,000
1933	4-Jun-1933	105,000	1974	18-Oct-1973	281,000
1934	9-Mar-1934	77,000	1975	25-Apr-1975	195,000
1935	4-Jun-1935	306,000	1976	27-Apr-1976	161,000
1936	14-Mar-1936	134,000	1977	15-Sep-1977	246,000
1937	25-Jul-1937	123,000	1978	26-Mar-1978	259,000
1938	19-Jul-1938	142,000	1979	27-Mar-1979	238,000
1939	18-Apr-1939	170,000	1980	1-Apr-1980	190,000
1940	17-Aug-1940	76,700	1981	29-Jul-1981	238,000
1941	17-Jun-1941	201,000	1982	11-Jun-1982	278,000
1942	29-Jun-1942	312,000	1983	7-Apr-1983	317,700
1943	22-Jun-1943	366,000	1984	13-Jun-1984	285,000
1944	27-Apr-1944	504,000	1985	24-Feb-1985	292,000
1945	20-Apr-1945	280,000	1985	13-Oct-1985	283,000
1946	10-Jan-1946	150,000	1986	5-Oct-1986	334,000
1947	27-Jun-1947	448,000	1987	21-Dec-1987	125,000
1948	24-Mar-1948	247,000	1989	12-Sep-1989	223,000
1949	9-Mar-1949	196,000	1990	17-May-1990	294,000
1950	20-Jul-1950	209,000	1991	6-May-1991	133,000
1951	17-Jul-1951	550,000	1992	28-Jul-1992	205,000
1952	27-Apr-1952	360,000	1993	29-Jul-1993	755,000
1953	8-May-1953	150,000	1994	1-Oct-1993	254,000
1954	5-Jun-1954	132,000	1995	19-May-1995	361,000
1955	21-Feb-1955	128,000	1996	29-May-1996	296,000
1956	6-Jul-1956	89,200	1997	14-Apr-1997	281,000
1957	20-Jun-1957	145,000	1998	2-Apr-1998	239,000
1958	22-Jul-1958	252,000	1999	7-Oct-1998	287,000
1959	2-Jun-1959	175,000	2000	26-Jun-2000	134,000
1960	5-Apr-1960	332,000	2001	8-Jun-2001	301,000
1961	16-Sep-1961	267,000	2002	14-May-2002	233,000
1962	4-Nov-1961	200,000	2003	12-May-2003	113,000
1963	17-May-1963	118,000	2004	29-Aug-2004	162,000
1964	25-Jun-1964	184,000	2005	14-Jun-2005	199,000
1965	24-Sep-1965	261,000	2006	5-Oct-2005	112,000

Table 2.3-8—{Monthly Mean Streamflow for Boonville, MO, USGS Station No. 06909000, (1957 through 2007)}

(Page 1 of 2)

	Discharge, cubic feet per second											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1957	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	46,740	29,710	26,130
1958	18,490	24,920	57,750	50,150	57,810	58,200	129,100	87,670	62,550	47,300	36,780	18,080
1959	17,010	38,190	54,640	62,350	84,420	69,480	54,410	51,710	50,150	69,080	29,280	24,220
1960	41,110	35,770	50,120	181,400	99,790	75,300	71,700	50,440	49,140	38,870	38,650	20,220
1961	18,230	27,910	87,660	82,780	88,810	70,310	66,340	47,420	109,000	68,800	108,800	31,200
1962	34,210	96,750	93,130	86,240	56,310	97,260	71,930	48,270	50,360	49,670	39,890	21,870
1963	14,770	23,200	56,200	40,440	56,210	47,010	42,340	38,380	37,540	36,890	36,820	13,840
1964	16,110	17,620	19,460	55,210	50,870	92,590	51,200	38,570	50,930	36,280	40,520	21,020
1965	36,090	31,040	82,080	94,300	56,420	82,930	129,200	49,460	113,900	67,650	51,410	39,150
1966	31,270	41,140	41,610	48,820	50,050	66,000	44,950	46,920	40,120	40,080	40,920	23,290
1967	18,090	20,530	27,830	70,490	46,210	199,100	81,000	49,590	49,520	64,650	56,790	34,090
1968	25,680	36,310	33,620	62,110	52,460	49,120	52,050	67,900	43,130	53,720	52,120	36,130
1969	33,500	53,560	83,690	135,300	101,800	104,700	143,600	68,530	78,080	84,170	59,770	38,790
1970	25,020	35,530	43,830	73,840	81,220	93,470	48,680	55,410	88,760	75,090	63,050	44,270
1971	29,020	67,050	85,710	56,790	82,180	94,650	71,110	55,550	52,400	56,040	67,660	58,190
1972	31,580	33,130	50,420	60,150	91,170	66,770	61,550	65,580	77,600	62,300	88,680	49,800
1973	90,150	101,000	183,900	212,700	138,600	87,920	81,180	65,310	81,250	187,800	103,900	85,160
1974	79,490	80,700	72,200	65,310	118,900	97,080	49,220	45,980	45,000	44,590	58,020	34,580
1975	34,820	45,850	57,570	85,940	66,990	96,320	73,650	70,160	76,270	69,850	73,090	54,300
1976	32,640	41,750	57,490	81,570	80,260	61,000	50,250	44,740	41,910	43,660	42,590	32,910
1977	21,060	28,510	35,010	45,340	49,900	63,690	49,060	56,960	116,900	81,440	95,820	38,300
1978	28,980	24,550	123,200	132,600	109,500	76,420	85,890	72,250	82,780	64,790	75,160	49,520
1979	25,650	45,040	173,100	121,500	91,850	80,260	83,040	65,340	55,280	48,920	67,100	47,410
1980	36,290	38,110	54,750	98,940	54,190	73,390	43,480	48,260	48,570	44,420	45,830	37,240
1981	24,090	26,000	28,190	46,490	69,590	71,100	95,720	63,330	48,690	47,370	46,520	35,690
1982	29,060	106,300	84,160	64,800	118,900	175,000	105,500	82,360	82,780	66,400	71,860	106,200
1983	57,360	78,350	111,500	181,700	129,900	105,500	97,550	57,860	54,760	56,290	74,030	54,630
1984	43,420	73,090	107,000	175,400	163,700	201,100	137,200	68,460	63,230	68,890	85,640	66,770
1985	53,780	86,380	90,560	61,250	76,260	73,500	52,070	67,000	60,850	131,400	93,220	48,900
1986	45,120	52,920	72,440	86,670	138,900	83,850	119,500	72,260	103,400	180,600	91,700	93,460
1987	56,020	51,400	108,400	139,900	115,000	92,330	88,580	74,200	67,550	51,330	54,670	60,200
1988	34,930	48,400	49,170	56,580	48,150	41,990	41,560	38,830	42,160	42,970	36,280	24,190
1989	22,570	24,740	31,250	39,060	40,770	44,680	42,980	41,850	83,720	40,120	27,960	22,150

ER Section 2.3

Table 2.3-8—{Monthly Mean Streamflow for Boonville, MO, USGS Station No. 06909000, (1957 through 2007)}

(Page 2 of 2)

	Discharge, cubic feet per second											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1990	26,120	29,690	49,900	45,920	107,300	112,800	65,450	61,240	38,310	37,890	24,600	20,240
1991	26,370	35,070	34,650	67,820	88,240	79,850	46,270	36,570	36,730	37,120	25,570	30,660
1992	30,580	36,060	50,920	78,980	51,840	50,260	96,300	86,550	69,820	51,800	77,730	91,760
1993	53,500	68,040	123,800	161,900	161,500	134,000	375,200	213,600	165,900	99,490	70,960	58,740
1994	43,370	59,190	78,840	88,740	90,340	79,500	72,300	50,880	47,180	46,000	51,110	41,750
1995	38,030	42,990	51,270	81,980	234,700	189,400	120,800	91,510	74,310	74,180	76,800	54,320
1996	37,070	49,330	52,050	63,620	149,700	172,100	113,100	97,900	80,070	81,680	95,560	70,800
1997	45,680	96,010	96,110	162,300	137,600	111,100	95,440	83,450	82,860	89,530	93,110	84,300
1998	60,240	73,510	98,200	141,400	85,080	130,600	106,300	82,040	74,200	121,000	139,100	81,790
1999	54,750	76,380	75,180	147,100	171,400	135,900	122,700	82,460	69,390	60,970	60,130	48,810
2000	39,980	35,600	41,130	45,810	48,900	67,230	59,700	46,920	42,300	44,270	46,500	28,320
2001	30,980	64,680	104,000	98,090	110,600	166,800	74,770	50,590	56,820	49,070	42,700	33,600
2002	28,530	33,820	32,530	51,700	110,000	58,850	37,530	37,900	37,290	41,400	37,990	25,740
2003	22,590	25,190	28,460	39,370	61,990	53,430	49,360	33,550	43,020	35,630	38,250	32,800
2004	27,420	28,470	64,240	44,680	68,700	96,330	76,120	63,050	54,550	38,560	40,890	32,630
2005	45,360	56,680	31,640	53,180	67,210	102,100	46,670	48,600	41,040	42,850	24,280	26,670
2006	27,960	26,640	29,440	47,770	52,850	42,240	37,000	41,630	42,550	32,680	22,610	27,420
2007	29,380	40,070	67,090	79,580	183,600	98,990	54,570	58,120	48,170	n/a	n/a	n/a
Mean Monthly Discharge	**35,500**	**48,300**	**68,300**	**87,100**	**93,000**	**93,500**	**81,300**	**62,500**	**64,300**	**63,000**	**59,000**	**43,600**

Table 2.3-9—{Mean Daily Streamflow for Boonville, MO, USGS Station No. 06909000, (1957 through 2007)}

	Discharge, cubic feet per second											
Day	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	40,500	40,900	57,300	85,000	86,900	99,200	89,400	77,100	60,600	66,800	61,600	52,100
2	38,600	41,800	58,100	87,900	86,300	98,200	88,700	73,200	60,400	66,600	66,300	53,400
3	37,300	42,000	58,700	89,500	83,500	95,800	88,400	69,700	60,900	65,100	69,400	52,500
4	37,700	41,900	60,400	90,600	81,900	93,000	87,300	69,500	59,800	64,700	69,000	50,700
5	38,200	42,700	63,400	93,100	83,300	92,800	86,900	68,600	58,900	65,500	66,400	50,100
6	37,000	42,100	66,200	93,200	84,000	93,200	86,300	66,900	57,700	67,100	63,300	50,300
7	35,700	41,600	66,000	89,300	88,000	92,200	84,500	64,800	57,400	66,500	60,600	50,000
8	34,600	41,600	64,600	84,700	97,200	93,500	84,200	63,000	58,400	65,000	57,900	49,800
9	33,700	42,000	63,500	82,100	101,000	95,000	82,200	62,800	59,800	65,200	55,800	48,700
10	32,400	43,300	61,500	81,500	101,000	94,300	79,800	63,500	60,800	65,500	55,500	47,200
11	31,600	43,500	60,200	84,600	99,900	92,900	80,200	63,600	59,300	66,200	56,100	46,500
12	30,600	43,900	59,800	87,400	98,200	92,500	83,100	63,500	58,700	68,100	55,900	44,700
13	30,700	44,200	61,200	88,100	97,400	94,000	83,800	62,200	59,100	70,000	56,300	42,200
14	31,200	45,200	64,300	89,300	98,000	97,000	84,300	62,700	63,600	70,300	57,200	40,700
15	31,900	45,300	67,100	88,600	98,900	98,800	83,400	63,000	67,500	68,600	57,700	42,100
16	32,400	45,000	69,800	88,700	97,900	98,600	79,800	61,400	68,500	65,800	58,400	43,600
17	32,700	45,400	70,000	88,400	96,600	99,300	77,800	60,500	67,600	63,600	58,700	42,700
18	33,900	45,800	69,100	88,100	97,100	96,600	75,900	59,800	65,500	62,500	58,600	41,000
19	35,900	47,000	69,300	87,300	97,700	92,900	73,700	58,500	65,000	63,300	59,600	40,100
20	36,000	49,300	72,200	86,600	95,000	90,200	74,100	58,200	64,500	62,600	60,000	40,200
21	35,600	53,200	74,900	87,,800	93,000	91,300	77,100	57,200	64,500	60,400	60,900	40,300
22	36,100	57,100	73,900	89,200	90,500	92,100	91,300	56,600	65,700	58,100	61,400	39,400
23	36,800	60,300	70,700	89,800	89,500	91,200	81,600	56,000	68,100	56,700	59,900	38,100
24	36,600	61,300	69,600	89,900	88,700	90,500	78,000	56,500	71,200	57,600	58,300	37,100
25	35,600	62,400	71,100	87,300	88,400	92,000	75,100	56,600	73,500	59,100	56,200	37,400
26	35,700	62,200	74,000	83,200	90,200	92,500	75,800	57,200	74,600	58,700	55,600	37,900
27	35,700	60,600	75,900	80,300	92,900	90,200	78,000	59,900	71,500	57,800	54,800	37,900
28	36,400	59,300	80,100	80,800	94,300	88,800	79,600	61,400	70,000	57,100	54,400	37,600
29	38,000	41,600	82,400	85,000	93,900	88,100	81,200	61,000	67,900	56,400	53,200	38,300
30	39,600	n/a	81,100	86,300	93,200	87,400	79,900	60,100	66,700	55,800	52,000	39,200
31	41,100	n/a	82,300	n/a	96,900	n/a	78,700	61,100	n/a	57,500	n/a	41,200

Table 2.3-10—{Maximum Daily Streamflow for Boonville, MO, USGS Station No. 06909000, 1957 through 2007)}

	Discharge, cubic feet per second											
Day	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	150,000	138,000	149,000	288,000	225,000	275,000	247,000	603,000	169,000	267,000	134,000	115,000
2	130,000	121,000	142,000	302,000	238,000	269,000	242,000	479,000	163,000	292,000	195,000	128,000
3	112,000	186,000	136,000	315,000	248,000	251,000	256,000	387,000	154,000	313,000	219,000	158,000
4	92,300	190,000	174,000	324,000	239,000	231,000	275,000	340,000	149,000	325,000	249,000	150,000
5	95,600	174,000	220,000	329,000	214,000	213,000	282,000	311,000	148,000	326,000	255,000	153,000
6	93,000	159,000	228,000	327,000	242,000	245,000	273,000	289,000	151,000	298,000	233,000	189,000
7	106,000	150,000	195,000	314,000	230,000	277,000	283,000	269,000	141,000	283,000	201,000	193,000
8	106,000	134,000	203,000	297,000	245,000	294,000	303,000	249,000	129,000	273,000	167,000	179,000
9	95,200	110,000	200,000	270,000	303,000	275,000	312,000	230,000	123,000	243,000	151,000	168,000
10	84,300	113,000	189,000	241,000	330,000	246,000	301,000	212,000	172,000	204,000	158,000	156,000
11	72,800	106,000	208,000	225,000	338,000	270,000	318,000	197,000	214,000	224,000	176,000	142,000
12	63,900	100,000	219,000	234,000	338,000	276,000	375,000	204,000	218,000	269,000	185,000	120,000
13	60,800	97,400	224,000	274,000	339,000	279,000	400,000	211,000	180,000	277,000	173,000	97,400
14	75,000	105,000	223,000	277,000	337,000	267,000	458,000	214,000	222,000	262,000	154,000	86,300
15	92,200	128,000	223,000	257,000	320,000	252,000	439,000	206,000	266,000	268,000	147,000	193,000
16	91,600	118,000	219,000	235,000	286,000	250,000	405,000	190,000	264,000	276,000	182,000	238,000
17	100,000	127,000	208,000	248,000	279,000	256,000	383,000	171,000	242,000	277,000	174,000	237,000
18	97,000	122,000	191,000	262,000	314,000	260,000	353,000	154,000	205,000	281,000	179,000	212,000
19	181,000	130,000	194,000	249,000	354,000	255,000	328,000	142,000	177,000	266,000	161,000	184,000
20	167,000	153,000	195,000	228,000	353,000	253,000	315,000	134,000	149,000	250,000	180,000	162,000
21	148,000	203,000	216,000	292,000	333,000	262,000	304,000	131,000	157,000	224,000	163,000	131,000
22	151,000	230,000	214,000	320,000	300,000	267,000	305,000	135,000	215,000	182,000	191,000	108,000
23	143,000	249,000	217,000	313,000	269,000	269,000	314,000	143,000	246,000	143,000	195,000	89,600
24	138,000	284,000	234,000	300,000	265,000	273,000	321,000	144,000	258,000	125,000	190,000	76,500
25	133,000	280,000	249,000	274,000	272,000	273,000	340,000	139,000	244,000	146,000	158,000	79,800
26	165,000	248,000	256,000	241,000	278,000	269,000	393,000	135,000	263,000	151,000	139,000	95,800
27	170,000	207,000	269,000	194,000	291,000	258,000	487,000	131,000	277,000	175,000	126,000	90,300
28	152,000	167,000	270,000	213,000	296,000	252,000	606,000	152,000	280,000	170,000	113,000	88,700
29	140,000	75,400	260,000	248,000	296,000	241,000	706,000	156,000	273,000	157,000	120,000	126,000
30	133,000	n/a	247,000	260,000	293,000	228,000	721,000	151,000	259,000	141,000	111,000	130,000
31	164,000	n/a	265,000	n/a	289,000	n/a	662,000	140,000	n/a	131,000	n/a	140,000

Table 2.3-11—{Minimum Daily Streamflow for Boonville, MO, USGS Station No. 06909000, (1957 through 2007)}

	Discharge, cubic feet per second											
Day	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	14,000	10,500	15,300	26,800	39,200	40,800	37,100	33,700	35,400	35,100	26,300	22,200
2	12,800	10,000	15,300	30,400	40,600	39,800	38,400	34,400	35,000	35,000	25,500	21,700
3	12,600	9,150	15,100	33,800	40,900	39,800	37,800	33,500	35,100	35,400	24,200	20,600
4	15,000	9,300	15,100	34,200	39,500	41,000	39,600	32,800	36,500	35,400	23,400	19,200
5	14,500	9,900	15,300	33,500	39,200	43,000	39,700	32,200	36,100	35,000	23,000	18,800
6	8,340	11,100	15,500	33,200	38,800	40,100	38,500	31,700	35,800	34,900	22,600	18,800
7	8,200	11,400	16,000	33,300	38,400	38,700	38,000	31,500	33,800	34,900	22,500	18,400
8	8,200	13,400	16,900	33,800	38,200	40,000	36,600	31,200	32,900	34,900	22,400	17,800
9	8,340	17,000	17,300	34,700	37,800	39,800	36,000	31,300	32,900	34,500	22,100	17,100
10	9,390	15,900	18,700	34,900	37,400	38,500	35,500	31,600	33,700	34,400	21,300	16,900
11	10,300	14,900	19,100	35,500	37,400	38,000	35,300	32,700	34,500	34,600	20,600	16,900
12	10,500	13,800	18,500	36,300	37,300	39,000	36,000	34,100	34,600	34,800	20,000	15,600
13	11,000	15,600	17,300	35,000	36,900	36,500	36,700	34,000	34,800	34,900	19,500	12,400
14	12,500	14,200	17,100	36,000	36,400	37,600	38,700	33,000	34,700	35,100	19,400	12,400
15	12,300	13,000	16,400	35,200	35,900	38,400	37,000	33,200	34,900	35,200	19,000	11,000
16	10,000	12,400	16,000	35,200	36,100	38,100	37,800	33,800	35,800	35,000	18,700	10,000
17	8,000	12,400	15,800	35,200	36,300	38,300	38,200	33,400	36,400	34,200	20,000	9,000
18	8,000	11,800	15,800	35,600	36,400	38,200	37,600	33,900	36,100	32,500	21,500	7,200
19	7,000	11,100	16,000	36,500	36,400	38,100	36,600	32,900	36,400	30,500	21,100	6,600
20	6,500	11,300	16,600	36,900	35,300	37,700	36,100	31,600	37,600	28,800	19,800	5,500
21	6,000	12,600	17,100	38,200	34,800	37,600	35,900	30,400	37,000	27,300	18,600	5,000
22	5,500	14,000	18,000	39,100	34,500	37,400	35,600	29,400	36,200	26,200	17,400	5,000
23	6,000	15,400	17,800	39,200	33,400	37,700	35,100	29,100	35,600	25,500	16,600	5,500
24	5,500	16,000	17,300	37,900	33,100	37,300	34,500	30,500	35,600	25,800	16,200	6,000
25	6,000	15,800	17,300	37,400	34,800	38,000	33,700	31,600	35,900	25,500	19,600	6,500
26	9,000	16,200	20,000	37,900	37,800	38,300	33,100	31,200	35,700	24,800	20,200	7,000
27	12,000	16,400	24,500	38,000	37,500	37,800	33,200	30,700	35,200	24,900	20,400	9,000
28	10,000	15,800	24,300	38,100	37,000	37,700	32,900	30,500	35,100	27,300	21,300	11,000
29	9,500	16,200	24,200	37,900	37,800	37,800	33,200	30,500	35,100	27,500	22,400	12,000
30	9,000	n/a	26,400	37,800	41,500	37,200	34,800	30,500	35,200	26,900	22,400	13,000
31	10,000	n/a	28,000	n/a	41,500	n/a	34,100	33,200	n/a	26,600	n/a	14,000

Table 2.3-12—{Details of Harry S. Truman and Bagnell Dams}

Information	Bagnell Dam	Harry S. Truman Dam
Dam Name	Bagnell Dam	Harry S. Truman
NID ID	MO30014	MO20725
Longitude (decimal degree)	-92.6248	-93.4017
Latitude (decimal degree)	38.2031	38.2667
County	Miller	Benton
River	Osage	Osage
Owner Name	Ameren UE	USACE
Year Completed	1931	1978
Total Crest Length (ft, top of the dam)	2,543 (775 m)	5,964 (1,818 m)
Dam Height (to the nearest ft)	148 (45 m)	126 (38 m)
Maximum Discharge at Normal max Pool (cfs)	Not available	Not available
Maximum Storage (ac-ft)	1,893,670 (2.34 E+9 m^3)	3,999,300 (4.93E+9 m^3)
Surface Area (acres)	55,000 (22,258 ha)	55,600 (22,501 ha)
Drainage Area (mi^2)	14,000 (36,260 km^2)	11,500 (29,785 km^2)
Downstream Hazard Potential	Hazard Class 1	Hazard Class 1
Regulated Agency	FERC	FERC
Spillway Type	Controlled	Controlled
Spillway Width (to the nearest ft)	520 (159 m)	190 (58 m)

Table 2.3-13—{Callaway Plant Unit 2 Monitoring Well Construction Details}

(Page 1 of 2)

Well ID	Northing State Plane[1] (ft)	Easting State Plane[1] (ft)	Ground Surface Elevation[2] (ft msl)	Top of Casing Elevation[2] (ft msl)	Boring Depth (ft Bgs)	Screen Diameter/ Slot Size (in)	Screen Interval Top (ft bgs)	Screen Interval Bottom (ft bgs)	Screen Interval Elevation Top (ft msl)	Screen Interval Elevation Bottom (ft msl)	Hydrogeologic Unit
Plateau Shallow Wells											
PW-1	1067801.65	1845747.19	845.4	848.01	50.0	4/0.010	30.0	50.0	815.4	795.4	Glacial/Graydon Chert
MW-2S	1076444.82	1846189.87	781.1	783.77	35.0	2/0.010	15.0	35.0	766.1	746.1	Alluv/Glacial/Graydon Chert
MW-3S	1068236.86	1850889.85	824.7	827.32	60.0	4/0.010	35.0	55.0	789.7	769.7	Graydon Chert
MW-5S	1066063.58	1839748.89	821.5	824.19	52.0	2/0.010	32.0	52.0	789.5	769.5	Graydon Chert
MW-6S	1071137.82	1840344.23	834.5	837.14	50.0	2/0.010	30.0	50.0	804.5	784.5	Glacial/Graydon Chert
MW-8	1069314.02	1845853.56	842.5	844.81	62.0	2/0.010	42.0	62.0	800.5	780.5	Graydon Chert
MW-9	1067031.11	1846943.76	833.7	836.28	45.0	2/0.010	25.0	45.0	808.7	788.7	Graydon Chert
MW-10	1065231.21	1845930.93	845.3	848.02	52.0	2/0.010	30.0	50.0	815.3	795.3	Graydon Chert
MW-11	1067242.14	1843435.83	854.5	856.91	80.0	2/0.010	47.0	67.0	807.5	787.5	Graydon Chert
MW-12	1068338.49	1843101.33	851.5	853.91	60.0	2/0.010	35.0	55.0	816.5	796.5	Graydon Chert
MW-18	1068101.78	1844187.77	839.9	842.35	70.0	2/0.010	25.0	45.0	814.9	794.9	Glacial/Graydon Chert
Plateau Intermediate Well											
MW-1I	1067776.08	1845723.45	844.6	847.25	400.0	4/0.010	167.0	182.0	677.6	662.6	Cotter-Jefferson City Confining Unit (Aquitard)
Plateau Deep Cotter-Jefferson City Wells											
MW-1D	1067745.62	1845729.23	844.1	846.66	380.0	4/0.010	345.0	375.0	499.1	469.1	Cotter-Jefferson City
MW-2D	1076453.63	1846204.02	780.9	783.44	290.0	4/0.010	270.0	290.0	510.9	490.9	Cotter-Jefferson City
MW-3D	1068262.36	1850885.26	824.2	826.86	350.0	4/0.010	325.0	350.0	499.2	474.2	Cotter-Jefferson City
MW-4D	1058085.89	1843973.82	817.6	820.24	370.0	4/0.010	345.0	370.0	472.6	447.6	Cotter-Jefferson City
MW-5D	1066050.55	1839738.72	821.7	824.44	350.0	4/0.010	330.0	350.0	491.7	471.7	Cotter-Jefferson City
MW-6D	1071109.51	1840342.79	834.3	836.79	360.0	4/0.010	334.0	359.0	500.3	475.3	Cotter-Jefferson City
MW-7D	1085262.95	1821950.45	780.3	782.74	340.0	4/0.010	315.0	340.0	465.3	440.3	Cotter-Jefferson City
Study Boundary Cotter-Jefferson City Wells											
MW-13	1087151.31	1837276.03	554.6	554.31	48.0	2/0.010	28.0	48.0	526.6	506.6	Cotter-Jefferson City
MW-14	1073323.07	1826004.31	566.5	568.69	75.0	2/0.010	52.0	72.0	514.5	494.5	Cotter-Jefferson City
MW-15	1046106.89	1833429.15	540.6	540.30	117.0	2/0.010	94.0	114.0	446.6	426.6	Cotter-Jefferson City
MW-16	1052711.25	1839372.03	547.3	549.97	41.0	2/0.010	21.0	41.0	526.3	506.3	Cotter-Jefferson City
MW-17	1049043.77	1845199.81	556.0	558.49	45.0	2/0.010	25.0	45.0	531.0	511.0	Cotter-Jefferson City

Table 2.3-13—{Callaway Plant Unit 2 Monitoring Well Construction Details}

(Page 2 of 2)

Well ID	Northing State Plane(1) (ft)	Easting State Plane(1) (ft)	Ground Surface Elevation(2) (ft msl)	Top of Casing Elevation(2) (ft msl)	Boring Depth (ft Bgs)	Screen Diameter/ Slot Size (in)	Screen Interval Top (ft bgs)	Screen Interval Bottom (ft bgs)	Screen Interval Elevation Top (ft msl)	Screen Interval Elevation Bottom (ft msl)	Hydrogeologic Unit
PW-2	1065502.13	1828469.86	532.5	535.42	75.0	4/0.010	55.0	75.0	477.5	457.5	Cotter-Jefferson City
PZ-2,1	1065508.35	1828483.50	532.8	532.39	75.0	2/0.010	55.0	75.0	477.8	457.8	Cotter-Jefferson City
PZ-2,2	1065508.02	1828455.75	532.2	531.86	75.0	2/0.010	55.0	75.0	477.2	457.2	Cotter-Jefferson City
PZ-2,3	1065486.33	1828470.37	532.8	532.46	75.0	2/0.010	55.0	75.0	477.8	457.8	Cotter-Jefferson City
PW-3	1061781.07	1855490.04	569.8	572.17	52.0	4/0.010	32.0	52.0	537.8	517.8	Cotter-Jefferson City
PZ-3,1	1061771.77	1855477.26	569.6	569.35	52.0	2/0.010	32.0	52.0	537.6	517.6	Cotter-Jefferson City
PZ-3,2	1061795.91	1855490.12	569.8	569.48	52.0	2/0.010	32.0	52.0	537.8	517.8	Cotter-Jefferson City
PZ-3,3	1061775.66	1855503.58	570.4	570.05	52.0	2/0.010	32.0	52.0	538.4	518.4	Cotter-Jefferson City
Missouri River Alluvial Wells											
FMW-1D	1038992.76	1837942.63	525.2	524.94	135.0	2/0.010	114.0	134.0	411.2	391.2	Cotter-Jefferson City
FMW-1S	1038995.53	1837956.06	525.3	524.93	65.4	2/0.010	45.0	65.0	480.3	460.3	Alluvium
FMW-5	1047388.10	1851772.50	525.0	528.13	54.0	2/0.010	33.5	48.5	491.5	476.5	Alluvium
FMW-6	1040481.32	1851066.54	525.2	524.63	106.0	2/0.010	81.5	101.5	443.7	423.7	Alluvium
FMW-7	1039841.12	1849706.88	526.1	525.80	98.5	2/0.010	78.5	98.5	447.6	427.6	Alluvium
FMW-8	1039529.50	1848383.31	524.4	523.98	99.0	2/0.010	77.0	97.0	447.4	427.4	Alluvium
FMW-9	1039620.36	1846762.66	525.4	524.84	97.0	2/0.010	75.0	95.0	450.4	430.4	Alluvium
FMW-10	1039680.35	1845265.75	525.9	525.60	99.0	2/0.010	77.0	97.0	448.9	428.9	Alluvium
FMW-11	1039136.45	1839487.41	530.8	530.42	95.3	2/0.010	75.0	95.0	455.8	435.8	Alluvium
FMW-12	1045810.79	1857168.19	520.3	522.72	104.0	2/0.010	81.5	101.5	438.8	418.8	Alluvium
Missouri River Alluvial Borings											
FSB-2	1043787.02	1836579.86	527.4	NA	NA	NA	NA	NA	NA	NA	Alluvium
FSB-3	1039453.66	1840680.39	524.3	NA	NA	NA	NA	NA	NA	NA	Alluvium
FSB-4	1045261.95	1843189.48	526.1	NA	NA	NA	NA	NA	NA	NA	Alluvium
FSB-13	1036766.57	1841334.31	527.0	NA	NA	NA	NA	NA	NA	NA	Alluvium
FSB-14	1039565.20	1853906.80	525.4	NA	NA	NA	NA	NA	NA	NA	Alluvium

Notes:

(1) Horizontal Datum NAD83 Stare Plane feet
(2) Vertical Datum NAVD 88 feet
FMW-1D is screened into bedrock beneath the alluvial aquifer.

Table 2.3-14—{Callaway Plant Unit 2 Formation Depths and Thicknesses}

(Page 1 of 5)

Well I.D.	Ground Surface Elevation (ft msl)	Depth to Top of Loess/ Misc. Fill (ft bgs)	Elevation Top of Loess/ Misc. Fill (ft msl)	Thickness of Loess/ Misc. Fill (ft)	Depth to Top of Accretion Gley (ft bgs)	Elevation Top of Accretion Gley (ft msl)	Thickness of Accretion Gley (ft)	Depth to Top of Glacial Till (ft bgs)	Elevation Top of Glacial Till (ft msl)	Thickness of Glacial Till (ft)	Depth to Top of Graydon Chert (ft bgs)	Elevation Top of Graydon Chert (ft msl)	Thickness of Graydon Chert (ft)
Plateau Wells													
PW-1, MW-1I/D	844	0	844	10	NP	NP	NP	10	834	26	36	808	24
MW-2S/D	781	0	781	32	32	749	3	NP	NP	NP	35	746	45
MW-3S/D	824	0	824	27	27	797	6	NP	NP	NP	33	791	42
MW-4D	818	0	818	10	NP	NP	NP	10	808	29	39	779	16
MW-5S/D	822	0	822	3	NP	NP	NP	3	819	12	15	807	61
MW-6S/D	834	0	834	5	5	829	12	17	817	16	33	802	33
MW-7D	780	0	780	15	NP	NP	NP	15	765	5	20	760	58
MW-8	843	0	843	9	NP	NP	NP	9	834	11	20	823	42
MW-9	834	0	834	1	NP	NP	NP	1	833	19	20	814	25
MW-10	845	0	845	14	NP	NP	NP	14	831	9	23	822	27
MW-11	855	0	855	2	NP	NP	NP	2	853	20	22	833	45
MW-12	852	0	852	4	NP	NP	NP	4	848	20	23	829	37
MW-18	840	0	840	4	NP	NP	NP	4	836	26	30	810	40

Table 2.3-14— {Callaway Plant Unit 2 Formation Depths and Thicknesses}

(Page 2 of 5)

Well I.D.	Elevation Ground Surface (ft msl)	Depth to Top of Burlington Limestone (ft bgs)	Elevation Top of Burlington Limestone (ft msl)	Thickness of Burlington Limestone (ft)	Depth to Top of Bushburg Sandstone (ft bgs)	Elevation Top of Bushburg Sandstone (ft msl)	Thickness of Bushburg Sandstone (ft)	Depth to Top of Snyder Cr. Limeston e (ft bgs)	Elevation Top of Snyder Cr. Limestone (ft msl)	Thickness of Snyder Cr. Limestone (ft)	Depth to Top of Callaway Lime-stone (ft bgs)	Elevation Top of Callaway Lime-stone (ft msl)	Thickness of Callaway Lime-stone (ft)
MW-1I/D	844	60	784	6	NP	NP	NP	66	778	12	78	766	71
MW-2S/D	781	80	701	25	NP	NP	NP	105	676	29	134	647	21
MW-3S/D	824	75	749	15	90	734	5	95	729	10	105	719	30
MW-4D	818	55	763	20	75	743	5	80	738	35	115	703	45
MW-5S/D	822	75	747	25	100	722	10	110	712	30	140	682	20
MW-6S/D	834	65	769	45	NP	NP	NP	110	724	25	135	699	35
MW-7D	780	78	702	37	NP	NP	NP	115	665	30	145	635	40

Table 2.3-14—{Callaway Plant Unit 2 Formation Depths and Thicknesses}
(Page 3 of 5)

Well I.D.	Elevation Ground Surface (ft msl)	Depth to Top of CJC (Upper) Dolomitic Limestone (ft bgs)	Elevation Top of CJC (Upper) Dolomitic Limestone (ft msl)	Thickness of CJC (Upper) Dolomitic Limestone (ft)	Depth to Top of CJC (Lower) Dolomitic Limestone (ft bgs)	Elevation Top of CJC (Lower) Dolomitic Limestone (ft msl)	Thickness Penetrated of CJC (Lower) Dolomitic Limestone (ft)
MW-1I/D	844	149	695	200	349	495	51
MW-2S/D	781	155	626	105	260	521	30
MW-3S/D	824	135	689	190	325	499	25
MW-4D	818	160	658	185	345	473	20
MW-5S/D	822	160	662	170	330	492	20
MW-6S/D	834	160	674	174	334	500	25
MW-7D	780	185	595	130	315	465	25

ER Section 2.3

Table 2.3-14—{Callaway Plant Unit 2 Formation Depths and Thicknesses}

(Page 4 of 5)

Well ID	Elevation Ground Surface (ft msl)	Depth to Top of Alluvium (ft bgs)	Elevation Top of Alluvium (ft bgs)	Thickness of Alluvium (ft)	Depth to Top of CJC Dolomitic Limestone (ft bgs)	Elevation Top of CJC Dolomitic Limestone (ft msl)	Thickness Penetrated of CJC Dolomotic Limestone (ft)
Study Boundary Cotter-Jefferson City Wells							
MW-13	555	0	555	21	21	534	27
MW-14	567	0	567	44	44	523	31
MW-15	541	0	541	89	89	452	28
MW-16	547	0	547	9	9	538	32
MW-17	556	0	556	20	20	536	25
PW-2	533	0	533	42	42	491	33
PW-3	570	0	570	10	10	560	42

Table 2.3-14—{Callaway Plant Unit 2 Formation Depths and Thicknesses}

(Page 5 of 5)

Well ID	Elevation Ground Surface (ft msl)	Depth to Top of CJC (Lower) Dolomitic Limestone (ft bgs)	Elevation Top of CJC (Lower) Dolomotic Limestone (ft msl
Missouri River Alluvial Wells			
FMW-1D	525	94	431
FMW-1S	525	94	431
FSB-2	527	85	443
FSB-3	524	100	424
FSB-4	526	96	430
FMW-5	525	50	475
FMW-6	525	101	424
FMW-7	526	99	427
FMW-8	524	96	428
FMW-9	525	96	430
FMW-10	526	97	429
FMW-11	531	91	440
FMW-12	520	104	416
FSB-13	530	97	433
FSB-14	525	100	425

ER Section 2.3

Table 2.3-15—{Callaway Plant Unit 2 Monitoring Well Water Level Depths and Elevations}

(Page 1 of 3)

Well ID	Top of Casing[a]	Depth to Water							Water Level Elevation						
		March 26, 2007	April 19, 2007	April 26, 2007	May 7, 2007	May 13, 2007	June 5, 2007	June 26 - 28 2007[b]	March 26, 2007	April 19, 2007	April 26, 2007	May 7, 2007	May 13, 2007	June 5, 2007	June 26 - 28 2007[b]
	(ft msl)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)
Plateau Shallow Wells															
PW-1	848.01	18.16	NR	18.08	18.15	18.19	18.31	18.30	829.85	NR	829.93	829.86	829.82	829.70	829.71
MW-2S	783.77	13.02	NR	11.79	11.61	11.82	11.95	[3]12.62	770.75	NR	771.98	772.16	771.95	771.82	771.15
MW-3S	827.32	27.38	NR	20.41	21.61	20.82	19.90	22.84	799.94	NR	806.91	805.71	806.50	807.42	804.48
MW-5S	824.19	31.69	NR	29.91	29.82	29.86	29.34	[3]30.24	792.50	NR	794.28	794.37	794.33	794.85	793.95
MW-6S	837.14	21.61	NR	21.87	21.91	21.94	21.67	[3]22.15	815.53	NR	815.27	815.23	815.20	815.47	814.99
MW-8	844.81	15.87	NR	15.58	15.62	15.68	15.88	15.68	828.94	NR	829.23	829.19	829.13	828.93	829.13
MW-9	836.28	9.14	NR	8.88	8.94	8.93	8.49	[3]8.74	827.14	NR	827.40	827.34	827.35	827.79	827.54
MW-10	848.02	24.37	NR	24.03	24.06	24.12	24.56	24.26	823.65	NR	823.99	823.96	823.90	823.32	823.76
MW-11	856.91	65.58	NR	69.48	69.60	69.61	69.60	69.68	791.33	NR	787.43	787.31	787.30	787.31	787.23
MW-12	853.91	27.17	NR	26.78	26.85	26.87	26.41	[3]26.66	826.74	NR	827.13	827.06	827.04	827.50	827.25
MW-18	842.35	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Plateau Intermediate Well															
MW-1I	847.25	182.82	NR	183.01	183.08	183.10	183.17	183.20	664.43	NR	664.24	664.17	664.15	664.08	664.05
Plateau Cotter-Jefferson City Wells															
MW-1D	846.66	293.18	NR	293.11	293.02	293.08	293.60	[3]292.78	553.48	NR	553.55	553.64	553.58	553.06	553.88
MW-2D	783.44	230.32	NR	230.02	230.20	230.49	229.78	230.26	553.12	NR	553.42	553.24	552.95	553.66	553.18
MW-3D	826.86	273.41	NR	273.28	273.29	273.36	272.85	[3]273.15	553.45	NR	553.58	553.57	553.50	554.01	553.71
MW-4D	820.24	266.62	NR	266.50	266.41	266.56	266.08	266.68	553.62	NR	553.74	553.83	553.68	554.16	553.56
MW-5D	824.44	268.04	NR	267.80	267.98	268.11	267.70	268.10	556.40	NR	556.64	556.46	556.33	556.74	556.34
MW-6D	836.79	283.28	NR	283.06	283.11	283.27	282.10	283.02	553.51	NR	553.73	553.68	553.52	554.69	553.77
MW-7D	782.74	227.65	NR	227.47	227.55	227.70	227.48	228.02	555.09	NR	555.27	555.19	555.04	555.26	554.72
Study Boundary Cotter-Jefferson City Wells															
MW-13	554.31	9.19	NR	8.02	8.72	9.54	10.51	[3]10.81	545.12	NR	546.29	545.59	544.77	543.80	543.50
MW-14	568.69	44.61	NR	43.02	44.04	[1]39.91	44.80	[3]46.51	524.08	NR	525.67	524.65	528.78	523.89	522.18
MW-15	540.29	25.23	NR	23.89	22.84	[1]19.12	19.53	21.07	515.06	NR	516.40	517.45	521.17	520.76	519.22
MW-16	549.97	18.59	NR	17.11	17.11	18.77	19.95	20.67	531.38	NR	532.86	532.86	531.20	530.02	529.30
MW-17	558.49	24.75	NR	22.59	18.22	20.73	28.22	31.45	533.74	NR	535.90	540.27	537.76	530.27	527.04
PW-2	535.42	NA	18.66	16.62	17.27	[1]7.08	14.41	19.59	NA	516.76	518.80	518.15	528.34	521.01	515.83
PZ-2,1	532.39	NA	15.12	13.34	13.95	[1]3.57	11.32	NR	NA	517.27	519.05	518.44	528.82	521.07	NR
PZ-2,2	531.86	NA	15.61	13.09	13.70	[1]4.03	10.83	NR	NA	516.25	518.77	518.16	527.83	521.03	NR
PZ-2,3	532.46	NA	15.69	13.68	14.33	[1]3.99	11.32	NR	NA	516.77	518.78	518.13	528.47	521.14	NR
PW-3	572.17	NA	10.40	9.56	9.81	[2]10.64	10.94	11.70	NA	561.77	562.61	562.36	561.53	561.23	560.47
PZ-3,1	569.35	NA	7.67	6.91	7.17	[2]8.02	8.28	NR	NA	561.68	562.44	562.18	561.33	561.07	NR
PZ-3,2	569.48	NA	8.25	7.43	7.64	[2]8.50	8.77	NR	NA	561.23	562.05	561.84	560.98	560.71	NR
PZ-3,3	570.05	NA	7.66	6.82	7.06	[2]7.90	8.17	NR	NA	562.39	563.23	562.99	562.15	561.88	NR
Missouri River Alluvial Wells															
FMW-1D	524.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-1S	524.93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-5	528.13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-6	524.63	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-7	525.80	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-8	523.98	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-9	524.84	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-10	525.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-11	530.42	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FMW-12	522.72	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

FMW-1D is screened in the bedrock beneath the alluvial aquifer.

Table 2.3-15—{Callaway Plant Unit 2 Monitoring Well Water Level Depths and Elevations}

(Page 2 of 3)

Well ID	Top of Casing [a]	Depth to Water							Water Level Elevation						
		August 12, 2007	August 26-29, 2007[b]	October 3, 2007	November 20, 2007	December 19, 2007	January 9, 2008	February 1, 2008	August 12, 2007	August 26-29, 2007[b]	October 3, 2007	November 20, 2007	December 19, 2007	January 9, 2008	February 1, 2008
	(ft msl)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)
Plateau Shallow Wells															
PW-1	848.01	18.16	18.34	18.33	18.31	18.36	18.16	18.25	829.85	829.67	829.68	829.70	829.65	829.85	829.76
MW-2S	783.77	14.06	14.40	14.99	15.22	14.87	14.54	14.70	769.71	769.37	768.78	768.55	768.90	769.23	769.07
MW-3S	827.32	20.42	20.25	20.75	20.20	20.89	20.55	20.96	806.90	807.07	806.57	807.12	806.43	806.77	806.36
MW-5S	824.19	29.79	29.69	30.42	30.10	30.55	30.67	30.69	794.40	794.50	793.77	794.09	793.64	793.52	793.50
MW-6S	837.14	23.12	23.24	23.46	23.65	23.69	23.81	23.92	814.02	813.90	813.68	813.49	813.45	813.33	813.22
MW-8	844.81	15.58	15.50	15.88	15.94	16.43	16.49	16.68	829.23	829.31	828.93	828.87	828.38	828.32	828.13
MW-9	836.28	8.62	8.65	8.78	8.50	9.10	9.19	9.35	827.66	827.63	827.50	827.78	827.18	827.09	826.93
MW-10	848.02	24.28	24.36	24.25	24.29	24.49	24.65	24.62	823.74	823.66	823.77	823.73	823.53	823.37	823.40
MW-11	856.91	69.68	NR	69.70	69.71	69.72	69.72	69.71	787.23	NR	787.21	787.20	787.19	787.19	787.20
MW-12	853.91	26.79	26.79	26.93	27.78	27.08	27.18	27.20	827.12	827.12	826.98	826.13	826.83	826.73	826.71
MW-18	842.35	[5]10.82	10.46	10.14	10.86	11.50	11.76	12.06	831.53	831.89	832.21	831.49	830.85	830.59	830.29
Plateau Intermediate Well															
MW-1I	847.25	183.41	183.48	183.57	183.70	183.79	183.14	183.88	663.84	663.77	663.68	663.55	663.46	664.11	663.37
Plateau Cotter-Jefferson City Wells															
MW-1D	846.66	293.36	293.74	294.12	294.29	293.29	293.26	293.04	553.30	552.92	552.54	552.37	553.37	553.40	553.62
MW-2D	783.44	230.18	230.84	231.12	231.37	231.28	230.91	230.78	553.26	552.60	552.32	552.07	552.16	552.53	552.66
MW-3D	826.86	273.64	273.71	274.22	274.46	274.41	274.13	273.91	553.22	553.15	552.64	552.40	552.45	552.73	552.95
MW-4D	820.24	267.10	267.31	267.72	268.06	267.76	267.31	267.22	553.14	552.93	552.52	552.18	552.48	552.93	553.02
MW-5D	824.44	268.70	268.98	NR	269.50	269.8	269.41	269.32	555.74	555.46	NR	554.94	554.64	555.03	555.12
MW-6D	836.79	283.51	283.68	283.97	284.23	284.19	283.96	283.78	553.28	553.11	552.82	552.56	552.60	552.83	553.01
MW-7D	782.74	228.51	228.51	228.54	228.78	228.94	229.04	229.21	554.23	554.23	554.20	553.96	553.80	553.70	553.53
Study Boundary Cotter-Jefferson City Wells															
MW-13	554.31	11.04	11.10	11.06	10.93	10.78	9.73	10.90	543.27	543.21	543.25	543.38	543.53	544.58	543.41
MW-14	568.69	47.66	47.74	47.92	47.91	47.54	46.20	47.49	521.03	520.95	520.77	520.78	521.15	522.49	521.20
MW-15	540.29	23.47	24.03	25.42	25.59	26.21	25.97	25.97	516.82	516.26	514.87	514.70	514.08	514.32	514.32
MW-16	549.97	21.42	20.65	21.28	20.96	19.42	16.5	19.95	528.55	529.32	528.69	529.01	530.55	533.47	530.02
MW-17	558.49	33.82	34.34	35.64	36.40	36.27	35.62	36.09	524.67	524.15	522.85	522.09	522.22	522.87	522.40
PW-2	535.42	20.23	20.53	20.21	20.09	20.09	18.06	19.88	515.19	514.89	515.21	515.33	515.33	517.36	515.54
PZ-2,1	532.39	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
PZ-2,2	531.86	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
PZ-2,3	532.46	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
PW-3	572.17	12.85	13.03	12.73	12.76	11.11	9.84	11.42	559.32	559.14	559.44	559.41	561.06	562.33	560.75
PZ-3,1	569.35	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
PZ-3,2	569.48	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
PZ-3,3	570.05	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Missouri River Alluvial Wells															
FMW-1D	524.94	[4]15.88	16.40	17.77	18.36	23.60	16.79	19.15	509.06	508.54	507.17	506.58	501.34	508.15	505.79
FMW-1S	524.93	[4]15.81	16.58	18.08	18.94	17.76	16.23	18.96	509.12	508.35	506.85	505.99	507.17	508.70	505.97
FMW-5	528.13	[4]18.34	18.51	19.44	19.80	20.14	20.17	20.87	509.79	509.62	508.69	508.33	507.99	507.96	507.26
FMW-6	524.63	[4]17.48	17.98	19.75	20.36	19.30	19.35	20.67	507.15	506.65	504.88	504.27	505.33	505.28	503.96
FMW-7	525.80	[4]18.64	19.23	20.00	21.73	20.19	19.98	21.91	507.16	506.57	505.80	504.07	505.61	505.82	503.89
FMW-8	523.98	[4]16.82	17.41	19.16	19.77	18.44	18.56	19.95	507.16	506.57	504.82	504.21	505.54	505.42	504.03
FMW-9	524.84	[4]16.39	17.06	18.98	19.44	18.86	19.12	20.11	508.45	507.78	505.86	505.40	505.98	505.72	504.73

Table 2.3-15—{Callaway Plant Unit 2 Monitoring Well Water Level Depths and Elevations}

(Page 3 of 3)

Well ID	Top of Casing [a]	Depth to Water							Water Level Elevation						
		August 12, 2007	August 26-29, 2007[b]	October 3, 2007	November 20, 2007	December 19, 2007	January 9, 2008	February 1, 2008	August 12, 2007	August 26-29, 2007[b]	October 3, 2007	November 20, 2007	December 19, 2007	January 9, 2008	February 1, 2008
	(ft msl)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)
Missouri River Alluvial Wells															
FMW-10	525.60	[4]16.83	17.46	19.26	20.23	19.21	19.42	20.51	508.77	508.14	506.34	505.37	506.39	506.18	505.09
FMW-11	530.42	[4]21.62	22.39	23.89	24.55	23.63	22.09	24.65	508.80	508.03	506.53	505.87	506.79	508.33	505.77
FMW-12	522.72	[4]17.15	17.68	19.22	19.82	18.70	18.25	20.20	505.57	505.04	503.50	502.90	504.02	504.47	502.52

NA - not applicable; well was not constructed.
NR - not recorded.

[a]vertical datum NAD88 feet
[b]measured in conjunction with water quality sampling – recorded on water quality sampling form.

[1]effected by flood stage of Auxvasse Creek.
[2]not fully recovered from pump test - 5/9 - 5/10
[3]gauged during week prior in conjunction with water quality sampling.
[4]gauged 8/22/07 in conjunction with water quality sampling.
[5]gauged 8/24/07

ER Section 2.3

Table 2.3-16—{Callaway Plant Unit 2 Groundwater Water Quality Data}

(Page 1 of 5)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[1,2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
Plateau Shallow Wells									
PW-1	6/26/07	7.13	0.788	1514.3	1.98	18.03	150.1	0.39	0.511
	8/26/07	7.11	0.988	42.4	4.64	21.38	60.4	0.49	0.642
	11/13/07	6.94	0.929	81.4	3.78	16.34	69.5	0.46	0.604
	01/13/08	7.22	0.944	482.6	0.88	11.17	-9.3	0.47	0.614
MW-2S	6/27/07	7.00	0.851	652.0	1.42	20.00	150.2	0.42	0.553
	8/27/07	7.02	0.96	199.2	3.25	18.27	115.9	0.47	0.623
	11/16/07	6.97	0.913	36.8	3.59	17.71	57.5	0.45	0.584
	01/10/08	6.99	0.898	114.3	3.43	14.05	56.1	0.45	0.504
MW-3S	6/27/07	7.20	0.780	1469.2	3.85	15.88	74.0	0.38	0.507
	8/27/07	7.24	0.852	868.0	6.94	16.48	74.2	0.42	0.553
	11/18/07	7.06	0.800	10.0	4.12	14.29	29.2	0.39	0.520
	01/11/08	7.12	0.772	5.8	7.50	13.47	53.1	0.38	0.502
MW-5S	6/19/07	7.03	0.879	44.7	3.58	19.68	174.2	0.83	0.571
	8/28/07	7.22	1.822	210.0	9.19	17.76	78.4	0.93	1.183
	11/18/07	6.93	1.799	15.5	10.48	15.37	56.5	0.92	1.170
	01/11/08	6.95	1.754	14.9	8.75	13.91	53.5	0.89	1.139
MW-6S	6/19/07	7.31	0.926	1525.6	4.01	18.05	191.2	0.46	0.601
	8/28/07	7.24	1.019	644.6	6.92	20.99	76.9	0.50	0.661
	11/16/07	7.18	1.054	64.6	8.45	15.70	29.3	0.53	0.686
	01/11/08	7.12	1.028	64.1	7.97	14.12	43.8	0.51	0.668
MW-8	6/26/07	7.05	0.906	1527.3	2.47	18.21	150.0	0.45	0.588
	8/26/07	7.09	0.954	1136.9	5.76	17.80	118.3	0.47	0.620
	11/13/07	6.93	0.923	16.6	4.50	16.56	84.1	0.46	0.599
	01/13/08	7.06	0.900	19.2	4.87	13.64	45.2	0.45	0.585

Table 2.3-16—{Callaway Plant Unit 2 Groundwater Water Quality Data}
(Page 2 of 5)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[1,2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
MW-9	6/19/07	7.04	0.703	0.8	3.18	17.94	197.4	0.34	0.458
	8/26/07	7.02	0.755	8.5	8.52	18.33	113.3	0.37	0.491
	11/13/07	6.85	0.719	21.9	8.54	16.78	95.1	0.35	0.468
	01/13/08	7.07	0.715	6.2	7.07	12.94	33.4	0.35	0.465
MW-10	6/26/07	7.03	0.792	1454.6	2.14	17.86	151.8	0.39	0.514
	8/28/07	7.15	0.873	65.4	7.39	18.26	75.8	0.43	0.576
	11/18/07	6.90	0.807	20.3	6.31	17.44	42.2	0.40	0.525
	01/13/08	6.97	0.797	11.7	6.81	13.66	48.5	0.39	0.518
MW-12	6/19/07	7.27	0.538	1.9	3.69	21.74	191.10	0.26	0.365
	8/27/07	7.14	1.067	207.1	9.97	16.41	78.1	0.53	0.693
	11/13/07	6.92	0.981	40.2	7.53	15.49	75.7	0.49	0.638
	01/11/08	7.04	0.971	14.4	7.85	14.52	48.6	0.48	0.631
MW-18	8/26/07	7.15	0.952	211.3	7.43	18.03	84.3	0.47	0.618
	11/13/07	6.97	0.892	5.5	4.70	17.62	78.1	0.44	0.580
	01/13/08	7.13	0.890	39.0	5.45	11.95	35.4	0.44	0.577
Plateau Deep Wells									
MW-1D	6/17/07	7.04	0.705	-44.7	-0.03	20.97	12.6	0.34	0.458
	8/29/07	7.48	0.833	15.4	1.25	16.22	16.3	0.41	0.541
	11/13/07	7.24	0.772	9.2	3.45	14.84	-109.4	0.38	0.502
	01/13/08	7.37	0.774	5.1	1.66	13.99	-87.8	0.38	0.503
MW-2D	6/27/07	7.21	0.928	-28.2	-0.12	18.97	-211.3	0.48	0.612
	8/27/07	7.25	1.075	14.2	-0.18	18.44	-184.1	0.53	0.698
	11/18/07	7.13	0.928	2.0	0.08	18.42	-18.8	0.46	0.603
	01/10/08	7.22	0.949	0.0	0.0	16.89	-8.9	0.47	0.617
MW-3D	6/27/07	7.37	0.564	-34.8	-0.10	19.24	-152.6	0.27	0.366
	8/27/07	7.36	0.601	-0.4	-0.16	19.11	14.1	0.29	0.391
	11/18/07	7.22	0.548	3.0	0.62	16.47	-61.5	0.27	0.357
	01/11/08	7.25	0.548	0.0	0.01	17.88	-24.1	0.27	0.356

Table 2.3-16—{Callaway Plant Unit 2 Groundwater Water Quality Data}

(Page 3 of 5)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[1,2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
MW-4D	6/28/07	7.21	0.667	-38.3	-0.08	18.57	-232.5	0.32	0.433
	8/28/07	7.25	0.727	2.9	-0.01	18.34	-91.5	0.36	0.472
	11/18/07	7.11	0.678	7.9	0.82	18.13	-35.2	0.33	0.441
	01/11/08	7.18	0.678	0.0	0.05	18.20	20.0	0.33	0.440
MW-5D	6/28/07	7.24	0.305	-40.1	-0.03	19.88	-188.3	0.15	0.198
	8/28/07	7.27	0.619	1.0	0.30	21.54	-11.7	0.30	0.403
	11/18/07	7.13	0.578	10.2	0.69	20.83	-66.5	0.28	0.376
	01/11/08	7.16	0.572	0.0	0.04	18.27	-11.1	0.28	0.372
MW-6D	6/28/07	7.03	0.826	-37.1	-0.06	19.29	-79.5	0.41	0.537
	8/29/07	7.28	0.824	7.7	3.88	16.11	82.6	0.41	0.536
	11/15/07	7.18	0.790	3.8	3.46	14.43	26.1	0.39	0.514
	01/11/08	6.97	0.827	0.0	0.02	18.90	-46.4	0.41	0.538
MW-7D	6/27/07	7.15	0.812	-40.2	0.0	17.65	-137.3	0.40	0.528
	8/27/07	7.18	0.941	2.9	-0.19	17.79	-153.0	0.47	0.612
	11/14/07	7.02	0.890	1.8	0.39	18.61	-44.6	0.44	0.578
	01/10/08	7.11	0.878	0.0	0.0	16.46	-45.0	0.43	0.571
Study Boundary Rock Wells									
MW-13	6/19/07	7.15	0.789	643.5	0.29	15.49	44.2	0.39	0.513
	8/27/07	7.17	0.861	0.7	-0.23	17.97	-2.2	0.42	0.559
	11/16/07	7.15	0.798	10.6	0.02	15.34	-21.5	0.39	0.519
	01/10/08	7.10	0.805	0.0	0.0	15.37	-32.7	0.40	0.523
MW-14	6/19/07	7.19	0.724	-25.8	0.85	16.55	131.0	0.36	0.471
	8/27/07	7.21	0.788	3.3	1.83	18.49	44.5	0.39	0.512
	11/14/07	7.15	0.738	11.2	0.28	15.99	5.5	0.36	0.479
	01/10/08	7.14	0.730	1.4	0.0	14.35	-13.2	0.36	0.474

Table 2.3-16—{Callaway Plant Unit 2 Groundwater Water Quality Data}

(Page 4 of 5)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[1,2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
MW-15	6/26/07	7.18	0.675	175.5	-0.14	16.87	-306.2	0.33	0.438
	8/29/07	7.28	0.780	3.7	-0.04	17.90	-252.8	0.38	0.507
	11/18/07	7.12	0.718	6.7	0.43	15.19	-138.1	0.35	0.466
	01/13/08	7.17	0.713	3.3	0.06	13.88	-115.1	0.35	0.463
MW-16	6/26/07	7.09	0.689	2.3	-0.15	15.73	33.8	0.34	0.448
	8/28/07	7.17	0.749	4.1	-0.25	16.71	-49.6	0.37	0.487
	11/18/07	6.92	0.698	0.6	0.02	14.84	-22.2	0.34	0.454
	01/13/08	7.05	0.682	0.0	0.01	13.84	5.6	0.33	0.443
MW-17	6/26/07	6.91	0.896	-18.8	0.78	17.25	156.6	0.44	0.582
	8/28/07	6.99	0.974	7.3	1.99	17.66	72.5	0.48	0.633
	11/18/07	6.85	0.902	1000.1	2.34	15.19	-10.9	0.45	0.586
	01/13/08	6.90	0.890	59.1	1.80	13.83	18.9	0.44	0.579
PW-2	6/28/07	7.33	0.620	38.7	-0.12	15.64	-117.2	0.30	0.403
	8/28/07	7.33	0.668	-1.4	-0.28	16.36	-37.8	0.33	0.442
	11/18/07	7.19	0.621	0.0	0.81	13.52	-45.6	0.30	0.404
	01/12/08	7.23	0.616	0.0	0.0	13.10	-30.3	0.30	0.401
PW-3	6/26/07	7.21	0.595	-9.0	0.36	16.68	71.8	0.29	0.387
	8/28/07	7.29	0.643	7.1	0.59	16.92	32.5	0.31	0.418
	11/18/07	7.11	0.600	0.0	0.08	14.41	-20.5	0.29	0.390
	01/11/08	7.20	0.597	0.0	1.11	15.43	-13.1	0.29	0.388
Missouri River Alluvial Wells									
FMW-1D	8/22/07	7.39	0.711	-29.4	0.27	20.07	39.3	0.35	0.462
	11/17/07	7.37	0.678	0.0	0.16	14.33	-157.0	0.33	0.441
	01/12/08	7.40	0.669	0.0	0.07	15.10	-129.3	0.33	0.434
FMW-1S	8/22/07	6.99	0.778	-35.1	-0.22	19.74	-146.0	0.38	0.506
	11/17/07	6.92	0.748	0.0	0.0	15.09	-136.1	0.37	0.486
	01/12/08	6.94	0.738	0.0	0.0	15.04	-142.0	0.36	0.480

Table 2.3-16—{Callaway Plant Unit 2 Groundwater Water Quality Data}

(Page 5 of 5)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[1,2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
FMW-5	8/22/07	7.10	0.946	-40.8	-0.18	18.78	-182.7	0.47	0.615
	11/17/07	7.05	0.894	0.0	0.0	16.13	-170.2	0.44	0.581
	01/12/08	7.03	0.889	0.0	0.04	15.64	-168.0	0.44	0.578
FMW-6	8/22/07	6.96	0.955	-37.3	-0.26	21.00	-130.5	0.47	0.620
	11/17/07	6.93	0.902	0.0	0.78	17.33	-135.1	0.45	0.586
	01/12/08	6.95	0.905	0.0	0.03	15.24	-144.1	0.45	0.589
FMW-7	8/22/07	6.95	1.014	-24.8	-0.22	22.54	-139.9	0.50	0.659
	11/17/07	6.92	0.962	0.0	0.07	16.86	-139.9	0.48	0.626
	01/12/08	6.94	0.964	0.0	0.07	15.01	-142.4	0.48	0.627
FMW-8	8/22/07	6.96	1.063	-32.5	-0.21	21.66	-147.5	0.53	0.691
	11/17/07	6.93	1.08	0.0	0.0	16.57	-148.3	0.50	0.655
	01/12/08	6.94	1.019	0.0	0.02	15.35	-152.6	0.51	0.663
FMW-9	8/22/07	6.97	0.938	-36.8	0.18	22.56	-162.5	0.46	0.603
	11/17/07	6.95	0.847	0.0	0.0	16.55	-148.5	0.42	0.551
	01/12/08	6.95	0.851	0.0	0.01	15.44	-151.5	0.42	0.553
FMW-10	8/22/07	6.96	0.872	-38.3	-0.02	23.05	-142.7	0.43	0.567
	11/17/07	6.94	0.834	0.0	0.03	16.04	-140.3	0.41	0.542
	01/12/08	6.94	0.835	0.0	0.0	15.37	-150.6	0.41	0.543
FMW-11	8/22/07	7.01	0.709	-25.4	0.14	21.38	-122.9	0.35	0.461
	11/17/07	6.94	0.718	0.0	0.61	16.05	-124.1	0.35	0.466
	01/12/08	6.94	0.757	0.0	0.0	14.49	-126.9	0.37	0.492
FMW-12	8/22/07	6.99	0.886	-45.1	-0.22	21.14	-160.5	0.44	0.576
	11/17/07	6.97	0.858	0.0	1.62	14.59	-135.9	0.42	0.558
	01/12/08	6.99	0.859	0.0	0.06	14.85	-163.1	0.42	0.558

Notes

1 Small negative turbidity and DO values indicate near zero and values are within the calibration tolerance. In subsequent rounds these values were recorded as 0.0 on the field form.

2 Units for DO reported as (mg/L) are summarized as (ppm) in the text. Units for TDS reported as (gm/L) are summarized as (ppt) in the text. FMW-1D is screened in the bedrock beneath the alluvial aquifer.

ER Section 2.3

Table 2.3-17—{Callaway Plant Unit 2 Surface Water Gauge Elevations}

{Page 1 of 3}

Gauge Location ID	Northing[1]	Easting[1]	Reference Elevation[2]	Measured Value[3]					Water Level Elevation[3]				
				March 4, 2007	May 7, 2007	May 11, 2007	June 3, 2007	August 12, 2007	March 4, 2007	May 7, 2007	May 11, 2007	June 3, 2007	August 12, 2007
	(ft)	(ft)	(ft msl)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft msl)
Stream Gauges – Auxvasse Creek													
SG-A1	1087234.88	1836873.30	568.65	25.50	25.70	25.20	26.22	26.66	543.15	542.95	543.45	542.43	541.99
SG-A2	1073436.78	1825657.45	565.03	43.50	43.39	35.27	43.95	43.93	521.53	521.64	529.76	521.08	521.10
SG-A3	1066250.69	1828527.05	559.83	43.10	43.90	33.70	38.73	43.38	516.73	515.93	526.13	521.10	516.45
SG-A4	1047515.99	1828074.57	538.15	23.40	20.10	9.80	19.65	27.08	514.75	518.05	528.35	518.50	511.07
SG-A5	1043774.56	1832214.10	536.60	18.20	14.75	7.25	5.42	22.68	518.40	521.85	529.35	531.18	513.92
Stream Gauges – Logan Creek													
SG-L1	1061636.17	1855466.49	571.97	10.80	11.00	NR	12.84	DRY	561.17	560.97	NR	559.13	DRY
SG-L2	1047720.06	1845224.58	531.35	15.60	14.40	NR	14.65	DRY	515.75	516.95	NR	516.70	DRY
SG-L3	1048138.31	1852818.23	525.82	20.20	13.55	NR	11.84	DRY	505.62	512.27	NR	513.98	DRY
SG-L4	1047749.17	1856430.12	543.82	36.70	29.85	NR	27.31	34.32	507.12	513.97	NR	516.51	509.50
Stream Gauges - Mud Creek													
SG-M1	1054407.67	1838934.36	553.71	11.30	11.00	NR	13.24	DRY	542.41	542.71	NR	540.47	DRY
SG-M2	1049152.44	1841555.34	525.88	9.00	9.37	NR	9.30	DRY	516.88	516.51	NR	516.58	DRY
SG-M3	1047717.12	1842259.33	530.19	13.80	13.50	NR	13.59	DRY	516.39	516.69	NR	516.60	DRY
SG-M4	1047510.92	1844557.31	531.76	22.50	18.69	NR	17.43	DRY	509.26	513.07	NR	514.33	DRY
SG-M5	1047416.53	1845138.56	521.86	13.60	8.69	NR	5.21	DRY	508.26	513.17	NR	516.65	DRY
Stream Gauges – Logan Camp Branch													
SG-LB1	1046622.84	1837832.04	531.49	6.10	6.49	NR	9.92	DRY	525.39	525.00	NR	521.57	DRY
SG-LB2	1047479.45	1841901.15	519.56	DRY	DRY	NR	3.25	DRY	DRY	DRY	NR	516.31	DRY
Pond Gauges													
PG-1	1068834.92	1853480.09	796.48	NA	2.10	NR	1.90	NR	NA	791.92	NR	791.72	NR
PG-2	1069782.92	1849411.34	798.97	NA	1.40	NR	0.78	NR	NA	793.71	NR	793.09	NR
PG-3	1069816.48	1846920.44	828.97	NA	2.95	NR	2.86	NR	NA	825.26	NR	825.17	NR
PG-4	1071117.38	1845705.70	827.61	NA	1.79	NR	1.82	NR	NA	822.74	NR	822.77	NR
PG-5	1070083.38	1844331.41	827.97	NA	2.53	NR	2.69	NR	NA	823.84	NR	824.00	NR
PG-6	1066292.04	1841261.07	838.56	NA	2.29	NR	2.38	NR	NA	834.19	NR	834.28	NR
PG-7	1064701.63	1842159.33	817.98	NA	2.20	NR	NR	NR	NA	813.52	NR	NR	NR
PG-9	1064480.81	1845349.41	824.27	NA	2.48	NR	2.40	NR	NA	820.09	NR	820.01	NR
PG-10	1067417.76	1845707.88	836.22	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lake Gauges													
LG-1	1081814.27	1837486.20	683.20	NA	2.75	NR	2.48	NR	NA	679.29	NR	679.02	NR
LG-2	1085165.81	1842458.86	659.19	NA	2.59	NR	3.30	NR	NA	655.12	NR	655.83	NR
LG-3	1081881.43	1846080.95	691.47	NA	3.30	NR	3.04	NR	NA	688.11	NR	687.85	NR

Table 2.3-17—{Callaway Plant Unit 2 Surface Water Gauge Elevations}

{Page 2 of 3}

Gauge Location ID	Northing[1] (ft)	Easting[1] (ft)	Reference Elevation[2] (ft msl)	Measured Value[3] August 23, 2007 (ft)	Measured Value[3] October 4, 2007 (ft)	Measured Value[3] November 17, 2007 (ft)	Measured Value[3] December 20, 2007 (ft)	Measured Value[3] January 9, 2008 (ft)	Water Level Elevation[3] August 23, 2007 (ft msl)	Water Level Elevation[3] October 4, 2007 (ft msl)	Water Level Elevation[3] November 17, 2007 (ft msl)	Water Level Elevation[3] December 20, 2007 (ft msl)	Water Level Elevation[3] January 9, 2008 (ft msl)
Stream Gauges – Auxvasse Creek													
SG-A1	1087234.88	1836873.30	568.65	26.85	26.78	26.76	26.43	20.00	541.80	541.87	541.89	542.22	548.65
SG-A2	1073436.78	1825657.45	565.03	45.35	45.31	45.17	44.63	37.60	519.68	519.72	519.86	520.40	527.43
SG-A3	1066250.69	1828527.05	559.83	43.83	47.28	43.65	43.48	36.50	516.00	512.55	516.18	516.35	523.33
SG-A4	1047515.99	1828074.57	538.15	NR	32.64	32.91	32.56	26.75	NR	505.51	505.24	505.59	511.40
SG-A5	1043774.56	1832214.10	536.60	24.34	30.16	30.40	29.11	26.55	512.26	506.44	506.20	507.49	510.05
Stream Gauges – Logan Creek													
SG-L1	1061636.17	1855466.49	571.97	NR	DRY	DRY	13.05	10.37	NR	DRY	DRY	558.92	561.60
SG-L2	1047720.06	1845224.58	531.35	NR	23.52	23.32	23.23	20.82	NR	507.83	508.03	508.12	510.53
SG-L3	1048138.31	1852818.23	525.82	NR	20.02	25.10	22.87	17.60	NR	505.80	500.72	502.95	508.22
SG-L4	1047749.17	1856430.12	543.82	NR	38.16	37.73	38.38	36.16	NR	505.66	506.09	505.44	507.66
Stream Gauges - Mud Creek													
SG-M1	1054407.67	1838934.36	553.71	DRY	DRY	DRY	13.39	13.10	DRY	DRY	DRY	540.32	540.61
SG-M2	1049152.44	1841555.34	525.88	NR	DRY	DRY	9.52	8.81	NR	DRY	DRY	516.36	517.07
SG-M3	1047717.12	1842259.33	530.19	NR	18.70	18.22	18.52	17.05	NR	511.49	511.97	511.67	513.14
SG-M4	1047510.92	1844557.31	531.76	NR	23.14	25.26	25.03	21.13	NR	508.62	506.50	506.73	510.63
SG-M5	1047416.53	1845138.56	521.86	DRY	DRY	14.23	14.13	11.47	DRY	DRY	507.63	507.73	510.39
Stream Gauges – Logan Camp Branch													
SG-LB1	1046622.84	1837832.04	531.49	NR	DRY	DRY	10.91	9.40	NR	DRY	DRY	520.58	522.09
SG-LB2	1047479.45	1841901.15	519.56	DRY	DRY	DRY	DRY	3.99	DRY	DRY	DRY	DRY	515.57
Pond Gauges													
PG-1	1068834.92	1853480.09	796.48	0.88	0.58	0.38	0.74	1.25	790.70	790.40	790.20	790.56	791.07
PG-2	1069782.92	1849411.34	798.97	0.20	3.20	3.36	4.24	4.30	792.51	795.51	795.67	796.55	796.61
PG-3	1069816.48	1846920.44	828.97	2.04	1.84	1.62	NR	NR	824.35	824.15	823.93	NR	NR
PG-4	1071117.38	1845705.70	827.61	0.89	0.56	0.38	1.08	2.04	821.84	821.51	821.33	822.03	822.99
PG-5	1070083.38	1844331.41	827.97	2.08	2.28	2.42	2.82	2.90	823.39	823.59	823.73	824.13	824.21
PG-6	1066292.04	1841261.07	838.56	1.98	1.76	1.62	1.94	2.19	833.88	833.66	833.52	833.84	834.03
PG-7	1064701.63	1842159.33	817.98	1.60	1.44	1.38	1.30	2.64	812.92	812.76	812.70	812.62	813.96
PG-9	1064480.81	1845349.41	824.27	2.56	2.58	0.56	2.56	2.68	820.17	820.19	818.17	820.17	820.29
PG-10	1067417.76	1845707.88	836.22	0.60	0.65	0.68	1.24	NR	830.16	830.21	830.24	830.80	NR
Lake Gauges													
LG-1	1081814.27	1837486.20	683.20	1.76	2.08	1.98	2.36	3.54	678.30	678.62	678.52	678.90	680.08
LG-2	1085165.81	1842458.86	659.19	1.66	1.39	1.24	1.60	NR	654.19	653.92	653.77	654.13	NR
LG-3	1081881.43	1846080.95	691.47	1.81	1.57	1.52	2.14	3.66	686.62	686.38	686.33	686.95	688.47

Table 2.3-17—{Callaway Plant Unit 2 Surface Water Gauge Elevations}

{page 3 of 3}

Gauge Location ID	Northing[1] (ft)	Easting[1] (ft)	Reference Elevation[2] (ft msl)	Measured Value[3] February 2, 2008 (ft)					Water Level Elevation[3] February 2, 2008 (ft msl)				
Stream Gauges – Auxvasse Creek													
SG-A1	1087234.88	1836873.30	568.65	26.18					542.47				
SG-A2	1073436.78	1825657.45	565.03	45.96					519.07				
SG-A3	1066250.69	1828527.05	559.83	43.66					516.17				
SG-A4	1047515.99	1828074.57	538.15	32.37					505.78				
SG-A5	1043774.56	1832214.10	536.60	30.28					506.32				
Stream Gauges – Logan Creek													
SG-L1	1061636.17	1855466.49	571.97	13.02					558.95				
SG-L2	1047720.06	1845224.58	531.35	23.31					508.04				
SG-L3	1048138.31	1852818.23	525.82	23.10					502.72				
SG-L4	1047749.17	1856430.12	543.82	38.76					505.06				
Stream Gauges - Mud Creek													
SG-M1	1054407.67	1838934.36	553.71	DRY					DRY				
SG-M2	1049152.44	1841555.34	525.88	9.59					516.29				
SG-M3	1047717.12	1842259.33	530.19	17.62					512.57				
SG-M4	1047510.92	1844557.31	531.76	25.25					506.51				
SG-M5	1047416.53	1845138.56	521.86	14.19					507.67				
Stream Gauges – Logan Camp Branch													
SG-LB1	1046622.84	1837832.04	531.49	7.09					524.40				
SG-LB2	1047479.45	1841901.15	519.56	DRY					DRY				
Pond Gauges													
PG-1	1068834.92	1853480.09	796.48	1.31					791.13				
PG-2	1069782.92	1849411.34	798.97	4.24					796.55				
PG-3	1069816.48	1846920.44	828.97	2.28					824.59				
PG-4	1071117.38	1845705.70	827.61	2.06					823.01				
PG-5	1070083.38	1844331.41	827.97	2.76					824.07				
PG-6	1066292.04	1841261.07	838.56	2.16					834.06				
PG-7	1064701.63	1842159.33	817.98	2.27					813.59				
PG-9	1064480.81	1845349.41	824.27	2.52					820.13				
PG-10	1067417.76	1845707.88	836.22	NR					NR				
Lake Gauges													
LG-1	1081814.27	1837486.20	683.20	3.34					679.88				
LG-2	1085165.81	1842458.86	659.19	2.84					655.37				
LG-3	1081881.43	1846080.95	691.47	2.84					687.65				

Notes

1 - Horizontal Datum NAD83 State Plane feet

2 - Vertical Datum NAD88 feet

3 - Measured value for streams with designated prefix “SG” is depth to water below surveyed bridge reference point. Water level elevation for streams is the reference elevation minus the measured value. Measured value for ponds and lakes with designated prefix “PG” or “LG” is the water level above 0.0 mark on the staff gauge. Water level elevation for ponds and lakes is the reference elevation (top of staff gauge) minus 6.66 feet (distance from top of staff gauge to 0.0 mark) plus the measured value above the 0.0 mark.

NA – not applicable; staff gauge not installed.

NR – not reported

Table 2.3-18—{Callaway Plant Unit 2 Estimated Average Flow Rates, Velocities and Depths of Streams}

(Page 1 of 2)

Location	Date	Total Width (ft)	Avg. Depth (ft)	Avg. Mean Velocity (ft/sec)	Total Discharge (ft^3/sec)
SG-A1	6/14/2007	91.0	2.03	0.015	2.80
	8/12/2007	84.0	1.74	0.011	1.55
	11/18/2007	90.0	1.85	0.042	7.07
	1/12/2008	96.0	2.21	0.139	29.7
SG-A2	6/14/2007	105.0	1.48	0.023	3.53
	8/12/2007	75.0	1.70	0.005	0.67
	11/18/2007	105.0	1.01	0.041	4.37
	1/12/2008	102.0	1.73	0.203	35.8
SG-A3	6/15/2007	140.0	1.53	0.015	3.13
	8/12/2007	130.0	0.76	0.024	2.41
	11/18/2007	138.0	0.70	0.050	4.87
	1/12/2008	149.0	1.38	0.440	90.5
SG-A4	6/15/2007	160.0	7.76	0.018	22.0
	8/12/2007	150.0	5.48	0.057	46.9
	11/18/2007	9.0	1.10	0.422	4.18
	1/12/2008	136.0	2.87	0.204	79.8
SG-A5	6/29/2007	170.0	8.92	0.020	30.0
	8/12/2007	170.0	8.86	0.065	98.1
	11/18/2007	140.0	2.26	0.049	15.5
	1/12/2008	172.0	6.14	0.062	65.8
SG-L1	1/10/2008	41.50	0.26	0.456	4.96
SG-L2	5/24/2007	60.0	5.02	0.035	10.7
	6/15/2007	52.0	3.69	0.030	5.74
	8/12/2007	Standing Water - No Flow			
	11/17/2007	16.50	0.72	0.045	0.53
	1/10/2008	24.0	0.75	0.339	6.07
SG-L3	5/24/2007	78.0	7.54	0.023	13.4
	6/14/2007	76.0	5.85	0.027	12.1
	8/12/2007	Pooled Water - No Flow			
	11/17/2007	39.0	1.16	0.046	2.07
	1/10/2008	46.0	1.37	0.094	5.87
SG-L4	6/29/2007	80.0	4.31	0.069	23.9
	8/12/2007	Standing Water - No Flow			
	11/17/2007	54.0	1.38	0.050	3.74
	1/10/2008	60.0	1.51	0.091	8.28
SG-M1	1/11/2008	14.0	0.25	0.342	1.20
SG-M2	1/11/2008	14.0	0.18	0.376	0.96
SG-M3	5/23/2007	21.0	3.16	0.024	1.59
	6/14/2007	13.5	2.09	0.011	0.30
	8/12/2007	Pooled Water - No Flow			
	11/16/2007	14.0	1.24	0.020	0.34
	1/11/2008	14.3	1.41	0.196	3.93

Table 2.3-18—{Callaway Plant Unit 2 Estimated Average Flow Rates, Velocities and Depths of Streams}

(Page 2 of 2)

Location	Date	Total Width (ft)	Avg. Depth (ft)	Avg. Mean Velocity (ft/sec)	Total Discharge (ft^3/sec)
SG-M4	5/23/2007	38.0	4.46	0.016	2.76
	6/14/2007	36.0	3.71	0.013	1.72
	8/12/2007	Pooled Water – No Flow			
	11/16/2007	9.0	0.61	0.024	0.13
	1/11/2008	13.0	0.59	0.165	1.27
SG-M5	5/21/2007	30.0	6.67	0.053	10.7
	6/14/2007	31.0	4.30	0.019	2.47
	8/12/2007	Pooled Water - No Flow			
	11/16/2007	9.6	0.86	0.216	1.78
	1/11/2008	11.0	1.29	0.170	2.41
SG-LB1	1/10/2008	8.0	1.56	0.030	0.37

Table 2.3-19—{Callaway Plant Unit 2 Surface Water Quality Data}

(Page 1 of 4)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
Stream Sampling Locations									
SG-A1	6/12/07	7.87	0.402	74.6	3.78	29.14	NR	0.19	0.261
	6/30/07	7.72	0.250	41.3	3.30	22.05	217.9	0.12	0.162
	8/24/07	7.51	0.486	1.5	3.79	27.98	312.2	0.23	0.316
	11/15/07	7.98	0.615	5.0	8.23	7.86	3.5	0.30	0.399
	01/09/08	8.11	0.183	160.1	10.96	7.06	210.9	0.09	0.119
SG-A2	6/12/07	7.68	0.401	80.3	4.10	27.47	NR	0.19	0.261
	6/30/07	7.82	0.263	46.6	3.31	22.54	215.2	0.12	0.171
	8/24/07	7.74	0.495	7.0	5.42	26.38	239.2	0.24	0.322
	11/14/07	7.78	0.417	7.3	6.14	12.01	-1.0	0.20	0.271
	01/09/08	8.16	0.183	238.3	10.60	7.11	242.1	0.09	0.119
SG-A3	6/12/07	7.68	0.505	92.9	3.40	23.79	NR	0.24	0.328
	6/30/07	7.91	0.346	2.2	3.34	22.64	216.8	0.16	0.225
	8/24/07	7.99	0.877	6.2	6.31	26.14	228.1	0.43	0.570
	11/15/07	8.07	1.018	9.8	11.89	10.42	88.0	0.51	0.662
	01/09/08	8.15	0.218	195.8	11.0	7.23	133.4	0.10	0.142
SG-A5	6/12/07	7.69	0.515	82.4	3.73	26.75	NR	0.25	0.335
	6/30/07	7.69	0.575	-31.6	1.86	25.84	230.1	0.28	0.374
	8/24/07	7.94	0.675	3.3	6.38	29.19	225	0.33	0.439
	11/15/07	7.93	0.894	18.3	9.58	10.75	69.9	0.44	0.581
	01/09/08	8.13	0.223	199.8	10.61	7.40	126.3	0.11	0.145
SG-L1	6/12/07	8.16	0.415	74.4	4.84	30.51	NR	0.20	0.269
	6/30/07	8.13	0.389	-38.6	4.07	22.75	210.6	0.19	0.253
	8/24/07	DRY							
	11/15/07	DRY							
	01/09/08	7.95	0.333	8.3	11.33	7.11	164.6	0.16	0.216
SG-L2	6/12/07	7.17	0.510	82.2	3.53	26.18	NR	0.25	0.337
	6/30/07	7.52	0.609	-13.9	2.24	22.23	234.3	0.30	0.396
	8/24/07	DRY							
	11/15/07	7.62	0.659	12.4	2.80	8.24	-5.3	0.32	0.429
	01/09/08	7.93	0.353	17.9	10.94	6.24	144.2	0.17	0.229

Table 2.3-19—{Callaway Plant Unit 2 Surface Water Quality Data}

(Page 2 of 4)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
SG-L3	6/12/07	8.08	0.508	87.2	4.76	26.61	NR	0.24	0.330
	6/30/07	7.86	0.609	6.8	2.37	25.26	221.2	0.29	0.396
	8/24/07	DRY							
	11/15/07	7.44	0.692	12.6	2.41	9.10	-34.9	0.34	0.450
	01/09/08	8.09	0.359	34.4	11.04	6.07	123.9	0.17	0.234
SG-M1	6/12/07	DRY							
	6/30/07	7.48	0.938	-38.4	3.30	19.19	182.5	0.46	0.610
	8/24/07	DRY							
	11/15/07	DRY							
	01/09/08	7.98	0.514	11.4	11.83	6.54	135.4	0.25	0.334
SG-M5	6/12/07	7.87	0.529	84.8	4.04	25.36	NR	0.25	0.344
	6/30/07	7.57	0.601	-14.1	2.71	22.62	237.6	0.29	0.390
	8/24/07	DRY							
	11/15/07	7.38	0.630	33.2	2.77	10.54	-41.9	0.31	0.410
	01/09/08	8.06	0.485	18.7	11.86	6.88	184.8	0.23	0.315
SG-LB1	6/12/07	8.00	0.591	103.1	2.12	21.34	NR	0.29	0.384
	6/30/07	DRY							
	8/24/07	DRY							
	11/15/07	DRY							
	01/09/08	8.07	0.426	0.1	11.18	6.52	132.0	0.21	0.277
Pond Sampling Locations									
PG-1	6/12/07	7.45	0.136	-33.2	4.11	29.16	47.7	0.06	0.089
	8/23/07	7.20	0.170	179.8	6.13	31.76	115	0.08	0.111
	11/14/07	8.25	0.171	6.0	10.30	12.14	35.3	0.08	0.111
	01/09/08	8.29	0.159	6.3	12.12	7.86	180.7	0.08	0.103
PG-2	6/12/07	8.94	0.343	-28.1	5.66	32.00	140.5	0.16	0.223
	8/23/07	8.88	0.500	12.5	12.71	31.51	119.5	0.24	0.325
	11/14/07	8.80	0.463	10.2	11.85	12.60	60.2	0.22	0.301
	01/09/08	8.39	0.380	165.8	12.32	9.48	167.8	0.18	0.247
PG-3	6/12/07	8.30	0.554	-39.5	4.00	28.48	166.2	0.27	0.360
	8/23/07	8.34	0.532	2.8	9.26	29.70	160.0	0.25	0.345
	11/14/07	8.18	0.484	5.3	10.10	11.67	77.6	0.23	0.315
	01/09/08	8.21	0.482	10.2	11.65	7.75	171.1	0.23	0.313

Table 2.3-19—{Callaway Plant Unit 2 Surface Water Quality Data}

(Page 3 of 4)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
PG-4	6/12/07	9.89	0.195	-39.2	6.08	28.89	79.9	0.09	0.127
	8/23/07	9.97	0.201	2.2	11.71	29.86	43.0	0.09	0.131
	11/14/07	9.47	0.183	12.3	11.42	12.31	23.2	0.09	0.119
	01/09/08	8.22	0.285	10.9	10.36	8.36	193.2	0.14	0.185
PG-5	6/13/07	7.88	0.446	-13.1	3.97	30.26	132.0	0.21	0.290
	8/23/07	9.38	0.367	26.1	19.01	31.96	121.2	0.17	0.239
	11/14/07	9.37	0.34	13.1	11.832	13.18	36.0	0.16	0.221
	01/09/08	8.17	0.436	46.5	9.04	8.30	166.5	0.21	0.284
PG-6	6/12/07	8.68	0.476	-15.4	4.50	29.37	137.4	0.23	0.309
	8/23/07	8.57	0.627	11.2	10.01	30.25	173.0	0.30	0.408
	11/15/07	8.18	0.647	13.2	10.38	10.17	84.7	0.32	0.420
	01/09/08	8.23	0.620	8.3	11.52	8.10	150.9	0.30	0.403
PG-7	6/13/07	DNS - Stormy Weather							
	6/30/07	DNS - Newly Erected Electric Fence							
	8/23/07	8.11	0.994	38.4	8.36	31.11	181.6	0.48	0.646
	11/15/07	8.28	0.995	22.4	10.32	9.55	50.2	0.49	0.646
	01/09/08	8.23	1.078	24.5	11.33	8.31	144.2	0.54	0.701
PG-9	6/13/07	8.74	1.738	-30.4	4.57	30.43	165.2	0.87	1.129
	8/23/07	9.67	1.027	4.1	18.65	31.28	146.7	0.50	0.668
	11/15/07	9.65	0.560	16.5	12.65	10.01	59.5	0.27	0.364
	01/09/08	8.47	1.476	58.6	12.53	7.91	135.0	0.74	0.960
PG-10	6/12/07	DNS							
	8/24/07	8.09	0.563	0.7	1.15	26.55	225.1	0.27	0.366
	11/13/07	8.70	0.419	18.6	11.39	14.33	-12.3	0.20	0.272
	01/09/08	8.22	0.533	10.5	11.84	6.43	169.4	0.26	0.346
Lake Sampling Locations									
LG-1	6/13/07	8.46	0.200	-41.9	3.99	28.22	175.5	0.09	0.130
	6/30/07	8.13	0.389	-38.6	4.07	22.75	210.6	0.19	0.253
	8/23/07	8.47	0.233	-0.5	8.75	30.11	210.5	0.11	0.152
	11/14/07	7.92	0.215	3.8	7.28	12.38	98.6	0.10	0.140
	01/09/08	8.12	0.160	5.6	9.98	4.36	228.1	0.08	0.104

Table 2.3-19—{Callaway Plant Unit 2 Surface Water Quality Data}

(Page 4 of 4)

Location	Date	pH	S.Cond (mS/cm)	Turbidity (NTU)[1]	DO (mg/L)[2]	Temp. (Celsius)	ORP (mV)	Salinity (ppt)	TDS (gm/l)[2]
LG-2	6/13/07	8.34	0.189	-43.9	3.87	27.76	196.0	0.09	0.123
	6/30/07	7.52	0.609	-13.9	2.24	22.23	234.3	0.30	0.396
	8/23/07	8.45	0.205	-0.9	8.46	29.86	113.1	0.10	0.133
	11/14/07	7.80	0.203	3.3	6.95	11.67	96.1	0.10	0.132
	01/09/08	7.89	0.205	1.0	10.47	4.31	230.1	0.10	0.134
LG-3	6/13/07	8.70	0.212	-38.0	4.23	28.61	156.3	0.10	0.138
	6/30/07	7.86	0.609	6.8	2.37	25.26	221.2	0.29	0.396
	8/23/07	8.52	0.260	2.6	9.59	30.22	166.4	0.12	0.169
	11/14/07	7.72	0.270	6.1	8.00	11.49	102.9	0.13	0.175
	01/09/08	8.04	0.242	23.3	11.01	6.24	211.4	0.12	0.157

1 Small negative turbidity values indicate near zero and values are within the calibration tolerance. In subsequent rounds these values were recorded as 0.0 on the field form.

2 Units for DO reported as (mg/L) are summarized as (ppm) in the text. Units for TDS reported as (gm/L) are summarized as (ppt) in the text.

NR – not reported.

DNS – did not sample.

Table 2.3-20—{Callaway Plant Unit 2 Aquifer Hydraulic Gradients}

Well Pair	General GW Flow Direction	May, 2007	August, 2007	November, 2007	January, 2008	Arithmetic Average[2]
Graydon Chert Aquifer – Central Area of Plateau – Horizontal Gradients						
MW-18/MW-12	WNW	0.00280[1]	0.00429	0.00482	0.00347	0.00419
MW-18/MW-10	SSE	0.00242[1]	0.00245	0.00231	0.00215	0.00230
PW-1/MW-9	ESE	0.00177	0.00143	0.00135	0.00194	0.00162
MW-18/MW-8	NNE	0.00180[1]	0.00125	0.00127	0.00110	0.00121
Graydon Chert Aquifer – Periphery of Plateau – Horizontal Gradients						
MW-12/MW-6S	NW	0.00301	0.00336	0.00322	0.00341	0.00325
MW-12/MW-5S	SW	0.00807	0.00805	0.00791	0.00820	0.00806
PW-1/MW-3S	E	0.00468	0.00438	0.00438	0.00447	0.00448
MW-8/MW-2S	NNE	0.00799	0.00840	0.00845	0.00828	0.00837
CJC Aquifer – Horizontal Gradients						
MW-2D/MW-13	NNW	0.00055	0.00067	0.00062	0.00057	0.00060
MW-6D/MW-14	WNW	0.00200	0.00222	0.00219	0.00209	0.00212
MW-5D/PW-2	W	0.00340	0.00360	0.00351	0.00334	0.00348
MW-4D/MW-16	SSW	0.00296	0.00334	0.00327	0.00275	0.00312
MW-16/MW-15	SW	0.00173	0.00147	0.00161	0.00216	0.00174
Graydon Chert/CJC Aquifers – Vertical Gradients						
PW-1/MW-1D	Downward	0.860	0.861	0.863	0.861	0.861
MW-2S/MW-2D	Downward	0.855	0.846	0.845	0.846	0.848
MW-3S/MW-3D	Downward	0.834	0.867	0.870	0.868	0.866
MW-5S/MW-5D	Downward	0.813	0.816	0.817	0.814	0.815
MW-6S/MW-6D	Downward	0.850	0.847	0.848	0.846	0.848

1 No reading was available at MW-18 for the May, 2007 round. Hydraulic gradients were estimated from the 830 foot mean sea level (msl) potentiometric surface contour in the area of MW-18 to the downgradient well. These estimates were not included in the arithmetic average.

2 Arithmetic average is calculated from four rounds, except in cases described in note 1.

Table 2.3-21—{Callaway Plant Unit 2 Monitoring Well Slug Test Results}

Well ID	Kh (ft/sec)	Kh (cm/sec)	Kh (ft/day)
Plateau Shallow Wells			
PW-1	8.17E-07	2.49E-05	7.06E-02
MW-2S	1.90E-06	5.79E-05	1.64E-01
MW-3S	1.04E-04	3.18E-03	9.02E+00
MW-5S	6.69E-07	2.04E-05	5.78E-02
MW-6S	8.16E-08	2.49E-06	7.05E-03
MW-8	2.56E-06	7.80E-05	2.21E-01
MW-9	4.94E-06	1.51E-04	4.27E-01
MW-10	1.50E-06	4.59E-05	1.30E-01
MW-11	NT	NT	NT
MW-12	2.37E-07	7.23E-06	2.05E-02
MW-18	3.29E-07	1.00E-05	2.84E-02
Geometric Mean	1.30E-06	3.95E-05	1.12E-01
Plateau Intermediate Well			
MW-1I	NT	NT	NT
Plateau Cotter-Jefferson City Wells			
MW-1D	6.96E-06	2.12E-04	6.01E-01
MW-2D	1.35E-05	4.13E-04	1.17E+00
MW-3D	9.93E-06	3.03E-04	8.58E-01
MW-4D	4.04E-06	1.23E-04	3.49E-01
MW-5D	3.65E-06	1.11E-04	3.15E-01
MW-6D	3.58E-05	1.09E-03	3.09E+00
MW-7D	9.12E-06	2.78E-04	7.88E-01
Geometric Mean	8.92E-06	2.72E-04	7.71E-01
Study Boundary Cotter-Jefferson City Wells			
MW-13	4.36E-06	1.33E-04	3.77E-01
MW-14	4.53E-06	1.38E-04	3.91E-01
MW-15	4.65E-06	1.42E-04	4.02E-01
MW-16	1.82E-06	5.54E-05	1.57E-01
MW-17	4.09E-06	1.25E-04	3.53E-01
PW-2	7.82E-06	2.38E-04	6.76E-01
PW-3	2.36E-06	7.20E-05	2.04E-01
Geometric Mean	3.85E-06	1.17E-04	3.33E-01
Missouri River Alluvial Wells			
FMW-1D	6.62E-07	2.02E-05	5.72E-02[1]
FMW-1S	TF	TF	TF
FMW-5	1.88E-04	5.72E-03	1.62E+01
FMW-6	TF	TF	TF
FMW-7	TF	TF	TF
FMW-8	TF	TF	TF
FMW-9	TF	TF	TF
FMW-10	TF	TF	TF
FMW-11	TF	TF	TF
FMW-12	TF	TF	TF

Notes

NT Not tested
TF Recovery to fast to estimate Hydraulic Conductivity
1 FMW-1D is screened in the bedrock beneath the alluvial aquifer.

ER Section 2.3

Table 2.3-22—{Callaway Plant Unit 2 Pumping Test Results}

Well ID	T (ft^2/day)	T (cm^2/sec)	Kh (ft/day)	Kh (cm/sec)	S
Pumping Test PW-2					
PZ-2-1	13.2	1.42E-01	5.30E-01	1.87E-04	2.89E-04
PZ-2-2	15.4	1.66E-01	6.17E-01	2.18E-04	3.19E-04
PZ-2-3	13.0	1.40E-01	5.19E-01	1.83E-04	3.01E-04
Geometric Mean	13.8	1.49E-01	5.54E-01	1.95E-04	3.03E-04
Pumping Test PW-3					
PZ-3-1	2.58	2.77E-02	1.03E-01	3.63E-05	1.83E-04
PZ-3-2	2.48	2.67E-02	9.93E-02	3.50E-05	1.44E-04
PZ-3-3	2.74	2.95E-02	1.10E-01	3.88E-05	1.49E-04
Geometric Mean	2.60	2.79E-02	1.04E-01	3.67E-05	1.58E-04

Note: Transmissivity was assumed over the screened interval plus the sand pack above the well. It is not representative of the entire thickness of the CJC aquifer.

Table 2.3-23—{Callaway Plant Unit 2 Aquifer Unit Geotechnical Parameters}

Boring Location	Sample Number	Sample Depth	Origin	Geotechnical Laboratory Analyses: Moisture Content[1]	Moist Unit Weight[2] (lb/ft^3)	Specific Gravity	Total Organic Content (%)	Vertical Hydraulic Conductivity (cm/sec)	Calculated Values: Void Ratio	Porosity (%)
Plateau Shallow Unconsolidated Materials										
PW-1	ST-1	15-17	Till	0.198	122.7	2.567	1.4	1.2E-07	0.56	36.1
MW-2S	ST-1	15-16.3	Loess	0.164	133.5	2.615	1.4	7.1E-08	0.42	29.7
MW-5S	ST-1	10-12	Till	0.188	130.3	2.590	1.7	6.1E-07	0.47	32.1
MW-6S	ST-1	15-17	Gley	0.212	129.3	2.529	1.3	1.1E-07	0.48	32.4
MW-8	ST-1	15-17	Till	0.264	121.8	2.876	2.0	6.0E-09	0.86	46.3
MW-8	ST-2	20-22	Chert	0.208	128.7	2.562	1.3	6.8E-08	0.50	33.4
MW-9	ST-1	15-17	Till	0.222	131.1	2.527	1.4	4.2E-09	0.47	32.0
MW-10	ST-1	15-17	Till	0.258	126.7	2.524	1.3	1.7E-06	0.56	36.1
MW-11	ST-1	15-17	Till	0.183	126.0	2.516	1.6	6.9E-09	0.47	32.2
			Mean =	0.211	127.8	2.590	1.5	6.1E-08	0.53	34.8
Missouri River Alluvium										
FMW-5	S-5	10-12	Alluvium	0.12	103.0	2.53	0.67	2.1E-04	0.72	41.7
FMW-8	S-5	10-12	Alluvium	0.48	106.0	2.61	1.56	4.6E-08	1.27	56.1
FMW-8	S-6	14-15.5	Alluvium	0.38	110.0	2.52	1.42	7.6E-08	0.97	49.3
FMW-12	S-3	10-12	Alluvium	0.37	110.0	2.56	2.35	8.7E-08	0.99	49.7
FSB-13	S-3	10-12.5	Alluvium	0.03	98.0	2.59	0.27	1.8E-04	0.70	41.1
			Mean =	0.27	105.4	2.56	1.25	1.6E-06	0.93	47.5

Note:
Moisture Content = Water Content = weight of water in the sample divided by the weight of dry solids.
Moist Unit Weight = Bulk Density = weight of water and solids divided by the sample volume.
Calculations:
Void Ratio = (Specific Gravity (x) Unit Weight of Water (x) (1+ Natural Moisture))/(Moisture Unit Weight) - 1
Unit Weight Water = 62.4 lb/ft^3
Porosity = (Void Ratio)/(1+Void Ratio)
Means are calculated as arithmetic except geometric mean for hydraulic conductivity.

ER Section 2.3

Table 2.3-24—{Callaway Plant Unit 2 Grain Size Distribution}
(Page 1 of 2)

Boring Location	Sample Number	Sample Depth	Origin	Grain Size Characteristics: Coarse Gravel (%)	Fine Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)
Plateau Shallow Unconsolidated Materials										
PW-1	ST-1	15-17	Till	0.0	0.0	0.0	2.5	6.3	42.1	49.1
MW-2S	ST-1	15-16.3	Loess	0.0	0.0	0.0	6.4	11.2	33.6	48.8
MW-5S	ST-1	10-12	Till	0.0	0.0	0.0	7.4	19.9	30.9	41.8
MW-6S	ST-1	15-17	Gley	0.0	0.0	0.0	1.2	5.3	45.3	48.2
MW-8	ST-1	15-17	Till	0.0	0.0	0.0	1.2	5.7	37.5	55.6
MW-8	ST-2	20-22	Chert	0.0	0.0	0.0	5.7	23.0	31.3	40.0
MW-9	ST-1	15-17	Till	0.0	0.0	0.0	6.9	17.3	29.0	46.8
MW-10	ST-1	15-17	Till	0.0	0.0	0.0	1.0	4.4	43.1	51.5
MW-11	ST-1	15-17	Till	0.0	0.0	0.0	0.7	3.3	40.8	55.2
Missouri River Alluvium										
FMW-1D	SS-10	45-50	Alluvium	0.0	18.7	50.7	26.7	3.1	0.5	0.3
FMW-1D	SS-11	50-55	Alluvium	0.0	3.7	33.8	56.7	4.7	0.5	0.6
FMW-1D	SS-12	55-60	Alluvium	0.0	4.8	35.1	52.7	5.9	0.8	0.7
FMW-1D	SS-13	60-65	Alluvium	0.0	30.0	47.7	19.3	2.4	0.2	0.4
FMW-1D	SS-16	75-80	Alluvium	0.0	19.0	53.1	26.0	1.2	0.4	0.3
FMW-1D	SS-17	80-85	Alluvium	0.0	13.1	46.4	34.8	3.4	1.2	1.1
FMW-1D	SS-18	85-90	Alluvium	0.0	15.2	54.4	26.5	2.3	0.4	1.2
FMW-1D	SS-19	90-94	Alluvium	0.0	2.1	51.1	39.1	4.7	1.0	2.0
FSB-2	SS-14	65-70	Alluvium	0.0	0.3	22.4	68.0	8.8	0.1	0.4
FSB-2	SS-15	70-75	Alluvium	0.0	0.1	8.3	83.5	7.4	0.2	0.5
FSB-2	SS-16	75-80	Alluvium	0.0	0.2	15.0	71.5	12.4	0.4	0.5
FSB-2	SS-17	80-85	Alluvium	0.0	0.3	24.6	69.8	5.0	< 0.3% silt and clay	
FSB-3	SS-17	80-85	Alluvium	0.0	4.3	45.5	48.2	1.6	< 0.4% silt and clay	
FSB-3	SS-18	85-90	Alluvium	0.0	4.9	24.1	53.1	14.1	2.3	1.5
FSB-3	SS-19	90-95	Alluvium	0.0	2.6	18.7	58.6	18.4	0.8	0.9
FSB-3	SS-20	95-100	Alluvium	0.0	0.1	12.1	81.4	4.6	0.8	1.0
FSB-4	SS-19	80-85	Alluvium	0.0	19.0	48.7	30.7	1.5	< 0.1% silt and clay	
FSB-4	SS-20	86-91	Alluvium	0.0	3.5	42.6	53.0	0.8	< 0.1% silt and clay	
FSB-4	SS-21	91-96	Alluvium	0.0	32.9	46.3	19.1	1.3	< 0.4% silt and clay	
FSB-4	SS-22	96-99.5	Alluvium	0.0	15.3	45.4	34.2	3.8	0.9	0.4

Table 2.3-24—{Callaway Plant Unit 2 Grain Size Distribution}

(Page 2 of 2)

Boring Location	Sample Number	Sample Depth	Origin	Grain Size Characteristics: Coarse Gravel (%)	Fine Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)
FMW-5	S-3	10-12.5	Alluvium	0.0	0.0	0.0	0.2	79.0	16.7	4.1
FMW-5	SS-9	35-40	Alluvium	0.0	0.0	9.3	26.3	62.5	1.0	0.9
FMW-5	SS-10	40-45	Alluvium	0.0	0.1	1.0	36.9	60.4	0.9	0.7
FMW-5	SS-11	45-49.5	Alluvium	0.0	0.1	6.6	16.9	73.1	1.1	2.2
FMW-8	S-5	10-12	Alluvium	0.0	0.0	0.0	0.3	0.5	61.4	37.8
FMW-8	S-6	14-15.5	Alluvium	0.0	0.0	0.0	0.8	16.0	37.0	46.2
FMW-12	S-3	10-12	Alluvium	0.0	0.0	0.0	0.1	0.1	46.4	53.4
FSB-13	S-3	10.0-12.5	Alluvium	0.0	0.0	0.0	0.1	77.7	18.4	3.8
FSB-13	SS-18	80-85	Alluvium	0.0	4.6	54.9	38.0	2.0	< 0.5% silt and clay	
FSB-13	SS-19	85-90	Alluvium	0.0	2.7	42.8	51.0	3.0	< 0.5% silt and clay	
FSB-13	SS-20	90-95	Alluvium	0.0	12.4	53.2	32.7	1.5	< 0.2% silt and clay	
FSB-13	SS-21	95-99.5	Alluvium	0.0	4.8	52.6	38.6	3.2	0.3	0.5
FSB-14	SS-16	80-85	Alluvium	0.0	0.1	7.7	80.0	11.3	0.6	0.3
FSB-14	SS-17	85-90	Alluvium	0.0	0.2	32.0	60.2	7.3	< 0.3% silt and clay	
FSB-14	SS-18	90-95	Alluvium	0.0	0.6	35.9	55.5	7.6	< 0.4% silt and clay	
FSB-14	SS-19	95-100	Alluvium	0.0	11.1	51.8	32.7	4.1	< 0.3% silt and clay	

Table 2.3-25—{Callaway Plant Unit 2 Groundwater Flow Velocities and Travel Times}

Well Pair	General GW Flow Direction	Average Gradient (ft/ft)	Hydraulic Conductivity[1] (ft/day)	Porosity	Ground-water Velocity (ft/day)	Travel Distance[2] (ft)	Travel Time (years)[3]
Graydon Chert Aquifer – From Callaway Plant Unit 2 – Horizontal Groundwater Flow							
MW-18/MW-12	WNW	0.00419	0.112	0.05	0.0094	128.3	37.4
MW-18/MW-10	SSE	0.00230	0.112	0.05	0.0052	70.5	37.4
PW-1/MW-9	ESE	0.00162	0.112	0.05	0.0036	49.7	37.4
MW-18/MW-8	NNE	0.00121	0.112	0.05	0.0027	37.0	37.4
Graydon Chert Aquifer – From Callaway Plant Unit 2 – Vertical Groundwater Flow							
PW-1/MW-1D	Downward	0.8612	1.7E-4	0.05	0.0029	40	37.4
Aquitard – Vertical Groundwater Flow							
PW-1/MW-1D	Downward	0.8612	1.7E-5	0.05	0.00029	275	2573
Cotter-Jefferson City Aquifer – Horizontal Groundwater Flow							
MW-2D/MW-13	NNW	0.00060	0.771	0.05	0.0093	13,934	4097
MW-6D/MW-14	WNW	0.00212	0.771	0.05	0.0328	14,508	1213
MW-5D/PW-2	W	0.00346	0.771	0.05	0.0534	11,282	579
MW-4D/MW-16	WSW	0.00308	0.771	0.05	0.0475	7,076	408

(1) For the Graydon Chert, horizontal hydraulic conductivity is the geometric mean from slug test results and vertical hydraulic conductivity is from geometric mean from permeability tests. For the aquitard, vertical hydraulic conductivity is 10% of value for the Graydon Chert aquifer. For the CJC aquifer, horizontal hydraulic conductivity is the geometric mean from slug test results.

(2) Horizontal travel distance in Graydon Chert aquifer is based on travel time of 37.4 years estimated as the time for a groundwater particle at the top of the chert to travel downward and leave the aquifer.

(3) Travel time through CJC aquifer is the time to travel from the first well to the second well in the pair.

Table 2.3-26—{Total Surface Water Usage by Major Water Users}

(Page 1 of 2)

Register ID	County	Waterbody Name	Waterbody Type	Water Pumped, gal/yr	Water Pumped, m^3/yr	Purpose
027300009	Callaway	MISSOURI RIVER @ MILE 115.4	RIVER	8.04E+09	3.04E+07	Power
027300004	Callaway	ATKINSON-GUTHRIE LAKE	IMPOUNDMENT	6.00E+07	2.27E+05	Irrigation
027200012	Callaway	LAKE	IMPOUNDMENT	8.64E+07	3.27E+05	Irrigation
007200059	Audrain	SHELLABARGER LAKE	IMPOUNDMENT	1.40E+07	5.30E+04	Irrigation
007300060	Audrain	DUSTIN BENNE LAKE	IMPOUNDMENT	2.32E+07	8.79E+04	Irrigation
007200057	Audrain	PRIVATE MANMADE RESERVOIR	IMPOUNDMENT	3.26E+07	1.23E+05	Irrigation
137200004	Monroe	PRIVATE MANMADE RESERVOIR	IMPOUNDMENT	7.74E+07	2.93E+05	Irrigation
007200006	Audrain	WEST LICK CREEK	CREEK	4.87E+07	1.84E+05	Irrigation
151300002	Osage	MISSOURI RIVER @ MILE 117.1	RIVER	2.49E+10*	9.41E+07*	Power
139300007	Montgomery	IRRIGATION LAKE	IMPOUNDMENT	2.20E+07	8.33E+04	Irrigation
007200017	Audrain	LAKE	IMPOUNDMENT	3.02E+07	1.14E+05	Irrigation
007200017	Audrain	LAKE	IMPOUNDMENT	3.02E+07	1.14E+05	Irrigation
007300034	Audrain	25 ACRE LAKE	IMPOUNDMENT	1.36E+07	5.14E+04	Irrigation
007300034	Audrain	17 ACRE LAKE AT NORTH FARM	IMPOUNDMENT	1.58E+07	5.96E+04	Irrigation
007200020	Audrain	JOHN FREYER LAKE	IMPOUNDMENT	7.39E+07	2.80E+05	Irrigation
007200003	Audrain	CUIVRE RIVER-USED FILL LK 001	IMPOUNDMENT	3.26E+06	1.23E+04	Irrigation
007200003	Audrain	16 ACRE LAKE FILLED BY RUN OFF	IMPOUNDMENT	5.70E+06	2.16E+04	Irrigation
007300053	Audrain	MATHEWS LAKE	IMPOUNDMENT	6.50E+06	2.46E+04	Irrigation
007200007	Audrain	9 ACRE LAKE	IMPOUNDMENT	2.00E+06	7.57E+03	Irrigation
007200007	Audrain	15 ACRE LAKE	IMPOUNDMENT	5.00E+06	1.89E+04	Irrigation
007200007	Audrain	6 ACRE LAKE	IMPOUNDMENT	5.00E+06	1.89E+04	Irrigation
007200007	Audrain	S. FORK OF SALT RIVER	RIVER	6.80E+06	2.57E+04	Irrigation
007200004	Audrain	YOUNG CREEK	CREEK	2.50E+07	9.46E+04	Irrigation
139200005	Montgomery	LAKE	IMPOUNDMENT	3.25E+07	1.23E+05	Irrigation
151200003	Osage	BIG LOOSE CREEK	CREEK	6.00E+06	2.27E+04	Irrigation
051200011	Cole	OSAGE RIVER	RIVER	1.37E+07	5.19E+04	Irrigation
007200050	Audrain	LAKE	IMPOUNDMENT	1.50E+07	5.68E+04	Irrigation
MO3010409	Cole	MISSOURI RIVER		2.25E+09	8.51E+06	Municipal Water Supply

Table 2.3-26—{Total Surface Water Usage by Major Water Users}
(Page 2 of 2)

Register ID	County	Waterbody Name	Waterbody Type	Water Pumped, gal/yr	Water Pumped, m^3/yr	Purpose
163200002	Pike	WELDON "PETE" STEINER RESERVOIR	IMPOUNDMENT	9.80E+07	3.71E+05	Irrigation
139200009	Montgomery	SPORTSMAN LAKE	IMPOUNDMENT	4.38E+07	1.66E+05	Irrigation
007200037	Audrain	LAKE (3 PUMPS-550 GPM EACH)	IMPOUNDMENT	6.36E+07	2.41E+05	Irrigation

Notes

* Water pumped is returned to Missouri River after passing through condenser.

Source: **MDNR, 2007** Water Resources Center, www.dnr.mo.gov/env/wrc

Table 2.3-27—{Callaway Plant Unit 1 Cooling Tower Blowdown Discharge Permit No. MO-0098001}

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Yearly Average
Monthly Average (Million Gallons/Day (MGD))													
2004	4.47	2.70	4.82	7.02	6.12	5.03	4.87	3.36	5.55	4.90	4.83	4.82	4.87
2005	4.32	4.55	4.60	4.57	4.97	6.37	5.96	7.65	4.97	0.23	3.25	5.49	4.74
2006	4.81	4.31	4.82	5.81	2.21	4.83	6.66	5.88	NA	4.70	5.62	4.98	4.97*
2007	5.05	5.21	7.01	3.73	2.40	NA	NA	NA	NA	NA	NA	NA	NA
Monthly Average (m^3/day)													
2004	1.7E+04	1.0E+04	1.8E+04	2.7E+04	2.3E+04	1.9E+04	1.8E+04	1.3E+04	2.1E+04	1.9E+04	1.8E+04	1.8E+04	1.8E+04
2005	1.6E+04	1.7E+04	1.7E+04	1.7E+04	1.9E+04	2.4E+04	2.3E+04	2.9E+04	1.9E+04	8.7E+02	1.2E+04	2.1E+04	1.8E+04
2006	1.8E+04	1.6E+04	1.8E+04	2.2E+04	8.4E+03	1.8E+04	2.5E+04	2.2E+04	NA	1.8E+04	2.1E+04	1.9E+04	1.9E+04*
2007	1.9E+04	2.0E+04	2.7E+04	1.4E+04	9.1E+03	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA= not available

*Monthly yearly average based on 11-month period, since September data was not available.

Source: MDNR, 2007 Missouri Clean Water Commission, Missouri State Operating Permit.

Table 2.3-28—{Listing of U.S. Environmental Protection Agency (US EPA) SDWIS Community, Non-Transient Non-Community, and Transient Non-Community Water Systems in Callaway and Osage Counties, Missouri}

(Page 1 of 3)

County	Type	System Name	System ID	Population Served	Primary Water Source	Status	Date Closed
Callaway	Community	AUXVASSE	MO3010039	1135	Groundwater	Active	N/A
Callaway	Community	CALLAWAY #2 WATER DISTRICT	MO3024085	13500	Groundwater	Active	N/A
Callaway	Community	CALLAWAY CO PWSD #1	MO3024084	8350	Groundwater	Active	N/A
Callaway	Community	FULTON	MO3010296	12128	Groundwater	Active	N/A
Callaway	Community	FULTON STATE HOSPITAL	MO3069004	2005	Groundwater	Active	N/A
Callaway	Community	HATTON HILLS MHP	MO3041238	25	Groundwater	Active	N/A
Callaway	Community	JEFFERSON CITY - NORTH	MO3010146	95	Groundwater	Active	N/A
Callaway	Community	KINGDOM CITY	MO3010424	162	Groundwater	Active	N/A
Callaway	Community	MOKANE WATER CO-OP	MO3010535	186	Groundwater	Active	N/A
Callaway	Community	NEW BLOOMFIELD	MO3010563	560	Groundwater	Active	N/A
Callaway	Community	NEW CHRISTIAN LIFE FELLOWSHIP	MO3048994	87	Groundwater	Active	N/A
Callaway	Community	RIVERVIEW NURSING CENTER	MO3069003	60	Groundwater	Active	N/A
Callaway	Community	SCOTCHMAN PLACE	MO3048263	67	Groundwater	Active	N/A
Callaway	Community	COUNTRY MANOR	MO3069077	35	Groundwater	Closed	12/1/1985
Callaway	Community	MC DONALD MHP	MO3048262	130	Groundwater	Closed	2/1/1984
Callaway	Community	REFORM MOBILE RENTALS	MO3048260	100	Groundwater	Closed	11/1/1984
Callaway	Community	RENZ FARM	MO3069002	320	Groundwater	Closed	8/1/1993
Callaway	Community	SALMONS TRAILER COURT	MO3040740	30	Groundwater	Closed	9/1/1996
Callaway	Community	TOWER MHP	MO3048261	115	Groundwater	Closed	4/1/2005
Callaway	Non-Transient Non-Community	AMEREN U.E.-CALLAWAY PLT	MO3182219	860	Groundwater	Active	N/A
Callaway	Non-Transient Non-Community	SOUTH CALLAWAY CO R-II SCHOOLS	MO3171252	760	Groundwater	Active	N/A
Callaway	Non-Transient Non-Community	HATTEN MCCREDIE R-1 ELEM	MO3171127	255	Groundwater	Closed	7/1/1984
Callaway	Non-Transient Non-Community	KINGDOM CITY SINCLAIR	MO3181315	25	Groundwater	Closed	1/1/1988
Callaway	Non-Transient Non-Community	MERIAL LIMITED	MO3181380	29	Groundwater	Closed	10/1/1998
Callaway	Non-Transient Non-Community	NORTH CALLAWAY R-I SR. HIGH	MO3171251	400	Groundwater	Closed	7/1/1995

Table 2.3-28—{Listing of U.S. Environmental Protection Agency (US EPA) SDWIS Community, Non-Transient Non-Community, and Transient Non-Community Water Systems in Callaway and Osage Counties, Missouri}

(Page 2 of 3)

County	Type	System Name	System ID	Population Served	Primary Water Source	Status	Date Closed
Callaway	Non-Transient Non-Community	WILLIAMSBURG R-1 ELEM SCHOOL	MO3171128	210	Groundwater	Closed	4/1/1984
Callaway	Transient Non-Community	CROOKED CREEK CAMPGROUND	MO3240054	40	Groundwater	Active	N/A
Callaway	Transient Non-Community	WILDWOOD LOT OWNERS ASSOCIATION	MO3242162	100	Groundwater	Active	N/A
Callaway	Transient Non-Community	EBENEZER BAPTIST CHURCH	MO3270305	25	Groundwater	Closed	7/1/1991
Callaway	Transient Non-Community	FOREST'S STANDARD SERV	MO3232044	200	Groundwater	Closed	12/1/1991
Callaway	Transient Non-Community	FRONTIER MOTEL	MO3190681	60	Groundwater	Closed	12/1/1991
Callaway	Transient Non-Community	KINGDOM CITY SERVICES INC	MO3210680	800	Groundwater	Closed	11/15/2006
Callaway	Transient Non-Community	LAY'S MOTEL	MO3191737	25	Groundwater	Closed	12/1/1991
Callaway	Transient Non-Community	MOC 1 TRAVEL PLAZA	MO3290603	50	Groundwater	Closed	1/1/2000
Callaway	Transient Non-Community	OLD AUXVASSE NM PRESBY CHURCH	MO3270503	25	Groundwater	Closed	12/1/1991
Callaway	Transient Non-Community	POPLAR TREE RESTAURANT	MO3211456	500	Groundwater	Closed	12/1/1991
Callaway	Transient Non-Community	PORTLAND BAPTIST CHURCH	MO3270306	25	Groundwater	Closed	7/1/1991
Callaway	Transient Non-Community	RICHLAND BAPTIST CHURCH	MO3271314	25	Groundwater	Closed	7/1/1991
Callaway	Transient Non-Community	SKELLY TRUCK PLAZA	MO3212043	750	Groundwater	Closed	12/1/1991
Callaway	Transient Non-Community	SONNY'S RESTAURANT	MO3211600	300	Groundwater	Closed	12/1/1991
Osage	Community	CHAMOIS	MO3010155	456	Groundwater	Active	N/A
Osage	Community	FRANKENSTEIN	MO3010904	113	Groundwater	Active	N/A
Osage	Community	FREEBURG	MO3010291	850	Groundwater	Active	N/A
Osage	Community	LINN	MO3010470	1220	Groundwater	Active	N/A

Table 2.3-28—{Listing of U.S. Environmental Protection Agency (US EPA) SDWIS Community, Non-Transient Non-Community, and Transient Non-Community Water Systems in Callaway and Osage Counties, Missouri}
(Page 3 of 3)

County	Type	System Name	System ID	Population Served	Primary Water Source	Status	Date Closed
Osage	Community	META	MO3010517	410	Groundwater	Active	N/A
Osage	Community	OSAGE CO PWSD #1	MO3024437	1003	Groundwater	Active	N/A
Osage	Community	OSAGE CO PWSD #2-NORTH	MO3024438	650	Groundwater	Active	N/A
Osage	Community	OSAGE CO PWSD #2-SOUTH	MO3024441	400	Groundwater	Active	N/A
Osage	Community	OSAGE CO PWSD #3	MO3024439	1155	Groundwater	Active	N/A
Osage	Community	OSAGE CO PWSD #4	MO3024440	358	Groundwater	Active	N/A
Osage	Community	LINN MANOR REST HOME	MO3069011	40	Groundwater	Closed	6/1/1991
Osage	Non-Transient Non-Community	DIAMOND PET FOODS	MO3181615	60	Groundwater	Active	N/A
Osage	Non-Transient Non-Community	CENTRAL ELECTRIC POWER COOP	MO3182248	25	Groundwater	Closed	10/1/2004
Osage	Non-Transient Non-Community	LINN MIDDLE ELEM SCHOOL	MO3171204	155	Groundwater	Closed	7/1/1982
Osage	Non-Transient Non-Community	QUAKER WINDOW CO	MO3180620	25	Groundwater	Closed	11/1/1987
Osage	Non-Transient Non-Community	STANDARD MILLING CO	MO3180622	25	Groundwater	Closed	2/1/1988
Osage	Transient Non-Community	MARI-OSA-DELTA	MO3190087	30	Groundwater	Active	N/A
Osage	Transient Non-Community	OSAGE COUNTRY CLUB	MO2202792	60	Groundwater	Active	N/A
Osage	Transient Non-Community	RAINBOW LANES BOWLING	MO3281735	25	Groundwater	Active	N/A
Osage	Transient Non-Community	MFA SERVICE	MO3231465	25	Groundwater	Closed	1/1/1992
Osage	Transient Non-Community	ROY & JOAN'S COUNTRY LOUNGE	MO3211484	25	Groundwater	Closed	1/1/1992
Osage	Transient Non-Community	WILLIBRANDS, INC	MO3231384	50	Groundwater	Closed	2/26/2007

Reference: U.S. Environmental Protection Agency, Safe Drinking Water Information System (SDWIS) Website, http://www.epa.gov/enviro/html/sdwis, Accessed August 29, 2007.

Table 2.3-29—{Listing of Missouri Department of Natural Resources Public Water Use for Callaway and Osage Counties, Missouri}

(Page 1 of 2)

County	Type	System Name	System ID	# Wells	1st Year	Pop. Served	Service Connections	Supply (MGD)	Consumption (MGD)	Storage (MG)
Callaway	Community	AUXVASSE	MO3010039	3	1913	1,135	454	0.2880	0.0860	0.4000
Callaway	Community	CALLAWAY #2 WATER DISTRICT	MO3024085	10	1973	13,500	4,910	4.5000	1.0280	1.3047
Callaway	Community	CALLAWAY CO PWSD #1	MO3024084	6	1968	8,350	3,600	3.2112	0.8600	2.7500
Callaway	Community	FULTON	MO3010296	6	1937	12,128	4,500	4.3900	1.3000	5.7000
Callaway	Community	FULTON STATE HOSPITAL	MO3069004	2	2005	2,005	2	0.8000	0.2530	0.2500
Callaway	Community	HATTON HILLS MHP	MO3041238	1	2006	25	100	NR	NR	NR
Callaway	Community	JEFFERSON CITY - NORTH	MO3010146	2	1963	95	30	0.3000	0.0230	0.0500
Callaway	Community	KINGDOM CITY	MO3010424	1	1989	162	62	0.5000	0.0820	0.5000
Callaway	Community	MOKANE WATER CO-OP	MO3010535	1	1961	186	105	0.0700	0.0150	0.0370
Callaway	Community	NEW BLOOMFIELD	MO3010563	2	1961	560	264	0.2100	0.0400	0.0500
Callaway	Community	NEW CHRISTIAN LIFE FELLOWSHIP	MO3048994	1	1979	87	25	0.0400	0.0200	0.0006
Callaway	Community	RIVERVIEW NURSING CENTER	MO3069003	1	1978	60	1	0.0700	0.0050	0.0002
Callaway	Community	SCOTCHMAN PLACE	MO3048263	1	1989	67	40	0.0430	0.0096	0.0004
Callaway	Non-Transient Non-Community	AMEREN U.E.-CALLAWAY PLT	MO3182219	3	1976	860	NR	NR	NR	NR
Callaway	Non-Transient Non-Community	SOUTH CALLAWAY CO R-II SCHOOLS	MO3171252	2	1958	760	NR	NR	NR	NR
Callaway	Transient Non-Community	CROOKED CREEK CAMPGROUND	MO3240054	1	1995	40	NR	NR	NR	NR
Callaway	Transient Non-Community	WILDWOOD LOT OWNERS ASSOCIATION	MO3242162	1	1973	100	NR	NR	NR	NR
Osage	Community	CHAMOIS	MO3010155	2	1923	456	243	0.4000	0.0500	0.1500
Osage	Community	FRANKENSTEIN	MO3010904	1	1976	113	45	0.0640	0.0060	0.0010
Osage	Community	FREEBURG	MO3010291	2	1965	850	340	0.3600	0.0650	0.1500
Osage	Community	LINN	MO3010470	4	1937	1,220	629	0.9300	0.2900	0.3000
Osage	Community	META	MO3010517	1	1959	410	133	0.3000	0.0500	0.1000
Osage	Community	OSAGE CO PWSD #1	MO3024437	2	1966	2,150	325	0.3740	0.0700	0.0740
Osage	Community	OSAGE CO PWSD #2-NORTH	MO3024438	2	1969	650	221	0.1080	0.0400	0.0300

Table 2.3-29—{Listing of Missouri Department of Natural Resources Public Water Use for Callaway and Osage Counties, Missouri}
(Page 2 of 2)

County	Type	System Name	System ID	# Wells	1st Year	Pop. Served	Service Connections	Supply (MGD)	Consumption (MGD)	Storage (MG)
Osage	Community	OSAGE CO PWSD #2-SOUTH	MO3024441	2	1969	400	158	0.0790	0.0270	0.0370
Osage	Community	OSAGE CO PWSD #3	MO3024439	1	1975	750	327	0.2300	0.0800	0.0870
Osage	Community	OSAGE CO PWSD #4	MO3024440	2	1974	400	135	0.1000	0.0210	0.0370
Osage	Non-Transient Non-Community	DIAMOND PET FOODS	MO3181615	1	1997	60	NR	NR	NR	NR
Osage	Transient Non-Community	MARI-OSA-DELTA	MO3190087	1	NR	30	NR	NR	NR	NR
Osage	Transient Non-Community	OSAGE COUNTRY CLUB	MO2202792	1	NR	60	NR	NR	NR	NR
Osage	Transient Non-Community	RAINBOW LANES BOWLING	MO3281735	1	1960	25	NR	NR	NR	NR

NR – not reported.

Table 2.3-30—{Listing of Local, Public and Private Wells for Callaway and Osage Counties, Missouri}

(Page 1 of 6)

Dataset[1]	Twp.	Rge.	Sect.	ID or Ref. Num.	MO#	Type	Distance[2] from site (miles)	Year	Gnd Elev. (ft msl)	Depth bgs (ft)	Casing bgs (ft)	Formation[3]	Yield (gpm)	Remarks[4]
Inside Study Area Boundary – Callaway County														
1	47N	8W	19	00053030	NA	Well	NA	NR	NR	395	232	Ls	40	Private
1	47N	8W	19	00357839	NA	Pump	NA	NR	NR	NR	NR	NR	NR	Private
1	47N	8W	20	00080777	NA	Well	NA	1991	NR	363	238	Ls	30	Private
1	47N	8W	21	00047677	NA	Well	NA	1991	NR	450	147	Ls-sh-flint	40	Private
1	47N	8W	21	00080740	NA	Well	NA	1992	NR	343	261	Ls/cht	40	Private
1	47N	8W	21	00151442	NA	Well	NA	1996	700	410	148	Sh-cht	30	Private
1	47N	8W	23	00395853	NA	Well	NA	NR	690	426	240	NR	25	Private
1	47N	7W	19	00116829	NA	Heat Pump	NA	NR	NR	NR	NR	NR	NR	Private
1	47N	8W	28	00335855	NA	Well	NA	2004	NR	395	80	ls to sh to ls	30	Private
1	47N	8W	29	00335833	NA	Well	NA	2004	NR	350	80	Ls-flint	30	Private
1	47N	8W	32	00113586	NA	Heat Pump	NA	NR	622	155	NR	NR	NR	Private
1	47N	8W	34	00057084	NA	Reconstruct	NA	1994	NR	NR	NR	NR	NR	Thunderbird Lake Assoc.
1	47N	8W	34	00064627	NA	Well	NA	1991	NR	150	NR	NR	NR	Private
1	47N	8W	34	00064628	NA	Well	NA	1991	730	365	103	Ls	22	Private
1	47N	8W	34	00191092	NA	Well	NA	1998	740	450	169	Cotter flint	25	Private
1	46N	7W	5	00077892	NA	Well	NA	1992	NR	435	218	Ls-ls/cht	30	Private
1	46N	8W	2	00114869	NA	Abandoned	NA	1996	NR	29	NR	NR	NR	AmerenUE (abandoned)
1	46N	8W	2	00211756	NA	Well	NA	1998	780	426	210	Ls-ls/flint	35	Private
1	46N	8W	3	00044091	NA	Unknown	NA	1989	NR	435	184	Ls – sh – ls/flint	30	Private
1	46N	8W	3	00169520	NA	Well	NA	1996	NR	426	164	Ls – ls/flint	30	Private
1	46N	8W	6	00008038	NA	Well	NA	NR	NR	210	80	NR	30	Private
1	46N	8W	6	00010329	NA	Pump	NA	NR	NR	210	NR	NR	NR	Private
1	46N	8W	7	00007056	NA	Reconstruct	NA	1988	NR	375	NR	NR	NR	Private
1	46N	8W	11	00316189	NA	Monitoring	NA	NR	834	31	60	NR	NR	AmerenUE
1	46N	7W	7	00164558	NA	Reconstruct	NA	1998	NR	NR	NR	NR	NR	Private
1	46N	8W	13	00316191	NA	Monitoring	NA	NR	842	42	60	NR	NR	AmerenUE
1	46N	8W	13	00003458	NA	Well	NA	1987	NR	377	186	NR	NR	AmerenUE
1	46N	8W	14	00003459	NA	Well	NA	1987	NR	402	136	NR	NR	AmerenUE

Table 2.3-30—{Listing of Local, Public and Private Wells for Callaway and Osage Counties, Missouri}

(Page 2 of 6)

Dataset[1]	Twp.	Rge.	Sect.	ID or Ref. Num.	MO#	Type	Distance[2] from site (miles)	Year	Gnd Elev. (ft msl)	Depth bgs (ft)	Casing bgs (ft)	Formation[3]	Yield (gpm)	Remarks[4]
1	46N	8W	14	00122521	NA	Monitoring	NA	1995	NR	29	NR	Grvl – clay	NR	AmerenUE
1	46N	8W	14	00122522	NA	Monitoring	NA	1995	NR	28	NR	Sty clay – grvl	NR	AmerenUE
1	46N	8W	14	00122524	NA	Monitoring	NA	1995	NR	29	NR	Sty clay – grv	NR	AmerenUE
1	46N	8W	14	00122525	NA	Monitoring	NA	1996	NR	30	NR	Ls/grvl	NR	AmerenUE
1	46N	8W	14	00122526	NA	Monitoring	NA	1996	NR	28	NR	Ls/grvl	NR	AmerenUE
1	46N	8W	14	00122531	NA	Monitoring	NA	1995	NR	27	NR	Sty clay-grvl-clay	NR	AmerenUE
1	46N	8W	14	00131867	NA	Abandoned	NA	1995	NR	29	9	NR	NR	AmerenUE (abandoned)
1	46N	8W	14	00131868	NA	Abandoned	NA	1996	NR	18	NR	NR	NR	AmerenUE (abandoned)
1	46N	8W	14	00145125	NA	Monitoring	NA	NR	NR	25	NR	NR	NR	AmerenUE
1	46N	8W	14	00145126	NA	Monitoring	NA	NR	NR	29	NR	NR	NR	AmerenUE
1	46N	8W	14	00275184	NA	Abandoned	NA	2002	840	64.4	NR	NR	NR	AmerenUE (abandoned)
1	46N	8W	14	00316190	NA	Monitoring	NA	NR	829	35	60	NR	NR	AmerenUE
1	46N	8W	16	00007729	NA	Well	NA	1988	NR	390	104	Ls-sh-cotter	30	Private
1	46N	8W	16	00308414	NA	Pump	NA	2004	NR	450	NR	NR	NR	Private
1	46N	8W	16	00308468	NA	Well	NA	2002	NR	450	106	Ls-rx/flint	30	Private
1	46N	8W	17	00242018	NA	Heat Pump	NA	NR	NR	150	NR	Ls	NR	Private
1	46N	8W	19	00000079	NA	Well	NA	1987	NR	375	62	Ls-flint	25	Private
1	46N	8W	19	00064288	NA	Well	NA	1991	NR	350	126	Sh-rx	30	Private
1	46N	7W	19	00211752	NA	Well	NA	1998	680	306	82	Ls-ls/flint	30	Private
1	46N	8W	20	00213227	NA	Well	NA	1998	680	NR	426	Ls-ls/sh-ls/flint	40	Private
1	46N	8W	21	00135670	NA	Well	NA	1995	700	450	168	Rx/sh-rx/flint	30	Private
1	46N	7W	29	00374270	NA	Pump	NA	NR	NR	365	NR	NR	NR	Private
1	46N	7W	29	00402075	NA	Well	NA	NR	NR	365	120	NR	40	Private
1	46N	7W	30	00200378	NA	Well	NA	1997	720	465	90	Ls-clay-sh-ls	30	Private
1	46N	8W	25	00003452	NA	Well	NA	1987	550	301	105	Ls/flint	30	Private
1	46N	8W	27	00006638	NA	Well	NA	1988	520	147	82	Ls	20	Private
1	46N	8W	27	00048226	NA	Well	NA	1990	NR	170	80	Ls-flint	NR	Private
1	46N	8W	27	00087075	NA	Well	NA	1992	600	450	122	Sh-flint	40	Private
1	46N	8W	27	00198973	NA	Well	NA	1998	600	386	102	Ls-ls/flint	NR	Private

Table 2.3-30—{Listing of Local, Public and Private Wells for Callaway and Osage Counties, Missouri}

(Page 3 of 6)

Dataset[1]	Twp.	Rge.	Sect.	ID or Ref. Num.	MO#	Type	Distance[2] from site (miles)	Year	Gnd Elev. (ft msl)	Depth bgs (ft)	Casing bgs (ft)	Formation[3]	Yield (gpm)	Remarks[4]
1	46N	8W	27	00224427	NA	Well	NA	1999	NR	306	126	Ls/sh-ls	50	Private
1	46N	8W	28	00228356	NA	Well	NA	1999	740	426	123	Ls-ls/flint	40	Private
1	46N	8W	29	00191043	NA	Well	NA	1997	NR	510	106	Flint	30	Private
1	46N	7W	31	00134215	NA	Well	NA	1994	NR	375	84	Ls-ls/flint	30	Private
1	46N	7W	31	00188914	NA	Reconstruct	NA	1999	NR	270	NR	NR	NR	Private
1	46N	7W	32	00001376	NA	Well	NA	1987	NR	227	61	Ls	25	Private
1	46N	7W	32	00010425	NA	Well	NA	1988	640	247	82	Ls	20	Private
1	46N	7W	32	00081995	NA	Well	NA	1991	640	330	82	Ls-ls/cht	50	Private
1	46N	7W	32	00169268	NA	Well	NA	1997	NR	190	80	Ls/flint	30	Private
1	46N	7W	32	00273760	NA	Well	NA	2002	600	330	82	Ls-sand-ls-ls/flint -pink ls	25	Private
1	45N	8W	6	00018802	NA	Well	NA	1996	580	306	102	Ls/flint	35	Private
1	45N	8W	6	00180662	NA	Well	NA	1997	BR	450	148	Sh-flint	30	Private
1	45N	8W	7	00019262	NA	Well	NA	1996	660	426	102	Ss/flint	NR	Private
1	45N	8W	7	00151208	NA	Well	NA	1996	NR	330	82	Ls/flint/ss	25	Private
1	45N	8W	7	00148453	NA	Well	NA	1996	NR	270	90	Ls/cht	30	Private
1	46N	8W	33	00308424	NA	Pump	NA	NR	NR	430	NR	NR	NR	Private
1	46N	8W	33	00318634	NA	Well	NA	NR	NR	430	106	NR	40	Private
1	46N	8W	34	00289232	NA	Pump	NA	NR	NR	NR	NR	NR	NR	Private
1	46N	8W	34	00318658	NA	Well	NA	NR	NR	450	148	NR	80	Private
1	45N	7W	5	00100248	NA	Unknown	NA	1996	510	854	350	Fill/grvl-la-dol-ls/ dol	665	Union Electric Co (AmerenUE)
1	45N	8W	5	00000081	NA	Well	NA	1987	NR	250	62	Ls-flint-ls	30	Private
1	45N	8W	1	00000328	NA	Public	NA	1987	530	95	75	Med-cse sand & boulders	1002	Central Electric Power
1	45N	8W	1	00274562	NA	Irrigation	NA	2005	530	97	78	Med-cse sand	1007	Central Electric Power
1	45N	8W	1	00323237	NA	Abandoned	NA	2005	NR	95	75	NR	NR	Central Electric Power
1	45N	8W	10	00239778	NA	Well	NA	2000	NR	230	80	Ls/flint	25	Private
1	45N	8W	12	00024151	NA	Well	NA	1998	NR	290	82	Ls/flint	30	Private
1	45N	8W	12	00200091	NA	Well	NA	1998	600	350	143	Ls/flint	25	Private

Table 2.3-30—{Listing of Local, Public and Private Wells for Callaway and Osage Counties, Missouri}

(Page 4 of 6)

Dataset[1]	Twp.	Rge.	Sect.	ID or Ref. Num.	MO#	Type	Distance[2] from site (miles)	Year	Gnd Elev. (ft msl)	Depth bgs (ft)	Casing bgs (ft)	Formation[3]	Yield (gpm)	Remarks[4]
1	45N	8W	12	00374281	NA	Pump	NA	NR	NR	326	NR	NR	NR	Private
1	45N	7W	8	00242685	NA	Heat Pump	NR	NR	NR	180	NR	NR	NR	Private
1	45N	7W	8	00385871	NA	Abandoned	NR	NR	NR	12	NR	NR	NR	IBID Co. Inc
2	47N	8W	22	010796	NA	Outcrop	4.5	1949	740	177	NA	Alluvial	NA	No well
2	47N	8W	35	027390	3242162	Non-comm	2.5	1973	782	755	450	CJC-Roub	200	Lost Canyon Estates
2	46N	8W	1	018462	NA	Private	2.0	1959	761	325	38	Cotter	20	Private
2	46N	8W	2	028021	3024085	Non-comm	1.8	1975	795	705	400	CJC-Roub	100	Callaway PWSD#2 W5
2	46N	8W	9	019953	NA	Non-comm	3.1	1961	779	500	225	CJC	15	Church of God
2	**46N**	**8W**	**11**	**027975**	**3182219**	**Industrial**	**Site**	**1976**	**845**	**1506**	**380**	**CJC-DDR**	**210**	**AmerenUE #1**
2	46N	8W	12	018459	NA	Private	0.8	1959	830	375	73	Cotter	25	Private
2	**46N**	**8W**	**13**	**028347**	**3182219**	**Industrial**	**Site**	**1980**	**824**	**1480**	**400**	**CJC-DDR**	**565**	**AmerenUE #3**
2	**46N**	**8W**	**14**	**028076**	**3182219**	**Industrial**	**Site**	**1977**	**822**	**1100**	**405**	**CJC-Emin**	**194**	**AmerenUE #2**
2	46N	8W	28	012615	NA	Private	3.2	1953	795	300	108.5	Cotter	8	Private
2	46N	8W	28	012616	NA	Private	3.2	1953	795	250	27	Cotter	5	Private
2	46N	8W	35	022569	NA	Private	3.2	1964	807	520	170	CJC-Roub	15	Private
2	46N	8W	25	013368	NA	Private	2.6	1955	545	275	22	Cotter	8	Private
2	46N	8W	35	024567	NA	Profile Test	3.7	1966	521	47	NA	Alluvial	NA	No well
2	46N	7W	18	019774	NA	Private	2.1	1961	662	260	37	CJC	10	Private
2	46N	7W	30	020390	NA	Private	2.6	1961	587	205	100	CJC	7	Private
2	45N	8W	3	012619	NA	Private	4.5	1953	534	200	31	Cotter	2	Private
2	45N	8W	2	024508	NA	Profile Test	4.7	1967	525	35	NA	Alluvial	NA	No well
3	47N	8W	35	NR	NA	Private	2.8	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	7	NR	NA	Private	1.7	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	1	NR	NA	Private	2.0	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	2	NR	NA	Private	2.5	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	10	NR	NA	Private	1.9	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	15	NR	NA	Private	1.6	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	15	NR	NA	Private	1.7	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	15	NR	NA	Private	1.6	NR	NR	NR	NR	NR	NR	Private

Table 2.3-30—{Listing of Local, Public and Private Wells for Callaway and Osage Counties, Missouri}

(Page 5 of 6)

Dataset[1]	Twp.	Rge.	Sect.	ID or Ref. Num.	MO#	Type	Distance[2] from site (miles)	Year	Gnd Elev. (ft msl)	Depth bgs (ft)	Casing bgs (ft)	Formation[3]	Yield (gpm)	Remarks[4]
3	46N	8W	16	NR	NA	Private	1.9	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	25	NR	NA	Private	2.9	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	25	NR	NA	Private	3.1	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	26	NR	NA	Private	2.7	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.7	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.8	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.7	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.6	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.4	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.8	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	27	NR	NA	Private	2.7	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	34	NR	NA	Private	3.2	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	28	NR	NA	Private	2.4	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	34	NR	NA	Private	3.2	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	35	NR	NA	Private	3.4	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	35	NR	NA	Private	3.0	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	18	NR	NA	Private	2.1	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	19	NR	NA	Private	2.2	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	30	NR	NA	Private	3.1	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	31	NR	NA	Private	3.2	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	31	NR	NA	Private	3.2	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	31	NR	NA	Private	4.0	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	31	NR	NA	Private	3.8	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	31	NR	NA	Private	4.0	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	31	NR	NA	Private	4.0	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	36	NR	NA	Private	3.3	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	36	NR	NA	Private	3.2	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	36	NR	NA	Private	3.6	NR	NR	NR	NR	NR	NR	Private
4	46N	8W	12	NR	NR	Private	0.8	NR	NR	NR	NR	NR	NR	Private
4	**45N**	**7W**	**5**	**0100248**	**NR**	**Industrial**	**4.6**	**1996**	**541**	**854**	**350**	**LS + Dolo**	**665**	**AmerenUE (intake)**

Table 2.3-30—{Listing of Local, Public and Private Wells for Callaway and Osage Counties, Missouri}

(Page 6 of 6)

Dataset[1]	Twp.	Rge.	Sect.	ID or Ref. Num.	MO#	Type	Distance[2] from site (miles)	Year	Gnd Elev. (ft msl)	Depth bgs (ft)	Casing bgs (ft)	Formation[3]	Yield (gpm)	Remarks[4]
4	**45N**	**7W**	**5**	**NR**	**NR**	**Industrial**	**4.6**	**1988**	**NR**	**103**	**4**	**NR**	**300**	**AmerenUE (intake)**
	Outside Study Area Boundary – Callaway County													
2	47N	7W	31	013024	NA	Private	3.5	1954	801	330	100	Cotter	10	Private
2	45N	8W	5	019153	NA	Private	5.9	1960	669	340	NR	Roub	NR	Private
2	45N	8W	6	022026	NA	Private	6.2	1963	654	342	32	CJC	NR	Private
2	45N	8W	6	022019	NA	Private	6.4	NR	NR	NR	NR	NR	NR	Private
2	45N	8W	7	018964	NA	Private	6.9	1960	540	200	76	Cotter	35	Private
3	46N	7W	6	NR	NA	Private	2.3	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	6	NR	NA	Private	2.4	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	1	NR	NA	Private	2.1	NR	NR	NR	NR	NR	NR	Private
3	46N	8W	1	NR	NA	Private	2.1	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	19	NR	NA	Private	2.5	NR	NR	NR	NR	NR	NR	Private
3	46N	7W	30	NR	NA	Private	3.1	NR	NR	NR	NR	NR	NR	Private
	Outside Study Area Boundary – Osage County													
2	45N	8W	12	019910	3010155	Comm	6.2	1961	567	705	354	Cotter-Eminence	1200	Chamois W2
2	45N	8W	12	013591	NA	Private	6.5	1955	685	220	NR	NR	NR	Private

1 Dataset Codes:
1 – MDNR Well Search for Callaway County, written response to request for information, dated November 20, 2007 (Township-Range-Section was only location information given for wells);
2 – MDNR, DGLS database;
3 – Callaway Plant 2006 Land Use Census Report;
4 – AmerenUE Confirmed Well Locations.

2 Wells within the Callaway Plant site Boundary are labeled as "Site."

3 Formation name reported from well log or material description from database (material abbreviations are not decipherable).

4 Property Owner – Private wells were from the MDNR DGLS database and/or identified directly with the current property owner and reported in the Callaway Plant 2006 Land Use Census Report. Private well owner names are withheld.

Table 2.3-31—{Listing of MDNR Monitoring Well Network}

(Page 1 of 4)

County	Station Name	Legal Location			Well Elevation (feet, msl)	Well Depth (feet)	Casing Depth (feet)	Screen Length (feet)	Formations Open Below Casing Depth (uppermost-lowermost)	Aquifer(s) Penetrated	Date Installed
		Sec.	Twn.	Rng.							
Audrain	**Mexico**	**32**	**51N**	**8W**	**815**	**610**	**382**	**NA**	**Devonian – St. Peters (e)**	**Cambrian-Ordovician aquifer**	**9/7/2000**
Barry	Butterfield Spfld. Plateau aquifer	36	24N	28W	1,505	304	85	NA	Reeds Spring-Pierson	Springfield Plateau aquifer	6/18/2007
Barry	Butterfield Ozark aquifer	36	24N	28W	1,505	803	357	NA	Cotter-Roubidoux	Ozark aquifer	6/18/2007
Barry	Cassville	29	23N	27W	1,326	1,200	300	NA	Cotter – Gasconade	Ozark aquifer	1/5/2001
Barry	Monett Well No. 10	6	25N	27W	1,288	1,475	500	NA	Cotter – Derby-Doerun	Ozark aquifer	5/17/2006
Barton	Asbury Spfld. Plateau aquifer	7	30N	33W	925	404	145	NA	Warsaw-Pierson	Springfield Plateau aquifer	NR
Barton	Asbury Ozark aquifer	7	30N	33W	925	657	483	NA	Cotter-Jefferson City	Ozark aquifer	NR
Barton	Golden City	26	31N	29W	1,060	893	400	NA	Jefferson City – Gasconade	Ozark aquifer	2/28/1996
Barton	Lamar	30	35N	30W	980	981	575	NA	Cotter – Gasconade	Ozark aquifer	6/17/1958
Benton	Cole Camp	35	43N	21W	1,045	510	60	NA	Jefferson City-Eminence	Ozark aquifer	4/19/2007
Benton	Warsaw	4	40N	22W	747	1,406	210	NA	Gasconade – Lamotte	Ozark and St. Francois aquifers	7/20/1979
Benton	Lost Valley Hatchery	4	40N	22W	723	151	80	NA	Roubidoux Formation	Ozark aquifer	7/9/2007
Bollinger	Duck Creek	32	28N	9E	346	75	70.5	4.5	Quaternary alluvium	Southeast Lowlands alluvial aquifer	11/1/1956
Boone	**Columbia**	**16**	**48N**	**13W**	**640**	**1,353**	**661**	**NA**	**Roubidoux – Derby-Doerun**	**Cambrian-Ordovician aquifer**	**12/28/2000**
Buchanan	St. Joseph	31	57N	35W	821	75	71	4	Quaternary alluvium	Missouri River alluvial aquifer	5/14/1957
Buchanan	Lewis and Clark	33	55N	37W	787	83	NR	NR	Quaternary alluvium	Missouri River alluvial aquifer	3/30/2001
Butler	Qulin	36	23N	7E	315	81	76	5	Quaternary alluvium	Southeast Lowlands alluvial aquifer	9/22/2000
Callaway	**Jefferson City**	**10**	**44N**	**11W**	**558.3**	**95**	**91**	**4**	**Quaternary alluvium**	**Missouri River alluvial aquifer**	**4/20/1956**
Camden	Ozark Fisheries	30	37N	14W	815	910	NR	NA	NR – Derby-Doerun	Ozark aquifer	9/22/2001
Camden	Camdenton	25	38N	17W	1,042	1,100	435	NA	Eminence – Derby-Doerun	Ozark aquifer	11/4/2000
Cape Girardeau	Delta	8	29N	12E	338	75	70.5	4.5	Quaternary Alluvium	Southeast Lowlands alluvial aquifer	11/1/1956
Cape Girardeau	Jackson	28	32N	13E	600	1,800	450	NA	Plattin-Powell/Smithville	Ozark aquifer	8/24/2007
Carroll	Carrollton	5	52N	23W	672	71	56	15	Quaternary Alluvium	Missouri River alluvial aquifer	11/7/2006
Carter	Big Spring	6	26N	1E	470	56	NR	NA	Eminence (e)	Ozark aquifer	4/19/1971
Christian	Billings	10	27N	24W	1,364	804	303	NA	Cotter-Roubidoux	Ozark aquifer	9/25/2007
Christian	Ozark	35	27N	21W	1,300	688	327	NA	Cotter – Jefferson City (e)	Ozark aquifer	8/31/2000
Clark	Wayland	29	65N	6W	540	150e	NR	NR	Pleistocene glacial drift	Drift-filled preglacial channel aquifer	10/8/1974

Table 2.3-31—{Listing of MDNR Monitoring Well Network}

(Page 2 of 4)

County	Station Name	Legal Location			Well Elevation (feet, msl)	Well Depth (feet)	Casing Depth (feet)	Screen Length (feet)	Formations Open Below Casing Depth (uppermost-lowermost)	Aquifer(s) Penetrated	Date Installed
		Sec.	Twn.	Rng.							
Cooper	Arrow Rock	12	49N	19W	700	230	NR	NA	Burlington – Chouteau (e)	Springfield Plateau aquifer	3/29/1962
Cooper	Blackwater	34	49N	19W	620	70	59	10	Quaternary alluvium	Blackwater River alluvial aquifer	5/17/2007
Crawford	Bourbon	33	40N	3W	962	625	375	NA	Eminence-Potosi	Ozark aquifer	6/12/2007
Daviess	Jameson	18	60N	27W	860	92	89	5	Pleistocene glacial drift	Drift-filled preglacial channel aquifer	4/30/1996
Daviess	Coffey	18	61N	27W	906	NR	NR	NR	Pleistocene glacial drift	Drift-filled preglacial channel aquifer	9/29/2000
Dunklin	Malden	34	22N	10E	287	108	104	4	Quaternary alluvium	Southeast Lowlands alluvial aquifer	8/8/1956
Franklin	New Haven	36	45N	3W	519	1,075	216	NA	Jefferson City-Potosi	Ozark aquifer	9/20/2007
Franklin	St. Clair	26	42N	1W	739	255	80	NA	Roubidoux – Gasconade	Ozark aquifer	4/28/1956
Franklin	Sullivan	17	40N	2W	985	810	440	NA	Eminence -Derby	Ozark aquifer	3/13/2007
Gasconade	**Drake**	**22**	**43N**	**5W**	**865**	**400**	**222**	**NA**	**Jefferson City – Roubidoux (e)**	**Ozark aquifer**	**8/23/2000**
Greene	Springfield	4	29N	21W	1,375	565	252	NA	Cotter – Jefferson City (e)	Ozark aquifer	8/25/2000
Greene	McDaniel Lake	25	30N	22W	1,157.60	1,404	302	NA	Jefferson City – Derby-Doerun	Ozark aquifer	6/13/2001
Greene	Valley Water Mills (shallow)	5	29N	21W	1,220	63	100	NA	Elsey-Pierson	Springfield Plateau aquifer	3/22/2007
Greene	Valley Water Mills (deep)	5	29N	21W	1,220	168	600	NA	Cotter-Roubidoux	Ozark aquifer	3/22/2007
Greene	Valley Park	4	28N	21W	1,295	685	403	NA	Jefferson City – Roubidoux	Ozark aquifer	7/26/2006
Grundy	Spickard	20	63N	25W	790	140	136	4	Pleistocene glacial drift	Drift-filled preglacial channel aquifer	11/15/1973
Henry	Urich	3	42N	28W	770	246	70	NA	Cherokee group	Pennsylvanian Cherokee Sand	10/1/2001
Hickory	Pomme de Terre	12	36N	22W	890	298	178	NA	Jefferson City-Roubidoux	Ozark aquifer	4/18/2007
Howell	West Plains	18	24N	8W	1,107	1,605	796	NA	Gunter – Potosi	Ozark aquifer	11/22/2000
Iron	Bixby	1	34N	2W	1,380	640	120	NA	Eminence – Potosi (e)	Ozark aquifer	1/1/1988
Iron	Viburnum Trend #2	11	34N	2W	1,420	310	120	NA	Eminence-Potosi	Ozark aquifer	5/30/2007
Jasper	Atlas Powder	36	28N	32W	970	1,747	375	NA	Cotter – Reagan	Ozark and St. Francois aquifers	2/8/1956
Jasper	Carthage	2	28N	31W	963	1,825	498	NA	Jefferson City – Precambrian	Ozark and St. Francois aquifers	11/6/2003
Jefferson	S. Jefferson Co.	22	38N	5E	780	NR	NR	NA	NR	Ozark aquifer	8/8/2000
Jefferson	De Soto	22	39N	4E	790	1,500	NR	NA	NR – Bonneterre (e)	Ozark and St. Francois aquifers	11/18/1960
Jefferson	Festus	6	40N	6E	450	1,084	425	NA	Roubidoux – Potosi (e)	Ozark aquifer	11/21/2001
Johnson	Warrensburg	30	46N	25W	770	1,001	410	NA	Jefferson City – Gasconade (e)	Ozark aquifer	6/28/2001
Johnson	Knob Noster	22	46N	24W	806	840	293	NA	Cotter-Gasconade	Ozark aquifer	NR
Laclede	Lebanon	24	34N	16W	1,320	405	210	NA	Gasconade (e)	Ozark aquifer	8/17/2000

Table 2.3-31—{Listing of MDNR Monitoring Well Network}
(Page 3 of 4)

County	Station Name	Legal Location			Well Elevation (feet, msl)	Well Depth (feet)	Casing Depth (feet)	Screen Length (feet)	Formations Open Below Casing Depth (uppermost-lowermost)	Aquifer(s) Penetrated	Date Installed
		Sec.	Twn.	Rng.							
Lawrence	Aurora	24	26N	26W	1,460	1,425	725	NA	Jefferson City – Eminence (e)	Ozark aquifer	7/2/1988
Lawrence	Mt. Vernon Spfld. Plateau aquifer	36	28N	27W	1,215	204	126	NA	Elsey-Pierson	Springfield Plateau aquifer	5/10/2007
Lawrence	Mt. Vernon Ozark aquifer	36	28N	27W	1,215	252	624	NA	Cotter-Jefferson City	Ozark aquifer	5/10/2007
Lawrence	Pierce City	21	26N	28W	1,205	1,160	409	NA	Cotter-Gasconade	Ozark aquifer	1/9/2007
Lincoln	Troy (2, deep)	27	49N	1W	642	1,470	440	NA	Kimmswick – Gasconade	Cambrian-Ordovician aquifer	5/20/2000
Lincoln	Troy (1, shallow)	26	49N	1W	533	813	400	NA	Kimmswick – St. Peter	Cambrian-Ordovician aquifer	4/15/1980
Livingston	Fountain Grove	6	56N	21w	672	65	45	20	Pleistocene glacial drift	Drift-filled preglacial channel	10/27/2000
McDonald	Noel	22	21N	33W	830	850	99	NA	Cotter – Roubidoux	Ozark aquifer	5/2/1962
McDonald	Longview	18	23N	30W	1,289.60	346	44	NA	Burlington – Compton	Springfield Plateau aquifer	1/3/1956
Madison	Fredericktown	20	33N	7E	857.2	590	187	NA	Bonneterre – Lamotte	St. Francois aquifer	11/18/1958
Marion	Hannibal	10	58N	5W	484	85	81	4	Quaternary alluvium	Mississippi River alluvial aquifer	5/28/1957
Mississippi	East Prairie	29	25N	16E	307	118	114	4	Quaternary alluvium	Southeast Lowlands alluvial aquifer	11/1/1956
Montgomery	**New Florence**	**23**	**48N**	**5W**	**877**	**1,030**	**323**	**NA**	**Joachim – Roubidoux**	**Cambrian-Ordovician aquifer**	**5/29/1981**
Newton	Joplin	28	27N	33W	900	1,505	500	NA	Jefferson City – Potosi (e)	Ozark aquifer	11/5/2003
Newton	Neosho Spfld. Plateau aquifer	18	24N	31W	1,265	344	105	NA	Burlington-Reeds Spring	Springfield Plateau aquifer	7/17/2007
Newton	Neosho Ozark aquifer	18	24N	31W	1,265	696	460	NA	Cotter-Jefferson City	Ozark aquifer	7/17/2007
Nodaway	Hopkins	2	66N	35W	1,045	28	24	4	Quaternary	One Hundred and Two River alluv.	5/2/2007
Osage	**Linn**	**17**	**43N**	**8W**	**941**	**1,080**	**427**	**NA**	**Gasconade - Derby-Doerun**	**Ozark aquifer**	**12/1/2005**
Ozark	Theodosia	19	22N	15W	710	264	215	NA	Jefferson City	Ozark aquifer	12/1/2000
Pemiscot	Caruthersville	16	18N	13E	270	1,388	1,306	85	Wilcox	Wilcox aquifer	8/30/2007
Pemiscot	Steele	36	17N	11E	260	131	127	4	Quaternary alluvium	Southeast Lowlands alluvial aquifer	8/22/1956
Perry	National Lead	34	34N	8E	992	1,526	NR	NA	NR – Lamotte (e)	Ozark (?) and St. Francois aquifers	7/18/1960
Pettis	Dresden	26	46N	22W	820	NR	NR	NA	NR – Cotter (e)	Springfield Plateau/Ozark aquifers	8/30/1996
Pettis	Dresden School	21	46N	22W	836	456	202	NA	Cotter – Jefferson City (e)	Ozark aquifer	8/18/2000
Pettis	Sedalia	34	47N	22W	824	1,410	432	NA	Jefferson City – Davis	Ozark aquifer	11/12/1973
Phelps	Ramada Inn	10	37N	8W	974	650	420	NA	Gunter – Eminence	Ozark aquifer	1/2/1968
Phelps	Mo. Cons. Dept.	3	37N	8W	1,192	450	212	NA	Jefferson City – Gasconade	Ozark aquifer	9/8/1980

Table 2.3-31—{Listing of MDNR Monitoring Well Network}
(Page 4 of 4)

County	Station Name	Legal Location			Well Elevation (feet, msl)	Well Depth (feet)	Casing Depth (feet)	Screen Length (feet)	Formations Open Below Casing Depth (uppermost-lowermost)	Aquifer(s) Penetrated	Date Installed
		Sec.	Twn.	Rng.							
Phelps	Rolla Indust. Park	29	38N	7W	1,189	800	400	NA	Gasconade – Eminence	Ozark aquifer	4/30/1975
Pike	Clarksville	16	53N	1E	459	650	144	NA	Kimmswick-Cotter	Cambrian-Ordovician aquifer	9/25/2007
Polk	Halfway	5	33N	21W	1,114	200	43	NA	Jefferson City – Cotter	Ozark aquifer	3/5/1956
Reynolds	Viburnum Trend #5	25	33N	2W	1,160	170	126	NA	Eminence	Ozark aquifer	5/30/2007
Reynolds	Viburnum Trend #6	12	32N	2W	1,150	250	210	NA	Eminence	Ozark aquifer	6/7/2007
Ripley	Naylor	3	22N	4E	303	65	61	4	Quaternary alluvium	Southeast Lowlands alluvial aquifer	8/8/1956
St. Charles	Wentzville	24	47N	2E	608	1,337	380	NA	Kimmswick – Roubidoux	Cambrian-Ordovician aquifer	5/13/1980
St. Clair	Osceola	22	38N	26W	877	875	20	NA	Pennsylvanian - Eminence	Ozark aquifer	11/12/1958
St. Francois	Farmington	12	35N	5E	890	325	80	NA	Bonneterre – Lamotte (e)	St. Francois aquifer	1/20/2001
St. Louis	Eureka	35	44N	3E	615	820	300	NA	Cotter – Gasconade	Ozark aquifer	10/14/2000
St. Louis	Columbia Bottoms	18	47N	8E	432.5	104	100	4	Quaternary alluvium	Mississippi River alluvial aquifer	6/24/1957
Schuyler	Vandike Farms	29	66N	14W	935	27	27	27	Pleistocene glacial drift, rock walled	Glacial drift aquifer	7/21/1980
Scott	Sikeston	21	26N	14E	312	136	131.5	4.5	Quaternary alluvium	Southeast Lowlands alluvial aquifer	11/1/1956
Shannon	Akers	24	31N	6W	865	425	NR	NA	Eminence – Potosi (e)	Ozark aquifer	11/15/1971
Shelby	Shelbina	32	57N	10W	770	82	62	20	Pleistocene glacial drift	Drift-filled preglacial channel	9/8/2000
Stone	Silver Dollar City	29	23N	22W	1,102	910	250	NA	Cotter-Gasconade	Ozark aquifer	3/7/2007
Taney	Cooper Creek	7	22N	21W	840	1,400	380	NA	Roubidoux – Derby-Doerun	Ozark aquifer	4/22/1996
Taney	Branson	32	23N	21W	845	1,002	393	NA	Roubidoux – Gasconade	Ozark aquifer	11/17/1993
Texas	Fairview	17	30N	11W	1,467	481	50	NA	Cotter – Roubidoux	Ozark aquifer	2/27/1956
Washington	Potosi	11	37N	2E	930	1,100	555	NA	Bonneterre – Lamotte	St. Francois aquifer	7/26/1988
Webster	Marshfield		30N	18W	1,485	1,315	362	NA	Roubidoux - Potosi	Ozark aquifer	6/22/2005
Worth	Sheridan	23	66N	33W	955	41	31	10	Pleistocene Glacial Drift	Glacial Drift aquifer	12/2/2004
Wright	Norwood	13	28N	14W	1,519	1,221	450	NA	Roubidoux - Eminence	Ozark aquifer	4/27/2005

Table 2.3-32—{Surface Water Sample Minima, Maxima, and Mean Values for All Sampling Rounds at Callaway Plant Site}

(Page 1 of 2)

Analysis Type	Parameter	Water Quality Criteria for the Protection of Aquatic Life	Units	Streams			Storm Water Collection Ponds		
				Min	Max	Mean	Min	Max	Mean
Anion	**Chlorides[a]**								
	Chronic	230 see notes	mg/L	5	112	30	2	865	94
	Acute	860 see notes	mg/L	5	112	30	2	865	94
	Sulfate[b]	see note	mg/L	12.9	123	63.0	2.6	356	36.4
Biological	**Coliform, Fecal**	N/A	cfu/100 mL	10	2,500	282	10	900	85
	Streptococci, Fecal	N/A	cfu/100 mL	10	90	36	3	80	19
	Coliform, Total	N/A	mpn/100 mL	45	2,420	1,463	1	2,420	1,139
	Phytoplankton (chlorophyll a)	N/A	mg/m^3	4	210	41	4	130	27
Field	**Conductivity**	N/A	umhos/cm 25°C	255	767	516	100	3620	575
	Dissolved Oxygen[c]	5	mg/L	5.5	14.27	10.1	1.29	16.95	9.74
	pH	N/A	SU	7.03	8.32	7.66	6.57	9.77	8.26
	Temperature[d]	see notes	°C	2.3	29.5	15.9	1.76	32.8	17.1
	Turbidity	N/A	NTU	4.6	220	71.5	0	652	91
Metals	**Aluminum[h]**	750	ug/L	114	3630	1119	81.4	1320	423
	Arsenic	20	ug/L	ND	ND	ND	10.8	12.8	12.0
	Barium	N/A	ug/L	56	394	133	15	230	79
	Beryllium	5	ug/L	1.2	1.2	1.2	ND	ND	ND
	Calcium	N/A	ug/L	39,000	79,300	60,650	15,600	74,100	35,428
	Lead[e]	see notes	ug/L	10.6	17.1	13.85	ND	ND	ND
	Magnesium	N/A	ug/L	12,300	36,600	19,962	3,620	16,300	7,503
	Manganese	N/A	ug/L	6	1,380	218	7.3	1,020	103.2
	Nickel[e]	see notes	ug/L	6.4	22.1	10.2	5.9	5.9	5.9
	Potassium	N/A	ug/L	1,650	12,200	6,064	1,170	6,080	3,484
	Sodium	N/A	ug/L	3,710	87,800	30,327	1,950	518,000	60,167
Nitrogen	**Ammonia[f]**		mg/L	0.11	0.11	0.11	0.13	0.18	0.15
	Nitrate	N/A	mg/L	1.5	4.6	2.6	1	1	1
	Nitrogen, Kjeldahl, Total	N/A	mg/L	0.27	0.5	0.39	ND	ND	ND
	Organic Nitrogen	N/A	mg/L	0.27	3.9	1.12	0.27	2.7	0.81

Table 2.3-32—{Surface Water Sample Minima, Maxima, and Mean Values for All Sampling Rounds at Callaway Plant Site}

(Page 2 of 2)

Analysis Type	Parameter	Water Quality Criteria for the Protection of Aquatic Life	Units	Streams			Storm Water Collection Ponds		
				Min	Max	Mean	Min	Max	Mean
Quality	**Alkalinity**	N/A	mg/L	119	291	189.9	51.7	153	92.5
	BOD	N/A	mg/L	5.4	6.3	5.9	2	10.4	3.5
	COD	N/A	mg/L	10	72.6	32.2	10.3	89.5	30.8
	Color	N/A	mg/L	6	150	63	9	115	35
	Hardness	N/A	mg/L	166	635	256	42.2	227	120.1
	Oil and Grease	10	mg/L	5.7	5.7	5.7	9.2	9.2	9.2
	Orthophosphate	N/A	mg/L	0.12	0.22	0.17	0.1	0.1	0.1
	Phosphorous, Total	N/A	mg/L	0.13	1.2	0.54	0.13	0.13	0.13
	Suspended Solids	N/A	mg/L	9	2,920	446	5	268	26
	Total Dissolved Solids	N/A	mg/L	191	531	349	93	1,800	320
Radiological	**Strontium^{90}**	N/A	pCi/L	1.72	1.72	1.72	0.678	1.37	1.02

NA – not applicable

e – estimated

NR – Not reported (no data available)

[a] – Chloride & Sulfate – The regulations at 10 CSR 20-7 indicate chloride and sulfate criteria depending upon the type of receptor stream and its flow characteristics. Streams in the vicinity of the Callaway Plant site include Class P Streams (maintain permanent flow even in drought periods) and Class C Streams (may cease flow in dry periods but maintain permanent pools which support aquatic life).

[b] – Chloride plus Sulfate – There are additional combined chloride plus sulfate criteria.

[c] – Dissolved Oxygen – Minimum value. AQL is dependent upon type of fish receptor (i.e. cold-water fisheries, cool-water fisheries, warm- water fisheries). Value shown is for warm-water and cool water fisheries.

[d] – Temperature – AQL is dependent upon month the surface water body is sampled and type of fish receptor (i.e. cold-water fisheries, cool-water fisheries, warm-water fisheries).

[e] – Metals – Many of the criteria for metals are dependent upon hardness. These include Cadmium, Chromium III, Copper, Lead, Nickel, Silver, and Zinc.

[f] – Ammonia Nitrogen – Acute and Chronic criteria dependent upon pH, and chronic criteria also dependent upon presence or absence of early life stages.

[g] AQL is for acute toxicity.

[h] AQL criteria from 10 CSR20-7 Table A, Criteria for Designated uses.

References:

CSR, 2007. Title 10 Code of State Regulations, Division 20, 7.031, Surface Water Regulation Standards, July 2007.

NRC, 1992. U.S. Nuclear Regulatory Commission, Decommissioning and Regulatory Issues Branch, "A Summary of NRC's Interim Radiological Cleanup Criteria and Current Dose Bases," November 1992.

Table 2.3-33—{Groundwater Sample Minima, Maxima, and Mean Values for All Sampling Rounds at Callaway Plant Site}

Analysis Type	Parameter	Ground-water Criteria[a]	Units	Drinking Water Wells			Shallow Aquifer Wells			Deep Wells[b]		
		µg/L		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Metals	**Arsenic**	50	µg/L	ND	ND	ND	13.1	66.1	25.6	ND	ND	ND
	Barium	2,000	µg/L	ND	ND	ND	72.6	1,520	306.6	10.2	10.2	10.2
	Beryllium	4	µg/L	ND	ND	ND	1.3	18.7	4.9	ND	ND	ND
	Chromium, Total[c]	100	µg/L	ND	ND	ND	5	265	55	ND	ND	ND
	Iron	300	µg/L	57.7	469	214.4	751	216,000	21,677	167	223	195
	Lead	15	µg/L	5.4	5.4	5.4	7	96.8	34.4	ND	ND	ND
	Manganese	50	µg/L	ND	ND	ND	8.9	4,040	382.3	5.4	8.2	6.8
	Mercury	2	µg/L	ND	ND	ND	0.2	0.2	0.2	ND	ND	ND
	Nickel	100	µg/L	ND	ND	ND	6	1050	167	ND	ND	ND
	Selenium	50	µg/L	ND	ND	ND	18.5	20.5	19.5	ND	ND	ND
	Zinc	5,000	µg/L	ND	ND	ND	66.2	623	178.5	ND	ND	ND
Radiological	**Strontium^{90}**	N/A	pCi/L	ND	ND	ND	1.34	1.34	1.34	ND	ND	ND

[a] Groundwater criteria from 10 CSR 20-7 Table A, Criteria for Designated Uses.

[b] MW-1D (the deep well) was damaged and samples were unrecoverable at the time of 4th round water quality sampling.

[c] Groundwater criteria is for chromium III (shown for illustration).

Table 2.3-34—{Analytical Parameters}
(Page 1 of 2)

Analytical Parameters	Water Quality Monitoring Program	
	Surface Water[1]	Ground/Drinking Water
Alkalinity		X
Alkalinity (dis)[a]	X	
Aluminum		X
Aluminum (dis)	X	
Ammonia		X
Ammonia (dis)	X	
Antimony		X
Antimony (dis)	X	
Arsenic		X
Arsenic (dis)	X	
Barium		X
Barium (dis)	X	
Beryllium		X
Beryllium (dis)	X	
Bicarbonate		X
BOD	X	X
Cadmium		X
Cadmium (dis)	X	
Calcium		X
Calcium (dis)	X	
Carbon Dioxide		X
Chlorides		X
Chlorides (dis)	X	
Chromium, Total		X
Chromium, Total (dis)	X	
COD	X	X
Coliform, Fecal	X	X
Coliform, Total	X	X
Color	X	X
Conductivity	X	X
Dissolved Oxygen	X	X
Flow (cfs)	X (MO River)	
Gamma Isotopic[b]	X	X
Hardness	X	X
Iron		X
Lead		X
Lead (dis)	X	
Magnesium		X
Magnesium (dis)	X	
Manganese		X
Manganese (dis)	X	
Mercury		X
Mercury (dis)	X	
Nickel		X
Nickel (dis)	X	
Nitrate		X
Nitrate (dis)	X	

ER Section 2.3

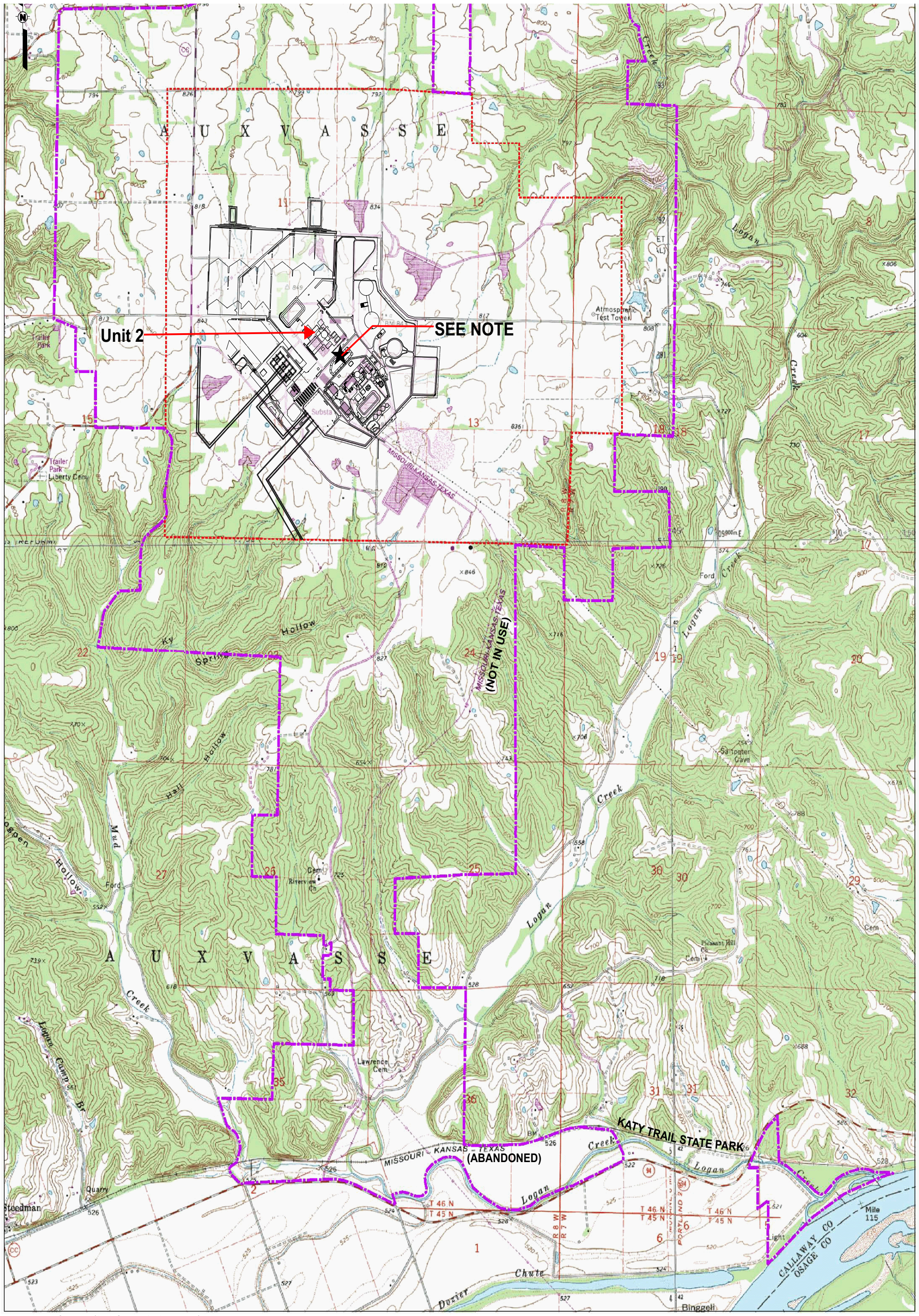
Table 2.3-34—{Analytical Parameters}
(Page 2 of 2)

Analytical Parameters	Water Quality Monitoring Program	
	Surface Water[1]	Ground/Drinking Water
Nitrite		X
Nitrite (dis)	X	
Odor	X	X
Oil and Grease	X	
Organic Nitrogen	X	X
Orthophosphate		X
Orthophosphate (dis)	X	
pH	X	X
Phosphorus, Total		X
Phosphorus, Total (dis)	X	
Phytoplankton	X	
Potassium		X
Potassium (dis)	X	
Selenium		X
Selenium (dis)	X	
Silica		X
Silver		X
Silver (dis)	X	
Sodium		X
Sodium (dis)	X	
Streptococci, Fecal	X	X
Strontium 90 (Sr^{90})		X
Sulfate		X
Sulfate (dis)	X	
Suspended Solids	X	X
Temperature	X	X
Thallium		X
Thallium (dis)	X	
Total Dissolved Solids	X	X
Tritium ($_1H^3$)	X	X
Turbidity	X	X
Zinc		X
Zinc (dis)	X	

Notes:
[1] Metals and other surface water parameters are reported as dissolved for comparability with regional data and promulgated AWQC
[a] (dis) = dissolved
[b]Mn^{54}, Fe^{59}, Co^{58}, Co^{60}, Zn^{65}, Zr^{95}, Nb^{95}, I^{131}, Cs^{134}, Cs^{137}, Ba^{140}, La^{140}

ER Section 2.3

Figure 2.3-1—{Plant Site Topography}



contours in feet (840 feet = 256 meters)

LEGEND:

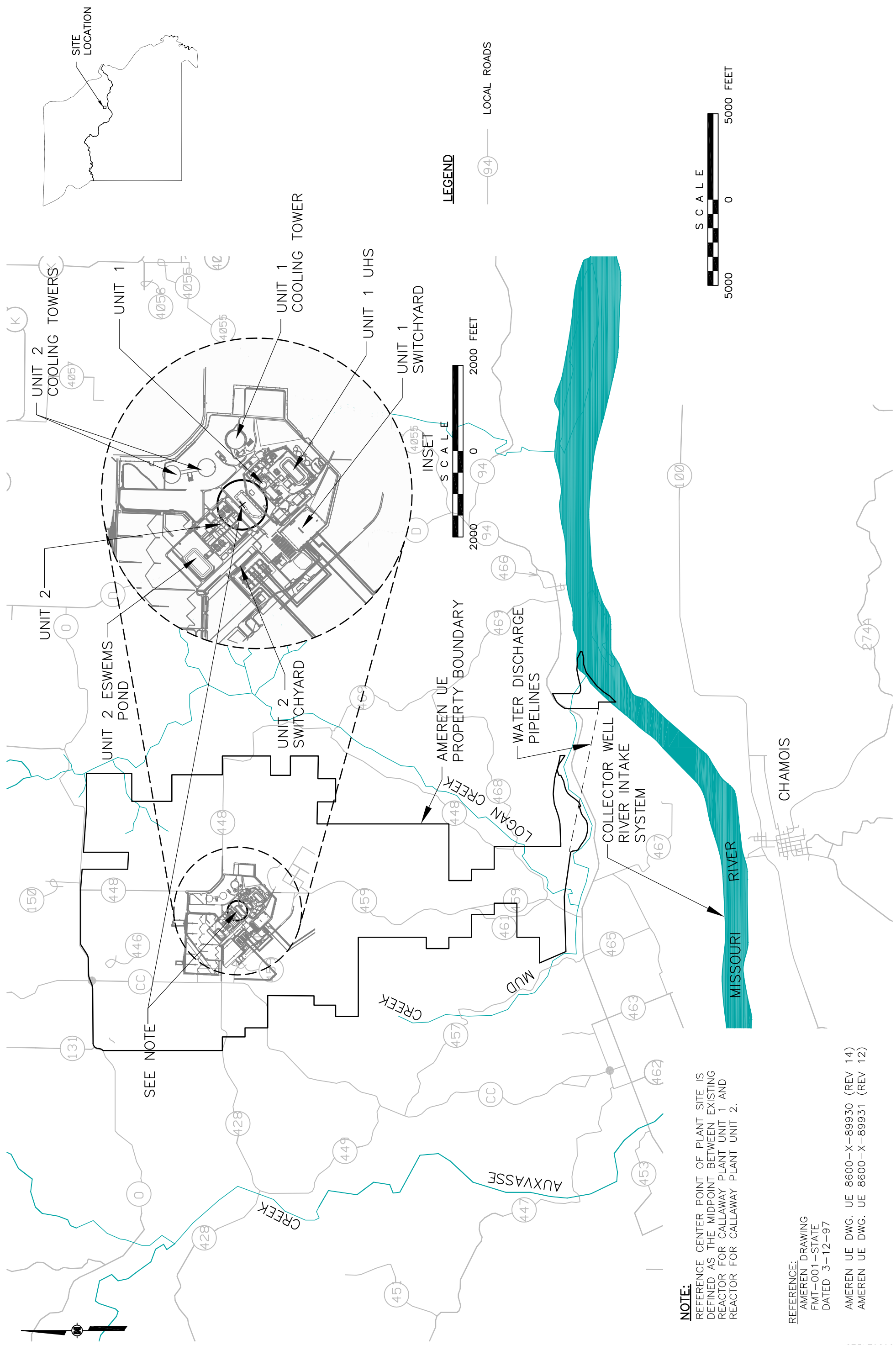
- Callaway Plant Site Area
- Ameren Property Boundary

0 0.25 0.5 Miles

NOTE:
REFERENCE CENTER POINT OF PLANT SITE IS DEFINED AS THE MIDPOINT BETWEEN EXISTING REACTOR FOR CALLAWAY PLANT UNIT 1 AND REACTOR FOR CALLAWAY PLANT UNIT 2. MISSOURI-KANSAS-TEXAS RAILROAD NOT IN USE, CURRENTLY USED AS KATY TRAIL STATE PARK.

REFERENCE:
USGS Missouri Topological Quadrangles: Mokane East, Morrison, Readsville, and Reform. Photo revised 1985.

Figure 2.3-2—{Site Utilization Plant Layout}



ER Section 2.3

Figure 2.3-3—{Site Grading Plan}

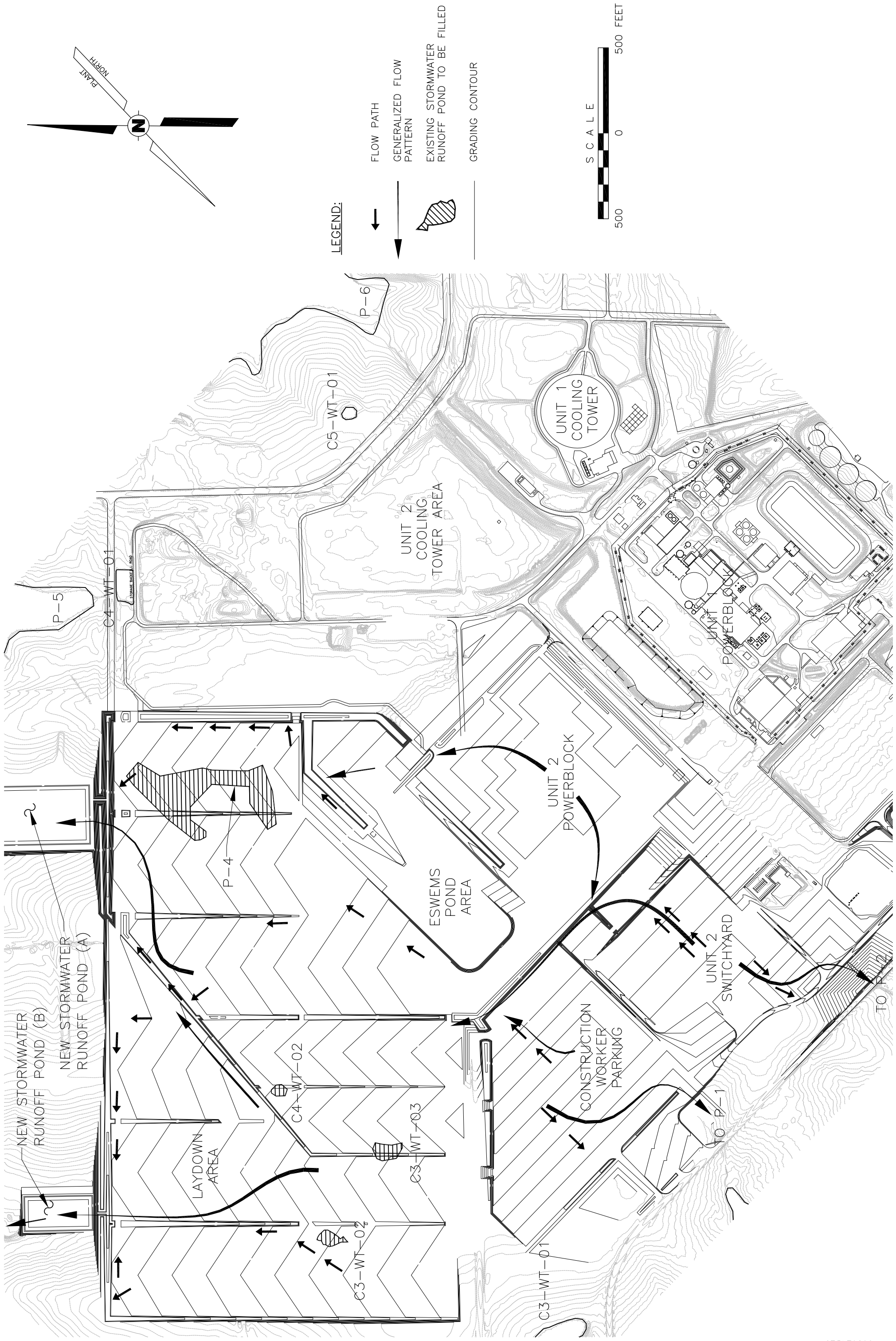
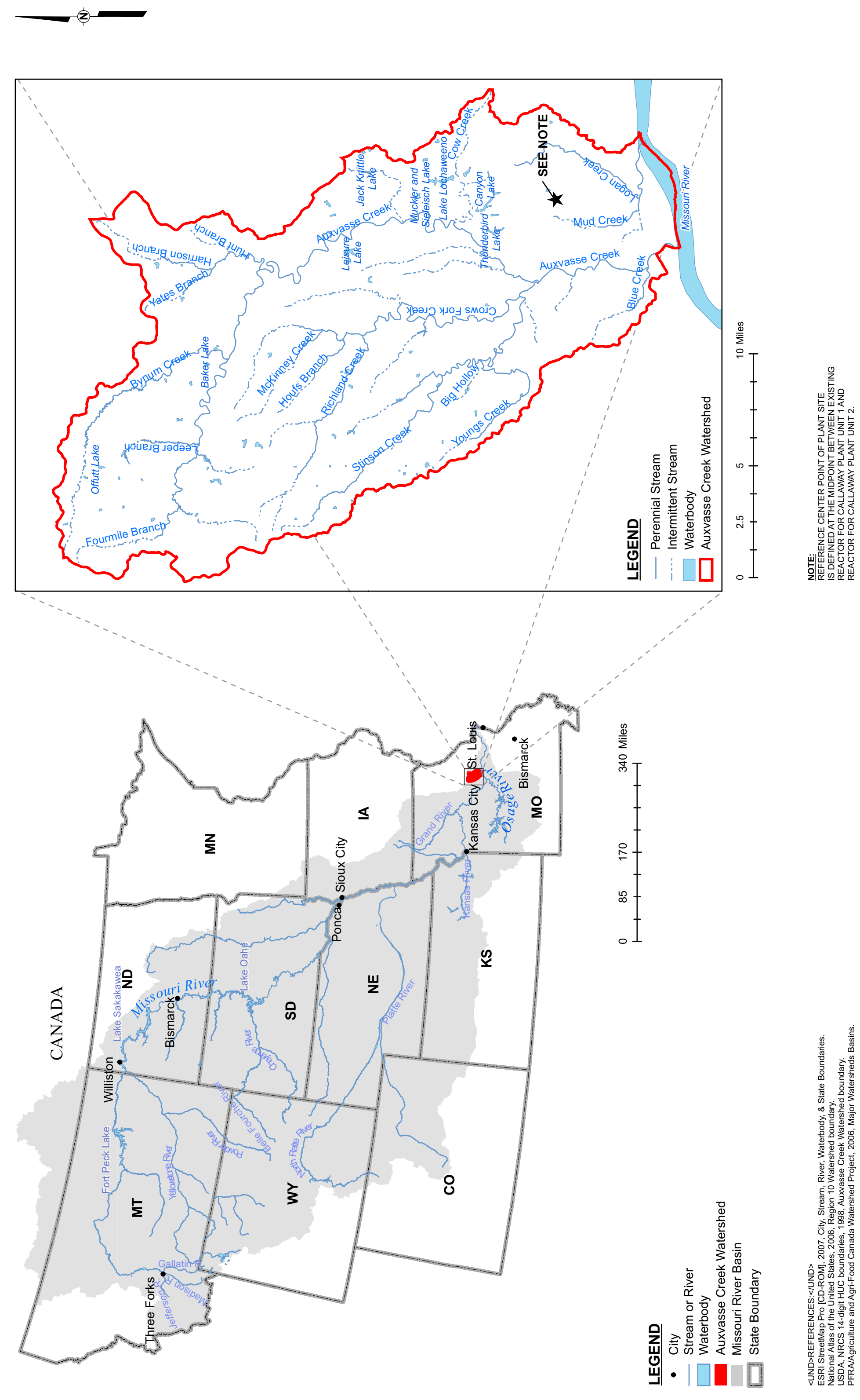
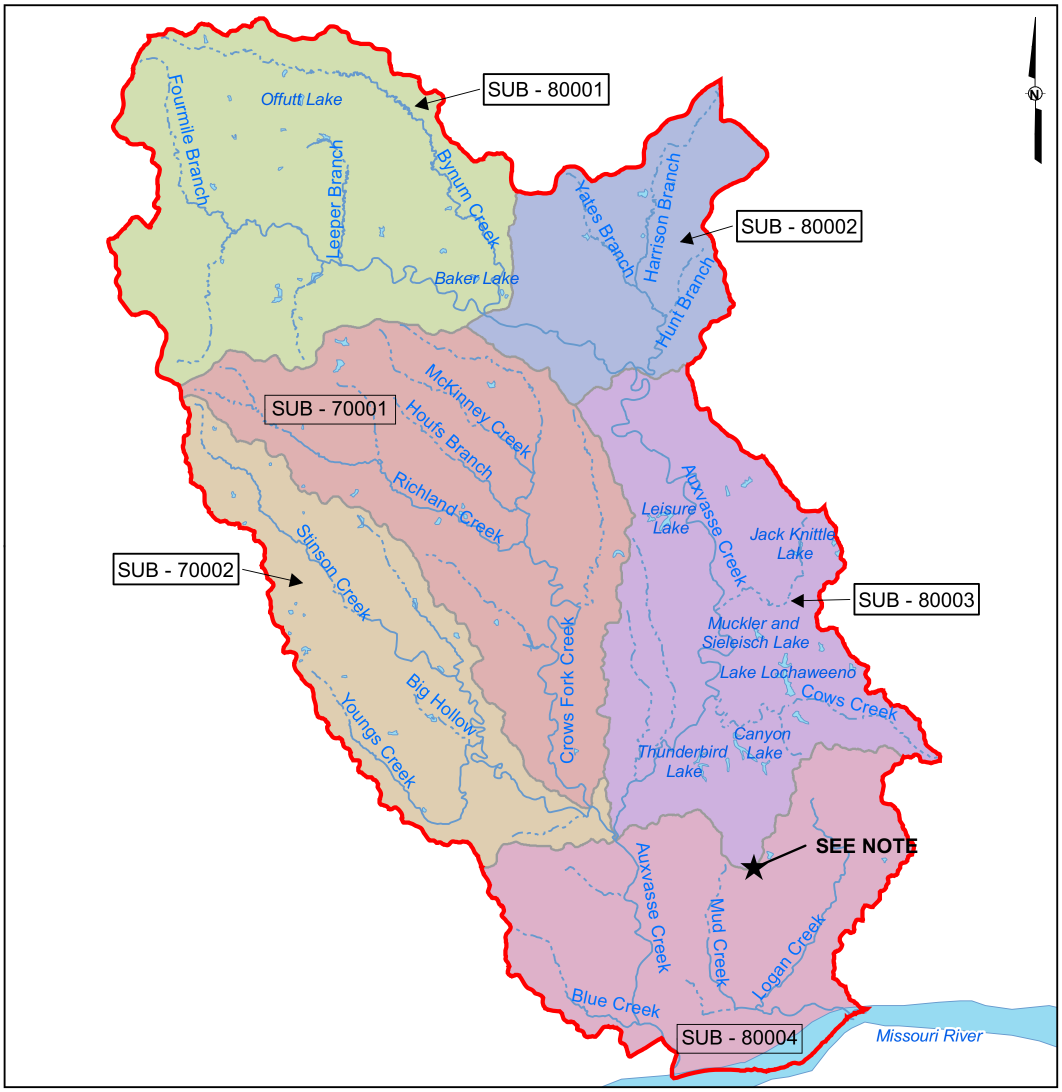


Figure 2.3-4—{Missouri River Basin and Auxvasse Creek Watershed}



ER Section 2.3

Figure 2.3-5—{Sub-watershed Delineation of Auxvasse Creek Watershed}



LEGEND

Auxvasse Creek Watershed Boundary

Auxvasse Creek Subwatersheds

SUB - 70001 SUB - 80001 SUB - 80003

SUB - 70002 SUB - 80002 SUB - 80004

Lakes/Impoundments

Perennial Stream

Intermittent Stream

REFERENCE:
ESRI StreetMap Pro [CD-ROM], 2007,
Rivers, Streams and Waterbodies.
USDA, NRCS 14-digit HUC boundaries, 1998,
Auxvasse Creek Watershed boundary.

NOTE:
REFERENCE CENTER POINT OF PLANT SITE IS DEFINED AT THE MIDPOINT BETWEEN EXISTING REACTOR FOR CALLAWAY PLANT UNIT 1 AND REACTOR FOR CALLAWAY PLANT UNIT 2.

Figure 2.3-6—{USGS Gauges Near Callaway Plant Unit 2 Site}

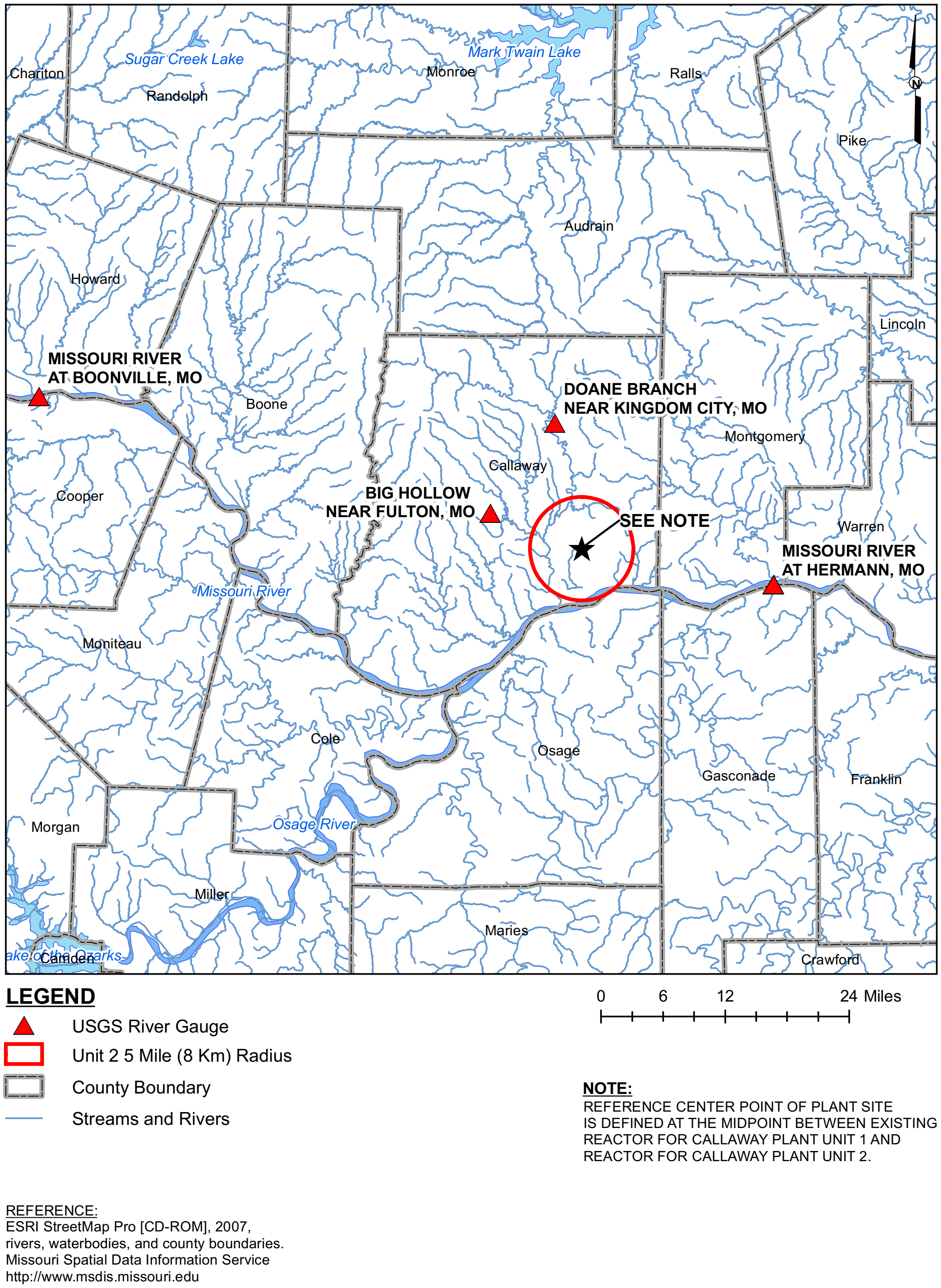
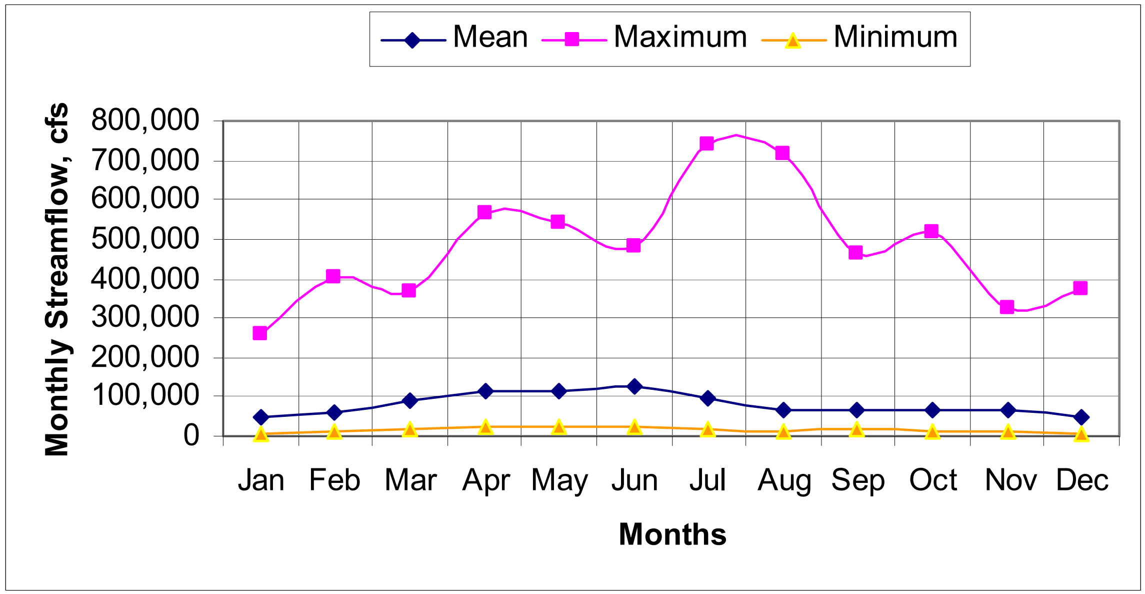
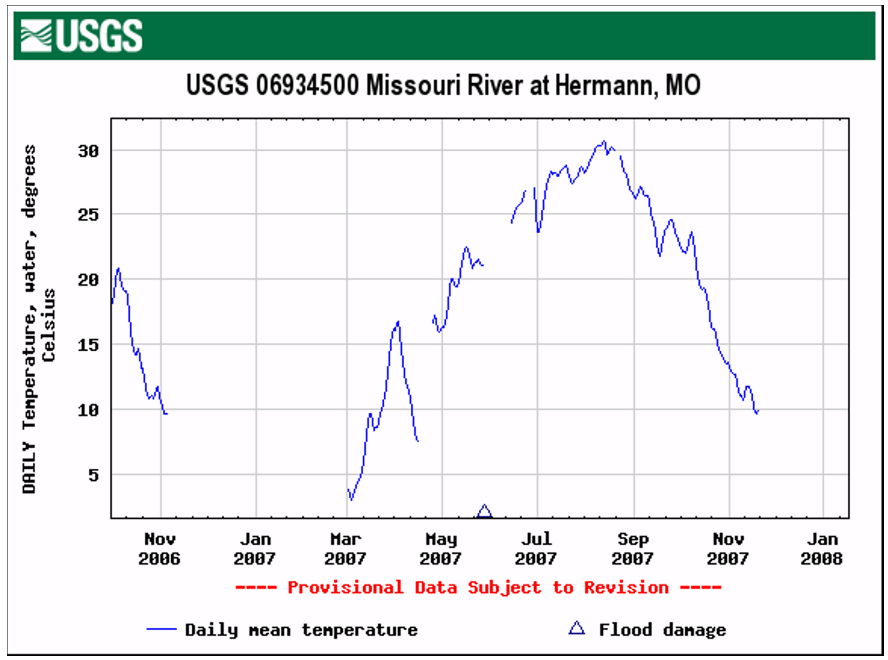


Figure 2.3-7—{Mean, Maximum and Minimum Streamflows for the Hermann, MO USGS 06934500, 1957 through 2006}



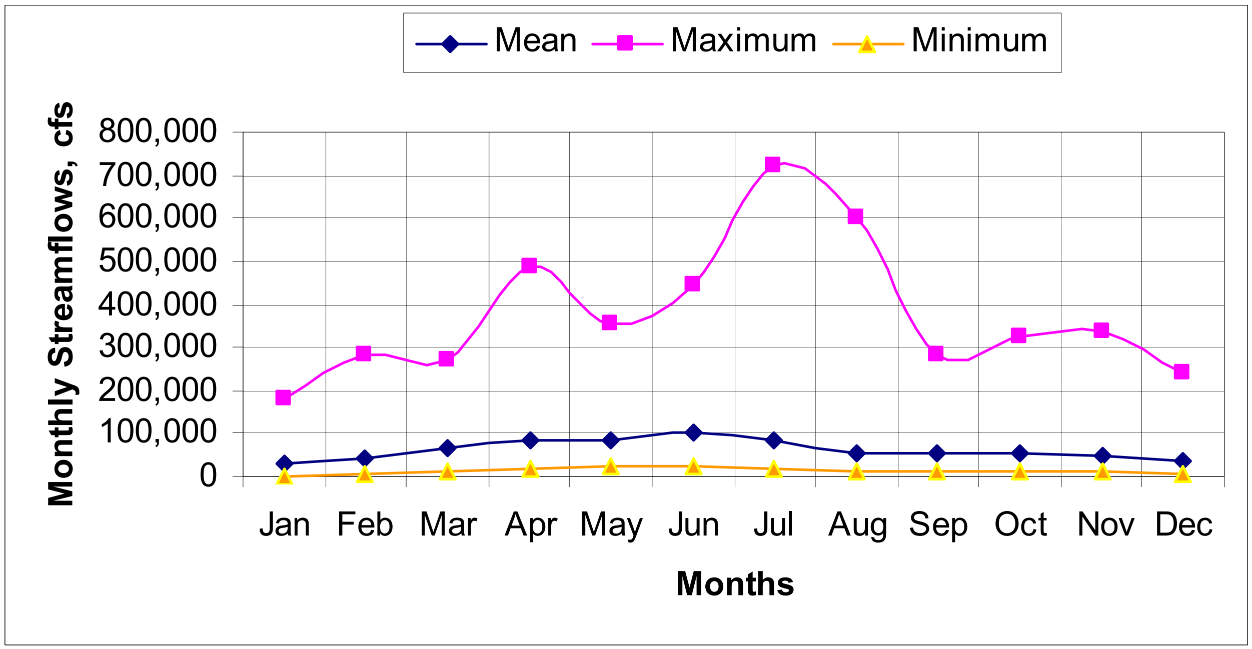
Source: USGS, 2008b

Figure 2.3-8—{Temperature for the Hermann, MO USGS 06934500, 2006 through 2007}



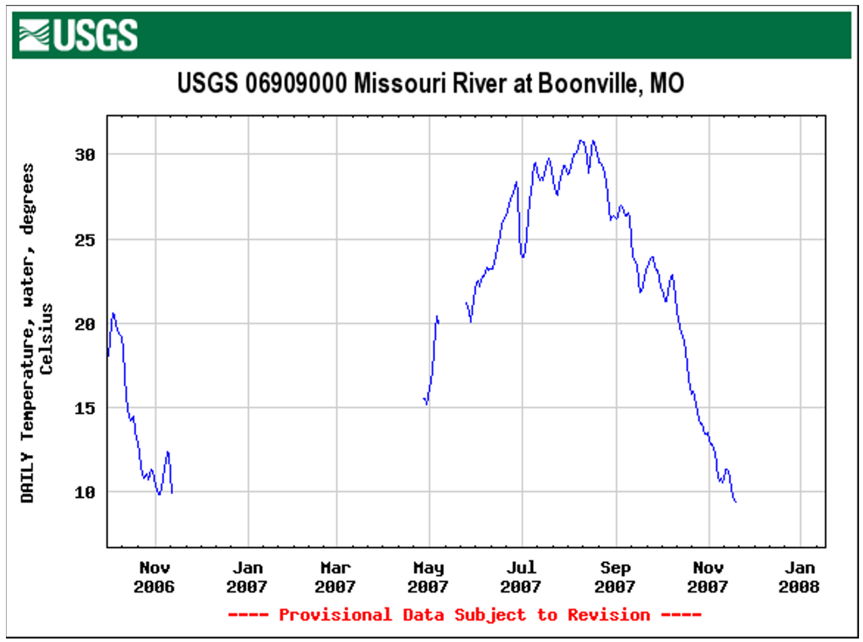
Source: USGS, 2008b

Figure 2.3-9—{Mean, Maximum and Minimum Streamflows for the Boonville, MO USGS 06909000, 1957 through 2007}



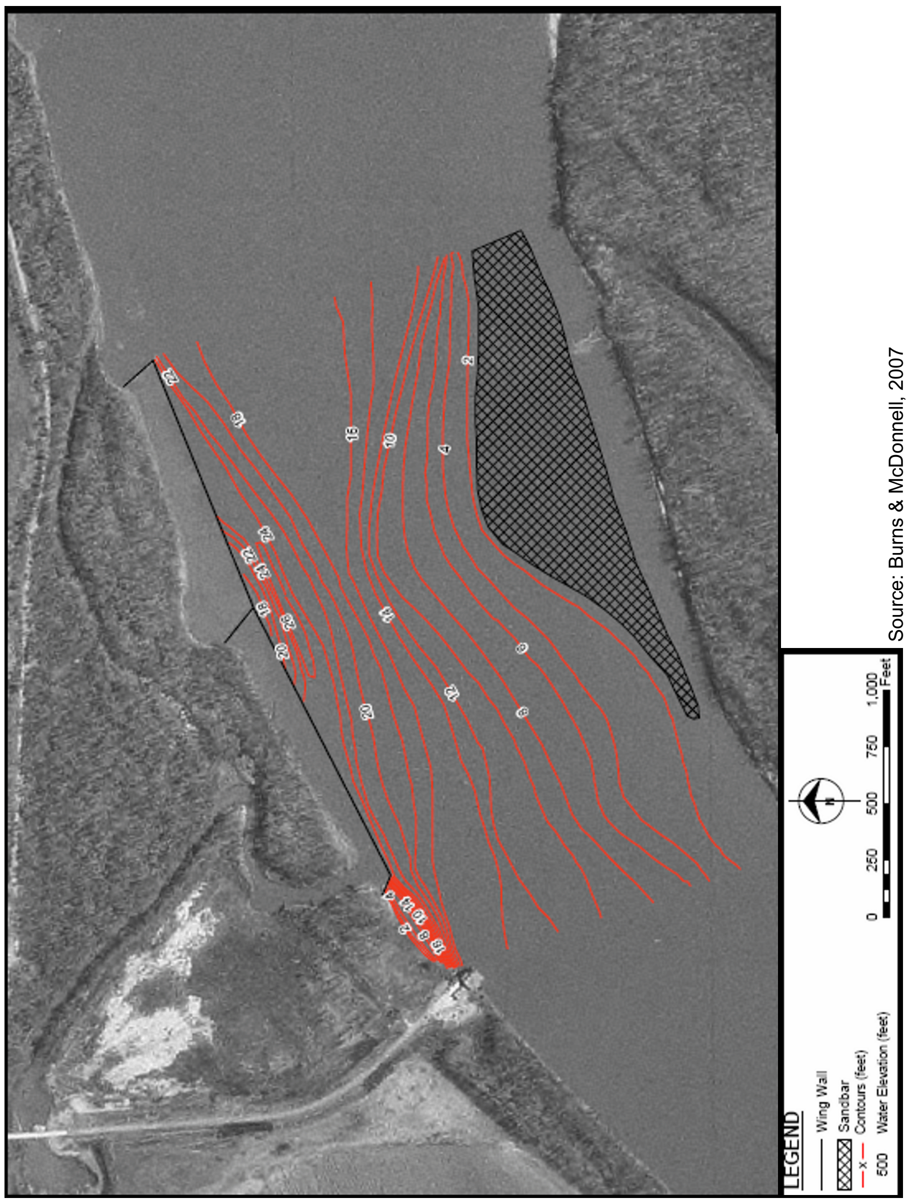
Source: USGS, 2008a

Figure 2.3-10—{Temperature for the Boonville, MO USGS 06909000, 2006 through 2007}



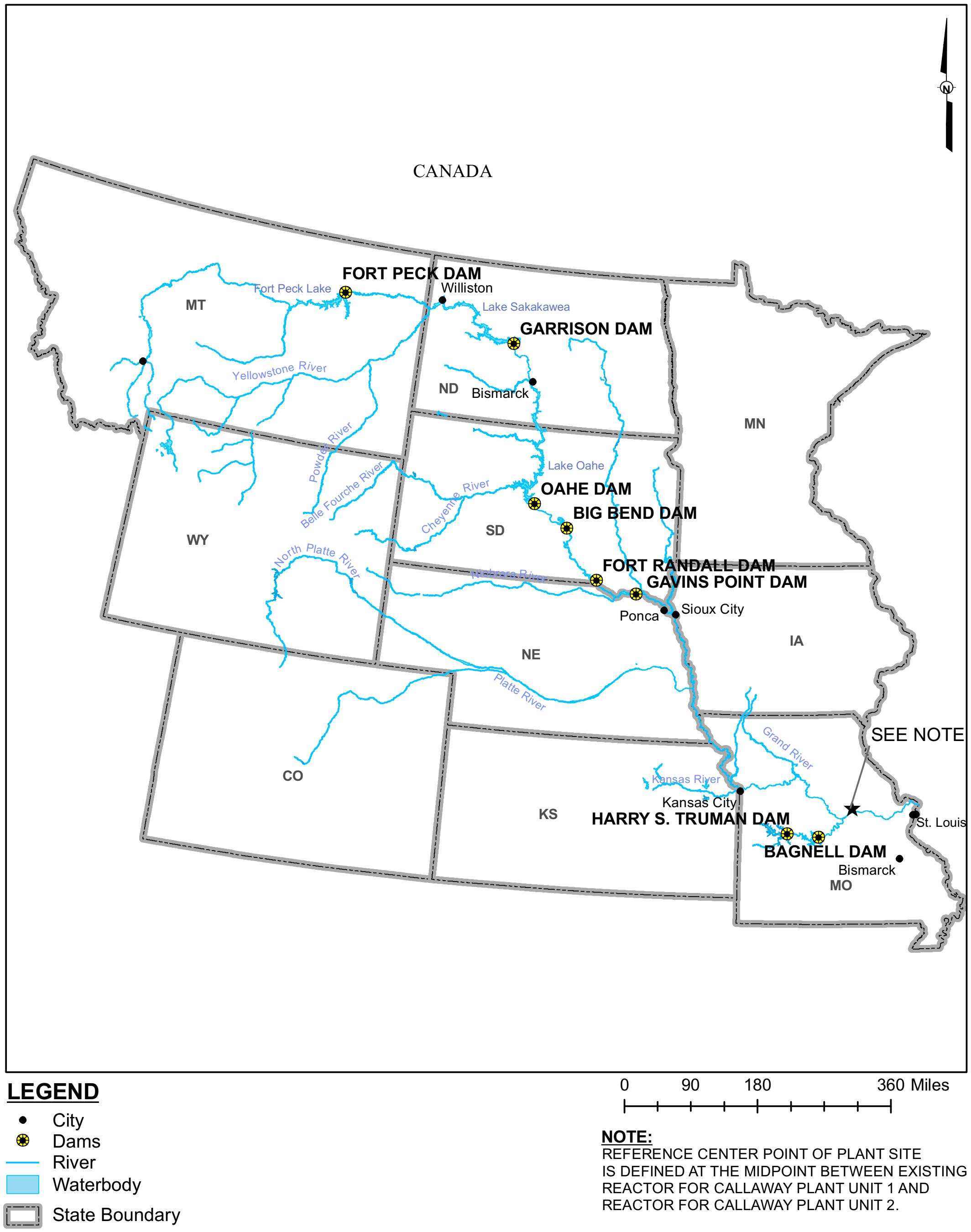
Source: USGS, 2008a

Figure 2.3-11—{Missouri River Bathymetry near Existing Unit 1 Intake}



Source: Burns & McDonnell, 2007

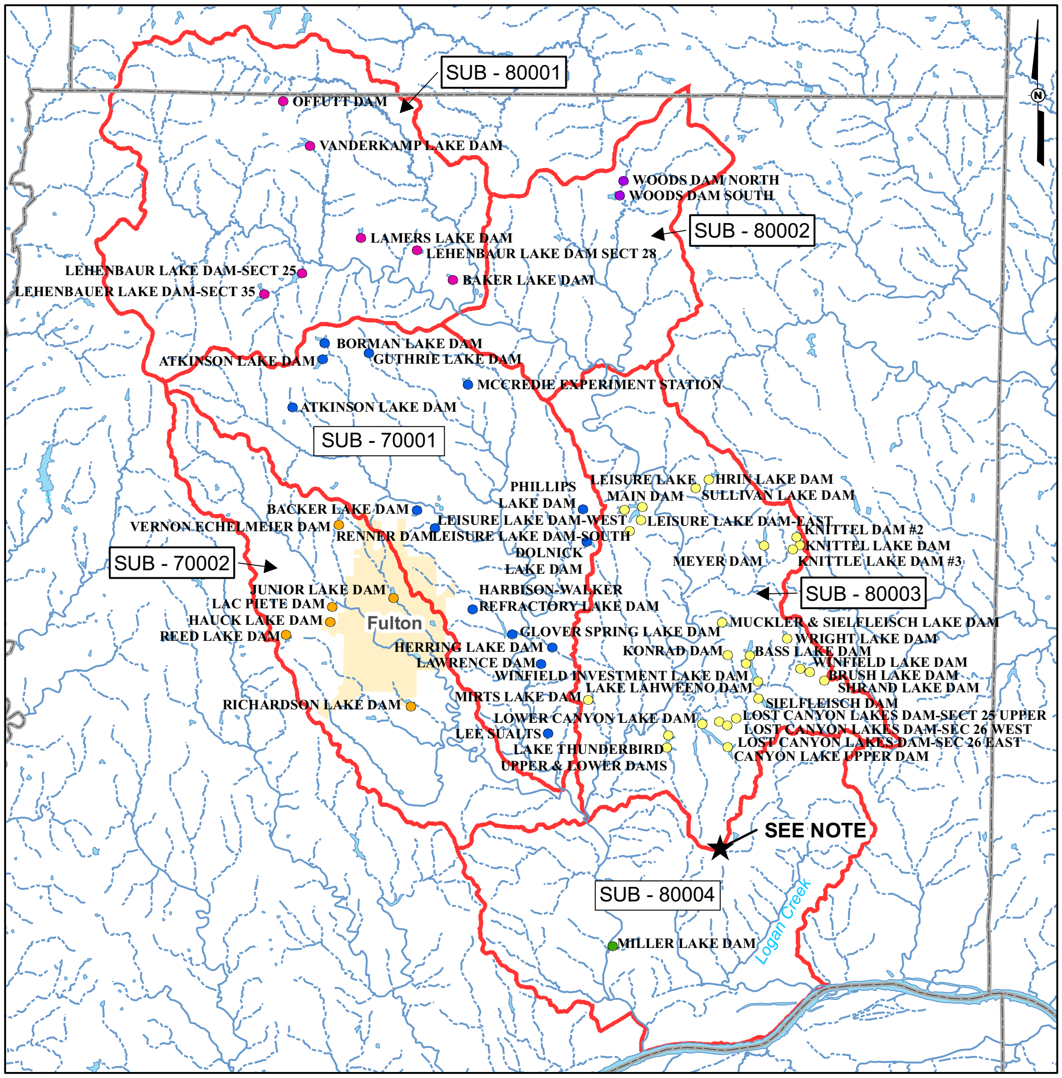
Figure 2.3-12—{Missouri River Main Stem and Osage River Dam System}



NOTE:
REFERENCE CENTER POINT OF PLANT SITE IS DEFINED AT THE MIDPOINT BETWEEN EXISTING REACTOR FOR CALLAWAY PLANT UNIT 1 AND REACTOR FOR CALLAWAY PLANT UNIT 2.

REFERENCES:
ESRI StreetMap Pro [CD-ROM], 2007, City, River & Waterbody, & State Boundaries.
National Atlas of the United States, 2006, Major Dams of the United States.
Watershed boundaries created by theUSDA, NRCS (1998).

Figure 2.3-13—{Dams Within Auxvasse Creek Watershed}



LEGEND

Dam by Auxvasse Creek Subwatershed

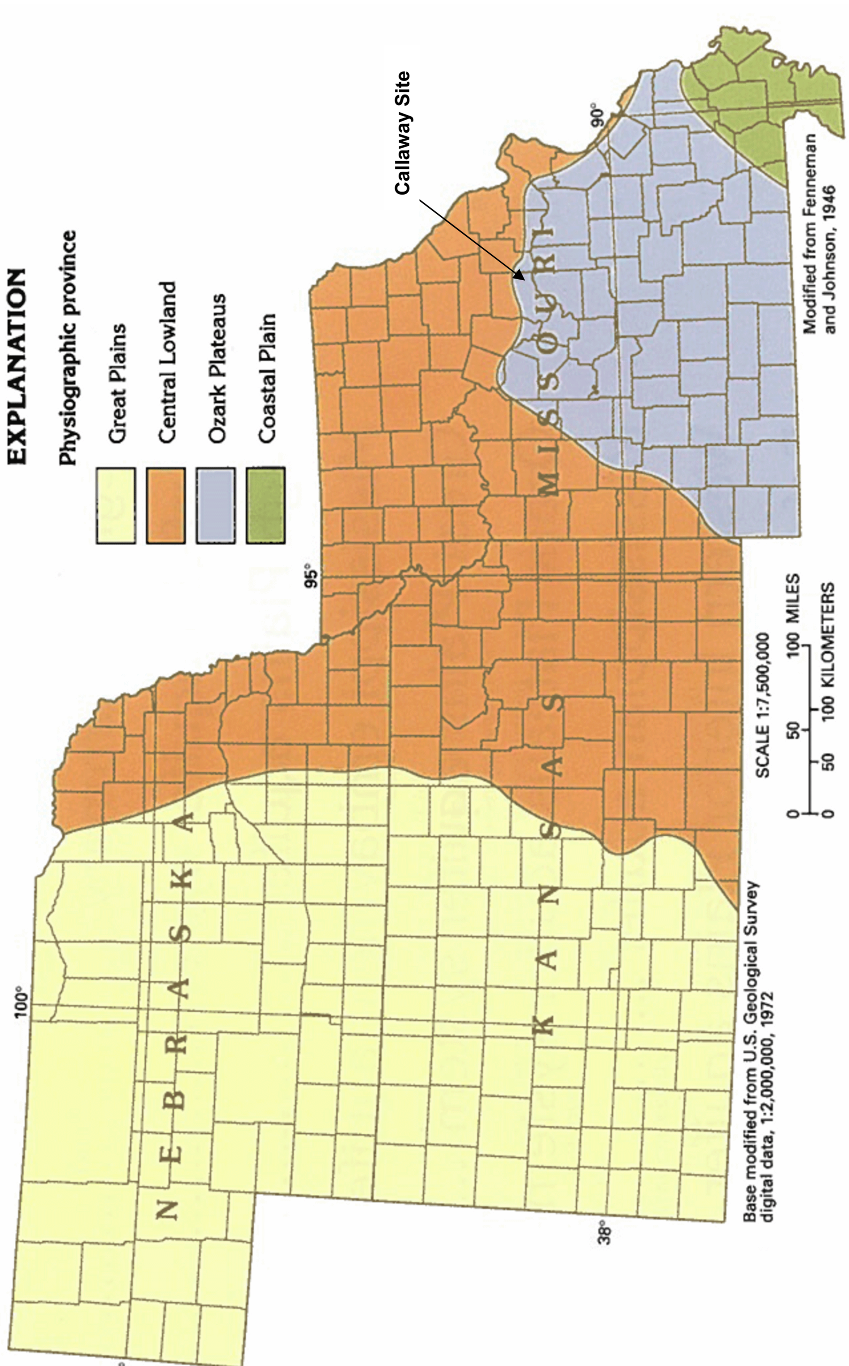
- 70001
- 70002
- 80001
- 80002
- 80003
- 80004
- Stream
- Waterbody
- County Boundary
- Incorporated Area

0 2 4 8 Miles

NOTE:
REFERENCE CENTER POINT OF PLANT SITE IS DEFINED AT THE MIDPOINT BETWEEN EXISTING REACTOR FOR CALLAWAY PLANT UNIT 1 AND REACTOR FOR CALLAWAY PLANT UNIT 2.

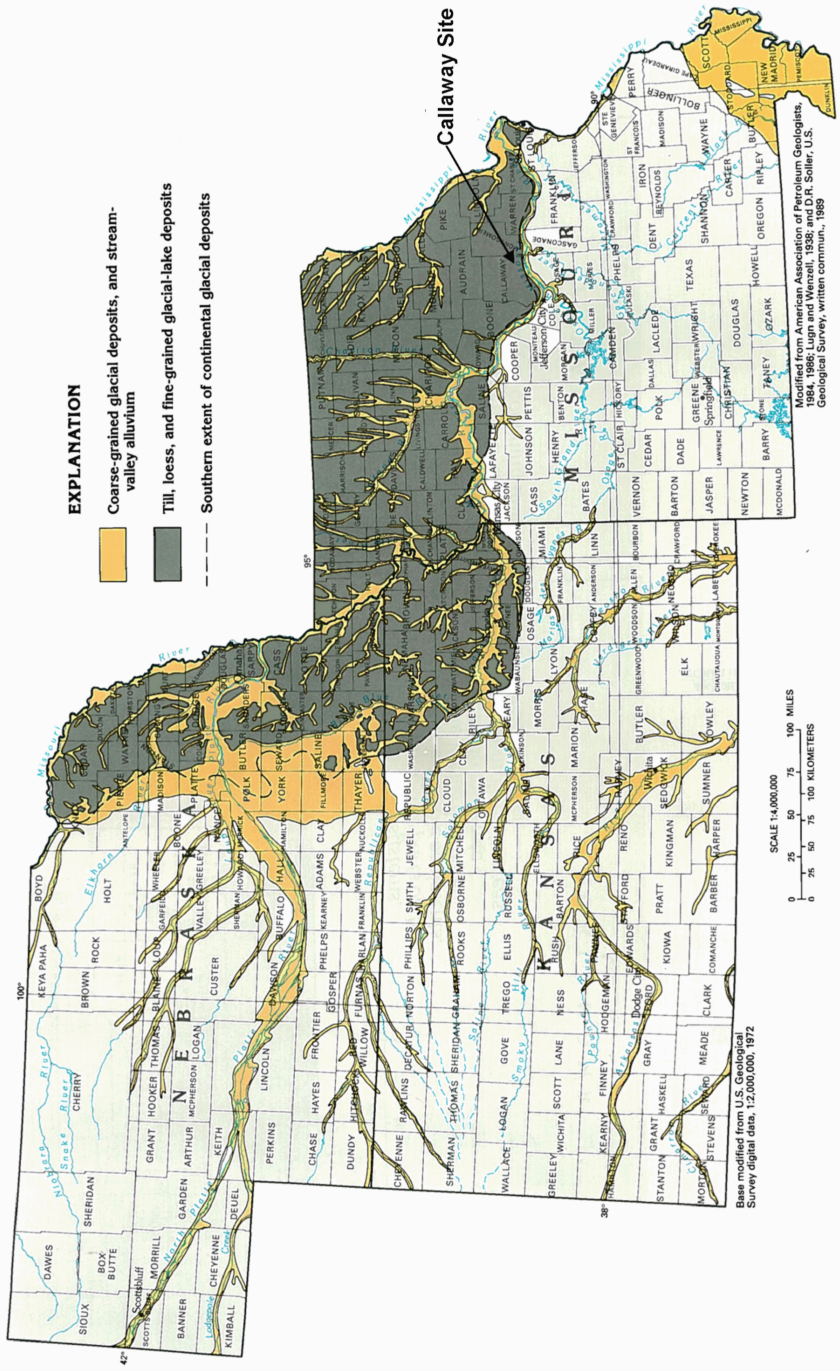
REFERENCE:
ESRI StreetMap Pro [CD-ROM], 2007,
Streams, Waterbody, Incorporated Area, and County Boundary.
MoDNR, Water Resources Center, 2007,
Regulated and Non-Regulated Dams in Missouri.
USDA, NRCS 14-digit HUC boundaries, 1998, Auxvasse Creek Watershed boundary.

Figure 2.3-14—{Regional Physiographic Provinces}



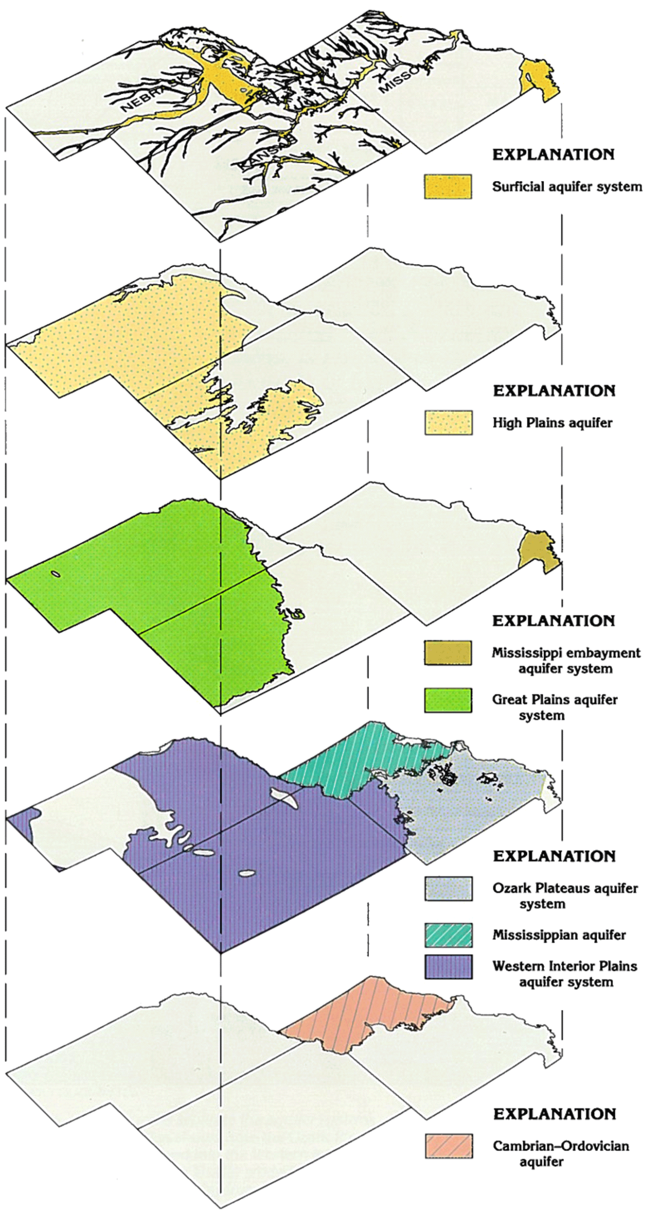
Reference: Groundwater Atlas of the United States, Segment 3, USGS, 1997.

Figure 2.3-15—{Regional Extent of Glaciation and Alluvium}



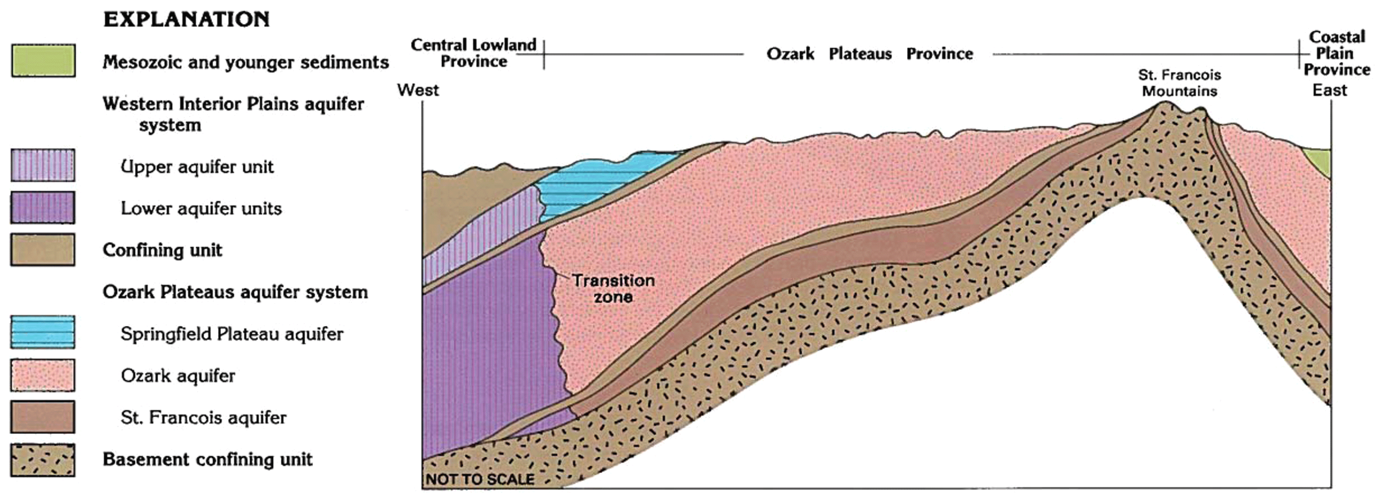
Reference: Groundwater Atlas of the United States, Segment 3, USGS, 1997.

Figure 2.3-16—{Regional Vertical Sequence of Aquifers}



Reference: Groundwater Atlas of the United States, Segment 3, USGS, 1997.

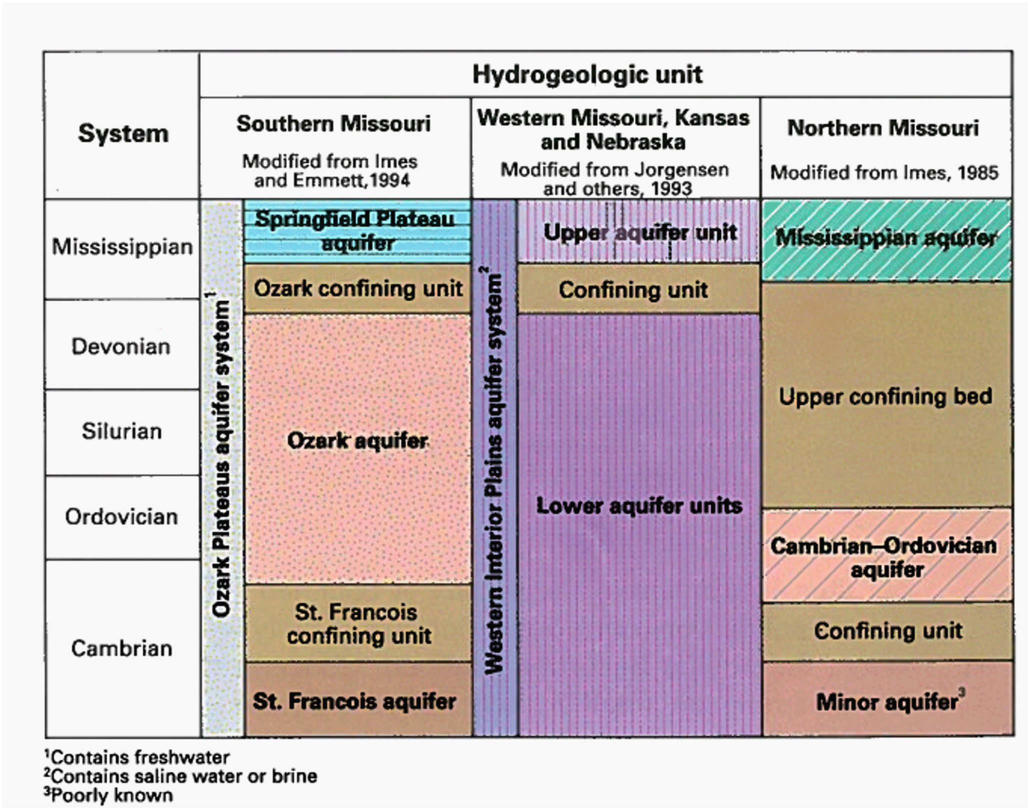
Figure 2.3-17—{Aquifer Systems of Missouri}



Note: This is a regionally generalized section. The Ozark Plateau aquifer system is present in southern Missouri. The Cambrian-Ordovician aquifer and overlying Mississippian aquifer are the corresponding aquifers in northern Missouri.

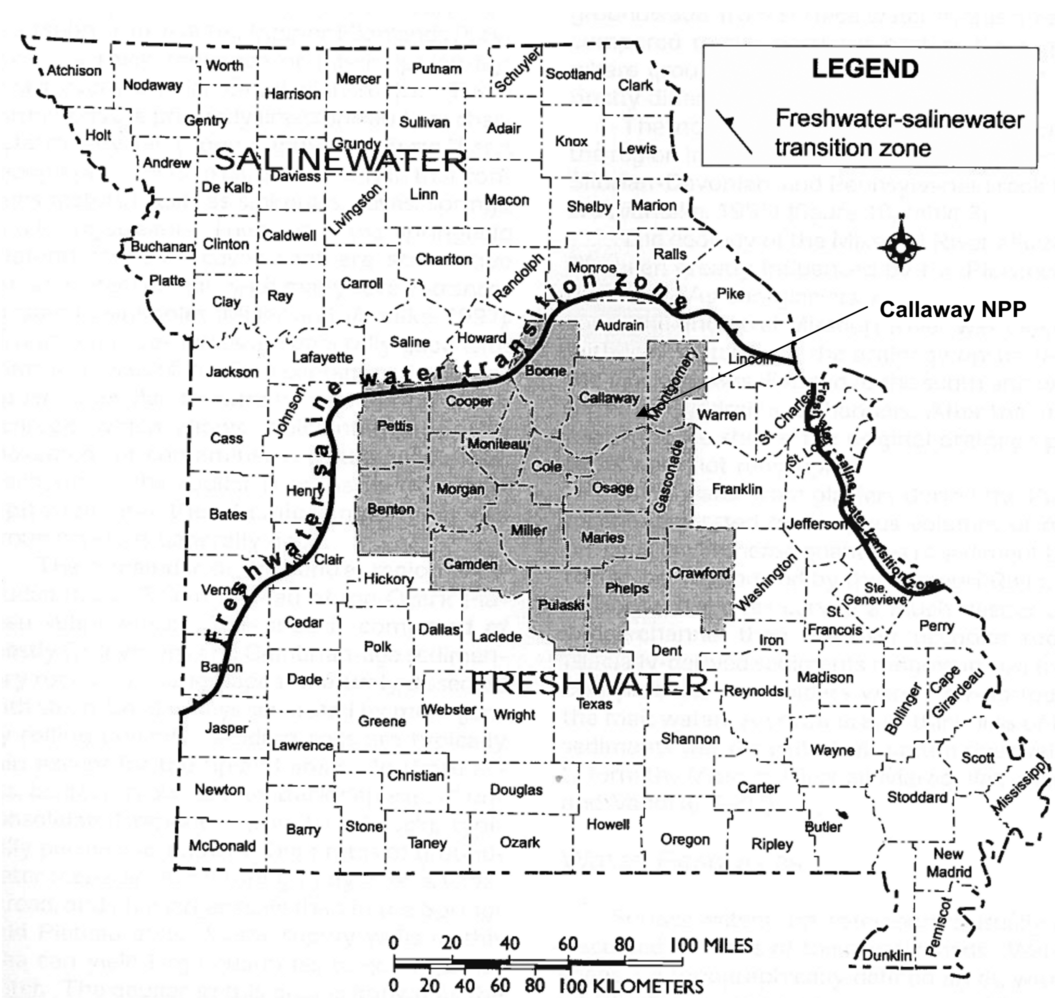
Reference: Groundwater Atlas of the United States, Segment 3, USGS, 1997.

Figure 2.3-18—{Aquifer Systems of Northern, Western, and Southern Missouri}



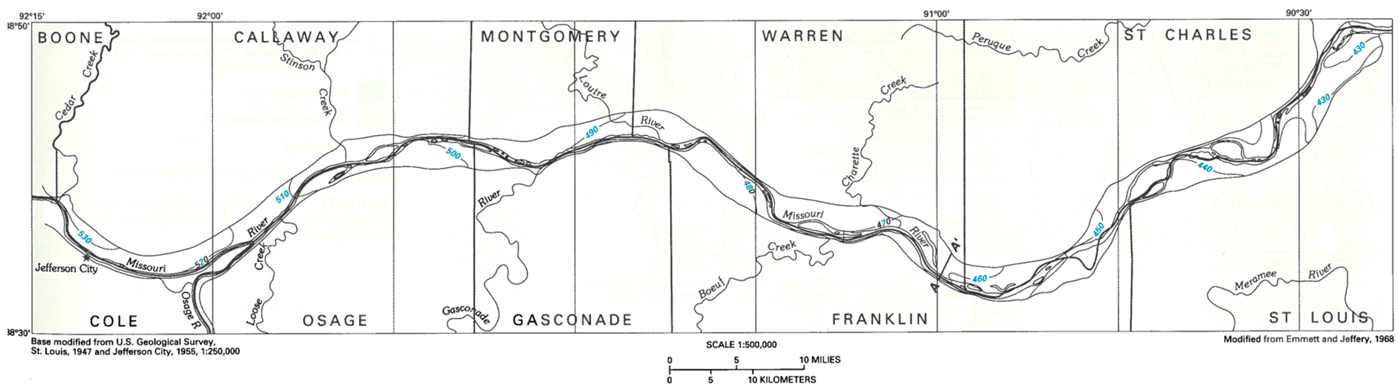
Reference: Groundwater Atlas of the United States, Segment 3, USGS, 1997.

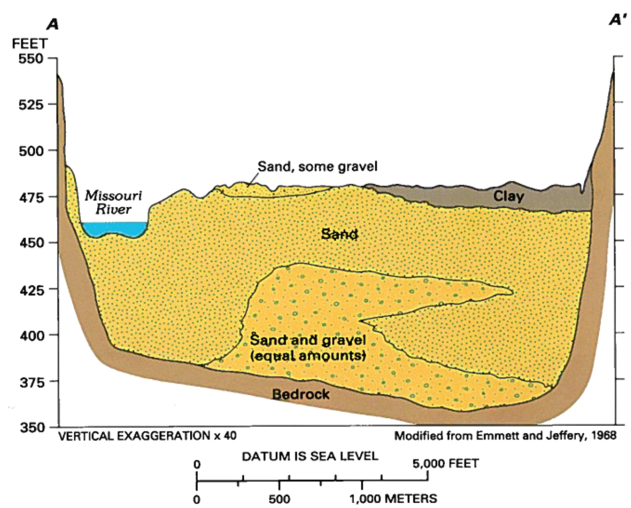
Figure 2.3-19—{MDNR Central Missouri Area and Groundwater Transition Zone}



Reference: Topics in Water Use: Central Missouri, MDNR, 2002.

Figure 2.3-20—{Missouri River and Alluvial Aquifer Section}





Reference: Groundwater Atlas of the United States, Segment 3, USGS, 1997.

Figure 2.3-21—{Hydrogeological Units}

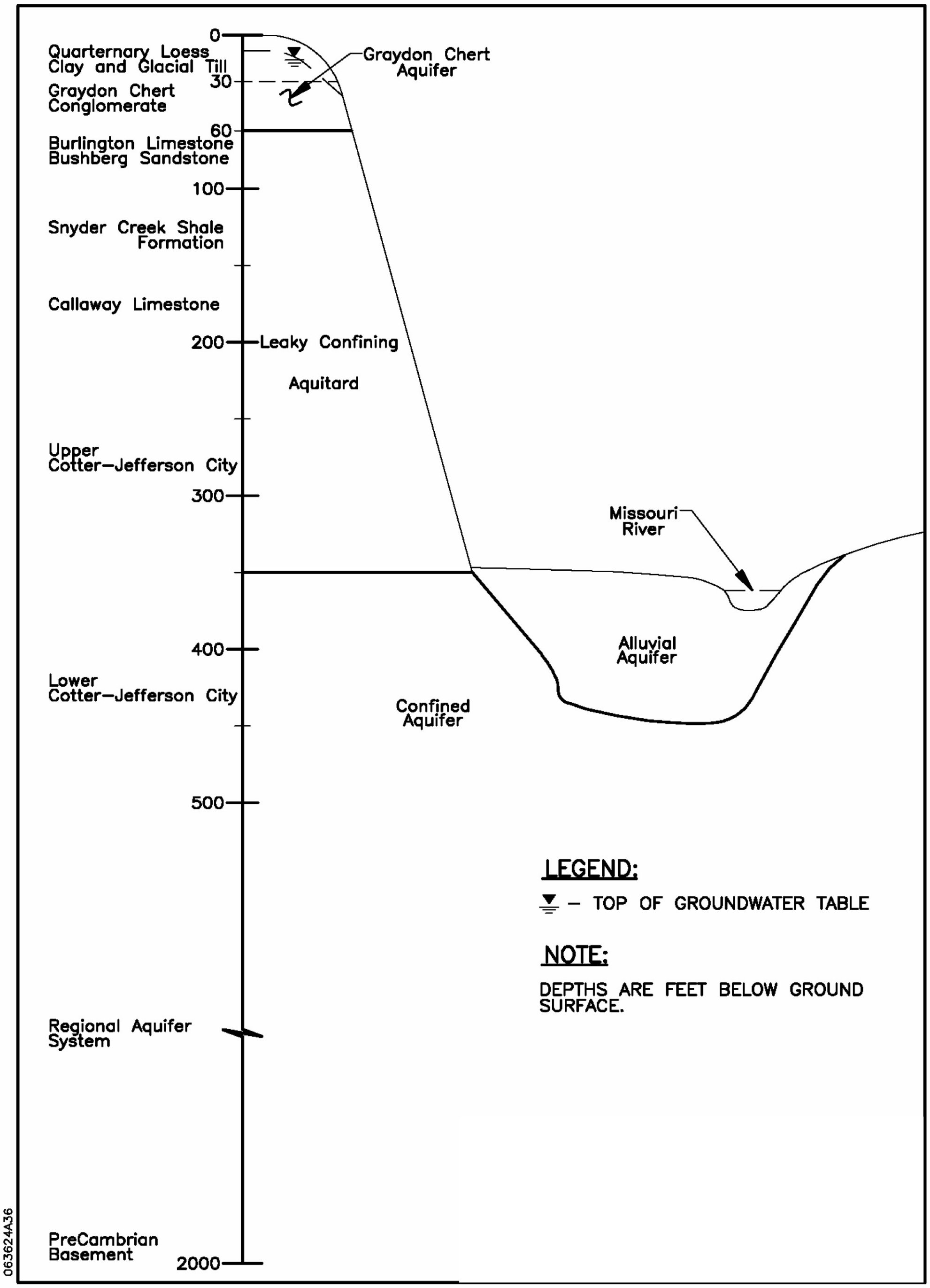
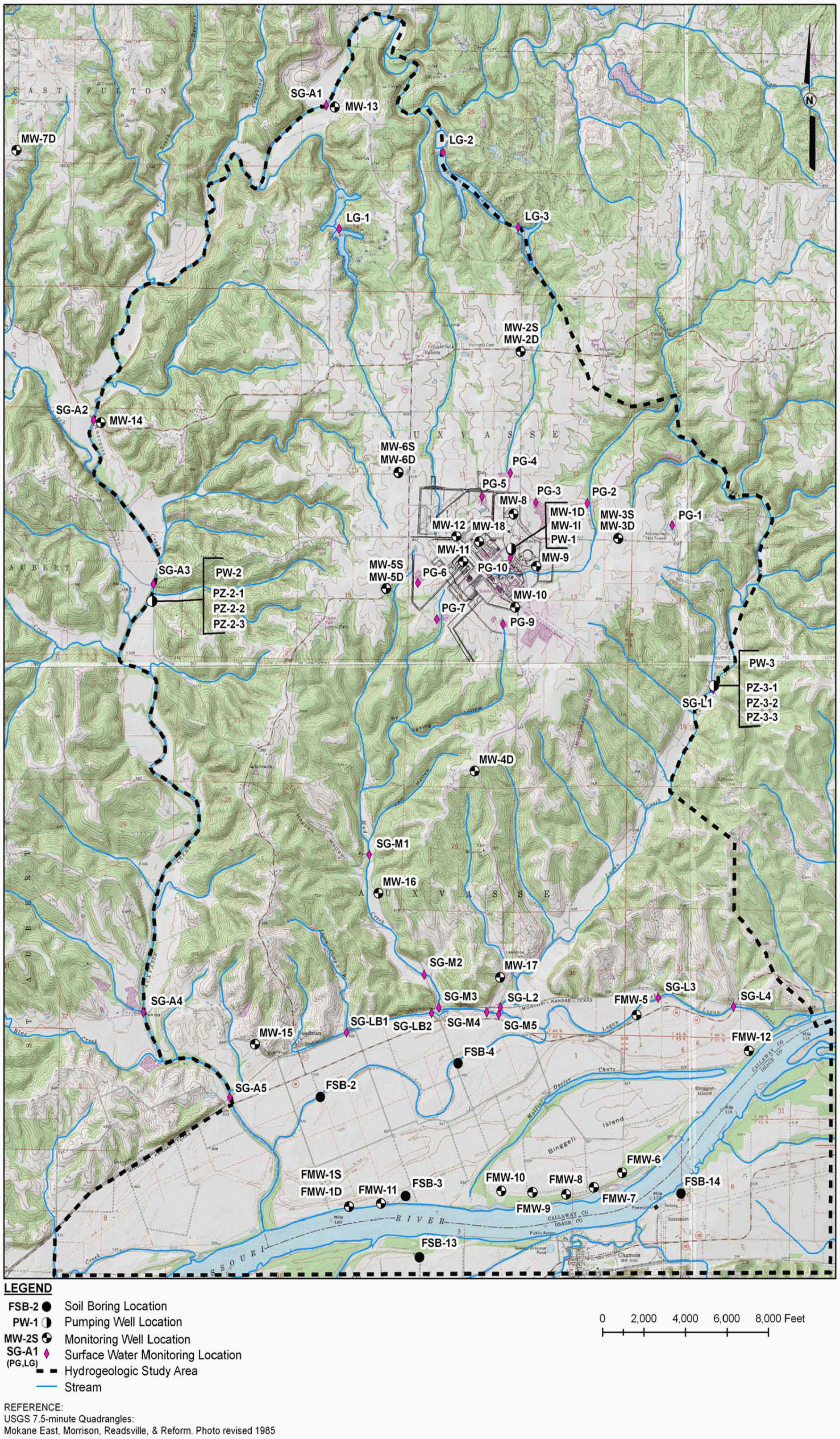
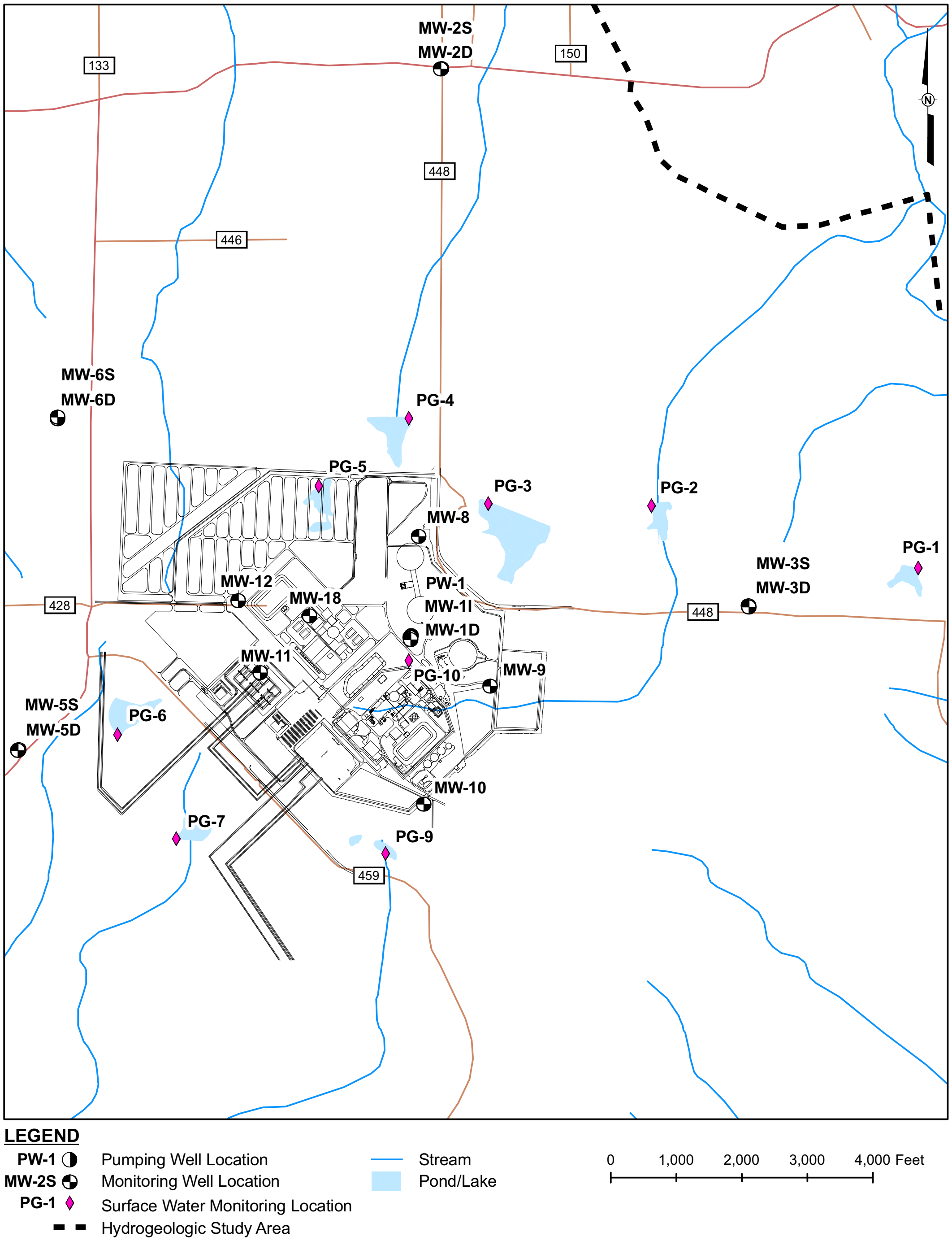


Figure 2.3-22—{Hydrogeologic Site Investigation Locations}



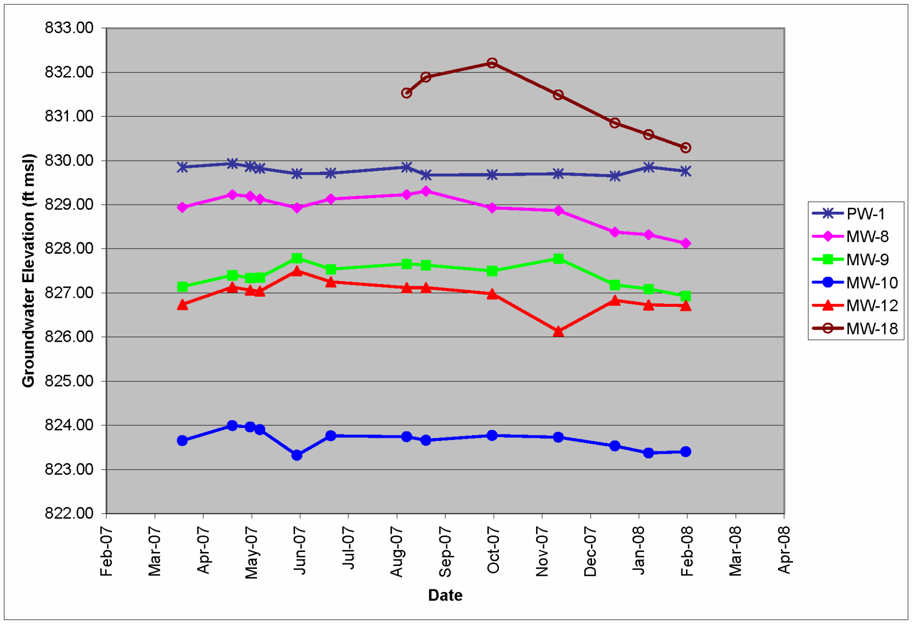
ER Section 2.3

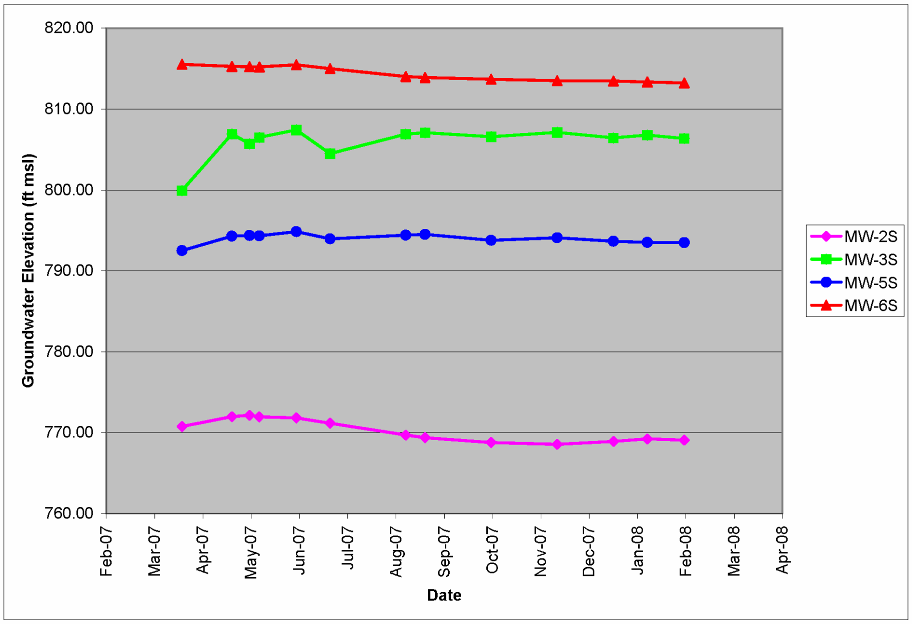
Figure 2.3-23—{Hydrogeologic Site Investigation Locations – Inset}



REFERENCES:
ESRI StreetMap Pro [CD-ROM}, 2007,Road & Railroad.
Ponds/Lakes delineated by MACTEC, March 17, 2007.
Streams downloaded from Missouri Spatial Data Information Service
(MSDIS) web site http://www.msdis.missouri.edu/. Accessed September 2007.

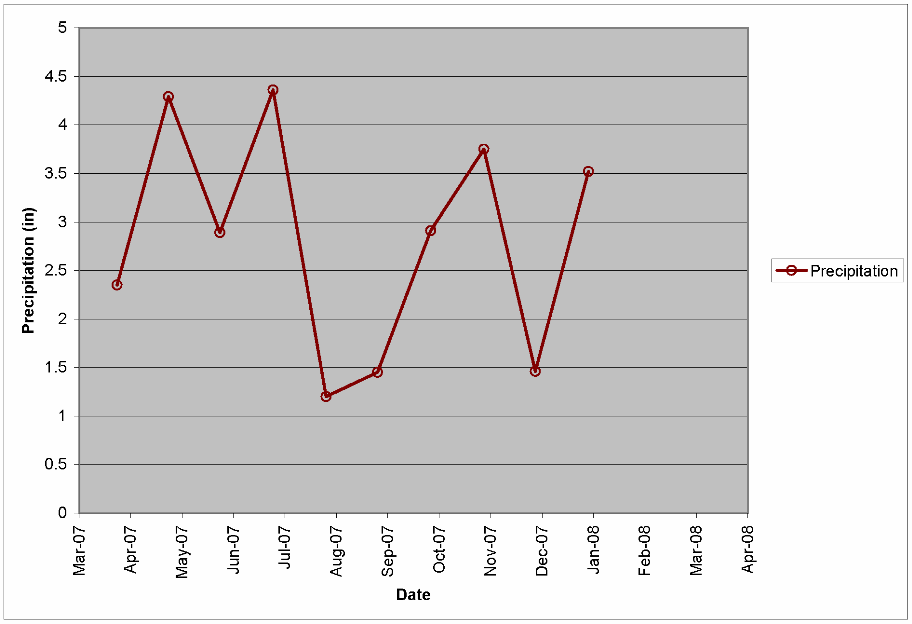
Figure 2.3-24—{Groundwater Elevation versus Time, Graydon Chert Aquifer Wells}





ER Section 2.3

Figure 2.3-25—{Precipitation versus Date, Columbia Regional Airport Station}



Note: The Columbia Regional Airport Station is located approximately 25 miles from the Callaway NPP site.

Figure 2.3-26—{Surface Water Elevation versus Date, Plateau Ponds}

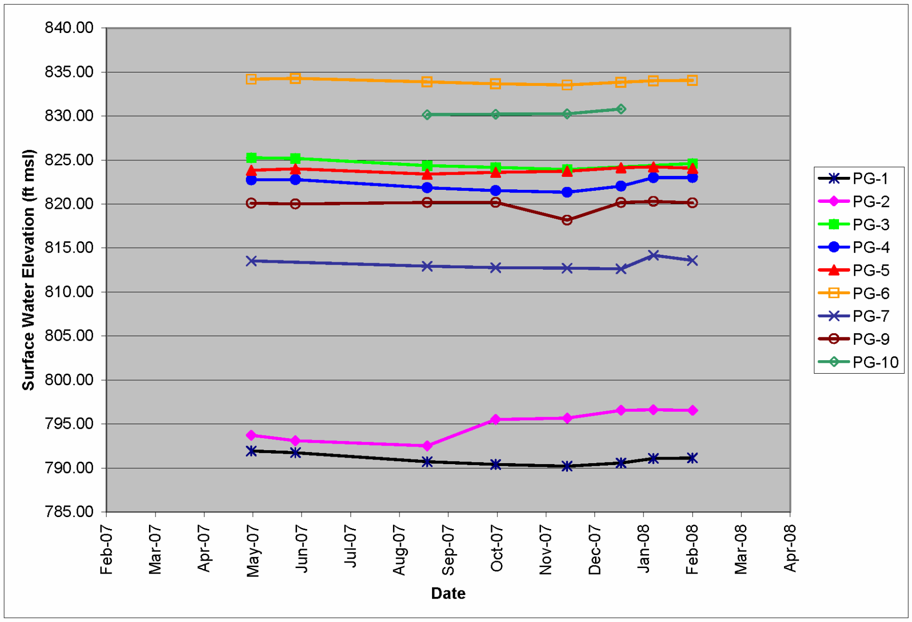
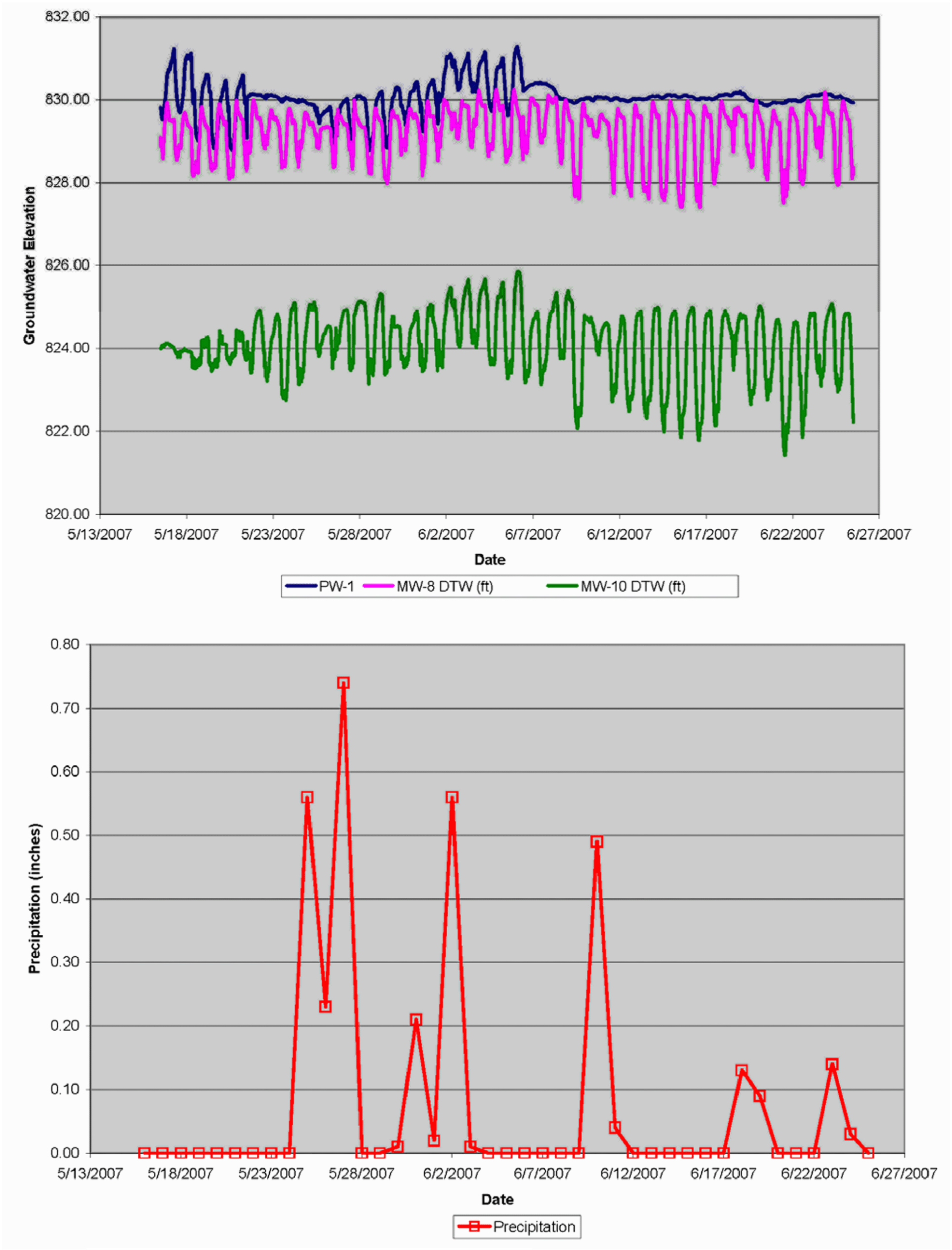


Figure 2.3-27—{Groundwater Elevation and On-Site Precipitation versus Date}



Note: Precipitation was measured with an on-site rain gauge.

Figure 2.3-28—{Potentiometric Surface Map, Graydon Chert Aquifer, May 2007}

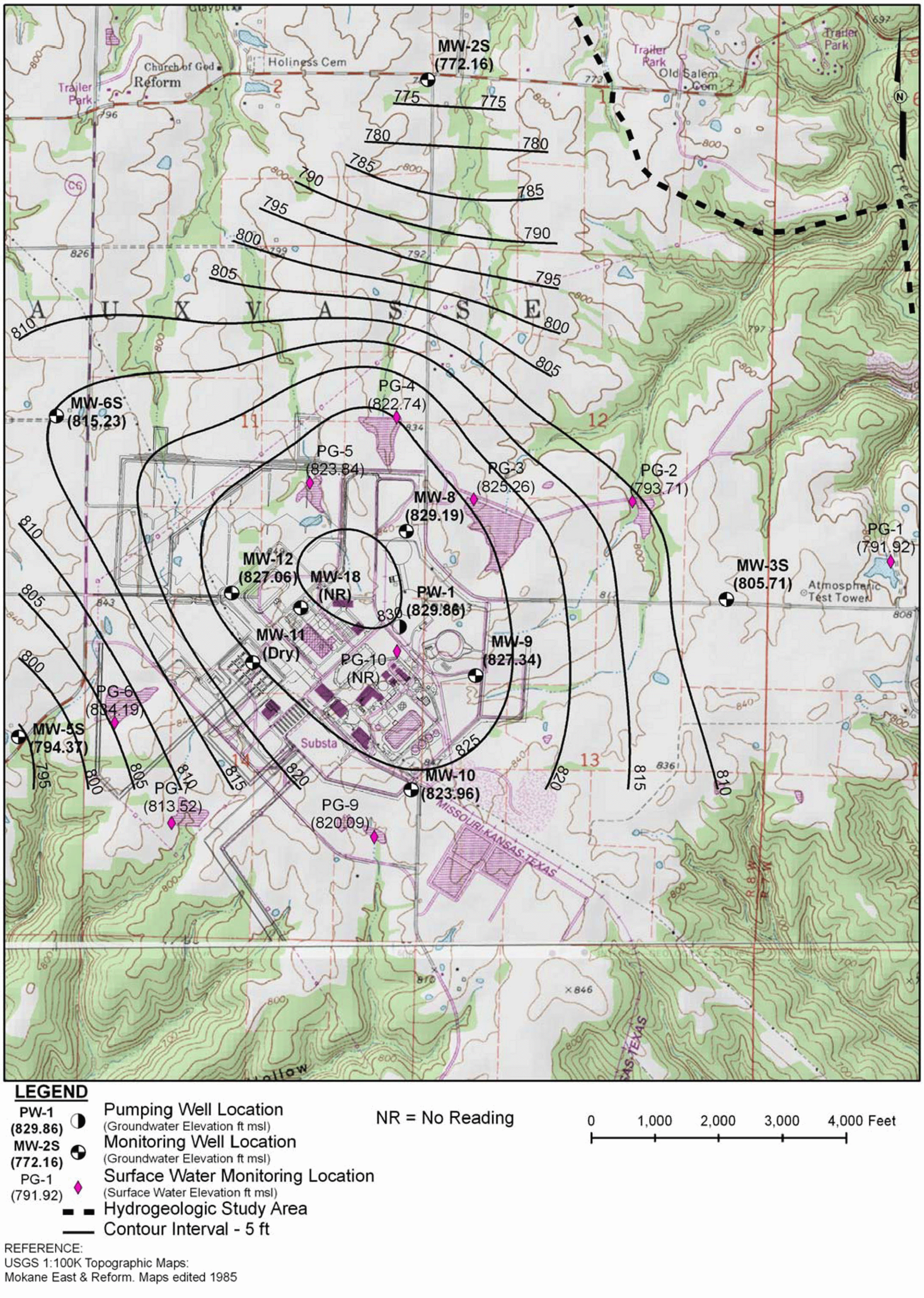


Figure 2.3-29—{Potentiometric Surface Map, Graydon Chert Aquifer, August 2007}

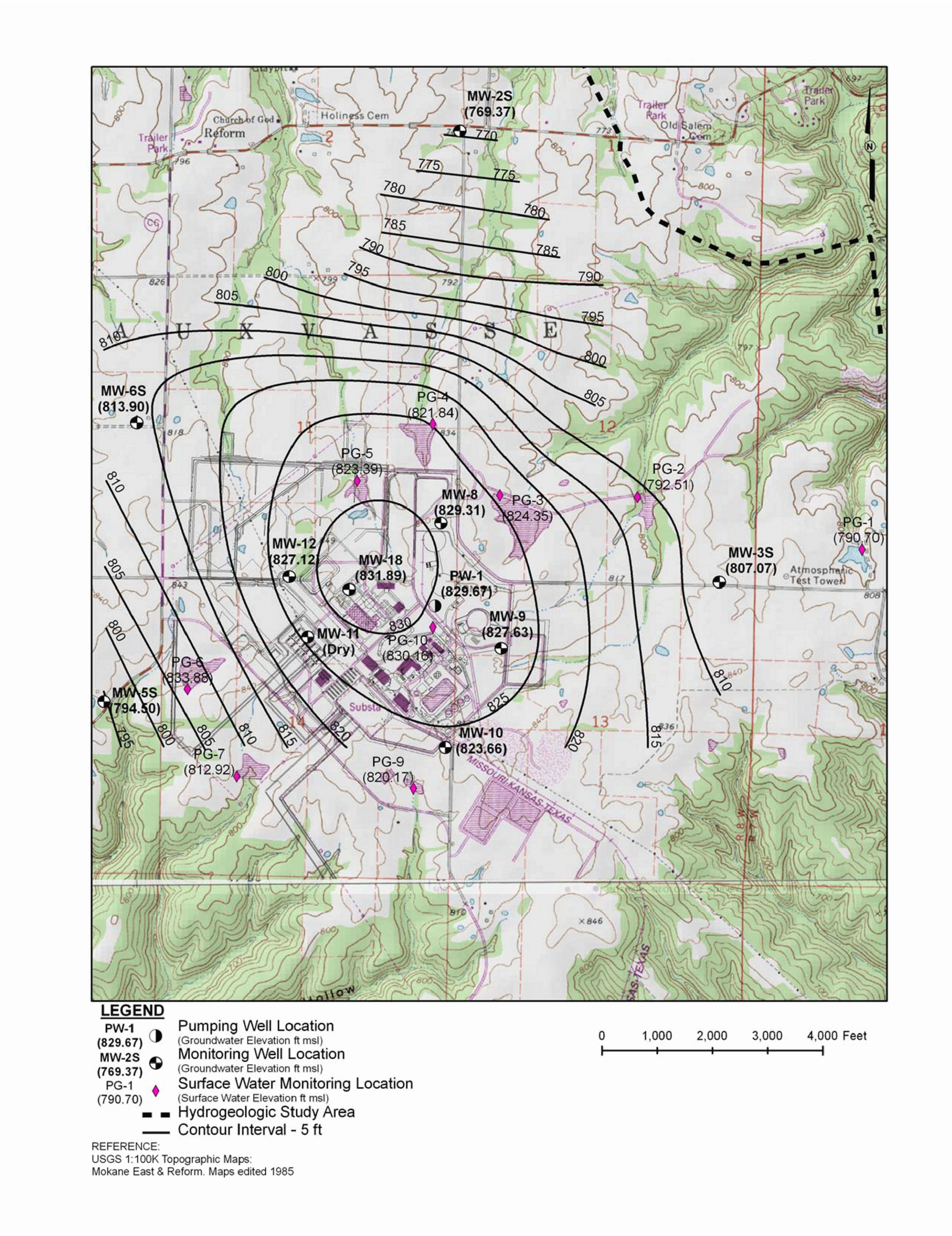


Figure 2.3-30—{Potentiometric Surface Map, Graydon Chert Aquifer, November 2007}

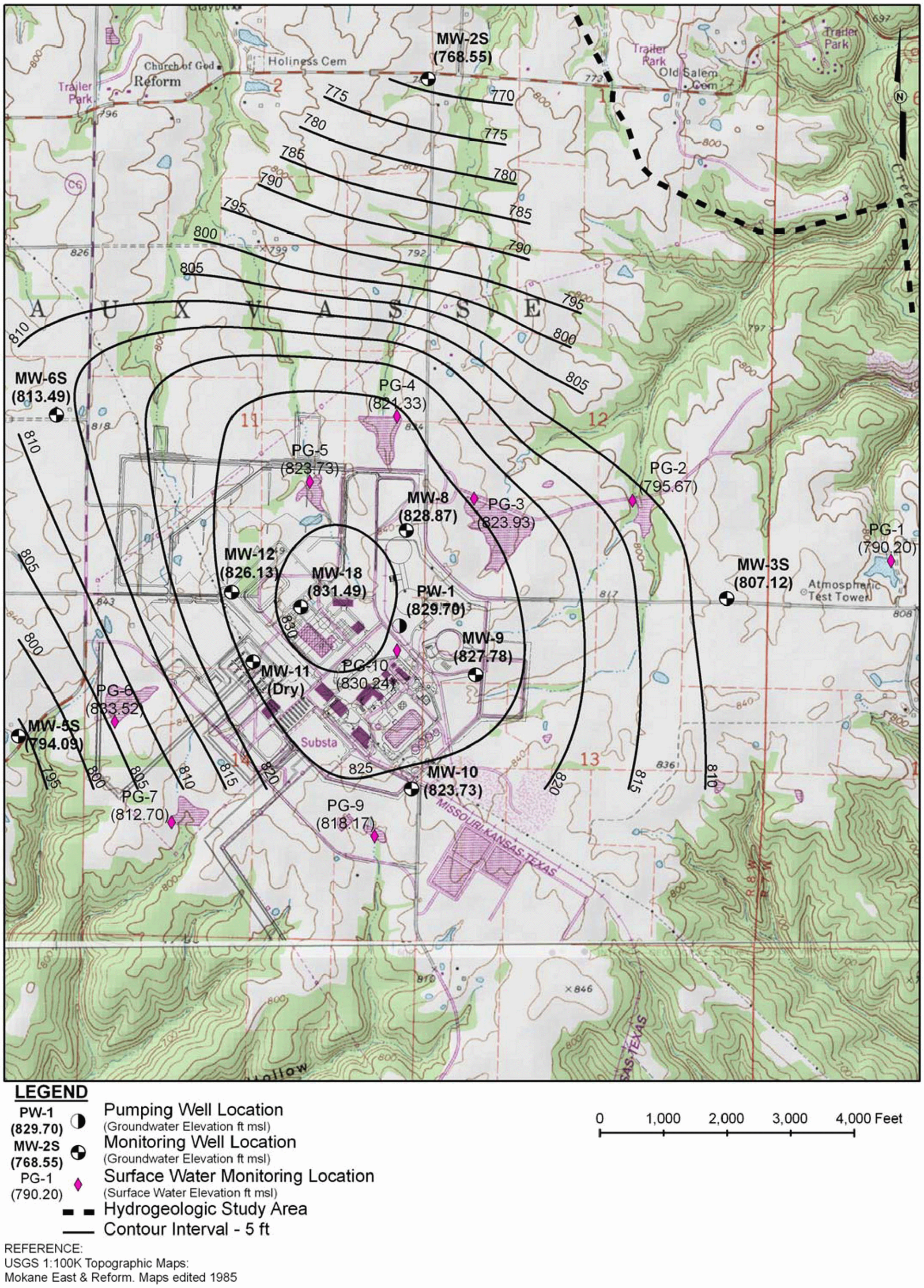


Figure 2.3-31—{Potentiometric Surface Map, Graydon Chert Aquifer, January 2008}

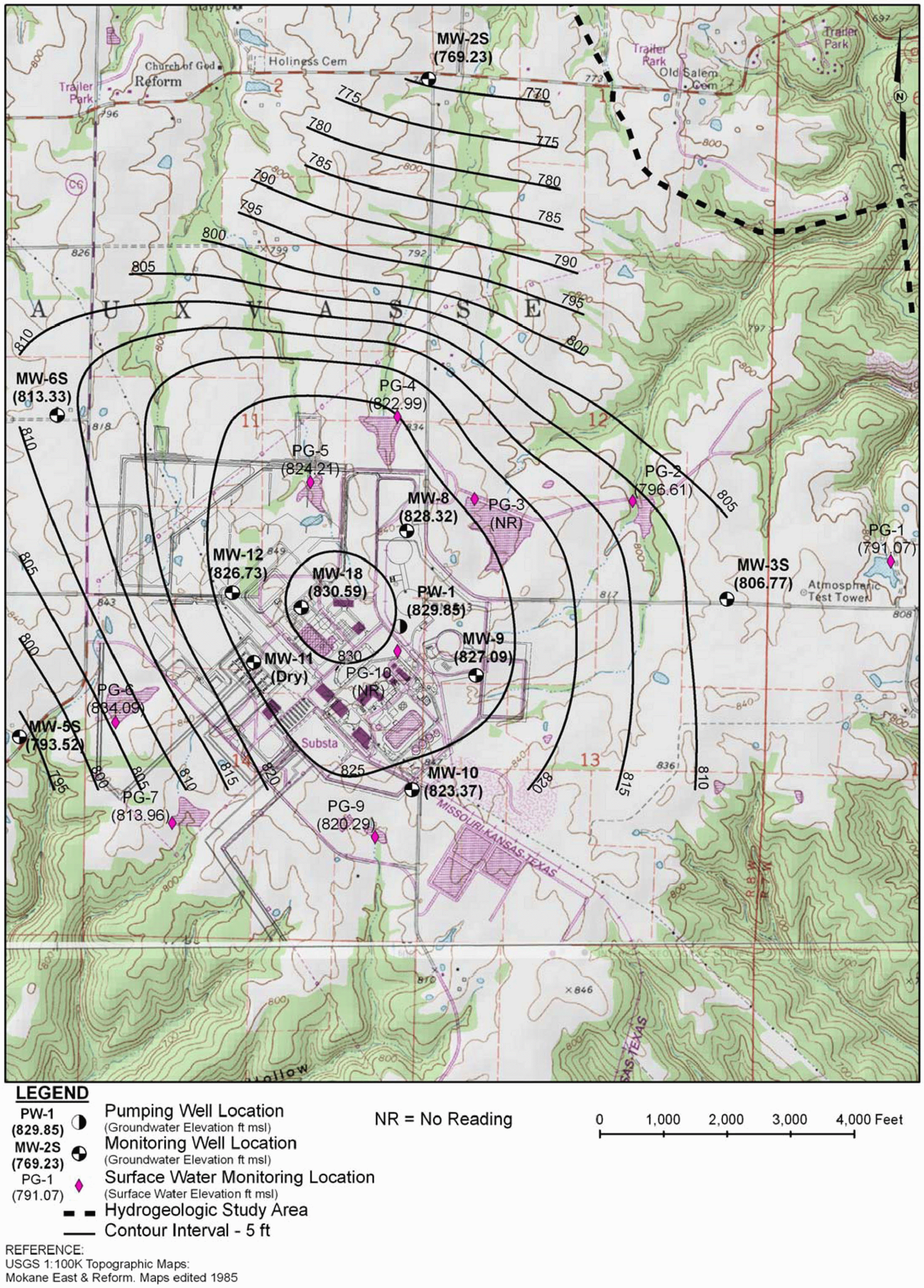


Figure 2.3-32—{Groundwater Elevation versus Date, Aquitard}

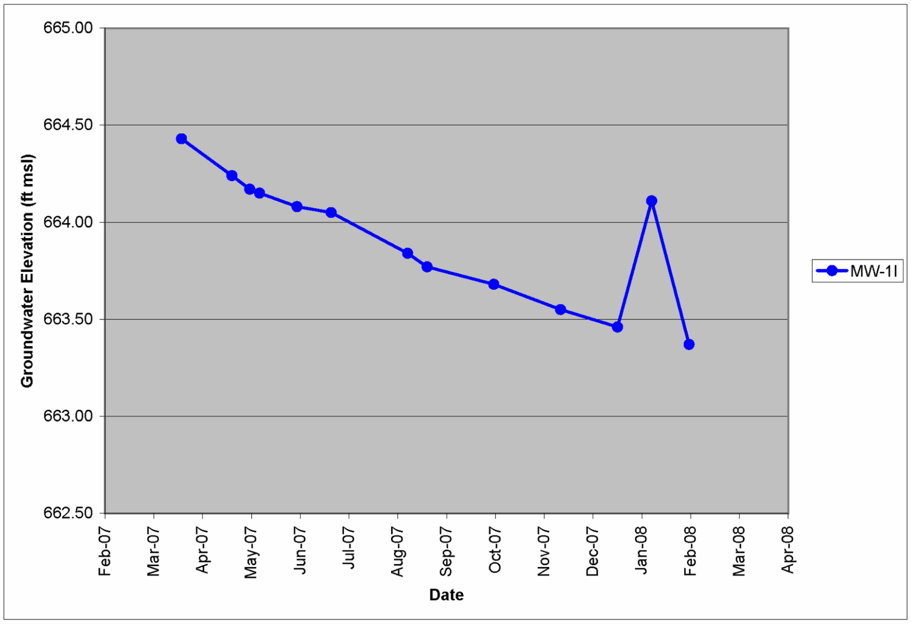
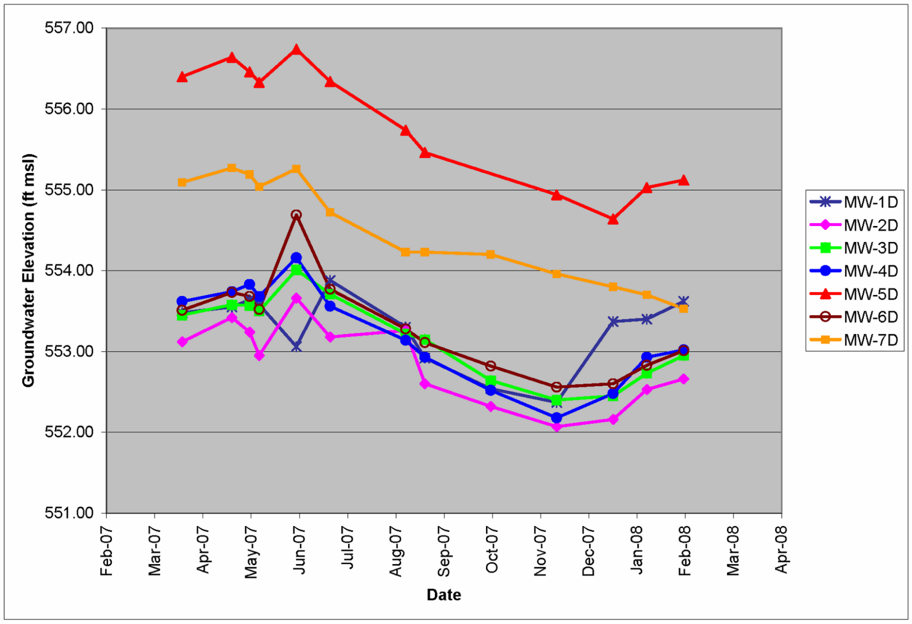
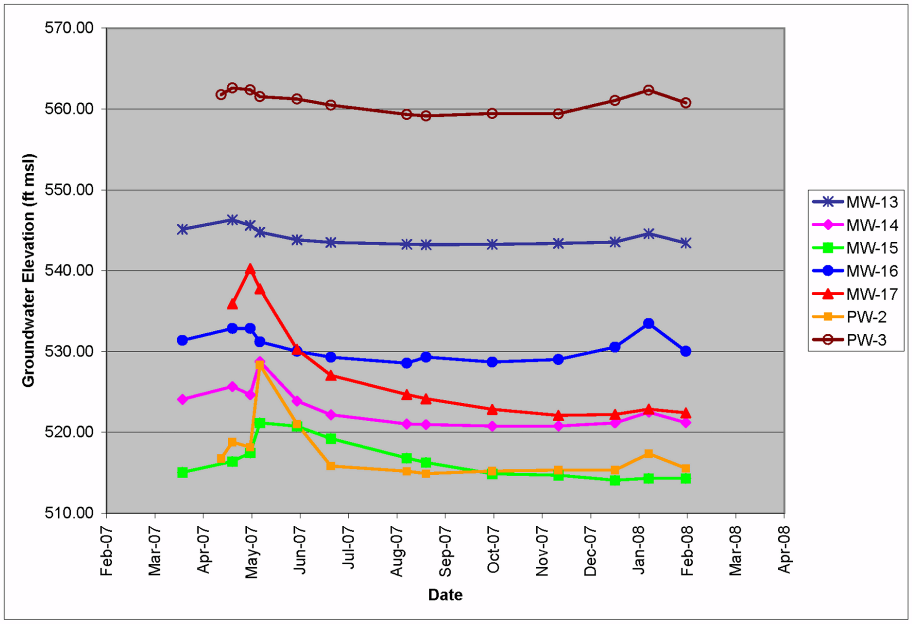


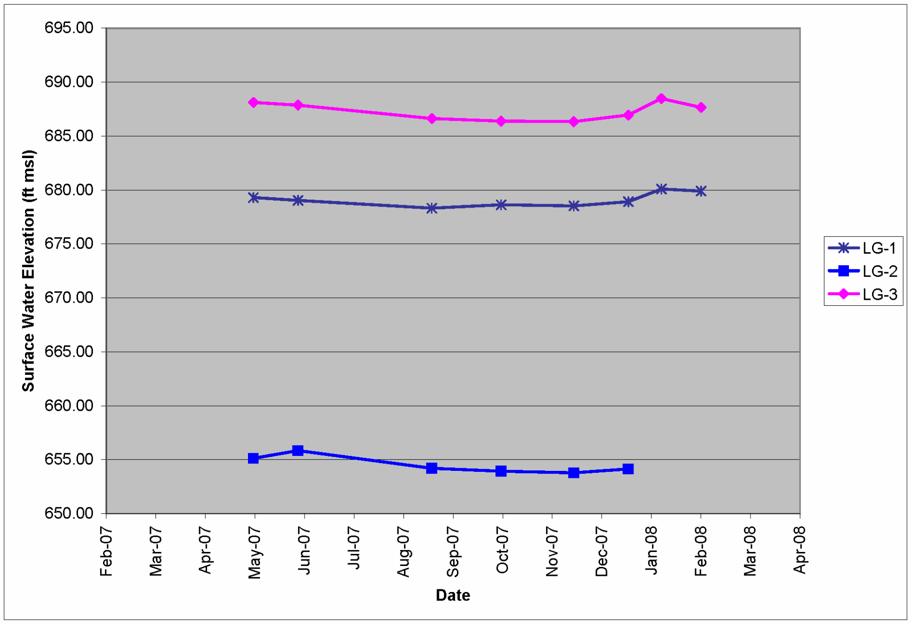
Figure 2.3-33—{Groundwater Elevation versus Date, Cotter-Jefferson City Aquifer Wells}

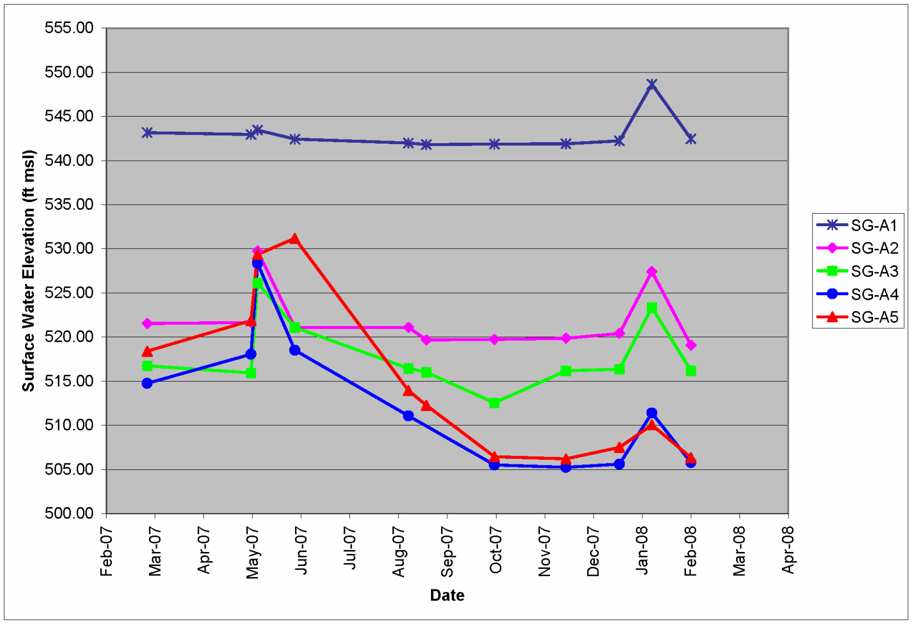




ER Section 2.3

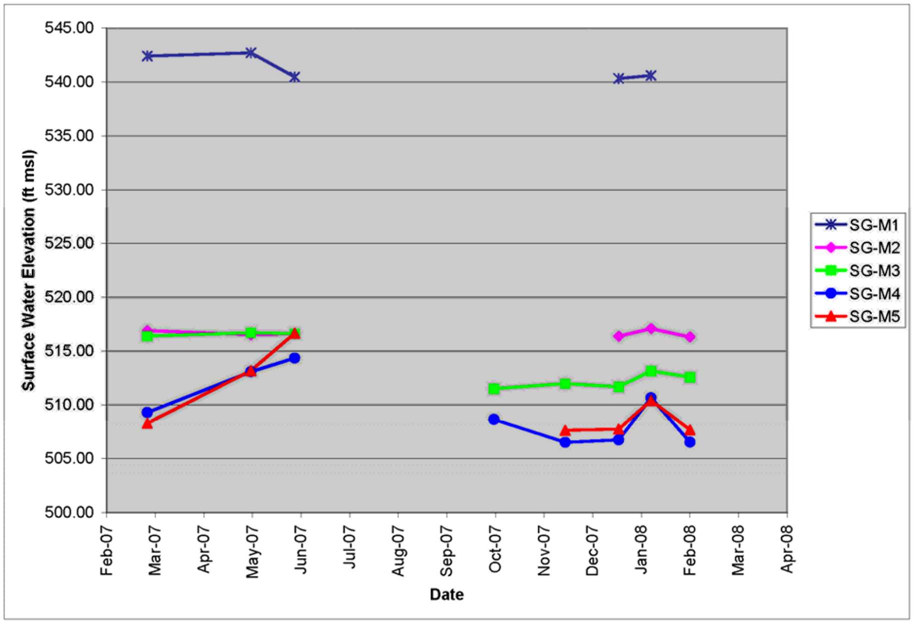
Figure 2.3-34—{Surface Water Elevation versus Date, Lakes and Auxvasse Creek}

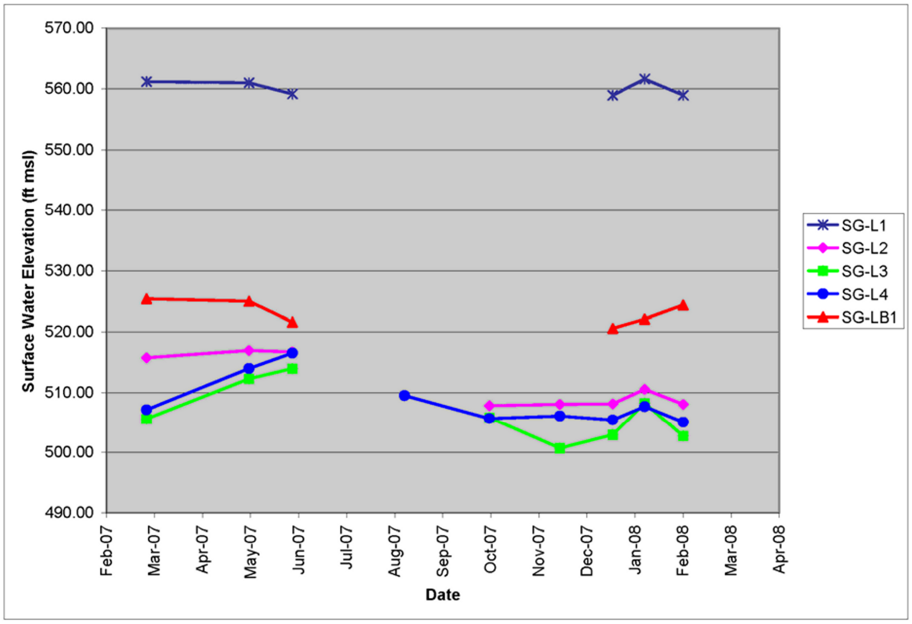




ER Section 2.3

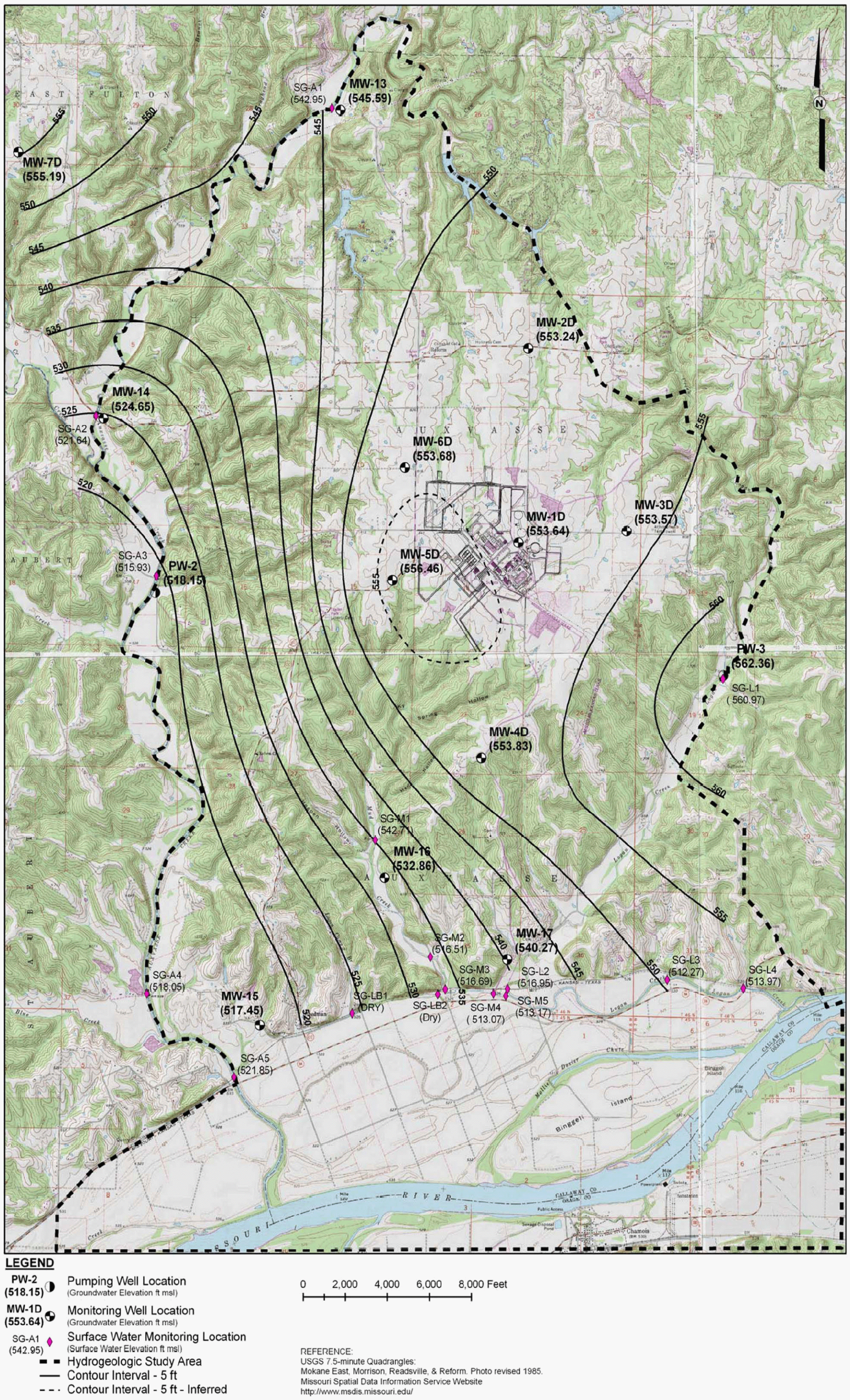
Figure 2.3-35—{Surface Water Elevation versus Date, Mud, Logan and Logan Camp Branch Creeks}





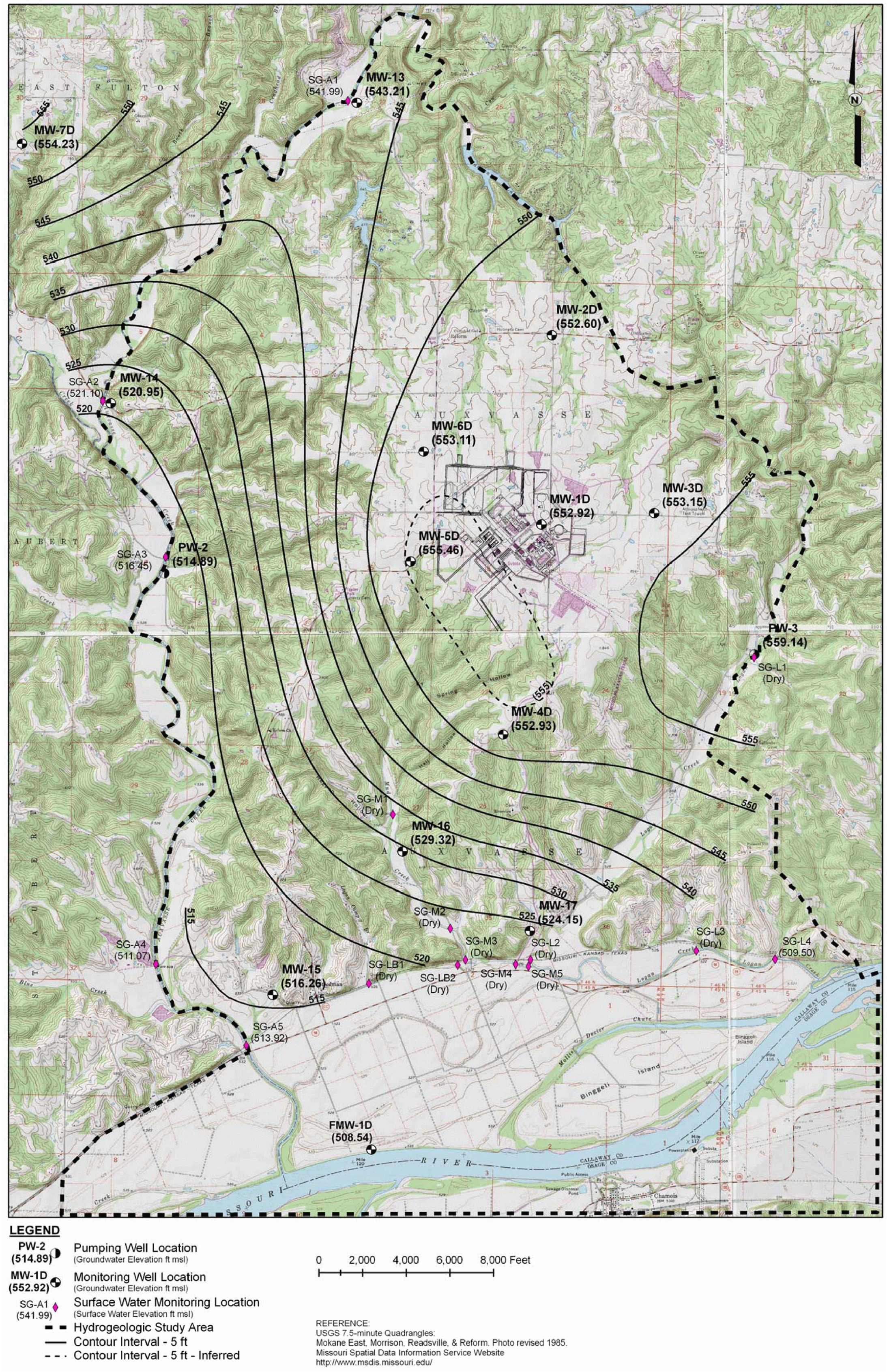
ER Section 2.3

Figure 2.3-36—{Potentiometric Surface Map, Cotter-Jefferson City Aquifer, May 2007}



ER Section 2.3

Figure 2.3-37—{Potentiometric Surface Map, Cotter-Jefferson City Aquifer, August 2007}



ER Section 2.3

Figure 2.3-38—{Potentiometric Surface Map, Cotter-Jefferson City Aquifer, November 2007}