MONTGOMERY
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Water Resource Consultants

REPORT

September 19, 2017

Prepared for: aps

Cholla Power Plant Coal Combustion Residuals Program - Design, Installation, and Evaluation of Completeness of Groundwater Monitoring Networks Navajo County, Arizona

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ARIZONA PUBLIC SERVICE, NAVAJO COUNTY, ARIZONA

CERTIFICATION STATEMENT

I, Lyle Davis, P.E., have reviewed Montgomery & Associates' report entitled *Cholla Power Plant Coal Combustion Residuals Program – Design, Installation, and Evaluation of Completeness of Groundwater Monitoring Networks* (Report), dated September 18, 2017, and certify the following for the Arizona Public Service Cholla Power Plant in relation to requirements for the U.S. Environmental Protection Agency Coal Combustion Residual (CCR) Rule (the Rule):

- Groundwater monitoring systems associated with each of the CCR Units have been designed and constructed to ensure that monitoring data will accurately represent the quality of groundwater that has not been affected by leakage from the CCR unit (background) and the quality of groundwater passing the waste boundary (downgradient), consistent with requirements of § 257.91 of the Rule.
- A sufficient number of monitor wells has been installed at each of the CCR Units to meet the performance standards in § 257.91(a)(1) and (2).
- In cases where the number of downgradient monitor wells installed at a particular CCR Unit is equal to the Rule-required minimum of three (3), the Report provides satisfactory technical justification that the number of downgradient monitor wells installed is sufficient to characterize potential leakage, based on requirements of § 257.91 of the Rule.

Stamp

Signed: Lyle A Davis

Dated: September 19, 2017

Registered Professional Engineer (Civil)
CERTIFICATE NO.
18752
LYLE A.
DAVIS
Date Signed 9/19/2017
ARIZONA, U.S.A.
EXPIRES 9/30/2017

I, Leslie T. Katz, P.G., certify that I provided supervision for design and installation of monitor wells for the Cholla CCR monitoring program, pursuant to requirements of the Rule.

Stamp

Signed: Leslie T. Katz

Dated: September 19, 2017

REGISTERED GEOLOGIST
CERTIFICATE NO.
28245
LESLIE T.
KATZ
Date Signed 9/19/17
ARIZONA, U.S.A.
Expires 9/30/18

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1 SITE LOCATION AND PROJECT DESCRIPTION

Montgomery & Associates (M&A) designed monitoring networks and provided field oversight for installation of groundwater monitor wells at the Arizona Public Service (APS) Cholla Power Plant (Cholla) as part of the requirements for the U.S. Environmental Protection Agency (EPA) Coal Combustion Residual (CCR) Rule (the Rule). The Cholla facility is located near Joseph City in Navajo County, Arizona, along the north bank of the Little Colorado River (LCR). This report was prepared to describe monitoring network siting, design, drilling, construction, and development procedures associated with each of four Cholla CCR Units[1] that are subject to the Rule. The CCR Units include: the Fly Ash Pond (FAP), Bottom Ash Pond (BAP), Bottom Ash Monofill (BAM), and Sedimentation Pond (SEDI), as shown on **Figure 1**. The SEDI was the first of the CCR Units placed into service (1976). The FAP and BAP dams were completed in 1978 and the BAM came into operation in the late 1990s. It should be noted that the large pond located just southwest of the power plant, Cholla Reservoir, is used for cooling water recirculation and is not a CCR Unit (**Figure 1**). Significant hydrogeologic and water quality data were reviewed and interpreted in an effort to design comprehensive and responsive monitoring networks for each of the Units. Background information on provisions of the Rule, site hydrogeology, and the Cholla CCR Units is provided as context for siting and design of the new monitor wells. To ensure compliance with the Rule, field procedures and monitoring results for CCR monitor wells are evaluated promptly to ensure that the well networks continue to provide a complete and representative data set for each Unit.

[1] CCR Unit – *All new and existing landfills, surface impoundments, or lateral expansions that contain or manage CCR generated from coal combustion at an electric utility or independent power production facility.*

2 PURPOSE

2.1 Establish CCR Monitoring Networks

The primary purpose of this report is to document installation and provide justification for and certification of the monitoring networks established at each of the Cholla CCR Units relative to requirements of the Rule. The report describes monitoring network well locations, well design, field program planning, and well installation. The report also presents and analyzes hydrogeologic and water level data to justify the adequacy of groundwater monitoring systems for each Unit to meet requirements of the Rule.

Wellfield certification will be based on demonstrating that each groundwater monitoring system consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent: (1) the quality of background groundwater that has not been affected by leakage from each CCR unit, and (2) the quality of groundwater passing the waste boundary[2] of each CCR Unit (Rule, 257.91, a, 1 and 2). CCR monitor well network certification will be conducted by Lyle Davis, P.E. in a certification statement to accompany this report.

[2] Waste Boundary – *The waste boundary comprises a vertical surface located at the hydraulically downgradient limit of the CCR unit. The vertical surface extends down into the uppermost aquifer. Monitoring wells must be located as near as possible to the waste boundary.*

3 KEY COMPONENTS OF CCR RULE

On April 17, 2015, the EPA released the final version of the Rule regarding the disposal of CCR from power production facilities. The Rule defines CCR landfills and surface impoundments and establishes minimum criteria for the following: (1) CCR unit design and operation, (2) groundwater monitoring and corrective action, (3) closure requirements, (4) post-closure care, (5) recordkeeping, (6) notification, and (7) internet posting requirements. Programs in place at the Cholla Power Plant to meet criteria established for CCR unit groundwater monitoring are the focus of this report.

3.1 Monitoring Requirements

The Rule defines a minimum acceptable *groundwater monitoring system*[3] for a *CCR Unit* along with additional factors that should be considered in determining if the minimum system is adequate. Additionally, the Rule specifies the required sampling program for the groundwater monitoring network.

3.1.1 Number and Distribution of Wells

The Rule requires that a monitoring well network be developed for each CCR Unit, with upgradient and downgradient wells to determine background groundwater quality in the *uppermost aquifer*[4] and the quality of groundwater passing the waste boundary of each CCR Unit.

Upgradient / Background Wells

A minimum of one monitor well that is located beyond the upgradient extent of potential contamination is required for each Unit. The purpose of upgradient wells is to determine background water quality. The Rule recognizes that background water quality may be

[3] *Groundwater Monitoring System* – The objective of a groundwater monitoring system is to provide samples of groundwater to accurately represent the quality of background groundwater and groundwater passing the waste boundary of a CCR Unit. A groundwater monitoring system must include a minimum of one upgradient and three downgradient monitoring wells. Justification must be provided to support use of a groundwater monitoring system that includes only the minimum number of wells.

[4] *Uppermost Aquifer* – The uppermost aquifer comprises the geologic formation nearest the natural ground surface that may be considered an aquifer, as well as lower aquifers that are hydraulically connected with this aquifer within the facility's property boundary. The groundwater level used for this determination is the point nearest to the natural ground surface to which the aquifer rises during the wet season. Systems encompassed by this definition include shallow, deep, perched, confined or unconfined aquifers, provided they yield usable water. The term "usable" is not clearly defined in the Rule.

better established in wells that are not located hydraulically upgradient from a CCR Unit in the following circumstances:

1. Flow directions in the uppermost aquifer change seasonally, in response to surface water flows, or in response to pumping
2. Upgradient groundwater quality is contaminated by another source
3. The Unit overlies a groundwater divide
4. Geologic units present at downgradient locations are absent in a direction that would normally be considered to be upgradient from the Unit
5. Groundwater flow is modified by karst terrain or fault zones

Circumstance #4 is present at two of the four Cholla CCR Units, as described in **Section 4.3**.

Downgradient Wells

A minimum of three wells are required at the downgradient perimeter of each Unit, or at the closest practical distance from this location. The purpose of the downgradient wells is to accurately represent the quality of water that may be passing the waste boundary of the CCR Unit.

4 CCR UNIT MONITORING NETWORK DESIGN

4.1 Hydrogeologic and General Water Quality Conditions

The primary hydrogeologic units encountered at Cholla, from shallowest to deepest, include the alluvial sediments associated with the LCR and Tanner Wash, the Moenkopi Formation, which is a regional aquitard, and the regional Coconino Sandstone Aquifer. A general overview regarding geologic, hydrologic, and water quality conditions in these units, as they occur in the vicinity of the Cholla Plant, is provided below.

4.1.1 LCR and Tanner Wash Alluvium

The LCR and Tanner Wash alluvial units are present in localized areas at the Cholla site, as shown on **Figure 2**. The alluvial units range in thickness from non-existent to nearly 200 feet. These alluvial deposits are fairly heterogeneous and include gravels, sands, silts, and clays. While both are unconsolidated, Tanner Wash Alluvium is generally more fine-grained than LCR Alluvium in the Cholla area, due to the nature of source rocks and the depositional environment. Over much of the study area, the LCR and Tanner Wash Alluvium are underlain by the Moenkopi Formation. Contours for thickness of the Moenkopi Formation are shown on **Figure 3**. The Chinle Formation over-lies the Moenkopi north of the Cholla area.

Tanner Wash drains a watershed comprised chiefly of the fine-grained rocks of the Chinle and Moenkopi Formations. Based on permeability testing conducted during design and construction of the BAP, hydraulic conductivity for the Tanner Wash Alluvium is reported to range from 0.06 to 0.44 feet per day (APS, 1984). The FAP was generally constructed on Moenkopi Formation bedrock, covered by a veneer of alluvial sediments within a historical drainage that previously contributed runoff to the LCR. A pumping test conducted at alluvium monitor well W-123, located immediately downgradient from the FAP indicated a hydraulic conductivity of 0.03 feet per day (APS, 1984). This test suggests that alluvial sediments immediately downgradient of the FAP have similar hydraulic properties as those in Tanner Wash.

Apart from areas immediately downstream of current or historical Chinle/Moenkopi drainages, lithologic information from drilling in the LCR Alluvium indicates that below the water table, which occurs at a depth of between about 25 and 45 feet, the unit generally comprises well-graded, gravelly sand. A slug test conducted following installation of background LCR Alluvium well M-64A yielded an average hydraulic conductivity of 66 feet per day. This value is anticipated to be fairly typical for the LCR Alluvium.

Depth to water level in the LCR and Tanner Wash Alluvium ranges from a few feet to more than 40 feet below land surface (bls) in the Cholla area, varying spatially based on proximity to recharge sources and topography as well as seasonally based on rainfall-runoff patterns. Direction of groundwater movement generally parallels the stream channels, flowing chiefly from east to west in the LCR Alluvium and from northeast to southwest in the Tanner Wash Alluvium. Groundwater movement in the LCR Alluvium is influenced by the presence of deeper paleochannels, where alluvium thickness exceeds 100 feet; these paleochannels do not always coincide with the location of the present river channel (**Figure 2**). Contours for water level elevation in the alluvial aquifer for June – July 2017 are shown on **Figure 4**.

Background alluvial water quality is known to vary widely based on geologic factors. With respect to Tanner Wash, there is reason to suspect that background water quality has naturally elevated TDS concentrations. Groundwater in the Tanner Wash alluvial aquifer moves through sediments derived from erosion of the Moenkopi and Chinle Formations, which occur at the surface in the Tanner Wash watershed. Both of these formations are composed of very fine-grained and evaporitic sediments, which would be anticipated to result in groundwater with high total dissolved solids (TDS) concentrations. With respect to the LCR, early data from the site suggests that background water quality in the LCR alluvium is variable and possibly fairly poor. Due to elevated TDS concentrations, limited saturated thickness, and recharge reliability constraints, groundwater in the LCR and Tanner Wash Alluvium is not used to a significant extent for water supplies. Outside of the Cholla area, the alluvium is reported to supply groundwater to stock wells along LCR tributaries and to a few domestic wells along the LCR. The LCR and Tanner Wash Alluvium are considered to be the uppermost aquifer for three of the four CCR units at the Cholla facility, as described in **Section 4.2**.

4.1.2 Moenkopi Formation

The Moenkopi Formation is present at land surface across a large portion of the Cholla area. The thickness of the Moenkopi Formation in the Cholla area ranges from non-existent to over 300 feet thick based on data from APS wells, as shown on **Figure 3**. Where a sufficient thickness is present, the Moenkopi Formation restricts the movement of groundwater from the shallow alluvial aquifers to the underlying Coconino Aquifer. The Moenkopi Formation is composed of three members; not all of these members are present in all locations, since part or all of the Moenkopi has been eroded away in certain areas. The upper Holbrook member is a blocky, well-consolidated sandstone and is relatively permeable. This member of the Moenkopi is not known to be present in the project area. The middle Moqui member is typically 250 to 300 feet thick near Cholla and makes up most of the Moenkopi Formation thickness. Consisting primarily of maroon and greenish mudstone with abundant gypsum, the Moqui Member is the primary confining unit within the Moenkopi Formation. The lower 30 to 50 feet of the Moenkopi Formation is the Wupatki member, comprised of relatively permeable sandstone. Where Moenkopi thickness is less than 50 feet (**Figure 3**), these sediments are assumed to comprise the Wupatki member.

Overall, the Moenkopi Formation has low permeability and poor water quality and is not, therefore, considered an aquifer. There are no reported uses of the Moenkopi for water supply in the region. With the exception of areas influenced by surface leakage, the shallower Moqui member of the Moenkopi Formation is reported to be dry. Only the more permeable lower Wupatki member is reported to be water bearing, and only in areas where the potentiometric surface in the underlying Coconino Aquifer is above the base of the Moenkopi.

4.1.3 Coconino Sandstone

The Coconino Sandstone underlies the Moenkopi Formation or the LCR Alluvium, where the Moenkopi is not present, across the Cholla area. It is a very fine- to fine-grained, cross-bedded, aeolian sandstone that has an average thickness of 375 to 400 feet in the Cholla area. Permeability of the Coconino Sandstone is highly variable and dependent on the degree of fracturing and cementation. Particularly where fractures are present, the Coconino Sandstone can be very permeable and yield significant quantities of water. It provides the water supply for operations at the Cholla facility and comprises the principal regional aquifer in the LCR basin of northern Arizona.

In southern Navajo County, groundwater in the Coconino Sandstone Aquifer generally moves from recharge areas in the higher altitudes along the Mogollon Rim to the north toward the LCR. Locally, however, patterns of groundwater movement have been affected by groundwater pumping in the Cholla wellfield. Pumping of Cholla water supply wells has created a cone of depression south of the LCR that results in localized convergent flow patterns. In the area along and south of the LCR, the direction of groundwater movement is generally westward. North of Cholla, direction of movement in the Coconino Aquifer is generally to the northwest. Contours for water level elevation in the Coconino Aquifer for June – July 2017 are shown on **Figure 5**.

Background water quality in the Coconino Aquifer is variable, and water quality is known to deteriorate significantly north of the LCR (Mann, 1976, and McGavock and others, 1986). Results of decades of Coconino Aquifer monitoring associated with the Cholla water supply wellfield indicate that TDS concentrations can vary over almost an order of magnitude in the Cholla area. Regional studies show that groundwater in the Coconino Aquifer generally contains less than 500 mg/L TDS in the area south of the LCR; however, TDS concentrations as high as 64,000 mg/L have been reported in the area north of the LCR (Mann, 1976, and McGavock and others, 1986). Background water quality in the Coconino Aquifer is also brackish in some areas south of the LCR due to upward leakage of saline groundwater from the underlying Supai Formation. The Holbrook anticline, located south of the Cholla water supply wellfield, represents an area of upward leakage from the Supai, which contains halite and gypsum beds (Mann, 1976). Other areas of suspected upward leakage occur along an inferred graben or syncline structure in the Coconino that coincides with the deeper, ancestral channel of the LCR (**Figure 2**). This structural feature likely provides an avenue for poor quality Supai Formation water to migrate upward into the Coconino and is interpreted to be responsible for poor quality water in several Coconino production and monitor wells near the current and ancestral channel of the LCR. Since the Coconino Aquifer historically discharged to the LCR and continues be a source of water to the LCR Alluvium in some areas, upward leakage from the Supai may also be a source of high TDS reported for groundwater samples from the LCR Alluvium.

4.2 Description of CCR Units

4.2.1 Fly Ash Pond

The FAP is the largest CCR surface impoundment at the site, with a surface area of 430 acres (**Figure 1**). The FAP was largely constructed on Moenkopi bedrock, with a veneer of alluvial sediments from the historic drainage. These alluvial sediments are up to 44 feet thick at the toe of the impoundment, where they merge with sediments of the LCR Alluvium aquifer, and are thin to absent near the edges of the current pond (**Figure 2**). The LCR alluvial aquifer is the uppermost aquifer for the FAP. Groundwater near the FAP waste boundary flows west-southwest through the shallow alluvial system adjacent to the dam and then to the west in the LCR Alluvium (**Figure 4**).

The Moenkopi Formation underlies the LCR Alluvium beneath the FAP. The Moenkopi has a thickness of 64 feet at well W-125, southwest of the FAP, and thickens to the north and east, where a thickness of 308 feet was encountered at well M-44D (**Figure 3**). The

Moenkopi is a confining unit and provides a barrier to vertical flow from the FAP into the Coconino Aquifer.

4.2.2 Sedimentation Pond

The SEDI is a small CCR surface impoundment comprising roughly 1.3 acres (**Figure 1**). The SEDI is constructed on LCR Alluvium and the LCR alluvial aquifer is considered the uppermost aquifer for this Unit. Groundwater in the LCR Alluvium beneath the SEDI flows from southeast to northwest approximately parallel to the direction of LCR surface water flows (**Figure 4**).

The LCR Alluvium rests on over 100 feet of Moenkopi in this area and is not anticipated to thin downgradient from the SEDI (**Figure 3**). The thick layer of Moenkopi in this area inhibits hydraulic communication between the LCR Alluvium and the Coconino Aquifer. The SEDI is located west and hydraulically downgradient from the FAP, BAP, and BAM (**Figure 1**).

4.2.3 Bottom Ash Pond

The BAP is a 105 acre CCR surface impoundment located in the Tanner Wash watershed. Tanner Wash is an ephemeral tributary to the LCR (**Figure 1**). The northern and western boundaries of the BAP rest directly on a thick section of Moenkopi Formation (**Figure 3**). The southern boundary of the BAP rests primarily on Tanner Wash Alluvium. The Tanner Wash alluvial aquifer is considered the uppermost aquifer for the BAP. Groundwater in the Tanner Wash alluvial aquifer flows south-southwest along Tanner Wash to its confluence with the LCR alluvial aquifer.

The Moenkopi Formation is more than 200 feet thick at wells south and east of the BAP, and thickens to the north (**Figure 3**). The thick layer of Moenkopi in this area inhibits hydraulic communication between the Tanner Wash Alluvium and the Coconino Aquifer at the BAP.

4.2.4 Bottom Ash Monofill

The BAM is a 41 acre CCR landfill constructed in the Tanner Wash watershed; however, Tanner Wash Alluvium is not present beneath or adjacent to the BAM (**Figure 2**). While lithologic logs for BAM monitor wells, which will be introduced later in the report, describe alluvial sediments at the surface, these sediments are dry, localized, and represent an erosional surface that is not connected with the Tanner Wash Alluvium. The BAM is constructed on rocks of the Moqui member of the Moenkopi Formation, an aquitard that is between about 250 and 350 feet thick and separates the BAM from the Coconino Sandstone Aquifer (**Figure 3**). Water levels indicate that the upper part of the Moenkopi is unsaturated beneath the BAM. As such, the Coconino Aquifer is considered the uppermost aquifer for the BAM.

4.3 Design of Monitoring Networks Using Existing and New Wells

The monitoring network for each CCR Unit was designed to characterize the uppermost aquifer at each Unit, as required by the Rule. Prior to designing the monitoring networks, data from existing wells were reviewed at each Unit to identify the uppermost aquifer and directions of groundwater movement. Based on provisions of the Rule, existing monitor wells were evaluated in relation to their potential use as part of the CCR program and additional proposed monitor well locations were selected to fill gaps in the monitoring networks.

4.3.1 Fly Ash Pond

When design of the FAP monitoring network was initiated, only one existing well, W-123, was located sufficiently close to the FAP's waste boundary in the LCR Alluvium to be considered a downgradient well under the Rule (**Figure 1**). In consideration of the FAP's size, it was initially recommended that three additional monitoring wells be installed in the LCR Alluvium along the FAP's downgradient waste boundary. However, due to limited alluvial thickness in this area, only two additional downgradient FAP monitor wells could be installed (M-50A and M-51A, **Figure 1**). As shown on **Figure 2**, there is only a narrow portion of the FAP waste boundary where alluvium thickness is about 50 feet, and thickness moving either northwest or southeast from this area declines rapidly and significantly. As will be described below, efforts to find a location with adequate alluvial thickness and saturation to install a fourth CCR well along the downgradient FAP waste boundary were not successful.

The upgradient boundary of the FAP rests on a thick section of Moenkopi Formation (**Figure 3**). The FAP was constructed in an historical drainage that used to flow into the LCR Alluvium. While up to 44 feet of alluvium was reported to be present beneath what is now the FAP prior to construction (SHB, 1973), there is no saturated alluvium present in the area upgradient from the current FAP footprint.

The first attempt to install a FAP background well was in the LCR floodplain in the area south of and upstream along the LCR from the FAP. Based on data from existing monitor wells, the LCR Alluvium in this area was known to be relatively thin and to have little to no saturation (**Figure 2**). However, a well site was selected based on the occurrence of vegetation, proximity to the LCR, and distance from surface outcrops of Moenkopi Formation. The monitor well (M-49A, **Figure 4**) that was completed in this area only encountered 20 feet of alluvium and has been dry since installation.

The second attempt to install a FAP background monitor well was in the area southwest from the FAP. Water level data suggested that is area may be cross- rather than down-gradient from the FAP and possibly suitable for characterizing background water quality conditions. The monitor well (M-63A, **Figure 4**) installed in this area encountered 55 feet of alluvium, with about 25 feet of saturation. However, water level data obtained following well construction demonstrated that M-63A was indeed downgradient from the FAP and, thus, cannot be used as a background well.

In a final attempt to install a background well for the FAP, potential downgradient LCR Alluvium well sites were considered. As will be discussed below, similar hydrogeologic conditions also prevented location of a background well hydraulically upgradient from the BAP. Because the Tanner Wash Alluvium discharges to the LCR, a decision was made to construct a combined FAP-BAP background monitor well in the LCR Alluvium at a location that was far enough downgradient to prevent impacts from either of these facilities. Well M-64A (**Figure 1**) is located in the vicinity of Coconino monitor well M-2 and has 65 feet of alluvium, about 40 feet of which is saturated. Travel time calculations conducted to ensure that M-64A is located far enough downgradient to represent groundwater that is not impacted by either the FAP or the BAP are described in **Section 6.1**.

4.3.2 Sedimentation Pond

Due to the small size of the SEDI (1.3 acres), the minimum CCR unit monitoring network of three downgradient wells and one upgradient well was recommended. No downgradient wells were present at the SEDI waste boundary when the monitoring network was designed. Therefore, three new downgradient LCR Alluvium monitor wells were installed immediately adjacent to the downgradient SEDI waste boundary (M-56A, M-57A, and M-58A, **Figure 1**). Additionally, no existing upgradient LCR wells were available to provide a clear indication of the quality of background groundwater flowing beneath the SEDI. Therefore, installation of a new upgradient LCR monitoring well was recommended between any potential upgradient sources and the SEDI (M-62A, **Figure 1**).

4.3.3 Bottom Ash Pond

When the BAP monitoring network was designed, three alluvial monitor wells existed in Tanner Wash that met the requirements of the Rule for downgradient monitor wells. Tanner Wash shallow/deep well pair W-305 and W-306 and Tanner Wash well W-314 are all as close to the downgradient boundary of the BAP as practicably achievable and are considered acceptable downgradient CCR monitoring wells (**Figure 1**). Two additional Tanner Wash Alluvial monitoring wells were installed to fill in gaps and complete the downgradient BAP monitoring network (M-52A and M-53A, **Figure 1**). As a result, there are a total of five downgradient monitoring wells at the BAP.

The Tanner Wash alluvial channel and sediments bend to the east along the eastern boundary of the BAP. Wells W-308 and W-309 are located in Tanner Wash east of the BAP and were initially considered as candidate upgradient wells for the BAP (**Figure 4**). However, further review of water level data showed that both wells are hydraulically down-gradient from the BAP. Therefore, an additional well was installed further upstream along Tanner Wash from well W-309 (M-55A, **Figure 4**). Alluvium thickness (54 feet) and saturation (about 27 feet) at M-55A were initially encouraging. However, while the gradient is very shallow, water level data demonstrated that this well is also downgradient rather that upgradient from the BAP (**Figure 4**).

Because Tanner Wash discharges to and is hydrologically connected to the LCR, and because hydrogeologic conditions prevented location of a background well hydraulically upgradient from the BAP, a decision was made to construct a combined FAP-BAP background monitor well in the LCR Alluvium at a location that was far enough downgradient to be beyond any potential impacts from either of these facilities. Well M-64A (**Figure 1**) is located in the vicinity of Coconino monitor well M-2 and has 65 feet of alluvium, about 40 feet of which is saturated. Travel time calculations conducted to ensure that M-64A is located far enough downgradient to represent groundwater that is not impacted by either the FAP or the BAP are described in **Section 6.1**.

4.3.4 Bottom Ash Monofill

No wells existed in the Coconino Aquifer adjacent to the BAM when the groundwater monitoring system was designed. Therefore, one upgradient well (M-54) and three downgradient wells (M-59, M-60, and M-61) were installed (**Figure 1**), fulfilling the minimum monitor well network requirements of the Rule. Due to the thick section of Moenkopi separating the BAM from the Coconino Aquifer in this area (**Figure 3**), there is little potential for impacts to the Coconino and the minimum monitoring requirements were deemed appropriate to provide an accurate representation of the quality of background groundwater and groundwater passing the waste boundary of the BAM.

5 WELL INSTALLATION FIELD PROGRAM

The installation program for the new CCR monitor wells included pre-construction activities, drilling, construction, and development of the new wells. While general aspects of the field program are summarized below, well-by-well details are provided in **Appendix A**. Available lithologic and well construction information for existing wells that are included in the CCR network are given in **Appendix B**. Locations for all CCR monitor wells are shown on **Figure 1**. Well construction details are summarized in **Table 1**.

5.1 Pre-construction Services

Pre-construction services included field reconnaissance to select locations for the new CCR monitor wells, preparation of technical specifications for drilling and well construction, preparation of site health and safety and emergency response plans, support for well permitting, preparation of a De Minimis Discharge permit application, and preparation of a CCR program sampling and analysis plan (SAP).

5.1.1 Field Reconnaissance and Well Siting

GoogleEarth images, occurrence and thickness maps for geologic units, and geologic cross-sections were examined to identify preliminary locations for the new monitor wells for each of the CCR units. Field reconnaissance was conducted on August 5 and 6, and on September 10, 2015 to finalize and, as appropriate, to modify preliminary well locations. Field reconnaissance for siting of monitor well M-64A, which was installed during a second phase of drilling, was conducted on February 1, 2017. APS personnel accompanied M&A for field reconnaissance tasks. Each CCR Unit was visited and locations for upgradient and downgradient monitor wells were staked and photographed, and GPS coordinates were recorded. Field reconnaissance resulted in changes to several of the well locations initially identified for each CCR Unit. These changes, and the associated rationale, are described below.

FAP

Because hydrogeologic conditions prevented installation of a monitor well upgradient from the FAP (see **Section 4.3.1**), the area between well W-127 and the LCR was initially identified for siting of a background LCR Alluvium well for the FAP. The location (M-49A, **Figure 4**) is on APS property and was believed to be cross- rather than downgradient from the FAP. Since it was known that saturated thickness was small and variable in the area, a secondary FAP background well location was marked near an old LCR Alluvium well, DM-3, which was already planned for replacement (M-63A, **Figure 4**). This location was also believed to be cross- rather than downgradient from the FAP. When well M-49A proved to be dry and well M-63A proved to be downgradient from FAP (**Figure 4**), the focus was shifted toward identifying a FAP background well location that would be far enough downgradient to ensure that the aquifer in the area could not have been impacted by the FAP. The location for the FAP-BAP background well was selected based on travel time analyses, described below, and the fact that data from an adjacent Coconino well, M-2, demonstrated the presence of a significant thickness of alluvium in the area (**Figure 2**).

Initially, three new monitor wells were planned for the downgradient perimeter of the FAP. During final well site selection, the proposed location farthest to the west was determined to be too close to bedrock outcrop, so it was moved slightly eastward. While the proposed location at the east end of the FAP was also acknowledged to be very close to Moenkopi outcrop and unlikely to have a significant thickness of alluvium, a decision was made to stake a site at the eastern location and attempt to install a well. In the end, drilling at this location (FAP-3D, **Figure 2**) confirmed that there was insufficient alluvial thickness (4 feet) and no saturation, so no well was installed at this location. As shown on **Figure 2**, only a relatively small portion of the downgradient waste boundary for the FAP has any significant thickness of LCR Alluvium; therefore, three wells were deemed sufficient to monitor conditions in this narrow area.

SEDI

A separate upgradient LCR alluvial well site was selected for the SEDI to ensure accurate characterization of background water quality passing beneath the Unit. The upgradient well location for the SEDI, M-62A, is shown on **Figure 1**. Three locations downgradient from the SEDI were staked west of the Unit along the access road near the western cooling tower. The final locations for the downgradient SEDI wells were moved approximately 40 feet to the west from those originally planned to prevent damage to the wells from traffic on the access road (M-56A, M-57A, and M-58A, **Figure 1**).

BAP

The areas east and north from the BAP were inspected for a potential location for an upgradient alluvial well in Tanner Wash or its tributaries. The tributary area to the north was ruled out because it was used historically for borrow materials for construction of the dams for the ponds. The land surface in this area was noted as being highly disturbed, with numerous depressions and areas of Moenkopi outcrop. The reconnaissance visit took place following above-average summer rains and many of the depressions were filled with standing water. While a preliminary location was staked, a decision was later made to further investigate the area along the main stem of Tanner Wash between well W-309 and soil boring W-316, where the alluvium was reported to be dry (**Figure 2**). A location for an upgradient BAP well, M-55A, was staked in this area (**Figure 4**). However, when well M-55A indicated potential impact from the BAP (**Figure 4**), the focus was shifted toward identifying a BAP background well location that would be far enough downgradient to ensure that the aquifer in the area could not have been impacted by the BAP. The location for FAP-BAP background well M-64A was selected based on travel time analyses, described below, and the fact that data from an adjacent Coconino well, M-2, demonstrated the presence of a significant thickness of alluvium in the area (**Figure 2**).

During inspection of proposed locations for downgradient alluvial wells along the southern waste boundary of the BAP, the original location farthest to the west was determined to be too close to a bedrock outcrop, so the location was moved eastward. The original location for the downgradient monitor well in the area east of the BAP also had to be reconsidered after the site inspection revealed that this was in an area of Moenkopi outcrop. The area east of the BAP waste boundary was traversed to identify an area of alluvium that might be used as an alternate monitor well location; however, most of the area had Moenkopi outcrop. Therefore, existing well W-314, located slightly farther to the east, was selected as the eastern downgradient well (**Figure 1**).

BAM

The preliminary upgradient well for the BAM was proposed for the same location as the upgradient Tanner Wash alluvial well; however, an alternate location was selected on APS land closer to the BAM and adjacent to an unnamed wash that is tributary to Tanner Wash (M-54, **Figure 1**). Three downgradient BAM wells were initially sited along the access road to the BAM, but due to traffic considerations and on-going construction activities, the downgradient locations were moved to areas outside of the storm water drainage channel to the northwest and west of the BAM (M-59, M-60, and M-61, **Figure 1**).

5.1.2 Technical Specifications and Well Designs

National Exploration Wells and Pumps (National) of Gilbert, Arizona conducted the drilling, well construction, and development program for the CCR wells. M&A developed proposed well designs, prepared technical specifications for the field program, and submitted them to National. Proposed designs included alluvial monitor wells completed to anticipated depths of up to 100 feet deep, drilled using the air rotary casing hammer (ARCH) method. Coconino monitor wells were proposed to be completed to a depth of approximately 60 feet below the Moenkopi/Coconino contact, to anticipated depths of 350 to 400 feet, and drilled using ARCH and air percussion and/or air rotary methods.

5.1.3 Health & Safety Plan

M&A prepared Health & Safety and Emergency Response Plans for the field program to cover activities of M&A on-site personnel. M&A coordinated with APS staff regarding site rules, procedures, and protocols for emergencies and with the National drill crew regarding instructions for working around the drill rig and communicating and interacting with the drilling crew.

5.1.4 Permitting

M&A provided information to National to assist with the well permitting process. National filed Notices of Intent (NOI) to drill forms with the Arizona Department of Water Resources (ADWR) for the new wells. Arizona well registration numbers are given in **Table 1**. Following well installation, National filed well completion reports with ADWR.

An Arizona Pollutant Discharge Elimination System (AZPDES) NOI for a General Permit for De Minimus Discharges to Waters of the United States was prepared and submitted to the Arizona Department of Water Quality (ADEQ) for anticipated discharges of drilling and development water from the Coconino Sandstone monitor wells (M-54, M-59, M-60, and M-61). A Best Management Practices Plan was prepared and submitted along with the De Minimus NOI. Permission to discharge was granted under Authorization Number AZDGP—87417 on September 30, 2015.

Minimal discharges to an unnamed ephemeral stream channel tributary to Tanner Wash occurred during development for the upgradient BAM well (M-54). Similarly, low volume discharges occurred to the storm water channel during development of the downgradient BAM wells (M-59, M-60, and M-61). Discharges occurred during the period November 16 – 23, 2015. A Notice of Termination of discharges was filed with ADEQ on January 14, 2016.

5.2 Well Installation

Most of the new CCR monitor wells were installed by National during the period September 14 – November 19, 2015. A final new CCR monitor well, M-64A, was installed in February 2016. Details for each of the new CCR monitor wells are summarized in **Appendix A**.

5.2.1 Drilling Methods

National drilled and constructed the CCR monitor wells at Cholla using a Speedstar 50K drilling rig (Rig 128). The ARCH drilling method was used for all of the wells completed in alluvium and for the upper 20 feet of the wells completed in the Coconino Sandstone. The lower portion of certain alluvial wells was drilled using the air rotary method without advancing casing, and the lower portion of all Coconino wells was drilled using the air percussion (hammer) method (**Appendix A**).

The ARCH method was used to advance the boreholes through the unconsolidated alluvial deposits. The method utilizes a temporary drive casing to support unconsolidated materials as the borehole is advanced. Following casing installation, the temporary casing is gradually removed from the borehole as the annular materials are installed. The air percussion method was used to drill the Moenkopi Formation and Coconino Sandstone. Minimal water was injected during drilling to assist with lifting drill cuttings and to prevent dust generation.

5.2.2 Installation of the New Wells

National mobilized to the site on September 14, and completed all well installation activities at Cholla on November 19, 2015. Locations for the wells are shown on **Figure1** and construction details are given in **Table 1**. **Appendix A** provides well-by-well summaries of drilling and construction information, along with schematic diagrams and lithologic logs. M&A personnel provided oversight of field activities.

National obtained variances from ADWR to modify surface seal requirements. ADWR requires a minimum 20 feet of surface casing; however, shallow depth to water level and shallow depth to bedrock were anticipated at many of the sites. Because installing deeper surface casing would have prevented well screen installation across the target aquifer zone, most of the wells completed in the alluvium for the Cholla CCR program were constructed with less than the minimum standard of 20 feet of surface casing (**Appendix A**).

At all sites, drilling began with advancement of 13-3/8-inch diameter drive casing to approximately 20 feet bls using the ARCH method. Surface casing was installed during well construction, as detailed below and in **Appendix A**.

At most of the alluvial wells, the 13-3/8-inch diameter drive casing was advanced to total depth or to a depth at which the alluvial deposits were stable and did not cave into the borehole. Where the deposits were more stable (M-50A and M-51A, **Figure 1**), the borehole was advanced to total depth using a 12-1/4-inch diameter rotary bit.

For the wells completed in the Coconino Sandstone, a 12-1/4-inch diameter borehole was advanced to approximately 10 feet below the Moenkopi/Coconino contact using the air percussion method. Then 8-5/8-inch diameter blank steel intermediate casing was installed in the borehole and cemented in place. Following curing of the cement, a 7-7/8-inch diameter borehole was advanced using the air percussion method to total depth, approximately 60 feet below the Moenkopi/Coconino contact.

All alluvium and Coconino monitor wells were constructed using 4-inch diameter blank and factory slotted Schedule 80 PVC casing from the designed depth to land surface. Annular materials, including filter pack, bentonite chips, and grout, were installed using a tremie pipe to ensure bridging did not occur.

5.2.3 Well Development

The new monitor wells were developed by National using a service rig during the period November 16 – 23, 2015. Well M-64A was developed on February 10, 2017. M&A personnel provided oversight of field activities. Development operations began by tagging the bottom of the well and bailing fine sediments that had accumulated during well construction. After bailing was completed, a temporary submersible pump was installed near the bottom of the well screen and pumping was conducted to remove fine suspended sediments from the casing column. Well M-64A was developed using swapping and bailing without use of a submersible pump.

Water quality parameters, including temperature, pH, specific electrical conductance, and oxidation reduction potential, were measured periodically until parameters stabilized and the discharge water was sufficiently free of sediment. After parameters stabilized with the pump installed near the bottom of the well, the pump was raised to the middle of the well screen and pumping and monitoring of water parameters was repeated until parameters stabilized and the discharge water was free of sediment. A water sample was collected at the end of development for screening purposes. Water quality data from the development program is considered qualitative and not included in this report. However, information on parameter stability at the end of development operations is provided in **Appendix A**.

6 DATA ANALYSIS

6.1 Travel Time Analysis

When hydrogeologic conditions prevented installation of background monitor wells upgradient from either the FAP or the BAP, a decision was made to install a background monitor well downgradient along the LCR at a distance that would be sufficient to ensure that alluvial groundwater in the area could not have been impacted by water seeping from either the FAP or the BAP. A travel time analysis was carried out to verify that water from the FAP and BAP could not reach the background monitor well, M-64A, during the time since the two Units began operating. Dams for the FAP and BAP were completed in 1978. Therefore, an estimated travel time of greater than 40 years was deemed to be protective relative to potential impacts at background monitor well M-64A.

It should be noted that potential leakage from either the SEDI or the BAM are not relevant to the travel time analysis. Any seepage from the SEDI would be detected at the downgradient CCR monitor wells associated with that Unit. The upper aquifer for the BAM is the Coconino, which is hydraulically isolated from the alluvium due to a thick sequence of Moenkopi sediments present in the area.

6.1.1 Conceptual Model

Surface geology in the vicinity of the FAP and BAP is comprised of alluvial sediments associated with either the LCR or Tanner Wash (**Figure 2**). Lithologic information from drilling in the LCR Alluvium indicates the unit generally comprises well-graded, gravelly sand. In contrast, Tanner Wash drains a watershed comprised chiefly of the fine-grained rocks of the Chinle and Moenkopi Formations. The lithologic logs from wells in the Tanner Wash area describe sediments that are mostly silt and clay, with some sand and gravel stringers (**Appendices A and B**). Similar to Tanner Wash, the FAP was constructed on Moenkopi Formation bedrock that is overlain by a veneer of alluvial sediments from the historical drainage that previously contributed runoff to the LCR from a Chinle/Moenkopi watershed. Lithologic logs from wells near the FAP indicate that the alluvium in this area is composed mostly of clay and sand, with some silt and gravel (**Appendices A and B**).

Groundwater moving from the BAP to well M-64A would pass through the Tanner Wash Alluvium before reaching the LCR Alluvium. Similarly, water moving from the FAP to well M-64A would pass through the finer-grained alluvial deposits beneath and immediately downgradient from the FAP (FAP alluvium) before entering the main portion of the LCR alluvial system. Water level contours show a steep gradient in the Tanner Wash Alluvium downgradient from the BAP and in the FAP alluvium to the west-southwest of the FAP dam, which is an indication of reduced hydraulic conductivity in the area.

6.1.2 Hydraulic Parameters

Estimates of hydraulic conductivity for the Tanner Wash Alluvium, FAP alluvium, and LCR Alluvium are summarized in **Table 2**.

Testing results indicated hydraulic conductivity values for the Tanner Wash Alluvium that reportedly range from 0.06 to 0.44 feet per day (APS, 1984). Calibration of a numerical groundwater model for the BAP area required hydraulic conductivities ranging between 0.32 and 0.96 feet per day (Woodward-Clyde, 1992). A pumping test conducted at alluvium monitor well W-123, located immediately downgradient from the FAP in the FAP alluvium, indicated a hydraulic conductivity of 0.03 feet per day. For the travel time calculation, a hydraulic conductivity of 1 foot per day was assumed for the FAP alluvium and Tanner Wash alluvium, which is larger (more conservative) than the largest reported estimate of hydraulic conductivity for this unit.

Table 2. Hydraulic Conductivity Estimates for Cholla-Area Alluvium

Unit	Date of Test	Method	Well Name	Hydraulic Conductivity (ft/day)
LCR	13-Feb-17	Slug Test[a]	M-64A	66
Tanner Wash	28-Feb-84	Pumping Test[b]	W-301[b]	3.10E-01
Tanner Wash	28-Feb-84	Pumping Test[c]	W-303[c]	7.50E-02
Tanner Wash	1-Mar-84	Pumping Test[c]	W-304[c]	1.60E-01
Tanner Wash	29-Feb-84	Pumping Test[c]	W-306[c]	6.20E-02
Tanner Wash	2-Mar-84	Pumping Test[b]	W-307[b]	1.50E-01
Tanner Wash	1-Mar-84	Pumping Test[b]	W-308[b]	4.40E-01
Tanner Wash	27-Feb-84	Pumping Test[b]	W-309[b]	3.80E-01
Tanner Wash	N/A	Calibrated Flow Model[d]	N/A	3.2E-01
Tanner Wash	N/A	Calibrated Flow Model[d]	N/A	9.6E-01
FAP	2-Mar-84	Pumping Test[c]	W-123	3.20E-02

a) Average of results of rising- and falling-head slug tests conducted after installation of monitoring well M-64A.
b) Reported in APS (1984). Pumping test analyzed using Jacob straight-line method.
c) Reported in APS (1984). Pumping test analyzed using Bouwer-Rice slug test method; the pumping rate exceeded the well capacity and could not be lowered due to equipment limitations, so these were treated as slug tests.
d) Reported in Woodward-Clyde (1992). Differing values represent the range of cases for the calibrated groundwater flow model.
N/A = Not applicable

A slug test conducted following installation of background LCR alluvium well M-64A, yielded an average hydraulic conductivity of 66 feet per day. This value is anticipated to be fairly typical for the LCR Alluvium and was used for travel time analysis for the portion of the flow path through the LCR Alluvium.

Site-specific effective porosity values are not available for the Cholla alluvial units. An effective porosity of 0.15 is reported in the literature for similar lithologic units (Fetter, 2001). A value of 0.13 was used for the travel time calculations.

6.1.3 Method

The time taken for groundwater to travel a given distance may be estimated by the following equation:

$$Travel\ time = \frac{D\ * n_e}{K * i}$$

where D is the distance traveled, n_e is the effective porosity of the formation, K is the hydraulic conductivity of the formation, and i is the hydraulic head gradient of the groundwater (Fetter, 2001).

Groundwater traveling from the FAP or the BAP to well M-64A would pass through two distinct hydraulic conductivity regimes: the FAP alluvium or Tanner Wash Alluvium, and the LCR Alluvium. Therefore, the travel time calculation for each CCR Unit was divided into two parts. The time to travel through the FAP alluvium or the Tanner Wash Alluvium to the edge of the LCR Alluvium downgradient from each Unit was first calculated, then added to the time to travel through the LCR Alluvium to well M-64A. Travel distances were measured using GIS tools. Straight-line travel was assumed from the CCR Units to the edge of either the Tanner Wash Alluvium (BAP) or the FAP alluvium (FAP), and then for the distance from where these sediments meet the LCR and monitor well M-64A, as these comprised the shortest (most conservative) potential flow paths.

Gradients were computed based on June – July 2017 water level data and associated elevation contours shown on **Figure 4**. For travel time through alluvial sediments immediately downgradient of the CCR Units, gradients were computed using water level elevation contours adjacent to the FAP and BAP dams and water level elevation contours for the areas downgradient from the ponds where the FAP alluvium and Tanner Wash Alluvium transition into the LCR Alluvium. Specifically, the 5,030-foot contour was used for the upgradient water level for the FAP and the 5,040-foot contour was used for the BAP for gradient calculations. On the downgradient side, the 4,990-foot contours downgradient from each of the ponds were used for gradient calculations. For both the FAP and the BAP, the 4,990-foot contours are interpreted to represent the approximate areas where sediments transition from the lower conductivity materials downgradient of the ponds and associated historical drainage areas to the higher conductivity sediments of the principal LCR channel. Water level contours support this interpretation. For travel time for the LCR Alluvium portion of the flow path, gradients were computed using the 4,990-foot contours downgradient from the FAP and BAP and the June – July 2017 water level for M-64A.

Because hydraulic gradients are known to change over time, historical water level data were evaluated for the various sections of the flow path to ensure that gradients used for travel time calculations were conservative relative to the period of operation of the FAP and BAP. Wells used in the historical gradient analysis are shown on **Figures 2 and 4**. Because the FAP and BAP are generally maintained at full to near full levels during routine plant operations, gradients immediately downgradient from these ponds are steeper than they were in the early years when the ponds were filling. Water level data from 1983 through present for the FAP show that levels have been generally increasing over time, with a slight decline over the last 2 years. Water level data for the BAP for the same period show increasing water levels through around 2000, with stable to slightly declining water levels since that time. Review of groundwater level data for well pairs in the area downgradient from the FAP and BAP provides further evidence that current gradients are conservatively high for the area immediately downgradient from these Units. Gradients computed for the well pair W-123 and DM-3/M-63A (M-63A was installed in 2015 to replace DM-3) downgradient from the FAP indicate that a maximum gradient of 0.0112 occurred during the period from 1994 through 2017. The hydraulic gradient used for travel time calculations for the portion of the flow path downgradient from the FAP was 0.0240. Similarly, gradients computed using historical water level data for the well pair W-306 and W-301 downgradient of the BAP indicate that a maximum gradient of 0.0145 occurred during the period from 1984 through 2017. The value used for this portion of the flow path for travel time calculations was 0.0196. Therefore, for both the FAP and BAP, current hydraulic gradients are conservative (high) relative to the entire period of operation of these Units.

With respect to the LCR Alluvium portion of travel time calculations, gradients between monitor wells DM-3/M-63A and DM-5 were evaluated to determine if using gradients based on June – July water level conditions would be conservative. These wells have historical water level data for 1974 and then for the period 1992 through 2017. The maximum gradient in the LCR Alluvium between these wells during the historical period was 0.0016, which is lower (less conservative) than the current gradient between the edge of the Tanner Wash Alluvium and M-64A (0.0019) and higher (more conservative) than the current gradient between the edge of the FAP alluvium and M-64A (0.0013). Therefore, to ensure that travel time estimates are protective, the higher historical gradient of 0.0016 was used instead of the recent gradient of 0.0013 for the portion of the LCR flow path between the edge of the FAP alluvium and background monitor well M-64A.

Table 3. Results of Travel Time Calculation

Description of Travel Path	Distance[a] (feet)	n_e[b]	K[c] (feet/day)	ΔH[d] (feet)	June – July 2017 i[e]	Historical Max i[f]	Travel time (days)	Travel time (years)
FAP to edge of FAP Alluvium	1,667	0.13	1	40	**0.0240**	0.0145	9,033	25
Edge of FAP Alluvium to M-64A	19,581	0.13	66	26	0.0013	**0.0016**	24,106	66
BAP to edge of Tanner Wash Alluvium	2,554	0.13	1	50	**0.0196**	0.0112	16,960	46
Edge of Tanner Wash Alluvium to M-64A	13,662	0.13	66	26	**0.0019**	0.0016	13,992	39
FAP to M-64A							**33,139**	**91**
BAP to M-64A							**30,952**	**85**

a) Straight-line distance
b) Effective porosity
c) Hydraulic conductivity of alluvium on travel path
d) Change in hydraulic head across travel path
e) Hydraulic gradient across travel path
f) Hydraulic gradient from historical maximum
Bold Blue = Gradients used in travel time calculation

6.1.4 Results

Results of conservative travel time analyses indicate that it would take at least 91 years for water seeping from the FAP and 85 years for water seeping from the BAP to reach the location of background monitor well M-64A (**Table 3**). The long travel time presented herein indicates that monitor well M-64A would not be anticipated to have been impacted by seepage from either the FAP or the BAP between pond construction (1978) and sampling to establish background water quality conditions in the LCR Alluvium aquifer (2017).

6.2 Analysis of Groundwater Conditions at CCR Units

6.2.1 Fly Ash Pond

Three CCR alluvial wells monitor groundwater conditions at the downgradient waste boundary of the FAP: M-50A, M-51A, and W-123. Since water was first encountered in the alluvium for all three downgradient wells, the alluvial aquifer is considered the uppermost aquifer for the FAP. Depth to groundwater was at 19.13 bls and 9.91 feet bls, respectively, at M-50A and M-51A during the June 2017 monitoring round. During the monitoring round, water was measured at a depth of 2.11 feet bls at W-123.

Water level elevations along the FAP downgradient waste boundary range from 5,019.05 feet mean sea level (msl) in well M-50A to 5,037.73 feet msl in well W-123 in June 2017 (**Figure 4**). Water levels south and west of the FAP have been measured in well W-126 at 5,026.38 feet mls and in well M-63A at 4,985.62 feet mls. Well M-49A completed in the alluvium in the area further south of the FAP is dry. Water level contours indicate that the FAP creates a mound in the alluvium southwest of the FAP. Water from this mound generally flows southwest from the FAP boundary. Background alluvium monitor well M-64A, located about 4.2 miles (22,197 feet) downgradient from the FAP waste boundary, had a water level elevation of 4,964.51 feet msl in June 2017.

Close to the waste boundary, the gradient away from the FAP is large and towards the west-southwest. As described in the **Section 6.1**, the hydraulic gradient from the 5,030-foot water level elevation contour, adjacent to the FAP, to the 4,990-foot contour, marking the edge of the FAP alluvium, was calculated based on June – July water level data to be to be 0.0240 feet/foot (**Figure 4**).

6.2.2 Sedimentation Pond

Three CCR wells, M-56A, M-57A, and M-58A, were installed on the downgradient waste boundary of the SEDI. Since water was first encountered in the alluvium for all three downgradient wells, the alluvial aquifer is considered the uppermost aquifer for the SEDI. Depth to water at the three downgradient wells was 42.09 feet bls, 42.86 feet bls, and 42.88 feet bls, respectively, during the June – July 2017 monitoring round. Well M-62A was drilled upgradient from the SEDI. Water was encountered in the alluvial aquifer at this well at a depth of 39.61 feet bls during the June – July 2017 monitoring round.

Water level elevations along the SEDI downgradient waste boundary ranged from 4,980.96 feet msl in well M-57A to 4,981.07 feet msl in well M-56A during the June – July 2017 monitoring round (**Figure 4**). Water level in upgradient well M-62A was slightly higher than at the downgradient wells, at 4,981.26 feet msl. Water level contours based on the June – July 2017 monitoring round data, along with other available alluvial water level data for July 2017, show that water flows from east to west beneath the SEDI and that M-62A is upgradient of the SEDI. This is consistent with both historical data and expectations that groundwater flow in alluvial systems is generally parallel to streamflow beneath active streams. The gradient beneath the SEDI is small and towards the west. The hydraulic gradient calculated from the 4,980 and 4,975-foot water level elevation contours downgradient from the SEDI waste boundary for the June – July 2017 data set is 0.0015 feet/foot (**Figure 4**).

6.2.3 Bottom Ash Pond

Two new wells, M-52A and M-53A, and three existing wells W-305, W-306, and W-314, comprise the CCR monitoring network along the downgradient waste boundary of the BAP. Since water was first encountered in the alluvium for all five downgradient wells, the alluvial aquifer is considered the uppermost aquifer for the BAP. Depth to water at new CCR wells M-52A and M-53A was 19.13 feet bls and 5.21 feet bls, respectively, during the June – July 2017 monitoring round. Depth to water at existing wells W-305, W-306, and W-314 during the June – July 2017 monitoring round was 20.47 feet bls, 17.58 feet bls, and 9.84 feet bls respectively.

Water level elevations along the BAP downgradient waste boundary range from 5,026.33 feet msl in well W-305 to 5,041.26 feet msl in well W-314 (**Figure 4**). Background alluvium monitor well M-64A, located about 3.14 miles (16,585 feet) downgradient from the BAP waste boundary, had a water level elevation of 4,964.51 feet msl in June 2017.

Water level contours based on the June – July 2017 monitoring round data, along with other available alluvial water level data from the same time period, indicate that the BAP creates a mound in the alluvium south and southeast of the Unit. Water from this mound generally flows south and southeast from the BAP boundary in the Tanner Wash Alluvium. The gradient away from the BAP is relatively large and ranges from south to southeast. Tanner Wash flows into the LCR, where the gradient is more shallow. Hydraulic gradient calculated from the 5,040- and 4,990-foot water level elevation contours downgradient from the BAP waste unit boundary for the June – July data set is 0.0196 feet/foot.

6.2.4 Bottom Ash Monofill

Three wells, M-59, M-60, and M-61, were installed to provide the CCR monitoring network along the downgradient waste boundary of the BAM. Since water was first encountered in the Coconino Aquifer for all three downgradient wells, the Coconino Aquifer is considered the uppermost aquifer for the BAM. Depth to water level at M-59, M-60, and M-61 was measured at 196.72 feet bls, 225.73 feet bls, and 194.89 feet bls, respectively, during the June – July 2017 monitoring round. Background Coconino well, M-54, was drilled upgradient from the BAM. Water was encountered in the Coconino Aquifer at a depth of 126.42 feet bls at M-54 during the June – July 2017 monitoring round.

Water level elevations along the BAM downgradient waste boundary ranged from 4,925.45 feet msl in well M-60 to 4,939.28 feet msl in well M-59 (**Figure 5**). Water level in upgradient well M-54, at 4,944.29 feet msl, is higher than at downgradient wells. Water level contours based on the June – July 2017 monitoring round data, along with other available Coconino water level data for the same time period, show that water flows from southeast to northwest beneath the BAM. This is consistent with both historical data and expectations for the flow of groundwater in this region of the Coconino Aquifer.

The hydraulic gradient beneath the BAM is moderate. Water levels drop about 19 feet between upgradient well M-54 and downgradient well M-60. The gradient beneath the BAM is toward the northwest. Hydraulic gradient calculated from the 4,940- and 4,930-foot water level elevation contour intervals adjacent to the BAM for the June – July 2017 data set was 0.0115 feet/foot.

7 SUMMARY EVALUATION OF CCR MONITORING NETWORKS

7.1 Fly Ash Pond

The uppermost aquifer for the FAP is the LCR Alluvial aquifer. The FAP monitoring network includes four wells completed in the LCR Alluvium. The FAP monitoring network meets requirements of the Rule and is believed to be sufficient for characterization of background water quality and monitoring groundwater passing the downgradient FAP waste boundary. With respect to monitoring in the uppermost aquifer, the LCR Alluvium, downgradient wells M-50A, M-51A, and W-123 are well positioned to monitor water quality at the FAP downgradient waste boundary. While efforts were made to find a location where alluvial thickness and saturation were adequate to install a fourth CCR well, this was not possible. As shown on **Figure 2**, there is only a narrow portion of the FAP waste boundary where alluvium thickness is about 50 feet, and thickness moving either northwest or southeast from this area declines rapidly and significantly. Because of the narrow extent of saturated alluvium at the downgradient waste boundary of the FAP, the three downgradient wells, M-50A, M-51A, and W-123, are deemed to be sufficient to monitor groundwater passing the FAP boundary.

The location for background alluvial well M-64A was selected for several reasons: (1) the FAP is constructed on Moenkopi bedrock, covered by a veneer of alluvium, and alluvial sediments are generally absent and, where present, anticipated to be unsaturated, in the area hydraulically upgradient from the FAP; (2) saturated thickness is limited and there are alluvial wells that are dry in the LCR Alluvium upstream from the FAP; and, (3) conservative travel time estimates indicate that it would take at least 91 years for FAP seepage to reach the vicinity of M-64A in the alluvium, which greatly exceeds the 40 year timeframe since FAP construction. Monitor well M-64A is interpreted to be located in an area that may be used to characterize and monitor groundwater quality that has not been affected by leakage from a CCR Unit.

7.2 Sedimentation Pond

The uppermost aquifer for the SEDI is the LCR alluvial aquifer. The SEDI CCR monitoring network includes four alluvial wells, which meets the Rule's minimum requirement. Given the small size of the SEDI (1.3 acres), the minimum number of wells is believed to be appropriate. The SEDI monitoring network meets all requirements of the Rule and is believed to be sufficient for characterization of background water quality and for monitoring the quality of groundwater passing the SEDI waste boundary.

LCR alluvial wells M-56A, M-57A, and M-58A are distributed along the downgradient waste boundary and are well positioned to monitor constituents in groundwater that might be passing the SEDI boundary. The upgradient well for the SEDI is alluvial well M-62A. M-62A is well situated to determine background groundwater quality in the LCR Alluvium that has not been affected by leakage from the SEDI.

7.3 Bottom Ash Pond

The uppermost aquifer for the BAP is the Tanner Wash alluvial aquifer, which flows into the LCR Alluvium to the southeast. The BAP monitoring network includes six wells. The five downgradient wells that are part of the BAP CCR monitoring network exceed requirements of the Rule and are believed to be sufficient for monitoring the quality of groundwater passing the BAP waste boundary.

Tanner Wash alluvial wells M-52A, M-53A, W-305, W-306, and W-314 are distributed along the downgradient waste boundary. This well configuration is both sufficient and protective. The location for background alluvial well M-64A was selected for several reasons: (1) the BAP is constructed principally on Moenkopi bedrock and alluvial sediments are absent in the area hydraulically upgradient from the BAP; (2) data from monitor wells in the Tanner Wash Alluvium upstream from the BAP indicate that saturated thickness is limited and that hydraulic gradients are influenced by the pond, making this area unsuitable for determining background water quality; and, (3) conservative travel time estimates indicate that it would take at least 85 years for BAP seepage to reach the vicinity of M-64A in the alluvium, which greatly exceeds the 40-year timeframe from BAP construction.

7.4 Bottom Ash Monofill

The uppermost aquifer for the BAM is the Coconino Aquifer. The BAM monitoring network includes four wells, which meets the Rule’s minimum requirement. Given the thick layer of fine grained Moenkopi Formation between the BAM and the Coconino Aquifer, the confined conditions in the Coconino aquifer, and the fact that the BAM is used to store de-watered bottom ash removed from the BAP rather than liquids, the minimum number wells is believed to be appropriate. The BAM monitoring network meets all requirements of the Rule and is believed to be sufficient for characterization of upgradient groundwater quality and for monitoring groundwater passing the BAM waste boundary. Coconino Aquifer wells M-59, M-60, and M-61 are distributed along the downgradient waste boundary. The upgradient well for the BAM is Coconino well M-54.

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TABLE 1. SUMMARY OF WELL CONSTRUCTION DETAILS
FOR CCR MONITORING NETWORK WELLS, APS CHOLLA POWER PLANT, NAVAJO COUNTY, ARIZONA

CCR Pond	Well Identifier	Hydrogeologic Unit	Cadastral Location	ADWR ID	Date Completed	Borehole Depth (feet, bls[a])	Total Cased Depth (feet, bls)	Screened Interval (feet, bls)	Depth to Top of Gravel Pack (feet, bls)	Well Location Data[b]				Depth to Groundwater Level (feet, bmp[d])	Groundwater Level Elevation (feet, msl)	Date Measured	Hydrogeologic Contacts	
										Northing	Easting	Land Surface Elevation (feet, amsl[c])	Measurement Point Elevation (feet, amsl)				Moenkopi Contact (feet, bls)	Coconino Contact (feet, bls)
Bottom Ash Monofill	M-54	Coconino	(A-18-19)13cab	918646	10/2/2015	370	365	315-365	312	1440088.61	665508.13	5068.21	5070.71	126.42	4944.29	6/26/2017	19	302
Bottom Ash Monofill	M-59	Coconino	(A-18-19)13cbb	918647	10/21/2015	425	423	373-423	365	1440604.73	664161.36	5133.86	5136.00	196.72	4939.28	6/26/2017	13	360
Bottom Ash Monofill	M-60	Coconino	(A-18-19)13bac	918649	11/1/2015	450	445	395-445	384	1441947.89	664249.99	5148.69	5151.18	225.73	4925.45	6/26/2017	14	380
Bottom Ash Monofill	M-61	Coconino	(A-18-19)13bca	918648	11/13/2015	420	415	365-415	354	1441383.55	664047.00	5124.95	5127.58	194.89	4932.69	6/26/2017	5	355
Bottom Ash Pond	M-52A	Alluvium	(A-18-19)24bbc	918657	9/22/2015	83	70	20 - 70	16	1437475.71	663614.27	5047.08	5049.36	19.91	5029.45	6/26/2017	79	N/A
Bottom Ash Pond	M-53A	Alluvium	(A-18-19)23aab	918651	9/22/2015	38	35	10-35	8	1437605.11	662529.37	5042.09	5044.68	5.21	5039.47	6/26/2017	34	N/A
Bottom Ash Pond	W-305	Alluvium	(A-18-19)23aaa	506364	10/7/1983	108	102	80-100	N/A	1437484.17	662998.76	5044.65	5046.80	20.47	5026.33	6/26/2017	>110	N/A
Bottom Ash Pond	W-306	Alluvium	(A-18-19)23aaa	506365	10/11/1983	54	52	30-50	N/A	1437482.84	663008.29	5044.78	5046.74	17.58	5029.16	6/26/2017	>55	N/A
Bottom Ash Pond	W-314	Alluvium	(A-18-19)13ccd	533814	1/27/1992	63	62	41-61	44	1438507.58	664796.73	5051.32	5051.10	9.84	5041.26	6/26/2017	>63	N/A
Fly Ash Pond	M-50A	Alluvium	(A-18-20)30bbc	918641	9/18/2015	32	29	9-29	7	1429799.42	669243.76	5035.65	5038.18	19.13	5019.05	6/26/2017	28	N/A
Fly Ash Pond	M-51A	Alluvium	(A-18-19)25add	918640	9/19/2015	14	12	7-12	6	1430360.14	668733.14	5039.10	5041.77	9.91	5031.86	6/26/2017	9	N/A
Fly Ash Pond	W-123	Alluvium	(A-18-20)30cbd	506587	11/4/1983	40	35	14-29	N/A	1429140.92	669925.02	5038.14	5039.84	2.11	5037.73	6/26/2017	>40	N/A
Fly Ash Pond & Bottom Ash Pond	M-64A	Alluvium	(A-18-19)21ccb	920353	2/9/2017	69	60	30-60	18	1434030.01	647702.04	4988.90	4991.90	24.39	4967.51	6/26/2017	63	N/A
Sedimentation Pond	M-56A	Alluvium	(A-18-19)23cbc	918661	10/7/2015	100	85	40-85	37	1434257.73	658887.35	5020.63	5023.17	42.09	4981.08	6/26/2017	>100	N/A
Sedimentation Pond	M-57A	Alluvium	(A-18-19)23cbc	918660	10/8/2015	100	85	40-85	37	1434198.68	658767.25	5021.16	5023.82	42.86	4980.96	6/26/2017	>100	N/A
Sedimentation Pond	M-58A	Alluvium	(A-18-19)23cbc	918659	10/13/2015	100	84	39-84	36	1434165.11	658698.92	5021.24	5023.84	42.88	4980.96	6/26/2017	>100	N/A
Sedimentation Pond	M-62A	Alluvium	(A-18-19)23cbd	918658	11/17/2015	97	84	39-84	32	1434008.67	659268.05	5021.01	5020.87	39.61	4981.26	6/26/2017	97	N/A

[a] bls = below land surface
[b] Well coordinates are in Arizona State Plane, Central zone, NAD83, Int. Feet; vertical NAVD88, Int. Feet
[c] amsl = above mean sea level
[d] bmp = below measuring point
N/A = data not available

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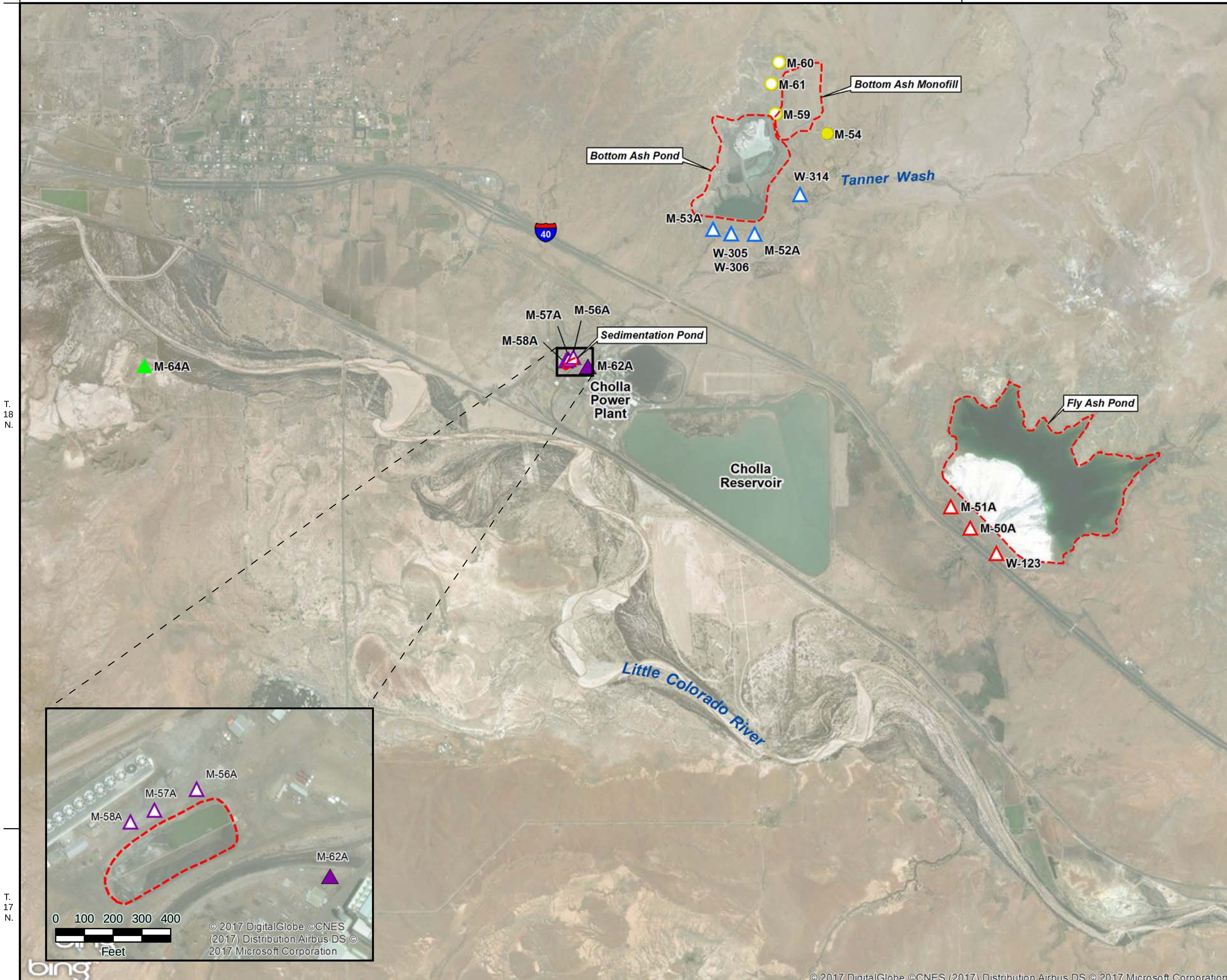
R. 19 E. R. 20 E.



T. 18 N. T. 17 N.

EXPLANATION

Approximate Extent of Coal Combustion Residual Unit

M-51A △ Monitor Well Location and Identifier

CCR WELLS:

- Alluvium, Background, Fly Ash Pond and Bottom Ash Pond
- Alluvium, Downgradient, Bottom Ash Pond
- Alluvium, Downgradient, Fly Ash Pond
- Alluvium, Upgradient, Sedimentation Pond
- Alluvium, Downgradient, Sedimentation Pond
- Coconino, Upgradient, Bottom Ash Monofill
- Coconino, Downgradient, Bottom Ash Monofill

0 1,000 2,000 3,000 4,000

Feet

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CHOLLA POWER PLANT
NAVAJO COUNTY, ARIZONA

CCR MONITORING NETWORK LOCATIONS

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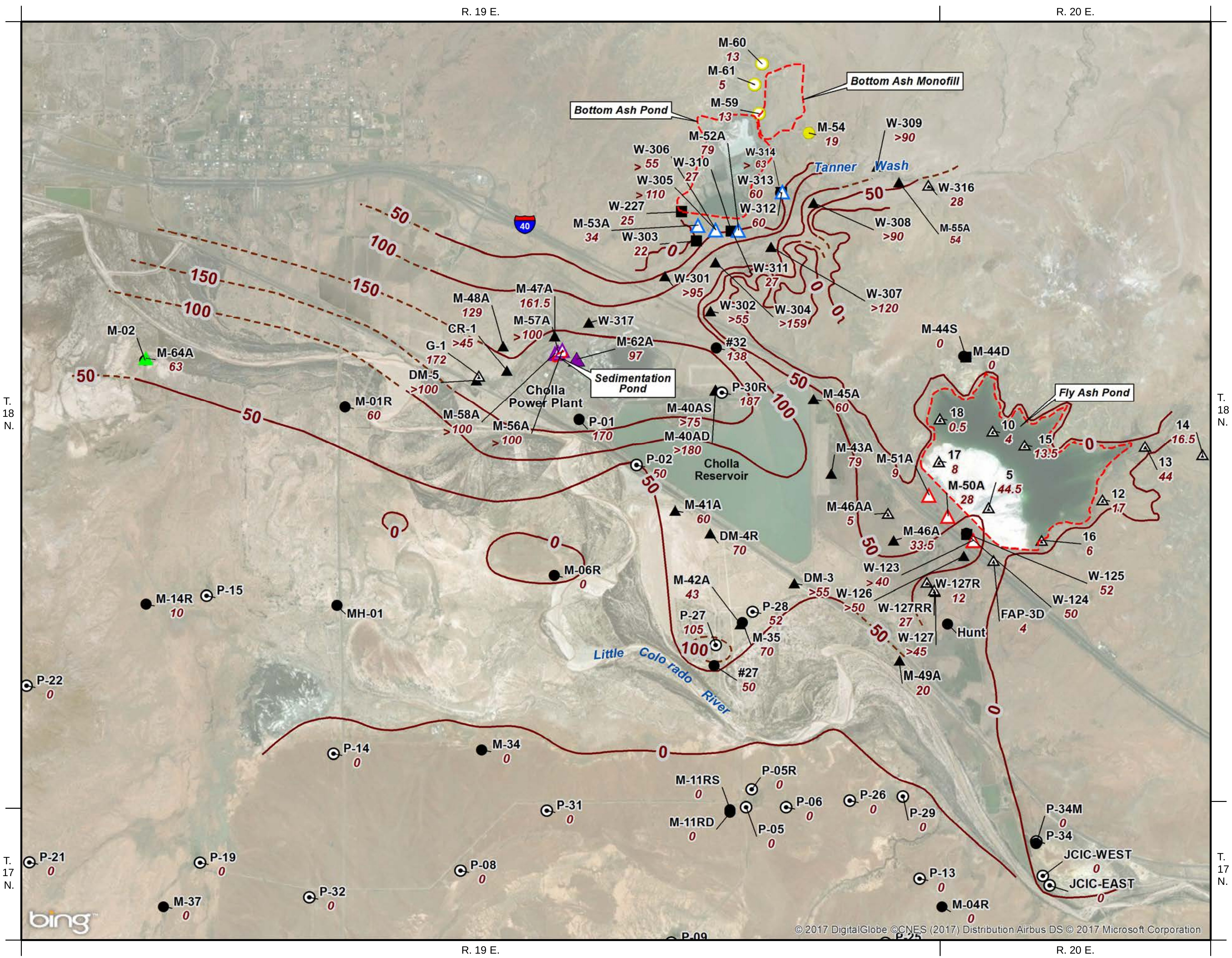
2017

FIGURE 1

GIS-TUC\897.0704\CCR_MonWellProgram_RevAug2017.mxd\19Sept2017 StatePlane Nad83_ft



EXPLANATION

- Approximate Extent of Coal Combustion Residual Unit
- 50 — Contour of Alluvium Thickness, in feet (dashed where inferred)
- M-51A / 9 — Well Location and Identifier; Thickness of Alluvium, in feet

CCR WELLS:

- Alluvium, Background, Fly Ash Pond and Bottom Ash Pond
- Alluvium, Downgradient, Bottom Ash Pond
- Alluvium, Downgradient, Fly Ash Pond
- Alluvium, Downgradient, Sedimentation Pond
- Alluvium, Upgradient, Sedimentation Pond
- Coconino, Downgradient, Bottom Ash Monofill
- Coconino, Upgradient, Bottom Ash Monofill

OTHER WELLS:

- Alluvium, Boring
- Alluvium, Monitor
- Moenkopi, Monitor
- Coconino, Monitor
- Coconino, Production

0 1,000 2,000 3,000 4,000
Feet

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NAVAJO COUNTY, ARIZONA

LCR AND TANNER WASH ALLUVIUM THICKNESS

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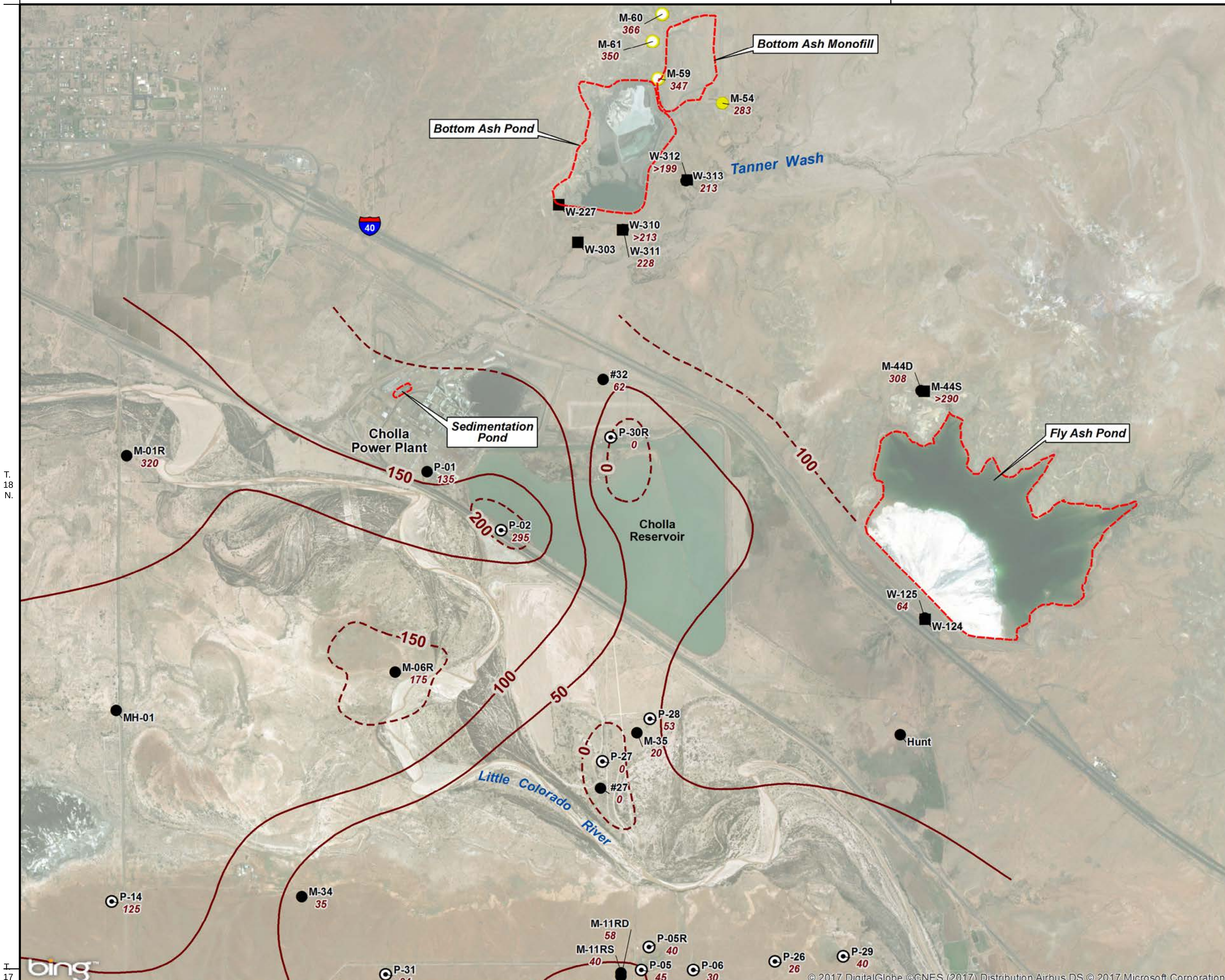
Water Resource Consultants

2017

FIGURE 2

GIS-TUC\897.0704\AlluvThickCont2017\19Sept2017 StatePlane Nad83_ft



EXPLANATION

- Approximate Extent of Coal Combustion Residual Unit
- 50 — Contour of Moenkopi Thickness, in feet (dashed where inferred)
- M-59 347 — Well Location and Identifier; Thickness of Moenkopi, in feet

CCR WELLS:

- Coconino, Downgradient, Bottom Ash Monofill
- Coconino, Upgradient, Bottom Ash Monofill

OTHER WELLS:

- Moenkopi, Monitor
- Coconino, Monitor
- Coconino, Production

N

0 1,000 2,000 3,000 4,000

Feet

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CHOLLA POWER PLANT
NAVAJO COUNTY, ARIZONA

MOENKOPI FORMATION THICKNESS

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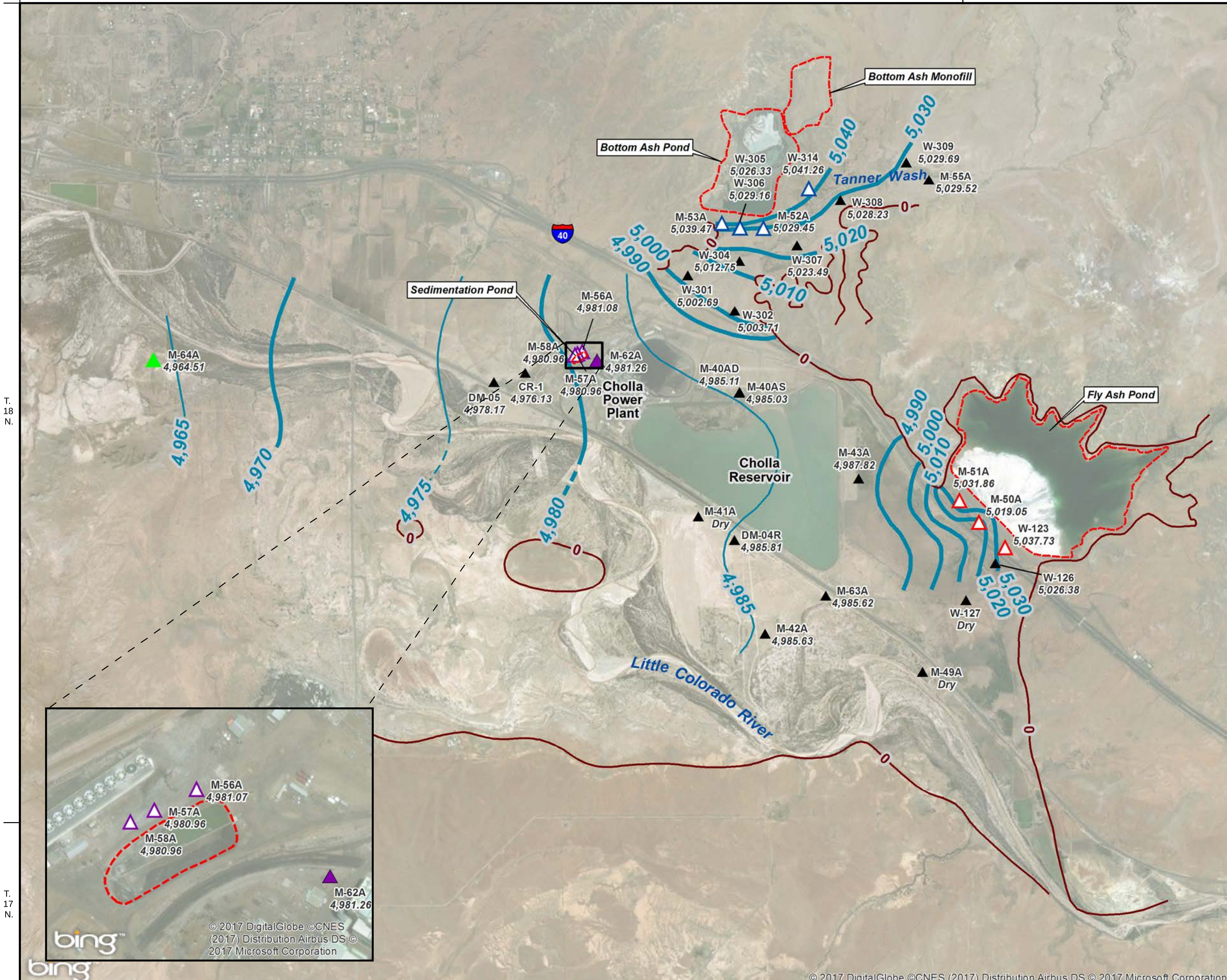
2017

FIGURE 3

GIS-TUC\897.0704\MoenkopiThickness2016-17\25Aug2017 StatePlane Nad83_ft



EXPLANATION

- Approximate Extent of Coal Combustion Residual Unit
- Estimated Extent of Alluvium
- 5,030 — 10-Foot Contour of Water Level Elevation in Alluvial Aquifer, in feet above mean sea level (dashed where inferred)
- 4,985 — 5-Foot Contour of Water Level Elevation in Alluvial Aquifer, in feet above mean sea level (dashed where inferred)
- M-51A — Alluvium Monitor Well Location and Identifier
- 5,031.85 — Elevation of Water Level, June - July 2017, in feet above mean sea level

CCR WELLS:

- Background, Fly Ash Pond and Bottom Ash Pond Well
- Downgradient, Bottom Ash Pond
- Downgradient, Fly Ash Pond
- Upgradient, Sedimentation Pond
- Downgradient, Sedimentation Pond

OTHER WELLS:

- Monitor Well

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ALLUVIAL AQUIFER WATER LEVEL ELEVATION JUNE - JULY 2017

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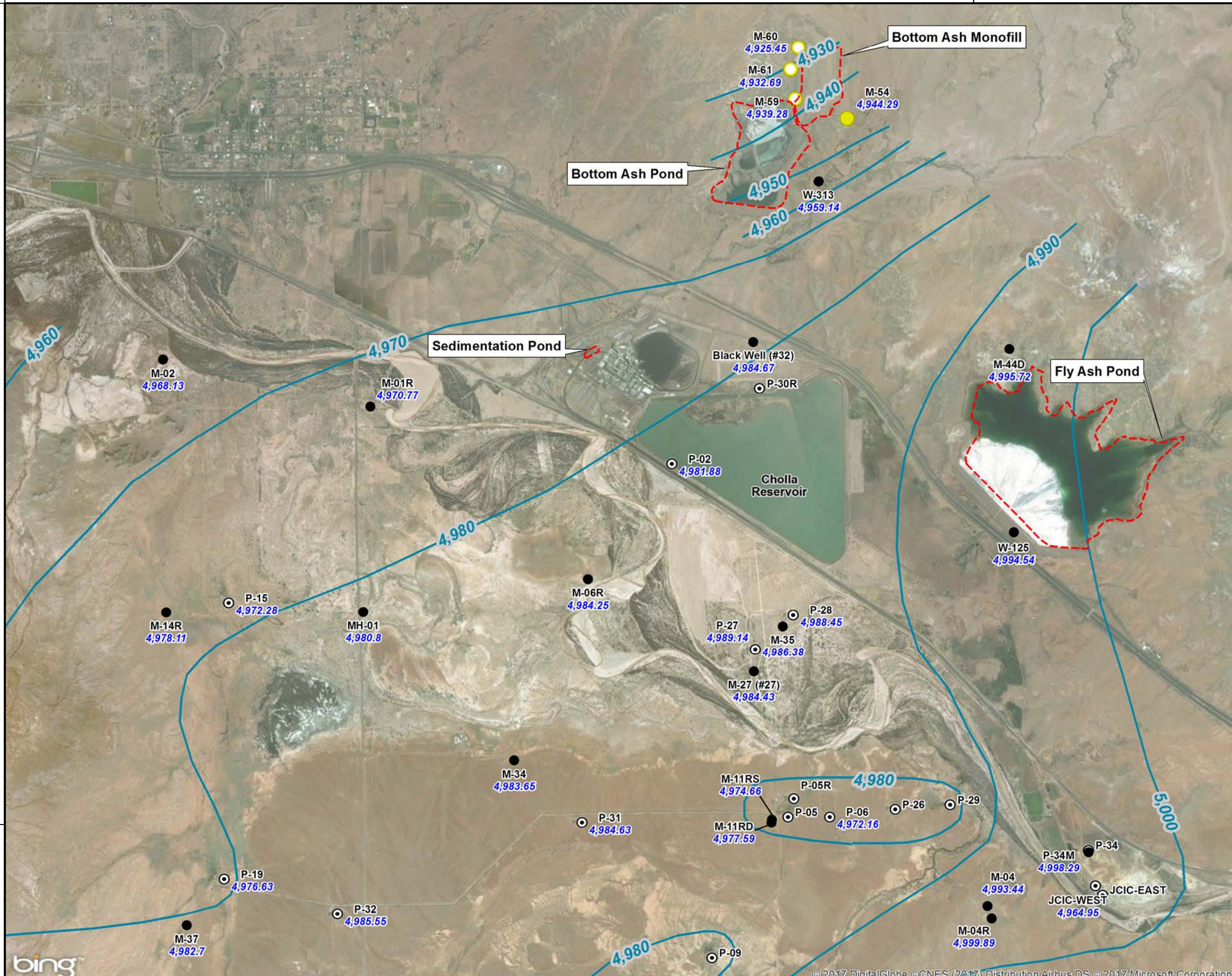
2017

FIGURE 4

GIS-TUC\897.0704\AlluvThickness_GWelevation_June-July2017\12Sept2017 StatePlane Nad83_ft

R. 19 E.
R. 20 E.



T. 18 N.

T. 17 N.

EXPLANATION

Approximate Extent of Coal Combustion Residual Unit

5,000 — 10-Foot Contour of Water Level Elevation in Coconino Sandstone Aquifer, in feet above mean sea level

M-44D — Coconino Monitor Well Location and Identifier

4,995.72 — Elevation of Water Level, June - July 2017, in feet above mean sea level

CCR WELLS:

- Downgradient, Bottom Ash Monofill
- Upgradient, Bottom Ash Monofill

OTHER WELLS:

- Monitor
- Production

N

0 4,000

Feet

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COCONINO AQUIFER WATER LEVEL ELEVATION JUNE - JULY 2017

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2017

FIGURE 5

GIS\897.0704\Coco_WaterLevelAlt_June-July2017\19Sept2017 UTM NAD27

APPENDIX A
CONSTRUCTION DETAILS FOR CCR NEW MONITOR WELLS
SEPTEMBER 2015 – February 2017

A total of 13 new wells were installed as part of the CCR monitoring network at Cholla Power Plant in two field programs implemented during the period September 2015 through February 2017. Detailed information regarding the construction for these wells is presented in the following sections. Locations for the new wells are shown on **Figure 1** in the main document. Schematic diagrams of well construction for the new CCR monitor wells are shown on **Figures A-1 through A-13** and lithologic logs are provided in **Tables A-1 through A-13**. **Table A-14** summarizes well development parameter stability measurements prior to collection of development samples. Wells are sequenced below and in associated figures and tables in order of well identification number, which coincides with the order in which the wells were drilled.

Monitor Well M-50A

- Location: Monitor well M-50A (55-918641) is located on land owned by Arizona Public Service (APS) in T18N, R20E, in the NW 1/4 of the NW 1/4 of the SW 1/4 of Section 30 (A-18-20)30bbc, at the base of the Fly Ash Pond (FAP) (**Figure 1**).
- Installation Dates: M-50A was drilled and constructed during the period September 17-18, 2015.
- Depth: Total drilled depth for M-50A is 32 feet below land surface (bls).
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary Alluvium (0 to 28 feet) and Moenkopi Formation (28 to 32 feet). Lithologic descriptions of drill cuttings for M-50A are presented in **Table A-1**.
- Screened Interval: M-50A was completed within the alluvium with a screened interval from 9 to 29 feet; non-pumping water level was 18.95 feet below measuring point (bmp) on November 30, 2015 (**Figure A-1**).
- Development: M-50A was developed by bailing and pumping on November 22, 2015 for a period of about 1 hour and 12 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-51A

- Location: Monitor well M-51A (55-918640) is located on land owned by APS in T18N, R19E, in the SE 1/4 of the SE 1/4 of the NE 1/4 of Section 25 (A-18-19)25add, at the base of the FAP (**Figure 1**).

- Installation Dates: M-51A was drilled and constructed during the period September 18-19, 2015.
- Depth: Total drilled depth for M-51A is 14 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 9 feet) and Moenkopi Formation (9 to 14 feet). Lithologic descriptions of drill cuttings for M-51A are presented in **Table A-2**.
- Screened Interval: M-51A was completed within the alluvium with a screened interval from 7 to 12 feet; non-pumping water level was 9.47 feet bmp on November 30, 2015 (**Figure A-2**).
- Development: M-51A was developed by bailing and pumping on November 22, 2015 for a period of about 1 hour and 42 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-52A

- Location: Monitor well M-52A (55-918657) is located on land owned by APS, in T18N, R19E, in the SW 1/4 of the NW 1/4 of the NW 1/4 of Section 24 (A-18-19)24bbc, north of the Little Colorado River (LCR) and U.S Highway 40 at the base of the Bottom Ash Pond (BAP) impoundment (**Figure 1**).
- Installation Dates: M-52A was drilled and constructed during the period September 21-22, 2015.
- Depth: Total drilled depth for M-52A is 83 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 79 feet) and Moenkopi Formation (79 to 83 feet). Lithologic descriptions of drill cuttings for M-52A are presented in **Table A-3**.
- Screened Interval: M-52A was completed within the alluvium with a screened interval from 20 to 70 feet; non-pumping water level was 19.13 feet bmp on December 1, 2015 (**Figure A-3**).
- Development: M-52A was developed by bailing and pumping on November 17, 2015 for a period of about 6 hour and 55 minutes; field parameters stabilized and water was described as slightly brown/reddish with no sand prior to sample collection (**Table A-14**).

Monitor Well M-53A

- Location: Monitor well M-53A (55-918651) is located on land owned by APS, in T18N, R19E, in the SW 1/4 of the SW 1/4 of the NW 1/4 of the NW 1/4 of Section 24 (A-18-19)23aab, north of the LCR and U.S Highway 40 at the base of the BAP impoundment (**Figure 1**).
- Installation Dates: M-53A was drilled and constructed during the period September 21-22, 2015.
- Depth: Total drilled depth for M-53A is 38 feet bls.

- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 34 feet) and Moenkopi Formation (34 to 38 feet). Lithologic descriptions of drill cuttings for M-53A are presented in **Table A-4**.
- Screened Interval: M-53A was completed within the alluvium with a screened interval from 10 to 35 feet; non-pumping water level was 4.49 feet bmp on December 1, 2015 (**Figure A-4**).
- Development: M-53A was developed by bailing and pumping on November 17, 2015 for a period of about 3 hours and 17 minutes; field parameters stabilized and water was described as clear with no sand prior to sample collection (**Table A-14**).

Monitor Well M-54

- Location: Monitor well M-54 (55-918646) is located on land owned by APS, in T18N, R19E, in the NW 1/4 of the NE 1/4 of the SW 1/4 of Section 13 (A-18-19)13cab, north of the LCR and U.S Highway 40 and east of the Bottom Ash Monofill (BAM) adjacent to an unnamed ephemeral wash that is tributary to Tanner Wash (**Figure 1**).
- Installation Dates: M-54 was drilled and constructed during the period September 23-October 2, 2015.
- Depth: Total drilled depth for M-54 is 370 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 19 feet), Moenkopi Formation (19 to 302 feet), and Permian Coconino Sandstone (302 to 370 feet). Lithologic descriptions of drill cuttings for M-54 are presented in **Table A-5**.
- Screened Interval: M-54 was completed within the Coconino Sandstone with a screened interval from 315 to 365 feet; non-pumping water level was 127.99 feet bmp on December 2, 2015 (**Figure A-5**).
- Development: M-54 was developed by bailing and pumping on November 18, 2015 for a period of about 4 hours; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-56A

- Location: Monitor well M-56A (55-918661) is located on land owned by APS, in T18N, R19E, in the SW 1/4 of the NW 1/4 of the SW 1/4 of Section 23 (A-18-19)23cbc, within the plant site adjacent to the western cooling towers and the Sedimentation Pond (SEDI) (**Figure 1**).
- Installation Dates: M-56A was drilled and constructed during the period October 4-7, 2015.
- Depth: Total drilled depth for M-56A is 100 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 100 feet). Lithologic descriptions of drill cuttings for M-56A are presented in **Table A-6**.

- Screened Interval: M-56A was completed within the alluvium with a screened interval from 40 to 85 feet; non-pumping water level was 43.52 feet bmp on November 30, 2015 (**Figure A-6**).
- Development: M-56A was developed by bailing and pumping on November 21, 2015 for a period of about 2 hours and 45 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-57A

- Location: Monitor well M-57A (55-918660) is located on land owned by APS, in T18N, R19E, in the SW 1/4 of the NW 1/4 of the SW 1/4 of Section 23 (A-18-19)23cbc, within the plant site adjacent to the western cooling towers and the SEDI (**Figure 1**).
- Installation Dates: M-57A was drilled and constructed during the period October 7-8, 2015.
- Depth: Total drilled depth for M-57A is 100 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 100 feet). Lithologic descriptions of drill cuttings for M-57A are presented in **Table A-7**.
- Screened Interval: M-57A was completed within the alluvium with a screened interval from 40 to 85 feet; non-pumping water level was 44.25 feet bmp on November 30, 2015 (**Figure A-7**).
- Development: M-57A was developed by bailing and pumping on November 21, 2015 for a period of about 3 hours and 4 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-58A

- Location: Monitor well M-58A (55-918659) is located on land owned by APS, in T18N, R19E, in the SW 1/4 of the NW 1/4 of the SW 1/4 of Section 23 (A-18-19)23cbc, within the plant site adjacent to the western cooling towers and the SEDI (**Figure 1**).
- Installation Dates: M-58A was drilled and constructed during the period of October 8 through October 13, 2015.
- Depth: Total drilled depth for M-58A is 100 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 100 feet). Lithologic descriptions of drill cuttings for M-58A are presented in **Table A-8**.
- Screened Interval: M-58A was completed within the alluvium with a screened interval from 39 to 84 feet; non-pumping water level was 44.25 feet bmp on November 30, 2015 (**Figure A-8**).

- Development: M-58A was developed by bailing and pumping on November 21, 2015 for a period of about 2 hours and 10 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-59

- Location: Monitor well M-59 (55-918647) is located on land owned by APS, in T18N, R19E, in the NW 1/4 of the NW 1/4 of the NW 1/4 of the SW 1/4 of Section 13 (A-18-19)13cbb, north of the LCR and U.S Highway 40 and northwest of the BAM (**Figure 1**).
- Installation Dates: M-59 was drilled and constructed during the period October 14-21, 2015.
- Depth: Total drilled depth for M-59 is 425 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 13 feet), Moenkopi Formation (13 to 360 feet), and Coconino Sandstone (360 to 425 feet). Lithologic descriptions of drill cuttings for M-59 are presented in **Table A-9**.
- Screened Interval: M-59 was completed within the Coconino Sandstone with a screened interval from 373 to 423 feet; non-pumping water level was 197.78 feet bmp on December 2, 2015 (**Figure A-9**).
- Development: M-59 was developed by bailing and pumping on November 20, 2015 for a period of about 2 hours and 25 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-60

- Location: Monitor well M-60 (55-918649) is located on land owned by APS, in T18N, R19E, in the SW 1/4 of the SW 1/4 of the NE 1/4 of the NW 1/4 of Section 13 (A-18-19)13bac, north of the LCR and U.S Highway 40 and west of the BAM (**Figure 1**).
- Installation Dates: M-60 was drilled and constructed during the period October 21-November 1, 2015.
- Depth: Total drilled depth for M-60 is 450 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 14 feet), Moenkopi Formation (14 to 380 feet), and Coconino Sandstone (380 to 450 feet). Lithologic descriptions of drill cuttings for M-60 are presented in **Table A-10**.
- Screened Interval: M-60 was completed within the Coconino Sandstone with a screened interval from 395 to 445 feet; non-pumping water level was 226.92 feet bmp on December 2, 2015 (**Figure A-10**).
- Development: M-60 was developed by bailing and pumping on November 20, 2015 for a period of about 3 hours and 24 minutes; field parameters generally stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-61

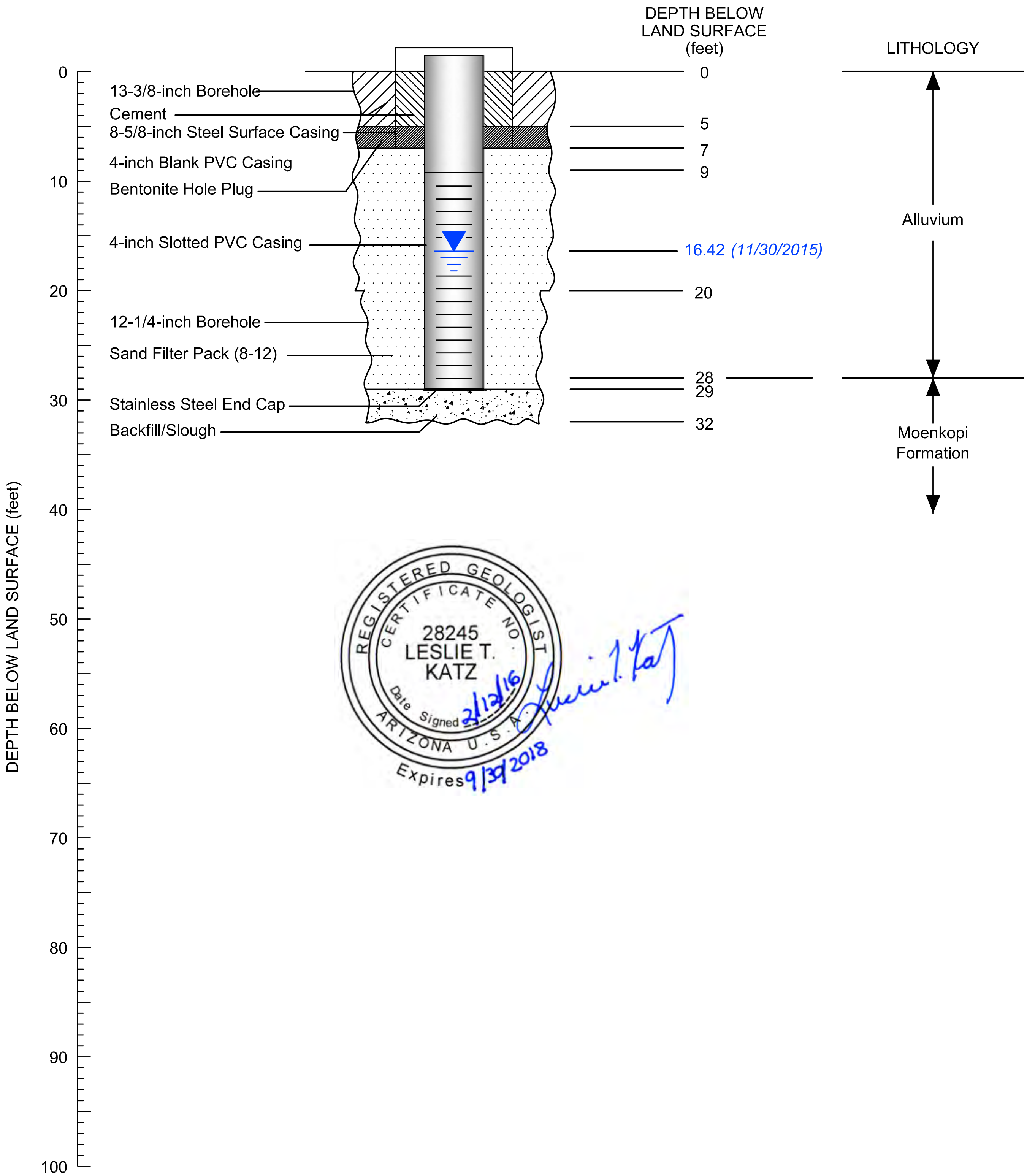
- Location: Monitor well M-61 (55-918648) is located on land owned by APS, in T18N, R19E, in the NE 1/4 of the SW 1/4 of the NW 1/4 of Section 13 (A-18-19)13bca, north of the LCR and U.S. Highway 40 and west of the BAM (**Figure 1**).
- Installation Dates: M-61 was drilled and constructed during the period November 2-13, 2015.
- Depth: Total drilled depth for M-61 is 420 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 5 feet), Moenkopi Formation (5 to 350 feet), and Coconino Sandstone (350 to 420 feet). Lithologic descriptions of drill cuttings for M-61 are presented in **Table A-11**.
- Screened Interval: M-61 was completed within the Coconino Sandstone with a screened interval from 365 to 415 feet; non-pumping water level was 195.93 feet bmp on December 2, 2015 (**Figure A-11**).
- Development: M-61 was developed by bailing and pumping on November 19, 2015 for a period of about 2 hours and 45 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).

Monitor Well M-62A

- Location: Monitor well M-62A (55-918658) is located on land owned by APS, in T18N, R19E, in the SE 1/4 of the NW 1/4 of the SW 1/4 of Section 23 (A-18-19)23cbd, within the plant site adjacent to the western cooling towers and the SEDI (**Figure 1**).
- Installation Dates: M-62A was drilled and constructed during the period November 14-17, 2015.
- Depth: Total drilled depth for M-62A is 97 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 97 feet). Lithologic descriptions of drill cuttings for M-62A are presented in **Table A-12**.
- Screened Interval: M-62A was completed within the alluvium with a screened interval from 39 to 84 feet; non-pumping water level was 41.13 feet bmp on November 30, 2015 (**Figure A-12**).
- Development: M-62A was developed by bailing and pumping on November 22, 2015 for a period of about 3 hours and 5 minutes; field parameters stabilized and water was described as clear prior to sample collection (**Table A-14**).
- Well M-62A was installed as a dual purpose well for both the CCR program and Voluntary Remediation Program (VRP). Split spoon samples were collected during drilling. Details of the split spoon sampling program and results were presented to the APS VRP group under a separate communication.

Monitor Well M-64A

- Location: Monitor well M-64A (55-920353) is located on land owned by APS in T18N, R19E, in the SW 1/4 of the SW 1/4 of the NW 1/4 of Section 21 (A-18-19)21ccb, south of the LCR and U.S. Highway 40 and west of the Cholla Power Plant (**Figure 1**).
- Installation Dates: M-64A was drilled and constructed during the period February 7-8, 2017.
- Depth: Total drilled depth for M-64A is 69 feet bls.
- Geology: Geologic units encountered during drilling from land surface to total depth include Quaternary alluvium (0 to 63 feet) and Moenkopi Formation (63 to 69 feet). Lithologic descriptions of drill cuttings for M-64A are presented in **Table A-13**.
- Screened Interval: M-64A was completed within the alluvium with a screened interval from 30 to 60 feet; non-pumping water level was 25.18 feet bmp on February 20, 2017 (**Figure A-13**).
- Development: M-64A was developed by swabbing and bailing on February 10, 2017 for a period of about 4 hours and 3 minutes; field parameters generally stabilized and water was described to have minimal sand prior to sample collection (**Table A-14**).



EXPLANATION

Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-50A (FAP-2D)	NORTHING: 1429799.42
REGISTRATION: 55-918641	EASTING: 669243.76
COUNTY: Navajo, Arizona	MP Elevation: 5038.179 feet amsl
DATE COMPLETED: 09/18/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-50A APS CHOLLA POWER PLANT

MONTGOMERY & ASSOCIATES

2016

FIGURE A-1

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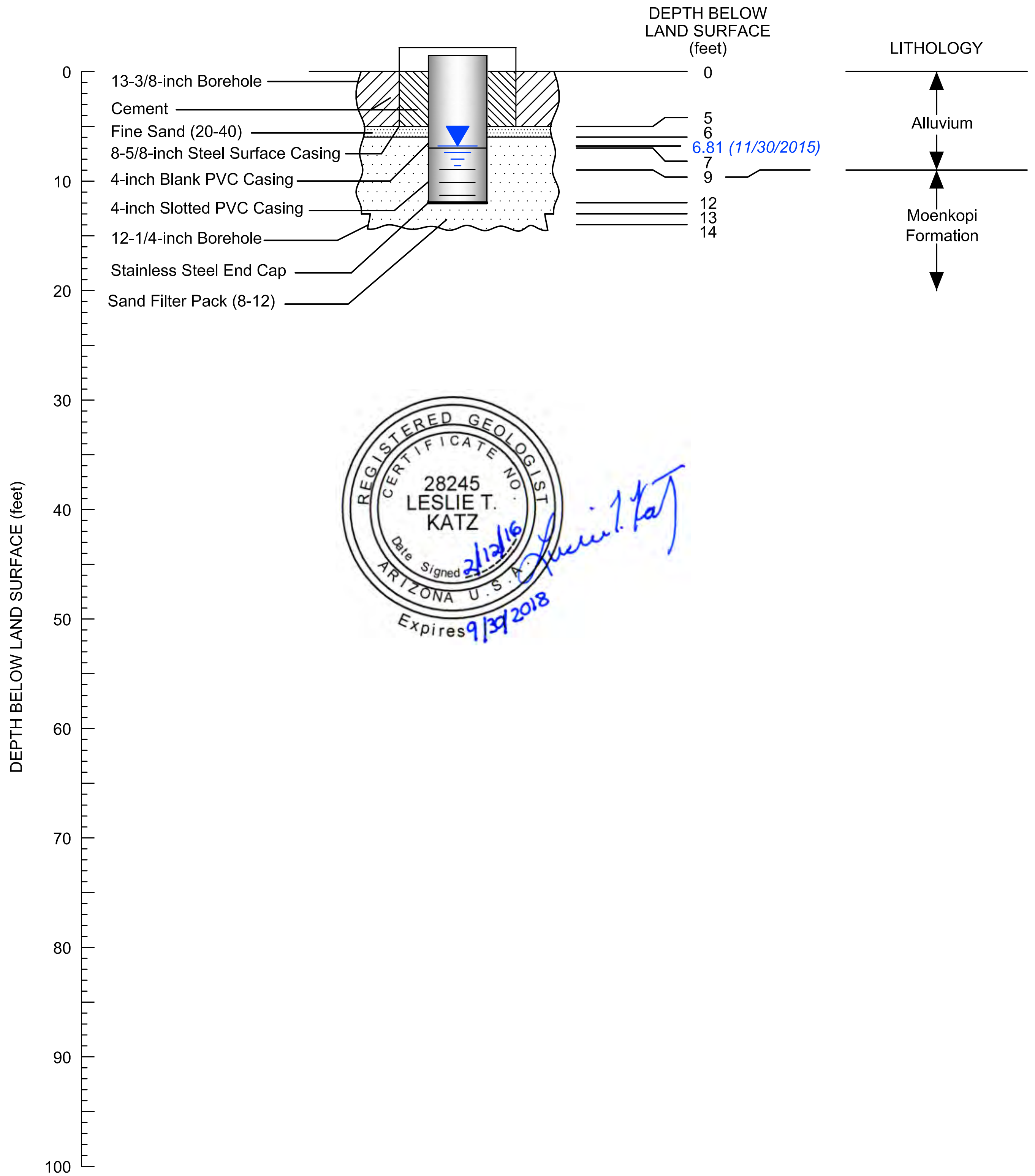

EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-51A (FAP-1D)	NORTHING: 1430360.14
REGISTRATION: 55-918640	EASTING: 668733.14
COUNTY: Navajo, Arizona	MP Elevation: 5041.765 feet amsl
DATE COMPLETED: 9/19/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-51A APS CHOLLA POWER PLANT

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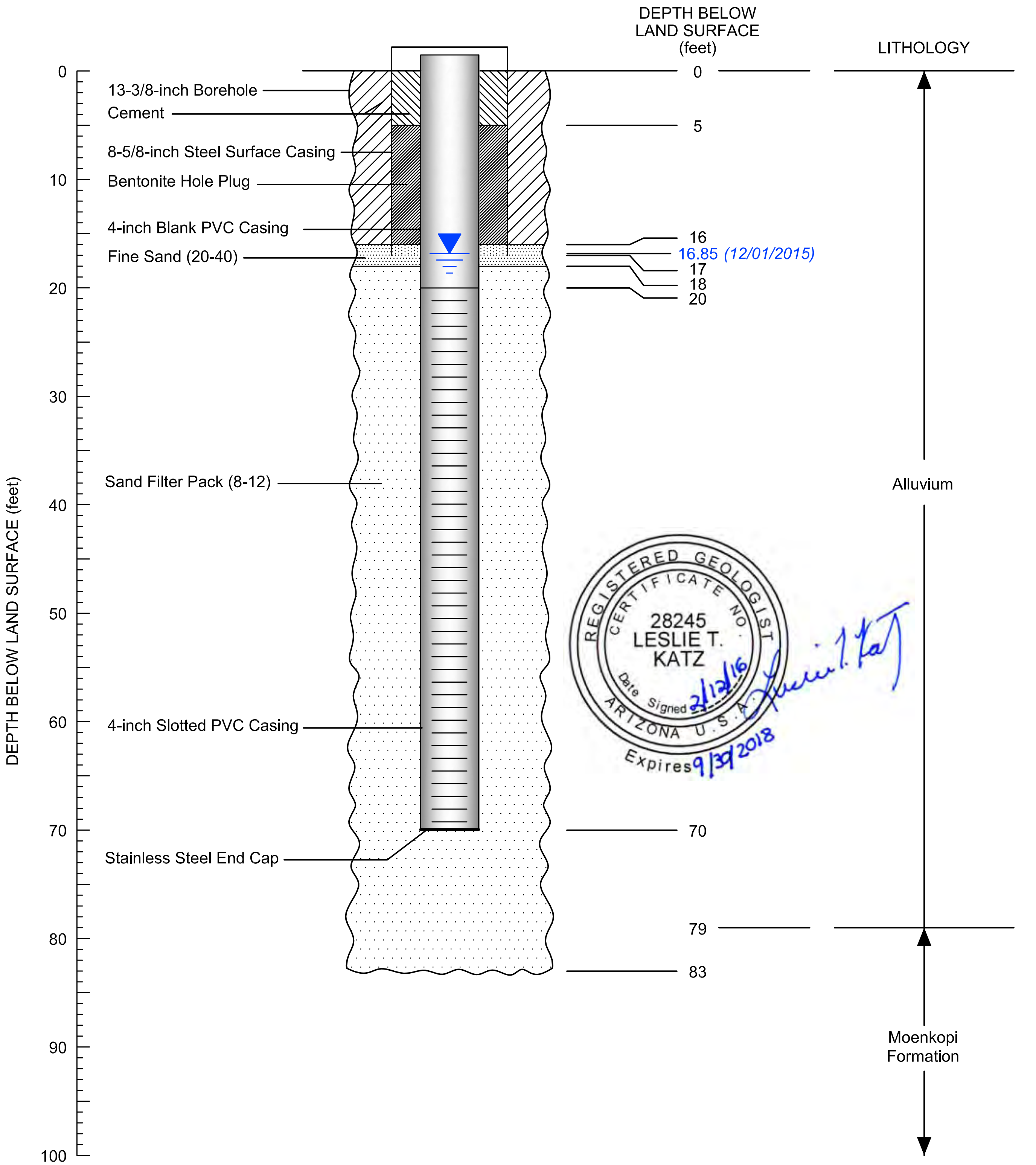
2016

FIGURE A-2

Drafting\897.0702\M51A_ws\12Feb2016



EXPLANATION

Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-52A (BAP-2D)	NORTHING: 1437475.71
REGISTRATION: 55-918657	EASTING: 663614.28
COUNTY: Navajo, Arizona	MP Elevation: 5049.363 feet amsl
DATE COMPLETED: 09/21/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-52A APS CHOLLA POWER PLANT

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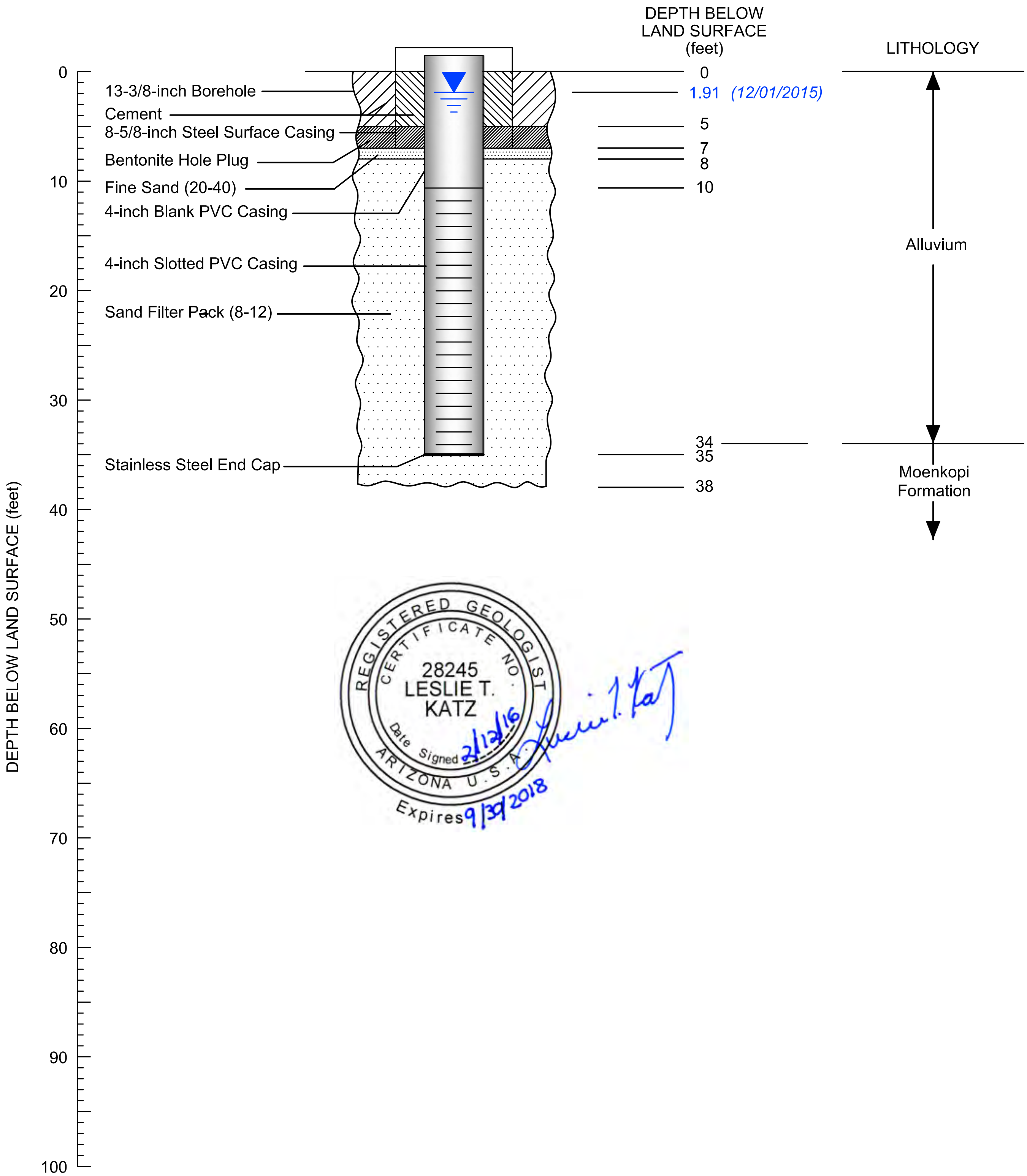
2016

FIGURE A-3

Drafting\897.0702\M52A_ws\12Feb2016



EXPLANATION

Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-53A (BAP-1D)	NORTHING: 1437605.11
REGISTRATION: 55-918651	EASTING: 662529.37
COUNTY: Navajo, Arizona	MP Elevation: 5044.677 feet amsl
DATE COMPLETED: 09/22/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-53A APS CHOLLA POWER PLANT

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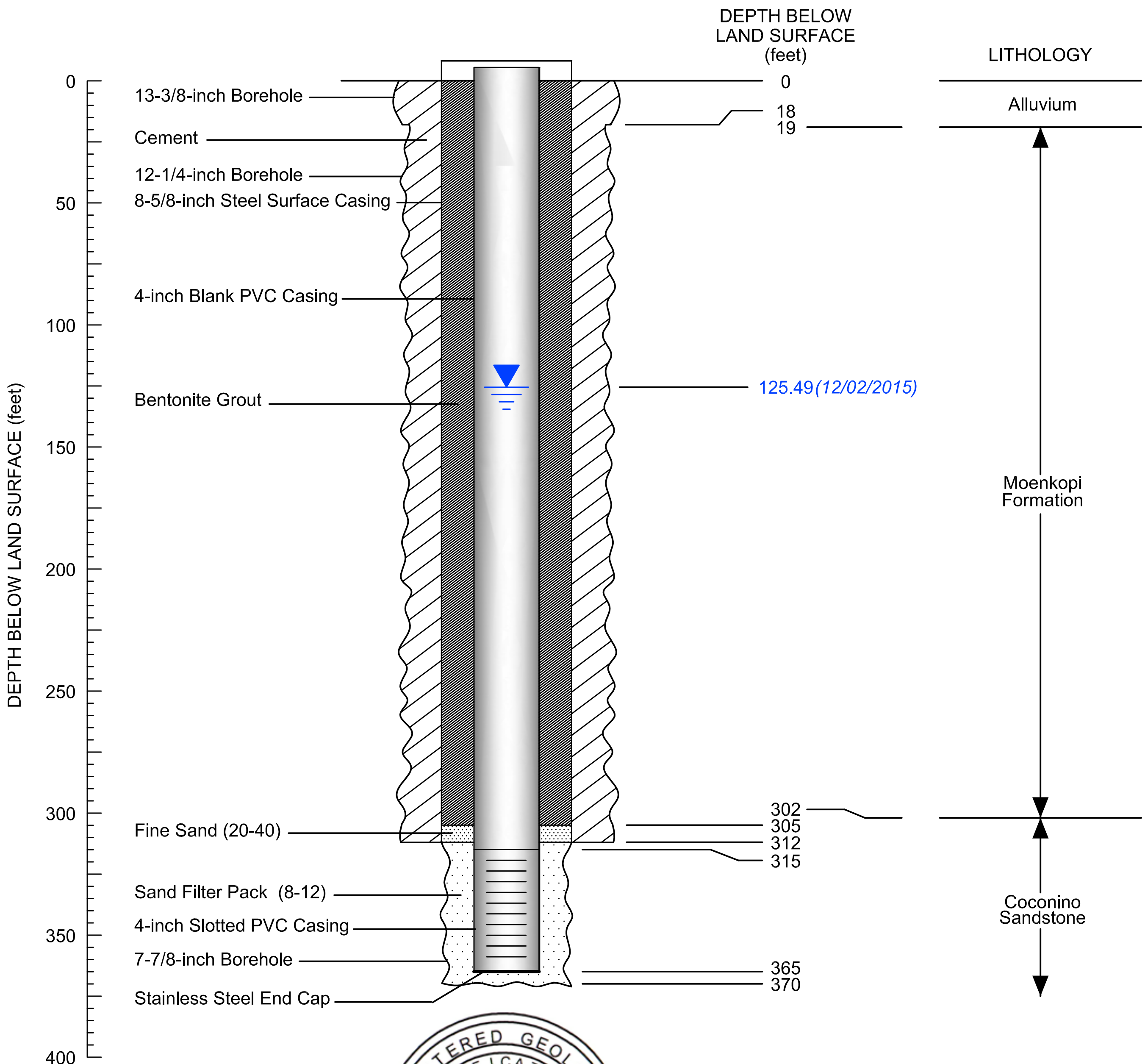
2016

FIGURE A-4

Drafting\897.0702\M53A_ws\12Feb2016



REGISTERED GEOLOGIST CERTIFICATE NO. 28245 LESLIE T. KATZ Date Signed 2/12/16 ARIZONA U.S.A. Expires 9/30/2018

EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-54 (BAM-1U)	NORTHING: 1440088.61
REGISTRATION: 55-918646	EASTING: 665508.13
COUNTY: Navajo, Arizona	MP Elevation: 5070.71 feet amsl
DATE COMPLETED: 10/02/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR COCONINO WELL M-54 APS CHOLLA POWER PLANT

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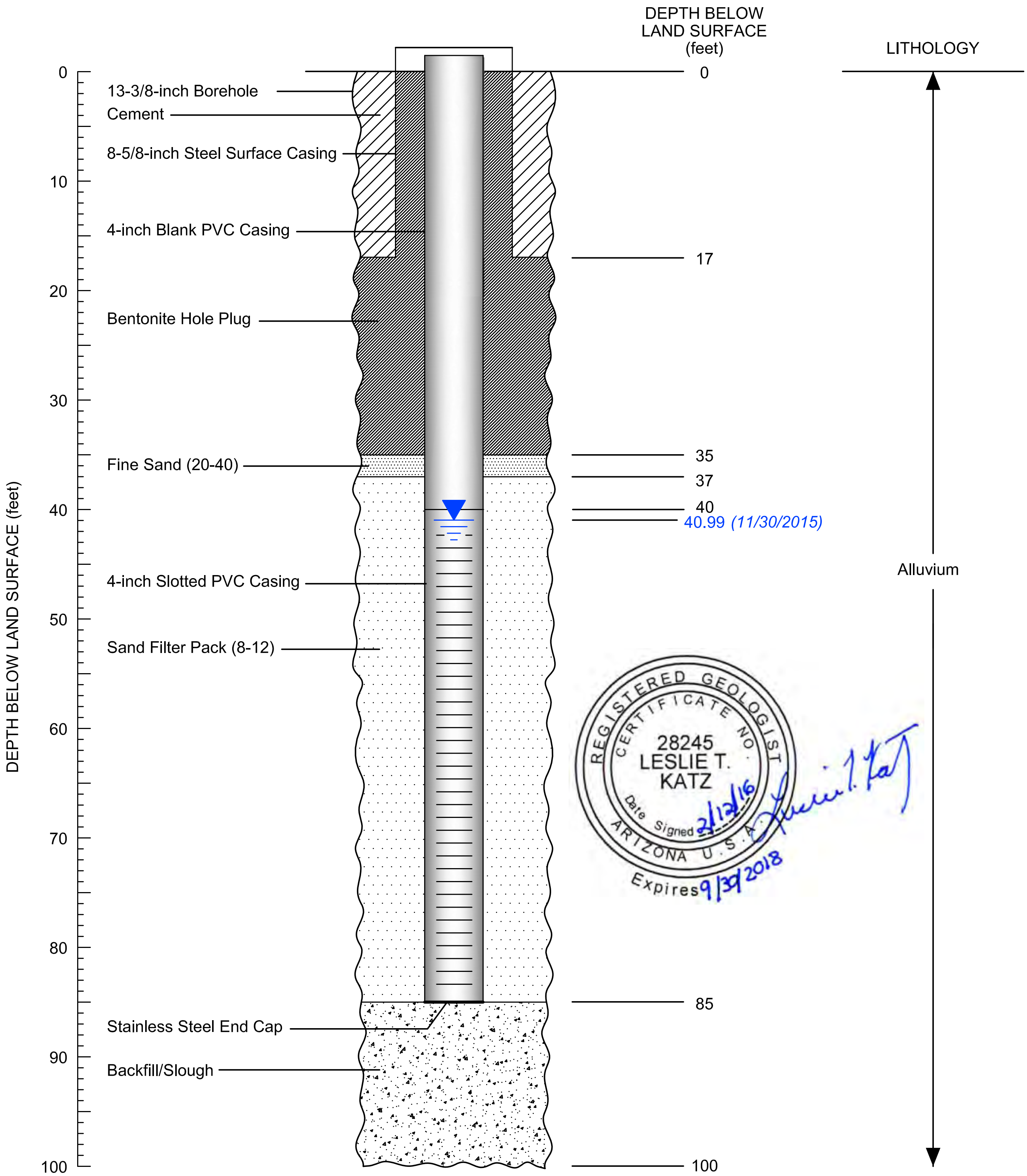
2016

FIGURE A-5

Drafting\897.0702\M54_ws\12Feb2016



EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-56A (SP-3D)	NORTHING: 1434257.73
REGISTRATION: 55-918661	EASTING: 658887.35
COUNTY: Navajo, Arizona	MP Elevation: 5023.165 feet amsl
DATE COMPLETED: 10/07/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-56A APS CHOLLA POWER PLANT

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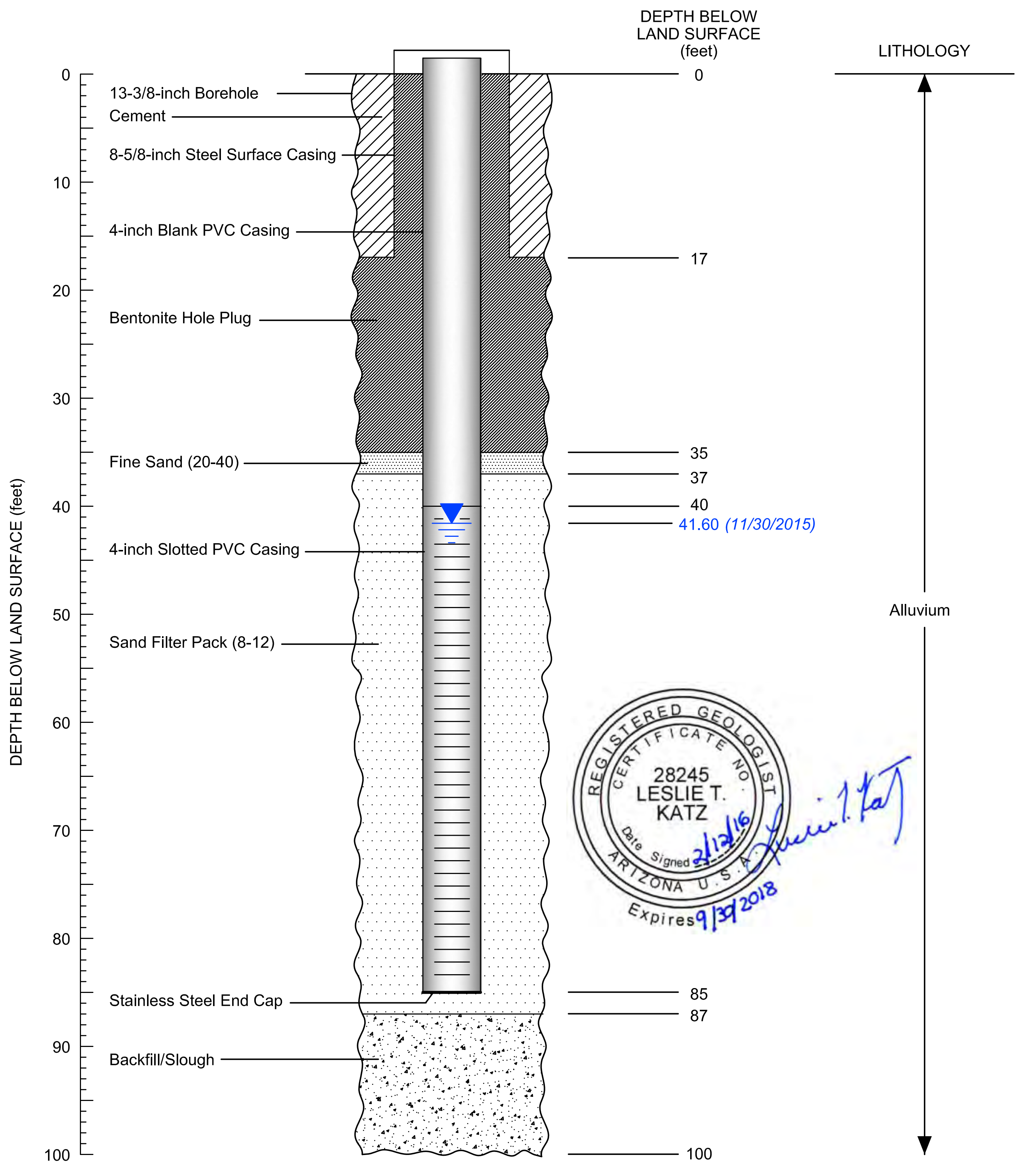
2016

FIGURE A-6

Drafting\897.0702\M56A_ws\12Feb2016



EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-57A (SP-2D)	NORTHING: 1434198.68
REGISTRATION: 55-918660	EASTING: 658767.25
COUNTY: Navajo, Arizona	MP Elevation: 5023.816 feet amsl
DATE COMPLETED: 10/08/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-57A APS CHOLLA POWER PLANT

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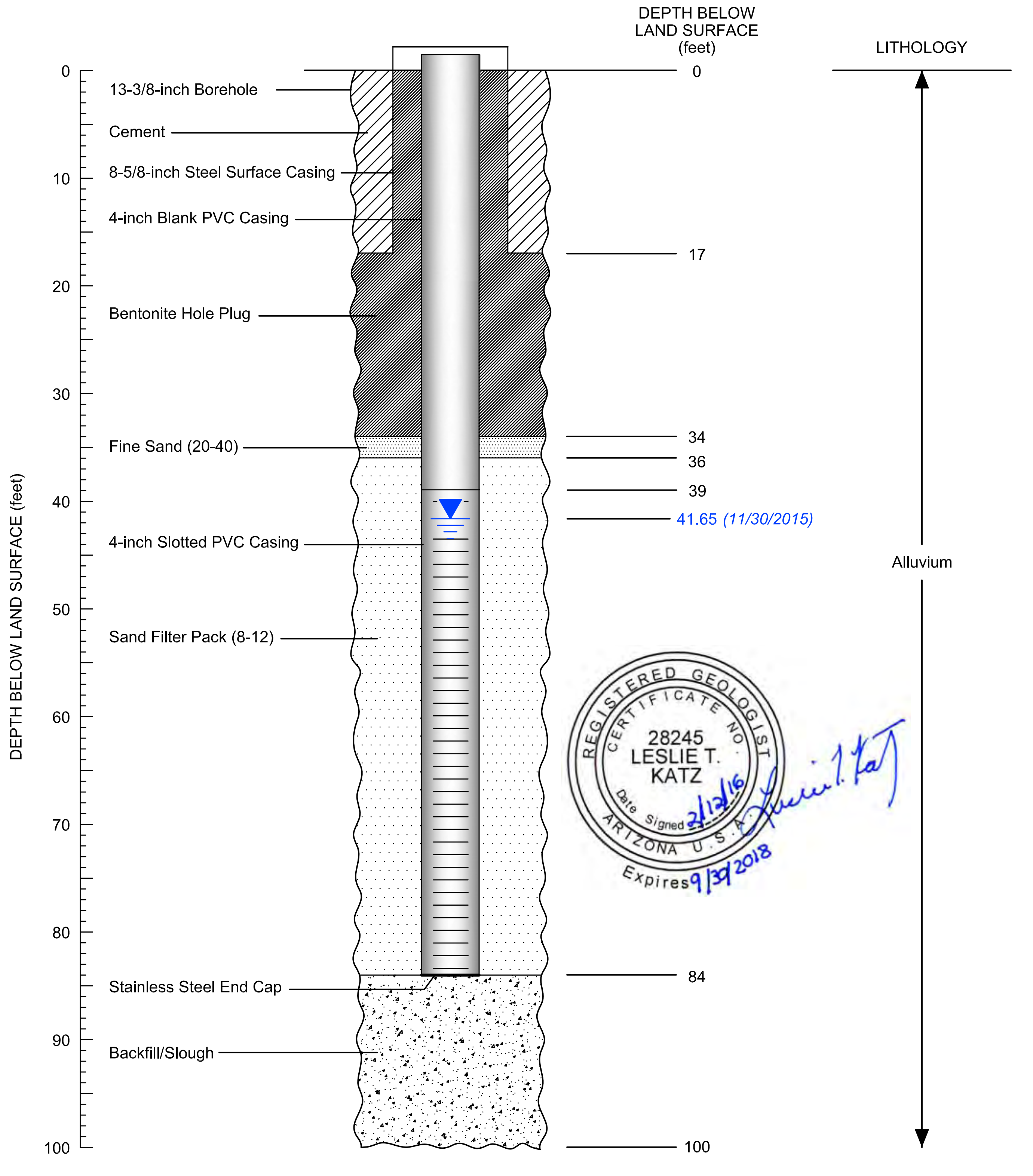
2016

FIGURE A-7



EXPLANATION

Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-58A (SP-1D)	NORTHING: 1434165.11
REGISTRATION: 55-918659	EASTING: 658698.92
COUNTY: Navajo, Arizona	MP Elevation: 5023.841 feet amsl
DATE COMPLETED: 10/13/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-58A APS CHOLLA POWER PLANT

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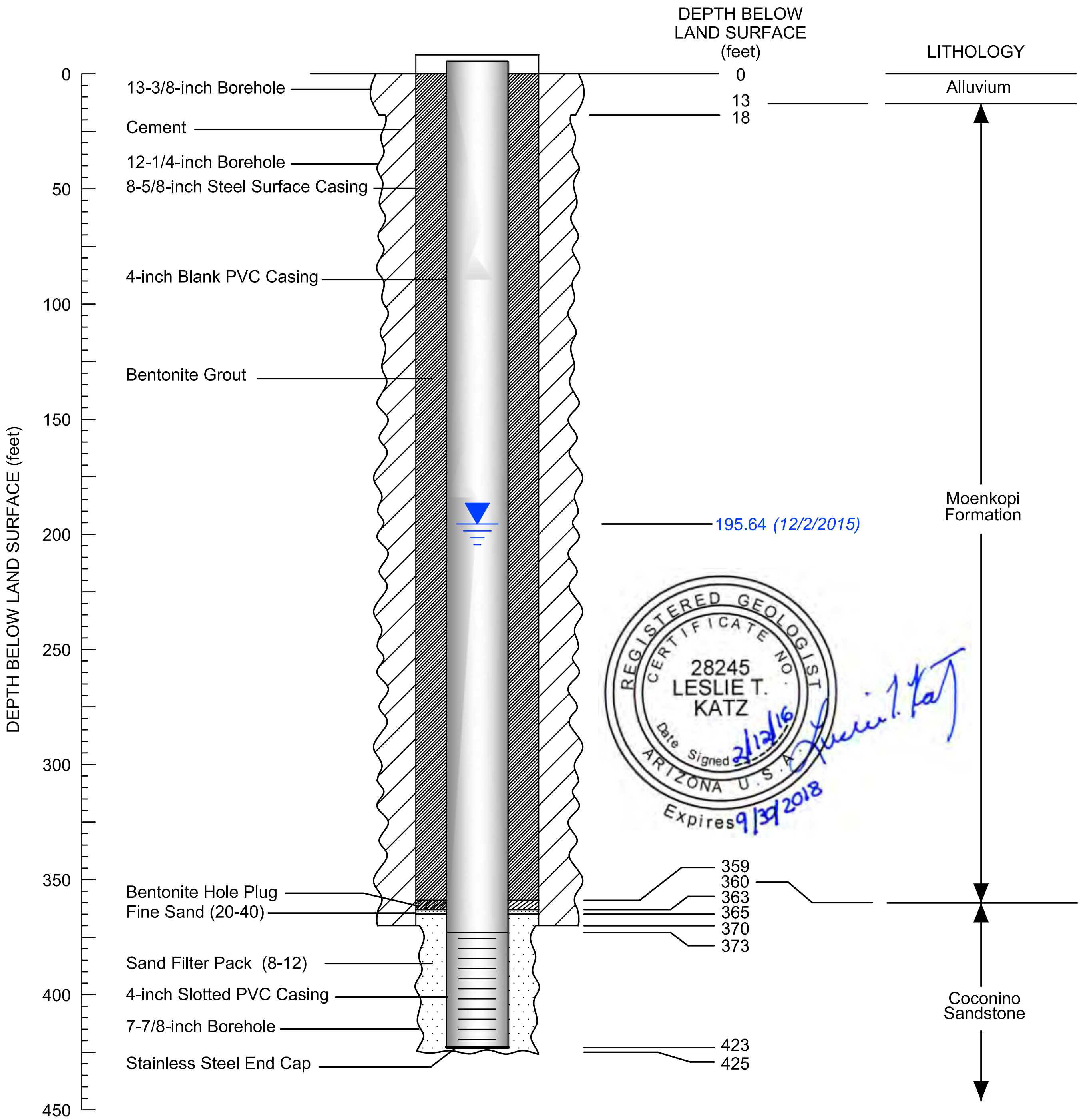
2016

FIGURE A-8

Drafting\897.0702\M58A_ws\12Feb2016



EXPLANATION

Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-59 (BAM-1D)	NORTHING: 1440604.73
REGISTRATION: 55-918647	EASTING: 664161.36
COUNTY: Navajo, Arizona	MP Elevation: 5136.002 feet amsl
DATE COMPLETED: 10/21/15	DATUM: NAD83, State Plane 1983

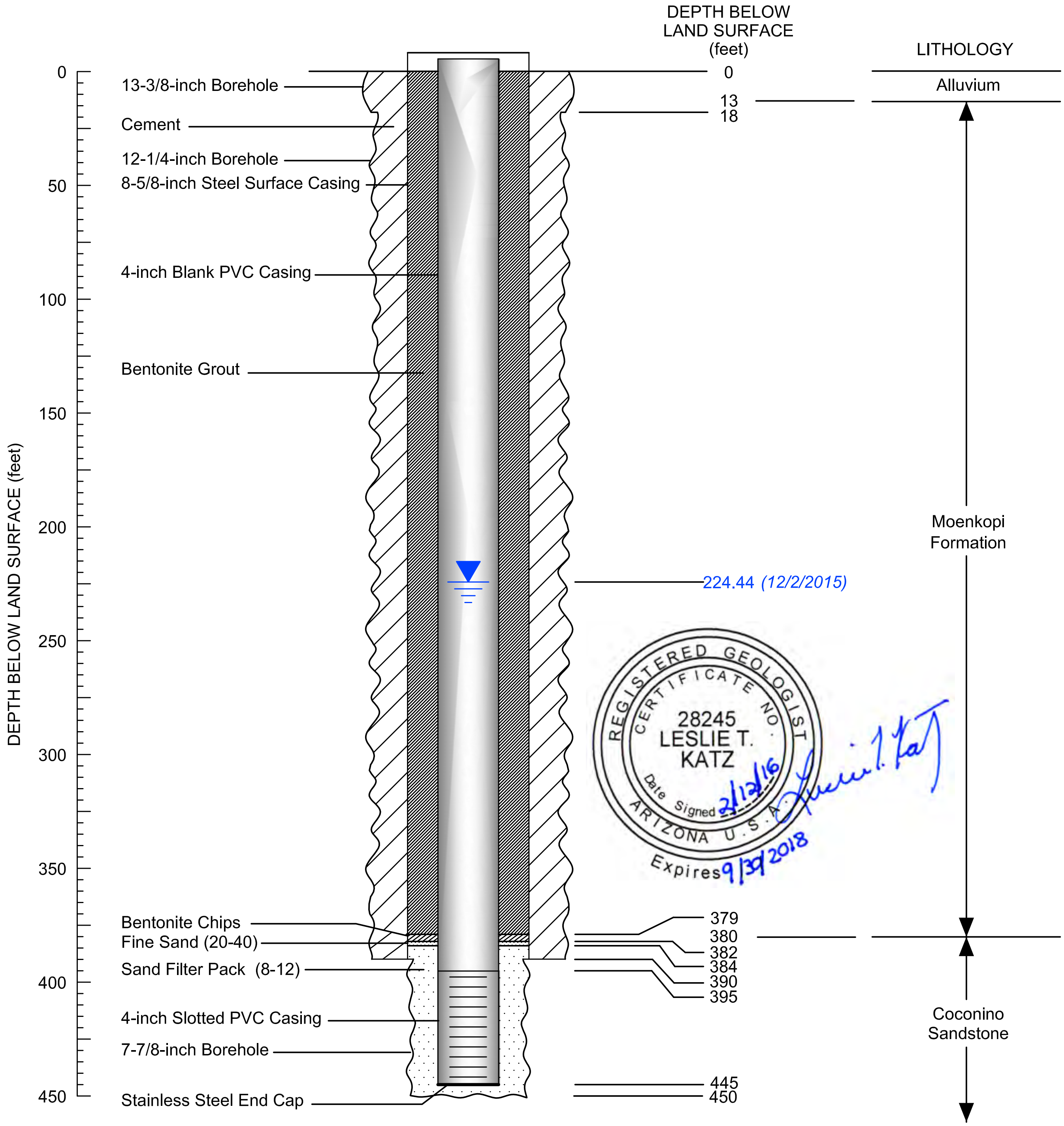
SCHEMATIC DIAGRAM OF CONSTRUCTION FOR COCONINO WELL M-59 APS CHOLLA POWER PLANT

MONTGOMERY & ASSOCIATES

2016

FIGURE A-9

Drafting\897.0702\M59_ws\12Feb2016



EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-60 (BAM-3D)	NORTHING: 1441947.89
REGISTRATION: 55-918649	EASTING: 664249.99
COUNTY: Navajo, Arizona	MP Elevation: 5151.175 feet amsl
DATE COMPLETED: 11/1/15	DATUM: NAD83, State Plane 1983

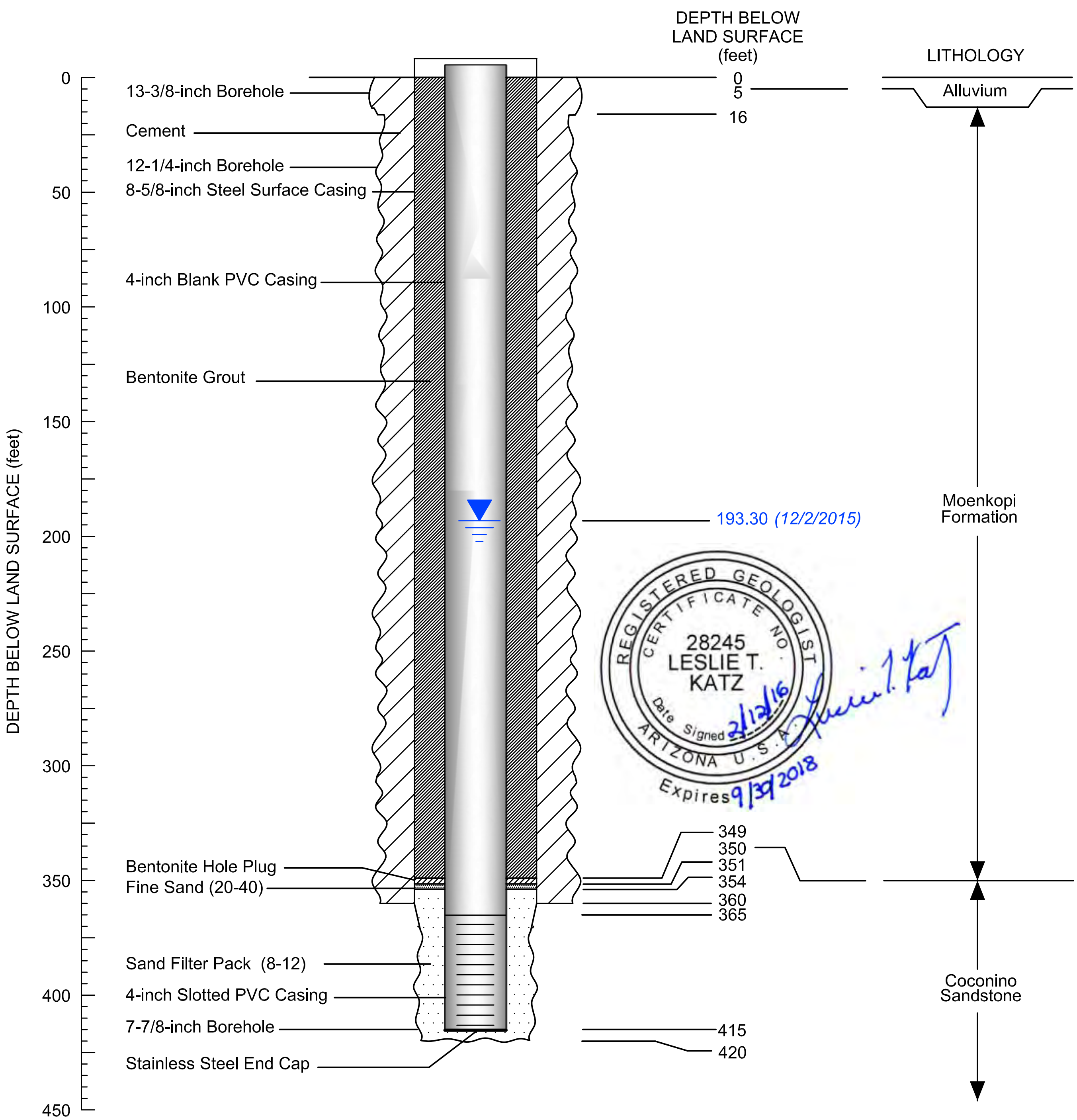
SCHEMATIC DIAGRAM OF CONSTRUCTION FOR COCONINO WELL M-60 APS CHOLLA POWER PLANT

MONTGOMERY & ASSOCIATES

2016

FIGURE A-10

Drafting\897.0702\M60_ws\12Feb2016



EXPLANATION

Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-61 (BAM-2D)	NORTHING: 1441383.55
REGISTRATION: 55-918648	EASTING: 664047.00
COUNTY: Navajo, Arizona	MP Elevation: 5127.577 feet amsl
DATE COMPLETED: 11/13/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR COCONINO WELL M-61 APS CHOLLA POWER PLANT

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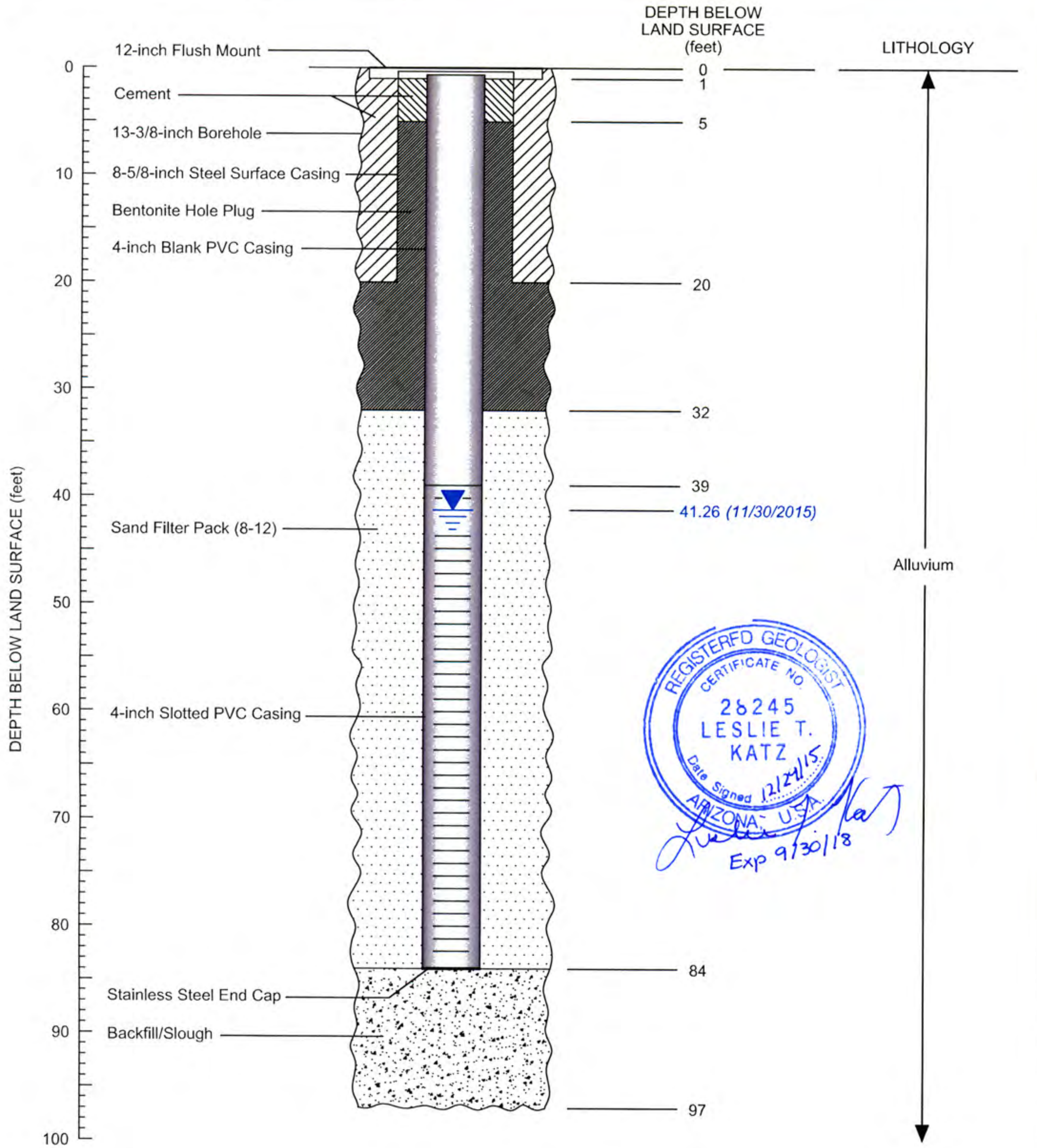
2016

FIGURE A-11

Drafting\897.0702\M61_ws\12Feb2016



EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-62A (SP-1U)	NORTHING: 1434008.665
REGISTRATION: 55-918658	EASTING: 659268.051
COUNTY: Navajo, Arizona	MP Elevation: 5020.874 feet amsl
DATE COMPLETED: 11/17/15	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-62A APS CHOLLA POWER PLANT

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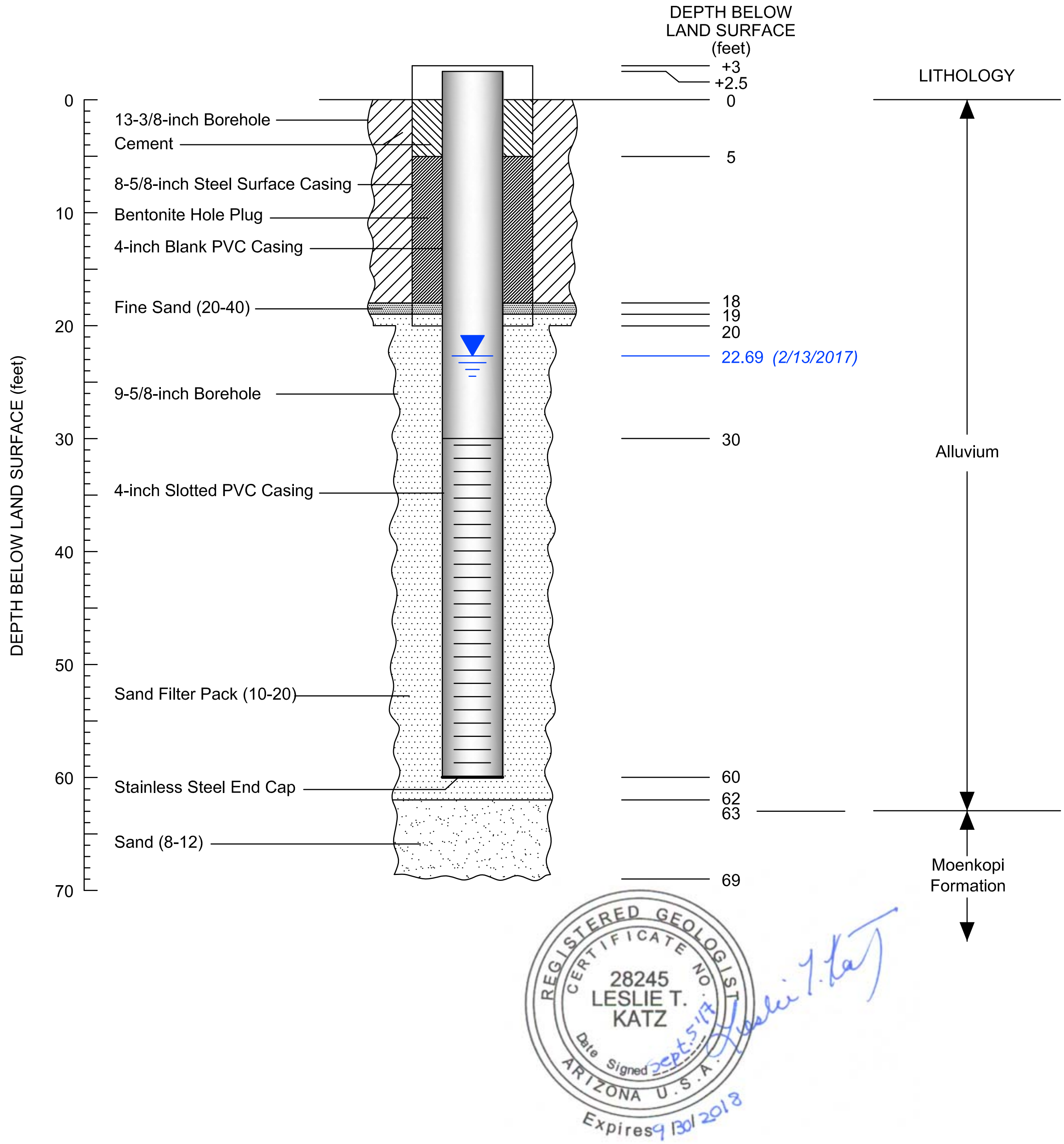
2015

FIGURE A-12

Drafting\897.0702\M62A_ws\29Dec2015



EXPLANATION

▼ Depth to Water Level

Note: All PVC blank and slotted casing is Schedule 80; slot size is 0.020 inches.

WELL: M-64A	NORTHING: 1434030.012
REGISTRATION: 55-920353	EASTING: 647702.043
COUNTY: Navajo, Arizona	MP Elevation: 4,988.904
DATE COMPLETED: 2/9/2017	DATUM: NAD83, State Plane 1983

SCHEMATIC DIAGRAM OF CONSTRUCTION FOR ALLUVIAL WELL M-64A APS CHOLLA POWER PLANT

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2017

FIGURE A-13

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TABLE A-1. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM Monitoring Well M-50A [*55-918641*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National	LOGGED BY: C. Stielstra
DEPTH DRILLED / LAND SURFACE ELEVATION: 32.0 feet / 5035.649 feet msl	DATE DRILLED: 9/18/2015
CADASTRAL / NAD83 : (A-18-20)30bbc / 1429799.423 N / 669243.755 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**CLAYEY SAND (SC)**: Reddish brown [5YR4/3]; subangular to rounded, fine to coarse sand 60%, silt and clay 40%, trace gravel. Gravel fraction: rounded to angular gravel to 1.3 in. consisting of chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: strong.
5.0 - 10.0	**Qal**	**CLAYEY SAND (SC)**: Dark reddish gray [5YR4/2]; subangular to rounded, fine to coarse sand 60%, silt and clay 40%, trace gravel. Gravel fraction: rounded to angular gravel to 1 in. consisting of chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate to strong.
10.0 - 15.0	**Qal**	**CLAYEY SAND (SC)**: Reddish brown [5YR4/3]; subangular to rounded fine sand 50%, silt and clay 50%, trace gravel. Gravel fraction: rounded to angular gravel to 0.3 in. consisting of chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: strong.
15.0 - 20.0	**Qal**	**CLAYEY SAND (SC)**: Moderate brown [5YR4/4]; subangular to rounded, fine to coarse sand 60%, silt and clay 30%, gravel 10%. Gravel fraction: gravel to 0.5 in. consisting of gypsum and trace chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: strong.
20.0 - 28.0	**Qal**	**WELL GRADED GRAVEL WITH CLAY (GW-GC)**: Yellowish red [5YR4/6]; gravel 80%, subangular to rounded, fine to medium sand 10%, silt and clay 10%. Gravel fraction: gravel to 0.8 in. consisting of gypsum and siltstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: strong.
TRIASSIC MOENKOPI FORMATION (TRm)		
28.0 - 32.0	**TRm**	**WEATHERED SILTSTONE**: Moderate brown [5YR4/4]; Moderately lithified. Well graded. Reaction to acid: strong.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-2. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM Monitoring Well M-51A [*55-918640*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National	LOGGED BY: C. Stielstra
DEPTH DRILLED / LAND SURFACE ELEVATION: 14.0 feet / 5039.100 feet msl	DATE DRILLED: 9/18/2015
CADASTRAL / NAD83 : (A-18-19)25add / 1430360.144 N / 668733.143 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**CLAYEY GRAVEL WITH SAND (GC)**: Moderate brown [5YR4/4]; gravel 50%, subangular to rounded, fine to coarse sand 25%, silt and clay 25%. Gravel fraction: gravel to 1.6 in. consisting of chert and gypsum. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: strong.
5.0 - 9.0	**Qal**	**WELL GRADED GRAVEL WITH SILT (GW-GM)**: Yellowish red [5YR4/6]; gravel 80%, subangular to rounded, fine to coarse sand 10%, silt and clay 10%. Gravel fraction: gravel to 1.2 in. consisting of weathered siltstone and fine sandstone, and trace gypsum. Weakly lithified. Low to medium plasticity. Well graded. Reaction to acid: moderate.
TRIASSIC MOENKOPI FORMATION (TRm)		
9.0 - 14.0	**TRm**	**WEATHERED SILTSTONE AND FINE SANDSTONE WITH TRACE GYPSUM**: Moderate brown [5YR4/4]; Moderately lithified. Reaction to acid: strong.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-3. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-52A [*55-918657*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National | LOGGED BY: C. Stielstra

DEPTH DRILLED / LAND SURFACE ELEVATION: 38.0 feet / 5047.080 feet msl | DATE DRILLED: 9/21 - 9/22/2015

CADASTRAL / NAD83 : (A-18-19)24bbc / 1437475.711 N / 663614.281 E

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**CLAYEY SAND (SC)**: Reddish brown [5YR4/3]; subangular to rounded, fine to medium sand 65%, silt and clay 30%, gravel 5%. Gravel fraction: gravel to 0.6 in. consisting of multicolored chert. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: strong.
5.0 - 10.0	**Qal**	**CLAYEY SAND (SC)**: Reddish brown [5YR4/3]; subangular to rounded, fine to medium sand 65%, silt and clay 30%, gravel 5%. Gravel fraction: gravel to 0.4 in. consisting of multicolored chert. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: strong.
10.0 - 15.0	**Qal**	**SILTY GRAVEL WITH SAND (GM)**: Reddish brown [5YR4/3]; gravel 50%, subangular to rounded, fine to coarse sand 30%, silt and clay 20%. Gravel fraction: gravel to 0.9 in. consisting of multicolored chert. Non-lithified. Low to medium plasticity. Well graded. Reaction to acid: moderate.
15.0 - 20.0	**Qal**	**SILTY SAND WITH GRAVEL (SM)**: Dark reddish gray [5YR4/2]; subangular fine sand 55%, gravel 30%, silt and clay 15%. Gravel fraction: gravel to 0.8 in. consisting of multicolored chert. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
20.0 - 25.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Dark reddish gray [5YR4/2]; subangular fine sand 65%, gravel 25%, silt and clay 10%. Gravel fraction: gravel to 0.7 in. consisting of multicolored chert. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
25.0 - 30.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Dark reddish gray [5YR4/2]; subangular to rounded fine sand 65%, gravel 25%, silt and clay 10%. Gravel fraction: gravel to 0.9 in. consisting of multicolored chert. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
30.0 - 35.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; angular to rounded fine sand 85%, silt and clay 10%, gravel 5%. Gravel fraction: gravel to 0.4 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
35.0 - 40.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; angular to rounded fine sand 80%, gravel 10%, silt and clay 10%. Gravel fraction: gravel to 0.5 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
40.0 - 45.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; angular to rounded fine sand 85%, silt and clay 10%, gravel 5%. Gravel fraction: gravel to 0.4 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-3. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-52A [*55-918657*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
45.0 - 50.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; angular to rounded fine sand 85%, silt and clay 10%, gravel 5%. Gravel fraction: gravel to 0.6 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
50.0 - 55.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; angular to rounded fine sand 85%, silt and clay 10%, gravel 5%. Gravel fraction: gravel to 0.5 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
55.0 - 60.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; angular to rounded fine sand 85%, silt and clay 10%, gravel 5%. Gravel fraction: gravel to 0.3 in. consisting of chert, fine grained brown sandstone, and trace siltstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
60.0 - 65.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Moderate brown [5YR4/4]; angular to rounded fine sand 65%, gravel 25%, silt and clay 10%. Gravel fraction: gravel to 2.3 in. consisting of fine grained brown sandstone, green sandy siltstone, and trace chert. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
65.0 - 70.0	**Qal**	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**: Moderate brown [5YR4/4]; gravel 60%, angular to rounded fine sand 30%, silt and clay 10%. Gravel fraction: gravel to 2.6 in. consisting of chert, fine grained brown sandstone, and green sandy siltstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
70.0 - 75.0	**Qal**	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**: Moderate brown [5YR4/4]; gravel 70%, angular to rounded fine sand 20%, silt and clay 10%. Gravel fraction: gravel to 0.6 in. consisting of fine grained brown sandstone, red and green sandy siltstone, and trace chert. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
75.0 - 79.0	**Qal**	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**: Moderate brown [5YR4/4]; gravel 70%, angular to rounded fine sand 20%, silt and clay 10%. Gravel fraction: gravel to 1.4 in. consisting of fine grained brown sandstone, red and green sandy siltstone, and trace chert. Non-lithified to moderately lithified. Low to medium plasticity. Well graded. Reaction to acid: weak to moderate.
TRIASSIC MOENKOPI FORMATION (TRm)		
79.0 - 83.0	**TRm**	**SANDSTONE AND SILTSTONE**: Moderate brown [5YR4/4]; Weakly to moderately lithified. Reaction to acid: weak to moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-4. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-53A [*55-918651*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National	LOGGED BY: C. Stielstra
DEPTH DRILLED / LAND SURFACE ELEVATION: 83.0 feet / 5042.094 feet msl	DATE DRILLED: 9/21 - 9/22/2015
CADASTRAL / NAD83 : (A-18-19)23aab / 1437605.112 N / 662529.371 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**SILTY SAND WITH GRAVEL (SM)**: Reddish brown [5YR4/3]; subangular to rounded fine sand 60%, silt and clay 25%, gravel 15%. Gravel fraction: gravel to 1.2 in. consisting of chert and black rock (fill). Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
5.0 - 10.0	**Qal**	**SILTY SAND WITH GRAVEL (SM)**: Reddish brown [5YR4/3]; subangular to rounded fine sand 60%, silt and clay 25%, gravel 15%. Gravel fraction: gravel to 0.7 in. consisting of chert and black rock (fill). Non-lithified. Low to medium plasticity. Well graded. Reaction to acid: moderate.
10.0 - 15.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; subangular to rounded fine sand 80%, gravel 10%, silt and clay 10%. Gravel fraction: gravel to 1.2 in. consisting of chert and black rock (fill). Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
15.0 - 20.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR4/3]; gravel 80%, subangular to rounded fine sand 15%, silt and clay 5%. Gravel fraction: gravel to 0.8 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
20.0 - 25.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; subangular to rounded fine sand 75%, gravel 15%, silt and clay 10%. Gravel fraction: gravel to 0.5 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
25.0 - 30.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Reddish brown [5YR4/3]; subangular to rounded fine sand 70%, gravel 20%, silt and clay 10%. Gravel fraction: gravel to 0.5 in. consisting of chert and fine grained brown sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
30.0 - 34.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR4/3]; gravel 70%, subangular to rounded fine sand 25%, silt and clay 5%. Gravel fraction: gravel to 0.9 in. consisting of chert, fine grained brown sandstone, and reddish-brown and green siltstone. Non-lithified to moderately lithified. Low plasticity. Well graded. Reaction to acid: moderate.
TRIASSIC MOENKOPI FORMATION (TRm)		
34.0 - 38.0	**TRm**	**FINE GRAINED SANDSTONE AND SILTSTONE**: Moderate brown [5YR4/4]; Moderately to well lithified. Reaction to acid: moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-5. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-54 [*55-918646*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: C. Stielstra
DEPTH DRILLED / LAND SURFACE ELEVATION: 370.0 feet / 5068.208 feet msl	DATE DRILLED: 9/23 - 10/2/2015
CADASTRAL / NAD83 : (A-18-19)13cab / 1440088.611 N / 665508.134 E	

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
QUATERNARY ALLUVIUM (Qal)				
0 - 10	**Qal**	alluvium; moderate brown [5YR4/4]; non-lithified to weakly lithified; reddish-brown and green siltstone; reaction to acid: weak	weathered, clayey cuttings	ARCH, Air Rotary; chips to 1 in
10 - 19	**Qal**	alluvium; moderate brown [5YR4/4]; non-lithified to weakly lithified; reddish-brown and green siltstone; fine grained sandstone; reaction to acid: weak	weathered, clayey cuttings	chips to 0.9 in
TRIASSIC MOENKOPI FORMATION (TRm)				
19 - 30	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown siltstone; fine grained green sandstone; reaction to acid: weak		chips to 0.7 in
30 - 40	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown siltstone; fine grained green sandstone; reaction to acid: weak to moderate	trace clay in cuttings	chips to 1.4 in
40 - 50	**TRm**	sandy siltstone; reddish brown [5YR4/3]; weakly to moderately lithified; reddish-brown siltstone; trace green siltstone; reaction to acid: weak to moderate	clayey cuttings	platy subangular-rounded chips to 0.9 in
50 - 60	**TRm**	sandy siltstone; dark reddish gray [5YR4/2]; moderately to well lithified; dark gray fine-grained sandstone; trace red and green siltstone; reaction to acid: weak		platy subangular-rounded chips to 0.5 in
60 - 70	**TRm**	sandy siltstone; yellowish red [5YR4/6], dark reddish gray [5YR4/2]; moderately to well lithified; reddish-brown siltstone; green fine-grained sandstone; dark grey, fine-grained sandstone; reaction to acid: weak to moderate	trace clay in cuttings	platy subangular-rounded chips to 0.9 in
70 - 80	**TRm**	sandy siltstone; moderate brown [5YR4/4]; weakly to moderately lithified; reddish-brown siltstone; trace green siltstone; reaction to acid: moderate to strong	trace clay in cuttings	platy subangular chips to 0.9 in
80 - 90	**TRm**	sandy siltstone; yellowish red [5YR4/6]; weakly to moderately lithified; reddish-brown siltstone; brown silty sandstone; reaction to acid: strong	trace clay in cuttings	platy subangular chips to 0.7 in

TABLE A-5. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-54 [*55-918646*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
90 - 100	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: moderate to strong		platy subangular chips to 0.6 in
100 - 110	**TRm**	sandy siltstone; moderate brown [5YR4/4]; moderately to well lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: moderate to strong		platy subangular chips to 0.6 in
110 - 120	**TRm**	sandy siltstone; yellowish red [5YR4/6]; moderately to moderately lithified; reddish-brown and green siltstone; reaction to acid: strong		platy subangular chips to 0.8 in
120 - 130	**TRm**	sandy siltstone; yellowish red [5YR4/6]; moderately to moderately lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: moderate	trace clay in cuttings	platy subangular chips to 0.6 in
130 - 140	**TRm**	sandy siltstone; yellowish red [5YR4/6]; moderately to moderately lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: weak to moderate	trace clay in cuttings	platy subangular chips to 0.7 in
140 - 150	**TRm**	sandy siltstone; yellowish red [5YR4/6], dark reddish brown [5YR3/2]; moderately to well lithified; reddish-brown and green siltstone; dark gray fine-grained sandstone; trace gypsum; reaction to acid: weak to moderate	trace clay in cuttings	platy subangular-angular chips to 0.9 in
150 - 160	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: weak to moderate		platy subangular-angular chips to 0.8 in
160 - 170	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to moderately lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: moderate		platy subangular-angular chips to 0.7 in
170 - 180	**TRm**	sandy siltstone; very dark brown [5YR2.5/2]; moderately to well lithified; dark gray fine-grained sandstone; trace fine green sandstone; reaction to acid: moderate to strong		platy rounded chips to 0.6 in
180 - 190	**TRm**	sandy siltstone; dark reddish brown [5YR3/4]; moderately to well lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: weak to moderate		platy subangular-angular chips to 0.6 in

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TABLE A-5. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-54 [*55-918646*]
CCR MONITOR WELLS
ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
190 - 200	**TRm**	sandy siltstone; dark reddish brown [5YR3/4]; moderately to well lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: weak to moderate		platy subangular-angular chips to 0.9 in
200 - 210	**TRm**	sandy siltstone; dark reddish brown [5YR3/4]; moderately to well lithified; reddish-brown and green siltstone; trace gypsum; reaction to acid: weak to moderate		platy subangular-angular chips to 0.8 in
210 - 220	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown and green siltstone; gypsum; reaction to acid: moderate to strong		platy subangular-angular chips to 0.9 in
220 - 230	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown and green siltstone; gypsum; reaction to acid: moderate to strong		platy subangular-angular chips to 0.9 in
230 - 240	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown siltstone; dark gray fine-grained sandstone; trace gypsum; reaction to acid: moderate to strong		platy subangular-angular chips to 0.7 in
240 - 250	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; well to well lithified; reddish-brown siltstone; dark gray fine-grained sandstone; trace gypsum; reaction to acid: strong		platy subangular-angular chips to 0.8 in
250 - 260	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; reddish-brown siltstone; dark gray fine-grained sandstone; trace gypsum; reaction to acid: strong		platy subangular-angular chips to 0.7 in
260 - 270	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; well to well lithified; fine dark reddish brown sandstone; reddish siltstone; trace tan sandstone; reaction to acid: moderate to strong		platy rounded chips to 0.7 in
270 - 280	**TRm**	sandy siltstone; moderate brown [5YR4/4]; well to well lithified; fine dark reddish brown sandstone; reaction to acid: moderate to strong		platy rounded chips to 0.5 in
280 - 290	**TRm**	sandy siltstone; moderate brown [5YR4/4]; well to well lithified; fine dark reddish brown sandstone; reaction to acid: weak to moderate		platy rounded chips to 0.6 in

TABLE A-5. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-54 [*55-918646*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
290 - 302	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], moderate brown [5YR4/4]; weakly to moderately lithified; fine dark reddish brown sandstone; reddish siltstone; trace green siltstone; reaction to acid: moderate to strong		platy subrounded-angular chips to 0.9 in
PERMIAN COCONINO SANDSTONE (Pc)				
302 - 310	**Pc**	fine sandstone; gray [5YR5/1], dark reddish brown [5YR3/3]; weakly to well lithified; fine reddish brown sandstone; fine gray sandstone; very fine buff sandstone; reaction to acid: weak to moderate		platy subrounded-subangular chips to 0.9 in
310 - 320	**Pc**	fine sandstone; light reddish brown [5YR6/3]; weakly to weakly lithified; very fine buff/tan sandstone; trace red clay; reaction to acid: weak to moderate		mostly pulverized; rounded chips to 0.4 in
320 - 330	**Pc**	fine sandstone; light yellowish brown [2.5Y6/3]; weakly to weakly lithified; very fine buff/tan sandstone; reaction to acid: weak to moderate		mostly pulverized; rounded chips to 0.4 in
330 - 340	**Pc**	fine sandstone; light gray [2.5Y7/2]; weakly to weakly lithified; very fine buff/tan sandstone; reaction to acid: moderate to strong		mostly pulverized; rounded chips to 0.2 in
340 - 350	**Pc**	fine sandstone; light gray [2.5Y7/2]; weakly to weakly lithified; very fine buff/tan sandstone; reaction to acid: moderate		mostly pulverized; rounded chips to 0.3 in
350 - 360	**Pc**	fine sandstone; light gray [2.5Y7/1]; weakly to weakly lithified; very fine buff/tan sandstone; reaction to acid: strong		mostly pulverized; rounded chips to 0.3 in
360 - 370	**Pc**	fine sandstone; light gray [2.5Y7/1]; weakly to weakly lithified; very fine buff/tan sandstone; reaction to acid: strong		mostly pulverized; rounded chips to 0.4 in

TABLE A-6. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-56A [*55-918661*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: J. Laney, C. Stielstra
DEPTH DRILLED / LAND SURFACE ELEVATION: 100.0 feet / 5020.630 feet msl	DATE DRILLED: 10/4 - 10/7/2015
CADASTRAL / NAD83 : (A-18-19)23cbc / 1434257.733 N / 658887.345 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**SANDY LEAN CLAY (CL)**: Dark reddish gray [5YR4/2]; silt and clay 65%, rounded fine sand 25%, gravel 10%. Gravel fraction: subangular gravel to 0.5 in. consisting of chert, coal (fill), and sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate to strong. Disturbed surface sample. Disturbed surface sample.
5.0 - 10.0	**Qal**	**SANDY LEAN CLAY (CL)**: Dark reddish gray [5YR4/2]; silt and clay 65%, rounded fine sand 30%, gravel 5%. Gravel fraction: subangular gravel to 0.2 in. consisting of chert, coal (fill), and sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate to strong. Disturbed surface sample. Disturbed surface sample.
10.0 - 15.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 80%, rounded very fine sand 20%, trace gravel. Gravel fraction: subrounded gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Medium plasticity. Poorly graded. Reaction to acid: moderate.
15.0 - 20.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 70%, rounded very fine sand 30%, trace gravel. Gravel fraction: subrounded gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
20.0 - 25.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded very fine sand 15%, gravel 10%. Gravel fraction: subangular gravel to 0.2 in. consisting of chert, sandstone, and quartz. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
25.0 - 30.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 80%, rounded very fine sand 15%, gravel 5%. Gravel fraction: subangular to subrounded gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: moderate.
30.0 - 35.0	**Qal**	**FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; silt and clay 90%, rounded very fine sand 10%, trace gravel. Gravel fraction: subangular gravel to 0.1 in. consisting of chert. Non-lithified. High plasticity. Poorly graded. Reaction to acid: moderate.
35.0 - 40.0	**Qal**	**FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; silt 95%, rounded very fine sand 5%. Non-lithified. Non-plastic. Poorly graded. Reaction to acid: moderate.
40.0 - 45.0	**Qal**	**SILTY SAND WITH GRAVEL (SM)**: Dark reddish gray [5YR4/2]; rounded very fine sand 45%, silt 40%, gravel 15%. Gravel fraction: subangular to subrounded gravel to 0.2 in. consisting of chert, sandstone, and green siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-6. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-56A [*55-918661*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
45.0 - 50.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded fine sand 80%, gravel 15%, silt 5%. Gravel fraction: subangular gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
50.0 - 55.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 75%, gravel 20%, silt 5%. Gravel fraction: subangular to subrounded gravel to 0.2 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
55.0 - 60.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 75%, gravel 25%. Gravel fraction: subangular to subrounded gravel to 0.2 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
60.0 - 65.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 70%, gravel 30%. Gravel fraction: subangular to subrounded gravel to 0.6 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
65.0 - 70.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 80%, gravel 20%. Gravel fraction: subangular to subrounded gravel to 0.6 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
70.0 - 75.0	**Qal**	**WELL GRADED SAND (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 90%, gravel 10%. Gravel fraction: subrounded gravel to 0.3 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
75.0 - 80.0	**Qal**	**WELL GRADED SAND (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 90%, gravel 10%. Gravel fraction: subrounded gravel to 0.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
80.0 - 85.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR5/3]; gravel 80%, rounded fine sand 20%. Gravel fraction: subangular to rounded gravel to 1.6 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
85.0 - 90.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR5/3]; gravel 80%, rounded, fine to medium sand 20%. Gravel fraction: subangular to rounded gravel to 1.6 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.
90.0 - 95.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR5/3]; gravel 75%, subrounded, fine to coarse sand 20%, silt 5%. Gravel fraction: subangular to rounded gravel to 2 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-6. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-56A [*55-918661*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
95.0 - 100.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR5/3]; gravel 80%, subrounded, fine to coarse sand 20%. Gravel fraction: angular to rounded gravel to 3.1 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-7. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-57A [*55-918660*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: J. Laney
DEPTH DRILLED / LAND SURFACE ELEVATION: 100.0 feet / 5021.164 feet msl	DATE DRILLED: 10/7 - 10/8/2015
CADASTRAL / NAD83 : (A-18-19)23cbc / 1434198.679 N / 658767.25 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**CLAYEY GRAVEL WITH SAND (GC)**: Dark reddish gray [5YR4/2]; silt and clay 50%, gravel 30%, rounded fine sand 20%. Gravel fraction: subangular to rounded gravel to 1.2 in. consisting of chert, sandstone, coal. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate. Disturbed surface sample. Disturbed surface sample.
5.0 - 10.0	**Qal**	**CLAYEY GRAVEL WITH SAND (GC)**: Dark reddish gray [5YR4/2]; silt and clay 50%, gravel 30%, rounded fine sand 20%. Gravel fraction: subangular to rounded gravel to 1.2 in. consisting of chert, sandstone, coal. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate. Disturbed surface sample. Disturbed surface sample.
10.0 - 15.0	**Qal**	**SANDY FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; silt and clay 60%, rounded very fine sand 30%, gravel 10%. Gravel fraction: subrounded gravel to 0.1 in. consisting of chert, sandstone. Non-lithified. High plasticity. Well graded. Reaction to acid: moderate.
15.0 - 20.0	**Qal**	**SANDY LEAN CLAY (CL)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded very fine sand 25%, trace gravel. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
20.0 - 25.0	**Qal**	**SANDY LEAN CLAY (CL)**: Dark reddish gray [5YR4/2]; silt and clay 80%, rounded very fine sand 20%, trace gravel. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
25.0 - 30.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 80%, rounded very fine sand 15%, gravel 5%. Gravel fraction: subrounded gravel to 0.1 in. consisting of chert, sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
30.0 - 35.0	**Qal**	**FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; silt and clay 80%, gravel 10%, rounded very fine sand 10%. Gravel fraction: subangular to subrounded gravel to 0.1 in. consisting of chert, sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
35.0 - 40.0	**Qal**	**FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; silt and clay 95%, rounded very fine sand 5%, trace gravel. Non-lithified. High plasticity. Well graded. Reaction to acid: moderate.
40.0 - 45.0	**Qal**	**SILTY SAND WITH GRAVEL (SM)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 60%, silt and clay 35%, gravel 5%. Gravel fraction: subrounded gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-7. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-57A [*55-918660*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
45.0 - 50.0	**Qal**	**WELL GRADED SAND WITH SILT (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 80%, gravel 10%, silt 10%. Gravel fraction: subangular to subrounded gravel to 0.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Poorly graded. Reaction to acid: weak.
50.0 - 55.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 65%, gravel 30%, silt 5%. Gravel fraction: subangular to rounded gravel to 0.8 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Poorly graded. Reaction to acid: weak.
55.0 - 60.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 80%, gravel 15%, silt 5%. Gravel fraction: subrounded to rounded gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
60.0 - 65.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to coarse sand 60%, gravel 40%, trace silt. Gravel fraction: subangular to rounded gravel to 1.2 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
65.0 - 70.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 70%, gravel 30%, trace silt. Gravel fraction: subangular to subrounded gravel to 2 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
70.0 - 75.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 80%, gravel 20%, trace silt. Gravel fraction: subangular to rounded gravel to 1.2 in. consisting of chert, sandstone, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
75.0 - 80.0	**Qal**	**WELL GRADED SAND (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 90%, gravel 10%, trace silt. Gravel fraction: subangular to subrounded gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
80.0 - 85.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR5/3]; gravel 80%, rounded, fine to coarse sand 20%, trace silt. Gravel fraction: subangular to rounded gravel to 2.4 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
85.0 - 90.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 70%, gravel 30%, trace silt. Gravel fraction: subangular to rounded gravel to 0.4 in. consisting of chert, sandstone, and petrified wood. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-7. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-57A [*55-918660*]
CCR MONITOR WELLS
ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
90.0 - 95.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to coarse sand 60%, gravel 40%, trace silt. Gravel fraction: subangular to subrounded gravel to 1.2 in. consisting of chert, sandstone, and petrified wood. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
95.0 - 100.0	**Qal**	**WELL GRADED GRAVEL WITH SAND (GW)**: Reddish brown [5YR5/3]; gravel 80%, rounded, fine to coarse sand 20%, trace silt. Gravel fraction: subangular to rounded gravel to 2 in. consisting of chert, sandstone, and petrified wood. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-8. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-58A [*55-918659*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: J. Laney
DEPTH DRILLED / LAND SURFACE ELEVATION: 100.0 feet / 5021.237 feet msl	DATE DRILLED: 10/8 - 10/13/2015
CADASTRAL / NAD83 : (A-18-19)23cbc / 1434165.11 N / 658698.919 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 65%, rounded, very fine to fine sand 25%, gravel 10%. Gravel fraction: subrounded gravel to 0.8 in. consisting of chert and sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate to strong.
5.0 - 10.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded, very fine to fine sand 20%, gravel 5%. Gravel fraction: subrounded gravel to 0.8 in. consisting of chert and sandstone. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate to strong.
10.0 - 15.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 80%, rounded, very fine to fine sand 20%, trace gravel. Gravel fraction: angular gravel to 0.4 in. consisting of chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
15.0 - 20.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 70%, rounded very fine sand 30%, trace gravel. Gravel fraction: angular gravel to 0.2 in. consisting of chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
20.0 - 25.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded very fine sand 25%, trace gravel. Gravel fraction: angular gravel to 0.2 in. consisting of chert. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
25.0 - 30.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 85%, rounded very fine sand 15%. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
30.0 - 35.0	**Qal**	**LEAN CLAY (CL)**: Dark reddish gray [5YR4/2]; silt and clay 90%, rounded very fine sand 10%. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: moderate.
35.0 - 40.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 80%, rounded very fine sand 20%. Non-lithified. Medium plasticity. Well graded. Reaction to acid: moderate.
40.0 - 45.0	**Qal**	**SILTY SAND (SM)**: Dark reddish gray [5YR4/2]; rounded fine sand 50%, silt and clay 40%, gravel 10%. Gravel fraction: subangular to rounded gravel to 0.8 in. consisting of chert and sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: moderate.
45.0 - 50.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 50%, gravel 40%, silt 10%. Gravel fraction: subangular to rounded gravel to 2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-8. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-58A [*55-918659*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
50.0 - 55.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 80%, gravel 20%. Gravel fraction: subangular to subrounded gravel to 1.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
55.0 - 60.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 90%, gravel 10%. Gravel fraction: subangular to subrounded gravel to 2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
60.0 - 65.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to coarse sand 70%, gravel 30%. Gravel fraction: subangular to subrounded gravel to 1.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
65.0 - 70.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 85%, gravel 15%. Gravel fraction: subangular to subrounded gravel to 0.4 in. consisting of sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
70.0 - 75.0	**Qal**	**WELL GRADED SAND (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 90%, gravel 10%. Gravel fraction: subangular to subrounded gravel to 0.2 in. consisting of sandstone and chert. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
75.0 - 80.0	**Qal**	**WELL GRADED SAND (SW)**: Reddish brown [5YR5/3]; rounded, very fine to fine sand 90%, gravel 10%. Gravel fraction: subangular to subrounded gravel to 0.1 in. consisting of sandstone and chert. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
80.0 - 85.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 80%, gravel 20%. Gravel fraction: subangular to subrounded gravel to 0.4 in. consisting of sandstone and chert. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
85.0 - 90.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to medium sand 80%, gravel 20%. Gravel fraction: subangular to subrounded gravel to 0.6 in. consisting of sandstone and chert. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
90.0 - 95.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to coarse sand 70%, gravel 30%. Gravel fraction: subangular to subrounded gravel to 2 in. consisting of sandstone and chert. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
95.0 - 100.0	**Qal**	**WELL GRADED SAND WITH GRAVEL (SW)**: Reddish brown [5YR5/3]; rounded, fine to coarse sand 70%, gravel 30%. Gravel fraction: subangular to rounded gravel to 2.4 in. consisting of sandstone, chert, and siltstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-9. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-59 [*55-918647*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps — LOGGED BY: J. Laney

DEPTH DRILLED / LAND SURFACE ELEVATION: 425.0 feet / 5133.863 feet msl — DATE DRILLED: 10/14 - 10/21/2015

CADASTRAL / NAD83 : (A-18-19)13cbb / 1440604.729 N / 664161.355 E

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
QUATERNARY ALLUVIUM (Qal)				
0 - 13	**Qal**	alluvium; brownish gray [5YR4/1]; 60% sand (subrounded, fine to coarse); 30% gravel (subangular to rounded, consisting of sandstone and chert); 10% silt; reaction to acid: weak		ARCH, Air Rotary; poorly sorted
TRIASSIC MOENKOPI FORMATION (TRm)				
13 - 20	**TRm**	sandy siltstone; moderate brown [5YR4/4]; non-lithified; 90% reddish brown siltstone; 10% fine-grained gray sandstone; reaction to acid: weak		subangular chips to 1.2 in
20 - 30	**TRm**	sandy siltstone; moderate brown [5YR4/4]; moderately to well lithified; 90% reddish brown siltstone; 10% fine-grained gray sandstone; reaction to acid: weak		subangular chips to 1.2 in
30 - 40	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], light greenish gray [5BG7/1]; moderately to well lithified; 60% reddish brown siltstone; 40% blue gray siltstone; platy; reaction to acid: weak		subangular chips to 0.8 in
40 - 50	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], light greenish gray [5BG7/1]; weakly lithified; 50% reddish brown siltstone; 50% blue gray siltstone; platy; reaction to acid: weak		subangular chips to 0.8 in
50 - 60	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], light greenish gray [5BG7/1]; weakly lithified; 50% reddish brown siltstone; 50% blue gray siltstone; platy; reaction to acid: weak		subangular chips to 1 in
60 - 70	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], light greenish gray [5BG7/1]; weakly lithified; 80% reddish brown siltstone; 20% blue gray siltstone; platy; reaction to acid: weak		subangular chips to 1 in
70 - 80	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; weakly lithified; 60% reddish brown siltstone; 40% blue gray sandstone; platy; reaction to acid: weak		subrounded to subangular chips to 1.2 in
80 - 90	**TRm**	sandy siltstone; gray [5YR5/1]; moderately to well lithified; reddish gray medium to fine-grained sandstone; reaction to acid: none		subrounded chips to 0.4 in

TABLE A-9. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-59 [*55-918647*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
90 - 100	**TRm**	sandy siltstone; gray [5YR5/1], dark reddish brown [5YR3/4]; weakly to well lithified; reddish gray medium to fine-grained sandstone; reddish brown siltstone; trace blue green siltstone; platy; reaction to acid: none		subrounded to subangular chips to 0.8 in
100 - 110	**TRm**	sandy siltstone; gray [5YR5/1]; moderately to well lithified; reddish gray medium to fine-grained sandstone; reaction to acid: none		subrounded chips to 0.4 in
110 - 120	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], light greenish gray [5BG7/1]; weakly lithified; 50% reddish brown siltstone; 50% blue gray siltstone; platy; reaction to acid: none		subangular chips to 0.8 in
120 - 130	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; weakly to moderately lithified; 70% reddish brown siltstone; 30% blue gray siltsone; platy; reaction to acid: weak		subangular chips to 0.8 in
130 - 140	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; weakly to moderately lithified; 90% reddish brown siltstone; 10% blue gray siltsone; trace gypsum; platy; reaction to acid: moderate	clayey cuttings	subangular chips to 0.8 in
140 - 150	**TRm**	sandy siltstone; light greenish gray [5BG7/1], gray [5YR5/1]; weakly to moderately lithified; 60% reddish brown siltstone; 40% blue gray siltsone; trace gypsum; reaction to acid: weak		subangular chips to 0.4 in
150 - 160	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; weakly to moderately lithified; 90% reddish brown siltstone; 5% blue gray siltsone; 5% gypsum; platy; reaction to acid: none		subangular to subrounded chips to 0.8 in
160 - 170	**TRm**	sandy siltstone; light greenish gray [5BG7/1], dark reddish brown [5YR3/3]; weakly to moderately lithified; 40% reddish brown siltstone; 60% blue gray sandstone; platy; reaction to acid: weak		subangular chips to 0.4 in
170 - 180	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; weakly lithified; 80% reddish brown siltstone; 20% blue gray siltstone; platy; reaction to acid: none	clayey cuttings	subangular chips to 0.6 in

TABLE A-9. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-59 [*55-918647*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
180 - 190	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; weakly to moderately lithified; 80% reddish brown siltstone; 20% blue gray siltstone; platy; reaction to acid: none		subangular chips to 0.4 in
190 - 200	**TRm**	sandy siltstone; light greenish gray [5BG7/1], dark reddish brown [5YR3/4]; moderately lithified; 80% reddish brown siltstone; 20% blue gray siltstone; trace gypsum; platy; reaction to acid: none		subangular chips to 0.4 in
200 - 210	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately lithified; 80% reddish brown siltstone; 20% blue gray siltstone; trace gypsum; platy; reaction to acid: none		subangular chips to 0.8 in
210 - 220	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately lithified; 80% reddish brown siltstone; 20% blue gray siltstone; trace gypsum; platy; reaction to acid: weak		subangular chips to 0.4 in
220 - 230	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately lithified; 80% reddish brown siltstone; 20% blue gray siltstone; trace gypsum; platy; reaction to acid: none		subangular chips to 0.4 in
230 - 240	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately to well lithified; 80% reddish brown siltstone; 15% blue gray sandstone (very fine to fine-grained); 5% gypsum needle crystals; reaction to acid: weak		subangular to subrounded chips to 0.4 in
240 - 250	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately to well lithified; 70% reddish brown sandstone (very fine to fine-grained); 30% blue gray sandstone (very fine to fine-grained); trace gypsum needle crystals; reaction to acid: weak		subangular chips to 0.4 in
250 - 260	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately to well lithified; 80% reddish brown sandstone (very fine to fine-grained); 15% blue gray sandstone (very fine to fine-grained); 5% gypsum needle crystals; reaction to acid: moderate		subangular chips to 0.4 in
260 - 270	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1]; moderately to well lithified; 45% reddish brown sandstone (very fine to fine-grained); 45% reddish brown siltstone; 10% blue gray sandstone (very fine to fine-grained); trace gypsum; reaction to acid: strong		subangular chips to 0.4 in

TABLE A-9. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-59 [*55-918647*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
270 - 280	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light gray [2.5Y7/2]; well lithified; reddish brown siltstone and sandstone; greenish-tan fine-grained sandstone; reaction to acid: moderate		subangular to subrounded chips to 0.4 in
280 - 290	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light gray [2.5Y7/2]; moderately to well lithified; 80% reddish brown siltstone; 20% red to green very fine-grained sandstone; reaction to acid: strong		subangular chips to 0.4 in
290 - 300	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light gray [2.5Y7/2]; moderately to well lithified; 80% reddish brown siltstone; 20% green-tan grained sandstone (very fine to fine-grained); reaction to acid: strong		subangular chips to 0.4 in
300 - 310	**TRm**	sandy siltstone; dark reddish brown [5YR3/4]; moderately to well lithified; 50% reddish brown siltstone; 50% reddish brown sandstone (very fine to fine-grained); reaction to acid: weak		subangular chips to 0.4 in
310 - 320	**TRm**	sandy siltstone; dark reddish brown [5YR3/4], light greenish gray [5BG7/1], light brown [5YR6/4]; moderately to well lithified; 80% reddish brown sandstone (very fine to fine-grained); 15% blue gray sandstone (very fine to fine-grained); 5% tan sandstone (fine-grained); reaction to acid: moderate		subrounded chips to 0.4 in
320 - 330	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; dark reddish brown sandstone (fine-grained); reaction to acid: none		subrounded chips to 0.4 in
330 - 340	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; dark reddish brown sandstone (fine-grained); reaction to acid: none		subrounded chips to 0.4 in
340 - 350	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; dark reddish brown sandstone (fine-grained); trace light brown sandstone; reaction to acid: none		subrounded chips to 0.4 in
350 - 360	**TRm**	sandy siltstone; dark reddish brown [5YR3/3], gray [5YR5/1]; moderately to well lithified; dark reddish brown sandstone (very fine to fine-grained); reaction to acid: none		subangular to angular chips to 0.4 in

TABLE A-9. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-59 [*55-918647*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
PERMIAN COCONINO SANDSTONE (Pc)				
360 - 370	**Pc**	fine sandstone; pale red [2.5YR6/2]; well lithified; greyish tan sandstone (very fine to fine-grained); reaction to acid: weak		subangular chips to 0.6 in
370 - 380	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine to fine-grained, rounded, well sorted quartz grains); reaction to acid: strong		mostly pulverized to fine sand; trace rounded chips to 0.2 in
380 - 390	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine to fine-grained, rounded, well sorted quartz grains); reaction to acid: strong		pulverized; very fine to fine sand
390 - 400	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine to fine-grained, rounded, well sorted quartz grains); reaction to acid: moderate		mostly pulverized to fine sand; trace rounded chips to 0.2 in
400 - 410	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine to fine-grained, rounded, well sorted quartz grains); reaction to acid: weak		mostly pulverized to fine sand; trace rounded chips to 0.2 in
410 - 420	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine to fine-grained, rounded, well sorted quartz grains); reaction to acid: weak		mostly pulverized to fine sand; trace rounded chips to 0.2 in
420 - 425	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine to fine-grained, rounded, well sorted quartz grains); reaction to acid: weak		mostly pulverized to fine sand; trace rounded chips to 0.2 in

TABLE A-10. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-60 [*55-918649*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: J. Laney
DEPTH DRILLED / LAND SURFACE ELEVATION: 450.0 feet / 5148.694 feet msl	DATE DRILLED: 10/21 - 11/1/2015
CADASTRAL / NAD83 : (A-18-19)13bac / 1441947.886 N / 664249.994 E	

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
QUATERNARY ALLUVIUM (Qal)				
0 - 14	**Qal**	alluvium; grayish orange [10YR7/4]; non-lithified to non lithified; 60% medium to high plasticity clay; 20% very fine to coarse subrounded sand; 20% gravel consisting of sandstone and chert; CL sandy loam clay with gravel; reaction to acid: moderate		ARCH, Air Rotary; subrounded-subangular chips to 0.8 in
TRIASSIC MOENKOPI FORMATION (TRm)				
14 - 20	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; 50% red brown siltstone; 40% blue gray siltstone; 10% gray fine-grained sandstone; reaction to acid: strong		subangular chips to 0.8 in
20 - 30	**TRm**	sandy siltstone; dark reddish brown [5YR3/3]; moderately to well lithified; 50% red brown siltstone; 40% blue gray siltstone; 10% gray fine-grained sandstone; reaction to acid: strong		subangular chips to 0.8 in
30 - 40	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3]; moderately to well lithified; 90% red brown siltstone; 10% blue gray siltstone; platy clayey cuttings; reaction to acid: strong		subangular chips to 0.4 in
40 - 50	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3]; weakly to moderately lithified; 70% red brown siltstone; 30% blue gray siltstone; platy; reaction to acid: strong		subangular chips to 0.4 in
50 - 60	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3]; weakly to moderately lithified; 70% red brown siltstone; 30% blue gray siltstone; platy; reaction to acid: moderate		subangular chips to 0.6 in
60 - 70	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3]; weakly to moderately lithified; 80% red brown siltstone; 20% blue gray siltstone; platy; reaction to acid: moderate		subangular chips to 0.4 in
70 - 80	**TRm**	sandy siltstone; dark reddish gray [2.5YR4/1]; well lithified; Dark gray fine- to medium-grained sandstone; reaction to acid: moderate		rounded-subrounded chips to 0.8 in
80 - 90	**TRm**	sandy siltstone; weak red [2.5YR4/2]; moderately to well lithified; Reddish gray fine- to medium-grained sandstone; reaction to acid: moderate		subrounded-subangular chips to 0.4 in

TABLE A-10. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-60 [*55-918649*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
90 - 100	**TRm**	sandy siltstone; weak red [2.5YR4/2]; moderately to well lithified; 90% red gray to blue gray fine- to medium-grained sandstone; 10% red brown siltstone; reaction to acid: moderate		subrounded-subangular chips to 0.8 in
100 - 110	**TRm**	sandy siltstone; dark reddish gray [2.5YR4/1]; well lithified; Dark gray fine- to medium-grained sandstone; reaction to acid: moderate		rounded-subrounded chips to 0.4 in
110 - 120	**TRm**	sandy siltstone; dark reddish gray [2.5YR4/1]; well lithified; Dark gray fine- to medium-grained sandstone; reaction to acid: moderate		rounded-subrounded chips to 0.4 in
120 - 130	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], dark reddish gray [2.5YR4/1]; moderately to well lithified; 80% red brown siltstone; 20% dark gray fine- to medium-grained sandstone; reaction to acid: moderate		subangular-subrounded chips to 0.8 in
130 - 140	**TRm**	sandy siltstone; dark reddish gray [2.5YR4/1]; well lithified; Dark gray fine- to medium-grained sandstone; reaction to acid: strong		rounded-subrounded chips to 0.6 in
140 - 150	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 60% red brown / blue gray siltstone; 40% red brown fine-grained sandstone; platy siltstone; reaction to acid: weak		subangular chips to 0.8 in
150 - 160	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 50% red brown siltstone; 50% red brown / blue gray fine- to medium-grained sandstone; platy siltstone; reaction to acid: weak		subangular chips to 0.8 in
160 - 170	**TRm**	sandy siltstone; weak red [2.5YR5/2], light blue green [5BG6/6]; moderately to well lithified; 60% red gray / blue gray fine-grained sandstone; 40% red brown siltstone; reaction to acid: weak		subangular chips to 0.6 in
170 - 180	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 90% red siltstone; 10% blue gray fine-grained sandstone; trace gypsum; reaction to acid: moderate		subangular chips to 0.6 in
180 - 190	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], dark reddish gray [2.5YR4/1]; moderately to well lithified; 70% red brown siltstone; 30% dark gray fine- to medium-grained sandstone; reaction to acid: weak		subangular-subrounded chips to 0.4 in

TABLE A-10. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-60 [*55-918649*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
190 - 200	**TRm**	sandy siltstone; dark reddish gray [2.5YR4/1]; moderately to well lithified; Dark gray / red gray fine to medium-grained sandstone; trace gypsum; reaction to acid: weak		subrounded chips to 0.4 in
200 - 210	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 60% red brown siltstone; 40% red brown / blue gray fine-grained sandstone; platy siltstone; reaction to acid: none		subangular chips to 0.6 in
210 - 220	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 60% red brown siltstone; 40% red brown / blue gray fine-grained sandstone; and trace gypsum; reaction to acid: none		subangular chips to 0.6 in
220 - 230	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 60% red brown siltstone; 40% red brown / blue gray fine-grained sandstone; trace gypsum; reaction to acid: none		subangular chips to 0.6 in
230 - 240	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 60% red brown / blue gray fine-grained sandstone; 40% red brown siltstone; reaction to acid: none		subangular chips to 0.6 in
240 - 250	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 70% red brown siltstone; 30% blue gray siltstone; trace gypsum; platy; reaction to acid: none		subangular chips to 0.6 in
250 - 260	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 60% blue gray siltstone; 35% red brown siltstone; 5% gypsum needle crystals; platy; reaction to acid: weak		subangular chips to 0.6 in
260 - 270	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 80% red brown siltstone; 15% blue gray siltstone; 5% gypsum needle crystals; platy; reaction to acid: moderate		subangular chips to 0.8 in
270 - 280	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3]; moderately lithified; 95% red brown siltstone; 5% gypsum needle crystals; platy; reaction to acid: weak		subangular chips to 0.8 in

TABLE A-10. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-60 [*55-918649*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
280 - 290	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 90% red brown siltstone; 10% blue gray siltstone; trace gypsum; platy; reaction to acid: weak		subangular chips to 0.4 in
290 - 300	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately to well lithified; 80% red brown siltstone; 20% blue gray siltstone; platy; reaction to acid: weak		subangular chips to 0.4 in
300 - 310	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 90% red brown siltstone; 10% blue gray siltstone; platy; reaction to acid: moderate		subangular chips to 0.8 in
310 - 320	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 90% red brown siltstone; 10% blue gray siltstone; platy; reaction to acid: weak		subangular chips to 0.8 in
320 - 330	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], reddish gray [2.5YR6/1]; moderately to well lithified; 90% red brown siltstone; 10% gray fine-grained sandstone; reaction to acid: weak		subangular chips to 0.4 in
330 - 340	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], reddish gray [2.5YR6/1]; moderately to well lithified; 80% red brown siltstone; 20% gray to blue gray fine-grained sandstone; reaction to acid: weak		subangular chips to 0.4 in
340 - 350	**TRm**	sandy siltstone; reddish brown [2.5YR4/4]; well lithified; Red brown fine- to medium-grained sandstone; reaction to acid: weak		subrounded chips to 0.2 in
350 - 360	**TRm**	sandy siltstone; reddish brown [2.5YR4/4]; well lithified; Red brown fine- to medium-grained sandstone; reaction to acid: weak		subrounded chips to 0.6 in
360 - 370	**TRm**	sandy siltstone; light brown [5YR5/6], dark reddish brown [2.5YR3/4]; moderately to well lithified; 60% brown fine-grained sandstone; 40% dark red brown siltstone; reaction to acid: none		subrounded-subangular chips to 0.6 in
370 - 378	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4]; moderately to well lithified; Dark red brown very fine- to fine-grained sandstone; reaction to acid: none		subangular chips to 0.4 in

TABLE A-10. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-60 [*55-918649*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
378 - 380	**TRm**	sandy siltstone; gray [5YR6/1]; moderately to well lithified; Grayish tan very fine- to fine-grained sandstone; reaction to acid: none		subangular chips to 0.6 in
PERMIAN COCONINO SANDSTONE (Pc)				
380 - 390	**Pc**	fine sandstone; pale yellow [2.5Y7/3]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		pulverized very fine-fine sand size chips
390 - 400	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		mostly pulverized very fine-fine sand size
400 - 410	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		rounded chips to 0.1 in
410 - 420	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		mostly pulverized very fine-fine sand size chips
420 - 430	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		rounded chips to 0.1 in
430 - 440	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		mostly pulverized very fine-fine sand size
440 - 450	**Pc**	fine sandstone; light gray [2.5Y7/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted quartz grains); reaction to acid: none		rounded chips to 0.1 in

TABLE A-11. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-61 [*55-918648*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: J. Laney
DEPTH DRILLED / LAND SURFACE ELEVATION: 420.0 feet / 5124.949 feet msl	DATE DRILLED: 11/2 - 11/17/2015
CADASTRAL / NAD83 : (A-18-19)13bca / 1441383.546 N / 664047 E	

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
QUATERNARY ALLUVIUM (Qal)				
0 - 5	**Qal**	alluvium; pink [7.5YR7/3]; non-lithified; 60% fine to coarse-grained sand; 20% rounded to subrounded gravel, up to 2.4 in., consisting of sandstone and chert; 20% low plasticity silt; reaction to acid: moderate		ARCH, Air Rotary
TRIASSIC MOENKOPI FORMATION (TRm)				
5 - 10	**TRm**	sandy siltstone; reddish brown [2.5YR4/3], light blue green [5BG6/6]; weakly to moderately lithified; 70% red brown sandy siltstone; 30% blue gray sandy siltstone; clayey cuttings; reaction to acid: moderate	weathered Moenkopi Fm.	subangular chips to 1.6 in
10 - 20	**TRm**	sandy siltstone; light blue green [5BG6/6], reddish brown [2.5YR4/3]; moderately lithified; 80% blue gray sandy siltstone; 20% red brown siltstone; reaction to acid: strong		subangular to subrounded chips to 0.8 in
20 - 30	**TRm**	sandy siltstone; light blue green [5BG6/6], reddish brown [2.5YR4/3]; moderately lithified; 80% blue gray sandy siltstone; 20% red brown siltstone; reaction to acid: strong		subangular to subrounded chips to 0.8 in
30 - 40	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4]; weakly lithified; red brown siltstone; reaction to acid: strong		subangular chips to 0.4 in
40 - 50	**TRm**	sandy siltstone; weak red [2.5YR4/2]; moderately to well lithified; 60% red brown fine- to medium-grained sandstone; 40% red brown siltstone; reaction to acid: weak		subrounded to subangular chips to 0.4 in
50 - 60	**TRm**	sandy siltstone; weak red [2.5YR4/2]; moderately to well lithified; reddish gray fine- to medium-grained sandstone; reaction to acid: weak		subrounded to subangular chips to 0.4 in
60 - 70	**TRm**	sandy siltstone; olive gray [5Y4/2]; moderately to well lithified; olive gray fine- to medium-grained sandstone; reaction to acid: moderate		subrounded to subangular chips to 0.4 in
70 - 80	**TRm**	sandy siltstone; weak red [2.5YR4/2]; moderately to well lithified; dark red gray fine- to medium-grained sandstone; reaction to acid: weak		subrounded to subangular chips to 0.4 in

TABLE A-11. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-61 [*55-918648*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
80 - 90	**TRm**	sandy siltstone; reddish brown [2.5YR4/3], light blue green [5BG6/6]; moderately to well lithified; 80% dark red gray / blue gray fine- to medium-grained sandstone; 20% blue gray siltstone; reaction to acid: weak		round to subangular chips to 0.8 in
90 - 100	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4]; weakly to moderately lithified; red brown sandy siltstone; reaction to acid: weak		subangular chips to 0.4 in
100 - 110	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], weak red [2.5YR4/2]; moderately to well lithified; 50% red brown siltstone; 50% dark red gray fine- to medium-grained sandstone; reaction to acid: weak		subangular to angular chips to 0.8 in
110 - 120	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately to well lithified; 50% dark red brown fine- to medium-grained sandstone; 40% red brown sandy siltstone; 10% blue gray siltstone; reaction to acid: strong		subangular to subrounded chips to 0.4 in
120 - 130	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 90% red brown siltstone; 10% blue gray siltstone; reaction to acid: strong		subangular chips to 0.4 in
130 - 140	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 60% red brown to red gray siltstone; 40% blue gray siltstone; reaction to acid: strong		subangular chips to 0.4 in
140 - 150	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 80% red brown siltstone; 15% blue gray siltstone; 5% gypsum; reaction to acid: moderate		subrounded to subangular chips to 0.4 in
150 - 160	**TRm**	sandy siltstone; weak red [2.5YR4/2]; well lithified; dark gray fine- to medium-grained sandstone; reaction to acid: moderate		subrounded chips to 0.8 in
160 - 170	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 90% red brown siltstone; 10% blue gray siltstone; trace gypsum; platy siltstone; reaction to acid: moderate		subangular chips to 0.6 in
170 - 180	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3]; moderately lithified; 90% red brown siltstone; 10% blue gray sandy siltstone; platy; reaction to acid: moderate		subangular chips to 0.6 in

TABLE A-11. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-61 [*55-918648*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
180 - 190	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/3], light blue green [5BG6/6]; moderately lithified; 60% red brown siltstone; 40% blue gray siltstone; trace gypsum; reaction to acid: moderate		subangular chips to 0.4 in
190 - 200	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 50% red brown siltstone; 50% blue gray siltstone; trace gypsum; platy; reaction to acid: moderate		subangular chips to 0.4 in
200 - 210	**TRm**	sandy siltstone; weak red [2.5YR4/2]; well lithified; dark red brown fine-grained sandstone; trace gypsum; reaction to acid: moderate		subrounded to subangular chips to 0.6 in
210 - 220	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 80% red brown siltstone; 20% blue gray siltstone; trace gypsum; platy; reaction to acid: moderate		subangular chips to 0.6 in
220 - 230	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 80% red brown siltstone; 20% blue gray siltstone; trace gypsum; reaction to acid: moderate		
230 - 240	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 75% red brown siltstone; 20% blue gray siltstone; 5% gypsum needle crystals; platy; reaction to acid: strong		subangular chips to 0.4 in
240 - 250	**TRm**	sandy siltstone; light blue green [5BG6/6], dark reddish brown [2.5YR3/4]; moderately lithified; 60% blue gray siltstone; 40% red brown siltstone; trace gypsum; reaction to acid: strong		subangular chips to 0.4 in
250 - 260	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 50% red brown siltstone; 25% blue gray siltstone; 20% blue gray fine-grained sandstone; 5% gypsum; reaction to acid: strong		subangular chips to 0.4 in
260 - 270	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], light blue green [5BG6/6]; moderately lithified; 90% red brown siltstone; 10% blue gray fine-grained sandstone; trace gypsum; reaction to acid: strong		subangular chips to 0.4 in

TABLE A-11. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-61 [*55-918648*]
CCR MONITOR WELLS
ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
270 - 280	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], reddish gray [2.5YR6/1]; moderately to well lithified; 80% red brown siltstone; 20% gray fine-grained sandstone; reaction to acid: strong		subangular chips to 0.4 in
280 - 290	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], reddish gray [2.5YR6/1]; moderately to well lithified; 90% red brown siltstone; 10% gray fine-grained sandstone; reaction to acid: moderate		subangular chips to 0.6 in
290 - 300	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4], reddish gray [2.5YR6/1]; moderately to well lithified; 90% red brown siltstone; 10% gray fine-grained sandstone; reaction to acid: moderate		subangular chips to 0.6 in
300 - 310	**TRm**	sandy siltstone; reddish brown [2.5YR4/3], light gray [2.5Y7/2], light blue green [5BG6/6]; moderately to well lithified; 50% red brown sandy siltstone; 40% light brown fine-grained sandstone; 10% blue gray fine-grained sandstone; reaction to acid: moderate		subangular to subrounded chips to 0.4 in
310 - 320	**TRm**	sandy siltstone; reddish brown [2.5YR4/3]; well lithified; red brown fine-grained sandstone; reaction to acid: none		subrounded chips to 0.3 in
320 - 330	**TRm**	sandy siltstone; reddish brown [2.5YR4/3]; well lithified; red brown fine-grained sandstone; reaction to acid: none		subrounded chips to 0.3 in
330 - 340	**TRm**	sandy siltstone; reddish brown [2.5YR4/3]; well lithified; red brown fine-grained sandstone; reaction to acid: none		subrounded chips to 0.4 in
340 - 348	**TRm**	sandy siltstone; dark reddish brown [2.5YR3/4]; well lithified; dark red brown fine- to very fine-grained sandstone; reaction to acid: none		subangular to subrounded chips to 0.4 in
348 - 350	**TRm**	sandy siltstone; gray [5YR6/1]; well lithified; grayish tan very fine- to fine-grained sandstone; reaction to acid: none		subangular chips to 0.6 in
PERMIAN COCONINO SANDSTONE (Pc)				
350 - 360	**Pc**	fine sandstone; pale yellow [2.5Y7/3]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		mostly pulverized, very fine to fine sand size; round chips to 0.3 in

TABLE A-11. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-61 [*55-918648*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	GENERAL DESCRIPTION	SECONDARY FEATURES	COMMENTS
360 - 370	**Pc**	fine sandstone; white [5Y8/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		pulverized very fine to fine sand size chips
370 - 380	**Pc**	fine sandstone; white [5Y8/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		pulverized very fine to fine sand size chips
380 - 390	**Pc**	fine sandstone; white [5Y8/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		mostly pulverized, very fine to fine sand size; round chips to 0.1 in
390 - 400	**Pc**	fine sandstone; white [5Y8/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		pulverized very fine to fine sand size chips
400 - 410	**Pc**	fine sandstone; white [5Y8/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		pulverized very fine to fine sand size chips
410 - 420	**Pc**	fine sandstone; white [5Y8/1]; moderately lithified; buff sandstone (very fine- to fine-grained; rounded, well sorted/uniform quartz grains); reaction to acid: none		pulverized very fine to fine sand size chips

TABLE A-12. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-62A [*55-918658*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: National Exploration Wells Pumps	LOGGED BY: J. Laney, M. Zelazny
DEPTH DRILLED / LAND SURFACE ELEVATION: 97.0 feet / 5021.006 feet msl	DATE DRILLED: 11/17/2015
CADASTRAL / NAD83 : (A-18-19)23cbd / 1434008.665 N / 659268.051 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
QUATERNARY ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**SANDY LEAN CLAY (CL)**: Dark reddish brown [5YR2.5/2]; silt and clay 60%, rounded to angular, fine to coarse sand 30%, gravel 10%. Gravel fraction: subrounded to subangular gravel to 0.8 in. consisting of chert and sandstone. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: weak.
5.0 - 10.0	**Qal**	**SANDY LEAN CLAY (CL)**: Dark reddish brown [5YR2.5/2]; silt and clay 60%, rounded to angular, fine to coarse sand 30%, gravel 10%. Gravel fraction: subrounded to subangular gravel to 0.4 in. consisting of chert and sandstone. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: weak.
10.0 - 15.0	**Qal**	**FAT CLAY WITH SAND (CH)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded to angular medium sand 25%. Gravel fraction: subrounded to subangular gravel. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: weak.
15.0 - 20.0	**Qal**	**SANDY FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; silt and clay 70%, rounded to angular medium sand 30%. Gravel fraction: subrounded to subangular gravel. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: moderate.
20.0 - 25.0	**Qal**	**SANDY FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; rounded to angular fine sand 50%, silt and clay 50%. Gravel fraction: subrounded to subangular gravel. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: weak.
25.0 - 30.0	**Qal**	**SANDY FAT CLAY (CH)**: Dark reddish gray [5YR4/2]; rounded to angular fine sand 50%, silt and clay 50%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of sandstone. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: weak.
30.0 - 35.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded to angular, fine to medium sand 25%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of sandstone. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: moderate.
35.0 - 40.0	**Qal**	**LEAN CLAY WITH SAND (CL)**: Dark reddish gray [5YR4/2]; silt and clay 75%, rounded to angular, fine to medium sand 25%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of sandstone. Non-lithified. Medium to high plasticity. Well graded. Reaction to acid: moderate.
40.0 - 45.0	**Qal**	**SANDY SILT (ML)**: Light reddish brown [5YR6/3]; silt and clay 55%, rounded to angular, fine to medium sand 45%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of chert and sandstone. Non-lithified. Low plasticity. Well graded. Reaction to acid: weak.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-12. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-62A [*55-918658*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
45.0 - 50.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 70%, gravel 20%, silt 10%. Gravel fraction: subrounded to subangular gravel to 0.4 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
50.0 - 55.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 70%, gravel 20%, silt 10%. Gravel fraction: subrounded to subangular gravel to 0.8 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
55.0 - 60.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 90%, silt 10%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
60.0 - 65.0	**Qal**	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 60%, gravel 30%, silt 10%. Gravel fraction: subrounded to subangular gravel to 0.6 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: weak.
65.0 - 70.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 90%, gravel 5%, silt 5%. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.
70.0 - 75.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 90%, gravel 5%, silt 5%. Gravel fraction: subrounded to subangular gravel to 0.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.
75.0 - 80.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 90%, gravel 5%, silt 5%. Gravel fraction: subrounded to subangular gravel to 1.2 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.
80.0 - 85.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 90%, gravel 5%, silt 5%. Gravel fraction: subrounded to subangular gravel to 1.0 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.
85.0 - 90.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 90%, gravel 5%, silt 5%. Gravel fraction: subrounded to subangular gravel to 0.1 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-12. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-62A [*55-918658*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
90.0 - 95.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 95%, silt 5%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.4 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.
95.0 - 97.0	**Qal**	**WELL GRADED SAND (SW)**: Light reddish brown [5YR6/3]; angular, medium to coarse sand 95%, silt 5%, trace gravel. Gravel fraction: subrounded to subangular gravel to 0.4 in. consisting of chert and sandstone. Non-lithified. Non-plastic. Well graded. Reaction to acid: moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-13. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-64A [*55-920353*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DRILLING COMPANY: Yellow Jacket Drilling	LOGGED BY: C.Stielstra, M. Zelazny
DEPTH DRILLED / LAND SURFACE ELEVATION: 69.0 feet / 4988.904 feet msl	DATE DRILLED: 2/8/2017
CADASTRAL : (A-18-19)21ccb / 1434030.012 N / 647702.043 E	

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
ALLUVIUM (Qal)		
0.0 - 5.0	**Qal**	**FAT CLAY (CH)**: Reddish brown [5YR4/3]; silt and clay 92%, sand 8%. Non-lithified. High plasticity. Well sorted. Reaction to acid: strong.
5.0 - 10.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR5/3]; sand 50%, silt 50%. Non-lithified. Very low plasticity. Moderately sorted. Reaction to acid: weak to moderate.
10.0 - 15.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR5/3]; sand 80%, silt 20%. Non-lithified. Non-plastic. Well sorted. Reaction to acid: weak to moderate.
15.0 - 20.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR5/3]; sand 75%, silt 25%. Non-lithified. Non-plastic. Well sorted. Reaction to acid: weak to moderate.
20.0 - 25.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR4/3]; sand 70%, silt 25%, gravel 5%. Gravel fraction: subangular gravel to 1 in. consisting of Sandstone, chert, siltstone and quartzite. Non-lithified. Non-plastic. Moderately sorted. Reaction to acid: weak to moderate.
25.0 - 30.0	**Qal**	**SILTY SANDS WITH GRAVEL (SM)**: Brown [7.5YR4/3]; sand 55%, gravel 25%, silt 20%. Gravel fraction: subangular gravel to 2 in. consisting of Chert, sandstone, coal and limestone. Non-lithified. Non-plastic. Moderately sorted. Reaction to acid: strong.
30.0 - 35.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR4/2]; sand 80%, silt 19%, gravel 1%. Gravel fraction: subangular gravel to 1.5 in. consisting of Chert, limestone, sandstone and quartzite. Non-lithified. Non-plastic. Moderately sorted. Reaction to acid: moderate.
35.0 - 40.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Brown [7.5YR4/3]; sand 90%, silt 10%, trace gravel. Gravel fraction: subangular gravel to 1.5 in. consisting of Clay stone, sandstone and quartzite. Non-lithified. Non-plastic. Well sorted. Reaction to acid: very strong.
40.0 - 45.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Brown [7.5YR5/3]; sand 90%, silt 10%, trace gravel. Gravel fraction: subangular gravel to 1 in. consisting of Clay stone, chert, limestone and sandstone. Non-lithified. Non-plastic. Well sorted. Reaction to acid: weak.
45.0 - 50.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Brown [7.5YR5/2]; sand 90%, silt 10%, trace gravel. Gravel fraction: subangular gravel to 1.8 in. consisting of Clay stone, chert and sandstone. Non-lithified. Non-plastic. Well sorted. Reaction to acid: moderate.
50.0 - 55.0	**Qal**	**WELL GRADED SAND WITH SILT (SW-SM)**: Brown [7.5YR5/2]; sand 90%, silt 10%, trace gravel. Gravel fraction: subangular gravel to 2.5 in. consisting of Clay stone, sandstone, chert and limestone. Non-lithified. Non-plastic. Well sorted. Reaction to acid: weak to moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

TABLE A-13. LITHOLOGIC DESCRIPTIONS FOR DRILL CUTTINGS FROM MONITOR WELL M-64A [*55-920353*] CCR MONITOR WELLS ARIZONA PUBLIC SERVICE CHOLLA POWER PLANT

DEPTH INTERVAL (feet)	FORMATION	DESCRIPTION
55.0 - 60.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR5/2]; sand 80%, silt 20%, trace gravel. Gravel fraction: subangular gravel to 1.3 in. consisting of Clay stone, sandstone, chert and limestone. Non-lithified. Non-plastic. Well sorted. Reaction to acid: weak to moderate.
60.0 - 65.0	**Qal**	**SILTY SANDS (SM)**: Brown [7.5YR5/3]; sand 75%, silt 25%, trace gravel. Gravel fraction: subangular gravel to 1.3 in. consisting of Clay stone, sandstone, chert and limestone. Non-lithified. Non-plastic. Well sorted. Reaction to acid: weak to moderate.
TRIASSIC MOENKOPI FORMATION (TRm)		.
65.0 - 69.0	**TRm**	**SILTY SANDS (SM)**: Brown [7.5YR5/3]; sand 55%, silt 42%, gravel 3%. Gravel fraction: subangular gravel to 1.3 in. consisting of Moenkopi chips. Non-lithified. Very low plasticity. Moderately sorted. Reaction to acid: weak to moderate.

Gravel/sand division based on USCS scale. Grain size fractions estimated using manual field methods.

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TABLE A-14. SUMMARY OF FIELD PARAMETER STABILITY AT THE END OF DEVELOPMENT OF CCR MONITORING NETWORK WELLS INSTALLED DURING SEPTEMBER 2015 THROUGH FEBRUARY 2017 APS CHOLLA POWER PLANT, NAVAJO COUNTY, ARIZONA

Well Identifier	EC[a] (% difference)[b]	Temp[c] (% difference)[b]	pH[d] (s.u. difference)[e]	ORP[f] (mV difference)[g]	Development Duration (h:mm)[h]	Remarks at End of Development
M-50A	0.77	2.37	<0.1	<10	1:12	Clear
M-51A	0.77	0.99	<0.1	<10	1:42	Clear
M-52A	1.82	5.45	<0.1	<10	6:55	Slightly brown/reddish, no sand
M-53A	1.29	3.37	<0.1	<10	3:17	Clear / no sand
M-54	0.24	0.00	<0.1	<10	4:00	Clear, no color
M-56A	0.08	1.69	<0.1	<10	2:45	Clear
M-57A	0.71	1.12	<0.1	<10	3:04	Clear
M-58A	0.18	1.13	<0.1	<10	2:10	Clear
M-59	0.15	1.53	<0.1	<10	2:25	Clear
M-60	0.72	5.24	<0.1	<10	3:24	Clear
M-61	0.10	0.51	<0.1	<10	2:45	Clear
M-62A	3.31	3.41	<0.1	<10	3:05	Clear
M-64A	12.44	4.14	<0.1	<10	4:03	Sand 1 millimeter per liter

[a] EC = Electrical Conductivity

[b] % difference = maximum percent difference between last three field parameter measurements during development

[c] Temp = temperature (measured in °C)

[d] pH = potential of hydrogen

[e] s.u. difference = maximum standard unit difference between last three pH measurements during development

[f] ORP = Oxygen-Reduction Potential

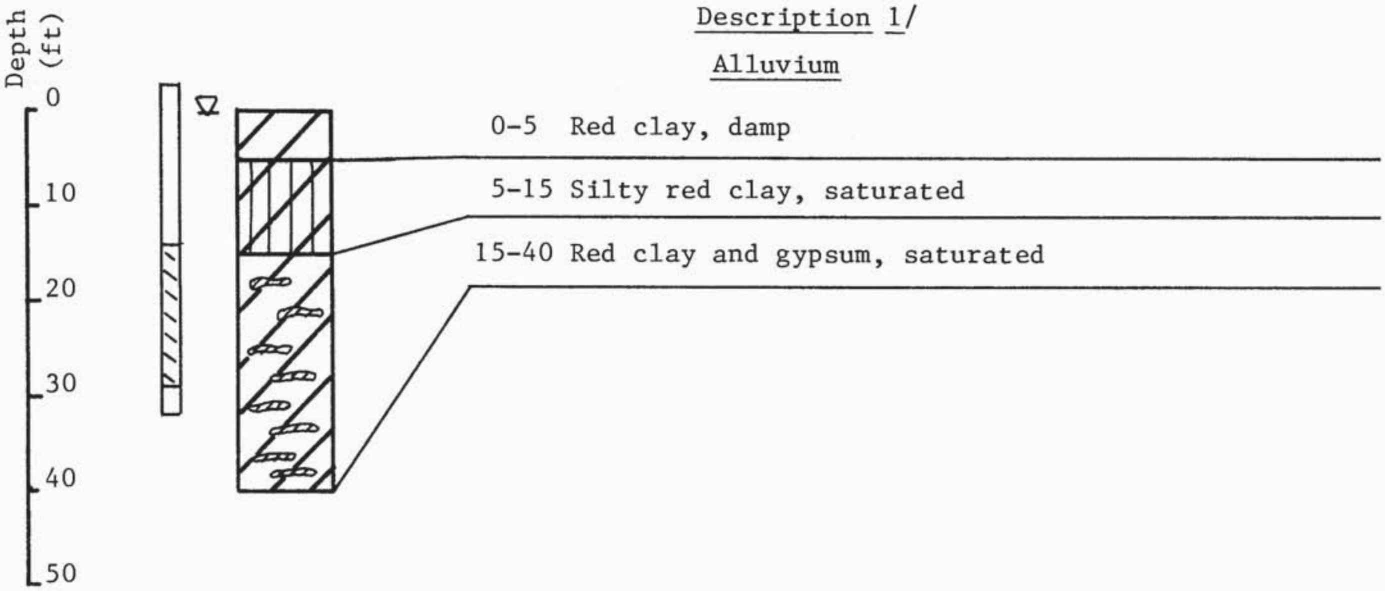
[g] mV difference = maximum millivolt difference between last three ORP measurements during development

[h] h:mm = hours:minutes

APPENDIX B
CONSTRUCTION DETAILS FOR CCR MONITORING NETWORK
PRE-EXISTING MONITOR WELLS

A total of five pre-existing monitoring wells are incorporated into the CCR monitoring network at Cholla Power Plant. Locations for these wells are shown on **Figure 1** in the main document. Well depths, screened intervals, and lithologic descriptions are provided in **Figures B-1 through B-4**. Wells are sequenced in order of well identification number. A typical well schematic diagram is shown for well W-314 on **Figure B-4** and for wells W-123, W-305 and W-306 on **Figure B-5.**

Log of Well: W-123



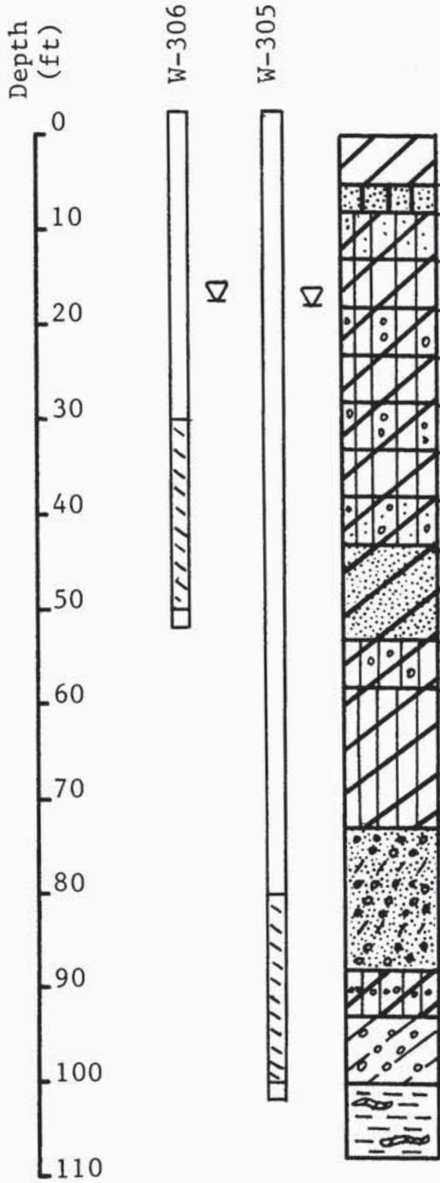
1/ Descriptions based on inspection of drill cuttings. Samples taken at 5 ft. intervals.

Note: Depth to water shown is for April 5, 1984

Source: Cholla Steam Electric Generating Station, Cholla Ash Ponds, Groundwater Interpretative Report #1, June, 1984. Report prepared by APS with John L. Boyer as the principal investigator

FIGURE B-1

Log of Well: W-305 2/



Description 1/

Tanner Wash Alluvium

0-5	Silty clay, BRN
5-8	Sandy silt, BRN
8-13	Silty clay, BRN, some sand
13-18	Silty clay, BRN
18-23	Silty clay, BRN, some 1/8" gravel
23-28	Silty clay, BRN
28-33	Silty clay, BRN, some 1/8" gravel
33-38	Silty clay, BRN
38-43	Silty clay, BRN, some coarse sand and ¼" gravel
43-53	Sandy clay, BRN
53-58	Silty clay, BRN, some gravel
58-73	Silty clay, BRN
73-88	Sandy gravel, w/layers of clay, BRN
88-93	Silty clay, BRN, thin layers gravel, some GRN sandstone chips
93-100	Clayey sandy gravel

Moqui Member of the Moenkopi Formation

100-108	Red claystone, some gypsum

1/ Descriptions based on inspection of drill cuttings. Samples taken at 5 ft. intervals.

2/ This log also applies for Well W-306 which was drilled approximately 10 feet east of W-305.

Note: Depth to water shown is for April 5, 1984

Source: Cholla Steam Electric Generating Station, Cholla Ash Ponds, Groundwater Interpretative Report #1, June, 1984. Report prepared by APS with John L. Boyer as the principal investigator

FIGURE B-2

LOG OF TEST HOLE No.: W314

DATE: **1/25/92** SURFACE ELEVATION: **5049.1' MSL** LOCATION: **BOTTOM ASH POND**

DEPTH, ft.	SYMBOL	DESCRIPTION	STRATUM EL / DEPTH	WELL	GAMMA (NATURAL)--API-GR 0–200; DENSITY--G-CC 0–5; RESISTIVITY(16N)--OHM-M 0–100
		ALLUVIUM CLAY, very hard to hard, dry, fat, (to 12'), silty lenses, indistinct laminations, color is pale brown (5 YR 5/2), to moderate brown (5 YR 4/4) to moderate brown (5 YR 3/4), (CH)			
5					
10		- @12' damp			
		- @14' moist			
15		- @16' slightly moist to damp			
20		- @20' clay balls in cuttings			
		- @23' color change to moderate brown (5 YR 4/4)			
25		- @26' gypsum in cuttings - @27' moist with abundant gypsum			
30			5019.1 30.0		
		CLAY, hard to stiff, very fine sand, slightly moist, with fine rounded chert gravels, color is moderate brown (5 YR 4/4) to light brown (5 YR 5/6)			

Casing Material:	4" SCHEDULE 40 PVC	Completed Well Head Elev:	5051.10' MSL
Casing Inner Dia:	3.96 INCHES	Geologist:	STEVEN C KAMINSKI
Slot Size:	0.01 INCH	Bit Diameter:	7.87
Screened Interval:	46' TO 61'	Drill Rig:	BARBER
Filter Pack Material:	20-40 SILICA SAND	Drill Contractor:	MAHER ENVIRONMENTAL
Casing Connection:	FLUSH THREAD W/ O-RING GASKET	Geophysic Contractor:	NOT CONDUCTED
Temporary Steel Casing (TSC) Dia:	10 INCH	Initial Water:	31' BG, POSSIBLY 15'
TSC Depth Of Penetration:	62'		
Drilling Method:	DUAL AIR ROTARY		

Completion Depth: **63.0 Ft.**

Water Depth: ______ ft., After ______ hrs.
______ ft., After ______ hrs.

Project No.: **914X236B**

Project Name: **APS - CHOLLA POWER PLANT**

Drawn By: STEVEN C KAMINSKI Reviewed By: LEO LEONHART

LOG OF TEST HOLE No.: W314

DATE: **1/25/92** SURFACE ELEVATION: **5049.1' MSL** LOCATION: **BOTTOM ASH POND**

DEPTH, ft.	SYMBOL	DESCRIPTION	STRATUM EL / DEPTH	WELL	GAMMA (NATURAL)–API-GR 0–200; DENSITY–G-CC 0–5; RESISTIVITY(16N)–OHM-M 0–100
		- @31' wet - @37' less sand, damp, forms clay balls	5010.1		
40, 45, 50, 55		GRAVEL, dense to very dense, wet, clayey, sandy, fine to coarse gravels of fine grained very friable, very dusky red (10 R 2/2) to dark reddish brown (10 R 3/4) sandstone,with chert and petrified wood of various colors, silty clay interbeds ranging up to 4 feet in thickness are moderate brown (5 YR 4/4) to moderate reddish brown (10 R 4/6)	39.0 4989.1		
60		BEDROCK Formation: Moenkopi, Member: Mouqi Shale, siltstone and sandstone, very soft (sandstones are friable), deeply weathered, fine grained fraction is moderate brown (5 YR 4/4), while sandstone fraction is greyish brown (5 YR 3/2) to moderate brown (5 YR 3/4) with some greyish green (10 GY 5/2) to greyish green (5 GY 5/2) - @62' Standard penetration split spoon sample collected produced poor recovery of deeply weathered pale brown (5 YR 5/2) to moderate brown (5 YR 3/4) sandy siltstone bedrock	60.0 4986.1 63.0		
		TOTAL DEPTH OF HOLE AT 63 FEET BELOW GRADE Surface protection consists of a 20 length of 5" dia. steel riser embedded to 18 feet. A second 7' length of 6" dia. steel riser with lockable cap was installed as well head security and embedded to approximately 5 feet			

Completion Depth: **63.0 Ft.**

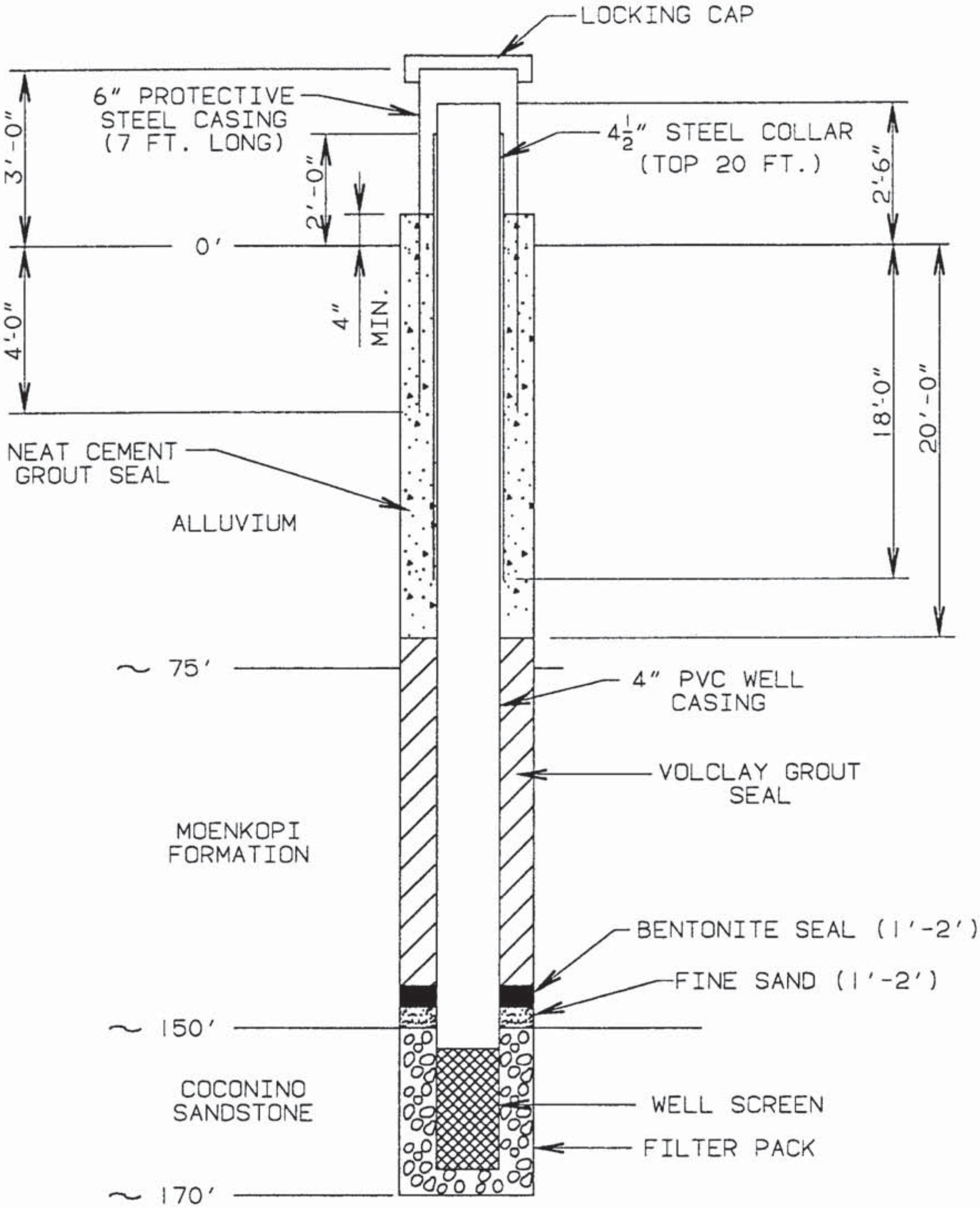
Water Depth: ______ ft., After ______ hrs.
______ ft., After ______ hrs.

Project No.: **914X236B**

Project Name: **APS - CHOLLA POWER PLANT**

Drilling Method: **DUAL AIR ROTARY**

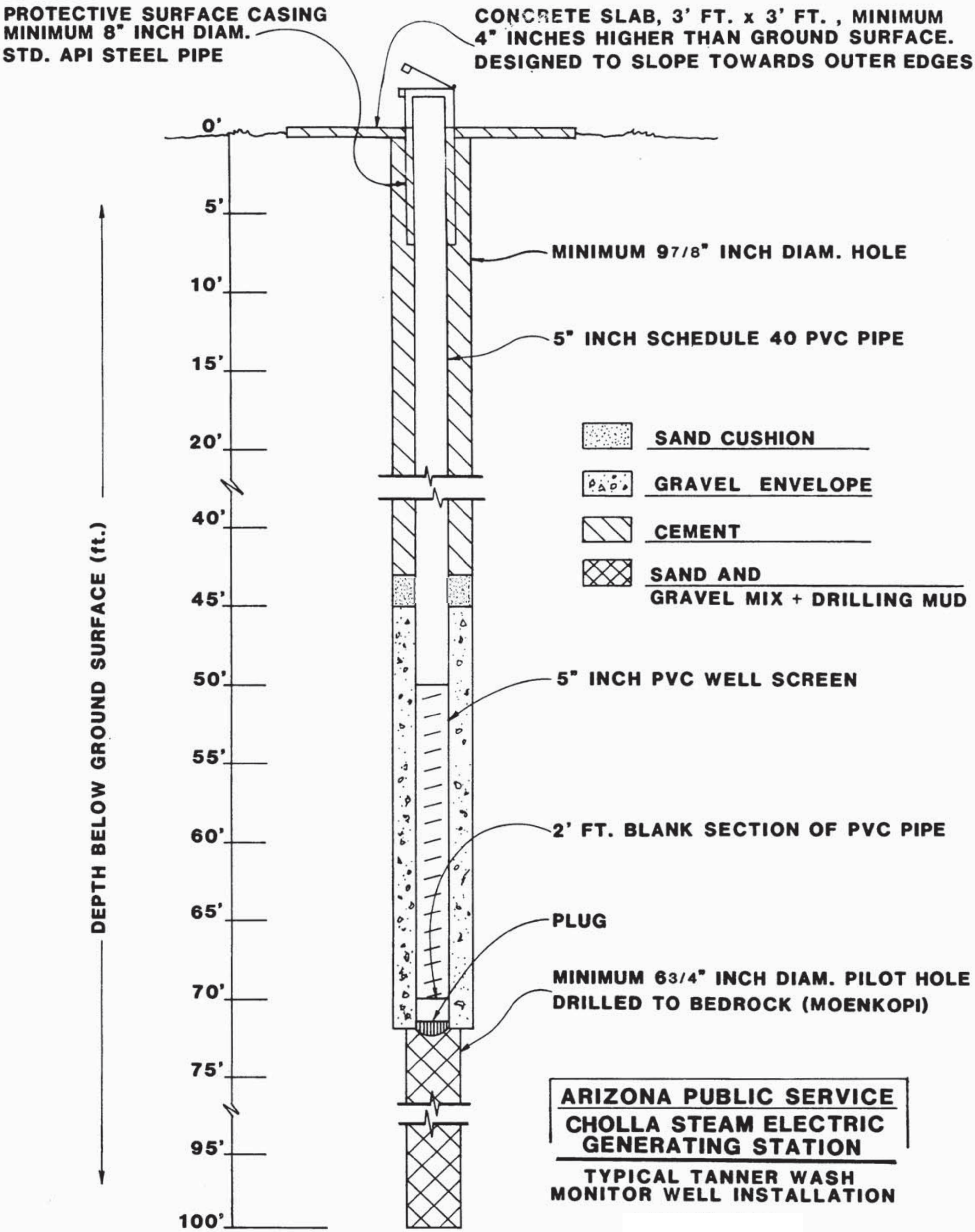
Woodward-Clyde Consultants



Source: Evaluation of Hydrogeologic Conditions,
Bottom Ash Pond,
Cholla Steam Electric Station, May 22, 1992
prepared by Woodward-Clyde Consultants

FIGURE B-4

NO.	DATE	REVISION	DWN	CHD	EXD	RVWD	APPD	W.A.



Source: Cholla Steam Electric Generating Station, Cholla Ash Ponds, Groundwater Interpretative Report #1, June, 1984. Report prepared by APS with John L. Boyer as the principal investigator

FIGURE B-5