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2017 Uranium Plumes in the San Andres-Glorieta and Alluvial Aquifers at the Bluewater, New Mexico, Disposal Site

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U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

ACL	alternate concentration limit
ARCO	Atlantic Richfield Company
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet
HMC	Homestake Mining Company
MCL	maximum concentration limit
mg/L	milligrams per liter
mi	miles
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NRC	U.S. Nuclear Regulatory Commission
POC	point-of-compliance (wells)
POE	point-of-exposure (wells)
SAG	San Andres-Glorieta (aquifer)

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Executive Summary

This report presents an updated assessment of uranium plumes in groundwater beneath and downgradient of the Bluewater, New Mexico, Disposal Site (Bluewater site or site) in the Grants-Bluewater Valley near Grants, New Mexico. The plumes are the result of remnant contamination from a uranium milling facility that operated on the Bluewater site from 1953 through 1982, leaving uranium in formations underlying former mill structures, particularly the Main Tailings Impoundment (now called the Main Tailings Disposal Cell). The uranium plumes occur in two aquifers: the San Andres-Glorieta bedrock aquifer (SAG aquifer) and the Ancestral Rio San Jose alluvial aquifer (alluvial aquifer).

The U.S. Department of Energy (DOE) has been managing the Bluewater site since 1997 and monitors groundwater quality beneath the site in both the SAG and alluvial aquifers. DOE's previous study of the plumes at the Bluewater site—*Site Status Report: Groundwater Flow and Transport in the Vicinity of the Bluewater, New Mexico, Disposal Site* (herein referred to as the 2014 Site Status Report) (DOE 2014)— provided an update to the groundwater contamination beneath the site and in offsite areas east and southeast of the site. The uranium plumes mapped in 2014 were located approximately 2 mi north of the nearest municipal water supply well in the Grants-Bluewater Valley. Given the plumes' relative stability and distance from groundwater receptors, the 2014 Site Status Report concluded that the Bluewater site-derived uranium plumes in the SAG and alluvial aquifers did not pose public health and safety concerns.

This study relies significantly on both groundwater data collected by DOE at the Bluewater site and groundwater data collected at the Homestake site, owned by the Homestake Mining Company (HMC), another uranium mill that operated on the east side of the Grants-Bluewater Valley from 1958 to 1990. The Homestake site has contributed to contamination in the Grants-Bluewater Valley primarily in the San Mateo Creek alluvial aquifer (which joins with the Ancestral Rio San Jose alluvial aquifer), Chinle aquifers, and localized parts of the SAG aquifer. HMC is conducting active remediation of the San Mateo Creek alluvial aquifer and Chinle aquifer.

History and Context

Mill operations, reclamation, and long-term stewardship activities at the Bluewater site have evolved under multiple site ownerships, regulatory authorities, and even regulatory standards, beginning in 1953 when the Anaconda Copper Company (Anaconda) first constructed and initiated operation of the mill. As early as the late 1950s, Anaconda recognized that seepage from tailings impoundments at the mill site was contaminating underlying aquifers. After purchasing Anaconda in 1977, Atlantic Richfield Company (ARCO) began a series of corrective actions in the early 1980s focused on reclamation of the former mill site and minimizing the groundwater contamination stemming from mill operations. The corrective actions included dewatering the Main Tailings Impoundment to the extent practicable via pumping and wick drains to reduce seepage from the impoundment. Although the dewatering effort was considered successful, no reduction in contaminant concentrations was seen in point-of-compliance (POC) wells immediately downgradient of the impoundment. ARCO also attempted to reduce contaminant levels to background concentrations via pumping of contaminated subsurface water from both aquifers (extracted water was piped to the evaporation ponds). However, the pumping did not reduce contaminant levels in water samples collected from wells in either aquifer.

Because of the unsuccessful groundwater remediation effort, ARCO recommended establishing alternate concentration limits (ACLs) for uranium in POC wells for mill-related contaminants in groundwater that were showing concentrations higher than background concentrations (Applied Hydrology Associates Inc. 1990). In February 1996, the U.S. Nuclear Regulatory Agency (NRC) approved ACLs of 2.15 milligrams per liter (mg/L) for the SAG aquifer for POC wells S(SG) and OBS-3 and 0.44 mg/L for the alluvial aquifer for POC wells T(M) and F(M)) (NRC 1996). Currently, 16(SG) is used as a surrogate to S(SG) and OBS-3. These ACLs were based on a health-based concentration limit of 0.44 mg/L in point-of-exposure (POE) wells for both aquifers at the site's east boundary, which was determined to be as low as reasonably achievable. The POE well for the SAG aquifer is I(SG) and the POE for the alluvial aquifer is X(M). At the time the ACLs were established, the state of New Mexico groundwater standard for uranium was 5 mg/L, a level higher than uranium concentrations measured at onsite monitoring wells at that time. The established ACLs formed the basis for groundwater monitoring and other provisions established in DOE's Long-Term Surveillance Plan for the site (DOE 1997).

In 2004, New Mexico revised their groundwater standard for uranium from 5 mg/L to 0.03 mg/L, consistent with a revised drinking water standard established by the U.S. Environmental Protection Agency in 2000. Observed uranium concentrations in some of the site wells and offsite wells impacted by the site exceed the revised New Mexico groundwater standard and U.S. Environmental Protection Agency drinking water maximum contaminant level (MCL) in both the SAG and the alluvial aquifer.

Hydrostratigraphy

The hydrostratigraphy near the Bluewater site is defined by the main water-bearing units: the San Andres Limestone and the Glorieta Sandstone (which combine to form the SAG aquifer) and the Ancestral Rio San Jose alluvium (alluvial aquifer). Approximately 1 mi to the southeast of the Bluewater site boundary, the Ancestral Rio San Jose alluvial aquifer merges with the San Mateo Creek alluvial aquifer.

San Andres-Glorieta Aquifer

Potentiometric maps were developed to illustrate the general groundwater flow directions in the SAG aquifer based on water level measurements taken in 2012 and 2017. These maps show that groundwater flow in the SAG aquifer is to the east and southeast. Comparison of the 2012 and 2017 potentiometric maps shows the groundwater levels in 2017 were approximately 2 to 4 feet lower across the site.

The SAG aquifer uranium plume maps represent uranium derived from the Bluewater site. The 2013 uranium plume trends in an east and southeast direction. The north and west boundary of the plume occurs within the Bluewater site and the south edge of the plume is relatively well defined using data from non-DOE wells. The extent of the plume is not well defined to the east and northeast due to a lack of wells and concentration data.

Despite some localized changes in uranium concentrations, the extent of the 2017 uranium plume is similar to the 2013 uranium plume. The highest uranium concentrations in 2013 and 2017 were detected in wells 16(SG) and I(SG) directly east and downgradient from the Main Tailings

Disposal Cell. The extent of the uranium plume, as defined by the 0.03 mg/L contour, remained unchanged. This stability reflects the fact that uranium concentrations in SAG wells defining the extent to the north, west, and south remained relatively stable from 2013 to 2017, and no data exist to define the east and northeast areas of the plume.

Alluvial Aquifer

Potentiometric maps developed for the alluvial aquifer show groundwater flow directions in 2012 were similar to flow directions in 2017. Groundwater in the alluvial aquifer (the Ancestral Rio San Jose alluvial aquifer) at the Bluewater site flows east in the area directly south of the Main Tailings Disposal Cell and then southeast near the east boundary of the site. The groundwater flow direction maintains a southeastward direction for about the first mile offsite to the confluence zone of the Ancestral Rio San Jose alluvial aquifer and San Mateo Creek alluvial aquifer and then heads south toward Toltec and Milan.

The 2013 uranium plume in the alluvial aquifer extends southeast from the Bluewater site to approximately 0.7 miles northeast of Toltec.

The 2017 uranium plume in the alluvial aquifer is similar in extent to the 2013 uranium plume. Comparison of the northernmost portions of the 2013 and 2017 uranium plumes in the alluvial aquifer indicate uranium concentrations were lower in 2017 than 2013 in the southeast part of the Bluewater site. Uranium concentrations in 2013 and 2017 in offsite portions of the Ancestral Rio San Jose alluvial aquifer show no definitive signs of decreasing or increasing uranium levels. There are indications of decreasing uranium concentrations in the San Mateo Creek alluvial aquifer which appear to be localized due to HMC's groundwater remediation and do not appear to influence concentrations in the confluence zone of the Ancestral Rio San Jose alluvial aquifer and San Mateo Creek alluvial aquifer.

Conclusions

Despite some localized changes in uranium concentrations, the interpreted extent of the 2017 uranium plume in the SAG aquifer was similar to the 2013 uranium plume. The 2017 uranium plume is located approximately 2 mi north of the nearest drinking water supply well that extracts groundwater from the SAG aquifer to serve the City of Milan. No municipal or permitted domestic water-supply wells are located within the SAG uranium plume. For both the 2013 and 2017 plume maps for uranium in the SAG aquifer, concentrations at the Bluewater site were below the established ACL of 2.15 mg/L for uranium for the SAG aquifer POC well. DOE continues to comply with the NRC-approved health-based standard of 0.44 mg/L at the Bluewater POE well for the SAG aquifer. As such, based on the available 2017 data presented in this report, the SAG uranium plume does not appear to pose public health and safety concerns.

Similar to the uranium plume in the SAG aquifer, the interpreted extent of the 2017 uranium plume in the alluvial aquifer was similar to the 2013 uranium plume. Comparison of the northernmost portions of the 2013 and 2017 uranium plumes in the alluvial aquifer indicate uranium concentrations were lower in 2017 than 2013 in the southeast part of the Bluewater site. For both the 2013 and 2017 plume maps for uranium in the alluvial aquifer, the concentrations at the Bluewater site were below the established ACL of 0.44 mg/L for uranium for the alluvial aquifer point of compliance well. DOE continues to comply with the NRC-approved health-based standard of 0.44 mg/L at the Bluewater POE wells for the alluvial aquifer.

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1.0 Introduction

The U.S. Department of Energy (DOE) monitors groundwater contamination resulting from operations at a former uranium mill site (the mill) between 1953 and 1982 on property now part of the DOE-owned Bluewater, New Mexico, Disposal Site (Bluewater site or site). The site was transitioned to DOE under a U.S. Nuclear Regulatory Commission (NRC) general license in 1997, after NRC accepted site reclamation as complete and terminated its specific license with the former licensee, Atlantic Richfield Company (ARCO). The site is in northwest New Mexico, in Cibola County about 9 miles (mi) northwest of Grants, New Mexico, in the Grants-Bluewater Valley at the base of the Zuni Mountains (Figure 1).

Remnant groundwater contamination from the mill occurs in two aquifers: the San Andres-Glorieta (SAG) aquifer and the Ancestral Rio San Jose alluvial aquifer (alluvial aquifer). DOE's previous study of the contamination at the Bluewater site—*Site Status Report: Groundwater Flow and Transport in the Vicinity of the Bluewater, New Mexico, Disposal Site* (herein referred to as the 2014 Site Status Report) (DOE 2014)—provided an update to the groundwater contamination beneath the site and in offsite areas east and southeast of the site. The uranium plumes mapped in 2014 were located approximately 2 mi north of the nearest municipal water supply well in the Grants-Bluewater Valley. Given the plumes' relative stability and distance from groundwater receptors, the 2014 Site Status Report concluded that the Bluewater site-derived uranium plumes in the SAG and alluvial aquifers did not pose public health and safety concerns.

This report provides an update on the groundwater flow conditions and distribution of uranium in groundwater in the Grants-Bluewater Valley, with particular focus on plumes originating beneath the Bluewater site and extending offsite in the SAG and alluvial aquifers. Specifically, plume maps developed for the 2014 Site Status Report, which represented 2013 conditions, were updated using uranium concentrations measured in 2017. The 2017 maps are compared with the corresponding 2013 maps and concentrations to assess if significant changes in concentrations have occurred. Potentiometric maps of the SAG and alluvial aquifers presented in the 2014 Site Status Report are also updated using groundwater elevations measured in 2017.

In the interest of conducting a comprehensive assessment of uranium plumes in the valley, this study relies significantly on both groundwater data collected by DOE at the Bluewater site and groundwater data collected at another uranium mill, the Homestake site, which operated on the east side of the valley from 1958 to 1990. The Homestake site, owned by the Homestake Mining Company (HMC), lies about 3 mi east-southeast of the Bluewater site and approximately 5 mi north-northeast of the Village of Milan (Figure 1). Milling activities by HMC have contributed uranium and other contaminants to the San Mateo Creek alluvial aquifer, which merges with the Ancestral Rio San Jose alluvial aquifer that carries contaminated groundwater from the Bluewater site. Milling activities by HMC also impacted the Chinle aquifer and localized parts of the SAG aquifer. HMC is conducting active remediation of the San Mateo Creek alluvial aquifer and Chinle aquifer.

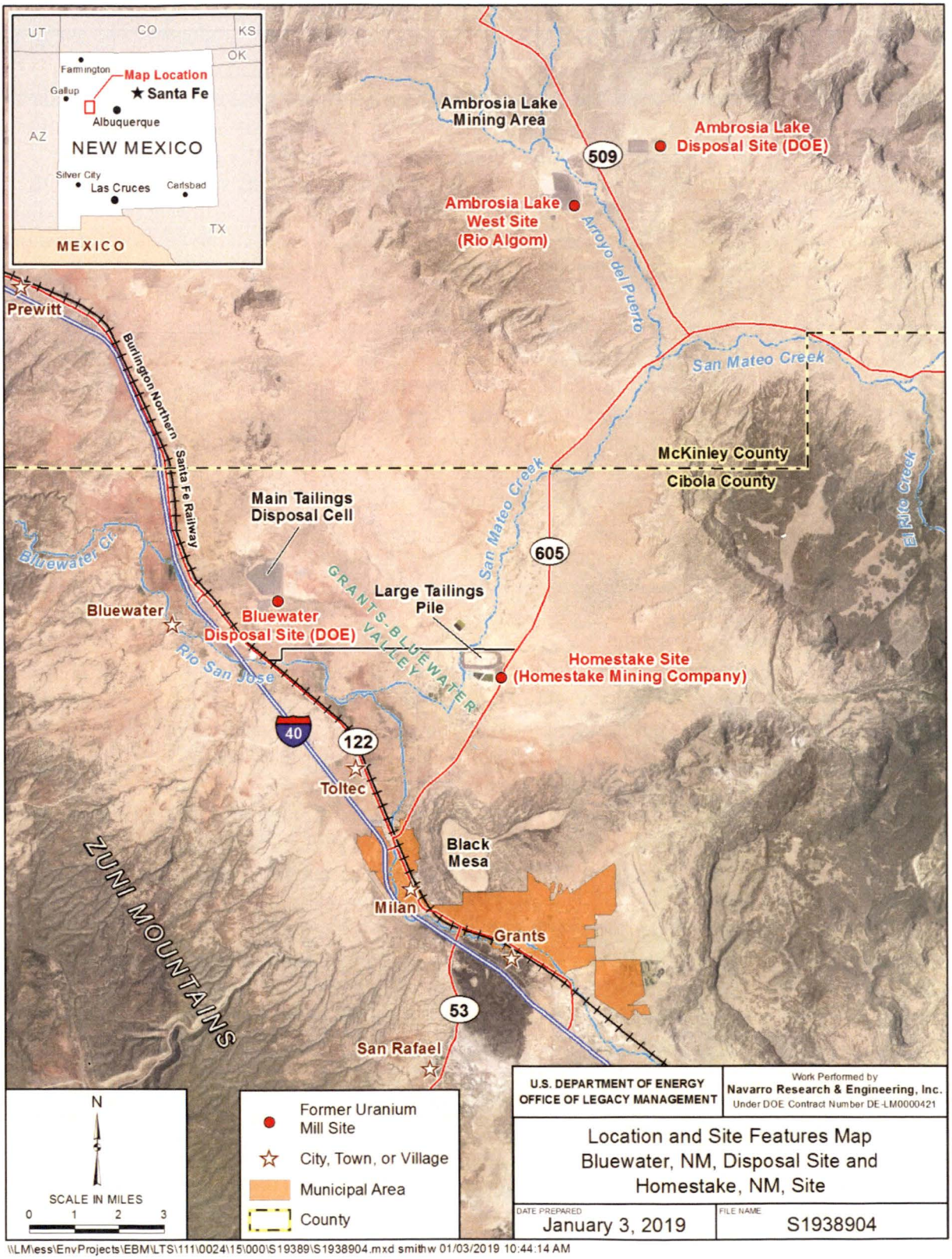

Figure 1. Location Map for the Bluewater Disposal Site and the Homestake Site

1.1 Site Background

The Anaconda Copper Company (Anaconda) first constructed and initiated operation of the mill in 1953. The U.S. Atomic Energy Commission was the first regulator for the site, but regulatory authority was later transferred to the state of New Mexico in 1974. ARCO purchased Anaconda in 1977, and the site was licensed under provisions of Title II of the Uranium Mill Tailings and Radiation Control Act in 1978. Active milling of uranium ore at the site ended in 1982. NRC assumed regulatory responsibilities from New Mexico in 1986 and continues to be the regulator for the Bluewater site. After submitting a decommissioning plan to NRC in 1987, ARCO completed site reclamation activities as approved by NRC in 1995, and the site was transitioned to DOE in 1997.

As early as the late 1950s, Anaconda recognized that seepage from tailings impoundments at the mill site was contaminating underlying aquifers. To reduce the seepage, in 1960 Anaconda began pumping tailings fluid ponded on the Main Tailings Impoundment to a gravity injection well into a formation below the SAG aquifer, the Yeso formation. Starting in 1977, after it was discovered that some of the injected fluids were migrating upward into the SAG, the ponded tailings fluids were pumped to synthetically lined evaporation ponds (Figure 2). ARCO estimated that approximately 5.7 billion gallons of tailings fluid seeped from the Main Tailings Impoundment into the underlying geologic formations before the impoundment was capped in 1995, with the majority of seepage occurring prior to 1960, when deep-well injection commenced (DOE 2014).

In the early 1980s, ARCO began a series of corrective actions focused on reclamation of the former mill site and minimizing the groundwater contamination stemming from mill operations. The corrective actions included dewatering the Main Tailings Impoundment to the extent practicable via pumping and wick drains to reduce seepage from the impoundment. It was estimated that the wick drains reduced the potential seepage volume of tailings fluid by approximately 40 million gallons (Applied Hydrology Associates Inc. 1993). Following the dewatering effort, no reduction in contaminant concentrations was seen in point-of-compliance (POC) wells immediately downgradient of the impoundment. Another remedial measure was attempted by ARCO that included pumping of contaminated subsurface water from both aquifers (extracted water was piped to the evaporation ponds). However, the pumping did not reduce contaminant levels in water samples collected from wells in either aquifer.

Completion of site reclamation included encapsulating the tailings impoundments in place. The Main Tailings Impoundment, an aboveground impoundment surrounded by a clean-fill dike, was modified by regrading (reducing) the side slopes of the dike, capping the tailings with a clay barrier to attenuate radon emissions from the tailings, and protecting the radon barrier and side slopes from erosion with rock riprap. In 1995, construction of the structure, referred to as the Main Tailings Disposal Cell, was completed (Figure 2). A smaller impoundment of tailings from early 1950s milling operations was engineered as the Carbonate Tailings Disposal Cell and is located immediately south of the Main Tailings Disposal Cell.

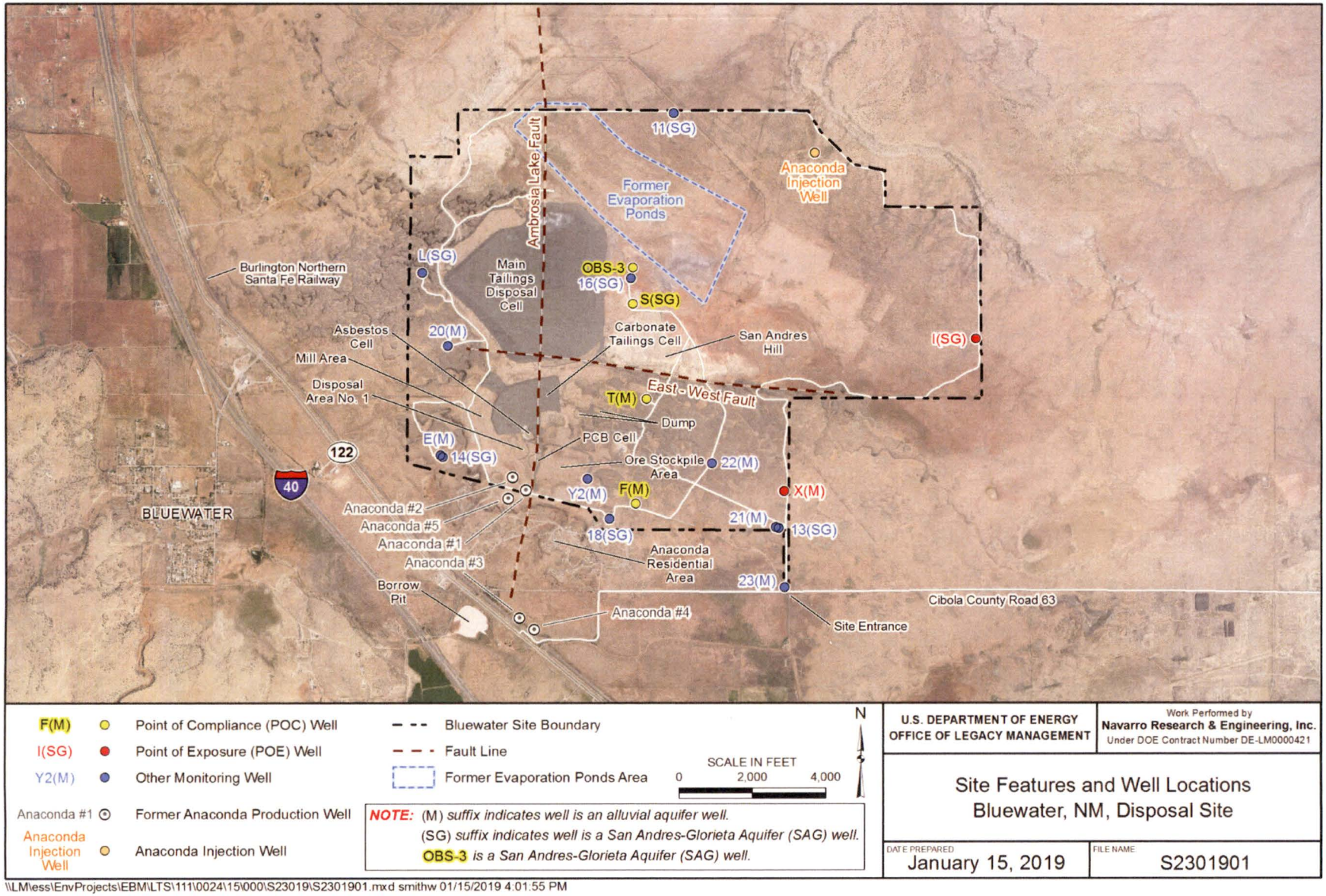

Figure 2. Bluewater Site Features and Well Locations

Because of the unsuccessful groundwater remediation effort, ARCO recommended establishing alternate concentration limits (ACLs) for uranium in POC wells (Figure 2) (Applied Hydrology Associates Inc. 1990). In February 1996, NRC approved ACLs of 2.15 mg/L for the SAG aquifer for POC wells S(SG) and OBS-3 and 0.44 mg/L for the alluvial aquifer for POC wells T(M) and F(M)) (NRC 1996). Currently, 16(SG) is used as a surrogate for SAG POC wells S(SG) and OBS-3. These ACLs were based on a health-based concentration limit in point-of-exposure (POE) wells for both aquifers at the site's east boundary of 0.44 mg/L, which was determined to be as low as reasonably achievable. The POE well for the SAG aquifer is I(SG), and the POE well for the alluvial aquifer is X(M). At the time the ACLs were established, the State of New Mexico groundwater standard for uranium was 5 mg/L, higher than uranium concentrations measured at onsite monitoring wells at that time. The established ACLs formed the basis for groundwater monitoring and other provisions established in DOE's Long-Term Surveillance Plan for the site (DOE 1997).

In 2004, New Mexico revised their groundwater standard for uranium from 5 mg/L to 0.03 mg/L, consistent with a revised drinking-water standard established by U.S. Environmental Protection Agency (EPA) in 2000. Observed uranium concentrations in some of the site wells and offsite wells impacted by the site exceed the revised standard in both the SAG and the alluvial aquifer.

1.2 Geology

The geologic formations relevant to this study underlying the Bluewater site range in age from Lower Permian-era (oldest in age), to the Upper Triassic era, to the Quaternary era (youngest in age). The Lower Permian-era deposits include the Yeso Formation, the Glorieta Sandstone and the San Andres Limestone, the Upper Triassic-era deposits include the Chinle Formation, and the Quaternary-era deposits include the Ancestral Rio San Jose alluvium, the Bluewater Basalt flow, and the surficial alluvium.

The structural geology of the Bluewater site is complex and is highlighted by the structural dip to the northeast and two main faults, the Ambrosia Lake Fault and the East-West Fault. Figure 3 presents a geologic map of the site, showing locations of the two faults and two cross sections (A-A′ and B-B′), detailed in Figure 4 and Figure 5, respectively. Cross section A-A′, extending from the Main Tailings Disposal Cell east to the site boundary, shows the offset from the Ambrosia Lake Fault, the structural dip to the northeast, and the general stratigraphic sequence in the northeast area of the site. Cross section B-B′, extending from the Main Tailings Disposal Cell to the southeast corner of the site boundary, shows the offset from both the East-West and Ambrosia Lake faults and the general stratigraphic sequence below the Bluewater Basalt in the southeast area of the site. The structural geology is discussed in more detail in the Site Status Report (DOE 2014).

1.3 Hydrostratigraphy

The main water bearing units near the Bluewater site are the San Andres Limestone and the Glorieta Sandstone which combine to form the San Andres-Glorieta (SAG) aquifer and the Ancestral Rio San Jose alluvium (alluvial aquifer). The Yeso Formation underlies the SAG aquifer and is a relatively less permeable unit compared to the overlying SAG aquifer (Hydro-Search 1977). The Chinle Formation above the SAG aquifer is considered a confining unit at the Bluewater site, although it contains three separate aquifers at the Homestake site. Both the

Bluewater Basalt and surficial alluvium deposits are above the shallowest regionally connected groundwater.

The Yeso Formation underlies the SAG aquifer. The Yeso comprises fine-grained sandstone and fine-grained clayey sandstone and siltstone with limestone beds (DOE 2014). An interval of low permeable siltstone, anhydrite, and gypsum in the upper part of the Yeso Formation separates the lower Yeso Formation from the SAG aquifer at the Bluewater site (West 1972). Overall, the Yeso Formation is relatively impermeable compared to the SAG aquifer.

The SAG aquifer is the most productive aquifer in the study area and the primary water source for municipal, commercial, irrigation, domestic, and livestock uses. The two formations—the San Andres Limestone and the Glorieta Sandstone—are treated as one aquifer, partly because the contact between them is gradational and difficult to identify, but also because there is good hydraulic connection between the formations (White and Kelly 1989). The San Andres Limestone is typically a mixture of limestone and fractured limy sandstone, and the Glorieta Sandstone comprises a fine to medium grained sandstone (DOE 2014). At the Bluewater site, the SAG aquifer is the uppermost aquifer in the area east of the Ambrosia Lake Fault and north of the East-West Fault (Figure 4). However, the SAG aquifer is approximately 100–300 ft below the base of the alluvial aquifer in the area west of the Ambrosia Lake Fault and south of the East-West Fault (Figure 5). In the Grants-Bluewater Valley, the thickness of the SAG is about 200–250 ft. Groundwater moves through the SAG aquifer through both the bedrock matrix and through well connected fractures, solution cavities, solution channels, and cavernous zones where the limestone has dissolved and has a general groundwater flow direction toward the east-southeast (White and Kelly 1989; DOE 2014).

The Chinle Formation is less permeable than the underlying SAG aquifer and overlying alluvial aquifer and generally regarded as an aquitard between the two aquifers at Bluewater site. The Chinle Formation consists of mudstones, siltstones, and low-permeability, fine-grained sandstones. Due to faulting and erosion, the Chinle Formation is absent in an area directly beneath the eastern half of the Main Tailings Disposal Cell to approximately 0.25 mi to the east of the disposal cell (Figure 4). In the areas where the Chinle Formation overlies the SAG aquifer, the formation acts as a confining layer (DOE 2014). Despite the Chinle Formation being regarded as an aquitard at the Bluewater site, the Chinle has three fine-grained sandstone units that are regarded as aquifers beneath the Homestake site. From youngest to oldest, these intervals are referred to as the Upper Chinle, Middle Chinle, and Lower Chinle aquifers (HMC 2018a). The Chinle aquifers present beneath the Homestake site have not been found beneath the Bluewater site.

The Ancestral Rio San Jose alluvial aquifer overlies the Chinle Formation and is the uppermost aquifer beneath the Main Tailings Disposal Cell. The Ancestral Rio San Jose alluvial aquifer is present in the region west of the Ambrosia Lake Fault and south of the East-West Fault at the Bluewater site (Figure 5). The Ancestral Rio San Jose alluvium was deposited by streams and consists of coarse sands and gravels (associated with high-energy deposits along paleochannels of the river) to fine-grained sands, silts, and clays (associated with non-channel, overbank deposits) (DOE 2014). Based on site monitoring well logs, the thickness of the Ancestral Rio San Jose alluvium beneath the Bluewater site is limited, ranging from approximately 5–25 feet (ft). The aerial extent of the Ancestral Rio San Jose alluvial aquifer is defined by the presence of Bluewater Basalt, which originated as lava flowing downgradient within the river valley. The

Bluewater Basalt flow extends from approximately 4 mi north of the Bluewater site, south and southeast, through the ancestral valley of the Rio San Jose to Toltec. Approximately 100–120 ft of Bluewater Basalt covers the Ancestral Rio San Jose alluvium at the Bluewater site (Figure 5).

Under current conditions, the top of the saturated zone in the alluvial aquifer is beneath the base of the basalt, resulting in unconfined, or water-table, flow conditions. The general groundwater flow direction in the alluvial aquifer is to the southeast (DOE 2014). At the base of the alluvial aquifer, a paleochannel exists where the former channel of the Ancestral Rio San Jose (Ancestral Rio San Jose paleochannel) incised into the top of the Chinle Formation. The approximate extent of the Ancestral Rio San Jose paleochannel and location of the present Rio San Jose channel is shown on Figure 6. Most of the groundwater within the Ancestral Rio San Jose alluvial aquifer occurs within the paleochannel.

Approximately 1 mi to the southeast of the Bluewater site boundary and 2 mi west and southwest of the Homestake site (Figure 6), the Ancestral Rio San Jose alluvial aquifer merges with the San Mateo Creek alluvial aquifer. Similar to the Ancestral Rio San Jose paleochannel, a paloechannel cuts into the bedrock formations at the base of the San Mateo Creek alluvial aquifer at the Homestake site (the San Mateo Creek paleochannel) (Figure 6). For discussion purposes, this area where the flows from the two aquifers merge is referred to as the paleochannel confluence zone. Most alluvial sediments in the San Mateo Creek paleochannel are similar to those in the Ancestral Rio San Jose paleochannel.

1.4 Sources of Uranium

As discussed in the 2014 Site Status Report, the primary source of uranium in groundwater at the Bluewater site is considered to be solid-phase uranium in the aquifers and faults beneath the Main Tailings Disposal Cell (DOE 2014). The solid phase uranium is residual uranium from the former mill operations and consists of precipitated compounds in mineralized zones formed when acidic tailings fluids seeping downward from the main tailings impoundment were neutralized, causing contaminants to precipitate and adsorb to geologic materials underlying the disposal cell (basalt, alluvium, limestone, and sandstone) and fault zones under the impoundments (DOE 2014). The solid phase uranium is probably mobilized by fresh inflowing groundwater that dissolves precipitated compounds from the mineralized zones. It is also likely that some of the dissolved uranium in groundwater beneath the Bluewater site originates from the desorption of uranium attached to the surfaces of impacted aquifer media (sedimentary grains and minerals) and aqueous-phase contamination that continues to reside in low permeability materials in the aquifers, and is slowly being released to more-permeable media (DOE 2014).

The 2014 Site Status Report also investigated the possibility that uranium in groundwater at the Bluewater site is partly the result of gradual or pulsed seepage of tailings fluids from the Main Tailings Disposal Cell. It is estimated that seepage from the tailings could be occurring at a rate of approximately 30–70 gallons per minute because the tailings were not fully dewatered before the impoundment was capped and due to continued infiltration of precipitation through the radon barrier (DOE 2014).

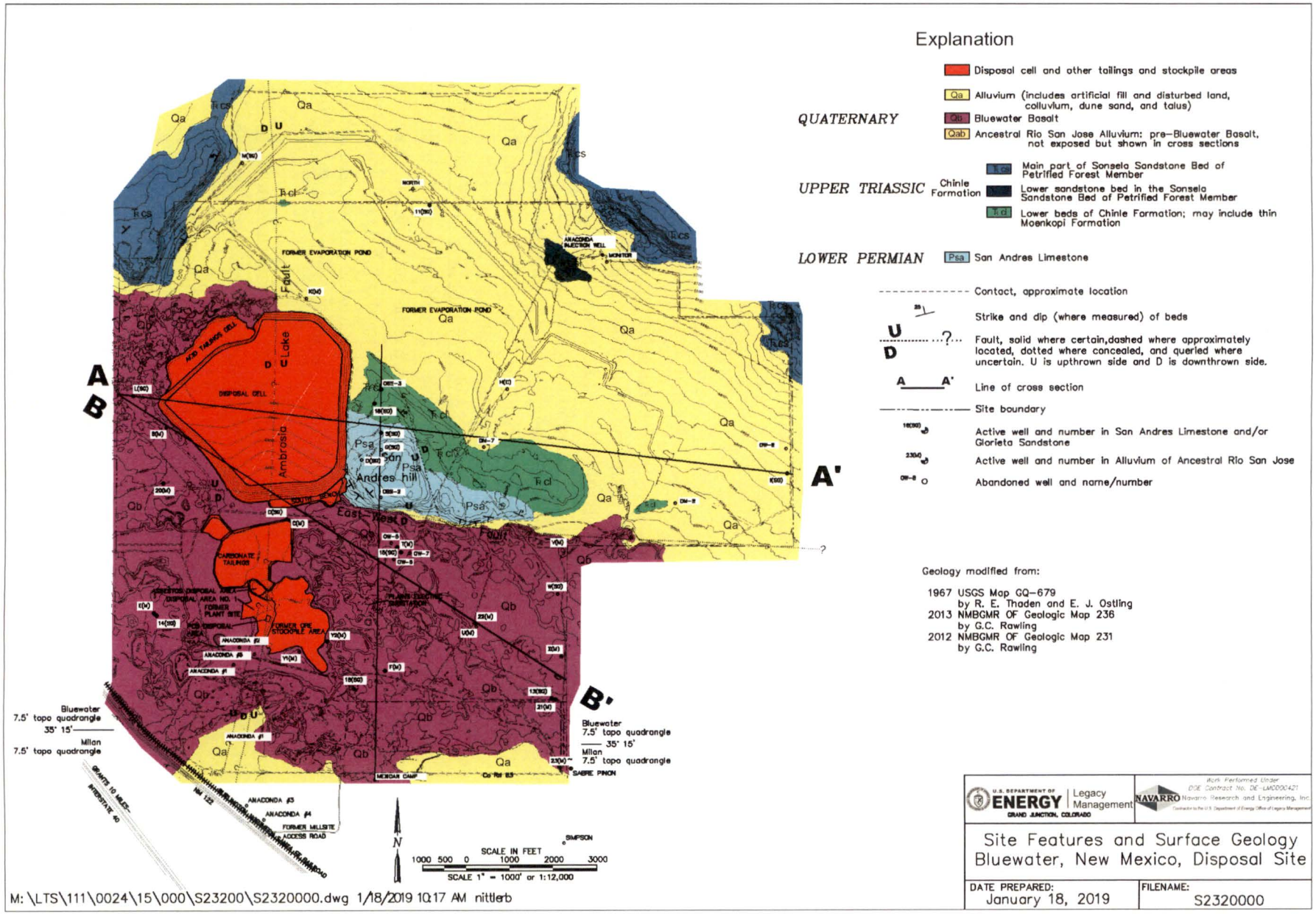

Figure 3. Bluewater Site Features and Surface Geology

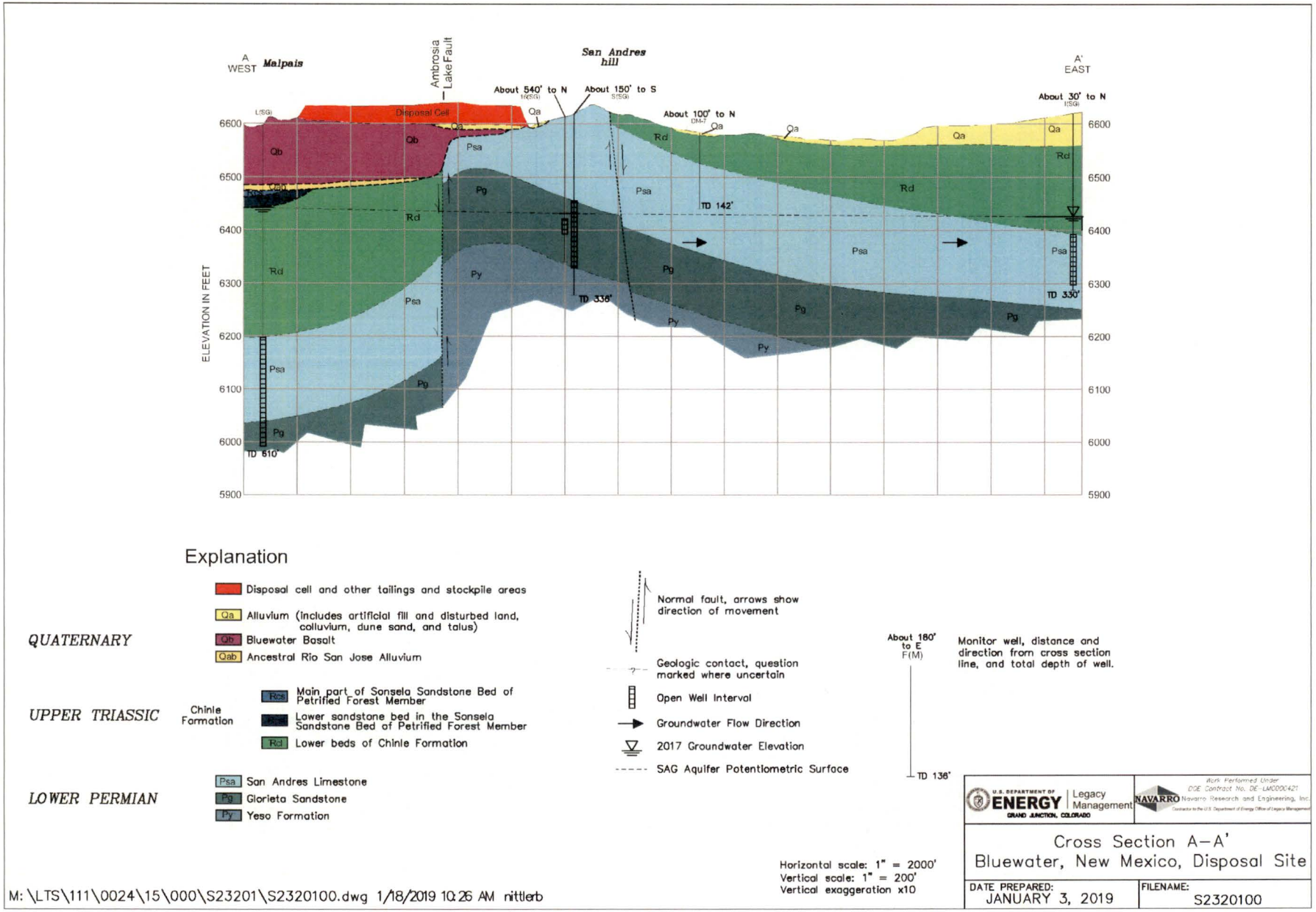

Figure 4. Hydrogeologic Cross-Section A-A'

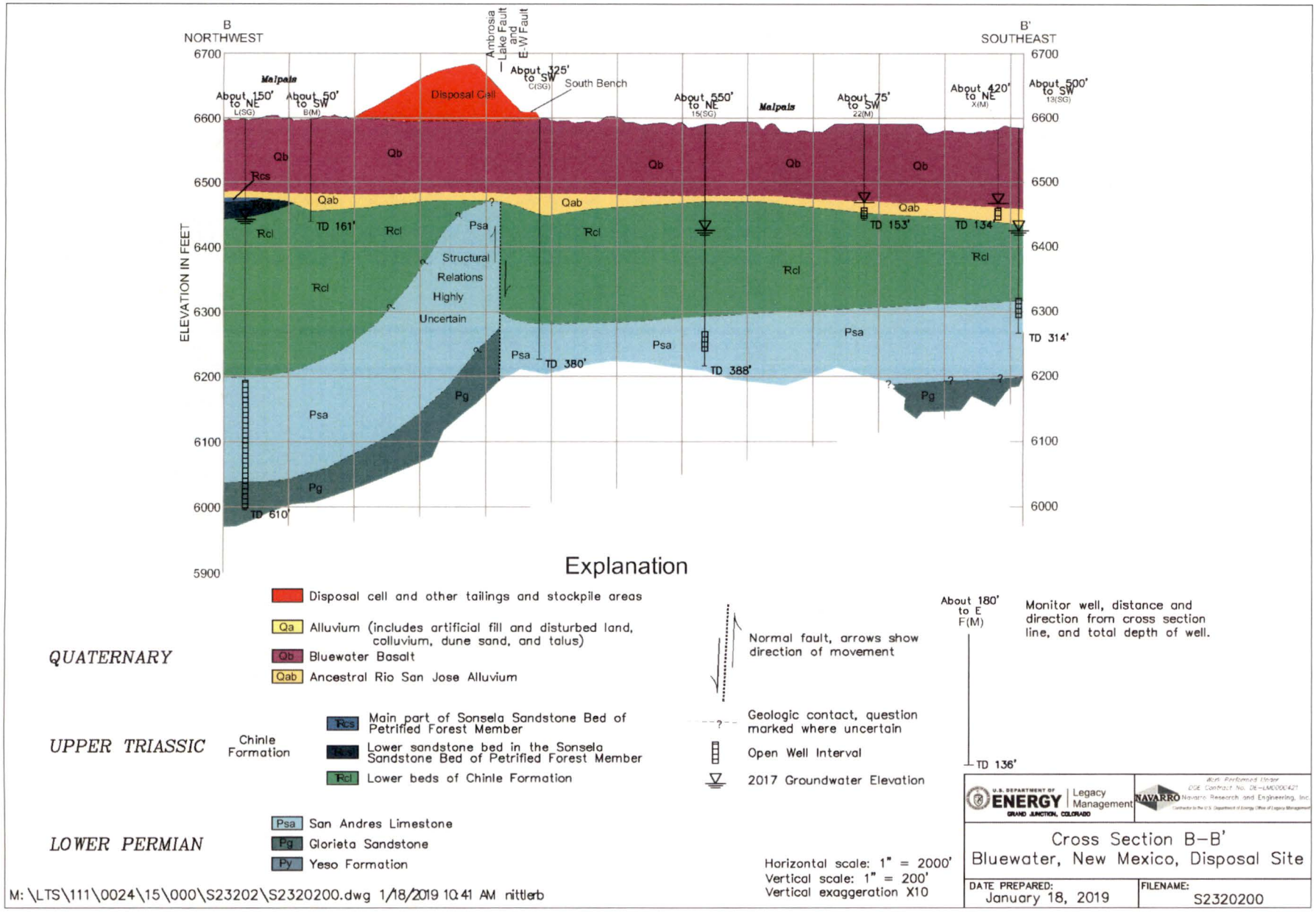

Figure 5. Hydrogeologic Cross-Section B-B'

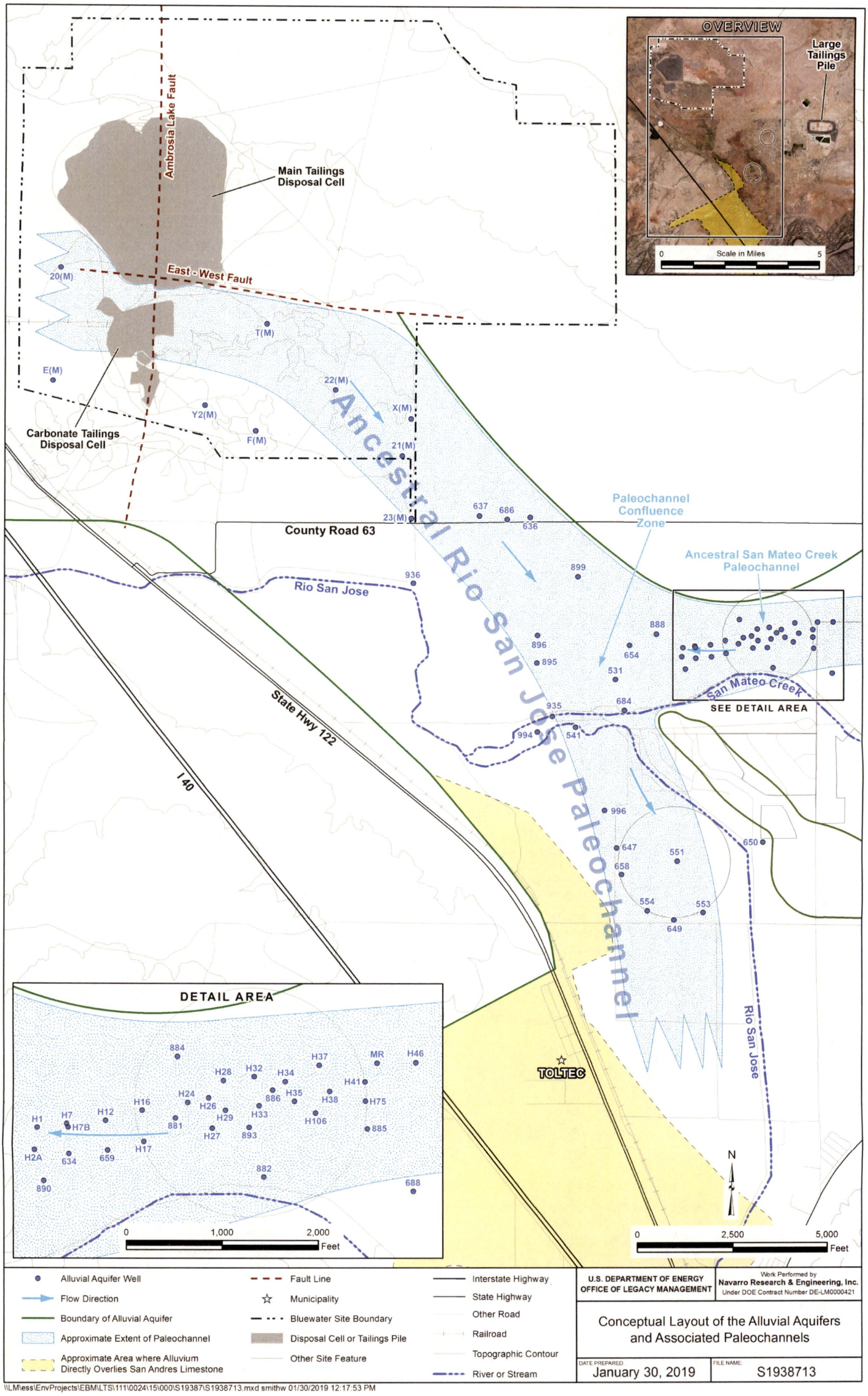

Figure 6. Conceptual Layout of the Alluvial Aquifers and Associated Paleochannels

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2.0 San Andres-Glorieta Aquifer

This section presents potentiometric maps of the SAG aquifer in 2012 and 2017 and the 2013 and 2017 plume maps for uranium in the SAG aquifer. As presented in the 2014 Site Status Report, the 2012 potentiometric map was developed using groundwater elevation data from DOE and HMC. The 2017 potentiometric map was developed using only DOE data. Sources used to delineate the 2013 and 2017 plumes include DOE, HMC, and the New Mexico Environment Department (NMED). Because of the inconsistency in nomenclature and (at times) well location and construction information, DOE developed a crosswalk of SAG wells within the Grants-Bluewater Valley study region. This crosswalk, detailed in Appendix A, Table A-1, provides well aliases (e.g., NMED well IDs and New Mexico Office of the State Engineer [NMOSE] permit numbers), geographic coordinates, well construction data (where available), and other information for SAG wells addressed in this section, as well as larger set of SAG wells within the study region. There are currently ten SAG aquifer wells owned by DOE on the Bluewater site identified by the suffix "SG" with the exception of OBS-3. Most remaining wells are identified using HMC's nomenclature (Figures A-1 and A-2).

2.1 2012 and 2017 San Andres-Glorieta Aquifer Potentiometric Surfaces

Potentiometric maps were developed to illustrate general groundwater flow directions in the SAG aquifer in 2012 and 2017; similar periods for which the 2013 and 2017 SAG aquifer plume maps were developed.

Figure 7 presents a map of the SAG aquifer potentiometric surface based on groundwater level measurements taken in the fall of 2012, as derived from a similar map prepared for the 2014 Site Status Report. This figure illustrates there is a predominant groundwater-flow direction to the east-southeast in the SAG aquifer and illustrates the effects of two key faults on hydraulic heads at the Bluewater site. The most noticeable impact is observed along the East-West Fault, west of the Ambrosia Lake Fault (Figure 7), where heads north of the East-West Fault are as much as 14 ft higher than corresponding heads south of the fault. In the east area of the Bluewater site, near well I(SG), the heads north of the East-West Fault are approximately 2–3 ft higher than the corresponding heads on the south side of the fault. This head difference could reflect the East-West Fault's capacity to act as a partial barrier to groundwater flow in the SAG (DOE 2014). In contrast, the Ambrosia Lake Fault, trending south to north beneath the Main Tailings Disposal Cell, appears less of a barrier to groundwater flow. However, the groundwater contours across the Ambrosia Lake Fault show a steeper horizontal gradient occurs north of the East-West Fault relative to the gradient south of the East-West Fault. The steeper horizontal gradient across the Ambrosia Lake Fault coincides with the region where approximately 300 ft of vertical offset between the SAG occurs (shown in Figure 4).

Groundwater level measurements southeast of the Bluewater site (in the region of the Homestake site) are often collected in or near pumping wells and are therefore less reliable. A lack of reliable groundwater level measurements and good spatial distribution of reliable water levels make it difficult to interpret potentiometric contours and flow directions in this area.

Figure 8 presents the 2017 potentiometric map of the SAG aquifer at the Bluewater site. Groundwater levels used to develop this figure were primarily collected in December 2017, during the non-irrigation season. Groundwater flow directions in the SAG aquifer in 2017 are

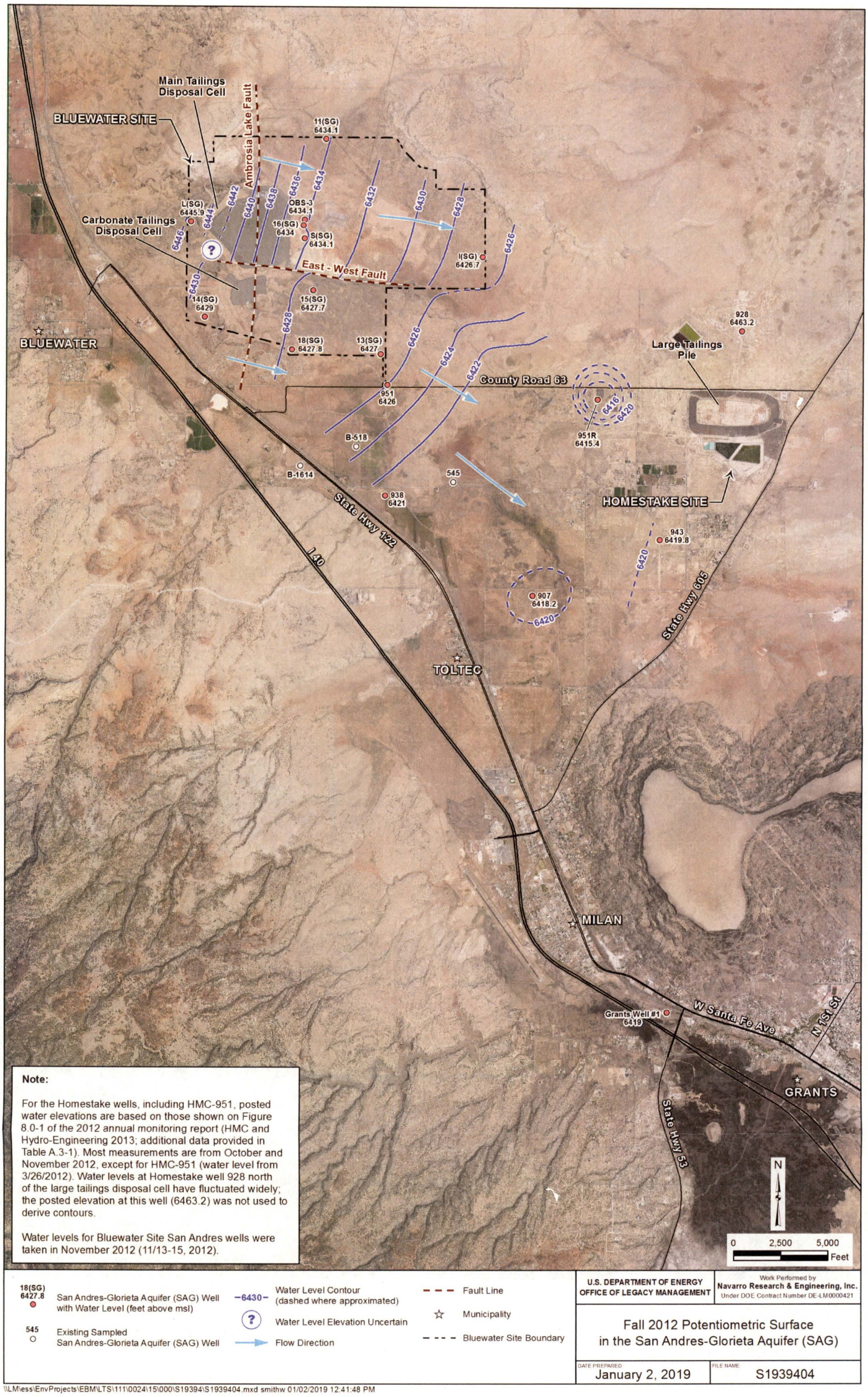
similar to the flow directions in 2012 (east-southeast direction). Comparison of the two potentiometric surfaces shows that the groundwater levels in 2017 were approximately 2–4 ft lower across the site (relative to those in 2012). The horizontal gradient (from west to east) was also less steep across the Bluewater site in 2017, particularly in the area south of the East-West Fault between wells 14(SG) and 13(SG). Groundwater levels measured and reported by HMC in their 2017 Annual Monitoring Report/Performance Review (HMC and Hydro-Engineering 2018a) were not used to develop the 2017 SAG potentiometric surface because of the aforementioned pumping (drawdown) influences. The SAG aquifer experiences significant groundwater withdrawals in this region, corresponding changes in groundwater elevations can occur over relatively short periods of time. However, HMC reports groundwater flow during 2017 in the SAG aquifer at the Homestake site was to the east-southeast (HMC and Hydro-Engineering 2018a), consistent with DOE's characterizations.

2.2 2013 San Andres-Glorieta Aquifer Uranium Plume

Figure 9 presents the 2013 plume map for uranium in the SAG aquifer, as derived from a similar map prepared for the 2014 Site Status. The uranium plume represents the estimated extent of groundwater with uranium concentrations exceeding the 0.03 mg/L EPA drinking water standard and New Mexico groundwater standard. The 2013 uranium plume was developed based on concentrations measured between December 2007 and 2013, with a majority of the concentration data collected in 2013. Data collected prior to 2013 were used to help delineate the full extent and provide resolution in areas where 2013 data were not collected. Table 1 provides a listing of the wells and the uranium concentrations used to prepare Figure 9, as well as other information including alternate well IDs (aliases), well installation and construction details, data sources, and sample collection dates.

As discussed in the 2014 Site Status Report, the 2013 uranium plume originates in a 2-mi-wide zone encompassing the area under the Main Tailings Disposal Cell and along the Ambrosia Lake Fault. The plume extends in an east and southeast direction at least 3.5 mi beyond the site boundary. The plume map shows the highest uranium concentrations were detected at well 16(SG) (1.4 mg/L) and well I(SG) (0.334 mg/L) located directly east and hydraulically downgradient from the Main Tailings Disposal Cell. The uranium concentration in 16(SG), the surrogate POC well, is below the established ACL of 2.15 mg/L, while the uranium concentration in I(SG), the POE well, is below the site-specific health-based concentration limit of 0.44 mg/L. The north and west boundary of the plume occurs within the Bluewater site and the south edge of the plume is relatively well defined using data from non-DOE wells. The extent of the plume is not well defined to the east and northeast due to a lack of wells and concentration data. As a result, concentration contours were not used to depict the leading edge of the plume in this region. Non-DOE wells within the plume boundary include B-3, 951, 951R, and 928. Well B-3 is a former ARCO production well that is privately owned and permitted for industrial use. Well 951 was used by HMC for fresh water for remediation activities from 1999 through 2012 and has been replaced by well 951R. Well 951 is currently used as a monitoring well as was well 928.

Well data used to develop the 2013 plume presented in this report is consistent with the data used to develop the 2013 plume presented in the 2014 Site Status Report with the exception data from wells 928, 986, and 943. Well 928 is a former irrigation well that was historically used to monitor the uranium plume in the SAG aquifer east of the site. This well, well 928, was abandoned in 2017 after well integrity testing revealed the well had become influenced by the Middle Chinle aquifer (Hydro-Engineering 2015).



Note:

For the Homestake wells, including HMC-951, posted water elevations are based on those shown on Figure 8.0-1 of the 2012 annual monitoring report (HMC and Hydro-Engineering 2013; additional data provided in Table A.3-1). Most measurements are from October and November 2012, except for HMC-951 (water level from 3/26/2012). Water levels at Homestake well 928 north of the large tailings disposal cell have fluctuated widely; the posted elevation at this well (6463.2) was not used to derive contours.

Water levels for Bluewater Site San Andres wells were taken in November 2012 (11/13-15, 2012).

18(SG) 6427.8 — San Andres-Glorieta Aquifer (SAG) Well with Water Level (feet above msl)

545 — Existing Sampled San Andres-Glorieta Aquifer (SAG) Well

−6430− Water Level Contour (dashed where approximated)

? Water Level Elevation Uncertain

Flow Direction

Fault Line

Municipality

Bluewater Site Boundary

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421

Fall 2012 Potentiometric Surface in the San Andres-Glorieta Aquifer (SAG)

DATE PREPARED: January 2, 2019

FILE NAME: S1939404

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Figure 7. Potentiometric Surface in the San Andres-Glorieta Aquifer (SAG) in 2012

Figure 8. Potentiometric Surface in the San Andres-Glorieta Aquifer (SAG) in 2017

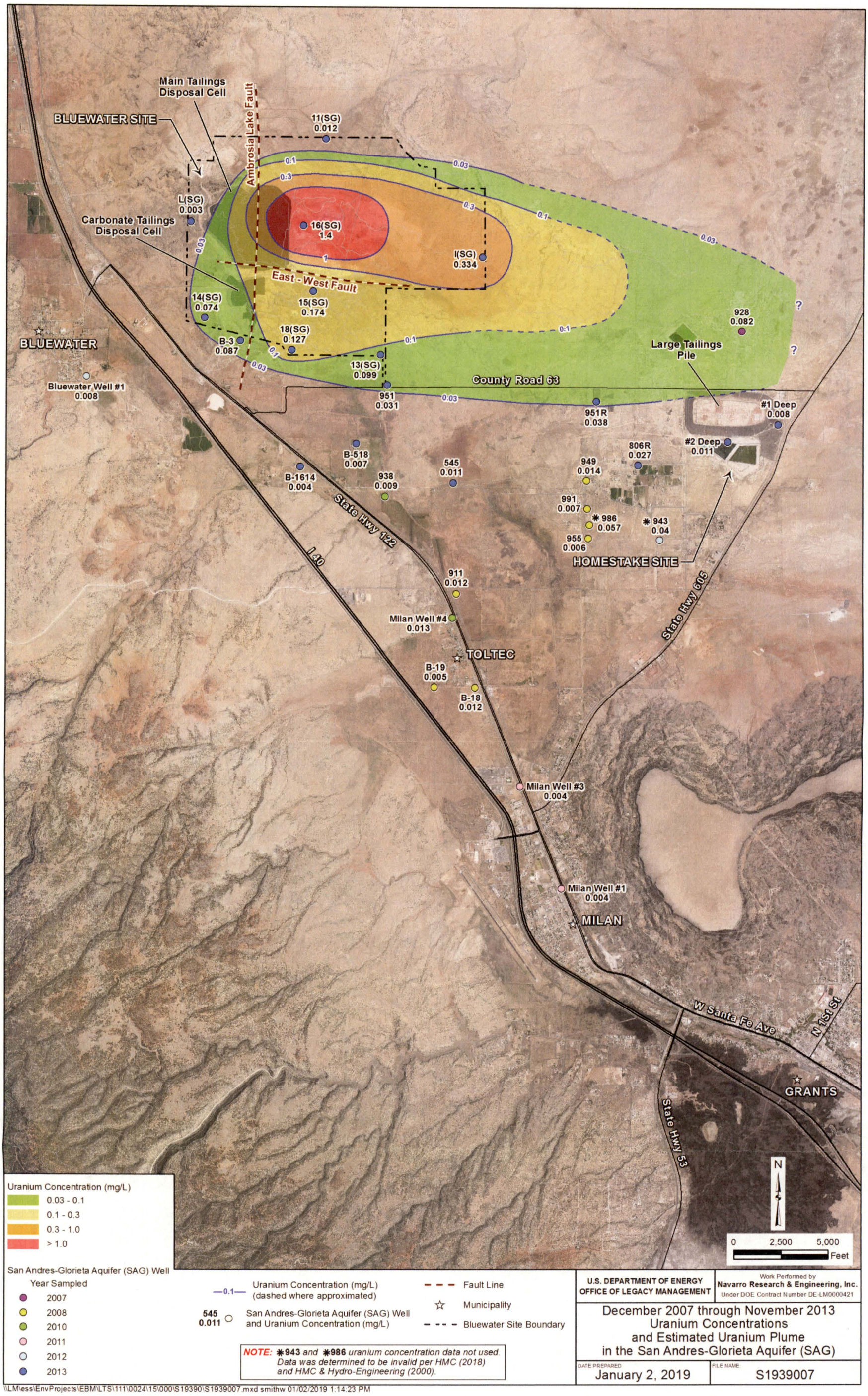

Figure 9. The 2013 Uranium Plume Map for the San Andres-Glorieta Aquifer (SAG) Based on Water Samples Collected Between December 2007 and 2013

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Table 1. SAG Wells Used to Develop the 2013 and 2017 Uranium Plume Maps, Well Information, and Corresponding Measured Concentrations

Well ID	Well ID Aliases[a]	X	Y	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs)	2013 Data Source[b]	2013 Sample Date	2013 Uranium (mg/L)	2017 Data Source[b]	2017 Sample Date	2017 Uranium (mg/L)	Change in Concentration (mg/L)[c]
DOE Wells													
11(SG)	--	469875	1558335	7/14/2012	306	265–295	DOE	11/19/2013	0.012	DOE	11/15/2017	0.010	−0.002
13(SG)	--	472766	1546949	6/27/2012	314	270–300	DOE	11/19/2013	0.099	DOE	11/16/2017	0.104	0.005
14(SG)	--	463599	1548886	7/11/2012	335	285–315	DOE	11/19/2013	0.074	DOE	11/14/2017	0.088	0.014
15(SG)	--	469224	1550341	6/18/2012	388	341–371	DOE	11/19/2013	0.174	DOE	11/16/2017	0.044	−0.13
16(SG)	--	468715	1553799	6/14/2012	235	195–225	DOE	11/19/2013	1.4	DOE	11/14/2017	1.09	−0.31
18(SG)	--	468136	1547203	6/7/2012	305	260–290	DOE	11/19/2013	0.127	DOE	11/15/2017	0.228	0.101
I(SG)	BW-28	478106	1552131	7/31/1979	330	Open hole	DOE	11/19/2013	0.334	DOE	11/16/2017	0.29	−0.044
L(SG)	BW-25	463035	1553955	1/18/1981	610	Open hole	DOE	11/19/2013	0.003	DOE	11/14/2017	0.003	no change
Wells Recently Sampled by HMC or NMED													
#1 Deep	#1 Deepwell, BW-29	493633	1543307	1/1/1979	1000	919–999	HMC	11/5/2013	0.008	HMC	Not used[d]	--	--
#2 Deep	#2 Deepwell, BW-30	490972	1542424	--	870	--	HMC	11/4/2013	0.011	HMC	Not used[d]	--	--
545	B00050A, B-50A, BSAG-8, BW-20	476604	1540223	4/3/1998	330	Open hole	DOE	10/1/2013	0.011	NMED	7/25/2017	0.011	no change
806R	B-5R (POD2), BSAG-15, LSM-46	486264	1541177	--	600	Open hole	HMC	10/18/2011	0.027	NMED	7/26/2017	0.017	−0.01
928	BW-32	491700	1548250	--	864	804–865	HMC	12/03/2007	0.082	HMC	12/03/2007	0.082	--
938	B-196, BSAG-4, BW-06	473140	1539621	--	253	--	HMC	9/14/2010	0.009	NMED	7/28/2017	0.008	−0.001
943 (abandoned Jul-2018)	BW-33	487407	1537222	1/9/1980	978	703–978	HMC	11/30/2012	0.040	HMC	Not used[d]	--	--
951	HMC-951, BW-34, SMC-01, Sabre Pinon	473124	1545336	2/1/1957	275	241–275	DOE	11/20/2013	0.031	DOE	11/15/2017	0.031	no change
951R	--	484100	1544500	4/20/2012	525	Open hole	HMC	3/6/2013	0.038	HMC	10/23/2017	0.037	−0.001
B-518	B-518, BSAG-7, BW-19	471504	1542278	6/26/2006	250	210-250	DOE	8/14/2013	0.007	NMED (BSAG-7)	7/27/2017	0.004	−0.003
Municipal Wells													
Milan Well #1	B-23, BSAG-16, LSM-43, 532 (HMC)	482345	1518855	6/5/1969 (repaired Nov-1971)	214[f]	--	NMDWB HMC	5/26/2011 3/20/2013	0.004 0.005	NMED	7/26/2017	0.004	no change
Milan Well #3	B-35, BSAG-10, LSM-44, 999 (HMC)	480145	1524202	--	180	--	NMDWB HMC	9/15/2011 3/20/13	0.004 0.0043	NMED	7/26/2017	0.004	no change
Milan Well #4 (Golden Acres)	B-50, BSAG-6, BW-16, 998 (HMC)	476615	1533105	1/1/1955	175[d]	--	NMDWB	5/26/2010	0.013	NMED	7/27/2017	0.012	−0.001
Grants Well #1	B-38, BSAG-11	487603	1512372	8/2/1960	300	--	--	No data	--	NMED	7/26/2017	0.005	--
Grants Well #3	B-40, BSAG-12	486764	1514640	9/30/1976	367[d]	--	--	No data	--	NMED	7/26/2017	0.005	--

Table 1. SAG Wells Used to Develop the 2013 and 2017 Uranium Plume Maps, Well Information, and Corresponding Measured Concentrations (continued)

Well ID	Well ID Aliases[a]	X	Y	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs)	2013 Data Source[b]	2013 Sample Date	2013 Uranium (mg/L)	2017 Data Source[b]	2017 Sample Date	2017 Uranium (mg/L)	Change in Concentration (mg/L)[c]
Remaining Wells with No Recent Data (results used in 2013 plume map only)													
911	B-49, BSAG-5, BW-15	476553	1534596	4/26/1957	188	--	NMED	8/25/2008	0.012	--	--	--	--
949	B-44, BW-23	483600	1540350	2/19/1950 (repaired 7/15/1984)	542–551[f]	505–551[f]	NMED	8/25/2008	0.014	--	No data since Aug-2008	--	--
955	BSAG-1, BW-02	483699	1537338	3/31/1978	498	385–498	NMED	8/25/2008	0.006	--	No data since Aug-2008	--	--
986	B-700, BSAG-2, BW-03	483690	1537894	4/1/1988	467	420–467	HMC	11/13/2008	0.057	--	Not used[d]	--	--
991	BSAG-3, BW-04	483630	1538873	--	500	--	NMED	8/27/2008	0.007	--	No data since Aug-2008	--	--
B-3 (Anaconda #1)	B-3-0 EXPL	465450	1547681	7/23/1979	511	--	DOE	8/13/2013	0.087	--	No data since Aug-2013	--	--
B-18	B-18, BW-21	477799	1529435	2/1/1957	275	--	NMED	8/25/2008	0.012	--	No data since Aug-2008	--	--
B-19	B-18 (POD B-19), BW-22	475656	1529454	2/1/1957	275	--	NMED	8/25/2008	0.005	--	No data since Aug-2008	--	--
B-1614	B-1614	468585	1541060	9/21/2004	185	165–185[f]	DOE	10/2/2013	0.004	--	No data since Oct-2013	--	--
Bluewater Well #1	B-1662 (B01662), BW-09	457395	1545737	12/31/1948	345	--	NMDWB	5/1/2012	0.008	--	No data since May-2012	--	--

Abbreviations:
-- = not known or not reported
bgs = feet below ground surface
NMDWB = New Mexico Drinking Water Branch, "Drinking Water Watch"
POD = Point of Diversion

Notes:
Geographic coordinates (X and Y) are provided in North American Datum of 1927 (NAD27_SP_NM_W_FT).
[a] Only the primary well aliases—those designated by NMED (BSAG-, BW-, LSM-, or SMC- prefix), HMC, or the NMOSE (permit numbers with a "B" prefix)—are listed above. BW- and SMC- were used for NMED's 2008 sampling, while BSAG- and LSM- have been used for more recent (2014–2017) sampling efforts.
[b] Data source denotes the source of the reported uranium concentration result. Some wells, with multiple aliases, have been sampled by several different agencies or entities over the years.
[c] Change in Concentration denotes difference between 2017 uranium concentration and 2008–2013 concentration. Blue-shaded cells denote wells where concentrations in 2017 are greater than concentrations detected in 2013.
[d] Recent results from several wells historically sampled by HMC—#1 Deepwell, #2 Deepwell, 943, and 986—are no longer used, as the wells are compromised or degraded and therefore no longer representative of SAG aquifer water quality.
[e] Abandonment of well 928 began in late 2017 following well integrity testing indicated the well water was influenced by leakage from the Middle Chinle Aquifer (Hydro-Engineering 2015).
[f] Reported well or screen depths are uncertain as they vary depending on agency or source.

Evaluation of groundwater elevations and corresponding uranium concentrations indicate that the integrity of well 928 may have been first compromised in 2008. As shown in Figure 10, groundwater elevation hydrographs of SAG wells 928, 907, and 938 (locations shown on Figure 7 and Figure A-1) during non-irrigation months are similar until the middle of 2008. In 2008, groundwater levels at well 928 began to trend upward while groundwater levels at wells 907 and 938 continued trending downward, marking the likely time at which water levels in the well began reflecting groundwater elevations in the overlying Middle Chinle aquifer. As shown in Figure 11, uranium concentrations at well 928 decreased from 0.082 to 0.04 mg/L between December 2007 and September 2008, coinciding with the period of increasing groundwater levels. This decrease in uranium concentration and increase in groundwater elevations suggests that well 928 became influenced by the Middle Chinle aquifer in the timeframe between December 2007 and September 2008. It should be noted that the uranium concentration used to represent the 2013 plume at well 928 in the 2014 Site Status Report (0.074 mg/L on 11/11/2011) was likely representative of the Middle Chinle and not the SAG aquifer. Therefore, the 2013 plume map for uranium in the SAG aquifer in this report (Figure 9) uses the most recent (December 2007) valid result of 0.082 mg/L for well 928; however, the extent of the plume remains unchanged.

Testing conducted by HMC at wells 986 and 943 also indicated contamination from a shallower aquifer was likely impacting samples from the wells and that the uranium concentrations in the wells were likely compromised prior to 2008 (HMC and Hydro-Engineering 2009; Hydro-Engineering 2016). The uranium concentrations for wells 986 and 943 presented on the 2013 plume map of the SAG aquifer (Figure 9) were collected after 2008 and are therefore not representative of the SAG aquifer. As a result, data from 986 and 943 were not used to develop the 2013 SAG uranium plume in this report.

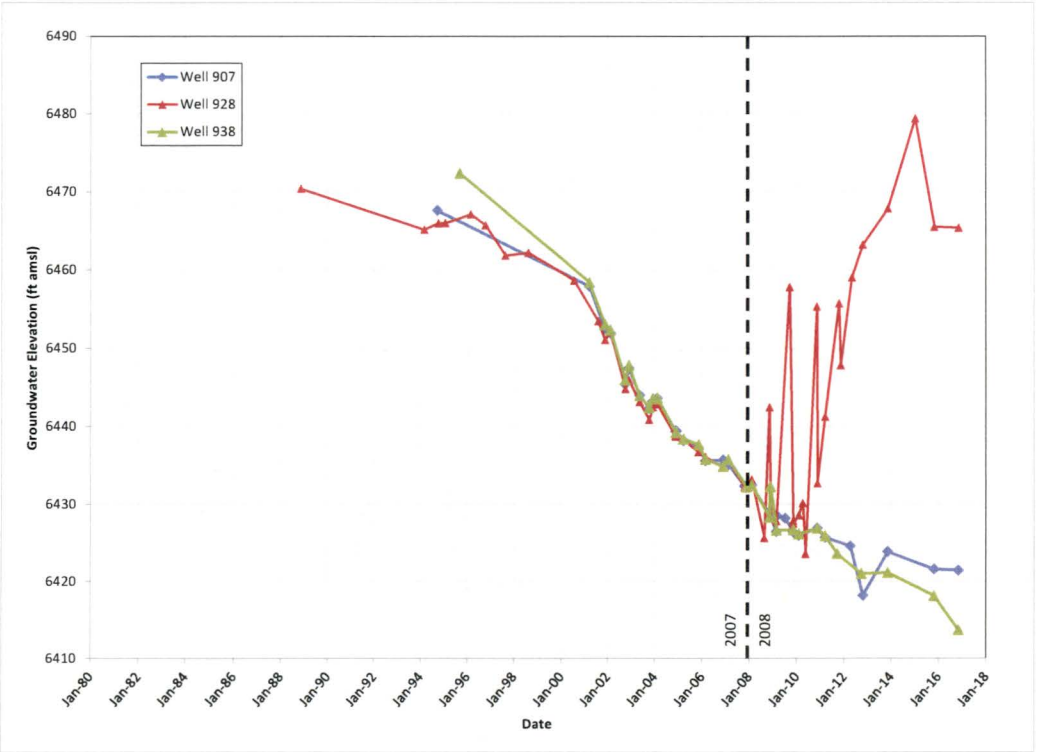

Figure 10. Groundwater Elevations at San Andres-Glorieta Aquifer (SAG) Wells 907, 928, and 938

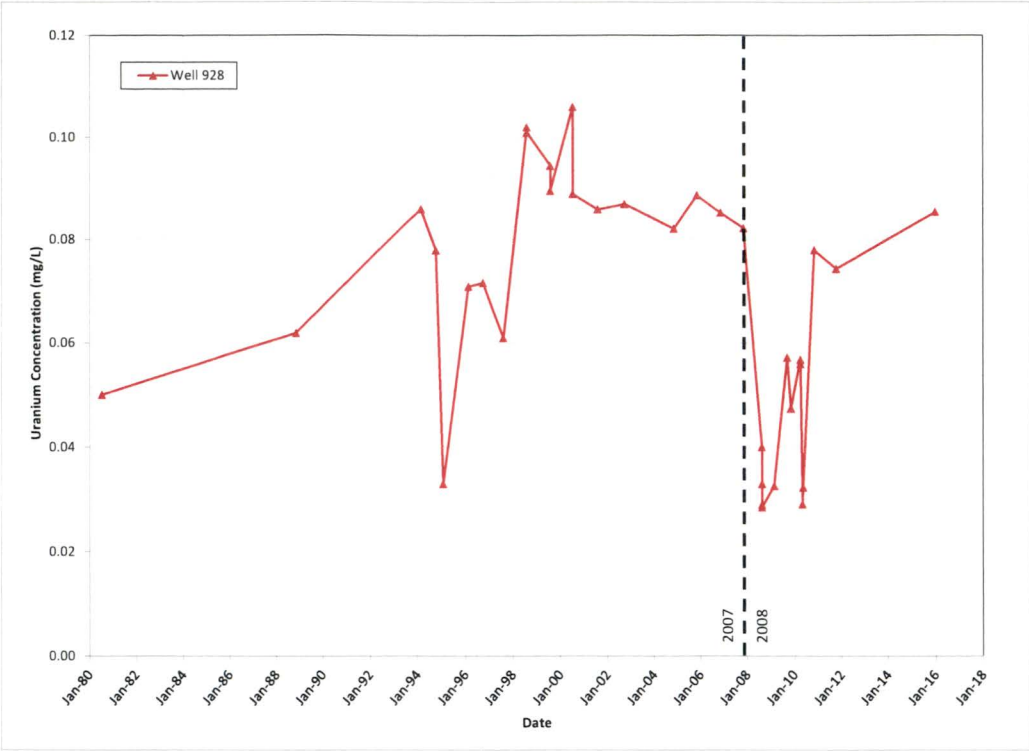

Figure 11. Measured Uranium Concentrations at San Andres-Glorieta Aquifer (SAG) Well 928 from 1980 Through 2011

2.3 2017 San Andres-Glorieta Aquifer Uranium Plume

Figure 12 presents the 2017 plume map for uranium in the SAG aquifer. This plume map was prepared using the wells and uranium concentration data listed in Table 1. All but one of the twenty water samples used to develop the 2017 uranium plume was collected in 2017. The single exception was the concentration listed for well 928. Similar to how the 2013 plume map for uranium was developed, the 2017 plume map used the most recent valid result for well 928 (December 2007 as discussed in Section 2.2) to represent uranium concentrations east of the site.

Overall, the shape and extent of the 2017 uranium plume is similar to the 2013 plume. The 2017 plume map shows that the highest uranium concentrations were detected at well 16(SG) (1.09 mg/L) and well I(SG) (0.29 mg/L) located directly east and hydraulically downgradient from the Main Tailings Disposal Cell. Concentrations in both wells 16(SG) and I(SG) were slightly less than those measured in 2013 (1.4 and 0.33 mg/L, respectively). The uranium concentration in 16(SG), the surrogate POC well, remains below the established ACL of 2.15 mg/L, while the uranium concentration in I(SG), the POE well, remains below the site-specific health-based concentration limit of 0.44 mg/L.

The north and west boundary of the 2017 SAG uranium plume occurs within the Bluewater site, and the south edge of the plume is relatively well defined using data from non-DOE wells. The extent of the plume is not well defined to the east and northeast, however, due to a lack of wells and concentration data. Therefore, concentration contours were not used to depict the leading edge of the plume in this region. Non-DOE wells within the plume boundary include 951, 951R,

928 (abandoned in 2017), and B-3 (well has not been sampled since August 2013). The 2017 uranium plume in the SAG is approximately 2 mi north of the nearest municipal water-supply well in the Grants-Bluewater Valley. No municipal water-supply wells or permitted drinking-water (domestic) wells are located within the 2017 SAG uranium plume. Uranium concentrations in the two Village of Milan municipal supply wells were reported to be 0.004 mg/L in 2017. Similarly, uranium concentrations in the two Grants municipal supply wells were 0.005 mg/L, also well below the 0.03 mg/L standard.

Homestake wells #1 Deep, and #2 Deep were used to develop the 2013 uranium plume but were not used to develop the 2017 SAG plume map because, similar to wells 928, 943, and 986, well integrity tests have indicated water samples from these wells could no longer be relied upon to represent groundwater in the SAG aquifer because they had been compromised due to vertical leakage of contamination from overlying Chinle Formation aquifers or alluvial aquifer sediments, or there was potential susceptibility to such leakage (HMC 2017a; HMC 2017b; HMC and Hydro-Engineering 2018b). All other wells used to develop the 2013 uranium plume map but not used to develop the 2017 uranium plume map were not sampled in 2017 (Table 1).

2.4 Comparison of the 2013 and 2017 San Andres-Glorieta Aquifer Uranium Plumes

Despite some localized changes in uranium concentrations, the extent of the 2017 uranium plume in the SAG aquifer (Figure 12) remained largely unchanged relative to the 2013 plume (Figure 9). The stability of the extent of the uranium plume reflects similar stability in uranium concentrations in wells defining the plume to the north, west, and south between 2013 and 2017. Because well 928, north of the Homestake site, is no longer representative of the SAG aquifer, no data exists to define uranium concentrations in the eastern region of the plume. The plume extent is also uncertain to the northeast given the lack of monitoring wells in this region. Uranium concentrations within the plume extent decreased slightly in wells east of and downgradient from the Main Tailings Disposal Cell (16(SG) and I(SG)), the plume region with the highest uranium concentrations. Between 2013 and 2017, uranium concentrations increased in only three wells: 13(SG), 14(SG) and 18(SG), all located in the southwest corner of the plume.

Figure 13 presents the changes in uranium concentrations at individual wells for data used to develop the 2013 and 2017 SAG aquifer uranium plumes; the changes in uranium concentrations are listed in Table 1. In general, DOE wells within the uranium plume show greater changes in uranium concentrations than offsite wells not within the plume, with the exception of 13(SG). From 2013 to 2017, the greatest decreases in uranium concentrations were found at wells 16(SG) (0.31 mg/L) and I(SG) (0.044 mg/L), located east of the Main Tailings Disposal Cell and north of the East-West Fault, and at well 15(SG) (0.13 mg/L), east of the Carbonate Tailings Disposal Cell and south of the East-West Fault (Figure 13). Uranium concentrations increased at wells 14(SG) (0.014 mg/L), 18(SG) (0.101 mg/L), and 13(SG) (0.005 mg/L) which are all located on the Bluewater site south of the East-West Fault. Uranium concentrations in the SAG aquifer upgradient of the Main Tailings Disposal Cell at well L(SG) are the same in 2013 and 2017 (0.003 mg/L). All offsite wells, including Village of Milan municipal supply wells show a decrease or no change in uranium concentrations between the data used to develop the 2013 and 2017 SAG aquifer uranium plumes.

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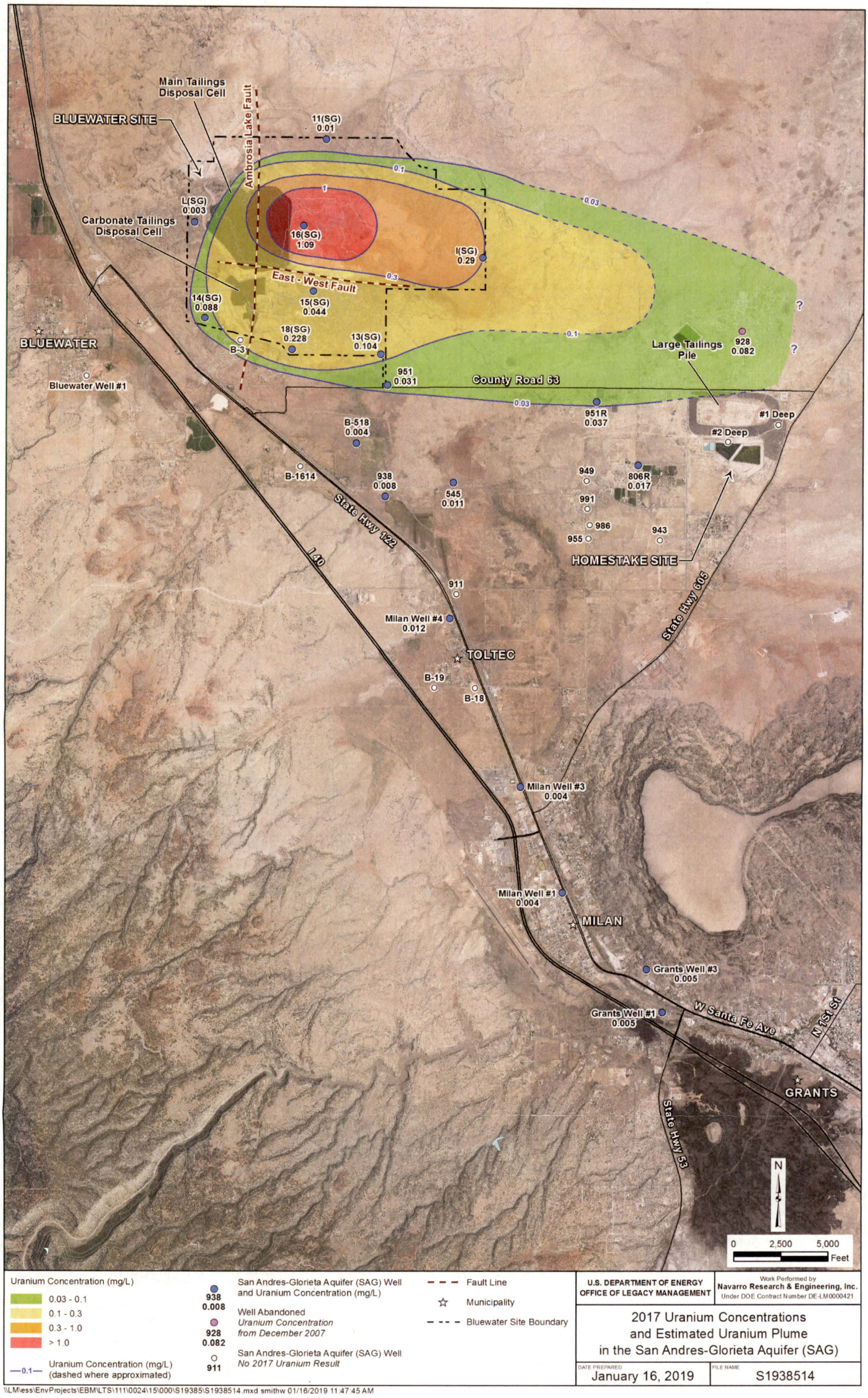

Figure 12. The 2017 Uranium Plume Map for the San Andres-Glorieta Aquifer (SAG)

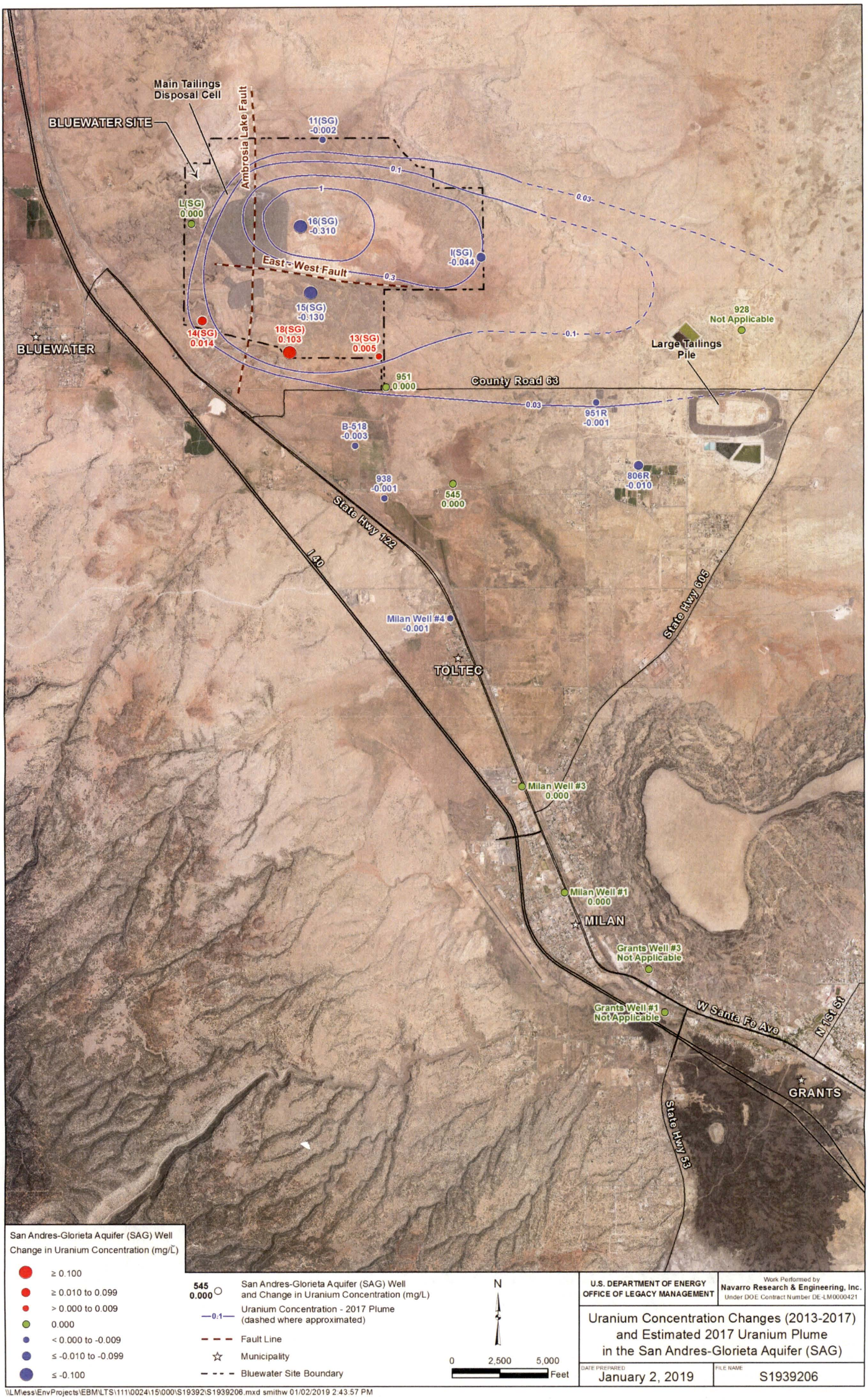

Figure 13. Posted Values of the Change in Uranium Concentration at Individual San Andres-Glorieta Aquifer Wells Between the Data Used to Develop the 2013 and 2017 Plume Maps for Uranium

Figure 14 shows a plot of uranium concentrations measured in DOE wells within the extent of the plume collected between November 2012 and November 2017. Because the scale in Figure 14 is driven by the higher magnitude uranium concentrations at well 16(SG), Figure 15 shows a plot of the same data but excludes well 16(SG) results. In general, observed trends are consistent with the increases and decreases presented in Table 1 and on Figure 13 that directly compare the November 2013 concentrations to the November 2017 concentrations, with the exception of 13(SG). As shown on Figure 14, uranium concentrations are highest at well 16(SG) and have generally decreased since November 2012. Uranium concentrations decrease to a lesser extent at well I(SG). On the other hand, uranium concentrations appear to increase from 2012 to 2017 in the southwest corner of the site at well 14(SG). Some uranium concentration trends are more difficult to interpret in wells 15(SG), 13(SG), and 18(SG). Additional monitoring data and statistical analysis will be helpful to more definitively evaluate long-term trends in uranium concentrations.

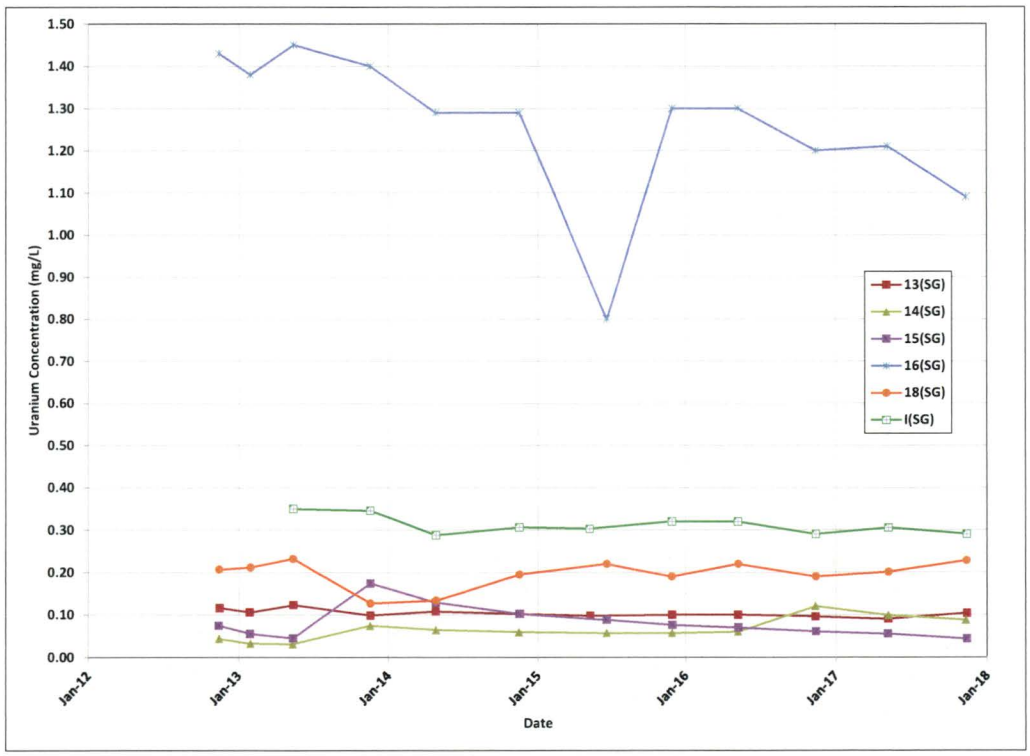

Figure 14. Uranium Concentrations in DOE SAG Wells 13(SG), 14(SG), 15(SG), 16(SG), 18(SG), and I(SG) Between 2012 and 2017

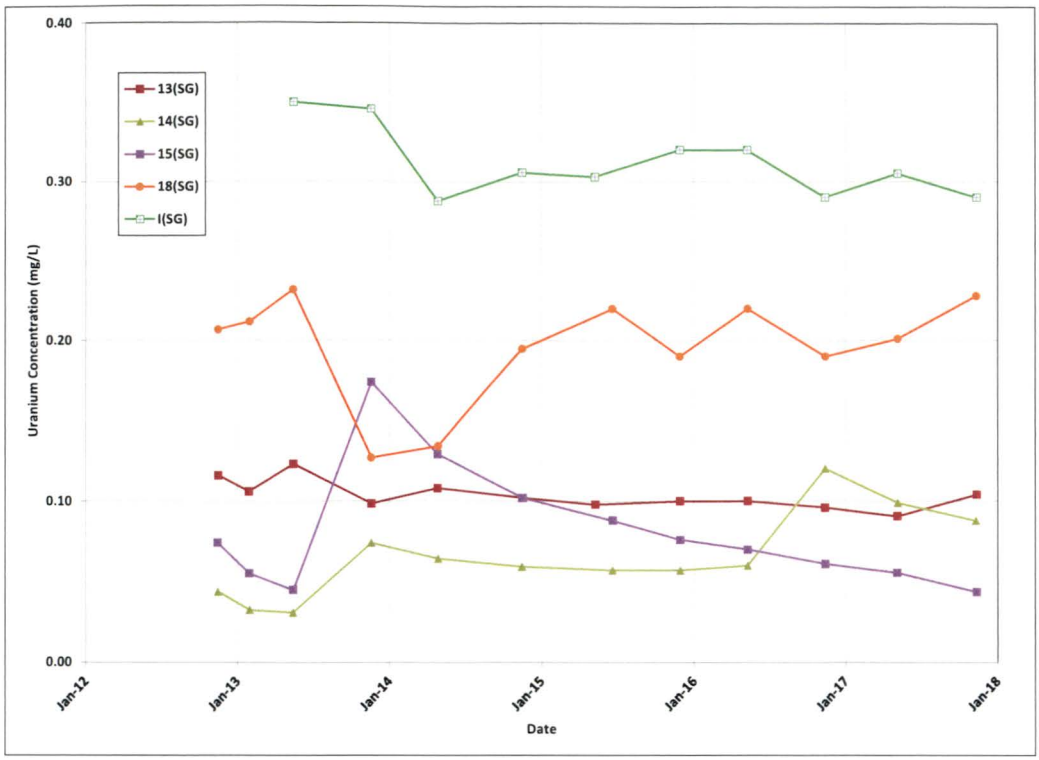

Figure 15. Uranium Concentrations in DOE SAG Wells 13(SG), 14(SG), 15(SG), 18(SG), and I(SG) Between 2012 and 2017

3.0 Alluvial Aquifer

This section presents the 2012 and 2017 potentiometric maps of the alluvial aquifer and the 2013 and 2017 plume maps for uranium in the alluvial aquifer. The 2012 and 2017 potentiometric maps and plume maps for uranium in the alluvial aquifer were developed using groundwater elevation and concentration data from DOE and HMC. There are currently nine alluvial aquifer wells on the Bluewater site; identified by the suffix (M). Most of the remaining wells are identified using HMC's nomenclature. The various wells installed in the alluvial aquifer by HMC are for remediation and monitoring that has been continuous at the Homestake site since 2013 (HMC and Hydro-Engineering 2018a).

3.1 2012 and 2017 Alluvial Aquifer Potentiometric Surfaces

Potentiometric maps were developed to illustrate general groundwater flow directions in the alluvial aquifer in 2012 and 2017; similar periods for which the 2013 and 2017 alluvial aquifer plume maps were developed.

Figure 16 shows a map of the 2012 alluvial aquifer potentiometric surface, as derived from a similar map prepared for the 2014 Site Status Report. This map shows that groundwater flow in the alluvial aquifer at the Bluewater site flows east in the area directly south of the Main Tailings Disposal Cell and then southeast near the east boundary of the site. The groundwater flow direction maintains a southeastward direction for about the first mile offsite to the confluence zone with the San Mateo Creek alluvial aquifer and then heads south toward Toltec and Milan.

The area of the alluvial aquifer outside the groundwater contours is interpreted to be mostly unsaturated.

Figure 17 shows the potentiometric surface of the alluvial aquifer in December 2017. Groundwater levels used to develop the 2017 potentiometric surface of the alluvial aquifer were primarily collected in December 2017, during the non-irrigation season. Some water levels collected in October and November 2017 were used in conjunction with the December 2017 data. Comparison of the 2012 and 2017 potentiometric surfaces show groundwater levels in the alluvial aquifer were similar across the Bluewater site, with the exception of T(M), which was dry in 2017. Groundwater levels were higher in 2017 than in 2012 down gradient of the Bluewater site in the Rio San Jose alluvial aquifer and in the San Mateo Creek alluvial aquifer just upgradient of the paleochannel confluence zone.

3.2 2013 Alluvial Aquifer Uranium Plume

Figure 18 shows the 2013 plume map of uranium in the alluvial aquifer. The uranium plume in the alluvial aquifer represents the estimated extent of groundwater with uranium concentrations exceeding the 0.03 mg/L EPA drinking water MCL and New Mexico groundwater standard. The 2013 plume map is modified from the depiction of the uranium plume in the 2014 Site Status Report to allow for a more robust comparison to the 2017 uranium plume map in the alluvial aquifer. The concentration contours representing the onsite portion of the uranium plume were developed using a previous depiction of the plume on the Bluewater site in the mid-1990s (Applied Hydrology Associates 1995) as a guide. The plume map uses a combination of data collected by DOE at DOE wells (DOE 2014) and data collected by HMC at HMC wells reported by HMC and Hydro-Engineering (2013). Table 2 contains a list of the wells screened in the Ancestral Rio San Jose alluvial aquifer and numerous wells in the San Mateo Creek alluvial aquifer that are included in Figure 18, along with corresponding sampling dates, measured uranium concentrations, and other data describing these select wells. Of the 49 wells used to develop the alluvial aquifer uranium plume for 2013, only 12 of them are assigned concentrations from water samples collected in 2013, and the remaining 37 wells are assigned concentrations from water samples collected in 2012 because the wells were not sampled in 2013 (HMC and Hydro-Engineering 2013).

As shown on Figure 18, the 2013 uranium plume in the alluvial aquifer extends southeast from the Bluewater site to approximately 1.25 mi southeast of the paleochannel confluence zone and approximately 0.7 mi northeast of Toltec. The south edge of the plume is somewhat defined and likely does not extend further southwest to the area where the alluvial aquifer directly overlies the SAG aquifer (Figure 18).

The highest uranium concentrations on the Bluewater site were observed at wells 22(M) (0.388 mg/L), X(M) (0.145 mg/L), and 21(M) (0.137 mg/L). Concentrations are below the established ACL of 0.44 mg/L for uranium for the alluvial aquifer POC well F(M) and below the site-specific health-based concentration limit for the POE well (X(M)). The uranium plume is not mapped in the area of well T(M), because T(M) has been dry since 2013.

In the area between the Bluewater site and the paleochannel confluence zone, uranium concentrations range between 0.06 mg/L (well 899) and 0.086 mg/L (well 637).Uranium concentrations within and downgradient of the paleochannel confluence zone reflect the mixing

of the Ancencestral Rio San Jose alluvial aquifer and the San Mateo Creek alluvial aquifer. Uranium concentrations are as high as 0.133 mg/L (well B-50B) within the confluence zone and 0.063 mg/L downgradient of the confluence zone. In the San Mateo Creek alluvial aquifer, uranium concentrations are as high as 0.5 mg/L, above the 0.16 mg/L uranium standard for the Homestake site, which is currently considered the background uranium concentration at the site (HMC and Hydro-Engineering 2017a). The distribution of uranium concentrations upgradient of the paleochannel confluence zone in the Ancestral Rio San Jose alluvial aquifer and the San Mateo Creek alluvial aquifer indicate that the higher uranium concentrations within the paleochannel confluence zone are likely from the San Mateo Creek alluvial aquifer.

3.3 2017 Alluvial Aquifer Uranium Plume

Figure 19 presents the 2017 plume map of uranium in the alluvial aquifer. The plume map uses a combination of data collected by DOE and HMC. Selection of the DOE wells shown in Figure 19 was based on data available in a data validation report recently published by DOE (DOE 2017). The non-DOE well locations were based on data included in several reports prepared on behalf of HMC for describing the behavior of Homestake-generated contamination in recent years (Environmental Restoration Group et al. 2011; HMC 2012; HMC 2017a; HMC 2017b; HMC and Hydro-Engineering 2017a, HMC and Hydro-Engineering 2017b, HMC and Hydro-Engineering 2018a; HMC et al. 2016; HMC et al. 2017). Table 3 lists the wells and data used to delineate the plume, sample collection dates, corresponding uranium concentrations, and additional information descriptive of each well. Samples collected from 62 wells in the alluvial aquifer were used to develop the plume. Of those 62 wells, 58 wells were sampled in 2017 and 4 wells were sampled in 2015 or 2016. The four water samples collected between 2015 and 2016 were included in the 2017 plume delineation to more accurately define the spatial distribution of uranium in the alluvial aquifer, particularly within the paleochannel confluence zone.

As shown on Figure 19, the 2017 uranium plume in the alluvial aquifer is similar to the 2013 uranium plume and extends southeast from the Bluewater site to approximately 1.25 mi southeast of the paleochannel confluence zone and approximately 0.7 mi northeast of Toltec. The highest uranium concentrations on the Bluewater site were observed at wells 22(M) (0.31 mg/L), X(M) (0.099 mg/L), and 21(M) (0.106 mg/L). The highest concentrations are below the established ACL of 0.44 mg/L for uranium for the alluvial aquifer POC well (F(M)) and below the site-specific health-based concentration limit for the POE well (X(M)).

Between the Bluewater site and the confluence zone in the Ancestral Rio San Jose Aquifer, uranium concentrations range between 0.21 mg/L (22(M)) and 0.066 mg/L (well 899). Uranium concentrations in the confluence zone are as high as 0.117 mg/L (well 654). In the San Mateo Creek alluvial aquifer, uranium concentrations are as high as 0.475 mg/L, which is above the 0.16 mg/L uranium standard for the Homestake site. Similar to the distribution of uranium concentrations in 2013, the distribution of uranium concentrations in 2017 above the paleochannel confluence zone in the Ancestral Rio San Jose alluvial aquifer and the San Mateo Creek alluvial aquifer indicate the higher uranium concentrations within the paleochannel confluence zone are likely derived from the Homestake site.

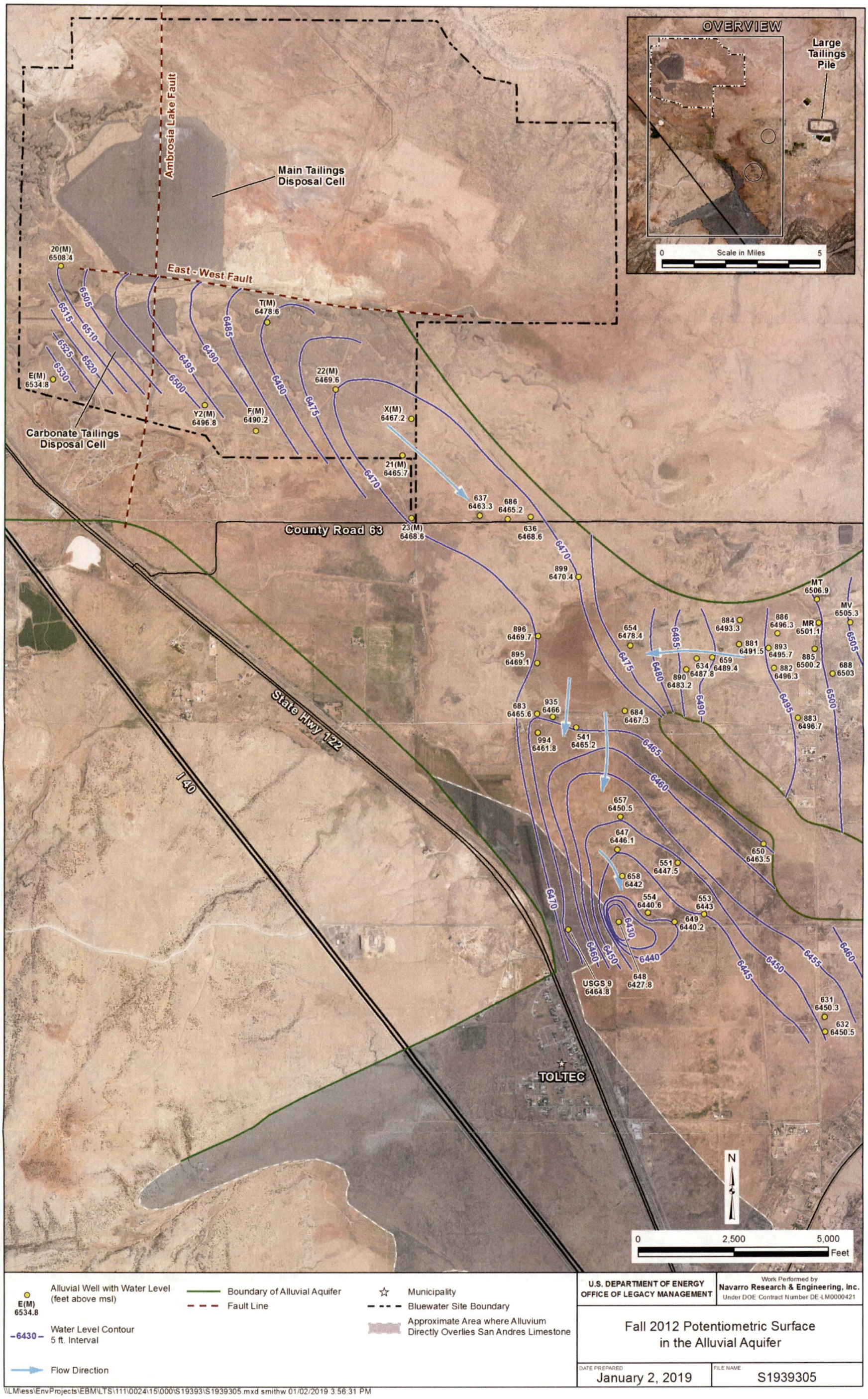

Figure 16. Potentiometric Surface in the Alluvial Aquifer in 2012

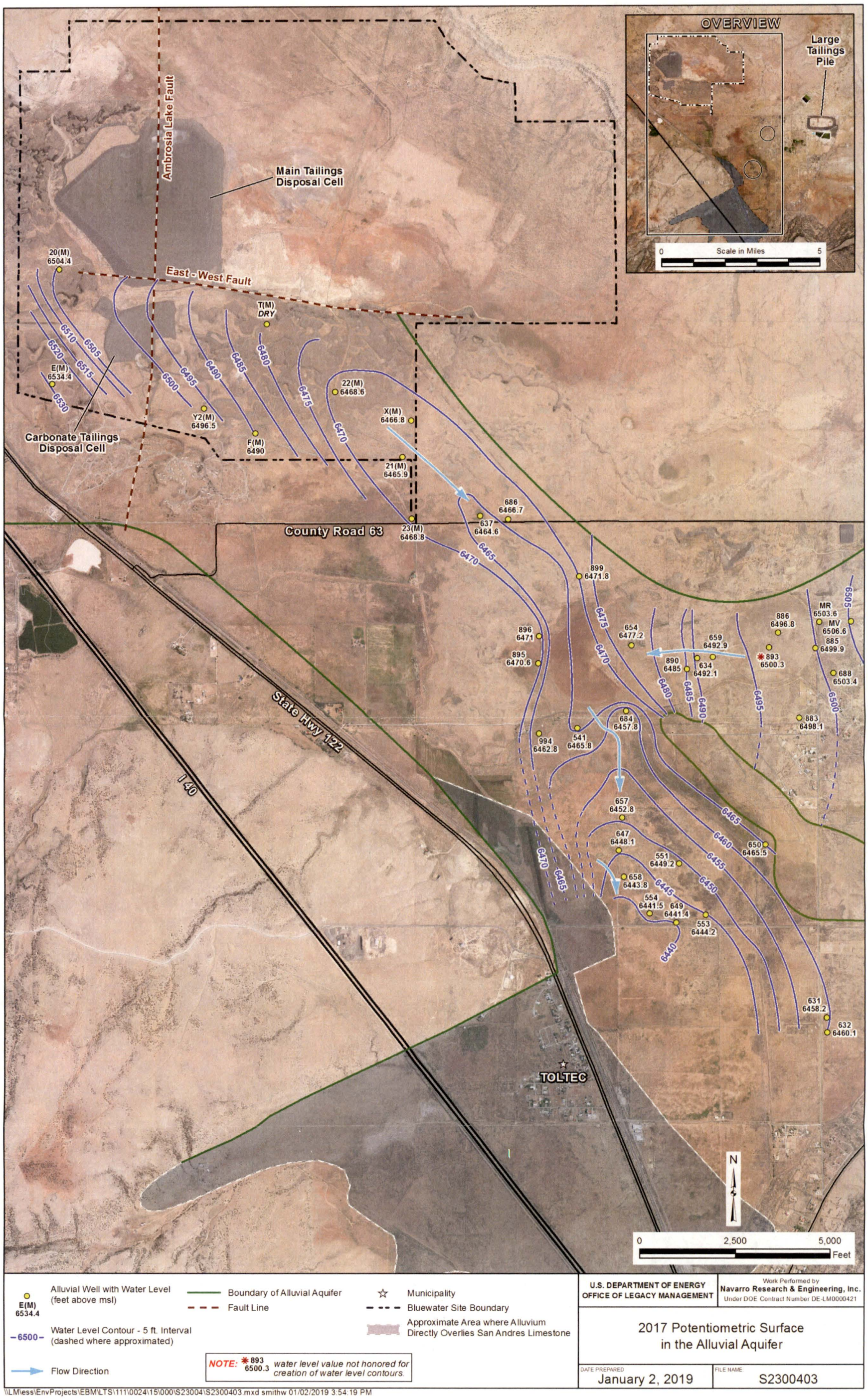

Figure 17. Potentiometric Surface in the Alluvial Aquifer in 2017

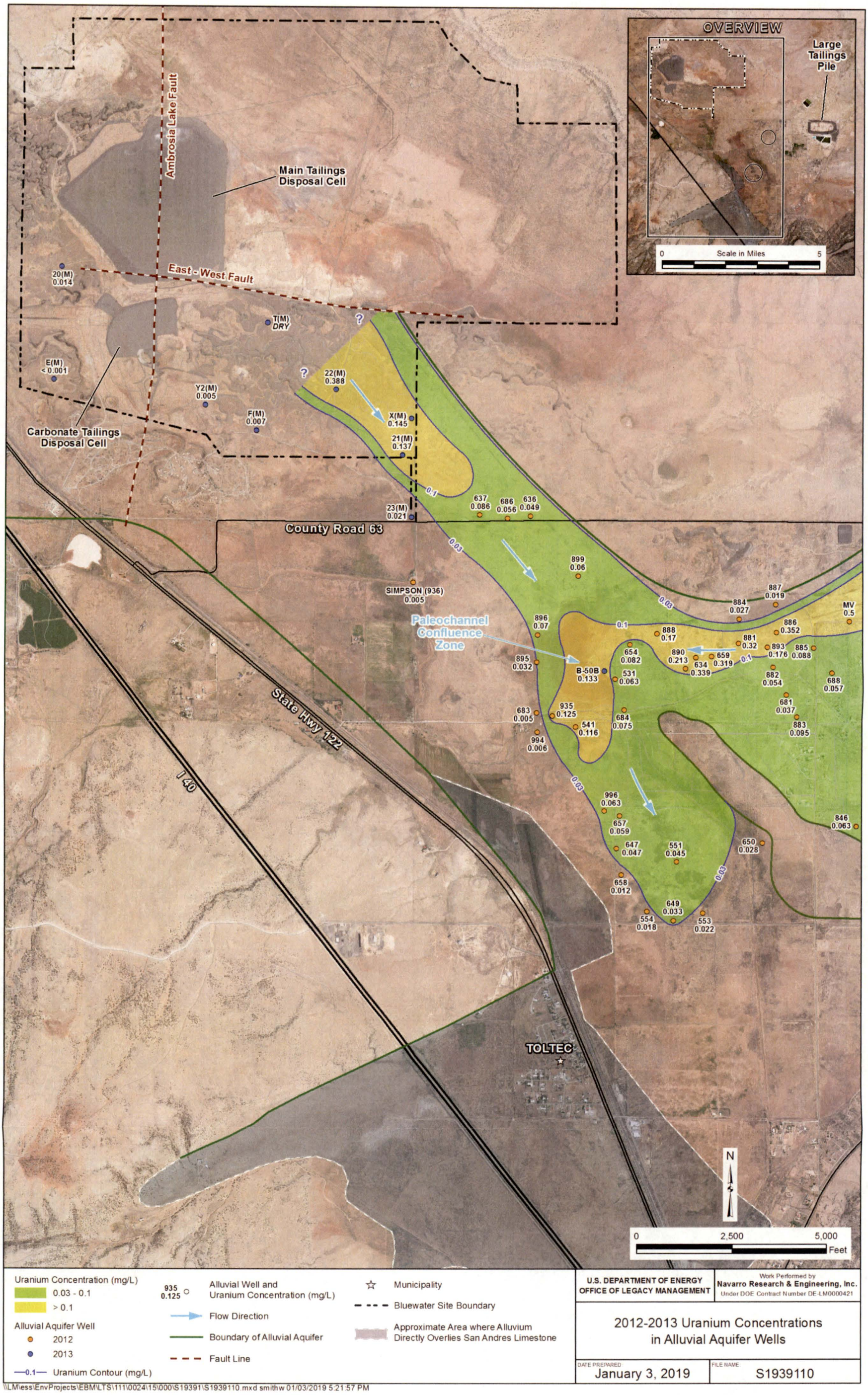

Figure 18. The 2013 Uranium Plume Map for the Alluvial Aquifer Based on Water Samples Collected in 2012 and 2013

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Table 2. Wells and Measured Concentrations Used to Develop the 2013 Uranium Plume Map for the Ancestral Rio San Jose Alluvial Aquifer and the San Mateo Creek Alluvial Aquifer

Well	Data Source	Sample Date	Uranium (mg/L)	Easting	Northing	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs)
20(M)	DOE	11/19/2013	0.014	463735	1551924	7/19/2012	127.5	110–125
21(M)	DOE	11/19/2013	0.137	472681	1546974	7/11/2011	152	139.6–149.6
22(M)	DOE	11/19/2013	0.388	470930	1548706	7/14/2011	149.2	136.8–146.8
23(M)	DOE	11/19/2013	0.021	472920	1545334	6/30/2012	111.5	89.0–109
E(M)	DOE	11/19/2013	0.0001	463535	1548938	5/31/1978	99.7	68.6–89.8
F(M)	DOE	11/19/2013	0.007	468854	1547618	6/6/1978	136	94.2–114.9
T(M)	DOE	11/19/2013	Dry	469141	1550461	11/16/1980	135	128–133
X(M)	DOE	11/19/2013	0.145	472907	1547949	12/18/1980	134.5	123–132
Y2(M)	DOE	11/19/2013	0.005	467532	1548289	9/11/1996	126	98–123
B-50B	DOE	10/1/2013	0.133	477982	1541294	-- (irrigation well)	--	--
SIMPSON (936)[a]	DOE	11/13/2012	0.005	472965	1543628	--	160	100–160
531	HMC	10/19/2012	0.063	478262	1541086	--	--	--
541	HMC	9/20/2012	0.116	477236	1539831	1/30/2004	120	78–118
551	HMC	3/9/2012	0.045	479881	1536272	3/8/2009	135	95–135
553	HMC	3/9/2012	0.022	480563	1534923	3/22/2009	130	90–125
554	HMC	3/9/2012	0.018	479107	1534967	3/14/2009	140	90–125
634	HMC	8/27/2012	0.339	480362	1541652	5/6/1999	103	80–100
636	HMC	10/17/2012	0.049	476038	1545374	6/29/1999	123	103–123
637	HMC	10/17/2012	0.086	474710	1545409	7/6/1999	124	104–124
647	HMC	9/20/2012	0.047	478308	1536623	1/2/1997	140	80–140
649	HMC	3/13/2012	0.033	479798	1534730	1/10/1997	124	84–124
650	HMC	8/15/2013	0.028	482135	1536779	1/22/1997	109	89–109
654	HMC	10/19/2012	0.082	478636	1541994	4/22/1999	120	60–120
657	HMC	5/9/2012	0.059	478392	1537497	1/22/1997	128	87–128
658	HMC	11/7/2012	0.012	478436	1535922	4/22/1999	130	89–130
659	HMC	8/27/2012	0.319	480772	1541689	1/22/1997	101	84–101
681	HMC	5/21/2012	0.0373	482734	1540676	9/19/1995	117	67–117
683	HMC	10/19/2012	0.005	476217	1540198	9/25/1995	120	80–120
684	HMC	10/19/2012	0.075	478499	1540273	9/21/1995	143	83–143
686	HMC	10/17/2012	0.056	475438	1545319	9/27/1995	115	75–115
688	HMC	8/27/2012	0.057	483955	1541257	10/31/1995	105	65–105
846	HMC	8/27/2012	0.063	484730	1537219	12/16/1982	75	40–65
881	HMC	11/1/2012	0.32	481478	1542034	8/3/1995	96	76–96
882	HMC	11/1/2012	0.054	482396	1541404	8/7/1995	110	70–110
883	HMC	10/23/2012	0.095	483039	1540097	8/8/1995	100	60–90
884	HMC	11/1/2012	0.027	481498	1542677	8/8/1995	90	58–88
885	HMC	10/23/2012	0.088	483474	1541919	8/10/1995	100	70–100
886	HMC	11/1/2012	0.352	482487	1542327	8/11/1995	90	60–90
887	HMC	5/29/2012	0.019	482469	1543063	8/14/1995	67	42–67
888	HMC	5/29/2012	0.17	479335	1542285	8/16/1995	105	75–105
890	HMC	8/27/2012	0.213	480088	1541365	8/24/1995	101	81–101
893	HMC	7/27/2012	0.176	482244	1541934	8/29/1995	98	78–98
895	HMC	10/19/2012	0.032	476222	1541521	8/29/1995	104	61–101
896	HMC	10/19/2012	0.070	476237	1542246	8/31/1995	113	73–113

Table 2. Wells and Measured Concentrations Used to Develop the 2013 Uranium Plume Map for the Ancestral Rio San Jose Aquifer and the San Mateo Creek Aquifer Paleochannel (continued)

Well	Data Source	Sample Date	Uranium (mg/L)	Easting	Northing	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs)
899	HMC	10/19/2012	0.060	477288	1543801	9/10/1995	110	70–110
935	HMC	10/19/2012	0.125	476629	1540115	--	300	95–132
994	HMC	10/30/2013	0.006	476240	1539700	3/31/1978	144	95–110
996	HMC	9/20/2012	0.063	477989	1537621	--	138	126–136
MV	HMC	11/17/2012	0.5	484418	1542618	8/11/1995	105	75–105

Notes:

Geographic coordinates (eastings and northings) are provided in North American Datum of 1927 (NAD27_SP_NM_W_FT).

[a] Of the wells listed above, SIMPSON (LM nomenclature) is the only alluvial well with known aliases. This well is also known as HMC well 936 and NMED well BW-18. This well was last sampled by HMC on 3/8/1996 (<0.01 mg/L uranium), by NMED on 8/28/2008 (0.0036 mg/L uranium), and by DOE in 2012 (0.005 mg/L uranium).

Abbreviation:

-- = not known or not reported
bgs = below ground surface

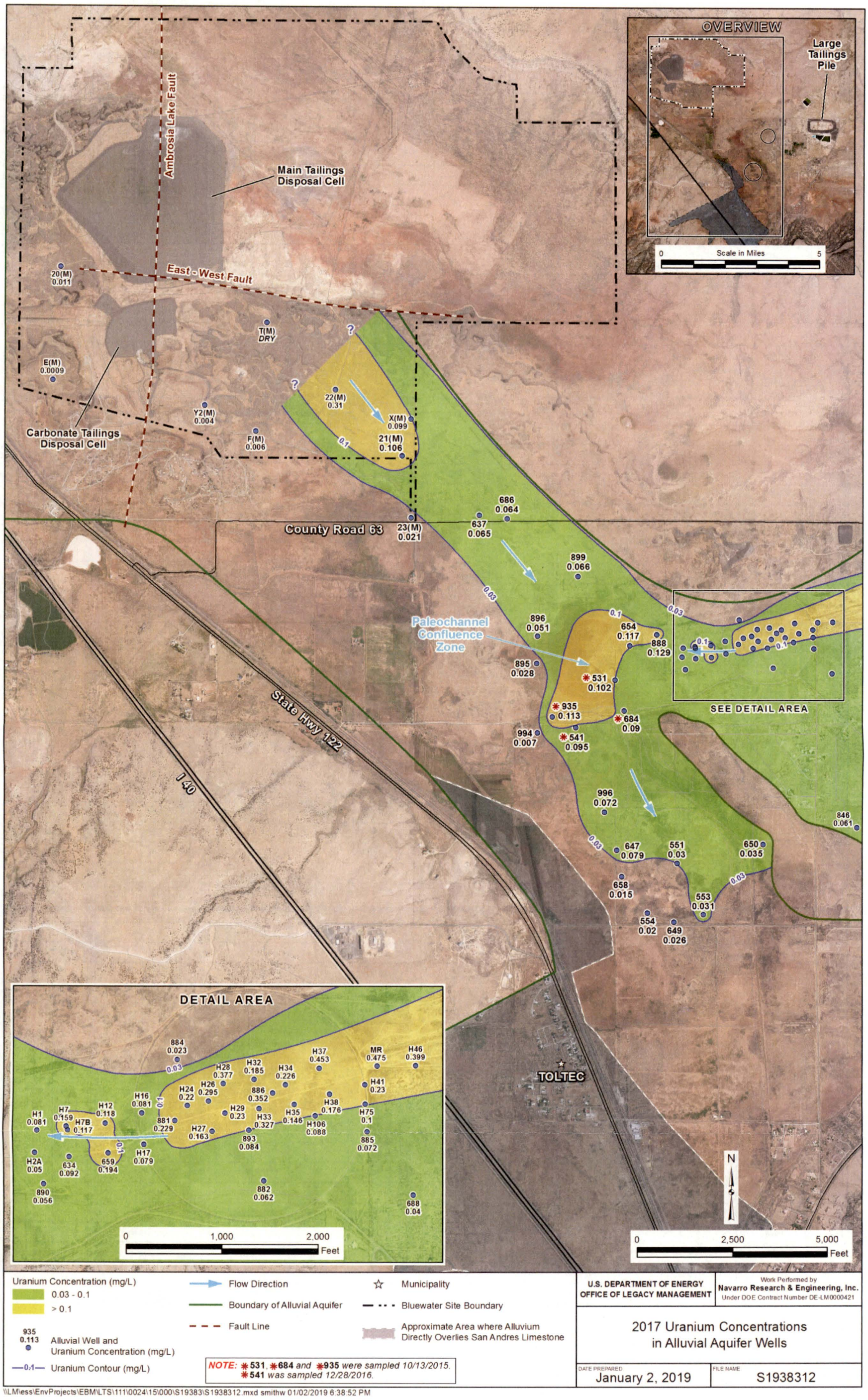

Figure 19. 2017 Uranium Plume Map for the Alluvial Aquifer

Table 3. Alluvial Aquifer Wells Used to Develop the 2017 Uranium Plume Map and Measured Concentrations

Well	Data Source	Sample Date	Uranium (mg/L)	Easting	Northing	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs)
20(M)	DOE	11/15/2017	0.011	463735	1551924	7/19/2012	127.5	110–125
21(M)	DOE	11/16/2017	0.106	472681	1546974	7/11/2011	152	139.6–149.6
22(M)	DOE	11/14/2017	0.310	470930	1548706	7/14/2011	149.25	136.8–146.8
23(M)	DOE	11/15/2017	0.021	472920	1545334	6/30/2012	111.5	89.0–109
E(M)	DOE	11/14/2017	0.0009	463535	1548938	5/31/1978	99.7	68.6–89.8
F(M)	DOE	11/15/2017	0.006	468854	1547618	6/6/1978	136	94.2–114.87
T(M)	DOE	11/16/2017	Dry	469141	1550461	11/16/1980	135	128–133
X(M)	DOE	11/16/2017	0.099	472907	1547949	12/18/1980	134.5	123–132
Y2(M)	DOE	11/15/2017	0.004	467532	1548289	9/11/1996	126	98–123
531	HMC	10/13/2015	0.102	478262	1541086	--	--	--
541	HMC	12/28/2016	0.095	477236	1539831	1/30/2004	120	78–118
551	HMC	3/28/2017	0.030	479881	1536272	3/8/2009	135	95–135
553	HMC	3/27/2017	0.031	480563	1534923	3/22/2009	130	90–125
554	HMC	3/27/2017	0.020	479107	1534967	3/14/2009	140	90–125
634	HMC	12/13/2017	0.092	480362	1541652	5/6/1999	103	80–100
637	HMC	10/6/2017	0.065	474710	1545409	7/6/1999	124	104–124
647	HMC	9/14/2017	0.079	478308	1536623	1/2/1997	140	80–140
649	HMC	3/15/2017	0.026	479798	1534730	1/10/1997	124	84–124
650	HMC	3/27/2017	0.035	482135	1536779	1/22/1997	109	89–109
654	HMC	11/14/2017	0.117	478636	1541994	4/22/1999	120	60–120
658	HMC	2/21/2017	0.015	478436	1535922	4/22/1999	130	89–130
659	HMC	3/30/2017	0.194	480772	1541689	1/22/1997	101	84–101
684	HMC	10/13/2015	0.090	478499	1540273	9/21/1995	143	83–143
686	HMC	10/6/2017	0.064	475438	1545319	9/27/1995	115	75–115
688	HMC	8/9/2017	0.040	483954	1541257	10/31/1995	105	65–105
881	HMC	2/23/2017	0.229	481478	1542034	8/3/1995	96	76–96
882	HMC	3/15/2017	0.062	482396	1541404	8/7/1995	110	70–110
884	HMC	12/13/2017	0.023	481498	1542677	8/8/1995	90	58–88
885	HMC	10/4/2017	0.072	483474	1541919	8/10/1995	100	70–100
886	HMC	11/9/2017	0.352	482487	1542327	8/11/1995	90	60–90
888	HMC	10/6/2017	0.129	479335	1542285	8/16/1995	105	75–105
890	HMC	12/13/2017	0.056	480088	1541365	8/24/1995	101	81–101
893	HMC	3/14/2017	0.084	482244	1541934	8/29/1995	98	78–98
895	HMC	10/3/2017	0.028	476222	1541521	8/29/1995	104	61–101
896	HMC	10/3/2017	0.051	476237	1542246	8/31/1995	113	73–113
899	HMC	10/3/2017	0.066	477288	1543801	9/10/1995	110	70–110
935	HMC	10/13/2015	0.113	476629	1540115	--	300	95–132
994	HMC	10/27/2017	0.007	476240	1539700	3/31/1978	144	95–110
996	HMC	10/4/2017	0.072	477989	1537621	--	138	126–136
H1	HMC	12/13/2017	0.081	480022	1541931	1/1/2014	98	78–98
H2A	HMC	12/13/2017	0.050	479997	1541694	1/1/2014	88	66–88
H7	HMC	12/13/2017	0.159	480333	1541974	1/1/2014	102	82–102
H7B	HMC	12/13/2017	0.117	480350	1541933	1/1/2014	98	78–98
H12	HMC	12/13/2017	0.118	480744	1542007	1/1/2014	100	80–100
H16	HMC	12/13/2017	0.081	481129	1542116	1/1/2014	92	72–92
H17	HMC	12/13/2017	0.079	481151	1541782	1/1/2014	99	79–99
H24	HMC	12/13/2017	0.220	481605	1542195	1/1/2014	100	80–100
H26	HMC	12/13/2017	0.295	481823	1542244	1/1/2014	98	78–98
H27	HMC	3/28/2017	0.163	481863	1541924	1/1/2014	96	96–96
H28	HMC	3/28/2017	0.377	481976	1542427	1/1/2014	97	77–97
H29	HMC	3/28/2017	0.230	481997	1542117	1/1/2014	100	80–100
H32	HMC	3/28/2017	0.185	482295	1542470	1/1/2014	98	78–98
H33	HMC	3/28/2017	0.327	482347	1542162	1/1/2014	98	78–98
H34	HMC	3/29/2017	0.226	482618	1542415	1/1/2014	96	76–96
H35	HMC	3/29/2017	0.146	482713	1542209	1/1/2014	97	77–97
H37	HMC	3/29/2017	0.453	482972	1542586	1/1/2014	96	76–96
H38	HMC	3/29/2017	0.176	483081	1542314	1/1/2014	93	73–93
H41	HMC	3/29/2017	0.230	483448	1542414	1/1/2014	100	80–100
H46	HMC	11/3/2017	0.399	483981	1542614	1/1/2014	95	75–95
H75	HMC	3/29/2017	0.100	483453	1542212	1/1/2014	93	73–93
H106	HMC	3/29/2017	0.088	482933	1542087	1/1/2014	94	74–94
MR	HMC	10/13/2017	0.475	483574	1542609	7/13/1995	100	54–94

Notes:
Geographic coordinates (eastings and northings) are provided in North American Datum of 1927 (NAD27_SP_NM_W_FT).
Shaded cells indicate samples were collected before 2017, specifically:

10/13/2015 2015–2016 result

Abbreviations:
-- = not known or not reported
bgs = below ground surface

3.4 Comparison of the 2013 and 2017 Alluvial Aquifer Uranium Plumes

Comparison of the 2013 and 2017 uranium plumes in the alluvial aquifer indicate uranium concentrations were lower in 2017 than 2013 in the southeast part of the Bluewater site. For example, the uranium concentration at well 22(M) was 0.388 mg/L in 2013 and 0.310 mg/L in 2017, a reduction of 0.078 mg/L. Similarly, the uranium concentration at well X(M) was 0.145 mg/L in 2013 and 0.099 mg/L in 2017, a reduction of 0.046 mg/L, and at well 21(M), the uranium concentration was 0.137 mg/L in 2013 and 0.106 mg/L in 2017, a reduction of 0.031 mg/L.

In offsite portions of the Ancestral Rio San Jose alluvial aquifer, comparison of uranium concentrations in 2013 and 2017 indicate no definitive signs of decreasing or increasing uranium. However, there is some evidence for decreasing uranium concentrations in the San Mateo Creek alluvial aquifer. Decreasing uranium concentrations in the San Mateo Creek alluvial aquifer appear to be localized due to HMC's groundwater remediation within the San Mateo Creek alluvial aquifer and do not appear to influence concentrations in the paleochannel confluence zone. A change in uranium concentration from 0.319 mg/L in 2013 to 0.129 mg/L in 2017 at well 659, just east of the paleochannel's confluence zone, possibly indicates the effects of remediation.

4.0 Summary and Conclusions

This study presented plume maps of uranium representing 2013 and 2017 concentrations in both the SAG aquifer and the alluvial aquifer in the vicinity of the Bluewater site. The uranium plumes were defined as the areas with uranium concentrations exceeding the EPA drinking water MCL and New Mexico groundwater standard of 0.03 mg/L. Plumes in SAG and alluvial aquifer originate beneath the Bluewater disposal site and have migrated to areas east and southeast of the site. However, uranium concentrations at the Bluewater site are below the ACLs established by NRC for the respective aquifers as part of the long-term surveillance plan for the site, and below the site-specific health-based concentration limit of 0.44 mg/L at the boundary.

4.1 San Andres-Glorieta Aquifer

Potentiometric maps were developed to illustrate general groundwater flow directions in the SAG aquifer in 2012 and 2017. Although groundwater levels were 2-4 ft lower in 2017 at the Bluewater site, potentiometric contours show the flow directions in 2012 and 2017 for the SAG aquifer were similar. The 2012 and 2017 potentiometric maps for the SAG aquifer show groundwater flow is to the east and southeast.

Despite some localized changes in uranium concentrations, the interpreted extent of the 2017 uranium plume in the SAG aquifer was similar to the 2013 uranium plume. The extent of the uranium plume remained unchanged because concentrations and data density available to define the extent to the north, west, and south remained relatively constant from 2013 to 2017 and no data exists to define the east and northeast areas of the plume. The highest uranium concentrations in 2013 and 2017 were detected in wells 16(SG) and I(SG) directly east and downgradient from the Main Tailings Disposal Cell. Uranium concentrations within the plume extent decreased in the area east of the Main Tailings Disposal Cell on the Bluewater site near

wells 16(SG) and I(SG) and increased in the southwest corner of the plume near wells 14(SG) and 18(SG) (Figure 8 and Figure 11).

The downgradient extent of the uranium plume in the SAG aquifer is uncertain. Although the location of the downgradient plume boundary is unknown, recent concentrations used to delineate the 2017 uranium plume indicate that it is located approximately 2 mi north of the nearest municipal water supply well that extracts groundwater from the SAG aquifer in the Grants-Bluewater Valley. No municipal or permitted domestic water-supply wells are located within the SAG uranium plume. In addition, for both the 2013 and 2017 plume maps for uranium in the SAG aquifer, concentrations are below the established ACL of 2.15 mg/L for uranium for the SAG aquifer point of compliance well. DOE continues to comply with the NRC-approved health-based standard of 0.44 mg/L at the Bluewater POE well for the SAG aquifer.

4.2 Alluvial Aquifer

Potentiometric maps were also developed to illustrate general groundwater flow directions in the alluvial aquifer in 2012 and 2017. Similar to the SAG aquifer, flow directions in 2012 and 2017 potentiometric maps for the alluvial aquifer were similar. Groundwater in the alluvial aquifer at the Bluewater site flows east in the area directly south of the Main Tailings Disposal Cell and then southeast near the east boundary of the site. The groundwater flow direction maintains a southeastward direction for about the first mile offsite to the confluence zone with the San Mateo Creek alluvial aquifer and then heads south toward Toltec and Milan.

Comparison of the northernmost portions of the 2013 and 2017 uranium plumes in the alluvial aquifer indicate uranium concentrations were lower in 2017 than 2013 in the southeast part of the Bluewater site. In addition, there is some evidence for slightly decreasing uranium concentrations in the San Mateo Creek alluvial aquifer, primarily the legacy of former uranium milling operations at the Homestake site. The apparent decrease in uranium concentration in the San Mateo Creek alluvial aquifer is attributed to HMC's active groundwater remediation. Uranium concentrations measured in 2013 and 2017 at wells elsewhere in offsite portions of the alluvial aquifer suggest that the active remediation has yet to influence uranium levels within and downgradient of the paleochannel confluence zone.

No permitted domestic wells are located between the Bluewater site and the paleochannel confluence zone within the Ancestral Rio San Jose alluvial aquifer. For both the 2013 and 2017 plume maps for uranium in the alluvial aquifer, concentrations at alluvial aquifer POC wells are below the established ACL of 0.44 mg/L for uranium. DOE continues to comply with the NRC-approved health-based standard of 0.44 mg/L at the Bluewater POE wells for the alluvial aquifer.

5.0 References

Applied Hydrology Associates Inc., 1990. *Corrective Action Program and Alternate Concentration Limits Petition for Uranium, Molybdenum and Selenium, Bluewater Uranium Mill Near Grants, New Mexico,* prepared for the Atlantic Richfield Company, June.

Applied Hydrology Associates Inc., 1993. *Ground Water Corrective Action Program Review, Bluewater Uranium Mill Near Grants, New Mexico,* prepared for the Atlantic Richfield Company, December.

Applied Hydrology Associates Inc., 1995. *Corrective Action Program and Alternate Concentration Limits Petition for Uranium, Molybdenum and Selenium, Bluewater Uranium Mill Near Grants, New Mexico,* prepared for the Atlantic Richfield Company, April.

DOE (U.S. Department of Energy), 1997. *Long-Term Surveillance Plan for the DOE Bluewater (UMTRCA Title II) Disposal Site Near Grants, New Mexico*, LTSM003407, July.

DOE (U.S. Department of Energy), 2014. *Site Status Report: Groundwater Flow and Contaminant Transport in the Vicinity of the Bluewater, New Mexico, Disposal Site,* Office of Legacy Management, LMS/BLU/S11381, November.

DOE (U.S. Department of Energy), 2017. *Data Validation Package, November 2016 Groundwater Sampling at the Bluewater, New Mexico, Disposal Site*, LMS/BLU/S01116, April.

Environmental Restoration Group, RIMCON, and Hydro-Engineering, 2011. *Grants Reclamation Project, Evaluation of Years 2000 Through 2010, Irrigation with Alluvial Groundwater*, January.

HMC (Homestake Mining Company), 2012. *Grants Reclamation Project, Updated Corrective Action Program (CAP)*, March.

HMC (Homestake Mining Company), 2017a. Thomas Wolford, Closure Manager, HMC, letter (about Responses to July 18, 2017 NMED Letter) to Matthew Meyer, Project Manager, U.S. Nuclear Regulatory Commission, August 17.

HMC (Homestake Mining Company), 2017b. *Groundwater Compliance Monitoring Plan Revisions, Homestake Mining Company of California, Grants Reclamation Project,* December.

HMC (Homestake Mining Company) and Hydro-Engineering, 2009. *Well 986 Uranium Evaluation for Homestake Grants Project Pursuant to NRC License SUA-1471*, January, Revised March.

HMC (Homestake Mining Company) and Hydro-Engineering, 2013. *2012 Annual Monitoring Report/Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200.* March.

HMC (Homestake Mining Company) and Hydro-Engineering, 2017a. *2016 Annual Monitoring Report/Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200*, March.

HMC (Homestake Mining Company) and Hydro-Engineering, 2017b. *Post-Closure Monitoring for Western Portion North Off-site Area*, August.

HMC (Homestake Mining Company) and Hydro-Engineering, 2018a. *2017 Annual Monitoring Report/Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200*, March.

HMC (Homestake Mining Company) and Hydro-Engineering, 2018b. *Well 943 Hydrologic Test Report*, April.

HMC (Homestake Mining Company), Hydro-Engineering, and Environmental Restoration Group, 2016. *2015 Monitoring of Former Irrigation Areas*, February.

HMC (Homestake Mining Company), Hydro-Engineering, and Environmental Restoration Group, 2017. *Land Application Impact Assessment,* September.

Hydro-Engineering, 2015. *Grants Reclamation Project, 2015 San Andres Well Integrity Testing*, December.

Hydro-Engineering, 2016. *Grants Reclamation Project, 1st Quarter 2016 San Andres Well Integrity Testing*, March.

Hydro-Search (Hydro-Search Inc.), 1977. *Hydrogeology of the Bluewater Mill Tailings Pond Area, Valencia County, New Mexico*, consultant's report to Anaconda Copper Company, October.

NRC (U.S. Nuclear Regulatory Commission), 1996. Hoseeph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, letter (Subject: Approval of Groundwater Alternate Concentration Limits, Amendment 30 to Source Material License SUA-1470, to Mr. R. S. Ziegler, Project Manager, Atlantic Richfield Company, February 22.

West, S.W., 1972. Disposal of Uranium-Mill Effluent by Well Injection in the Grants Area, Valencia County, New Mexico. Contributions to Problems of Radioactive Waste Disposal. Geological Survey Professional Paper 386-D. Prepared in cooperation with the New Mexico State Engineer Office and the U.S. Atomic Energy Commission.

White, W.D., and T.E. Kelly, 1989. The San Andres-Glorieta Aquifer in West-Central New Mexico. New Mexico Geological Society Guidebook, 40th Field Conference, Southeastern Colorado Plateau.

Appendix A

Crosswalk for San Andres-Glorieta Wells in the Grants-Bluewater Valley Study Region

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Abbreviations

DOE	U.S. Department of Energy
ft	feet
HMC	Homestake Mining Company
NMED	New Mexico Environment Department
NMWRRS	New Mexico Water Rights Reporting System
OSE	New Mexico Office of the State Engineer
PLSS	Public Land Survey System
POD	point of diversion
SAG	San Andres-Glorieta bedrock aquifer
USGS	U.S. Geological Survey

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A.1 Introduction and Objective

This appendix documents relevant information for wells installed in the San Andres-Glorieta bedrock aquifer (SAG) within the Grants-Bluewater Valley study region. This summary, and the associated SAG well crosswalk (Table A-1), was developed in support of the uranium plume evaluation presented in the main body of this report. A primary objective of this appendix is to provide a crosswalk of all applicable well names or identifiers, as designated by the following agencies or organizations:

- U.S. Department of Energy (DOE)
- Homestake Mining Company (HMC)
- New Mexico Environment Department (NMED)
- New Mexico Office of State Engineer (OSE)
- U.S. Geological Survey (USGS)

Groundwater characterization and monitoring efforts at the Bluewater and Homestake sites over the last several decades have yielded large data sets, with databases maintained by DOE and HMC, respectively. Additionally, at various SAG well locations within this study region, NMED has conducted supplemental monitoring since 2008, while USGS periodically measures groundwater elevations at other selected well sites. A catalyst for developing this crosswalk is that for many of the SAG wells, especially those not owned by DOE or HMC, there has been no consistency in nomenclature. Some wells have been identified using owner's names and others using OSE's nomenclature, while NMED has established unique sample IDs (and even *xy*-coordinate pairs) for each separate study or sampling objective. Adding to this complexity are differences in well locations (survey coordinates) depending on the data source.

An example of this variability is found with irrigation well 938 (HMC designation), which currently has four alternate IDs: BW-06 (NMED 2010), BSAG-4 (NMED 2015–2018), B 00196 or B-196 (OSE), and USGS site number 351354107552401 (12N.10W.32.111). This well was also formerly referred to as the Cottonwood Well (S-36) in early site characterization reports (Hydro-Search 1981). When the coordinates from all five separate sources are plotted, although fairly close (within 160 feet [ft]), they do not align. In some cases, there were major discrepancies between data sources regarding a well's location (*xy* coordinates). Additionally, within OSE's database, coordinates for older wells are usually based on the Public Land Survey System (PLSS), which often differ (sometimes markedly) from more recent survey data.

This lack of consistency in well nomenclature, location, and construction information makes developing a database difficult. Given the multiple IDs, and to facilitate analysis of uranium and other constituent trends, it was necessary to establish a unique study ID for each well while maintaining relevant information from all available sources.

A.2 SAG Well Crosswalk Scope

The well crosswalk provided in Table A-1, and mapped in Figures A-1 and A-2, includes wells near or downgradient of the Bluewater and Homestake mill sites in the following areas:

- Township 12 North (T12N), Range 10 West (10W), comprising the nearest SAG wells downgradient of the Bluewater site
- The easternmost central portion of Township 12 North (T12N), Range 11 West (11W), which excludes wells west of Highway 122 and most wells hydraulically upgradient of the Bluewater site
- Township 11 North (T11N), Range 10 West (10W), comprising farther downgradient SAG wells, including those in Milan and Grants
- A small portion of Township 12 North (T12N), Range 11 West (11W), north and east of the Homestake site (location of only one well, B-1496 or BSAG-13)

For purposes of this study, this crosswalk excludes non-DOE-owned wells hydraulically upgradient of the Bluewater site, including those west of Highway 122 in the northern portion of the study area. Additionally, except for recently abandoned wells (wells 806, 928, and 943), only existing (nondecommissioned) wells are included in this summary; locations of decommissioned wells are mapped in the Site Status Report (DOE 2014).

Two versions of the SAG well location map are provided; Figure A-1 shows the SAG wells and alternate IDs over a white background, while Figure A-2 shows the same information but overlying aerial imagery. In each of these figures, labels are color-coded based on the corresponding agency ID (DOE, HMC, NMED, OSE, or USGS), while the different symbols denote the original source of the well designation. The uppermost label, shown in bold and larger font, is the study ID, under which the alternate IDs are listed.

A.3 Information Sources

Sources used to develop the well crosswalk provided in Table A-1 are as follows:

- DOE's existing database and well construction logs (for DOE-owned wells)
- HMC annual reports (e.g., HMC and Hydro-Engineering 2018) and electronic database transmitted in April 2018
- Water rights and point of diversion (POD) summaries in OSE's New Mexico Water Rights Reporting System (NMWRRS) database:

  http://nmwrrs.ose.state.nm.us/nmwrrs/index.html
- New Mexico Drinking Water Bureau, Drinking Water Watch, which includes links to historical water quality data for municipal wells in the Milan and Grants area:

  https://dww.water.net.env.nm.gov/NMDWW/
- USGS National Water Information System Database:

  https://maps.waterdata.usgs.gov/mapper/index.html?state=nm

A.4 Crosswalk Organization and Nomenclature

In Table A-1, SAG wells are listed in the following order: DOE wells (Section A), Homestake well designations (Section B), Bluewater Basin municipal wells (Milan and Grants systems, Section C), other wells (those with "BSAG-" prefixes) recently sampled by NMED (Section D), and remaining SAG wells not routinely monitored by any agency or organization (Section E). For the wells with multiple aliases, in general, study IDs were chosen based on the well names established by either DOE (for DOE-owned wells) or HMC, as these entities are the source of the bulk of the corresponding well information and water quality data, and both maintain and continually update electronic databases. It is important to note that most of the SAG wells listed in Table 8.1-1 of HMC's annual reports are not owned by HMC. Nonetheless, their well designations are maintained in this crosswalk because HMC has developed the most comprehensive compendium of data for these more distal SAG wells.

For wells not routinely sampled by DOE or HMC, municipal or OSE well designations were selected as the primary label. For the most part, NMED's nomenclature was not used because it has not been consistent over the years. In their 2008 investigation (NMED 2010), a "BW-" prefix was used; in a 2014 investigation of the Lower San Mateo Creek Basin (NMED 2016), a "LSM-" prefix was used; while the more recent sampling efforts focused on SAG wells have used "BSAG-" prefixes (NMED 2015; NMED 2017; NMED 2018).

Where available, Table A-1 includes links to OSE well permits and well construction information. All currently monitored Bluewater site wells are under OSE permit B 00410, while those owned or installed by HMC wells are licensed under permit number B 00028. (Note: In some cases, links to well- or POD-specific information may not work unless OSE's home page is accessed first [http://nmwrrs.ose.state.nm.us/nmwrrs/index.html.].)

A.5 Uncertainties

The crosswalk of wells, documented in Table A-1, is the result of an exhaustive search of numerous records from multiple agencies or organizations. As indicated above, depending on the information source, in some cases there is conflicting information regarding well location, depth, screened intervals, or even presence of a screen. For some wells not owned or installed by DOE or HMC (e.g., irrigation and municipal wells), information regarding well use and construction is uncertain or not available. For the latter subset of wells, information was obtained primarily from OSE records, all of which are provided with the following caveat for each POD summary:

> The data is furnished by the NMOSE/ISC and is accepted by the recipient with the expressed understanding that the OSE/ISC make no warranties, expressed or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the data.

References

DOE (U.S. Department of Energy), 2014. *Site Status Report: Groundwater Flow and Contaminant Transport in the Vicinity of the Bluewater, New Mexico, Disposal Site*, LMS/BLU/S11381, Office of Legacy Management, November.

Homestake Mining Company (HMC) and Hydro-Engineering, 2018. *2017 Annual Monitoring Report / Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200*, prepared for U.S. Nuclear Regulatory Commission and New Mexico Environment Department, March.

Homestake Mining Company (HMC), 2018. Thomas Wolford, Closure Manager, HMC, letter (about Proposed Adjustment in Groundwater Monitoring of the San Andres-Glorieta Aquifer near the Grants Reclamation Project, Nuclear Regulatory Commission Docket No. 40-8903, License No. SUA 1471, and New Mexico Environmental Department DP-200 Ground Water Discharge Plan) to Jeffrey Whited, Project Manager, U.S. Nuclear Regulatory Commission, and Bill Pearson, Ground Water Quality Bureau, New Mexico Environment Department, July 26.

Hydro-Engineering, 2015. *Grants Reclamation Project, 2015 San Andres Well Integrity Testing*, December.

Hydro-Search (Hydro-Search Inc.), 1981. *Regional Ground-Water Hydrology and Water Chemistry, Grants-Bluewater Area, Valencia County, New Mexico*, report prepared for Anaconda Copper Company, June.

NMED (New Mexico Environment Department), 2010. *Geochemical Analysis and Interpretation of Ground Water Data Collected as Part of the Anaconda Company Bluewater Uranium Mill Site Investigation and San Mateo Creek Site Legacy Uranium Sites Investigation, McKinley and Cibola County, New Mexico*, draft released for public review, May.

NMED (New Mexico Environment Department), 2015. *Field Activities Summary Report, Groundwater Sampling of San Andres-Glorieta Aquifer Wells, Bluewater Disposal Site Area, Cibola County, New Mexico*, prepared by Superfund Oversight Section, Ground Water Quality Bureau, NMED, December.

NMED (New Mexico Environment Department), 2016. *Site Reassessment Report, Lower San Mateo Creek Basin Site, Cibola & McKinley Counties, New Mexico, CERCLIS ID NMN000606847*, revised, prepared by Superfund Oversight Section, Ground Water Quality Bureau, NMED, March.

NMED (New Mexico Environment Department), 2017. *Field Activities Summary Report, Groundwater Sampling of San Andres-Glorieta Aquifer Wells, Bluewater Disposal Site Area, Cibola County, New Mexico*, prepared by Superfund Oversight Section, Ground Water Quality Bureau, NMED, March.

NMED (New Mexico Environment Department), 2018. *Field Activities Summary Report, Groundwater Sampling of San Andres-Glorieta Aquifer Wells, Bluewater Disposal Site Area, Cibola County, New Mexico*, prepared by Superfund Oversight Section, Ground Water Quality Bureau, NMED, May.

Weston (Weston Solutions Inc.), 2018. *Phase 2 Ground-Water Investigation Report for the San Mateo Creek Basin Legacy Uranium Mines Site, Cibola and McKinley Counties, New Mexico*, prepared for U.S. Environmental Protection Agency Region 6, October.

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Table A-1. Crosswalk for Bluewater Study Area San Andres-Glorieta Wells

ROW NO.	STUDY ID[a]	HMC ID	OSE PERMIT NO. OSE POD NO.[b]	NMED ID(s)	WELL OWNER OR USER	ALL ALIASES COMBINED	X (NAD27)	Y (NAD27)	TWS RNG SEC	MOST RECENT RESULT (as of 12/31/17)	TD (ft bgs)	SCREENED INTERVAL (ft bgs) (SAG TOP DEPTH)[c]	WELL COMPLETION DATE[c]	LOCATION COMMENTS AND UNCERTAINTIES
A. DOE Wells			B 00410											
1 •	11(SG)		B 00410 POD31		DOE	B-410 POD31	469875	1558335	12N 10W 7	11/15/2017	306	265–295 (265)	7/14/2012	
2 •	13(SG)		B 00410 POD27		DOE	B-410 POD27	472766	1546949	12N 10W 19	11/16/2017	314	270–300	6/27/2012	
3 •	14(SG)		B 00410 POD28		DOE	B-410 POD28	463599	1548886	12N 11W 24	11/14/2017	335	285–315	7/11/2012	
4 •	15(SG)		B 00410 POD29		DOE	B-410 POD29	469224	1550341	12N 10W 19	11/16/2017	388	341–371	6/20/2012	
5 •	16(SG)		B 00410 POD25		DOE	B-410 POD25	468715	1553799	12N 10W 18	11/14/2017	235	195–225	6/14/2012	These data used in lieu of S(SG) or OBS-3.
6 •	18(SG)		B 00410 POD30		DOE	B-410 POD30	468136	1547203	12N 10W 19	11/15/2017	305	260–290	6/7/2012	
7 •	I(SG)	0923	B 00410 O-10	BW-28	DOE	BW-28, B-410 O-10, HMC-923	478106	1552131	12N 10W 17	11/16/2017	330	Open hole from 236–330 ft	7/23/1979	POE well located east of the Bluewater disposal cell.
8 •	L(SG)		B 00410 O-15	BW-25	DOE	BW-25, B-410 O-15	463035	1553955	12N 11W 13	11/14/2017	610	--	1/18/1981	Background well for the site.
9	OBS-3		B 00410 O-22	BW-27	DOE	BW-27, B-410 O-22	468776	1554101	12N 10W 18	11/15/2017	363	152–350	2/23/1981	Well integrity and more recent data in question. 16(SG) most representative of SAG aquifer conditions in this region.
10	S(SG)		B 00410 O-14	BW-26	DOE	BW-26, B-410-O-14	468775	1553098	12N 10W 18	11/14/2017	336	159–280	2/23/1981	Well integrity and more recent data in question. See comment for S(SG) above.
B. HMC Well Designations			B 00028	*Refer to Section C of this table (municipal wells) for information on HMC well IDs 532, 998, and 999. Coordinates listed below are those reported by HMC unless otherwise noted.*										
11 •	#1 Deepwell	#1 Deepwell		BW-29	HMC	BW-29, UN-HP #1 (HSI No. S-72)	493633	1543307	12N 10W 26	10/17/2016	1000	919–999 (955)	1/1/1979	Recent data not used to develop 2017 SAG uranium plume, given well structural issues reported by HMC. Well to be replaced by Deep #1R and monitored quarterly (HMC 2018).
12 •	#2 Deepwell	#2 Deepwell		BW-30	HMC	BW-30, UN-HP #2 (HSI No. S-71)	490972	1542424	12N 10W 26	11/20/2017	870	-- (800)		Fresh water supply well; HMC notes reduced production rate in recent years (HMC 2018). Recent well integrity tests indicate that the well may be compromised. Well to be replaced by Deep #2R and monitored quarterly (HMC 2018).
13	534	0534	Not found	--	Type = UNK --		476549	1534589	11N 10W 4	7/24/1956 (no uranium data)	1000	--	--	HMC coordinates uncertain as plotted location differs from that shown in their annual reports. Associated data are limited, for both water levels and groundwater chemistry.
14	535	0535	Not found	--	Type = UNK DUBL-J per HMC records	USGS 11N.10W.04.333, = Site No. 351216107541701 former Dow well (HSI Map No. S-8)	478450	1530100	11N 10W 4	7/24/1956	198	--	--	Limited chemical (uranium) data (n=2); USGS water level data from 1958–2016.
15 •	545* (BSAG-8)	0545	B 00050 A POD B 00050 A B-50A well log	BSAG-8, BW-20	Type = IRR Karl Gutierrez	B-50A, BSAG-8, BW-20, Gutierrez (= LM sample ID B00050A from SSR, [DOE 2014])	476604 (DOE)	1540223 (DOE)	12N 10W 29	7/25/2017	330	Open hole	4/3/1998	High-production irrigation well southeast of Bluewater and west-southwest of Homestake. Using DOE coordinates for 10/1/2013 sample point B00050A as well sampled only once by HMC (in 2004).
16	806	0806	B 00005 B-5 plug record Well abandoned in late 2014	LSM-41	Type = IRR Murray Acres Irrigation Assoc.	B-5, Murray Acres Irrigation Association, LSM-41	486320	1541120	12N 10W 27	10/9/2014 (invalid); 10/2/2007 (most recent valid result)	584	-- (520)	Sep-1955 (well construction records incomplete)	Well plugged in late 2014 due to a casing breach. Replaced by well 0806R (B-5R). Data from 1997–2007 appear to be valid (i.e., representative of the SAG); those from October 2014 (HMC and NMED) are likely not.
17 •	806R* (BSAG-15)	0806R	B 00005 B 00005 POD2 B-5R log B-5R OSE APP	BSAG-15, LSM-46 (not LSM-41 as reported by NMED, based on uranium chemistry)	Type = IRR W.A. Murray	B-5 (POD2), BSAG-15, LSM-46, Murray Acres Irrigation Association B-5 (POD2) is also referred to as B-5R and B-5 CLW in OSE documentation	486264	1541177	12N 10W 27	7/26/2017	580 (OSE, NMED) 600 (HMC)	510–580 (510) (annual report) 504–600 (GRANTS.mdb) Open hole (no perforations) per well log and OSE records	3/4/2008	Irrigation well installed in 2008 to replace well 0806. Well sampled by NMED 4 times: Oct-2014, Jun-2015, Nov-2016, and Jul-2017. Uncertainties: Discrepancies in reported TD (600 per HMC, but 580 per OSE and NMED) and screened interval (see columns to left). HMC's most recent (5/4/2017) uranium result, 0.114 mg/L, is anomalous and inconsistent with the historical record (uranium concentrations fairly stable at about 0.02 mg/L).
18	822	0822	B 00005 F POD B 00005 F	--	Type = IND Various: Tri-State (OSE), Plains (HMC), Siemens (HSI)	OSE B-5F (B 00005 F); various owners (see column to left)	488630	1538920	12N 10W 34 South of Murray Acres	11/20/1996	980	790–875 (790)	7/1/1964	Limited chemical data (n= 4) and over 20 years since last sampling. The most recent uranium result from Nov-1996 was 0.096 mg/L.

Table A-1. Crosswalk for Bluewater Study Area San Andres-Glorieta Wells (continued)

ROW NO.	STUDY ID[a]	HMC ID	OSE PERMIT NO. OSE POD NO.[b]	NMED ID(s)	WELL OWNER OR USER	ALL ALIASES COMBINED	X	Y	TWS RNG SEC	MOST RECENT RESULT (as of 12/31/17)	TD (ft bgs)	SCREENED INTERVAL (ft bgs) (SAG TOP DEPTH)[c]	WELL COMPLETION DATE[c]	LOCATION COMMENTS AND UNCERTAINTIES
B. HMC Well Designations Cont.	*Coordinates listed below are those reported by HMC unless otherwise noted.*													
19	907	0907	B 01827	--	Type = MON Village of Milan (per HMC and OSE)	USGS Site No. 351104107534701 (11N.10W.04.211) (identified as USGS 10 in the SSR [DOE 2014])	480800	1534250	11N 10W 4	1/26/2016	360 See notes	295–360 (262)	Before 2/26/1946 (date of initial USGS field measurements)	Well recently sampled as part of EPA's San Mateo Creek Basin groundwater investigation (Weston 2018). Total and dissolved uranium concentrations measured in the well were 0.011–0.013 mg/L and 0.012–0.019 mg/L, respectively (below the MCL). Discrepancies in well depth (TD) between HMC and USGS records attributed to the fact that the well was deepened from 315 ft to 360 ft in April 1947, but the USGS site was not updated to reflect this.
20 •	911* (BSAG-5)	0911	B 00049 B00049 POD B-49 well log B 00049 1990 APP	BSAG-5, BW-15	Type = SUB Village of Milan, former John Evans	B-49, BSAG-5, BW-15, HMC-911 Near, but not verified to be colocated with USGS 351304107541801 (11N.10W.05.212)	476553 (NMED)	1534596 (NMED)	11N 10W 5	6/30/2015 Data limited: 7/17/96, 8/25/08, and 6/30/15 only	188 Nearby USGS well TD=225	--	4/26/1957	Per NMED (2015), this is an inactive municipal well. Uncertainties: XYs differ, especially HMC's. For study purposes, using most recent latitude–longitude from NMED for BSAG-5. Possibly coincides with USGS location which corresponds to HSI Gallup Stake Irrigation Sec. 5.
21 •	928	0928	NA Well abandonment began in late 2017	BW-32	HMC	BW-32, Roundy Sec. 23 (HSI), USGS 351519107513901 (12N.10W.23.233)	491700	1548250	12N 10W 23	2016 Last valid SAG = Dec-2007	865	804–865 per HMC (801)	Before 6/27/1940 (date of initial USGS field measurements)	HMC well integrity tests revealed that this well was compromised and likely no longer fed by groundwater in the SAG (Hydro-Engineering 2015). The well was abandoned in late 2017.
22 •	938* (BSAG-4)	0938	B 00196 1994-02-25 APP	BSAG-4, BW-06	Type = IRR ARCO (owner of record)	BSAG-4, BW-06, B-196, USGS 351354107552401 former Cottonwood Well (S-36) in HSI 1981 report	473140 (NMED)	1539621 (NMED)	12N 10W 32 (12N.10W.32.111)	7/28/2017	253	No perforations noted (120)	1946	Private irrigation well. Given discrepancies in coordinates, for study purposes, using most recent latitude-longitude from NMED for BSAG-4. Also referred to as "USGS 6" well in the SSR (DOE 2014). There is no indication that this well is being used for irrigation at this time (POD record not found).
23 •	943	0943	Well abandoned (SAG sealed) on 7/19/2018	BW-33	HMC	BW-33 (B-28-S-329 not confirmed) USGS 351331107523401 (12N.10W.34.412, labeled as "USGS 12" in SSR [DOE 2014])	487407	1537222	12N 10W 34	10/17/2017	978	703–978 (704)	1/1/1980	Well found to be compromised based on recent HMC well integrity tests. Leakage into the SAG was observed prior to the well's abandonment in late July 2018 (HMC 2018). This well was replaced by 943M in late 2017.
24	943M New well	0943M	B 00028 POD 1384 943M well log 943M metadata	New well	HMC	B-28 POD 1384	487238	1537358	12N 10W 34	New well	800	740–800 (710)	12/28/2017	Well installed in December 2017 to replace well 943 (217 ft northwest of well 943). No chemical data yet as of June 2018. Along with well 951R, this well will be used for fresh water supply (HMC 2017). Well slated for semiannual to annual sampling (HMC 2018).
25 •	949	0949	B 00044 POD B 00044 B-44 well records 2000-07-14 APP	BW-23	Type = IND Tri-State Assoc. (former Plains Electric)	B-44, BW-23	483600	1540350	12N 10W 27	8/25/2008	542 (OSE) 551 (HMC)	Uncertain; HMC reports both: 400–493 (460) 505–551 (460)	Initial install: 2/19/1950 Repair: 7/15/1984	Well repaired/cleaned on 7/15/1984; newly reported depth of 542 ft (versus initial 551 ft). Screened interval uncertain. Along with well 995, well provides water supply for the Tri-State power plant. Well slated for semiannual to annual sampling (HMC 2018).
26 •	951	0951	B 00017 POD B 00017	BW-34, SMC-01	Type = MON Tri-State (per OSE); former Sabre-Pinon Corp. well	HMC-951, BW-34, SMC-01, Sabre Pinon, USGS 12N.10W.20.333A = Site No. 351452107552301 (UGSS 7 in SSR [DOE 2014])	473124 (DOE)	1545336 (DOE)	12N 10W 20	11/15/2017	275	241–275 (227)	2/1/1957	This well has been regularly sampled by both HMC and DOE. Coordinates listed here are those surveyed by DOE; these are slightly different from those documented in HMC reports. This well was replaced by 951R as HMC's fresh water supply in April 2012.
27 •	951R	0951R	B 00028 (OSE POD cross-reference is incorrect) B00028 POD1340 Well log and OSE main summary incorrectly cross-reference to: B00028 POD1338	None	HMC	No aliases	484100	1544500	12N 10W 27	10/23/2017	525	HMC: 415–425 (420) Well log indicates open-hole construction	4/20/2012	Fresh water supply well and replacement well for 0951; HMC notes reduced production rate in recent years (HMC 2018). Although HMC's reports and database indicate perforations at 415–425 ft, the well log indicates open hole construction.

Table A-1. Crosswalk for Bluewater Study Area San Andres-Glorieta Wells (continued)

ROW NO.	STUDY ID[a]	HMC ID	OSE PERMIT NO. OSE POD NO.[b]	NMED ID(s)	WELL OWNER OR USER	ALL ALIASES COMBINED[c]	X	Y	TWS RNG SEC	MOST RECENT RESULT (as of 12/31/17)	TD (ft bgs)	SCREENED INTERVAL (ft bgs) (SAG TOP DEPTH)[c]	WELL COMPLETION DATE[c]	LOCATION COMMENTS AND UNCERTAINTIES
B. HMC Well Designations Cont.														
28 ●	955 (BSAG-1)	0955	B 00510 POD B 00510 B-510 well record	BSAG-1, BW-02	Type = DOM Multiple per OSE records (current owner, uncertain)	B-510, BSAG-1, BW-02, HSI Guthrie (Map No. S-51) Although sampling was planned, BSAG-1 could not be accessed by NMED in 2015–2017	483699	1537338	12N 10W 34	8/25/2008	498	385–498 (420)	3/31/1978	West-central portion of Section 34, south of Valle Verde. Current owner not confirmed (many prior). Given reported leakage in well 943, HMC proposes to resume sampling of this well on a semiannual to annual basis (HMC 2018).
29 ●	986 (BSAG-2)	0986	B 00700 POD B 00700 B-700 well record	BSAG-2, BW-03	Type = DOM Lee Thompson per OSE (Leon Bachman per NMED)	B-700, BSAG-2, BW-03, HSI Guthrie (S-51) BSAG-2 could not be accessed by NMED in 2015–2017	483690	1537894	12N 10W 34	11/13/2008	467	420–467 (415)	4/1/1988	Well located east of Valle Verde. Not sampled since 2008.
30 ●	991 (BSAG-3)	0991	B-44 per NMED B 00044 Above not confirmed; conflicts with information for well 949; see row 25	BSAG-3, BW-04	Type = UNK Art Gebeau per NMED, HMC	BSAG-3, BW-04 (corresponding OSE permit no. not confirmed) BSAG-3 could not be accessed by NMED in 2015–2017	483630	1538873	12N 10W 34	8/27/2008	500	--	--	Uncertainties re: OSE permit number, owner, and location. Well last sampled by both HMC and NMED in Aug-2008 (U = 0.007 mg/L). The only previous sampling was in 1995 (U < 0.01 mg/L). HMC proposes to resume sampling of this well on a semiannual to annual basis (HMC 2018).
31	995	0995	B 00045 POD B 00045 B-45 well record		Type = IND/IRR Tri-State Assoc., former Plains B-45	Tri-State, Plains B-45	476594	1540115	12N 10W 29	8/23/1995 (uranium = 0.012 mg/L)	369	--	7/25/1984 (date of well repair; original install was August 1944)	Well just south of HMC well 545 (B-50A). Based on HMC records, there is limited information and data for this well: sampled 6/28/1956, 5/14/1958, and 8/23/1995. Uranium was analyzed only once (in 1995). This well is mentioned in HMC's recent letter (HMC 2018) as one of the Tri-State power plant supply wells.
C. Municipal SAG Wells in the Bluewater Study Region[d] *Milan Well #2 (B-24) is inactive with no corresponding sample point (25533002).*														
32 ●	Milan Well #1* (BSAG-16)	0532	B 00023 (includes links to logs and repair applications) POD B 00023	BSAG-16, LSM-43	Type = MUN Village of Milan	OSE B-23, B 00023, BSAG-16, LSM-43, Village of Milan Well #1, HMC-532, NMDWB Sample Point ID/Link: 25533001	482345	1518855	11N 10W 21	7/26/2017	214	Apparent open-hole construction	Original 135 ft well: 6/5/1969 repair/deepen: Nov-1971	Along with Village of Milan Wells #3 and #4 (HMC wells 999 and 998, respectively), these are the closest municipal wells to the Bluewater and Homestake sites. Uncertainties: coordinates differ depending on data source. For study purposes, using BSAG-16 *XY* data (these plot closely to those in the NMDWB database).
33 ●	Milan Well #3* (BSAG-10)	0999	B 00035 POD not found	BSAG-10, LSM-44	Type = MUN Village of Milan	OSE B-35; NMED BSAG-10 and LSM-44; HMC-999; City of Milan Well #3 NMDWB ID: 25533003	480145 (HMC= 483690)	1524202 (HMC= 483690)	11N 10W 9	7/26/2017	180	Well log not found	--	North of Milan Well #1, near junction of Hwy 122 and Hwy 605.
34 ●	Milan Well #4* (BSAG-6)	0998	B 00050 POD B 00050	BSAG-6, BW-16	Type = MUN Village of Milan (Golden Acres)	OSE B-50, BSAG-6, BW-16, HMC-998, Village of Milan Well (#4) Golden Acres. NMDWB ID: 25533004	476615	1533105	11N 10W 5	7/27/2017	175	Well log not found	1/1/1955	Uncertainties: coordinates differ depending on data source. For study purposes, using BSAG-6 *XY*.
35 ●	Grants Well #1* (BSAG-11)	--	B 00038 POD B 00038	BSAG-11	Type = MUN City of Grants	OSE B-38; BSAG-11, City of Grants Well #1;NMDWB ID 26133001	487603	1512372	11N 10W 27	7/26/2017	300	Well log not found	8/2/1960	This well was sampled by NMED in June 2015 and July 2017 (not in 2016).
36 ●	Grants Well #3* (BSAG-12)	--	B 00040 B 00040 POD	BSAG-12	Type = MUN City of Grants	OSE B-40 (B 00040), BSAG-12, City of Grants Well #3, HSI Map No. S-66 NMDWB ID: 26133003	486764	1514640	11N 10W 22	7/26/2017	367	Well log not found	9/30/1976	Well near the eastern edge of the subcrop of San Andres, south of Black Mesa. OSE and NMED cite a TD of 367 ft, while NMDWB cites a TD of 388 ft.

Table A-1. Crosswalk for Bluewater Study Area San Andres-Glorieta Wells (continued)

ROW NO.	STUDY ID[a]	HMC ID	OSE PERMIT NO. OSE POD NO.[b]	NMED ID(s)	WELL OWNER OR USER	ALL ALIASES COMBINED	X	Y	TWS RNG SEC	MOST RECENT RESULT (as of 12/31/17)	TD (ft bgs)	SCREENED INTERVAL (ft bgs) (SAG TOP DEPTH)[c]	WELL COMPLETION DATE[c]	LOCATION COMMENTS AND UNCERTAINTIES
D. NMED BSAG- Wells Not Addressed Above (most with limited information)														
37 •	B-518* (BSAG-7)	--	B 00518 B 00518 POD2 B-518 POD2 well record (former Sturges well under initial POD for 182 ft well, later plugged)	BSAG-7 BW-19	Type = DOM Robert E. and Marti Kay Smith	BSAG-7, BW-19, B00518 POD2, Smith well LM location code used in 2014 Was B00518 in SSR (DOE 2014)	471504 (NMED)	1542278 (NMED)	12N 10W 30	7/27/2017	250	210–250 Water-bearing stratifications: 190–240 ft sandstone/gravel/ conglomerate	6/26/2006	Household domestic well (formerly Sturges well). Numerous discrepancies in coordinates depending on source (B00518 versus B00518-2). NMED coordinates for BW-19 plot 1300 ft SW of those of the alleged alias BSAG-7. OSE *XY* based on PLSS; none align with those from LM or NMED. For study purposes, using most recent coordinates provided by NMED for BSAG-7.
38	B-1458* (BSAG-9)	--	B 01458 (Elkins) POD B 01458 B-1458 well record	BSAG-9 BW-35	Type = DOM Roy Mark Elkins	BSAG-9, BW-35	500595 (NMED)	1557110 (NMED)	12N 09W 7	7/25/2017	702	682–702	3/7/2001	Well in far northern part of study area, east of Hwy 605 along San Mateo Creek drainage. Most recent uranium = 0.001 mg/L. Results not posted in main report because of well's location far north of the plume area.
39	B-1771* (BSAG-13)	--	B 01771 B 01771 POD1 B-1771 LOG B-1771 APP	BSAG-13 LSM-47	Type = DOM Kit K South	BSAG-13, Kit South well, B 01771 (POD1)	497839 (NMED)	1555965 (NMED)	12N 10W 12	7/25/2017	635	Well log not found Water-bearing stratifications: 520–600	3/17/2009	Northern part of study area, about 0.3 mi west of Hwy 605. Slightly elevated uranium (0.022 mg/L) not attributable to Bluewater site contamination. Like BSAG-9, results not posted in main report because of well's location far north of the plume area.
40	BSAG-14*	--	OSE permit not found: near or possibly = B 01072	BSAG-14 LSM-42	Type = DOM? Georgia Matthews	BSAG-14, LSM-42, owner Georgia Matthews (owner not found in OSE records for this region)	488528 (NMED)	1529906 (NMED)	11N 10W 3	6/23/2015 (U = 0.02–0.03 mg/L)	--	Well log not found If B-1072, =484–510	If B-1072, 8/20/1984	South-southwest of Homestake site, ~ east of Hwy 605 In region of former SMC-04 and SMC-05 locations, about 1 mi north of Black Mesa. Well sampled by NMED in 2015 only. The lack of recent sampling data, combined with uncertainties re: permit number and corresponding well information, warranted this well's exclusion from the 2017 uranium plume map in the main body of this report.
E. Remaining SAG Wells in the Bluewater Study Region With Limited Data (no recent sample data; most with only one-time sampling)														
41 •	B-3	--	B 00003 B00003 EXPL B-3-0 well record	--	Type = IND ARCO (owner of record) C. Elkins (per DOE communication)	B-3, B 00003 EXPL, B-3-0 DOE location code used in 2014 Site Status Report was B00003. In 2014 Site Status report, this well was labeled as Anaconda #1.	465450 (DOE)	1547681 (DOE)	12N 11W 24	8/13/2013	511	Apparent open-hole construction Water-bearing stratifications: 270–500 ft	7/23/1979	Roughly 0.5 mile south of carbonate disposal cell. One-time sampling by DOE in August 2013. Uranium measured at 0.087 mg/L. Uncertainty: Because of differences in coordinates depending on data source (e.g., OSE versus DOE survey data), It is not clear whether the well sampled by DOE in 2013 corresponds to B 00003X or B 00003 EXPL.
42 •	B-18	--	B 00018 POD B 00018	BW-21	Type = IND Tri-State Generation and Trans.	B 00018, BW-21	477799 (NMED)	1529435 (NMED)	11N 10W 8	8/25/2008 (one-time sampling by NMED)	275	--	2/1/1957	Well information for both B-18 (BW-21) and B-19 (BW-22) are exactly the same, but based on coordinates, these wells are 0.5 mile away from one another. Limited information and data (one-time sampling in 2008).
43 •	B-19	--	B 00018 POD B 00019	BW-22	Type = IND Tri-State Generation and Trans.	POD B 00019, BW-22 (B00019 in 2014 SSR)	475656 (NMED)	1529454 (NMED)	11N 10W 8	8/25/2008 (one-time sampling by NMED)	275	--	2/1/1957	See notes above for B00018. The fact that these two apparently distinct wells (based on location) have exactly the same characteristics and install dates is a source of uncertainty.
44	B-168	--	B 00168 POD B 00168 *or(?)* B 00168 POD2	--	Type = DOM T. Rowley (owner of record) C. Elkins (per DOE communication)	LM location code in SSR (DOE 2014) was B00168	461282 (OSE) 458721 used in SSR (DOE 2014)	1549291 (OSE) 1555989 used in SSR (DOE 2014)	12N 11W 23	8/13/2013 (one-time sampling by LM; U = 0.009 mg/L)	490 (B00168 POD2)	430–490 (B 00168 POD2)	4/12/2011 (B 00168 POD2)	2014 SSR reported B 00168 as an alluvial well colocated with Berryhill House, based on coordinates that were in retrospect incorrect. After further examination of OSE records, this appears to be a SAG well. It is uncertain whether the well sampled by DOE corresponds to POD B 00168 or B 00168 POD2.
45 •	B-1614	--	B 01614 POD B 01614 B 01614 well log		Type = DOM Uncertain as to owner: Chavira or Martinez?	LM location code used in 2014 Site Status Report was B01614	468585 (DOE)	1541060 (DOE)		10/2/2013	185	165–185	9/21/2004	Per LM records: Frost-free spigot about 50 meters east from the Mr. Martinez home. However, OSE records indicate different owners: M. and R. Chavira.

Table A-1. Crosswalk for Bluewater Study Area San Andres-Glorieta Wells (continued)

Notes:

* Denotes well currently (or recently) sampled by NMED (with BSAG- prefix). To facilitate identification, NMED BSAG IDs are listed below the study IDs (in parentheses).
● Denotes San Andres-Glorieta well (and associated data) used to develop the previous (2008–2013) plume map, but not the current (2017) snapshot.
● Denotes San Andres-Glorieta well used to develop the current (2017) plume map only.
● Denotes San Andres-Glorieta well used to develop both the previous (2008–2013) and current (2017) plume maps in the main body of the report.

[a] Wells are listed in the following order: DOE wells; Homestake wells; Bluewater Basin municipal wells (Milan and Grants systems); and remaining SAG wells not routinely monitored by DOE, HMC, or NMED's Drinking Water Branch. Initial column (row number) provided to facilitate cross-referencing. Except for recently abandoned wells (wells 806, 928, and 943 [rows 16, 21, and 23]), only existing (nondecommissioned) wells are included in this summary.
[b] Links are to water rights and POD summaries and other well information provided on the OSE website. In most cases, links to OSE POD summaries are not provided for HMC-owned wells because of the sheer number (hundreds) of wells listed under HMC's general permit (B 00028). Note: In some cases, links to well- or POD-specific information may not work unless OSE's home page is accessed first (http://nmwrrs.ose.state.nm.us/nmwrrs/index.html).
[c] Well construction and completion information is based on a variety of sources, some of which conflict. Where available, well construction logs (including those maintained by DOE) were used as the primary source. If well construction logs were not available, these fields were populated based on HMC, NMED, NMDWB, OSE, or USGS records.
[d] Additional information regarding Bluewater Basin municipal wells can be found at: Milan Community Water System Fact Sheet and the Grants Domestic Water System Fact Sheet.

Abbreviations:

-- = unknown or not applicable
ARCO = Atlantic Richfield Company
bgs = below ground surface
DOM = domestic (one household) well use designation in OSE records
IND = industrial (water use)
IRR = irrigation (water use)
LM = Office of Legacy Management
LSM = Lower San Mateo (Creek)
MON = monitoring (well use)
MUN = municipal (well)
NMDWB = New Mexico Drinking Water Branch
his = HydroSearch, Inc., data source for early (1980–1981) site characterizations
mg/L = milligrams per liter
NA = not applicable
POE = point of exposure
RNG = range
SEC = section
SG = San Andres Glorieta aquifer
SSR = Site Status Report (DOE 2014)
SUB = subdivision (water use)
TD = total depth
TWS = township
U = uranium
UNK = unknown
X = Easting
Y = Northing

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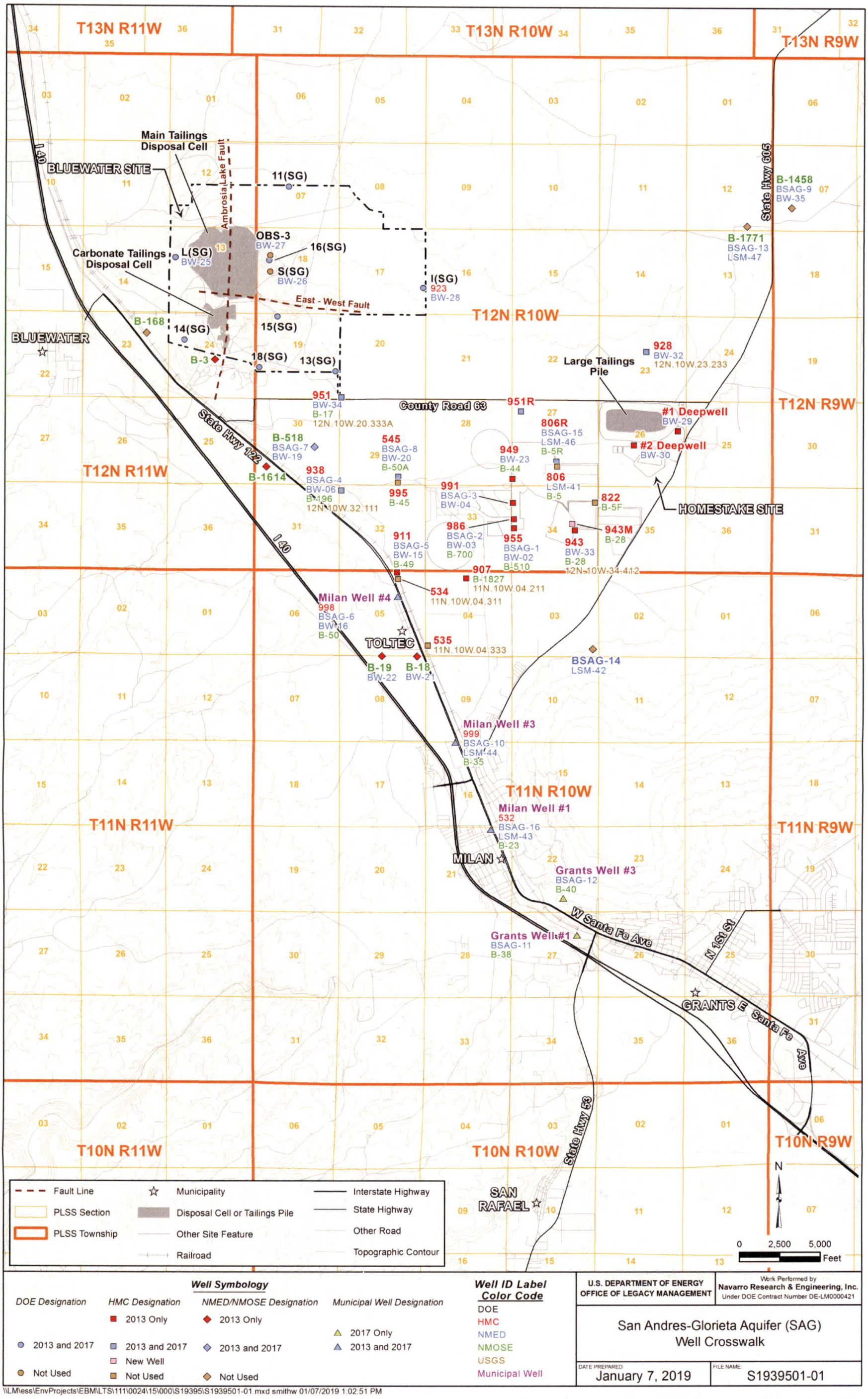
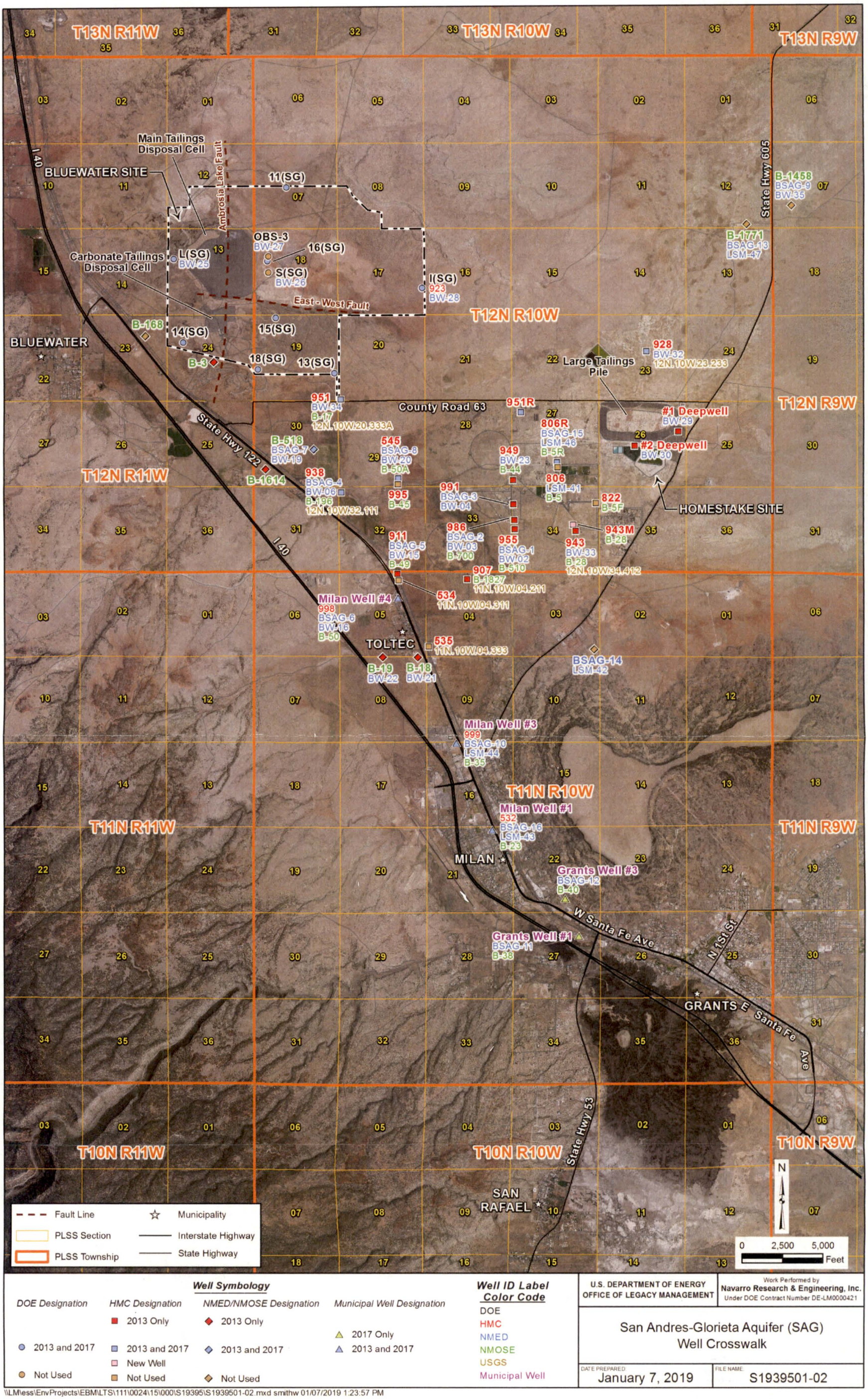


Note: SAG wells installed wells hydraulically upgradient of the Bluewater site and west of State Highway 122 (outside the recharge area) are excluded from this figure.

Figure A-1. San Andres-Glorieta Wells in the Grants-Bluewater Valley Study Region



Well Symbology

DOE Designation	HMC Designation	NMED/NMOSE Designation	Municipal Well Designation
	2013 Only	2013 Only	2017 Only
2013 and 2017	2013 and 2017	2013 and 2017	2013 and 2017
	New Well		
Not Used	Not Used	Not Used	

Well ID Label Color Code

DOE
HMC
NMED
NMOSE
USGS
Municipal Well

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421

San Andres-Glorieta Aquifer (SAG)
Well Crosswalk

DATE PREPARED: January 7, 2019

FILE NAME: S1939501-02

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Note: SAG wells installed wells hydraulically upgradient of the Bluewater site and west of State Highway 122 (outside the recharge area) are excluded from this figure.

Figure A-2. San Andres-Glorieta Wells in the Grants-Bluewater Valley Study Region Overlying Aerial Imagery