FINAL

PARCEL 3 GROUNDWATER BACKGROUND WELLS AND REPLACEMENT MONITORING WELLS INSTALLATION WORK PLAN

FORT WINGATE DEPOT ACTIVITY
MCKINLEY COUNTY, NEW MEXICO

December 2019

Contract No. W912PP-17-C-0003

Prepared for:

US Army Corps of Engineers®

Albuquerque District
4101 Jefferson St. NE
Albuquerque, New Mexico 87109

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
18-12-2019	Final	June 2019 to December 2023

4. TITLE AND SUBTITLE
Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan
Fort Wingate Depot Activity
McKinley County, New Mexico

5a. CONTRACT NUMBER
W912PP-17-C-0003

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
JohnDavid Nance, Sundance Consulting, Inc.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, New Mexico 87109

10. SPONSOR/MONITOR'S ACRONYM(S)
USACE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
This groundwater well installation Work Plan was prepared for submission to the New Mexico Environment Department– Hazardous Waste Bureau as required by comments 4, 7, 9, and 14 of NMED letter dated June 14, 2019 (FWDA-HWB-18-001).

14. ABSTRACT
This well installation Work Plan outlines the activities and methodologies to install monitoring wells within the Parcel 3 Hazardous Waste Management Unit to replace abandoned wells due to on-site soil excavation activities. This Work Plan also outlines the activities to install three additional groundwater background wells for use in determining groundwater background values at Parcel 3.

15. SUBJECT TERMS
Fort Wingate Depot Activity, groundwater, background, replacement, monitoring well, drilling, Parcel 3, HWMU

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Mark Patterson
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR	64	19b. TELEPHONE NUMBER *(include area code)* 505-721-9770

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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Final Approval Letter Placeholder

Upon approval by the New Mexico Environment Department–Hazardous Waste Bureau of this Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan, a copy of the signed approval letter will be placed here.

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Document Certification

40 CFR 270.11

December 2019

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information; the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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Final

Parcel 3 Groundwater Background Wells and

Replacement Monitoring Wells Installation Work Plan

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Notes:
BEC= Base Realignment and Closure Environmental Coordinator
BIA = U.S. Bureau of Indian Affairs
BRACD = Base Realignment and Closure Division
EPA = U.S. Environmental Protection Agency
FWDA = Fort Wingate Depot Activity
HWB = Hazardous Waste Bureau
NM = New Mexico
NMED = New Mexico Environment Department
NN = Navajo Nation
NRO = Navajo Regional Office
OH = Ohio
POZ = Pueblo of Zuni
USACE = U.S. Army Corps of Engineers

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Acronyms and Abbreviations

°F	degree Fahrenheit
APP	Accident Prevention Plan
ASTM	ASTM International
BEC	Base Realignment and Closure Environmental Coordinator
BRACD	Base Realignment and Closure Division
CFR	Code of Federal Regulations
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FWDA	Fort Wingate Depot Activity
GPS	global positioning system
HWB	Hazardous Waste Bureau
HWMU	hazardous waste management unit
IDW	investigation-derived waste
kg	kilogram
LDR	land disposal restriction
M&E	Metcalf & Eddy, Inc.
mph	mile per hour
msl	mean sea level
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
OSE	Office of the State Engineer
PA	Programmatic Agreement
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QASP	Quality Assurance Surveillance Plan
QCP	Quality Control Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SQG	small quantity generator
SSHP	Site Safety and Health Plan

Sundance	Sundance Consulting, Inc.
TCP	traditional cultural properties
TPMC	Terranear-Project Management Company
TSDF	treatment, storage, and disposal
USACE	U.S. Army Corps of Engineers
UXO	unexploded ordnance
Work Plan	Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan

ES.1 EXECUTIVE SUMMARY INTRODUCTION

This Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan (Work Plan) has been prepared by Sundance Consulting, Inc., for the U.S. Army Corps of Engineers for submission to the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) in response to comments 4, 7, 9, and 14 of NMED HWB letter dated June 14, 2019 (FWDA-HWB-18-001; NMED, 2019) and the Base Realignment and Closure Division (BRACD) response letter dated August 22, 2019 (BRACD, 2019). This Work Plan describes the specific field methods, activities, and procedures for installing additional bedrock background groundwater monitoring wells (background wells) and installing replacement groundwater monitoring wells (replacement wells) within the hazardous waste management unit (HWMU) boundary of Parcel 3 and adjacent areas of Parcel 2 and Parcel 1, Fort Wingate Depot Activity (FWDA), New Mexico.

ES.2 PURPOSE

The purpose of this Work Plan is to describe the specific field methods, activities, and procedures to install background wells to supplement the southern area groundwater background evaluation. The additional background monitoring wells are required to evaluate background metals concentrations within Parcel 3 water-bearing units and to determine if any contamination from other sources is migrating into the project site. This Work Plan also describes the specific field methods, activities, and procedures to install replacement wells for groundwater monitoring wells abandoned (abandoned wells) due to soil excavation activities performed within the HWMU. Replacing abandoned wells within the HWMU is required to maintain the groundwater monitoring well network and provide a sufficient data set for future groundwater monitoring of FWDA's southern area.

ES.3 PROPOSED ACTIVITIES

Field activities proposed within this Work Plan include the following.

- **Install One Background Well in Parcel 2.** Drill one soil boring and install a background well in a water-bearing unit adjacent to an identified arroyo in Parcel 2 approximately 2,500 feet northeast of dry background monitoring well BGMW05.
- **Install Two Background Wells in Parcel 1.** Drill two soil borings and install two background wells in a water-bearing unit adjacent to the main drainage arroyo in Parcel 1, approximately 1 mile south of the southern boundary of Parcel 3.
- **Install 11 Replacement Wells in Parcel 3.** Drill 11 soil borings proximal to previously abandoned groundwater monitoring wells within the HWMU of Parcel 3 and install 11 replacement wells screened to the specifications of the abandoned wells each new well will replace.
- **Perform Well Development.** Develop newly installed background wells and newly installed replacement wells.
- **Perform Well Survey.** Survey newly installed background wells and replacement wells.

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1.0 INTRODUCTION

This Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan (Work Plan) has been prepared by Sundance Consulting, Inc. (Sundance) for the U.S. Army Corps of Engineers (USACE) for submission to the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) in response to comments 4, 7, 9, and 14 of NMED HWB letter dated June 14, 2019 (FWDA-HWB-18-001; NMED, 2019) and the Base Realignment and Closure Division (BRACD) response letter dated August 22, 2019 (BRACD, 2019). This Work Plan describes the specific field methods, activities, and procedures to install three additional background groundwater monitoring wells in the southern Fort Wingate Depot Activity (FWDA) groundwater area and install groundwater monitoring wells to replace abandoned groundwater monitoring wells within the hazardous waste management unit (HWMU) boundary of Parcel 3, FWDA, New Mexico (NM).

This Work Plan was prepared in accordance with contract number W912PP-17-C-0003, Performance Work Statement, Section 5.11, Optional Task 42: Background/Replacement Wells Work Plan. The contract modification was issued by USACE-Albuquerque District, on October 1, 2019.

1.1 PURPOSE AND SCOPE

A Parcel 3 groundwater Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report, titled *Final, Revision 1 Parcel 3 Groundwater RCRA Facility Investigation Report, Fort Wingate Depot Activity, McKinley County, New Mexico* (Sundance, 2019), was previously submitted to NMED for review. NMED issued an Approval with Modification of the groundwater RFI report on June 14, 2019, however several comments required a work plan to install additional groundwater background monitoring wells (background wells) upgradient of Parcel 3 and adjacent to identified arroyos. As ongoing soil excavation operations in Parcel 3 have required abandoning several existing groundwater monitoring wells within the HWMU, NMED also requested a work plan to replace abandoned groundwater monitoring well CMW18 because it was essential to the groundwater monitoring well network. Replacing other abandoned groundwater monitoring wells (abandoned wells) within the HWMU is required to maintain the southern groundwater monitoring well network and provide a sufficient data set for future groundwater monitoring. This Work Plan presents which abandoned wells within the HWMU are proposed to be replaced.

This Work Plan outlines the methods, activities, and procedures to install additional background wells and install replacement groundwater monitoring wells (replacement wells) for wells abandoned because of Parcel 3 excavation operations.

Field activities proposed within this Work Plan include the following.

- **Install One Background Well in Parcel 2.** Drill one soil boring and install a background well in a water-bearing unit adjacent to an identified arroyo in Parcel 2 approximately 2,500 feet northeast of dry background monitoring well BGMW05 (comment 7, NMED 2019).
- **Install Two Background Wells in Parcel 1.** Drill two soil borings and install two background wells in a water-bearing unit adjacent to the main drainage arroyo in Parcel

1, approximately 1 mile south of the southern boundary of Parcel 3 (comment 9, NMED 2019).

- **Install 11 Replacement Wells in Parcel 3.** Drill 11 soil borings proximal to abandoned wells within the HWMU of Parcel 3 and install 11 replacement wells screened to the specifications of the abandoned wells each new well will replace (comment 14, NMED 2019; response to comment 4, BRACD, 2019).
- **Perform Well Development.** Develop newly installed background wells and newly installed replacement wells.
- **Perform Well Survey.** Survey newly installed background wells and replacement wells.

1.2 DOCUMENT ORGANIZATION

The remainder of this Work Plan is organized into the following sections.

- **Section 2** – Presents background information for FWDA and describes general site conditions and the cultural resources within and around the Parcel 3 boundary of FWDA.
- **Section 3** – Describes the proposed field methodology and provides detail of well screen intervals and proposed locations.
- **Section 4** – Presents information for investigation-derived waste (IDW) management.
- **Section 5** – Discusses project reporting and management.
- **Section 6** – Presents works cited within this Work Plan.

2.0 INSTALLATION AND SITE BACKGROUND

FWDA installation is located approximately 7 miles east of Gallup, NM, and currently occupies approximately 15,277 acres of land in McKinley County, NM (Figure 2-1). FWDA is mostly surrounded by federally owned or administered lands, including both national forest and tribal lands.

The installation has been divided into several sub-areas (parcels) based on their location and historical land use (Figure 2-2). This Work Plan focuses on the southern area of FWDA, specifically Parcel 3 and adjacent areas in Parcel 2 and Parcel 1 and will be referred to as the Study Area (Figure 2-2).

A groundwater RFI was conducted in 2017, which concluded shallow groundwater bearing units within Parcel 3 are located proximal to drainage arroyos (Sundance, 2019). The groundwater RFI indicated the need for additional groundwater background locations because background groundwater monitoring well locations within Parcel 3 did not produce sufficient, if any, groundwater to sample. It was determined additional background well locations should be installed outside of the Parcel 3 boundary and within proximity of identified arroyos. Three additional background well locations have been identified to potentially produce sufficient groundwater upgradient of known activities. Further detail is presented in Section 3.0.

The groundwater RFI field efforts preceded the current HWMU soil excavation removal action. Additional groundwater monitoring wells were installed during the groundwater RFI to supplement the existing groundwater monitoring well network within the parcel. The HWMU soil excavation operations have encroached on existing groundwater monitoring wells and required these wells to be abandoned before excavating surrounding soil. Eleven groundwater monitoring wells within the HWMU have been abandoned as a result of the soil excavation operations. Replacement wells are proposed to replace these abandoned wells and are proposed to be located approximately in the same location as the abandoned well being replaced.

2.1 CULTURAL RESOURCES

Traditional cultural properties (TCPs) and other cultural resources have been documented within the FWDA boundaries. Based on a review of available mapping (University of New Mexico/Office of Contract Archaeology, 1994), a limited number of identified sites are located within the southern FWDA groundwater area.

USACE-Fort Worth District has developed a Programmatic Agreement (PA) to specify procedures to be employed during environmental characterization and remediation activities. These procedures will be followed while performing field work. The PA has been presented in previous works and for this Work Plan is referenced from the Parcel 3 groundwater RFI work plan (Sundance, 2016).

Maps showing the locations of TCPs relative to proposed investigation locations are not included in this Work Plan because it is a public document. Instead, the consultation process will include review by tribal cultural resource personnel to confirm the presence or absence of identified cultural resources within the proposed investigation locations. During the Work Plan review period, tribal cultural staff may visit the Study Area and meet with U.S. Army representatives to view figures showing proposed monitoring well sites and inspect the area for cultural resources. Specific proposed monitoring well locations will not be flagged, but the area will be identified.

Pursuant to the PA, the U.S. Army will provide a letter to the Pueblo of Zuni, Navajo Nation, and State Historic Preservation Officer seeking comments on field operating procedures before beginning fieldwork.

2.2 SITE CONDITIONS

2.2.1 Climate

Northwestern NM is characterized by a semiarid continental climate. Most precipitation occurs from May through October. Most of the precipitation occurs as rain or hail in summer thunderstorms, and the remainder results from light winter snow accumulations (Metcalf & Eddy, Inc. [M&E], 1992). Average annual precipitation for Gallup, NM, and the surrounding area is approximately 12 inches of rainfall; the average snowfall amount is 35 inches. Most precipitation occurs during monsoon season from July through October, with minimal precipitation in the spring and late fall. Wind speed for the area averages approximately 6 miles per hour (mph) over the course of a year. However, wind gusts have been known to reach speeds of 60 mph or more (Sundance, 2019).

The average seasonal temperatures for the area vary with elevation and topographic features. During winter, daily temperatures fluctuate as much as 50°F to 70°F in a 24-hour period. In summer, daily high temperatures are between 85°F and 95°F (M&E, 1992). Average temperatures in winter are about 27°F and in summer 70°F, while extreme temperatures are as low as -30°F in winter and as high as 100°F in summer. There are 100 to 150 frost-free days during the year from the middle of May to the middle of October (M&E, 1992).

2.2.2 Topography

The topography of FWDA ranges from approximately 6,660 feet above mean sea level (msl) in the north to 8,200 feet above msl in the south. FWDA can be divided into three general topological areas: 1) the rugged north-to-south trending Nutria Monocline (also known as the Hogback) along the western and the southwestern boundaries, 2) the northern hill slopes of the Zuni Mountains in the southern portion, and 3) the alluvial plains marked by bedrock outcrops in the northern area. As shown on Figure 2-3, the Nutria Monocline comprises a significant portion of the western boundary of the Study Area. The highest elevation in the Study Area is approximately 7,820 feet above msl, located in the Nutria Monocline in Parcel 1 (Figure 2-3). The lowest elevation is approximately 7,320 feet above msl, located along the main north–south trending drainage arroyo. In general, topography is steep along the north-to-south trend of the Nutria Monocline and becomes more gradual toward the eastern parcel boundary.

Main drainages follow the topography, generally flowing from south to north, and discharging into the South Fork of the Rio Puerco near the FWDA northern boundary. Many local tributaries follow the regional trend of flowing from southwest to northeast. Drainages at FWDA are ephemeral with flow occurring only during and after heavy rainfall events or during snowmelt. During these events, streams transport sediment to low-lying areas in the northern part of FWDA, creating extensive alluvial deposits among bedrock remnants.

Within Parcel 3, surface water runoff is conveyed through two arroyos that merge near the Study Area's northern boundary, and a third minor arroyo on the eastern portion of Parcel 3 that flows into Parcel 2 then merges with the other arroyos at the northeast corner of Parcel 3 (Figure 2-3).

Drainages are fed by washes in the Zuni Mountains and the Nutria Monocline. The drainages from the Study Area generally flow north until they intersect the South Fork of the Rio Puerco.

2.2.3 Land Use

The current FWDA land use is commercial/industrial and it is expected to remain as such until federal property transfer. Parcel 3, specifically, is an improved conventional munitions-designated area that will require future land use controls. The U.S. Army intends to maintain ownership of most of Parcel 3 indefinitely.

2.2.4 Vegetation/Habitat

The vegetation cover for the Study Area consists of moderate grasslands, sagebrush, and piñon-juniper woodlands. The Study Area provides habitat for antelope, rattlesnakes, field mice, various other insects and animals, and occasionally mountain lions and bears.

2.2.5 Soils

Soil types found on FWDA are consistent with those occurring in cool plateau and mountain regions of NM. Major FWDA soil types are variants and complexes of sand, loams, clay, and rock as shown on Figure 2-4. Surface soil layers are relatively thin, and the parent bedrock is either at or near the surface in more than one-quarter of FWDA.

Figure 2-4 presents the Natural Resources Conservation Service (NRCS) soil map for the Study Area (NRCS, 2018). Thickness of soil types vary widely over FWDA, with alluvium accumulations deepest along canyon floors and in the Rio Puerco valley. Wind and surface water runoff cause extensive soil erosion, especially where vegetation is absent.

2.2.6 Geology

Mapped geologic units exposed at ground surface in the southwestern portion of FWDA are shown on Figure 2-5. The geologic and stratigraphic setting described in the following sections is based on this geologic mapping in combination with available geologic literature and recent subsurface investigations in the southern areas of FWDA.

2.2.6.1 Structural Geology

FWDA lies within a small basin defined by the Zuni Mountains (Zuni Uplift) to the south and east, the Nutria Monocline to the west, and the South Fork of the Rio Puerco to the north (Figure 2-6; U.S. Geological Survey, 2009). Laramide Orogeny processes, occurring approximately 75 million to 35 million years ago, provided the main uplifting force for the formation of the Zuni Uplift's current configuration, tilting the bedrock underlying the majority of FWDA to the northwest at an angle of approximately 5 degrees (USACE, 2011).

The northern boundary of FWDA terminates in the strike valley of the South Fork of the Rio Puerco. The valley represents the transition between the Zuni Uplift to the south and the gently north-dipping Chaco Slope to the north (USACE, 2011).

To the west, the dominant FWDA topographic and structural feature is the Nutria Monocline. The Nutria Monocline is a regionally northwest trending sharp-crested ridge that dips steeply to

the west–southwest and defines the northwestern flank of the Zuni Uplift. The Nutria Monocline rises as much as 2,000 feet above the surrounding area exposing Mesozoic formations whose dips commonly exceed 60 degrees (USACE, 2011).

To the west of the Study Area is the axis of the Nutria Monocline fold, cut by roughly north–south trending high-angle faults. This fault zone is overlain by Quaternary alluvium; with no surface exposure, the slip angle and direction have not been determined (Terranear-Project Management Company [TPMC], 2008).

2.2.6.2 Stratigraphy

The majority of FWDA is underlain by the Triassic-age Chinle Group, which is predominantly non marine, red-bed siliciclastics. A stratigraphic column with lithologic descriptions for FWDA is presented on Figure 2-7. The Chinle Group consists of the Shinarump, Bluewater Creek, Petrified Forest, and Owl Rock Formations (Anderson et al., 2003). The Petrified Forest Formation directly underlies much of the installation and is subdivided into three members: Blue Mesa, Sonsela, and Painted Desert. All three members of the Petrified Forest Formation crop out in various locations across the installation. The Blue Mesa, Sonsela, and Painted Desert lithologies are green-gray smectitic mudstone, light gray to yellowish-brown cross bedded sandstone, and reddish-brown and grayish-red smectitic mudstone, respectively (McCraw et al., 2009).

The Chinle Group is underlain by the older San Andres Limestone and Glorieta Sandstone, both Permian in age. The San Andres Limestone generally consists of fossiliferous limestone that intertongues the Glorieta Sandstone (Anderson et al., 2003). These two formations do not have outcrops within the boundaries of FWDA; however, the Glorieta Sandstone Formation does crop out south of the installation where a thrust fault juxtaposes Permian strata against the Cretaceous Dakota Sandstone. These two formations comprise the San Andres-Glorieta aquifer, which is the principal source of drinking water in the area (Malcolm Pirnie, Inc., 2000; Cooper and John, 1968).

Within the FWDA boundaries, bedrock outcrops of clastic sedimentary rocks are predominately Triassic in age, but in the western and southern portions of FWDA, Jurassic and Cretaceous sandstone, claystone, and shale are present. Jurassic and Cretaceous rocks are exposed in the Nutria Monocline, which is the dominant topographic feature within FWDA boundaries and west of the Study Area. Quaternary alluvial and colluvial deposits, derived from weathered bedrock, are present throughout FWDA.

Within the Study Area, the stratigraphy on the eastern side of the Nutria Monocline is largely the Triassic-aged Petrified Forest Formation. The Petrified Forest Formation is a purplish-red, cross-bedded, mudstone and sandstone containing greenish-gray calcrete nodules and petrified wood. The Petrified Forest Formation has low apparent permeability due to the fine to ultrafine muddy matrix. Extensive mudstone units of the underlying Blue Mesa Member of the Petrified Forest Formation, being of lower apparent permeability, will inhibit vertical movement of groundwater to underlying potable aquifer units, such as the San Andres-Glorieta aquifer (TPMC, 2008). The

Petrified Forest Formation has a combined thickness of approximately 980 feet (Sundance, 2019).

2.2.7 Hydrogeologic Conceptual Model

Based on surface water flow and the overall groundwater gradient observed along the south-to-north arroyo east of the Nutria Monocline, limited shallow groundwater may enter beneath Parcel 3 from south of well CMW02, the southernmost groundwater monitoring well located along the main arroyo (Figure 2-8). Groundwater also may be encountered in wells in the south-to-north-trending arroyo along the west side of the monocline, which cuts across the monocline from west to east through Fenced-up Horse Valley to join the main arroyo near the northern limit of the study area (Figure 2-8). However, the limited groundwater found beneath Parcel 3 appears likely to result from recharge from local precipitation and surface runoff in the arroyos.

As observed and presented in the Parcel 3 RFI report, groundwater monitoring wells located along the north–south trending arroyo east of the Nutria Monocline have sufficient groundwater for sampling and include CMW36A, CMW36B, CMW28B, CMW27B, and CMW26 (Sundance, 2019; Figure 2-8). Groundwater monitoring wells BGMW05 and CMW32, located outside and east of the arroyo, and KMW15B located outside and west of the main arroyo did not recharge following well development or purging activities during the 2017 RFI and are currently dry. Figure 2-8 shows an inferred dry line east and west of the main arroyo. This line represents a boundary between water producing wells within close proximity of the arroyo and wells that do not produce sufficient volume to sample or are dry. The dry line exhibits an approximate distance away from the arroyo where groundwater is generally not encountered. The locations of groundwater-producing monitoring wells provide evidence that groundwater recharge is correlated to surface infiltration from arroyos (Sundance, 2019).

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3.0 FIELD METHODOLOGY

The U.S. Army has identified the locations to install three background wells to supplement the southern area groundwater background evaluation (Figure 3-1). The U.S. Army will also replace 11 abandoned wells within the HWMU that were abandoned during the Parcel 3 soil removal action (Figure 3-2). The replacement wells will be designed and located according to the specifications of the abandoned wells they are replacing.

The following sections summarize the permitting, field planning documentation, unexploded ordnance (UXO) avoidance, and specific field methods and standards to be used to drill, install, develop, and sample the proposed background wells and replacement wells.

3.1 PERMITTING

Documents will be submitted to the NM Office of the State Engineer (OSE), District 1, for review and approval to drill the proposed groundwater monitoring wells. A form *WR-07 Application for Permit to Drill a Well with No Water Right* will be completed and filed with the OSE District 1 office for review and approval before beginning field activities. In the event any soil boring needs abandonment, a *Well Plugging Plan of Operations* will be completed and filed with the OSE District 1 office for review and approval. Field operations will be conducted in accordance with current OSE guidance for drilling groundwater monitoring wells (OSE, 2019). Global positioning system (GPS) coordinates of the proposed groundwater monitoring well locations will be collected to use in the location submission to OSE.

Coordination will be made with the FWDA caretakers to obtain a written utility clearance sign-off for the proposed groundwater monitoring wells per the GPS locations. The on-site representative will work with the FWDA caretakers and USACE to ground truth the proposed locations before beginning field operations. Notifications will be submitted to NMED, OSE, the Bureau of Indian Affairs, and White Sands Missile Range representatives before mobilizing field personnel.

A dig permit will be submitted to NM One Call, also known as NM-811. This site is a U.S. Army Installation in closure, so it is expected that NM-811 will not have access or utilities within the boundaries of FWDA; however, a proper submission will be conducted to verify and confirm no utilities from private entities exist at the proposed locations. Written documentation for submission to NM-811 will be retained for the project file.

Operations will not be performed until a signed clearance has been received from the FWDA caretakers, and concurrence of the operations is received from applicable stakeholders, including any inquiries from tribal cultural resource personnel. As outlined in Section 2.1, the U.S. Army will provide a letter to the Pueblo of Zuni, Navajo Nation, and State Historic Preservation Officer seeking comments on field operating procedures before beginning fieldwork.

3.2 FIELD PLANNING DOCUMENTS

Along with this Work Plan, the U.S. Army will use an approved Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP). The approved APP/SSHP, along with the corresponding accident hazard analyses, covers drilling operations as well as mobilization and vehicle operation. Most of the proposed locations are located within areas of known historic ordnance

operations (within the HWMU boundary), so the requirement for UXO support is necessary. Additional information regarding UXO avoidance operations is provided in the following section and will also be addressed in the APP/SSHP.

3.3 UNEXPLODED ORDNANCE AVOIDANCE

This section discusses the UXO avoidance processes to safely enter work areas within Parcel 3 for drilling soil borings, installing groundwater monitoring wells, and returning to well locations for data collection. This includes activities such as location surveying and site inspection. Each field team will have a designated UXO Technician III provide 100% escort and oversight during field activities performed under this Work Plan.

The project UXO Technician III will survey the area where the proposed soil boring is to be advanced, including the vehicle staging and work area(s) and ingress/egress locations, using a handheld magnetometer. The boring location will be surveyed to determine if any shallow subsurface anomalies are present. Once a location is deemed safe, site personnel and the UXO Technician III will hand-auger to the less than subsurface extent of the detection range of the instrument. The magnetometer will then be lowered down the hole to detect a depth ahead of the boring advancement. If deemed clear, personnel will continue to hand-auger to less than the extent of detection of the instrument. After reaching a depth of approximately 3 feet, a down-hole magnetometer will be used to monitor the boring as it is advanced. This process will continue until a depth of 8 feet below ground surface or refusal, whichever comes first. At this depth, the drill rig will be staged over the soil boring location and advanced to the hand-augered depth. The down-hole magnetometer will be lowered down the boring ahead of the boring advancement to determine if there are any subsurface anomalies. The drill rig will then advance to less than the extent of detection of the instrument, and the instrument will, once again, be lowered down the boring to detect for anomalies. This process will continue until a determined safe depth has been achieved, or the total depth of the boring is reached.

For activities that do not involve intrusive activities, the project UXO Technician III or designated Technician II will survey the area where the proposed activity is to take place, including the vehicle staging and work area(s) and ingress/egress locations, using a handheld magnetometer. The location will be surveyed to determine if any shallow subsurface anomalies are present. Once an area is deemed safe, site personnel will be allowed to perform the required activities with oversight by the designated UXO technician.

3.4 MONITORING WELL INSTALLATION

Groundwater monitoring well installation procedures are described in this section. Groundwater monitoring well installation will be performed in accordance with NM OSE regulations (OSE, 2019), the RCRA permit, and the NM Administrative Code (NMAC) 19.27.4.29 and 19.27.4.30 (NMAC, 2017).Three background wells are proposed for installation. The proposed background wells are strategically located proximal to identified drainage arroyos upgradient and away from known site activities (Figure 3-1). As discussed in Section 2.2.7, groundwater recharge is correlated to surface infiltration from arroyos. Table 3-1 provides the well construction information for the three proposed background wells. The proposed screened intervals for background wells are estimated based on similar groundwater monitoring wells located adjacent to arroyos in Parcel 3. The total depths and screened intervals for the background wells may vary

based on observed subsurface lithology, observed saturated zones, and the field geologist's professional judgment. The screened interval will be placed to capture first water, thus will not drill through multiple water-bearing zones.

In addition to installing background wells, installing replacement wells within the HWMU are proposed to replace monitoring wells abandoned due to HWMU soil excavation activities. These replacement wells are to be installed approximately to the same specifications as the abandoned well being replaced. Table 3-2 shows the well identification numbers of the proposed replacement wells, the abandoned well each new well will replace, well construction information, screen intervals, and location coordinates. Figure 3-2 presents the locations of the replacement wells within Parcel 3. The proposed replacement well depths were determined based on existing data of the abandoned well construction.

During the execution of this Work Plan, measures to eliminate contamination or cross contamination of groundwater at the proposed well sites will be performed. Selection of well installation and development supplies and materials, as well as performance of equipment decontamination procedures, worksite housekeeping, and IDW management practices are preventative measures to mitigate well contamination during drilling, construction, and completion (NMED, 2017; BRACD, 2018a). Precautions will be taken in the field consisting of material inventories to ensure appropriately selected materials, liquids, and tooling on site are utilized, as well as ensuring clean disposable gloves are worn and changed between activities, and decontamination procedures are performed and documented as planned. The following sections further discuss the planned drilling, construction, and decontamination procedures.

3.4.1 Drilling and Well Construction

For both the background wells and replacement wells, a track-mounted sonic drill rig will be used to continuously core the boring and advance a core barrel, drill string, and temporary steel conductor casing to the proposed total depth at each location. The conductor casing seals off the formation above the targeted zone preventing cross contamination during well advancement and construction. Sonic drilling technology also generates continuous soil and rock cores from the subsurface. Soil and rock cores will be contained in boxes and maintained on-site, thus eliminating soil IDW.

Field personnel will install 2-inch diameter schedule 40 polyvinyl chloride (PVC) groundwater monitoring wells with a minimum 2-inch annulus for each proposed monitoring well (Table 3-1; Table 3-2). The core barrel and drill string will be removed from the boring, leaving the temporary steel casing in place. Lengths of slotted PVC screen and solid PVC riser, equal to the total depth of the boring plus any well stick up above ground surface, will be screwed together and placed into the boring inside of the temporary steel casing. The temporary steel casing will then be slowly retracted as the well is constructed, keeping the water-bearing unit sealed from the formation above (BRACD, 2018b). For monitoring wells planned to be drilled deeper than 80 feet below ground surface, schedule 80 PVC will be utilized (Table 3-2). The PVC well materials used for all wells installed under this Work Plan are free of the additive bis(2-ethylhexyl) phthalate and will meet National Sanitary Foundation Standard 14 type well casing (NMED, 2018). Replacement wells will be installed with the same screen length and screen elevations as the abandoned well being replaced (Table 3-2). The well screen will be 2-inch inside diameter, schedule 40 PVC 0.010-inch machine-slotted screen with a cap attached to the

bottom. For monitoring wells screened below 80 feet below ground surface, schedule 80 PVC 0.010-inch machine-slotted screen will be used. Groundwater monitoring wells will have centralizers placed at the top and bottom of the screen when appropriate. The filter pack will be silica sand and will extend from the bottom of the borehole to 2 feet above the screened interval (Figure 3-3).

Above the filter pack, a bentonite chip or pellet seal will be installed with a thickness of approximately 5 feet and hydrated with potable water at every 1-foot interval to provide a competent seal. The bentonite chips or pellets will be installed by a tremie pipe.

Above the bentonite seal, a neat cement grout will be installed from the top of the bentonite seal to 3 feet below ground surface by a tremie pipe.

The surface completion for each groundwater monitoring well will consist of an 8-inch diameter by 6-foot long protective steel monument, which will be installed with 3 feet above the concrete pad and 3 feet into the ground. An approximate well monument stick-up height of 3 feet is required to accommodate a potential dedicated pump system. The concrete pad will be 4 feet long by 4 feet wide by 6 inches thick (Figure 3-3). The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade. Field personnel will install four 4-inch diameter by 5-feet tall steel protective bollards at each outside corner of the square concrete pad. Bollards will be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. The well will be equipped with a security lock and will be tagged with corrosion-resistant identification. The well monument and protective bollards will be coated with protective orange paint, as required by FWDA. The paint will be carefully applied to the well monument and bollards before installing so the groundwater monitoring well is not cross contaminated (NMED, 2017).

3.4.2 Decontamination

Field personnel will perform decontamination of reusable equipment to prevent cross contamination. Disposable nitrile gloves (or similar) will be utilized by field personnel during decontamination procedures and changed to prevent contaminated gloves contacting decontaminated equipment and materials. A temporary cleaning area will be designated at each proposed well location. The cleaning area will be a minimum of 30 feet away from the sampling location, or at the equipment staging area outside of the Study Area. Field personnel will use the standard equipment decontamination procedures during completion of drilling activities and between drilling locations. These procedures are as follows.

- Drillers will decontaminate drilling rigs (sonic) before entering the Study Area. This consists of spray-washing or steam-cleaning dirt and debris from rig exterior and components and fully inspecting for any oil, hydraulic fluid, fuels, or operational fluid leaks. If any leaks are detected, the deficient rig will not be allowed on-site until the deficiency is resolved.
- Drillers will decontaminate drilling rigs and equipment between soil boring locations, also consisting of spray-washing or steam-cleaning dirt and debris from rig exterior and components. A temporary decontamination pad will be constructed within the cleaning

area away from the proposed well and/or sampling location. Drill rig decontamination activities will be performed within the temporary decontamination pad.

- Drillers will decontaminate drilling casing (drill string), drilling bits, and down-hole equipment by steam cleaning and washing with a deionized water and non-phosphate detergent cleaning solution, then rinsing with deionized water and allow to air-dry. Drilling components will also be decontaminated within the temporary decontamination pad.

Field personnel will collect and manage decontamination fluids as outlined in Section 4.0. Field personnel will also dispose of the plastic sheeting, after fluids are removed, and associated decontamination pad materials in an approved on-installation dumpster. After field cleaning, personnel will don clean gloves before handling equipment to prevent recontamination. Personnel will move the equipment away from the cleaning area to prevent recontamination. If the equipment is not to be immediately reused, personnel will cover the equipment with plastic sheeting to prevent recontamination. The area where the equipment is stored prior to reuse must be free of contaminants.

Non-dedicated measurement equipment such as water-level meters and submersible pumps will be decontaminated before and after each use. Water-level meters will be decontaminated during extraction from monitoring wells using deionized water and a non-phosphate detergent cleaning solution. Non-dedicated measurement equipment will be decontaminated using the following procedure.

1. If necessary, remove particulate matter or debris using a brush or handheld sprayer filled with deionized water.
2. Scrub the surfaces of the equipment using deionized water and a non-phosphate detergent cleaning solution and reusable dedicated decontamination brushes.
3. Rinse the equipment thoroughly with deionized water.
4. Place the equipment on a clean surface and allow to air dry.
5. Containerize all decontamination liquids and manage as IDW, as described in Section 4.5.
6. After decontamination operations, handle equipment to prevent recontamination. The area where the equipment is stored before reuse will be free of contaminants.

Equipment dedicated for use at specific wells will not require decontamination before use. Disposable equipment that is used once and then disposed of will not require decontamination before use, provided it is wrapped in the manufacturer's packaging or otherwise protected from inadvertent contamination before use.

3.5 WELL DEVELOPMENT

Completed background wells and replacement wells will be developed in accordance with NM OSE regulations (OSE, 2019) and NMAC 19.27.4.29 and NMAC 19.27.4.30 (NMAC, 2017) as applicable. The groundwater monitoring wells will be developed after a minimum of 48 hours

have elapsed after completion of the well installation. Field personnel will develop groundwater monitoring wells by surge blocking, bailing, and/or pumping until the turbidity of the extracted water is less than 100 nephelometric turbidity units (NTUs), if obtainable. As the water-bearing units at FWDA contain high volumes of fines and silts, a determination whether a well has sufficiently developed may need to be made in the field and authorized by the Field Team Lead and the USACE Technical Lead.

3.6 WELL SURVEY

Initial survey for the proposed replacement well locations will be conducted to verify the ground elevation at the location of each well. This initial elevation survey is needed to verify the starting elevation for each boring. The replacement wells are intended to be installed and screened at approximately the same elevation as the abandoned well being replaced; however, the HWMU area has undergone extensive soil excavation and back fill. Once the ground elevation at each replacement well is verified, the total well depth can be calculated and adjusted to allow placing the screened interval consistent with the abandoned well's screened interval.

Following well completion, the background well and replacement well locations will be surveyed by a NM-licensed professional surveyor to the nearest tenth of a foot (horizontal). The surveyor will measure elevations for the new monitoring wells at ground surface, top of the surface monument, and top of inner well casing (PVC) at points on the north side of the well to the nearest one hundredth of a foot (vertical).

The professional surveyor will reference horizontal coordinates for all sample locations to the North American Datum of 1983, State Plane NM West Grid represented in units of feet. They will also reference vertical coordinates for monitoring well elevations to the North American Vertical Datum of 1988, or NAVD 88.

3.7 FIELD DOCUMENTATION

Field personnel will maintain appropriate field documentation for all activities as part of the formal project documentation. Field sampling documentation and data reporting will provide sufficient information to verify well installation report conclusions and demonstrate that quality control (QC) procedures were followed while implementing proposed field activities.

A soil classification log will be used by the field geologist to record the drilled soil borings. The soil classification log conforms to industry standards and includes the following information.

- Project number
- Soil boring name/number
- Names of the drilling company and the operator
- Name of the geologist completing the log information
- Soil logging information
- Dates drilling begins and ends
- Observed drilling conditions (hard or soft drilling, rig chattering, sticky conditions, etc.).

Each soil boring will be logged in accordance with ASTM International (ASTM) Standards D-2487, D-2488, and D-653 (ASTM, 2006; ASTM, 2009a; and ASTM, 2009b). Soil descriptions and classification will conform to the ASTM Unified Soil Classification System. Location and names for the proposed groundwater wells are provided on Figure 3-1 and Figure 3-2, and in Table 3-1 and Table 3-2.

Other documentation may be generated as a part of this field effort, and are listed below.

- Daily tailgate safety meeting forms
- Daily Field Logbooks
- Field Work Variances
- Soil classification logs
- Equipment calibration records
- IDW characterization documents
- Decontamination activity documentation
- Photo documentation.

3.7.1 Quality Assurance

Quality Assurance (QA) will be monitored by USACE in accordance with the Quality Assurance Surveillance Plan (QASP). USACE will evaluate field activities to verify the approved Work Plan is being followed. QA audits and inspections will be performed in accordance with established USACE guidelines and the project QASP.

3.7.2 Quality Control

A project Quality Control Plan (QCP) will describe the QC approach and chain of command to be followed to ensure activities are performed in accordance with this Work Plan. The QCP is a stand-alone document separate from this Work Plan.

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4.0 INVESTIGATION-DERIVED WASTE MANAGEMENT

Investigations and remedial activities at FWDA will generate IDW such as potentially contaminated soil, sediment, and groundwater; equipment decontamination fluids; disposable sampling equipment; used personal protective equipment (PPE); and general refuse. Properly managing IDW, as specified in this Work Plan, is required to ensure compliance with federal, state, and U.S. Army regulations applicable to the collection, storage, transport, and disposal of potentially hazardous materials.

IDW generated during the monitoring well installation activities will consist of water produced from drilling activities, decontamination fluids, disposable sampling equipment, and PPE. Note that it is anticipated that no soil and rock IDW will be generated because all recovered material will be contained in boxes and maintained on-site, thus eliminating soil and rock IDW.

4.1 IDW SEGREGATION

Generated IDW will be segregated by monitoring well type. IDW generated from background well locations will be separate from IDW generated from replacement well locations. IDW categories will also be segregated. Identified IDW categories are as follows.

1. **Drilling Fluids**—Large volumes of groundwater, potable drilling water, monitoring well development water, and pre-sample purge water from drilling activities are anticipated. Field personnel will use portable water tanks to collect, manage, and characterize groundwater and related drilling fluids during drilling. The collected water will be stored for appropriate characterization and disposal.
2. **Decontamination Fluids**—Small volumes of decontamination fluids are anticipated. Decontamination fluids consist of detergents, rinse water, and laboratory-grade detergents used to decontaminate non-disposable sampling equipment and PPE. Decontamination fluids will be contained within the temporary decontamination pad areas during active sampling and decontamination activities on-site. Accumulated wash and rinse water will then be containerized for appropriate characterization and disposal.
3. **Solid Wastes**—Used, non-decontaminated disposable sampling equipment, PPE, and general refuse are anticipated. Field personnel will place these items in polyethylene trash bags and treat as general refuse. Field personnel will place refuse in the approved on-installation dumpster daily.

Process knowledge for the HWMU, such as historical operational records, previous analytical data, and field screening results obtained during previous investigations and remedial actions has indicated only non-hazardous IDW has been generated within the HWMU and during groundwater activities within and adjacent to Parcel 3. Hazardous IDW is not anticipated during the work described in this Work Plan.

Characterization sampling will be composite samples of the segregated groups as listed above. Sample analysis will include flash point, reactivity, corrosivity, and toxicity tests. In the event analytical data indicate waters are a RCRA hazardous waste, a U.S. Department of Transportation (DOT)-certified hazardous waste transport and disposal company will be contacted to collect the hazardous IDW and ship it off site to the appropriate disposal facility

within 90 days. Shipment volume and disposal documentation will include waste manifests and confirmation of receipt by the receiving waste disposal facility.

4.2 IDW CONTAINERIZATION AND LABELING

Field personnel will dispose of used, non-decontaminated sampling equipment and PPE in polyethylene trash bags. Field personnel will use portable water tanks and/or drums to collect, manage, and characterize groundwater during drilling. The collected water will be disposed of in the evaporation pond, unless analytical data indicate that an alternate disposal method is appropriate. Drums and tanks will conform to United Nations Performance-Oriented Packaging standards and DOT specifications in 49 Code of Federal Regulations (CFR) 178. General refuse and decontaminated sampling equipment and PPE will be placed in polyethylene trash bags or other suitable containers.

A label reading *"Caution: This Drum/Container May Contain Hazardous Material"* or similar will be affixed to each container containing IDW. In addition, each drum, roll-off, or portable tank containing IDW will be labeled with a unique 12-character identifier: The first two characters are "FW;" the second two are the soil boring/well number; the next six are the day, month, and year (dd/mm/yy) on which filling commenced; and the last two are the consecutive number of the container among all being filled on a given day.

For example, an IDW container from:

FW - Fort Wingate Depot Activity

18 - Groundwater well number CMW18

-0609 - 6 September

23 - 2023

-01 - Container 01

would be identified and labeled as FW18-060923-01.

The label will also indicate the contents (groundwater, decontamination fluids) and the date on which filling is completed (the 90-day start date).

4.3 TEMPORARY STORAGE

Small IDW containers, such as drums and tanks, will be transported to designated holding areas or "satellites" within 3 days of the date that project activity is completed. Bulk IDW containers, such as roll-off containers, will be lined, covered, and secured at their respective staging area.

Currently, FWDA is considered a small quantity generator (SQG), which places restrictions on the amount of hazardous material that can be shipped off site and stored on-site. Under the SQG status, FWDA can ship up to 1,000 kilograms (kg) of IDW per month (kg/month) off site and can store up to 6,000 kg on-site while awaiting disposal. Based on a 55-gallon drum of water weighing 459 pounds, this translates into a shipping capacity of roughly 5 drums of water per month (or 264 gallons per month) and a storage capacity of roughly 29 drums of water (or 1,585 gallons). Additionally, based on a 55-gallon drum of soil weighing approximately 735 pounds, this translates into a shipping capacity of roughly three drums of soil per month and a storage capacity of roughly 18 drums of soil.

Characterization sampling will be composite samples of waste generated from like areas that were generated during the same timeframe.

Inventory forms will be completed for all IDW containers placed at the satellites. Information on the form will be verified with respect to container labeling. The Field Team Lead or person in charge will provide copies of inventory forms to the FWDA Base Realignment and Closure Environmental Coordinator (BEC). An example inventory form is provided on Figure 4-1.

4.4 IDW CHARACTERIZATION

4.4.1 IDW Sampling

Field personnel will collect representative samples from each container of groundwater or decontamination fluids consisting of a composite of the material to characterize IDW for disposal as hazardous, special, or non-hazardous waste. Samples may be collected as containers are filled at the soil boring/well location, or within 5 days of transfer to the satellite area. The analytical laboratory will provide analysis results within 15 business days of sampling. Small volumes of decontamination fluids are anticipated. Decontamination fluids will be contained within the temporary decontamination pad areas during active decontamination activities at a well site. Accumulated wash and rinse water will be left within the decontamination pad and allowed to evaporate.

A complete list of waste characterization parameters and analytical methods approved by U.S. Environmental Protection Agency (EPA) is published in Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, also known as SW-846. Process knowledge will be used to evaluate the physical state of the IDW to determine which specific parameters will be required to properly characterize waste generated from a given soil boring/well location.

Upon receipt of waste characterization results, copies of the data will be provided to the FWDA BEC and USACE Technical Manager. The inventory forms will then be updated with IDW classifications and applicable EPA waste codes for the containers located within the satellites.

4.4.2 IDW Classification

IDW will be classified as hazardous waste if the material exhibits the characteristics of ignitibility, corrosivity, reactivity, or toxicity as listed by EPA in 40 CFR 261.20-24 (Subpart C). Solid IDW not classified as hazardous waste will be classified as special waste if the material is listed as such by NMED in NMAC 20.9.8 (NMAC, 2007a).

IDW will be classified as non-hazardous waste if potential contaminants are not detected or are detected at concentrations less than applicable regulatory limits.

4.5 IDW DISPOSAL

The U.S. Army will manifest IDW and transport off site within 30 days of receipt of characterization results or within 90 days of placement at the satellites, whichever occurs first. No IDW containers will be stored beyond 90 days at the satellites unless the FWDA BEC grants an extension.

4.5.1 Hazardous Waste

IDW classified as hazardous waste will be disposed of offsite at a RCRA Subtitle C permitted treatment, storage, and disposal facility (TSDF). Before transport, containers will be labeled according to DOT regulations in 49 CFR 172. Additionally, those containers with a capacity of 110 gallons or less will be labeled as follows, in accordance with DOT requirements in 49 CFR 172.304:

> HAZARDOUS WASTE – Federal Law Prohibits Improper Disposal. If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.
>
> Generator's Name and Address: _____
>
> Manifest Document Number: _____

Manifests will be prepared according to EPA requirements in 40 CFR 262.20. Acquisition, copies, and use of the manifest will be in accordance with EPA requirements in 40 CFR 262.21-23. The FWDA site representative will sign the manifest as the generator. The transporter, who will be fully licensed and insured to transport hazardous waste, will then sign the manifest and provide a copy to the FWDA BEC, USACE Technical Manager, and the Project Manager. Inventory forms at the less-than-90-day storage area will be annotated with the transport date and manifest number.

Concurrent with the manifest, a land disposal restriction (LDR) will be prepared in accordance with EPA requirements in 40 CFR 268.7 and submitted for review and signature by the FWDA site representative. The signed LDR will accompany each shipment of hazardous waste and serve as notification to the receiving TSDF of any requirements for treatment before land disposal.

4.5.2 Special Waste

In the event IDW classified as special waste is generated, it will be disposed of off site at a solid waste landfill authorized for disposal of such material. Containers will be labeled, manifested, and transported in accordance with NMED requirements in 20 NMAC 20.9.7 (NMAC, 2007b). Requirements for manifest signatures, distribution of copies, and annotation of inventory forms at the satellite storage areas will be the same as those for hazardous waste.

4.5.3 Non-Hazardous/Non-Regulated Waste

Sampling equipment, PPE, and general refuse will be disposed of in an approved on-installation dumpster. If large quantities of material are generated, the materials will be transported off site for disposal as municipal waste. Liquid IDW classified as non-hazardous waste will be transported off site and disposed of at an appropriate disposal facility.

5.0 PROJECT REPORTING AND MANAGEMENT

A groundwater well installation report summarizing field activities conducted will be submitted. The expected schedule for conducting activities under this Work Plan is presented below:

Well Installation Field Activities	Start within 45 days following completion of Parcel 3 HWMU removal field activities. Well installation will take approximately 12 weeks.
Submittal of Draft Report	Submit Draft Report 30 days following completion of field activities under this Work Plan
Submittal of Final Report	Submit 30 days after receipt of USACE comments on Draft Report.

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FIGURES

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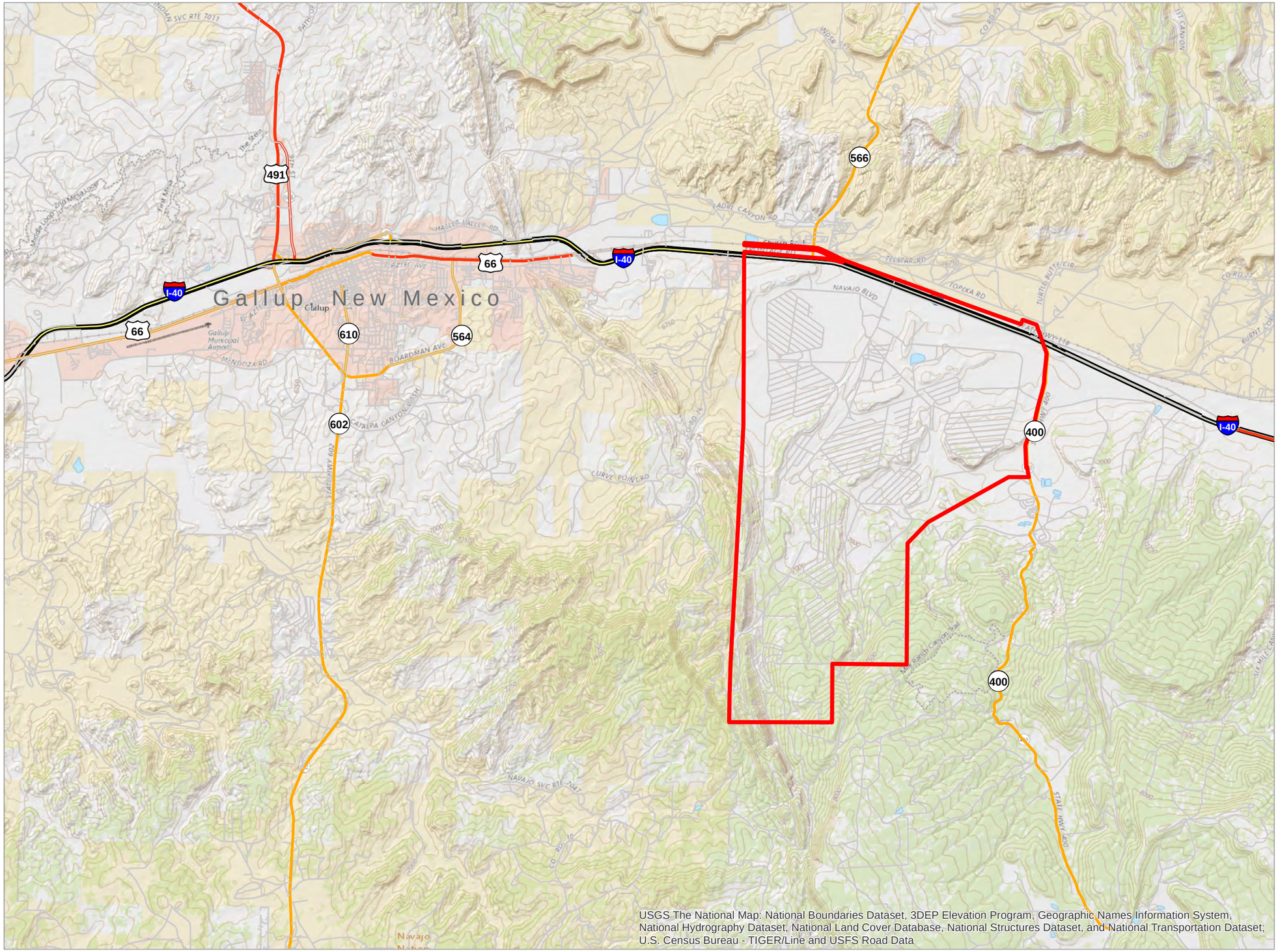


Legend

- FWDA Site Boundary
- Interstate
- US Highway
- State Highway
- County, Arterial Road

Notes

FWDA = Fort Wingate Depot Activity

N
W E
S

0 1 2 4
Kilometers

0 0.75 1.5 3
Miles

Coordinate System:
NAD 1983 StatePlane New Mexico West FIPS 3003 Feet

Figure 2-1

FWDA Site Location Map

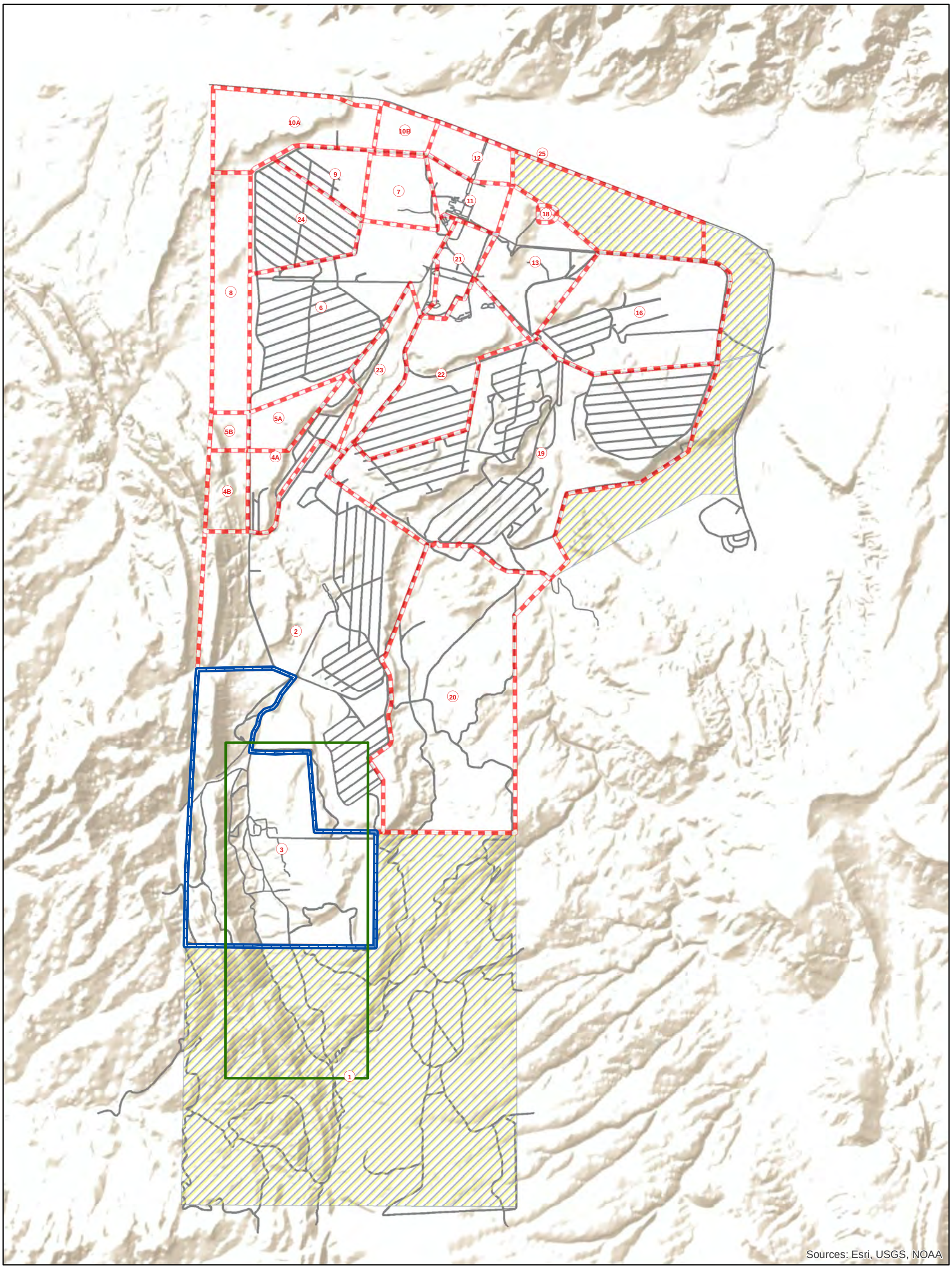
Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

Author: L. Beasley Document Path: N:\Fort_Wingate\FortWingate_GroundwaterGIS_Projects\Parcel 3section1\Figure1-2_updated_background.mxd Document Name: Figure1-2_updated_background

Updated on: 1/19/2018



Legend

- Study Area
- Parcel 3
- FWDA Parcels
- Transferred FWDA Property (includes Parcel 1)
- Roads

Notes

FWDA = Fort Wingate Depot Activity

N
W E
S

0 2,050 4,100 8,200
Feet

0 0.5 1 2
Miles

Coordinate System:
NAD 1983 StatePlane New Mexico West FIPS 3003 Feet

Figure 2-2

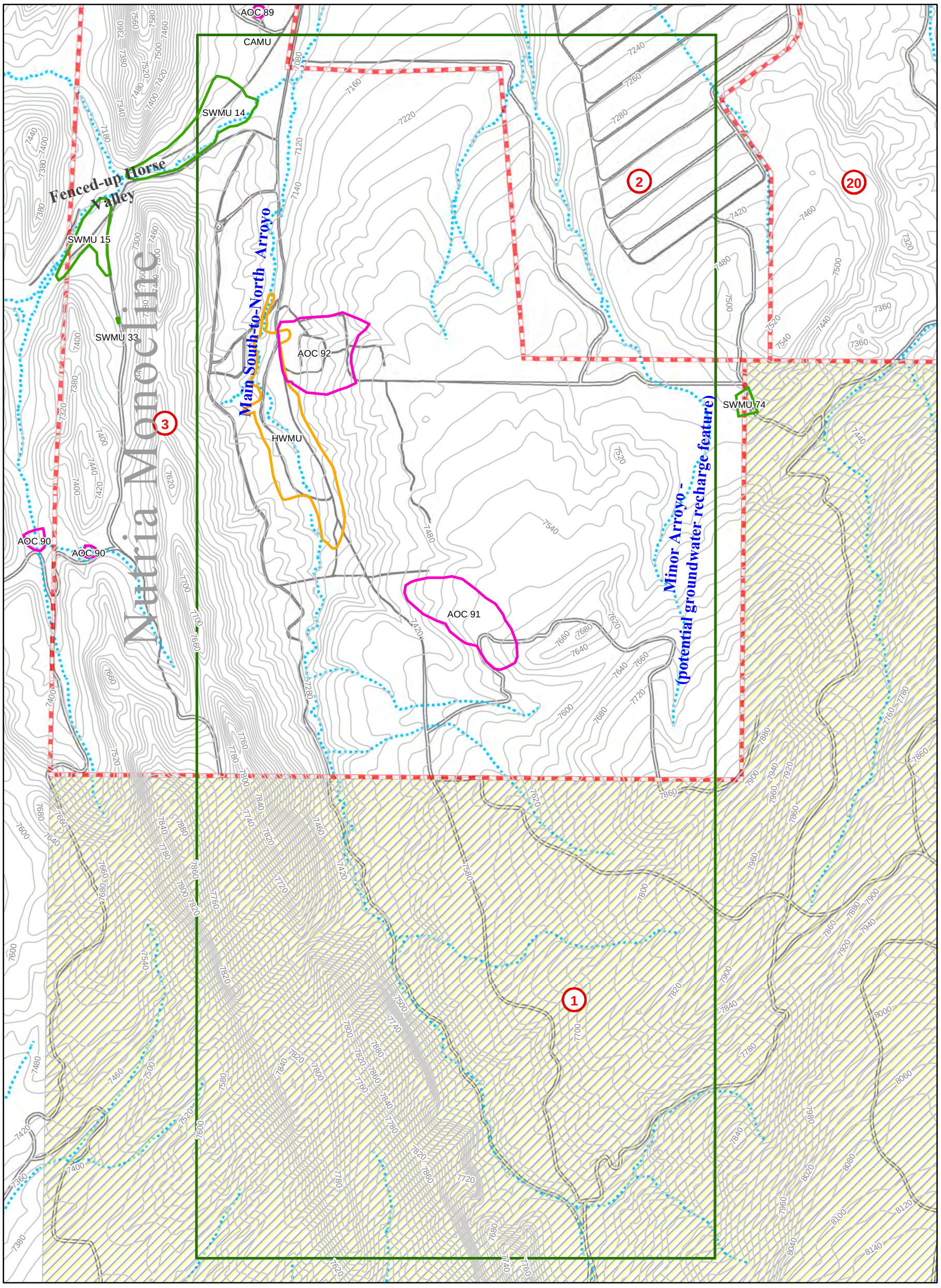
FWDA Parcel Locations and Study Area Map

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

Author: L. Beasley Document Path: \\abq-dc2\DataFiles\Fort_Wingate\FortWingate_Groundwater\GIS_Projects\P3_Well_Install_WP\Figure_2-2_ParcelLocationMap.mxd Updated on: 10/18/2019



Legend

- AOCs
- HWMU
- SWMUs
- Study Area
- Contours
- FWDA Parcels
- Transferred FWDA Property (includes Parcel 1)
- Arroyo
- Roads

Notes

AOC = Area of Concern
FWDA = Fort Wingate Depot Activity
HWMU = Hazardous Waste Management Unit
SWMU = Solid Waste Management Unit

N
W E
S

0 0.125 0.25 0.5
Miles

0 550 1,100 2,200
Feet

Coordinate System:
NAD 1983 StatePlane New Mexico West FIPS 3003 Feet

Figure 2-3

Elevation Contour Map

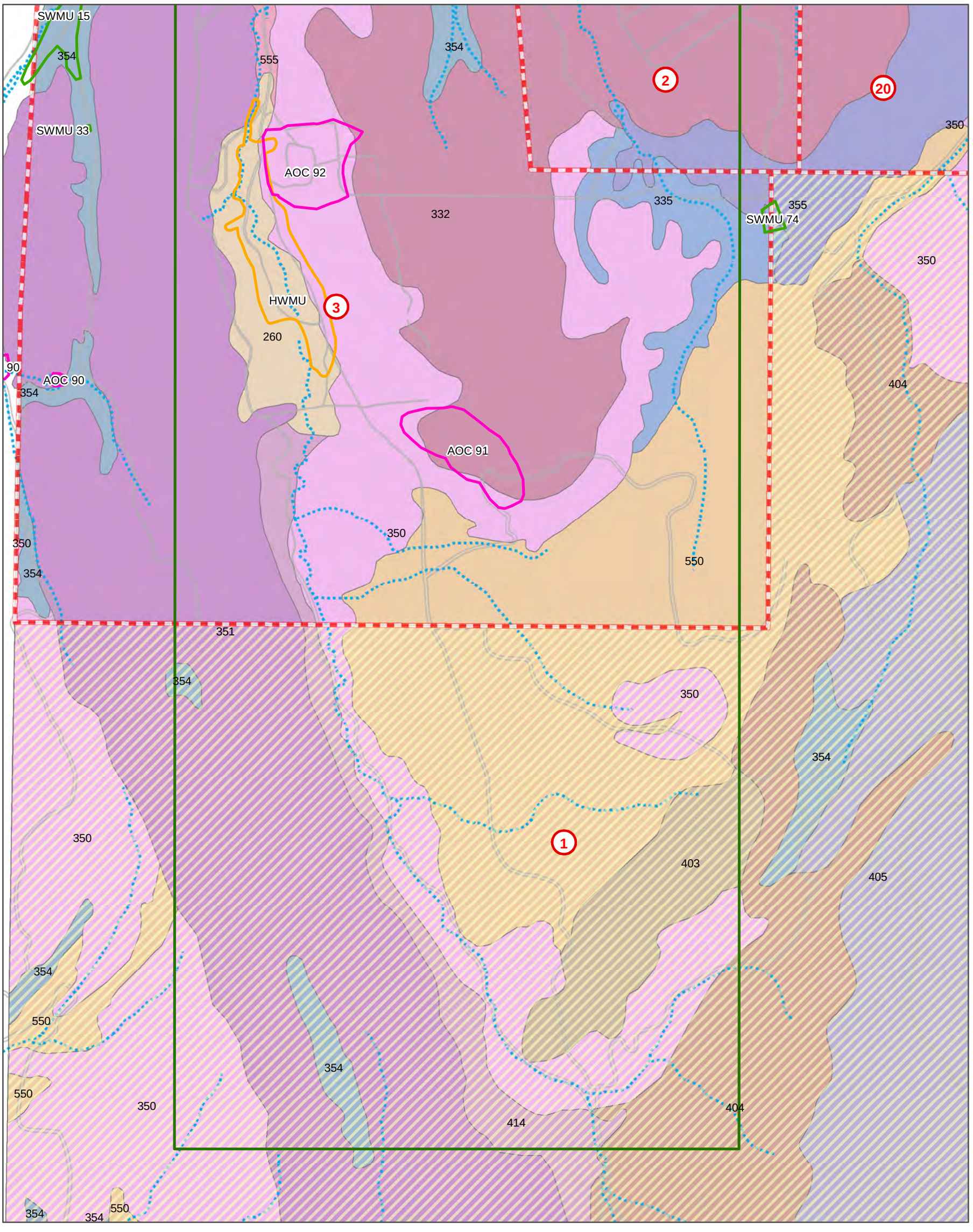
Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

Soil Legend

- 260, QUARRIES AND PITS/DEMOLITION
- 332, EVPARK-ARABRAB COMPLEX
- 335, VENADITO CLAY
- 350, TOLDOHN-VESSILLA-ROCK OUTCROP COMPLEX
- 351, ROCK OUTCROP-VESSILLA COMPLEX
- 354, KNIFEHILL LOAM
- 355, ROCK OUTCROP-RIZNO-TEKAPO COMPLEX
- 403, VALNOR-TECHADO COMPLEX
- 404, ROCK OUTCROP-TECHADO-STOZUNI COMPLEX
- 405, LOSEGATE-OWLROCK COMPLEX
- 414, ZUNALEI-CORZUNI LOAMY FINE SANDS
- 550, BRYWAY-GALZUNI LOAMS
- 555, PARKELEI-EVPARK FINE SANDY LOAM



Legend

- AOCs
- HWMU
- SWMUs
- Transferred FWDA Property (includes Parcel 1)
- Arroyo
- Roads
- Study Area
- FWDA Parcels

Notes

AOC = Area of Concern
FWDA = Fort Wingate Depot Activity
HWMU = Hazardous Waste Management Unit
SWMU = Solid Waste Management Unit

N
W E
S

0 485 970 1,940
Feet

0 0.125 0.25 0.5
Miles

Coordinate System:
NAD 1983 StatePlane New Mexico West FIPS 3003 Feet

Soil data provided from the Natural Resources Conservation Service (NRCS).

Figure 2-4

Soils Map

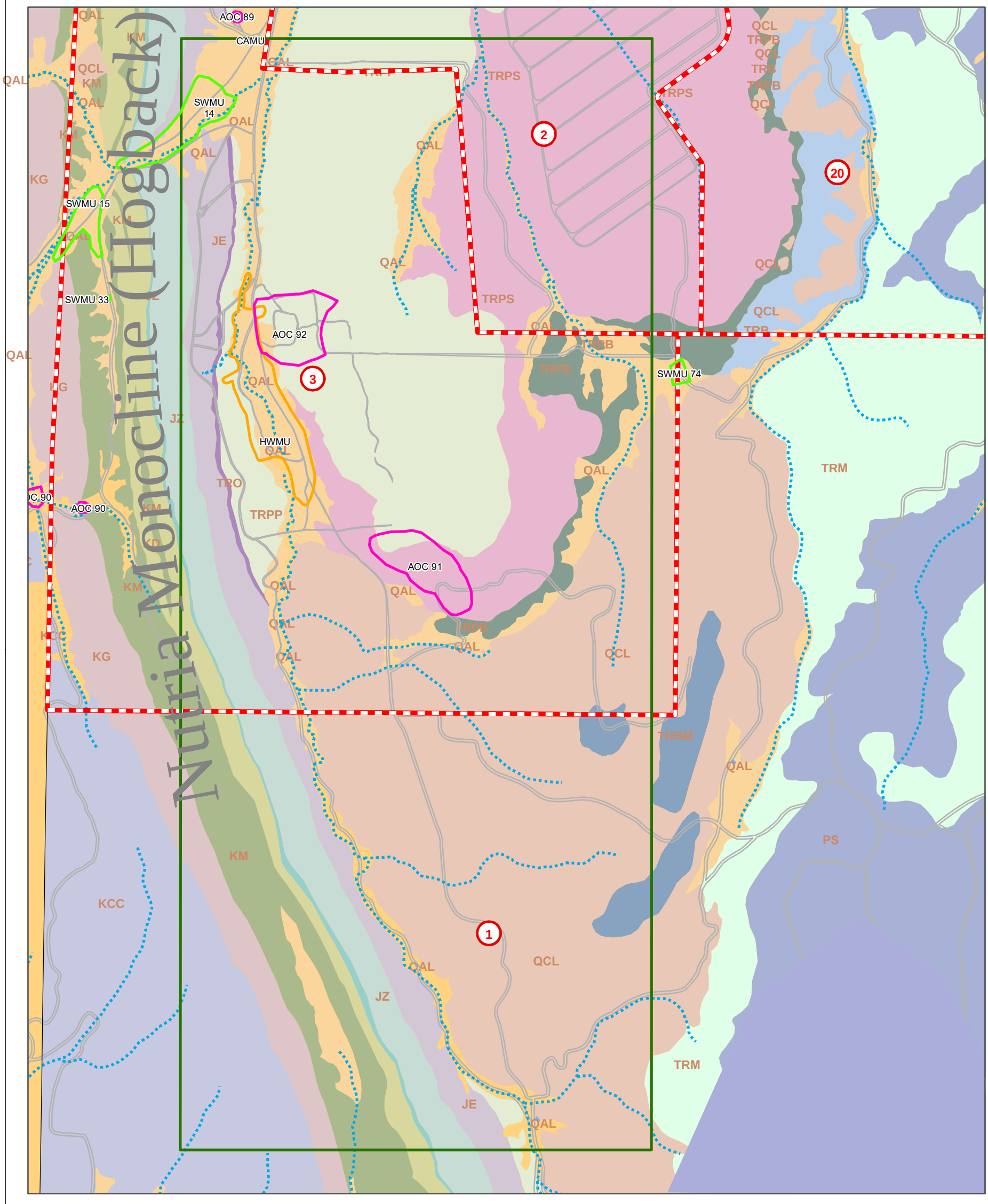
Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

Surface Geology

- JE- Entrada Sandstone
- JM-Morrison Formation
- JZ-Zuni Sandstone
- KCC-Crevasse Canyon Formation
- KD-Dakota Sandstone
- KG-Gallup Sandstone
- KM-Mancos Shale
- QAL-Quarternary Alluvial Deposits
- QCL-Quarternary Colluvial Deposits
- TRB-Bluewater Creek Formation
- TRBM-Bluewater Creek Formation Member
- TRO-Owl Rock Formation
- PS-San Andreas Limestone
- TRPB-Petrified Forest Formation-Blue Mesa Member
- TRPP-Petrified Forest Formation - Painted Desert Memeber
- TRPS-Petrified Forest Formation-Sonsela Sandstone Member
- TRM-Shinarump Formation and Moenkopi Formation Divided



Legend

- AOCs
- HWMU
- SWMUs
- Study Area
- FWDA Parcels
- Arroyo
- Roads
- 1 Parcel 1 - Transferred Property

Notes

AOC = Area of Concern
FWDA = Fort Wingate Depot Activity
HWMU = Hazerdous Waste Management Unit
SWMU = Solid Waste Management Unit

N W E S

0 550 1,100 2,200
Feet

0 0.15 0.3 0.6
Miles

Coordinate System:
NAD 1983 StatePlane New Mexico West FIPS 3003 Feet

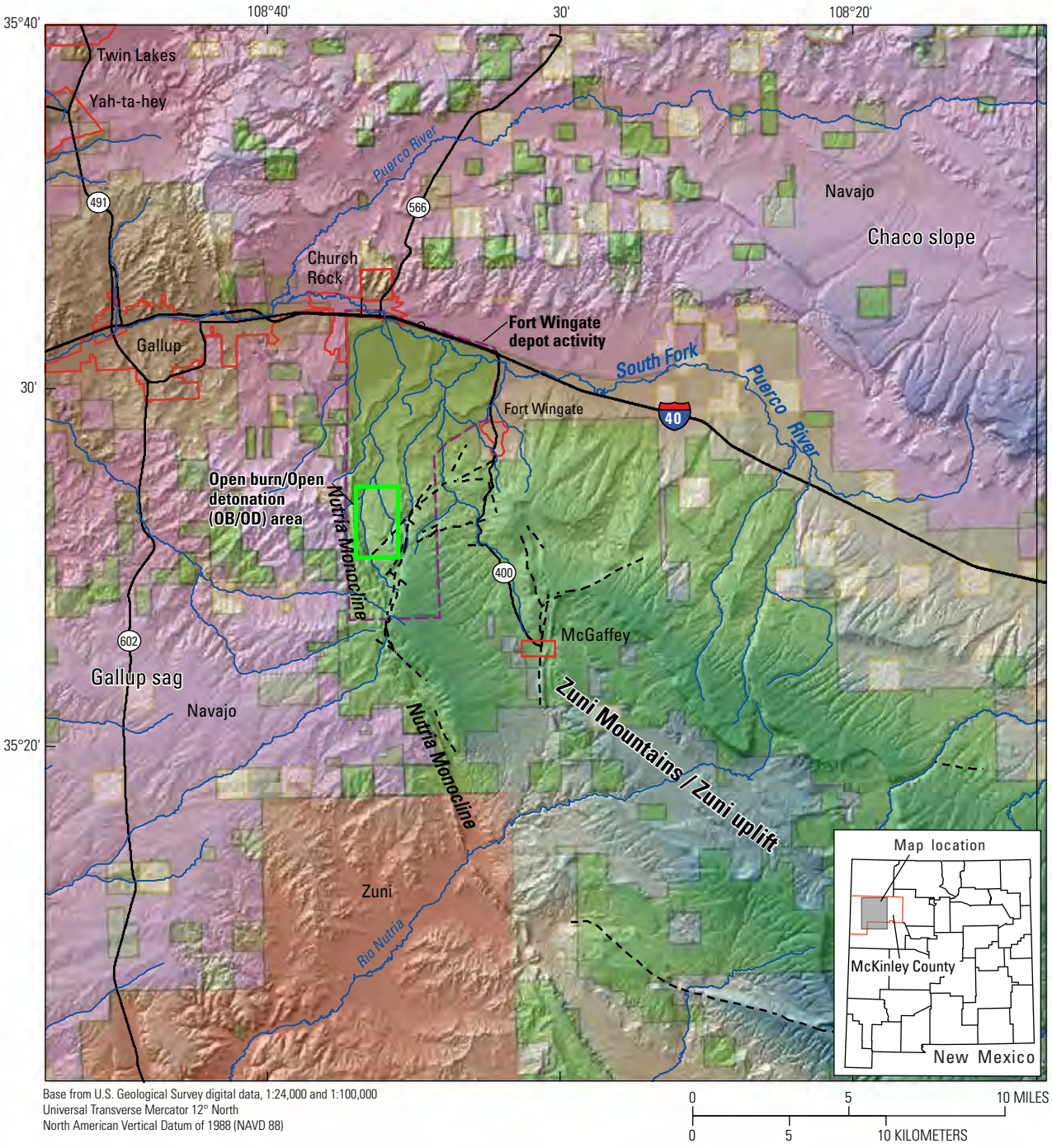
Figure 2-5

Geologic Map

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.



EXPLANATION

Navajo Zuni **Native American reservation and trust lands**

Federal land

Urban areas

State land

Fault

Study Area

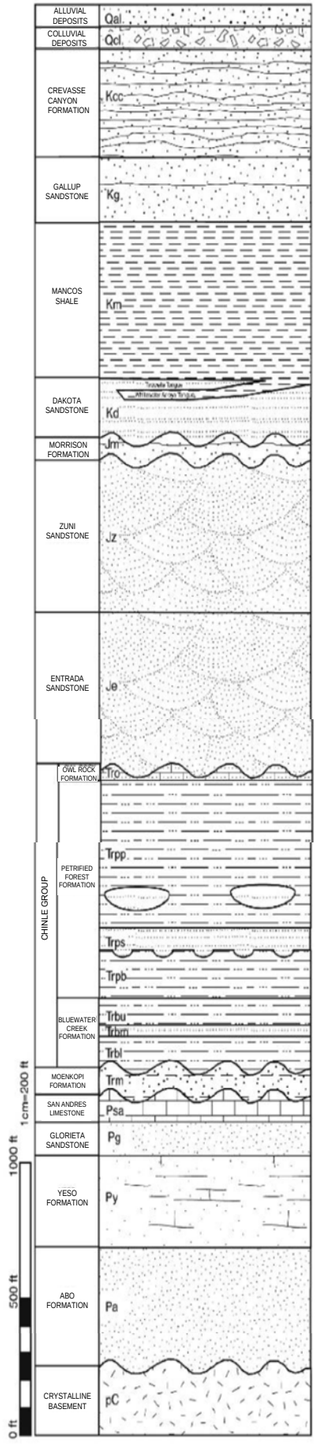
Adapted and altered from **Figure 1,** Location of Fort Wingate Depot Activity, New Mexico. **USGS, 2009. Geochemical Evidence of Groundwater Flow Paths and the Fate and transport of Constituents of Concern in the Alluvial Aquifer at Fort Wingate Deport Activity, New Mexico, 2009. United States Geological Survey for the United States Army Corps of Engineers, 2009.**

Figure 2-6
Regional Geologic Structural Features

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.



Description of Units

Qal - Alluvial deposits (Quaternary); sand, gravel, and clay in young valleys and drainages

Qcl – Colluvial deposits (Quaternary); landslides, and cobble deposits in young valleys and on steep slopes

Kcc – Crevasse Canyon Formation (Upper Cretaceous, 88 Ma); mudstone, shale, very fine- to medium-grained sandstone, carbonaceous shale, and thin lenticular coal beds; outcrops in southwest corner only; 400 feet thick

Kg – Gallup Sandstone (Upper Cretaceous, 90 Ma); tan to pale-orange, medium-grained, well-sorted calcareous sandstone, silty-sandstone, and coaly-carbonaceous layers; three prominent ridge-forming sandstone layers (<20 feet) are separated by silty, and carbonaceous intervals (<8 feet); sandstone layers have only minor amounts of cement and minimal matrix material resulting in high apparent-permeability; <220 feet thick

Km – Mancos Shale (Upper Middle Cretaceous, 97-90 Ma); light to dark-grey and mudstone, silty-mudstone, and shale; minor amounts of lenticular sandy-siltstone, limestone, and calcareous-sandstone present in upper portions; sandy layers have abundant cement and ultrafine matrix resulting in very low apparent-permeability; the Whitewater Arroyo Tongue of the Mancos Shale is inter-tongued with and underlies the Towels Tongue of the Dakota Sandstone, abundant fossil corrals and cephalopods in Whitewater Arroyo Tongue; <600 feet thick, excluding the Whitewater Arroyo Tongue which varies in thickness from 0-80 feet.

Kd – Dakota Sandstone (Upper Middle Cretaceous, 97-90 Ma); tan to pale-yellow, fine- to medium-grained, sub-angular to well-rounded, grain-supported sandstone; small amounts of matrix and grain support result in a very high apparent-permeability; Towels Tongue of Dakota Sandstone is inter-tongued with and overlies the Whitewater Arroyo Tongue of the Mancos Shale; basal contact of Dakota Sandstone unconformably overlies an irregular erosional surface developed in the Morrison Formation; <230-310 feet thick including the Whitewater Arroyo Tongue

Jm – Morrision Formation (Upper Jurassic, 160-145 Ma); greyish-white to pale-orange, subangular to well-rounded, fine- to coarse-grained sandstone and conglomeratic-sandstone; trough cross-stratification locally; clay-rich fine-grained intervals present near upper contact highly variable apparent-permeability; variable thickness possibly due to bedding-plane slip along monoclonal fold axis; <65 feet thick in northern part of base, thinning to <20 feet to the south

Jz – Zuni Sandstone (Middle Jurassic, 170-165 Ma); white, pink, and reddish-orange, well-rounded, clast-supported, fine- to very-fine-grained sandstone and silty-sandstone; horizontal color banding common; crossbedding in relatively thin sets (compared to Entrada Sandstone); siltier intervals correlate to shallow slopes and cleaner intervals correlate to steep slopes; very high apparent-permeability; <620 feet thick

Je – Entrada Sandstone (Middle Jurassic, 170-165 Ma); red, and pinkish-grey, moderately-rounded, matrix supported, fine- to medium-grained sandstone; large-scale crossbedding; less competent than Zuni Sandstone; calcareous cement; very high apparent-permeability; <650 feet thick

Tro – Owl Rock Formation (Upper Triassic, 225-210 Ma); white, greyish-pink, and orange, crystalline-limestone, sandy-limestone, and calcareous-sandstone; variable thickness possibly due to bedding plane slip along monoclonal fold axis; <30 feet thick

Trpp - Petrified Forest Formation, Painted Desert Member (Middle Triassic, 225-210 Ma); purplish-red, orangish-red and rust coloured, mudstone, siltstone, sandstone, and sandstone-conglomerate; sandstone intervals (<20 feet) have tabular and trough cross beds, abundant ultrafine matrix, and are generally dirty resulting in low apparent-permeability; abundant 1-2 cm greenish grey calcrete nodules present forming a distinctive mottled or speckled surface; shallow (<6 feet) channel deposits with inter-formational conglomerates containing mudstone and carbonate clasts; lenticular bodies of sandstone with similar lithology to the Sonsela Sandstone are laterally discontinuous; <600 feet thick

Trps - Petrified Forest Formation, Sonsela Sandstone Member (Middle Triassic, 225-210 Ma); yellow, tan, and olive-coloured, well-rounded, clast-supported, medium- to coarse-grained sandstone and conglomeratic-sandstone; conglomeratic intervals containing intra-formational (mudstone, carbonate) and extra-formational (chert, quartzite) clasts; thin crossbedding common; minimal matrix and grain support result in very high apparent-permeability; <100 feet thick, highly-variable thickness typical of large-scale channel deposits

Trpb - Petrified Forest Formation, Blue Mesa Member (Middle Triassic, 230-225 Ma); purple, and purplish-red, mudstone, and muddy sandstone, mudstones are smectitic; light-grey sandy-smectitic-siltstone interval (<8 feet) serves as marker bed for the base of the Petrified Forest Formation; high quantity of ultrafine matrix results in a very low apparent-permeability; petrified wood very common in upper portions; <280 feet thick

Trbu - Bluewater Creek Formation, Upper Member (Upper Triassic, 230-225 Ma); pinkish-grey to reddish-brown siltstone and mudstone; calcrete nodules present locally; high silt and ultrafine matrix result in low apparent-permeability; <100 feet thick

Trbm- Bluewater Creek Formation, McGaffey Member (upper Triassic, 230-225 Ma); white, pale-red and grey, medium-grained, ripple-laminated sandstone; color banding common; basal interval has carbonated-clast-conglomerate; calcareous cement; high apparent-permeability; <80 feet thick, highly-variable thickness typical of large-scale channel deposits, locally not recognized

Trbl - Bluewater Creek Formation, Lower Member (Middle to Upper Triassic, 240-225 Ma); yellowish-grey, and reddish-brown mudstone and siltstone; calcrete nodules are present locally; low apparent-permeability; <115 feet thick

Trm - Shinarump Formation and Moenkopi Formation Undivided (Middle Triassic, 240-225 Ma); Shinarump Formation is purple and reddish-grey, mottled chert- and quartzite-pebble-conglomerate and conglomeratic-sandstone with reddish-brown matrix; Moenkopi is red, tan, and black calcareous-mottled-sandstone and calcareous-mudstone; massive to thinly-laminated and ripple-laminated siltstone and very fine-grained sandstones; 30-200 feet thick combined

Psa - San Andres Limestone (Middle Permian, 275-250 Ma); grey and white, fossiliferous, crystalline-limestone and dolomitic-limestone; locally absent due to karsting; <165 feet thick

Pg - Glorieta Sandstone (280-275 Ma); greyish-orange to orange, well-sorted, moderate- to well-rounded, fine- to medium-grained quartzose-sandstone; horizontal and low-angle crossbedding locally; <130 feet thick

Py - Yeso Formation (280-275 Ma); dark-orange to reddish-oranged, very fine-grained gypsiferous-sandstone and silty-sandstone; three light-grey, dolomitic, carbonate beds present in formation; <375 feet thick

Pa - Abo Formation (280-275 Ma); greyish-red, very fine-grained silty-sandstone; non-calcareous; flat-bedded; basalt 3-12 feet are arkosic; <450 feet thick

pC - Precambrian Basement; typically granitic, to dioritic-igneous and metamorphic rocks

Notes

< = less than
cm = centimeters
FWDA = Fort Wingate Depot Activity
Ma = mega-annum (million years) R

Definitions apply to geologic formations found on Figure 2-5 of this Well Installation Work Plan.

Adapted from TerranearPMC, 2006, Supplemental Groundwater Investigation – Administration and TNT Leaching Beds Areas, Submitted to the FWDA 24 March 2006

Figure 2-7

Stratigraphic Column

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

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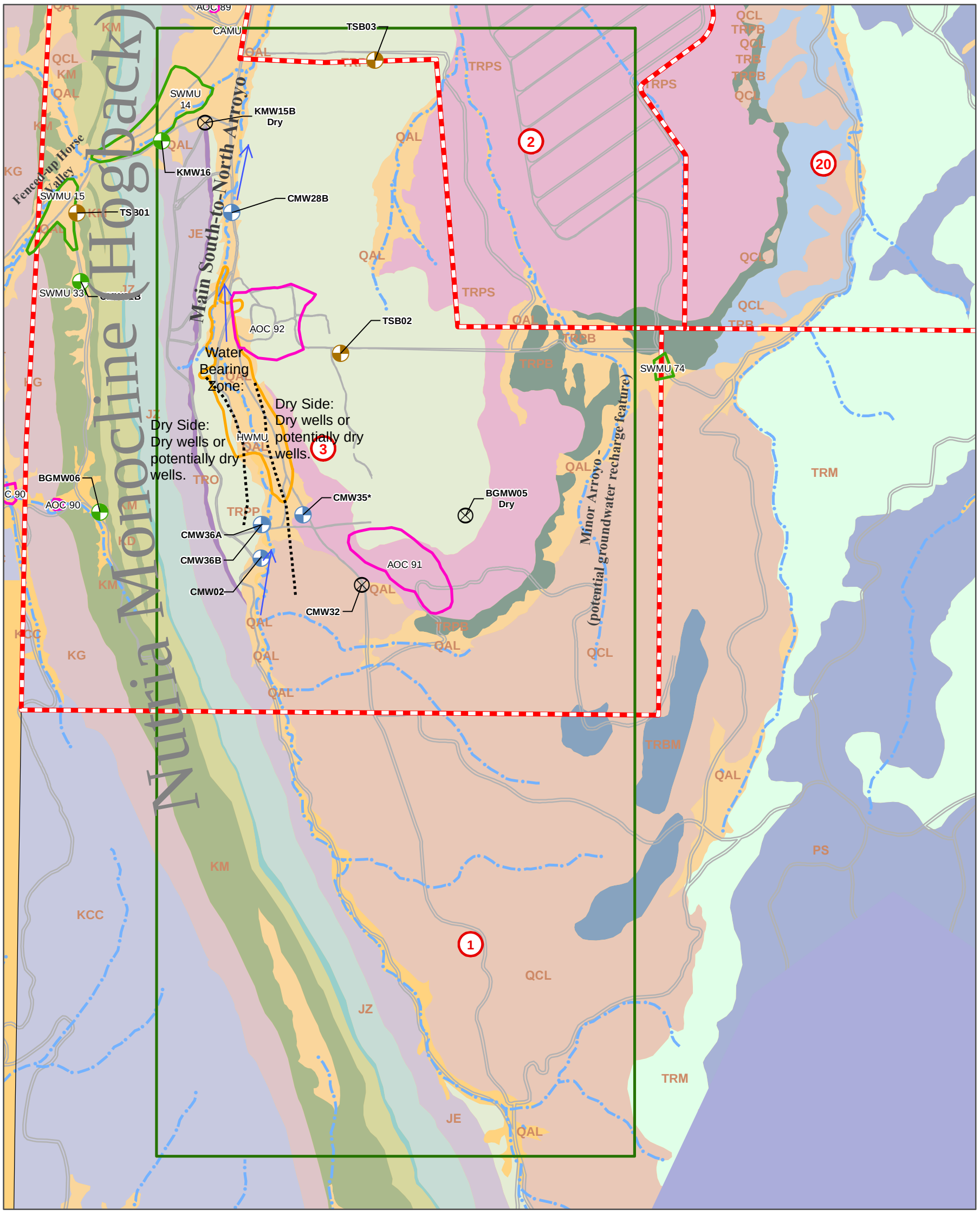
Surface Geology

- JE- Entrada Sandstone
- JM-Morrison Formation
- JZ-Zuni Sandstone
- KCC-Crevasse Canyon Formation
- KD-Dakota Sandstone
- KG-Gallup Sandstone
- KM-Mancos Shale
- QAL-Quarternary Alluvial Deposits
- QCL-Quarternary Colluvial Deposits
- TRB-Bluewater Creek Formation
- TRBM-Bluewater Creek Formation Member
- TRO-Owl Rock Formation
- PS-San Andreas Limestone
- TRPB-Petrified Forest Formation-Blue Mesa Member
- TRPP-Petrified Forest Formation - Painted Desert Memeber
- TRPS-Petrified Forest Formation-Sonsela Sandstone Member
- TRM-Shinarump Formation and Moenkopi Formation Divided



Legend

- Inferred Dry Line
- Dry Well
- West Hogback Well
- East Hogback Well
- Exploratory Soil Boring
- AOCs
- HWMU
- SWMUs
- FWDA Parcels
- Roads
- Arroyo
- Surface Water Flow Direction

Notes

* = Potentially dry well.
Dry Line is estimated extent from the main arroyo where groundwater is located. Groundwater located in proximity to arroyo.

AOC = Area of Concern
FWDA = Fort Wingate Depot Activity
HWMU = Hazerdous Waste Management Unit
SWMU = Solid Waste Management Unit

N W E S

550 1,100 2,200 Feet

0 0.125 0.25 0.5 Miles

Coordinate System:
NAD 1983 StatePlane New Mexico West FIPS 3003 Feet

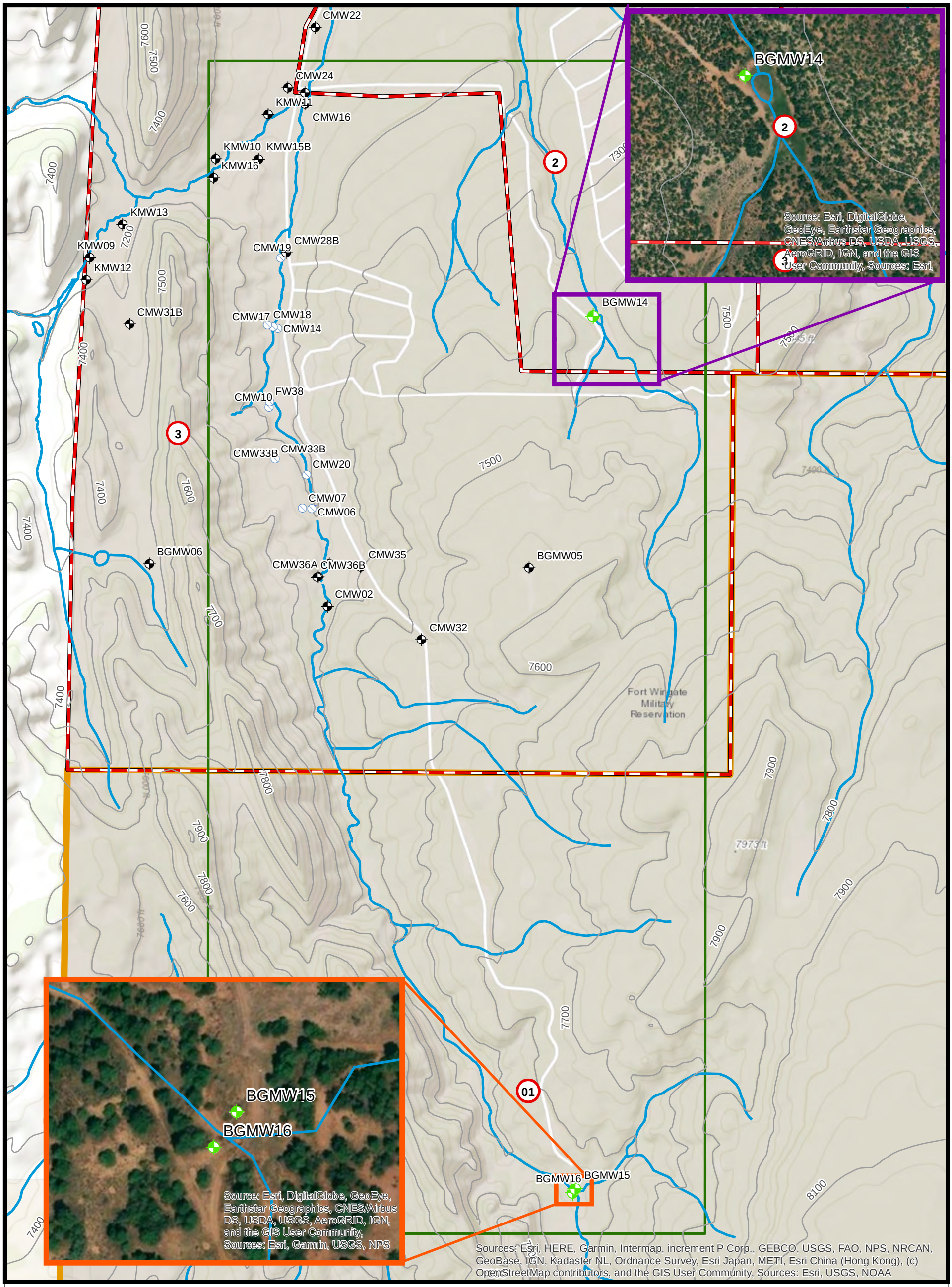
Figure 2-8

Hydrogeologic Map

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.



Legend

- Proposed Well Locations
- Existing Wells
- Abandoned Wells
- Elevation Contours
- Drainage Arroyos
- FWDA Parcel Boundaries
- Transferred FWDA Property (Parcel 1)

Notes

FWDA = Fort Wingate Depot Activity

N W E S

0 0.25 0.5
Miles

0 1,100 2,200
Feet

Figure 3-1

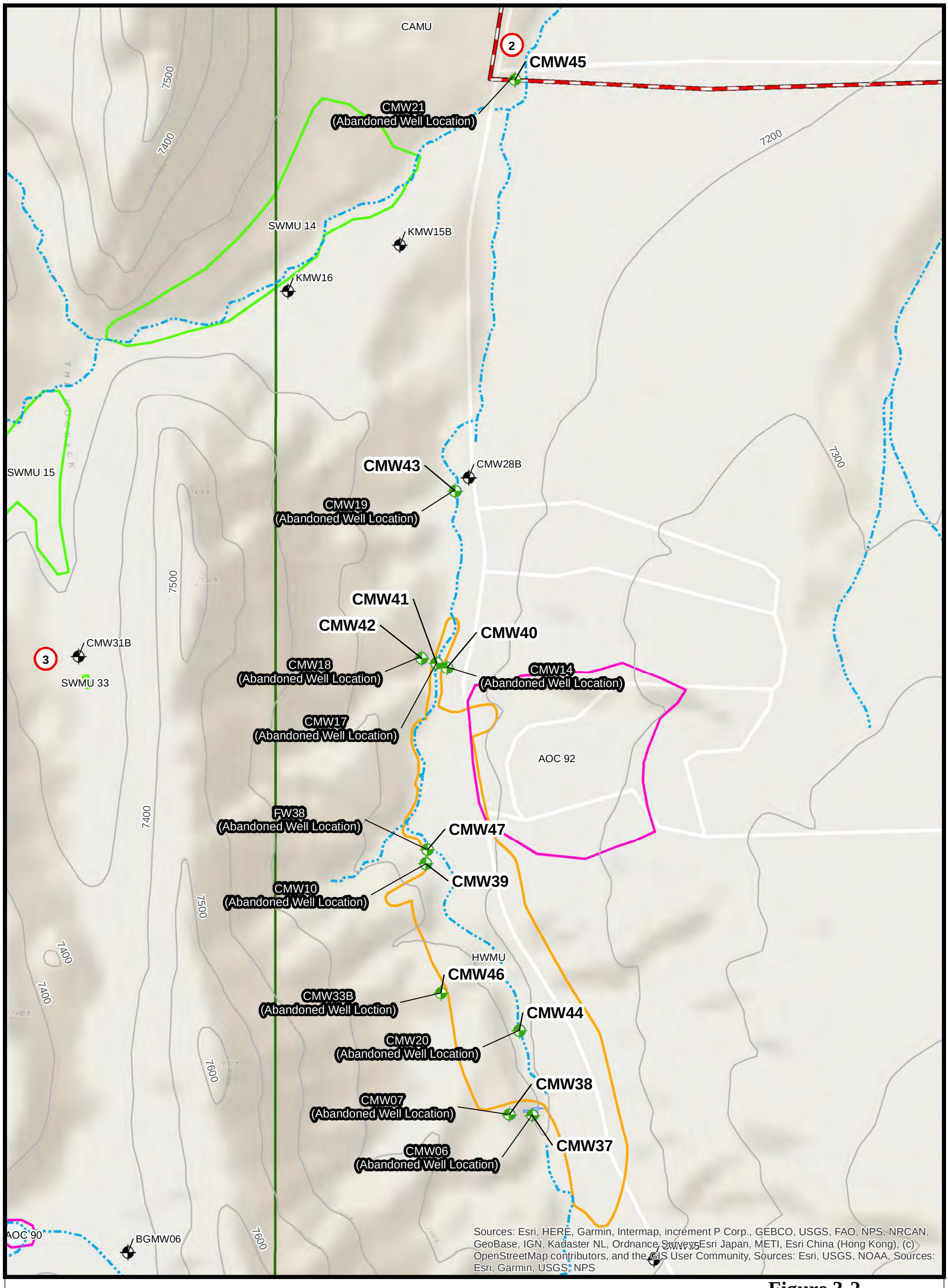
Proposed Background Well Locations

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

Updated on: 11/7/2019



Legend

- Proposed Replacement Monitoring Wells
- Existing Well
- Elevation Contours
- Drainage Arroyos
- Study Area
- AOCs
- HWMU
- SWMUs
- FWDA Parcel Boundaries

N
W E
S

0 0.1 0.2
Miles

0 450 900
Feet

Notes

FWDA = Fort Wingate Depot Activity
Proposed wells are in the same location as the abandoned wells. Well numbers for abandoned wells and the corresponding replacement wells are shown for each well location.

Figure 3-2

Proposed Replacement Well Locations

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Sundance Consulting Inc.

Updated on: 11/7/2019

-- Figure is not to scale --

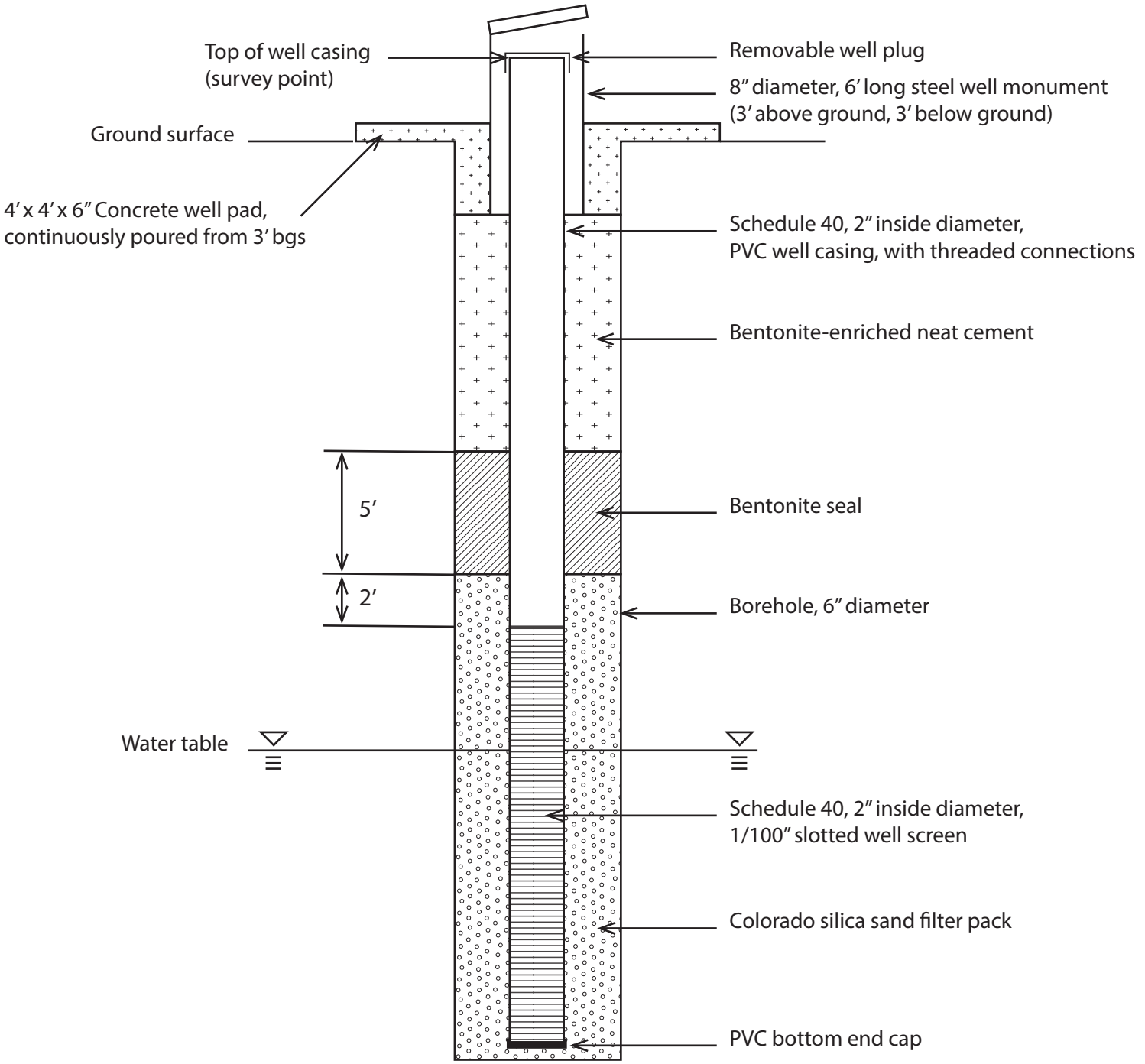


Figure 3-3
Schematic of Proposed Well Construction

Parcel 3 Groundwater Background Wells and
Replacement Monitoring Wells Installation
Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

Modified from Monitoring Well Guidelines Revision 1.1 (NMED, 2011)

FORT WINGATE
CARETAKERS
90-DAY FACILITY CHECK SHEET

CONTAINER NUMBER	NOMENCLATURE DESCRIPTION	START DATE	CHARACTERIZATION STATUS

CARETAKER SIGNATURE: **DATE:**

Figure 4-1

Sample IDW Inventory Form

Parcel 3 Groundwater Background Wells and Replacement Monitoring Wells Installation Work Plan,

Fort Wingate Depot Activity
McKinley County, New Mexico

TABLES

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Table 3-1: Proposed Background Well Construction Detail

Proposed Background Well ID	FWDA Parcel	Drilling Method	Northing[a]	Easting[a]	Proposed Well Depth (ft bgs)	Boring Diameter (in)	Casing Diameter (in)	Casing/ Screen Type	Proposed Screen Length (ft)	Proposed Screened Interval (ft bgs)
BGMW14	2	Sonic	1613477.48	2489087.84	75.00	6.00	2.00	PVC	20.0	55.0 - 75.0
BGMW15	1	Sonic	1613481.11	2488966.19	65.00	6.00	2.00	PVC	20.0	45.0 - 65.0
BGMW16	1	Sonic	1614801.68	2488525.71	65.00	6.00	2.00	PVC	20.0	45.0 - 65.0

Notes:

[a] Horizontal coordinate system: NM NAD83 State Plane West

Acronyms and Abbreviations:

bgs = below ground surface
ft = foot / feet
ID = identification
in = inch / inches
NAD83 = North American Datum of 1983
NM = New Mexico
PVC = polyvinyl chloride
Sonic = sonic drilling method

Table 3-2: Replacement Monitoring Well Construction Detail

Replacement Well ID	Abandoned Well ID	FWDA Parcel	Drilling Method	Northing[a]	Easting[a]	Previous Ground Elevation (ft amsl)[b]	Well Depth (ft bgs)	Previous Boring Diameter (in)	Proposed Boring Diameter (in)	Casing Diameter (in)	Casing/ Screen Type	Proposed Screen Length (ft)	Previous Screened Interval (ft bgs)	Proposed Screened Interval (ft amsl)	Screened Formation
CMW37	*CMW06*	3	Sonic	1613477.48	2489087.84	7214.13	18.60	4.00	6.00	2.00	PVC	10.0	8.3 - 18.3	7204-7194	Alluvium
CMW38	*CMW07*	3	Sonic	1613481.11	2488966.19	7233.04	65.80	8.00	6.00	2.00	PVC	20.0	44.0 - 64.0	7188-7168	Painted Desert Member
CMW39	CMW10	3	Sonic	1614801.68	2488525.71	7177.40	70.85	8.00	6.00	2.00	PVC	20.0	50.5 - 70.5	7126-7106	Painted Desert Member
CMW40[c]	*CMW14*	3	Sonic	1615835.54	2488638.31	7151.34	94.55	9.00	6.00	2.00	PVC	10.0	84.2 - 94.2	7066-7056	Painted Desert Member
CMW41	*CMW17*	3	Sonic	1615860.63	2488582.47	7143.72	53.00	8.00	6.00	2.00	PVC	20.0	32.0 - 52.0	7111-7091	Painted Desert Member
CMW42	*CMW18*	3	Sonic	1615886.04	2488504.59	7156.24	53.00	8.00	6.00	2.00	PVC	20.0	32.0 - 52.0	7124-7104	Painted Desert Member
CMW43	CMW19	3	Sonic	1616766.18	2488680.46	7128.11	52.80	8.00	6.00	2.00	PVC	15.0	33.5 - 48.5	7093-7078	Painted Desert Member
CMW44	*CMW20*	3	Sonic	1613921.71	2489020.26	7193.14	5.80	4.00	6.00	2.00	PVC	3.0	2.5 - 5.5	7189-7186	Painted Desert Member
CMW45	*CMW21*	3	Sonic	1618931.48	2488996.15	7192.70	74.50	6.00	6.00	2.00	PVC	10.0	57.0-67.0	7025-7015	Sonsela Member
CMW46[c]	*CMW33B*	3	Sonic	1614122.30	2488606.09	7231	155.00	6.00	6.00	2.00	PVC	20.0	135-155	7096-7076	Sonsela Member
CMW47	*FW38*	3	Sonic	1614875.40	2488533.75	7169.43	7.50	3.00	6.00	2.00	PVC	ND	ND	ND	Alluvium

Notes:

[a] Horizontal coordinate system: NM NAD83 State Plane West
[b] Vertical coordinate system: NAVD88
[c] Monitoring well planned total depth is greater than 80 feet bgs. Monitoring well will utilize schedule 80 PVC.
Monitoring wells will be constructed with schedule 40 PVC unless otherwise noted.

yellow highlight = due to shallow intervals of the abandoned well, the proposed well likely will be dry.

Acronyms and Abbreviations:

amsl = above mean sea level
bgs = below ground surface
ft = foot / feet
ID = idendification
in = inch / inches
NAD83 = North American Datum of 1983
NAVD88 = North American Vertical Datum of 1988
NM = New Mexico
PVC = polyvinyl chloride
sonic = sonic drilling method