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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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Abstract

There are two sites comprised of several parcels of land within the Kirtland Military Reservation, Bernalillo County, New Mexico. Site A is located within T 9N, R 4E, Section 13 and Site B is located within T 9N, R 4E, Section 36. The purpose of this EBS is to document the nature, magnitude, and extent of any environmental contamination of the property; identify potential environmental contamination liabilities associated with the property; develop sufficient information to assess the health and safety risks; and ensure adequate protection for human health and the environment related to a specific property.



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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Table of Contents

PURPOSE	1
PURPOSE OF THE ACTION	1
BOUNDARIES OF THE PROPERTY AND SURVEY AREA	2
SURVEY METHODOLOGY	2
APPROACH AND RATIONALE	2
<i>Description of Reviewed Documents</i>	2
<i>Property Inspections</i>	3
<i>Personnel Interviews</i>	3
<i>Sampling</i>	3
FINDINGS	4
HISTORY AND USAGE	4
<i>History</i>	4
<i>Current and Future Use</i>	4
<i>Activities, Structures, and Buildings</i>	4
ENVIRONMENTAL SETTING	4
<i>Geology</i>	5
<i>Hydrology</i>	5
<i>Vegetation and Wildlife</i>	5
HAZARDOUS SUBSTANCES	6
<i>Hazardous Materials and Petroleum Products</i>	6
<i>Hazardous and Petroleum Waste</i>	6
ENVIRONMENTAL RESTORATION PROGRAM (ERP) CONTAMINATION	6
STORAGE TANKS	8
<i>Aboveground Storage Tanks</i>	8
<i>Underground Storage Tanks</i>	8
<i>Pipelines, Hydrant Fueling, and Transfer Systems</i>	8
OIL/WATER SEPARATORS (O/WS)	8
PESTICIDES	9
MEDICAL OR BIOHAZARDOUS WASTE	9
ENERGETIC MATERIAL	9
RADIOACTIVE WASTE	9
SOLID WASTE	9
GROUNDWATER	10
WASTEWATER TREATMENT, COLLECTION, AND DISCHARGE	10
DRINKING WATER QUALITY	10
ASBESTOS	10
POLYCHLORINATED BIPHENYLS (PCBs)	10
RADON	10
LEAD-BASED PAINT	11
FINDINGS FOR ADJACENT PROPERTIES	11
LAND USES	11
SURVEYED PROPERTIES	11

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

APPLICABLE REGULATORY COMPLIANCE ISSUES.....	11
LIST OF COMPLIANCE ISSUES.....	11
DESCRIPTION OF CORRECTIVE ACTIONS	11
ESTIMATES OF VARIOUS ALTERNATIVES.....	11
OTHER ALTERNATIVES.....	11
CONCLUSIONS	12
FACILITY MATRIX.....	12
PROPERTY CATEGORIES MAP.....	12
RESOURCES MAP	12
DATA GAPS.....	12
CERTIFICATION	13
LIST OF APPENDICES.....	15

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

List of Abbreviations and Acronyms

ABCWUA	Albuquerque Bernalillo County Water Utility Authority
AC	Acres
ACM	Asbestos Containing Material
AFI	Air Force Instruction
AFOTEC	Air Force Operational Test and Evaluation Center
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
CEPR	Civil Engineering Property Real Estate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
EBS	Environmental Baseline Survey
ECP	Environmental Compliance Program
EPA	Environmental Protection Agency
ER	Environmental Restoration
ERP	Environmental Restoration Program
ft	feet
GEMS	Geographic Environment Management System
HR-1	Hydrogeologic Region 1
in	inches
KAFB	Kirtland Air Force Base
NMED	New Mexico Environment Department
O/WS	Oil/water separators
PCBs	Polychlorinated Biphenyls
pCi/l	picocuries per liter
RAMP	Radon Assessment and Mitigation Program
RCRA	Resource, Conservation, and Recovery Act
SNL	Sandia National Laboratories
U.S.	United States
USAF	United States Air Force
UST	Underground Storage Tank
~	Approximately

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

SECTION 1.0 PURPOSE

1.1 Purpose of the Action

This Phase I Environmental Baseline Survey (EBS) provides the findings of a survey and assessment for installation of 5 new Sandia National Laboratories (SNL) hydrogeologic groundwater monitoring wells to be located on Kirtland Air Force Base (KAFB), New Mexico. The purpose of this document is to provide information regarding baseline environmental conditions of the proposed sites. This document was prepared in accordance with U.S. Air Force (USAF) policy, as defined by Air Force Instruction (AFI) 32-7066, *Environmental Baseline Surveys in Real Estate Transactions* (1994), as supplemented by the Headquarters Air Force Materiel Command memorandum *HQ AFMC Supplemental Guidance for the Environmental Impact Analysis Process and Environmental Baseline Surveys*, dated 11 April 2011. To ensure that all site conditions are addressed, the American Society for Testing and Materials (ASTM) Standard E1527-05, 2005, "Practice for Environmental Site Assessments: Phase I Site Assessments"; E1528-06, 2006, "Standard Practice for Limited Environmental Due Diligence: Transaction Screen Process"; and ASTM Standard D6008-96, Reapproved 2005, "Standard Practice for Conducting Environmental Baseline Surveys" are also followed. In accordance with these guidance, this Phase I EBS will provide some of the information needed for the following objectives:

- Document the nature, magnitude, and extent of any environmental contamination of the sites.
- Identify potential environmental contamination liabilities associated with the sites.
- Develop sufficient information to assess the health and safety risks and to ensure adequate protection for human health and the environment related to the sites.
- Provide the basis for notice, when required under Section 120(h)(1) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 United States Code (U.S.C.) 9620 (h)(1), of the disposal of a hazardous substance on the sites.

The preparation of this document is limited to existing information that can be garnered through records searches, reviews of historical photographs, interviews, or field observations of the site. Field activities (e.g. trenching, drilling, or sample collection) would have to be used to quantify and confirm possible contamination and would need to be conducted under a Phase II EBS.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

This document does not address possible effects on property valuation from discovered contamination; effects on property valuation can only be effectively evaluated after the nature and extent of contamination are fully understood.

1.2 Boundaries of the Property and Survey Area

There are two sites comprised of several parcels of land within the Kirtland Military Reservation, Bernalillo County, New Mexico. Site A is located within T 9N, R 4E, Section 13 and Site B is located within T 9N, R 4E, Section 36 being described by a location map (see Appendix A of this document).

SECTION 2.0 SURVEY METHODOLOGY

2.1 Approach and Rationale

The approach of this action is to perform a document search and preliminary site investigation in order to identify potential environmental contamination associated with the sites. The EBS process involved the review of records compiled for the sites. The records reviewed included information on environmental restoration activities, testing activities (e.g., Safety Assessments), and the results of regulatory reports, and investigations (e.g., biological, cultural/archaeological) relevant to the sites. A thorough review of reasonably obtainable state, federal, local government and United States Air Force (USAF) records has been performed as part of this EBS. Additionally, Interviews were held with KAFB personnel to further discuss the history and surroundings, underground storage tanks, releases or spills, and permit and enforcement history. The information collected is presented in this EBS Phase I Environmental Site Assessment.

2.1.1 Description of Reviewed Documents

The following documents were reviewed in preparation of this EBS:

- Air Force Form 813 dated May 5, 2011: *Hydrogeologic Monitoring Wells Removal from Land Use Permit, PERM-KI-91-0010.*
- Air Force Form 813 dated February 2, 2011: *Hydrogeological Wells, PERM-KI-91-0010.*
- *Kirtland Air Force Base Environmental Compliance Program (ECP) and Environmental Restoration Program (ERP) sites location map; dated February 27, 2006.*
- *Kirtland Air Force Base Master Environmental Restoration Program Site List; dated July 20, 2011.*
- SNL SAND Report, *Sandia National Laboratories Environmental Information Document Calendar Year 2003 Update*, SAND2004-5058, October 2004, Sandia National Laboratories, Albuquerque, New Mexico. See Appendix C for relevant citations from this document.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

- Information from the Geographical Environmental Management Systems (GEMS).
- KAFB real property (377 MSG/CECR) files.

2.1.2 Property Inspections

A Sandia Corporation Environmental Technical Professional conducted a visual and physical walk-through inspection of the land use permit sites on November 9, 2012. No environmental concerns or issues were observed: no odors; pools of liquid; drums; hazardous substance and petroleum product containers; potential asbestos-containing material (ACM); polychlorinated biphenyl (PCB)-containing electrical equipment; drains and sumps; pits, ponds, and lagoons; stained soil or pavement; stressed vegetation; wastewater; or dead or diseased wildlife. No concerns relating to the health and safety of individuals or local flora or fauna, such as stains or leaks, were observed (See Appendix D for site photographs).

2.1.3 Personnel Interviews

The following personnel were interviewed in preparation of this document:

- Sandia Corporation Hydrologist working in the Environmental Safety and Testing Organization 06234 was interviewed on November 14, 2012.
- Sandia Corporation Real Estate Specialist working in the Facilities Management and Operations Center Organization 04853 was interviewed on November 14, 2012.
- No USAF personnel were contacted regarding the proposed Land Use Permit area. USAF personnel other than those associated with the 377 MSG/Civil Engineer Division, Natural Resources Management Branch are not considered to be a source of authoritative environmental information related to operations/activities within the land use permit site boundaries.

2.1.4 Sampling

As indicated by the negative findings in Section 2.1.2, Property Inspections, there were no observations that warranted sampling and analysis of drinking water quality, radon, asbestos, PCBs or lead based paint within the land use permit site. As a result, sampling was not conducted as part of this EBS.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

SECTION 3.0 FINDINGS

3.1 History and Usage

3.1.1 *History*

The area associated with Site A was historically associated with explosives testing at SNL between 1950 and the late 1960s. The area associated with Site B was historically associated with testing at SNL of radioactive material between 1956 and 1978.

In the late 1980s SNL personnel began Environmental Restoration (ER) activities at both sites, which continue to the present. Current ER activities consist primarily of groundwater monitoring. The New Mexico Environment Department (NMED) requires the groundwater monitoring at both sites under the Hazardous and Solid Waste Amendment (HSWA) Permit held by Sandia Corporation and the Department of Energy (DOE).

3.1.2 *Current and Future Use*

Both Sites A and B are located within remote areas of KAFB and currently have no specific use other than their association with SNL ER activities. ER activities, including ground water monitoring are anticipated to continue for the foreseeable future.

3.1.3 *Activities, Structures, and Buildings*

SNL personnel have installed 5 hydrogeologic monitoring wells. Wells at Location A are CCBA-MW1 and CCBA-MW2. Wells at Location B are OBS-MW1, OBS-MW2, and OBS-MW3. Each monitoring well is designed to provide for safe and efficient groundwater monitoring. A concrete pad approximately 3 feet (ft) by 3 ft contains a steel wellhead, which is 3 ft high by 1 ft in diameter. The wellhead is capped by an aluminum lid, which is padlocked in order to keep out unauthorized personnel. Steel poles that are 4 ft high by 4 inches (in.) in diameter are filled with concrete and placed at each of the four corners of the concrete pad to protect the wellhead. Both the wellhead and the steel poles are painted a "high traffic" yellow for optimal visibility.

3.2 Environmental Setting

Site A is located north of Coyote Springs Road. It is on an alluvial plain among the eastern slopes of the Rio Grande Valley, approximately ½ a mile north of the Tijeras Arroyo and approximately 7 miles east of the Rio Grande River at an elevation of 6,000 feet (ft). It is flat, open, and covered with a woodland on flat to rolling terrain association.

Site B is located north of Isleta Road. It is on an alluvial plain among the eastern slopes of the Rio Grande Valley, approximately 1 mile south of the Tijeras Arroyo and approximately 5 miles east of the Rio Grande River at an elevation of 5,800 feet (ft). It is flat, open, and covered with a shrub

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

grassland association.

The climate of both Site A and Site B is typical of a high desert plateau, with low precipitation, wide temperature extremes, and typically clear, sunny days. The regional groundwater flow in this area is typically to the northwest. The average yearly rainfall is 8.5 inches (in).

(SNL/NM, 1996).

3.2.1 Geology

The geologic makeup for Site A is based on Metamorphic of the Precambrian type. The predominant soil type at this land use area consists of Salas series soils.

The geologic makeup for Site B is based on Pleistocene and Holocene units of the Tertiary and Quaternary type. The predominant soil type at this land use area consists of Embudo and Tijeras series soils.

(SNL/NM, 1998)

3.2.2 Hydrology

Both Site A and Site B reside in Hydrogeologic Region 3 (HR-3). The saturated zone hydrology is characterized by a flow system, complicated by the juxtaposition of different stratigraphic units across one or more faults. The faults themselves also have a significant impact on groundwater flow. The nearest major fault is the Coyote Fault.

(SNL/NM, 1998)

The reported depth to groundwater at Site A wells is CCBA-MW1~47 ft. and CCBA-MW2 ~71 ft. (GEMS, January 2013).

The reported depth to groundwater at Site B wells is OBS-MW1~72 ft, OBS-MW2~175 ft, and OBS-MW3~69 ft. (GEMS, January 2013).

Storm-water discharge paths from the sites typically follow the natural topography toward lower elevations; however, storm water predominantly infiltrates the soil.

See Appendix C for more information on the KAFB hydrogeological zones.

3.2.3 Vegetation and Wildlife

Predominately native shrub and grasslands characterize vegetation in the immediate vicinity of both Site A and Site B.

See Appendix C of this document for more detailed environmental information relative to this land use permit site, including species that could potentially inhabit the site.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

3.3 Hazardous Substances

The information in Sections 3.3 through 3.18 is based upon personnel interviews and the preliminary site inspection.

3.3.1 Hazardous Materials and Petroleum Products

Records search and site investigations revealed there is no evidence that hazardous materials or petroleum products have been generated, stored, or released within the land use permit site boundaries.

3.3.2 Hazardous and Petroleum Waste

Records search and site investigations revealed there is no evidence that hazardous materials or petroleum waste has been generated, stored, or released within the land use permit site boundaries.

3.4 Environmental Restoration Program (ERP) Contamination

Review of the *Kirtland Air Force Base Environmental Compliance Program (ECP) and Environmental Restoration Program (ERP) Sites* map indicated that no ERP Sites would be located within the boundaries of either Site A or Site B and 1 ERP site would be located within ½ mile of the Site B boundaries. The following provides the current status of the 1 ERP site located within ½ mile of the Site B boundaries:

WP-087, Grab Site Waste Pile- The KAFB Master ERP Site List, dated 07-20-2011, Section 7.4, shows the current state of this ERP site is "Sites With Permit Modification to No Further Action".

(KAFB, 2013)

SNL Environmental Restoration (ER) Sites- There are 2 SNL ER sites located within the Site A boundaries and 3 SNL/NM ER sites located within ½ mile of the Site A boundaries. The following provides the current status of the ER sites:

ER site 8, Open Dump (Coyote Canyon Blast Area)- ER Site 8, Open Dump (Coyote Canyon Blast Area)- ER Site 8 is associated with the ER Site 58 test area. ER Site 8 contained mainly general refuse and demolition debris. On April 8, 2010, there was a request by NMED for additional site characterization, including a groundwater investigation. Approval for ER Site 8 is pending regulatory approval by NMED.

ER Site 58, Coyote Canyon Blast Area- ER Site 58, Coyote Canyon Blast Area- ER Site 58 was used to conduct more than a hundred explosive field tests, which took place between 1950 to the late 1960s. ER Site 58 is currently undergoing groundwater investigation in tandem with ER Site 8 per NMED direction, April 2010. Approval for ER Site 58 is pending regulatory approval.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

The following SNL ER sites are located within ½ mile of Site A:

ER Site 92, Pressure Vessel Test Site- ER Site 92 was used to perform pressure-failure tests on small-scale model pressure vessels. No hazardous materials were used during historical test operations, as only nitrogen gas or steam was used to pressurize the vessels. Corrective action is complete at ER Site 92, and no further action is required. This site is acceptable for residential land use, and there are no restrictions on future activities. NMED approved completion of corrective action in September 1997.

ER Site 21, Metal Scrap- ER Site 21 consisted of an empty 55-gallon drum, some scrap metal, and wood debris scattered at the southern edge of a large stand of Ailanthus trees (*Ailanthus altissima*). The site was defined as a 1 acre area centered on the empty 55-gallon drum. No documentation of activities that occurred at this site has been found. Corrective action is complete at Site 21, and no further action is required. This site is acceptable for residential land use, and there are no restrictions on future activities. NMED approved completion of corrective action in October 2000.

ER Site 62, Greystone Manor Site- ER Site 62 consists of minor scattered rubble associated with the former Greystone manor and its wading pool and bathhouse. Small explosive tests were conducted with terrain models at this site between 1952 and 1957. Corrective action is complete at ER Site 62, and no further action is required. This site is acceptable for residential land use, and there are no restrictions on future activities. NMED approved completion of corrective action in December 1995.

There is 1 SNL ER site located within the Site B boundaries and 2 SNL ER sites located within ½ mile of the Site B boundaries. The following provides the current status of the ER sites:

ER Site 68, Old Burn Site- This site covers approximately 6.5 acres and is located on the north side of Isleta Road, across from the Kirtland Air Force Base (KAFB) 200-ft shock tube facility. ER Site 68 was used to test weapons components from 1965 through 1978 for fire survivability and contained features associated with those tests, including a permanent burn pad, four excavated pits, four debris mounds, scattered test debris, and a burial pit containing radioactively contaminated materials. The NMED issued a Certificate of Completion for CAC without Controls for ER Site 68 on October 28, 2005. On April 8, 2010, there was a request by NMED for additional site characterization, including a groundwater investigation. Regulatory approval is pending.

The following SNL ER sites are located within ½ mile of Site B:

ER Site 71, Moonlight Shot Area-

Site 71 is an inactive site consisting of approximately 83 acres and is centered on a concrete and asphalt pad in an open area north of Isleta Road. Between 1956 and 1961 tests were conducted to simulate the extent of

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

radioactive fallout dispersion from a nuclear weapon detonation during a transport accident or an accidental detonation during assembly. The tests were noncriticality explosions and did not yield nuclear fission products. Corrective action is complete at ER Site 71, and no further action is required. This site is acceptable for residential land use, and there are no restrictions on future activities. NMED approved completion of corrective action in July 2000.

ER Site 22, Storage/Burn- ER site 22 was a fenced area approximately 50-ft by 50-ft square. The area inside the fence contained one empty, open-topped 55-gal drum, several wooden pallets, charcoal, and scraps of fiberboard. The drum had apparently been used as a fire barrel. Corrective action is complete at Site 22, and no further action is required. This site is acceptable for residential land use, and there are no restrictions on future activities. NMED approved completion of corrective action in July 2000.

(GEMS, January 2013)

3.5 Storage Tanks

A review of the Kirtland AFB and New Mexico Environment Department (NMED) underground storage tank (UST) and aboveground storage tank (AST) database found no tanks associated with either Site A or Site B. Furthermore, no active or abandoned pipelines, hydrant fueling, or transfer systems were associated with either Site A or Site B.

(NMED 2013).

3.5.1 Aboveground Storage Tanks

This topic is not applicable to this land use permit site.

3.5.2 Underground Storage Tanks

This topic is not applicable to this land use permit site.

3.5.3 Pipelines, Hydrant Fueling, and Transfer Systems

There are no underground water supply pipelines within either Site A or Site B. No other known pipelines, hydrant fueling, or transfer systems are associated with these areas except for the existing water delivery system pipeline.

3.6 Oil/Water Separators (O/WS)

There are no oil/water separators associated with either Site A or Site B. A list of O/WSs on KAFB was reviewed to determine their location and status in association with the land use sites. The list included active, inactive, and removed O/WS and O/WS converted to or serving as storm drains. The list identified no O/WS within the land use sites. No preexisting facilities of this nature are known to have existed within the land use sites.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

3.7 Pesticides

Records review, interviews, and site inspections revealed no evidence that pesticides or herbicides have resulted in any contamination within either Site A or Site B. The KAFB Integrated Pest Management Program includes regular inspections and maintenance for the control of wildlife, pests, and weeds. Typical chemicals approved for modern use are used for controlling pests and weeds at KAFB. The only restricted-use pesticide that has been used at KAFB is Fumitoxin, which is used to fumigate prairie dog burrows.

3.8 Medical or Biohazardous Waste

Records review and site inspections revealed there is no known medical or biohazardous waste associated with the either Site A or Site B.

3.9 Energetic Material

Records review and site inspections revealed that Site A was utilized for explosive field tests, which took place between 1950 to the late 1960s. SNL personnel began environmental restoration activities in the late 1980's that continue to the present.

Records review and site inspections revealed there has been no production or storage of any ordnance or explosive wastes at Site B. Site inspections revealed no visible ordnance. There is no known ordnance within the boundaries of Site B.

3.10 Radioactive Waste

Records review and site inspections revealed that there has been no generation or storage of radioactive materials or waste at Site A.

Records review and site inspections revealed that Site B was utilized to test weapons components from 1965 through 1978 and contained a burial pit containing radioactively contaminated materials. Sandia Corporation began environmental restoration activities in the late 1980's that continue to the present.

3.11 Solid Waste

Records review and site inspections revealed that Site A was associated with the ER Site 58 test area. The site contained mainly general refuse and demolition debris.

Records review and site inspections revealed that Site B contained a permanent burn pad, four excavated pits, four debris mounds, and scattered test debris associated with SNL testing from 1965 through 1978.

SNL personnel began environmental restoration activities in the late 1980's at both Site A and Site B. No concerns relating to the health and safety of individuals or local fauna or flora, such as stains or leaks, were observed. Personnel did not observe discolored soil or stressed vegetation at the subject easement during the site inspection.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

3.12 Groundwater

Records review and site inspections revealed that there are no known groundwater impacts associated with Both Sites A and B. Depth to groundwater at Site A is approximately 47 to 71 feet below ground level. Depth to groundwater at Site B is approximately 69 to 175 feet below ground level.

3.13 Wastewater Treatment, Collection, and Discharge

Records review and site inspections revealed that there are no wastewater treatment, collection, and discharge requirements or facilities are associated with either Site A or Site B.

3.14 Drinking Water Quality

Records reviews revealed that no drinking water supply system is associated with either Site A or Site B. Drinking water for KAFB is supplied by six supply wells and two distribution systems. Additional waters are provided by the City of Albuquerque through a combination of surface waters and groundwater which is treated and delivered through the city water utility lines. A records review revealed that the NMED ranked the KAFB wells from moderate to moderately high susceptibility because of the presence of potential contaminants that typically exist on active military installations. However, KAFB drinking water is within the safe drinking water standards established by the U.S. Environmental Protection Agency (USEPA) (KAFB 2011). A records search of the City of Albuquerque's drinking water revealed that the potable water supplied by the City of Albuquerque is within the safe drinking water standards established by the USEPA (Albuquerque Bernalillo County Water Utility Authority [ABCWUA], 2011).

3.15 Asbestos

Records review and site inspections revealed that there is no asbestos contamination associated with either Site A or Site B.

3.16 Polychlorinated Biphenyls (PCBs)

Records review and site inspections revealed that there is are no known PCB impacts at either Site A or Site B.

3.17 Radon

The Air Force Radon Assessment and Mitigation Program (RAMP) Initial Screen Survey Results, 24 May 1988, classified Kirtland Air Force Base as an installation with a *low* probability of radon concentrations in excess of 4 picocuries per liter (pCi/l). The installation was therefore precluded from the subsequent *Detailed Assessment Survey* and mitigation activities were deemed unnecessary and not advisable. No known radon issues are associated with this land use permit site; as such, sampling for radon was not conducted as part of this Phase I investigation.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

3.18 Lead-Based Paint

Records review and site inspections revealed that there is no lead-based paint issues associated with either Site A or Site B.

SECTION 4.0 FINDINGS FOR ADJACENT PROPERTIES

4.1 Land Uses

Adjacent properties to Site A include Manzano Base and withdrawn land.

Adjacent properties to Site B include the Defense Threat Reduction Agency Giant Reusable Air Blast Simulator (GRABS) Site, Starfire Optical Range, and other KAFB facilities.

4.2 Surveyed Properties

Adjacent areas (within 1/2 mi) have been evaluated for the presence of USAF ERP sites and SNL ER Sites. See Section 3.4 of this document for further information regarding KAFB ERP sites and SNL ER Sites.

SECTION 5.0 APPLICABLE REGULATORY COMPLIANCE ISSUES

This section presents the findings of the EBS as they relate to the environmental regulatory compliance issues identified during the assessment of the land use permit site that could pose either a risk of liability or a risk to human health or the environment.

5.1 List of Compliance Issues

There are no compliance issues identified during assessment of the land use permit site that might pose either a risk of liability or risk to human health or the environment. KAFB has responsibility for remediation of ERP/ECP sites on the installation.

5.2 Description of Corrective Actions

This topic is not applicable to this land use permit site.

5.3 Estimates of Various Alternatives

Proposed Action:

This topic is not applicable to this land use permit site.

5.4 Other Alternatives

No Action Alternative:

This topic is not applicable to this land use permit site.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

SECTION 6.0 CONCLUSIONS

To the best of the author's knowledge there are no known or undisclosed environmental impacts at this permit site, unless otherwise noted within this document.

6.1 Facility Matrix

Category 4 – Areas where release, disposal, and/or migration of hazardous substances has occurred, all removal or remedial actions has (sic) been taken.

6.2 Property Categories Map

This topic is not applicable to this land use permit site.

6.3 Resources Map

This topic is not applicable to this land use permit site.

6.4 Data Gaps

There appears to be sufficient information to categorize the subject sites and no further effort needs to be made to obtain additional information.

SECTION 7.0

CERTIFICATION

"I have conducted this Environmental Baseline Survey in cooperation with the U.S. Air Force in accordance with the requirements contained in Air Force Instruction 32-7066, *Environmental Baseline Surveys in Real Estate Transactions*. I have reviewed all reasonably obtainable records and conducted visual site inspections of the selected facilities following an analysis of information during the record search. The information contained within the survey report is based on records made available and, to the best of my knowledge, is correct and current as of January 15, 2013."

Certified by:

Christopher S. Catechis
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Commander, 377th Air Base Wing
Kirtland Air Force Base

Date: _____

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

LIST OF APPENDICES

Appendix A	Land Use Permit Site Location Maps and Historic Site Photographs
Appendix B	Environmental Restoration Program Site Location Maps;
Appendix C	Relevant Citations From Sandia National Laboratories/New Mexico. Environmental Information Document, SAND2004-5058, Printed October 2004.
Appendix D	Site Inspection Photographs
Appendix E	References
Appendix F	Personal Interviews

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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**INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER
MONITORING WELLS**

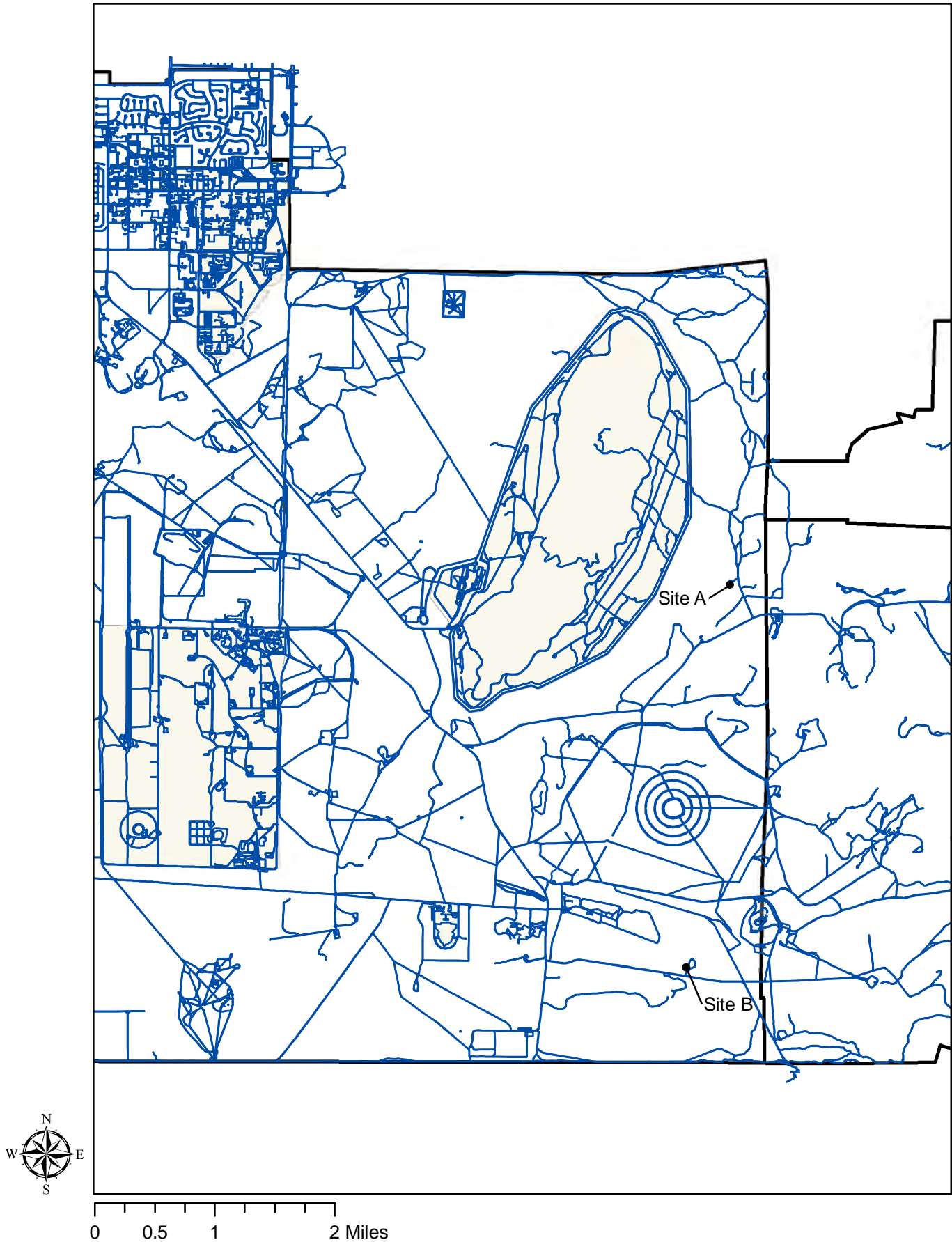
Appendix A

**Land Use Permit Site Location Maps and Historic Site
Photographs**

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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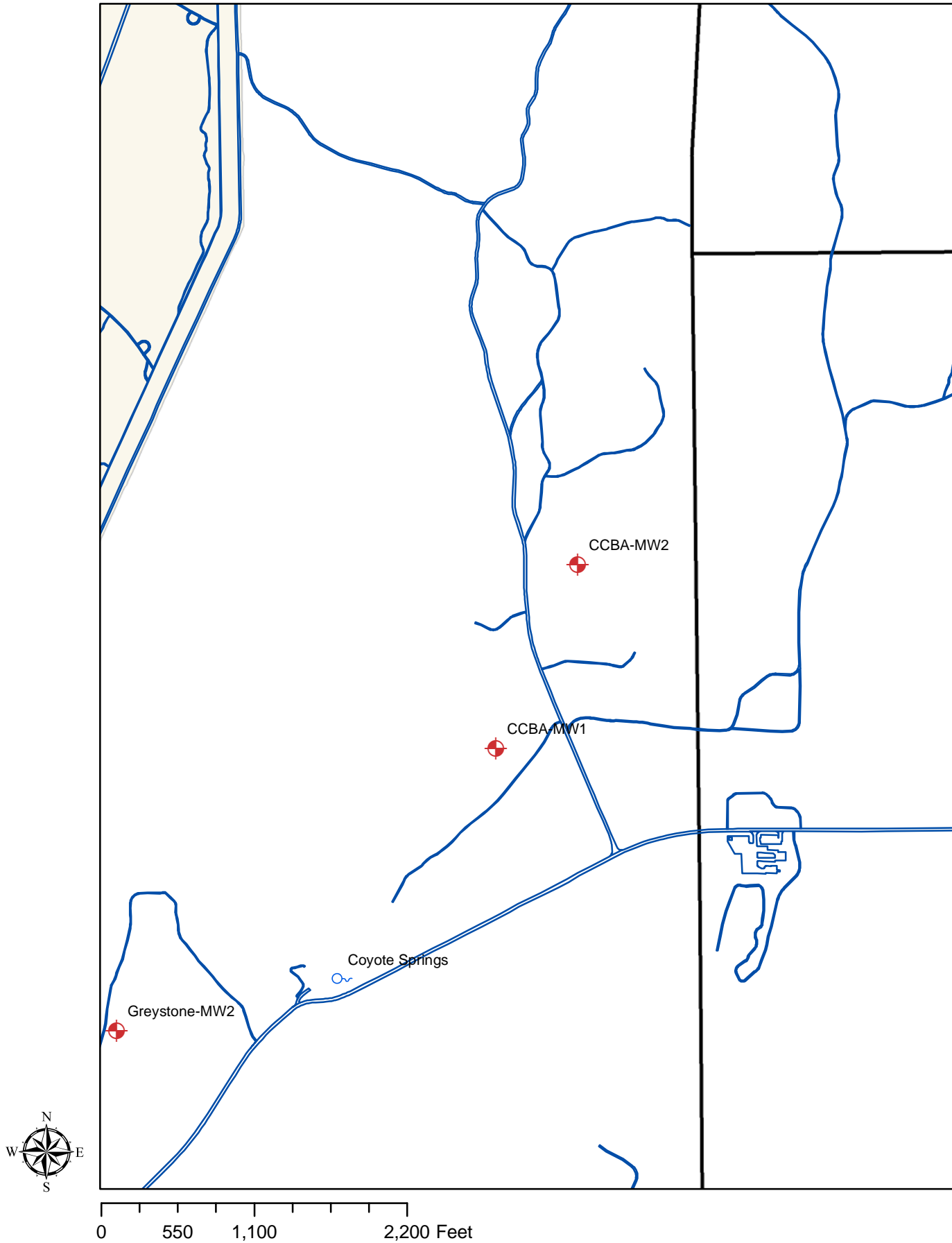
Sites A and B Location Map



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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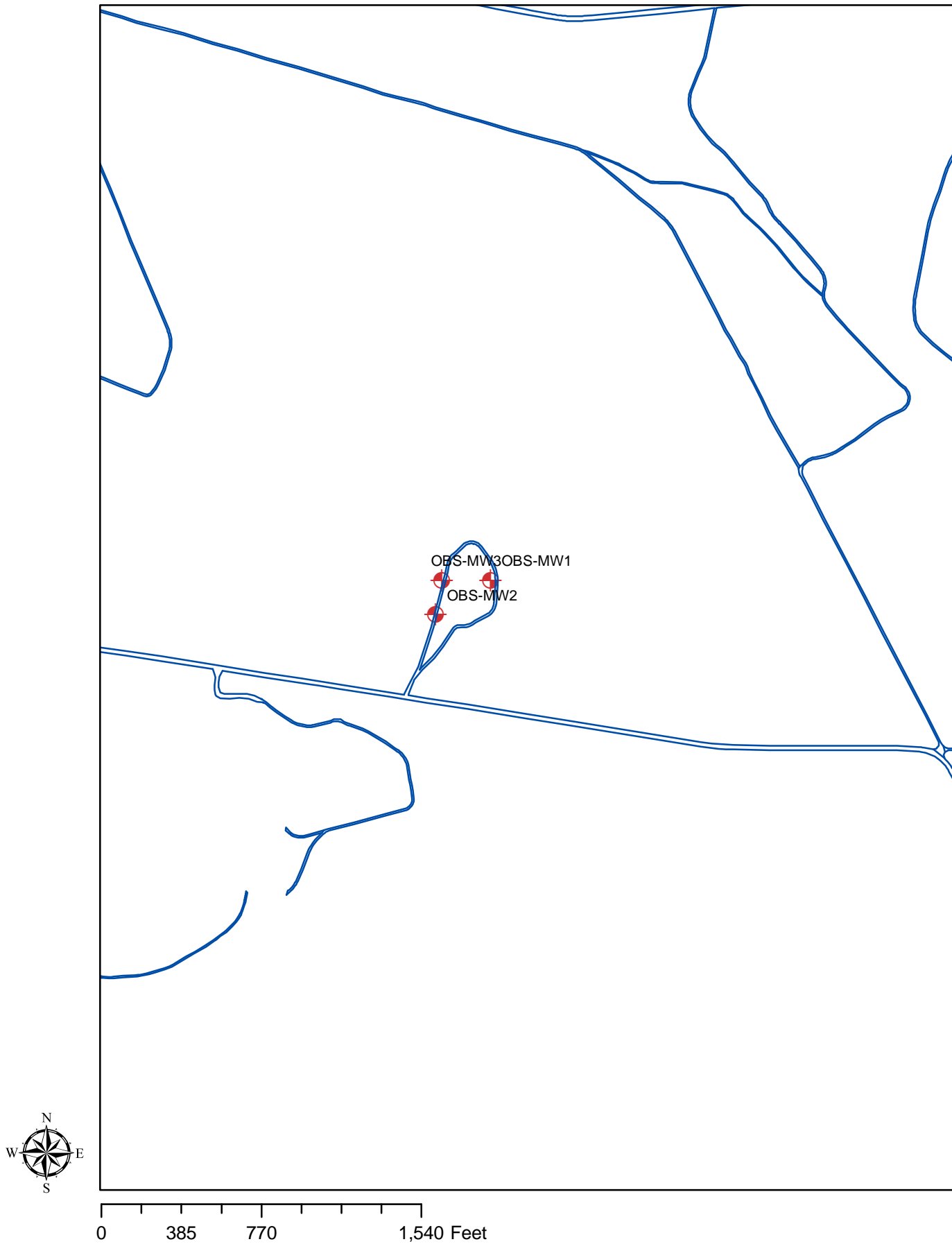
Location A Wells CCBA-MW1 and CCBA-MW2



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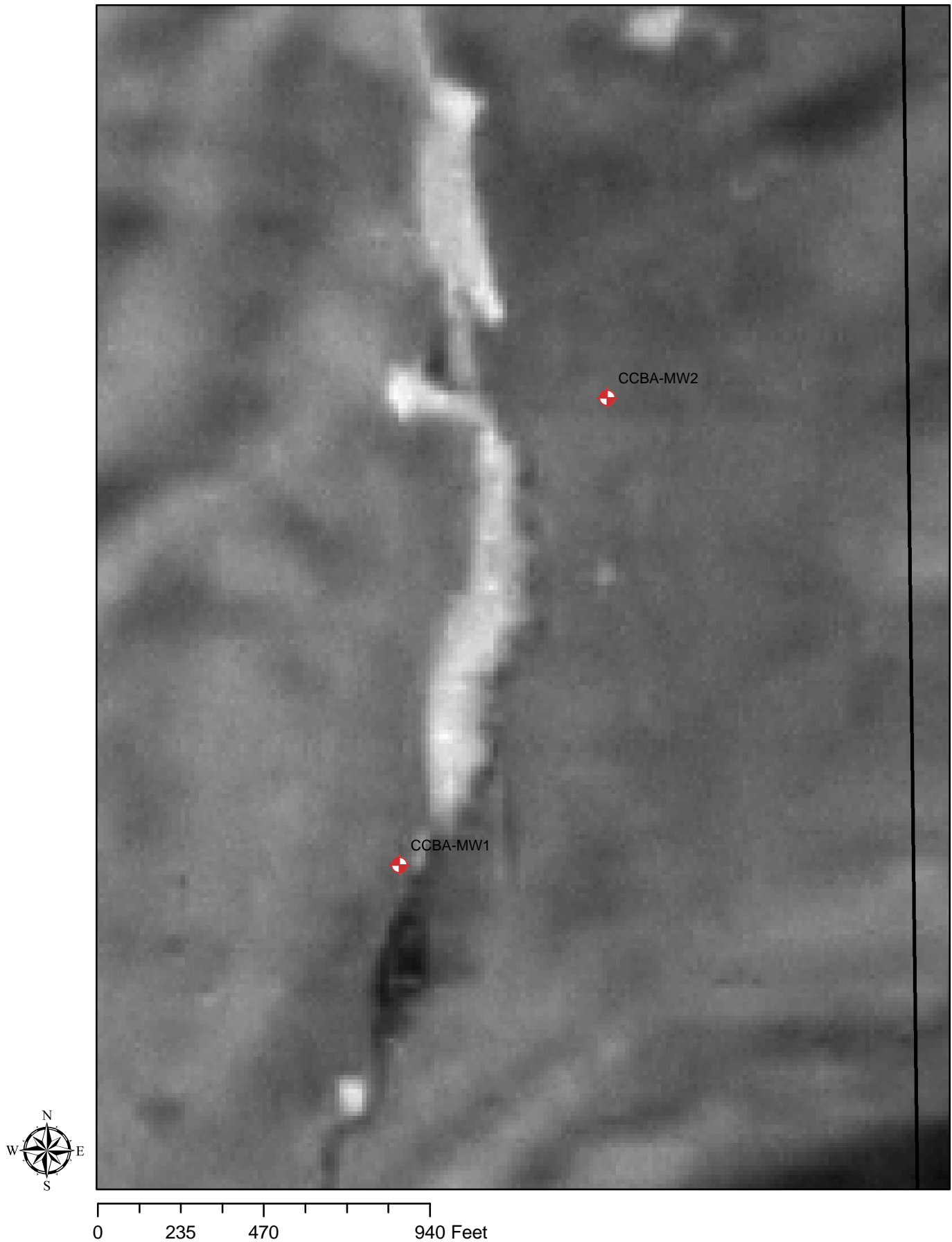
Location B Wells OBS-MW1, OBS-MW2, and OBS-MW3



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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Site A Location Aerial Photo 1935



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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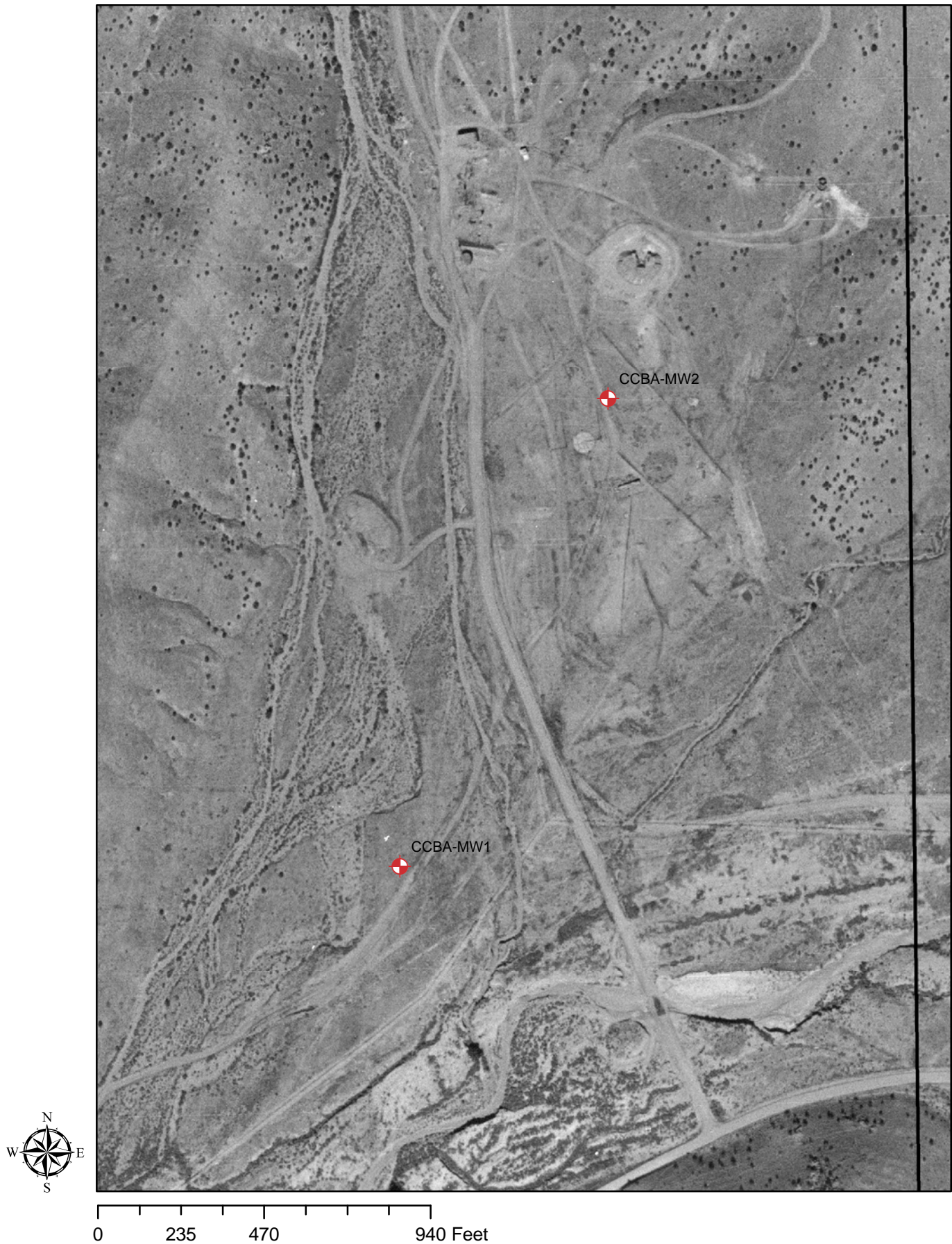
Site A Location Aerial Photo 1951



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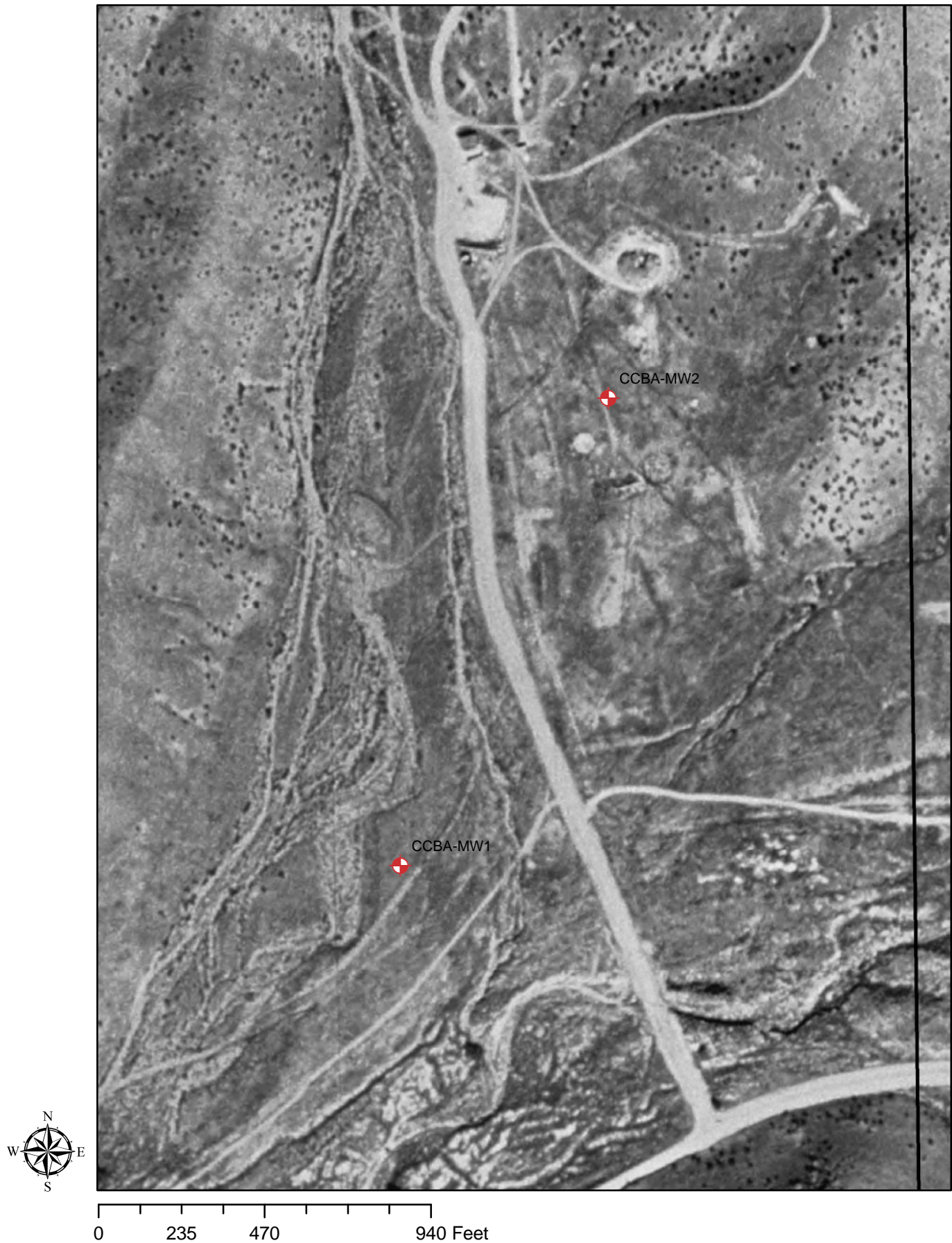
Site A Location Aerial Photo 1967



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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Site A Location Aerial Photo 1982



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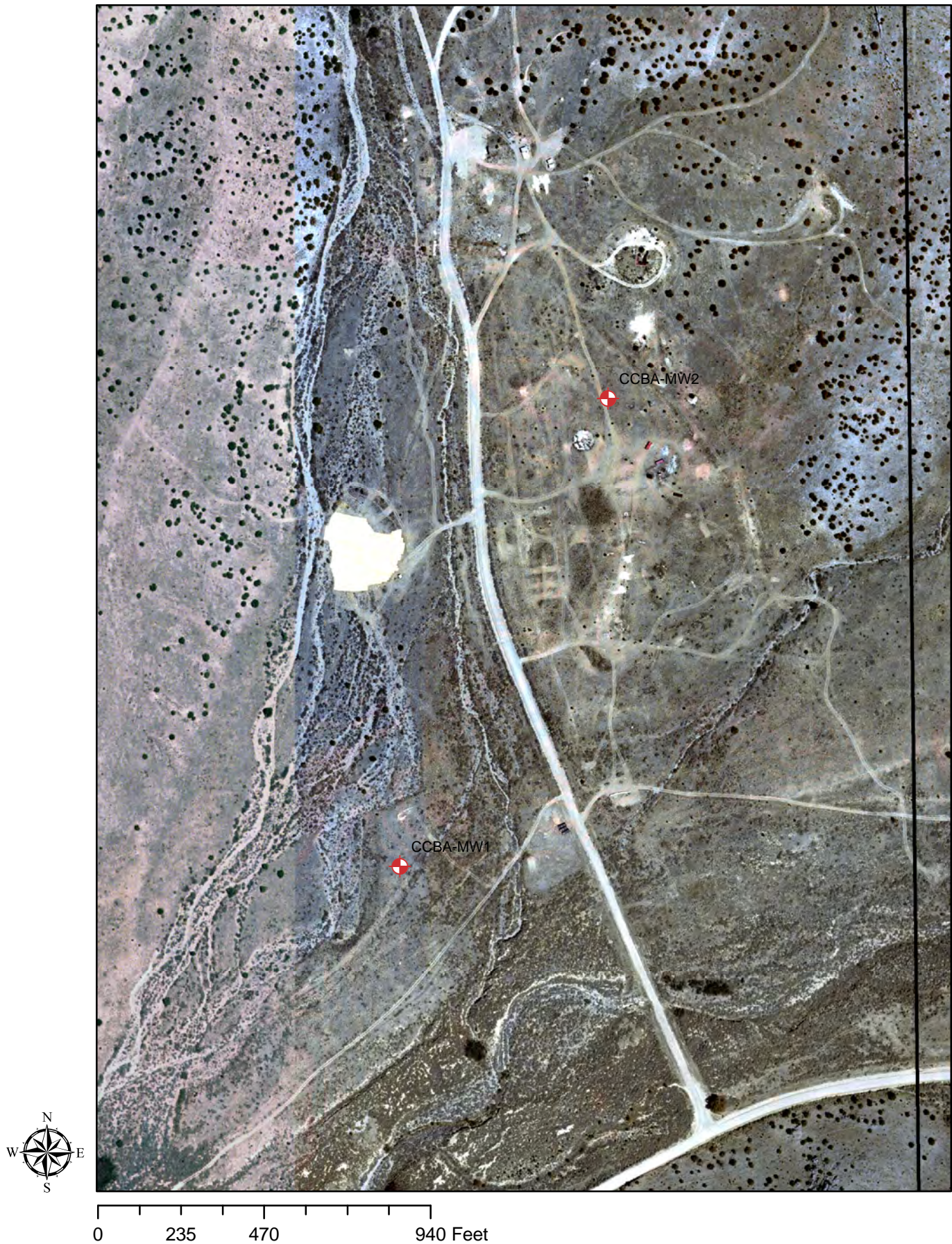
Site A Location Aerial Photo 1990



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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Site A Location Aerial Photo 2002



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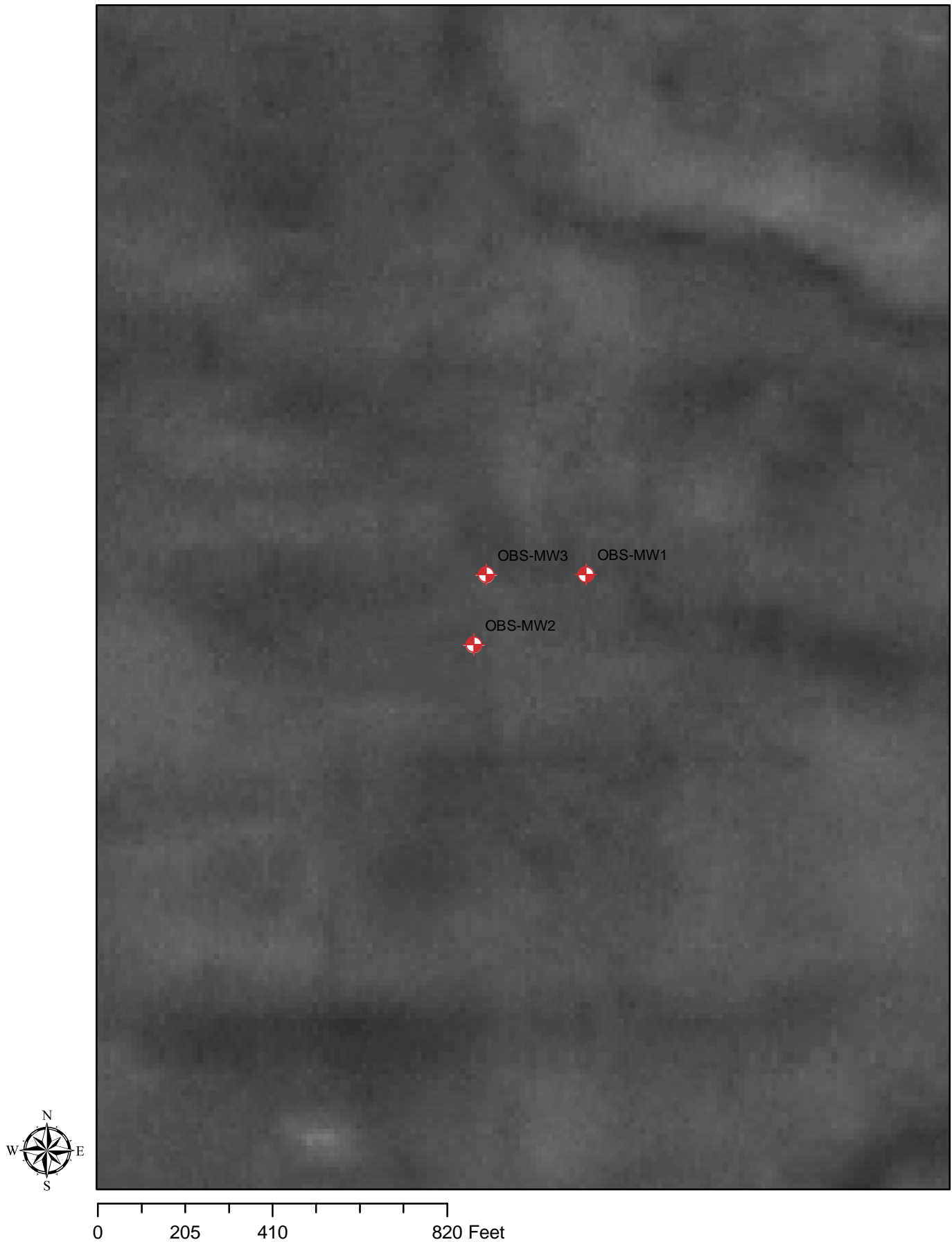
Site A Location Aerial Photo 2010



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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Site B Location Aerial Photo 1935



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Site B Location Aerial Photo 1951



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Site B Location Aerial Photo 1967



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Site B Location Aerial Photo 1983



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Site B Location Aerial Photo 1990



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Site B Location Aerial Photo 2002



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Site B Location Aerial Photo 2010



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**INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER
MONITORING WELLS**

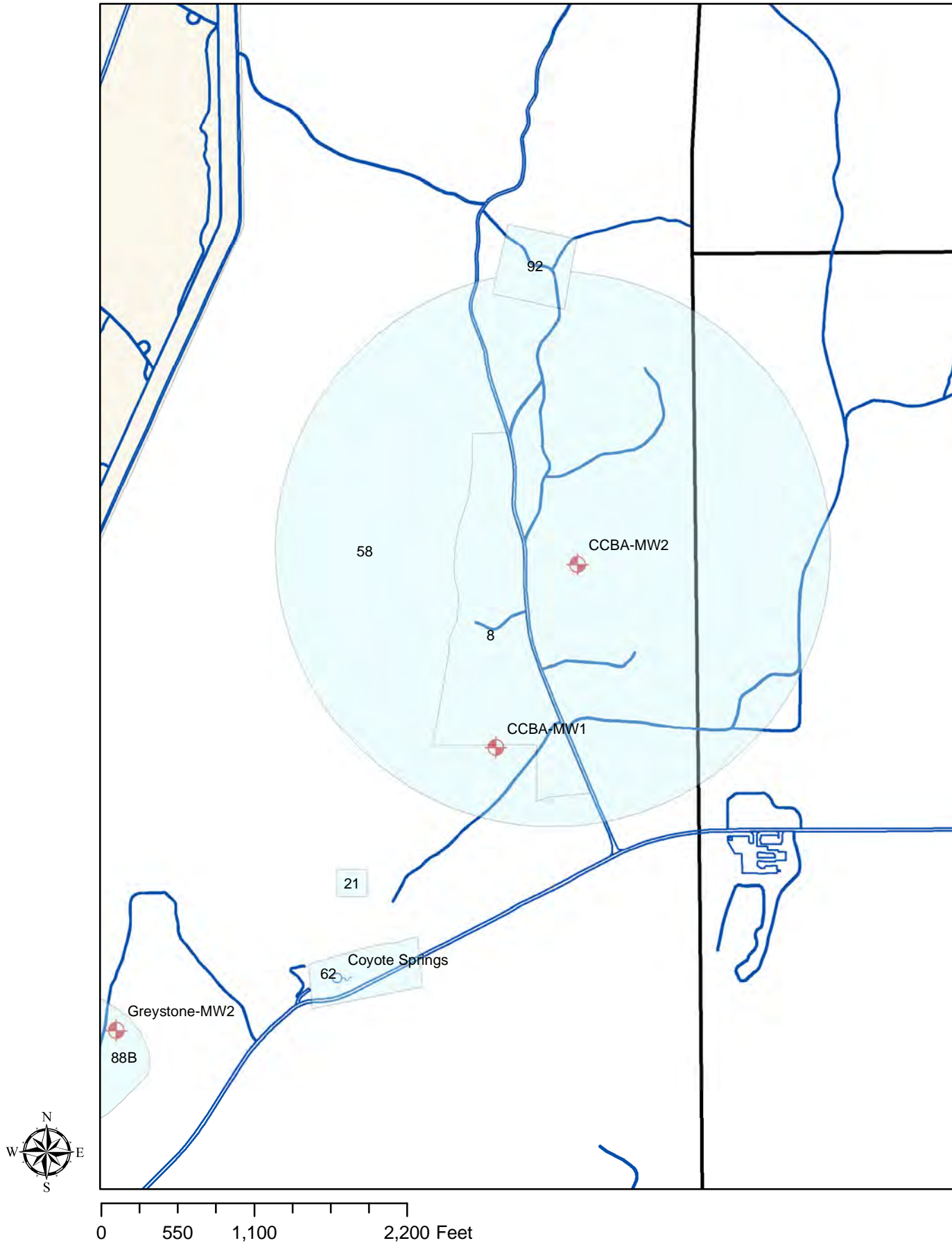
Appendix B

Environmental Restoration Program Site Location Maps

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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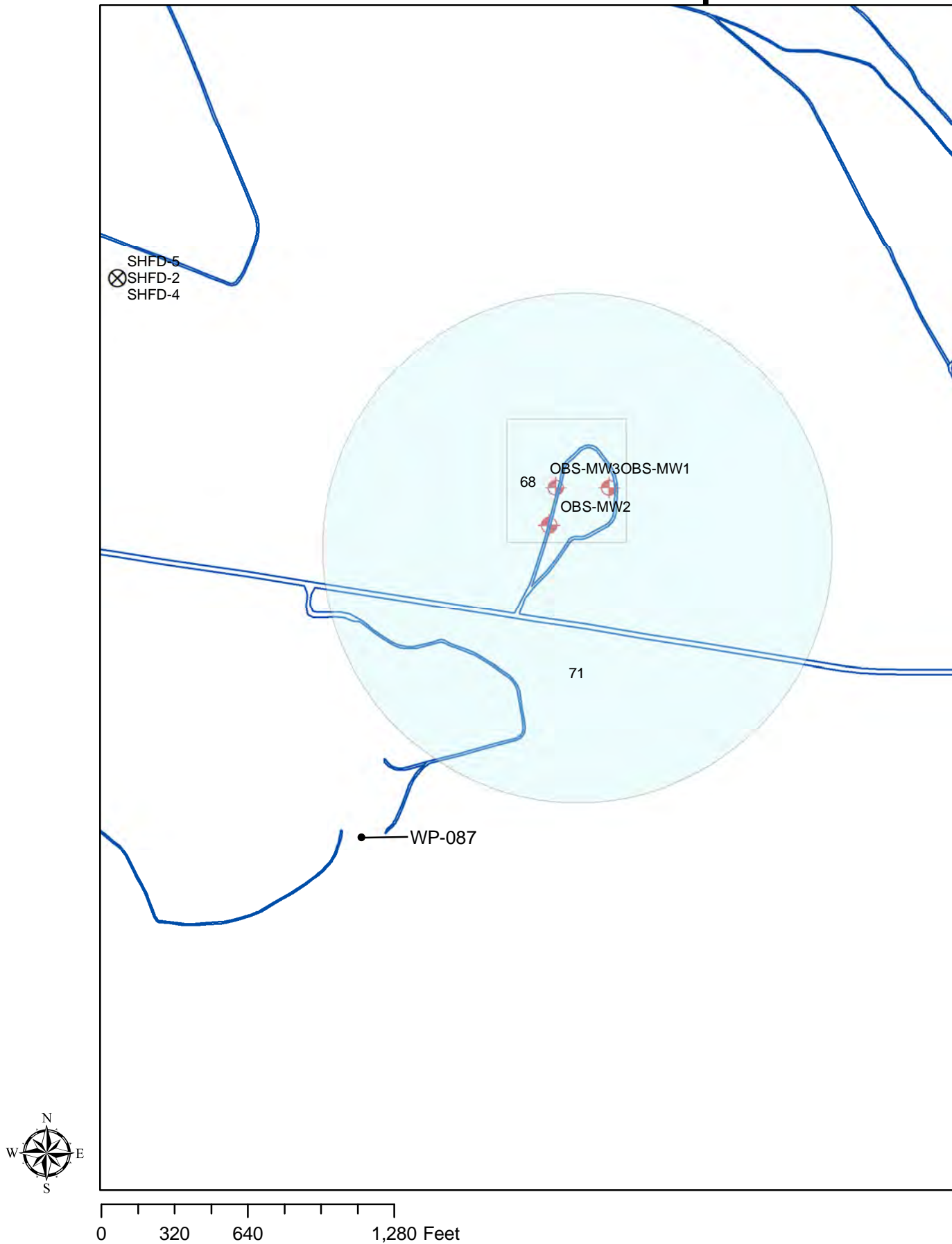
Location A SNL ER Sites



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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Location B SNL ER and KAFB ERP Sites Map



INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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**INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER
MONITORING WELLS**

Appendix C

**Relevant Citations from
Sandia National Laboratories/New Mexico
Environmental Information Document**

SAND2004-5058
Printed October 2004

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

GEOLOGY

(EID Chapter 1, Geology)

Local Faults

The KAFB is located in a structurally complex area. A number of major regional faults intersect within the area, resulting in a diverse pattern of fault trends and displacements. Generally, these faults are west-dipping normal faults that exhibit down-to-the-west displacement. There is no record of movement on these faults in historic times or during the last 10,000 years.

Soils

Overview and Geomorphic Relations

Surface soils at KAFB are developed in fluvial, alluvial-fan, colluvial, and eolian surficial deposits. Variations in soil properties reflect differences in sediment characteristics, length of exposure to surficial weathering, and local climate. Soils within the Llano de Manzano geomorphic province are developed primarily in:

- Alluvium derived from schist, greenstone, sandstone, siltstone, and limestone in the Manzanita Mountains
- Granitic alluvium derived from the Manzano Area (Four Hills)
- Eolian deposits in the McCormick Ranch subprovince

In general, soils developed on middle- to late-Pleistocene alluvial fans in the Upper Llano de Manzano and Manzano Area (Four Hills) subprovinces and on thin pediment deposits in the Tijeras Arroyo subprovince contain well-developed argillic (clay-rich) and calcic (calcium carbonate-rich) horizons. These horizons probably influence rates of infiltration and the geochemistry of percolating water. There is a moderate possibility of surface erosion of these soils, which primarily include:

- Tijeras gravelly, fine sandy loam
- Wink fine sandy loam
- Madurez loamy fine sand and Latene sandy loam

In the Upper Llano de Manzano and Manzano Area subprovinces, soils in Holocene deposits are less developed than those on older surfaces; e.g., soils developed on younger fans derived from the western side of Manzano Area include the Embudo gravelly fine sandy loam and the Tome very fine sandy loam. Moderately developed calcic horizons in these soils influence rates of infiltration and the geochemistry of percolating water. Areas underlain by the Embudo-Tijeras complex in this area contain Embudo soils in drainages and Tijeras soils on ridges, which is a result of erosion of the Tijeras soils. The heterogeneity of this complex shows that the locations and rates of infiltration, potential for surface erosion, and geochemical interactions between soils and percolating water may vary substantially in this part of KAFB.

Soils associated with the Tijeras Arroyo and Arroyo del Coyote valley floors are generally well drained, have moderate permeability, and have high potential for surface erosion. The Gila fine sandy loam is associated with the floors of large, active arroyos, such as the Tijeras Arroyo. This poorly developed soil lacks evidence of substantial clay or salt accumulation and likely

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

allows for rapid percolation of surface water. Escarpments flanking the large arroyos in the western part of KAFB are associated with poorly developed soils, such as the Bluepoint-Kokan association. Areas underlain by this soil series, however, locally contain well-developed calcic horizons, which are remnants of the Tijeras, Wink, and Madurez soils originally developed on older surficial deposits. The Bluepoint-Kokan soils reflect erosion of older soils and therefore are characterized by discontinuous soil horizons. This heterogeneity strongly influences the location and rates of infiltration and geochemical interactions between surface soils and percolating water.

Soils developed in the bedrock uplands and small valleys in the eastern part of KAFB (e.g., the Manzanita Mountains subprovince) are heterogeneous, consisting of the poorly developed soils of the Rock Outcrop-Orthids complex, the moderately developed Salas complex, and the moderately developed Tesajo-Millet series. The Rock Outcrop-Orthid soils are formed in limestone, sandstone, and schist bedrock and are characterized by substantial variation in carbonate content. The Salas complex contains well-drained soils developed in residuum derived from schist bedrock, and characterized by moderate amounts of clay and carbonate accumulation. The Tesajo-Millet soils are formed in alluvium on valley floors and low terraces. These three soil complexes differ substantially in properties that probably influence interactions between surface and vadose water.

Soils are developed in silty, sandy surficial deposits in the McCormick Ranch subprovince, in contrast to the coarse-grained deposits of the Upper Llano de Manzano subprovince. Eolian influx into surficial deposits and soil horizons is probably substantial in this subprovince. It is likely that the eolian dunes and eolian-modified alluvium are a substantially different parent material than that for limestone- and sandstone-rich alluvium in the Upper Llano de Manzano subprovince. At present, these possible differences are poorly characterized.

Soil Series

The Embudo Series consists of deep, well-drained gravelly fine sandy loam that formed from weathered granitic rocks on old fan-shaped deposits. Elevations range from 1,525 to 1,980 meters (5,000 to 6,500 ft) with slopes of up to 5%. Tijeras and Wink soils are associated with the Embudo Series.

The Tijeras Series is yellowish-brown, gravelly fine sandy loam. Elevations range from 1,524 to 1,980 m (5,000 to 6,500 ft), with 1% to 5% slopes. Embudo, Madurez, and Latene soils comprise 20% of this unit.

HYDROLOGY

(EID Chapter 3, Hydrology and Water Resources)

Hydrogeologic System

KAFB area topography is characterized by a series of coalescing alluvial fans of Holocene age that extend from the base of the mountains to the east to terraces along the Rio Grande. The north- to south-striking Sandia fault enters the base from northwest of the Four Hills area that comprise the Manzano Area uplift; almost co-linearly, the Hubbell Springs fault enters from the south, and the Tijeras fault cuts the base diagonally from the northeast. The fault system

bisects the area occupied by the KAFB. East of the Hubbell Springs and Sandia faults, the thin fan deposits rest on eroded pediment slopes with outcrops at various locations of Paleozoic and

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Precambrian rocks. West of the faults, the bedrock has been down-dropped into the basin, and the hydrogeologic setting consists of thick sedimentary deposits. Primarily on the basis of the complex fault structure, the local groundwater system can be divided into three distinct hydrogeologic regions: Hydrogeologic Region 1 (HR-1) is the region west of the fault system; Hydrogeologic Region 2 (HR-2) is associated with the fault system; and Hydrogeologic Region 3 (HR-3) is east of the fault system.

Hydrogeologic Region 1

The uppermost aquifer underlying HR-1 is within the upper Santa Fe Group, and is an unconsolidated to partially indurated, porous-media aquifer. The sediments that provide the framework for this aquifer include a heterogeneous mixture of coarse- to fine-grained sands, silts, and clays that exhibit a complex sedimentary structure, characterized by variability in bedding thickness, continuity, and connectivity. The complex sedimentary framework is reduced to two major subsets: (1) the ancestral Rio Grande fluvial facies, and (2) the alluvial fan facies, extending westward from the highlands across the fault zone and into the basin. Their juncture is effected by mutual interfingering rather than a distinct, well-defined boundary. The fluvial facies includes thick, well-sorted, cross-stratified sand and pebbly gravel channel deposits, and fine- to medium-grained sand overbank deposits. This fluvial facies is characterized by well-developed bedding, with channel deposits generally oriented north-south. The alluvial fan facies is characterized by poorly-sorted, weakly-stratified sand and conglomerate with an abundant silt and clay matrix. In this facies, the bedding is less continuous, with channel deposits generally oriented east-west.

Hydrogeologic Region 2

HR-2 straddles the Sandia/Tijeras/Hubbell Springs fault complex. The subsurface geology of HR-2 includes Santa Fe Group sediments to the south, a poorly-to-moderately cemented Tertiary conglomerate near the center, and Paleozoic/Precambrian bedrock to the north. The saturated zone hydrology is characterized by a flow system complicated by the juxtaposition of different stratigraphic units across one or more faults. The faults themselves also have a significant impact on groundwater flow.

Hydrogeologic Region 3

HR-3 is in the eastern portion of the KAFB area. The subsurface and exposed bedrock stratigraphy includes an unnamed, lower Tertiary unit; Paleozoic Yeso, Abo, Sandia, and Madera formations; and Precambrian igneous and metamorphic rocks. Faulting complicates this general stratigraphic framework. A thin veneer of alluvial material overlies portions of the bedrock. The saturated zone hydrology includes shallow, unconfined alluvial aquifers (especially in the foothill canyons) and confined bedrock aquifer systems. The bedrock aquifers include one or more confined porous-media aquifers in sandstones of the Paleozoic units (Yeso, Abo, and Sandia formations), and one or more confined fractured aquifers in the Paleozoic Madera limestone and Precambrian rocks.

Groundwater System Characteristics

The groundwater characteristics within the KAFB area vary among and within HRs-1, -2, and -3. These characteristics include aquifer types (i.e., unconfined/confined, porous media/fractured rock, and regional/perched), hydraulic properties (hydraulic conductivity, storativity, and porosity), horizontal groundwater-flow directions, vertical hydraulic gradients, trends in water-level decline resulting from water supply pumping, and groundwater geochemistry. Many of

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

these characteristics are directly related to the geologic media that provide the local framework for the regional aquifer.

Aquifer Types - The regional aquifer underlying HR-1 and the southern portion of HR-2 is a porous media aquifer in the upper unit of the Santa Fe Group. In HR-1, this upper unit includes two depositional facies: a fluvial facies deposited by the south-flowing ancestral Rio Grande and an alluvial fan facies deposited into the basin from the eastern mountains. These two facies intertongue along a north-south trend that bisects the locale near SNL/NM TA-III and TA-V. In the alluvial fan facies, field data from boreholes drilled in 1992 at SNL/NM's Liquid Waste Disposal System (LWDS) site and the Mixed Waste Landfill (MWL) indicate that the uppermost part of the aquifer may be semiconfined.

Shallow groundwater above the regional aquifer has been identified in the Tijeras Arroyo Groundwater (TAG) investigation area in the vicinity of TA-I, TA-II, and TA-IV underlying a large area extending from the Tijeras Arroyo Golf Course northwest to KAFB's former sewage lagoons near monitoring well KAFB-0506. Depth to groundwater in this perched zone ranges from 267 to 340 ft below ground surface. Based on a comparison of water level dynamics in wells completed in the shallow zone and the dynamics in nearby wells in the regional aquifer, the two aquifers appear to not be hydraulically connected in the central and western portion of the area. Furthermore, based on the analysis of core and geophysical well logs, the sediments between the two zones do not appear to be continuously saturated. Recent analyses of water levels and borehole geophysical logs suggest that the perched zone and the regional aquifer merge to the southeast. Shallow saturation may exist at other areas where natural or induced recharge is concentrated.

The uppermost aquifer in HR-2 occurs in three very different types of geologic media. In the southern portion of HR-2, the uppermost aquifer is a porous media aquifer in the alluvial fan facies of the upper Santa Fe Group. In the central portion of HR-2, between the Tijeras and Hubbell Springs faults, the aquifer unit is a poorly-to-moderately well-cemented Tertiary conglomerate. A pilot borehole drilled at the Solar Tower West (STW) monitoring well location

indicated the conglomerate extended to a depth greater than 500 ft. Several instances of significant loss of drilling fluid circulation during drilling at the STW location suggest the conglomerate may be weakly cemented or significant fractures exist within the cemented conglomerate. The northern portion of HR-2 includes the area between the Sandia and Tijeras faults. In this area, the uppermost aquifer may be in the thin alluvial cover or in the underlying granitic bedrock. An aquifer present in the shallow alluvium is an unconfined, porous-media aquifer. Where the uppermost aquifer is present in granitic bedrock, it is typically confined and fractured.

In HR-3, the uppermost aquifer is in shallow alluvium, occurring locally in the foothill canyons and on the gently sloping piedmont surface in the southern part of the region and in various bedrock units. An aquifer present in the shallow, saturated alluvium is an unconfined porous-media aquifer. Groundwater occurrence in the bedrock aquifer includes both confined, porous-media aquifers in sandstone/siltstone units and confined, fractured-rock aquifers in limestone and igneous/metamorphic rock.

Hydraulic Properties - The surface of the regional aquifer of the uppermost Santa Fe Group (in HR-1 and -2) underlying the KAFB area occurs in the fluvial facies of the ancestral Rio Grande to the west and in alluvial fan facies to the east. Based on an assessment of the ratio of sand + gravel to silt + clay in various lithofacies of the Santa Fe Group, estimated hydraulic conductivities in the upper Santa Fe Group could range from less than 0.3 ft per day in alluvial

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

fan facies to more than 30 ft per day in the fluvial facies. However, more recent aquifer test data from Chemical Waste Landfill (CWL) wells, TA-V, and elsewhere shows that hydraulic conductivities range from less than 0.1 ft per day to more than 100 ft per day. Hydraulic conductivity data for the fluvial facies of the ancestral Rio Grande is available from aquifer pumping tests performed on water supply wells. (These wells are generally screened over large intervals that include thick sections of the fluvial facies.) Slug tests and aquifer pumping tests in monitoring wells known to be completed in the fluvial facies also provide data.

VEGETATION

(EID Chapter 5, Ecology)

Grassland Habitat

The grassland habitat occupies the lower alluvial slopes and terrace surfaces of the Rio Grande Valley near the City of Albuquerque. It is the dominant habitat type on the KAFB west of the Withdrawn Area. Soils supporting grassland vegetation are typically fine sandy loams to gravelly sandy loams with slopes of less than 5%. These soils include: Latene Series, Wink Series, Madurez Series, Tijeras Series, Embudo Series, and Tome Series.

Steeper slopes in this habitat occur on the low hills in the southern portion within the KAFB boundary and along both sides of the Tijeras Arroyo floodplain. The soils in these areas are coarser and include the Laporte-Rock Outcrop-Escabosa complex and the Bluepoint-Kokan association, respectively.

Reference documents use various names to identify the vegetation of the grassland habitat depending on the classification system used. Under the hierarchical classification system and map of the biotic communities (biomes) in the southwestern United States developed in "Biotic Communities of the American Southwest - United States and Mexico," *Desert Plants* (Brown et al., 1982), the area within the KAFB boundary is located at the juncture of the Chihuahuan Semidesert Grassland, a warm-temperate biome, and the Great Basin Scrub Grassland and the Plains Grassland, both cold-temperate biomes. All three of these biomes influence the grassland vegetation of the area, with the appearance of each influenced by changes in elevation, slope, exposure, and soil.

The influence of the Chihuahuan Semidesert Grassland is most prevalent at lower elevations and southern exposures. It is typified by the presence of black grama (*Bouteloua eriopoda*) as a dominant or codominant species, but also includes mesa dropseed (*Sporobolus flexuosus*), purple threeawn (*Aristida purpurea*), and bush muhly (*Muhlenbergia porteri*), which are typical Chihuahuan desert grasses.

The influence of the Great Basin Scrub Grassland occurs in varying degrees throughout the grassland habitat of the area within the KAFB boundary but is most prevalent in areas of more moderate exposure, sandier soils, or higher elevation than those supporting the Chihuahuan desert species. Grass species typical of the Great Basin Scrub Grassland biome include galleta (*Hilaria jamesii*), sand dropseed (*Sporobolus cryptandrus*), and Indian ricegrass (*Oryzopsis hymenoides*).

The influence of the Plains Grassland, which has affinities to the Great Plains biotic province to the east, is strongly associated with higher elevations and coarser soils than either of the previously described biomes. Grass species typical of the Plains Grassland include blue grama

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

(*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), and little bluestem (*Andropogon scoparius*).

The national vegetation classification standard (NVCS) is the current system developed by the Federal Geographic Data Committee to produce uniform statistics from vegetation cover data at the national level. According to the NVCS, the KAFB area grasslands fall into the following four grassland vegetation cover types: short grasslands, dwarf shrub grasslands, grasslands with sparse dwarf-shrubs, and large shrub grasslands.

Short Grasslands (NVCS Classification V.A.5.N.f.) are dominated by grasses less than or equal to 0.5 meters (m) in height, and shrubs are sparse.

Dwarf Shrub Grasslands (NVCS Classification IV.A.2.N.a.) have low-growing (generally less than 0.5 m tall) shrubs that comprise 25 percent or greater of the total vegetative cover, as listed in Table 1. Grasses are moderate height.

Grasslands with Sparse Dwarf-Shrubs (NVCS Classification V.A.8.N.c.) contain primarily grasses of moderate height with dwarf shrubs forming less than 25 percent cover, as listed in Table 2.

Large Shrub Grassland (NVCS Classification III.A.5.N.b.) areas are dominated by shrubs greater than 0.5 m in height, as listed in Table 3.

Table 1. Common KAFB Plants of Dwarf Shrub Grasslands Cover Type

New Mexico needle and thread grass (<i>Stipa neomexicana</i>)	Ring muhly grass (<i>Muhlenbergia torreyi</i>)
Black grama grass (<i>Bouteloua eriopoda</i>)	Winterfat (<i>Krascheninnikovia lanata</i>)

Table 2. Common KAFB Plants of Grasslands with Sparse Dwarf-Shrubs Cover Type

Black grama grass (<i>Bouteloua eriopoda</i>)	Silverscale saltbush (<i>Atriplex argentea</i>)
Spike dropseed Grass (<i>Sporobolus contractus</i>)	Tumbleweed (<i>Salsola tragus</i>)

Table 3. Common KAFB Plants of Large Shrub Grasslands Cover Type

Sand sage (<i>Artemisia filifolia</i>)	Indian ricegrass (<i>Achnatherum hymenoides</i>)
Galleta grass (<i>Pleuraphis jamesii</i>)	Spike dropseed grass (<i>Sporobolus contractus</i>)

A distinctive element of the grassland vegetation within the KAFB area is New Mexico porcupine grass (*Stipa neomexicana*), which occurs in nearly monotypic stands, especially on alluvial slopes near the base of the mountains. Near the western boundary fence of KAFB, sand sagebrush dominates the vegetation in a true scrubland. Also of interest is a relict stand of creosote bush (*Larrea tridentata*) on the south-facing slope of a low hill in the North Thunder Range area of the Coyote Test Field and west of the Lovelace Respiratory Research Institute. This shrub species is characteristic of the warm-temperate deserts of North America.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

The grassland vegetation in the area is generally in very good condition and relatively free of shrubs and subshrubs over wide areas. Natural and human-caused fires occur periodically in the grassland areas and may be important in maintaining the dominance of grasses over woody plants. The current condition of the grasslands is also due to the long period of protection from grazing within the KAFB boundaries. A possible result of no cattle grazing is the presence of the grama grass cactus (*Pediocactus papyracanthus*). This small and cryptic cactus was previously listed as endangered by the State of New Mexico; however, it was delisted in 1995, in part as a result of the numbers found during sensitive species surveys conducted on site and on other lands protected from grazing. Although not abundant, this plant is widely distributed in the grassland habitat. The visnagita cactus (*Neolloydia intertexta*) and Wright's pincushion cactus (*Mammillaria wrightii*) are two other species of small grassland cacti that were previously listed as endangered by the State of New Mexico but were delisted in 1995. These species are limited in occurrence to the eastern part of the grassland habitat, near the transition with the woodlands.

Grassland Wildlife Communities

A lack of surface water is prevalent in the grassland habitats. No amphibians are documented in any grassland habitat on the site. Certain species, such as spadefoots and some toads that are capable of breeding in ephemeral surface water and spending long periods in dormancy underground during dry conditions, are expected to occur in parts of the grasslands. The western box turtle (*Terrapene ornata*) has been observed in the grasslands, and lizards are common in these habitats. Table 4 lists common grassland reptiles.

Table 4. Common Grassland Reptiles

New Mexico whiptail lizard (<i>Cnemidophorus neomexicanus</i>)	Side-blotched lizard (<i>Uta stansburiana</i>)
Lesser earless lizard (<i>Holbrookia maculata</i>)	Roundtail horned lizard (<i>Phrynosoma modestum</i>)
Great Plains skink (<i>Eumeces obsoletus</i>)	Bullsnake (<i>Pituophis melanoleucus</i>)
Western rattlesnake (<i>Crotalus viridis</i>)	Western diamondback rattlesnake (<i>Crotalus atrox</i>)

Raptors hunt in grassland areas throughout the year, but the lack of nesting sites (e.g., trees, cliffs) limits the use of this habitat type for breeding purposes. Manmade structures may occasionally be used by some species for nesting. The more common raptor and other bird species known to occur in the grassland habitat appear in Table 5. Turkey vultures (*Cathartes aura*) are common scavengers in this habitat.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Table 5. Common Grassland Birds

Red-tailed hawk (<i>Buteo jamaicensis</i>)	Scaled quail (<i>Callipepla squamata</i>)
American kestrel (<i>Falco sparverius</i>)	Say's phoebe (<i>Sayornis saya</i>)
Horned lark (<i>Eremophila alpestris</i>)	Burrowing owl (<i>Speotyto cunicularia</i>)
Eastern meadowlark (<i>Sturnella magna</i>)	Western meadowlark (<i>Sturnella neglecta</i>)

Rodents and lagomorphs (rabbits and hares) dominate the mammal community in the grasslands. Table 6 lists common mammals known to occur in the grasslands.

Table 6. Common Grassland Mammals

Spotted ground squirrel (<i>Spermophilus spilosoma</i>)	Gunnison's prairie dog (<i>Cynomys gunnisoni</i>)
Silky pocket mouse (<i>Perognathus flavus</i>)	Ord's kangaroo rat (<i>Dipodomys ordii</i>)
Banner-tailed kangaroo rat (<i>Dipodomys spectabilis</i>)	Merriam's kangaroo rat (<i>Dipodomys merriami</i>)
Western harvest mouse (<i>Reithrodontomys megalotis</i>)	White-footed mouse (<i>Peromyscus leucopus</i>)
Northern grasshopper mouse (<i>Onychomys leucogaster</i>)	Deer mouse (<i>Peromyscus maniculatus</i>)
Coyote (<i>Canis latrans</i>)	Kit fox (<i>Vulpes macrotis</i>)
Striped skunk (<i>Mephitis mephitis</i>)	Bobcat (<i>Lynx rufus</i>)

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Appendix D

Site Inspection Photographs

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Site Inspection Photographs



Photograph D-1. Site A looking south toward well CCBA-MW1.



Photograph D-2. Site A looking southwest toward well CCBA-MW2.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS



Photograph D-3. Site B looking east toward well OBS-MW3.



Photograph D-4. Site B looking northeast toward wells OBS-MW1 and 2.

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Appendix E

References

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Appendix F

Personal Interviews

INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

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INSTALLATION OF FIVE NEW HYDROGEOLOGIC GROUNDWATER MONITORING WELLS

Personal Interviews

- Sandia Corporation Hydrologist working in the Environmental Safety and Testing Organization 06234 was interviewed on November 14, 2012. Christopher Catechis, Sandia National Laboratories, spoke with the Hydrologist regarding Sandia National Laboratories environmental restoration activities at the well sites and the overall groundwater monitoring program at Sandia National Laboratories.
- Sandia Corporation Real Estate Specialist working in the Facilities Management and Operations Center Organization 04853 was interviewed on November 14, 2012. Christopher Catechis, Sandia National Laboratories, spoke with the Real Estate Specialist regarding the land use permit for the hydrogeologic wells and the proposed site boundaries and overall site footprint for the wells.

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