FACT SHEET/STATEMENT OF BASIS

Remedy Selection for the Tijeras Arroyo Groundwater Area of Concern

RCRA Permit Number NM5890110518

SANDIA NATIONAL LABORATORIES NEW MEXICO

August 2022

FACT SHEET/STATEMENT OF BASIS

Proposed Corrective Action Remedy for the
Tijeras Arroyo Groundwater Area of Concern
Class 3 Modification to the
Resource Conservation and Recovery Act (RCRA) Permit
Sandia National Laboratories
Albuquerque, New Mexico
EPA ID No. NM5890110518

INTRODUCTION

The New Mexico Environment Department (Department/NMED) proposes to select a remedy for corrective action for the Area of Concern (AOC) Tijeras Arroyo Groundwater (TAG) at Sandia National Laboratories (SNL). The United States Department of Energy/National Nuclear Security Administration (DOE/NNSA) and National Technology and Engineering Solutions of Sandia, LLC (NTESS) conducted a Corrective Measures Evaluation (CME) to evaluate different alternatives for remediation of the TAG and submitted a Revised CME Report to NMED on February 14, 2018 (SNL 2018a). NMED is proposing this action under the New Mexico Hazardous Waste Act, NMSA 1978 §§ 74-4-1 to 74-4-17, and under the terms of the Compliance Order on Consent (Consent Order), dated April 29, 2004, executed by NMED and by the DOE and Sandia Corporation. The TAG has been under investigation since the 1990s. Based on the information collected, NMED intends, pending public input, to select a remedy for the AOC TAG.

I. FACILITY OPERATIONS

SNL is located within the boundaries of Kirtland Air Force Base (KAFB) adjacent southeast of Albuquerque in Bernalillo County, New Mexico. KAFB covers 52,223 acres on a high arid mesa approximately 5 miles east of the Rio Grande. SNL occupies 2,829 acres of land owned by the DOE and an additional 14,920 acres of land provided through land-use permits with KAFB, the U.S. Forest Service (USFS), the State of New Mexico, and the Isleta Pueblo Indian Reservation. Sandia Corporation, a former subsidiary of American Telephone and Telegraph (AT&T) Corporation, operated the properties for the DOE from the time of its opening in 1945 until September 1993, when Martin Marietta Corporation (now Lockheed Martin) took over operations from AT&T. The management and operating name changed on May 1, 2017 from Sandia Corporation to National Technology and Engineering Solutions of Sandia, LLC (NTESS). NTESS is owned by Honeywell International. The Facility is owned by the DOE and jointly operated by the DOE and NTESS.

SNL is engaged in research and development of conventional and nuclear weapons, alternative energy sources and a wide variety of national security-related research and development. SNL consists of five technical areas (TAs) and several test areas. The primary mission of SNL is to provide engineering and testing support for nuclear weapons components and related systems. During the late 1940s, the final assembly of weapons was conducted at SNL. Since 1949, SNL has been dedicated to research, development, and testing. SNL currently employs approximately 9,300 people. Because of its testing and research activities, SNL generates hazardous, radioactive, mixed (wastes containing both hazardous and radioactive components), and solid wastes. From

1945 to 1988 most of these wastes were disposed of at SNL at numerous locations which have been classified by NMED as Solid Waste Management Units (SWMUs). The SWMUs include unpermitted landfills, septic system drain-fields and seepage pits, outfalls, waste piles, test areas, and surface discharge sites. Past waste management activities at SNL have caused the release of hazardous, mixed, and radioactive contaminants into the environment.

SNL is located at 1515 Eubank SE, Albuquerque, New Mexico, 87123. The National Nuclear Security Administration (NNSA)/DOE Site Field Office is located at KAFB East of Pennsylvania & H Street, Albuquerque, NM 87116. The Permittee's primary contact for this action is Mr. Daryl Hauck, DOE/NNSA/SFO, PO Box 5400, MS-0184, Albuquerque, NM 87185.

II. STATUTORY AND REGULATORY FRAMEWORK

The Statement of Basis is a decision document that discusses the proposed remedy selection and the key information supporting the proposed selection, primarily contained in the Current Conceptual Model/Corrective Measures Evaluation (CCM/CME) Report and other reports that the Respondents have submitted to NMED. In accordance with regulatory guidance (USEPA 1991) and the Consent Order (Section VII.C.5), the purpose of the Statement of Basis is to:

- Describe the remedies that were considered;
- Identify the remedies that are proposed;
- Explain the rationale for selecting the proposed remedies;
- Solicit public review and comment on the proposed remedies; and
- Provide information on how the public can be involved in the remedy selection process.

In 1976, Congress passed, and the President signed, the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §§ 6901 to 6992k, as an amendment to the Solid Waste Disposal Act of 1965. RCRA provides for the "cradle to grave" regulation of hazardous wastes, and requires the Environmental Protection Agency to develop regulations governing the generation, transportation, treatment, storage, and disposal of hazardous wastes, including corrective action for releases into the environment of hazardous wastes or hazardous waste constituents.

On November 19, 1980, the first RCRA regulations became effective, and it became unlawful to treat, store, or dispose of hazardous waste without having, or having applied for, a permit. For existing treatment, storage, or disposal facilities, the requirement to submit an application is satisfied by submitting the "Part A" portion of the application; the "Part B" portion was allowed to be submitted at a later time. The content and function of these permit parts are explained in 40 CFR § 270.10.

EPA authorized the State of New Mexico, through the Environment Department, to implement and enforce its own hazardous waste management program, including corrective action requirements, in lieu of the federal program, under the New Mexico Hazardous Waste Act (HWA), NMSA 1978, §§ 74-4-1 to 74-4-14. The HWA authorizes the New Mexico Environmental Improvement Board (EIB) to adopt hazardous waste management regulations for the management of hazardous waste. Pursuant to this authority, the EIB has adopted the Hazardous

Waste Management Regulations (HWMR), which govern the generation, transportation, treatment, storage, and disposal of hazardous waste, including permit requirements for facilities that treat, store, or dispose of hazardous waste, and including corrective action for releases of hazardous waste or hazardous waste constituents into the environment. These regulations incorporate by reference pertinent provisions of the Federal RCRA regulations – 40 CFR Parts 260 through 270, 273, and 280 – and are codified in the HWMR, 20.4.1 NMAC.

The HWA and HWMR require each person owning or operating an existing facility or planning to construct a new facility for the treatment, storage, or disposal of hazardous waste to have a HWA permit (see 42 U.S.C. 6925 and 20.4.1.900 NMAC incorporating 40 CFR § 270.1)). The HWA and HWMR also require corrective action for all releases of hazardous waste or hazardous constituents, regardless of when waste was placed in such a unit, from any solid waste management unit at a permitted facility, or a facility seeking a permit (NMSA 1978, § 74-4-4.2(B); 20.4.1.500 NMAC, incorporating 40 CFR § 264.101(a)). Corrective action is also required for releases of contaminants beyond the facility boundary (20.4.1.500 NMAC, incorporating 40 CFR § 264.101(c)).

On January 26, 1983, RCRA subjected "units" managing and disposing of hazardous waste to the closure and post-closure standards of 40 CFR Part 264, Subpart G and Part 265, Subpart G and required a post-closure care permit in some circumstances.

On January 25, 1985, the Environment Department received from EPA authorization to implement its hazardous waste program under the HWA. 50 Fed. Reg. 1515 (Jan. 11, 1985). Subsequent program revisions were approved effective on April 10, 1990, July 25, 1990, December 4, 1992, August 23, 1994, December 21, 1994, July 10, 1995, January 2, 1996, March 10, 1997, July 13, 1998, October 9, 2001, and October 16, 2007.

On July 25, 1990, the Environment Department received from EPA authorization that clarified its authority to regulate the hazardous component of mixed waste. 55 Fed. Reg. 28397 (July 11, 1990). Mixed waste is waste that contains both hazardous waste under RCRA and source material, special nuclear material, or byproduct material under the Atomic Energy Act of 1954. Due to its hazardous component, mixed waste is regulated under RCRA.

On January 2, 1996, the State received from EPA authorization to implement the corrective action program under the HWA. See 60 Fed. Reg. 53708 (Oct. 17. 1995); 61 Fed. Reg. 2450 (Jan. 26, 1996).

On August 6, 1992, NMED issued a Hazardous Waste Facility Permit (Permit) to DOE and its contractor to operate treatment and storage facilities at SNL. NMED issued a renewed Permit to DOE and SNL (Respondents) in January 27, 2015.

The corrective action requirements in the 1992 permit were vague and largely ineffective. Consequently, on September 3, 2002, NMED issued a draft Order requiring investigation and cleanup of environmental contamination at SNL. DOE and its contractor challenged the Order in state and federal court, and the parties entered into lengthy settlement negotiations. On April 29, 2004, the parties executed the Consent Order, which requires DOE and its contractor to conduct comprehensive investigation and cleanup of environmental contamination at SNL (NMED 2004). Therefore, corrective action at SNL is addressed primarily under the Consent Order, rather than the Permit.

Section IV.C of the Consent Order required the Respondents to conduct a thorough investigation of soil, sediment, groundwater, and surface water contamination at the TAG AOC. Section VII.C of the Consent Order required the Respondents to conduct a CME for the TAG AOC to evaluate a range of potential remedial alternatives and to recommend a preferred remedy. The Respondents were required to submit a CME Report to NMED (NMED 2004).

After review of the CME Report, NMED proposes a remedy for public comment as discussed in the Statement of Basis below. The public may also request a public hearing concerning the selected remedy. NMED will select the final remedy that will be protective of human health and the environment and attain the appropriate cleanup goals. All applicable closure and post-closure requirements in 40 CFR 264.110(c), incorporated by 20.4.1.500 NMAC, must also be satisfied by the selected remedy. The alternative requirements for groundwater monitoring, as described in 40 CFR 264.90(f), incorporated by 20.4.1.500 NMAC, also apply to the remedy for the TAG AOC. Section VII.D of the Consent Order requires that the Respondents implement the selected remedy.

Section VII.C.3.a of the Consent Order states, "[t] he Respondents shall evaluate each of the remedy alternatives for the following threshold criteria. To be selected, the remedy alternative must:

1. Be protective of human health and the environment.
2. Attain media cleanup standards.
3. Control the source or sources of releases so as to reduce or eliminate, to the extent practicable, further releases of contaminants that may pose a threat to human health and the environment; and
4. Comply with applicable standards for management of wastes."(NMED 2004).

Section VII.C.3.b of the Consent Order outlines the evaluation criteria for each potential remedy under consideration. These five criteria include:

1. Long-term reliability and effectiveness
2. Reduction of toxicity, mobility, or volume
3. Short-term effectiveness
4. Implementability
5. Cost(NMED 2004).

Pursuant to Section VII.D.2 of the Consent Order, after the selection of the remedy, the Respondents shall submit a Corrective Measures Implementation (CMI) Plan for NMED approval that must meet the general requirements for closure of the TAG AOC. The CMI Plan must include the specific design of the selected remedy including construction specifications, operation and maintenance plans, performance monitoring for the selected remedy, and an implementation schedule.

Following completion of corrective measures, the Respondents are required to submit a CMI Report to NMED in accordance with Section VII.D.5.a of the Consent Order. Following NMED approval of the CMI Report, the Respondents must submit a request for a Class 3 modification to the Permit to add the TAG AOC to Table K-3 (Corrective Action Complete With Controls) or Table K-4 (Corrective Action Complete Without Controls) (NMED 2004).

III. PUBLIC PARTICIPATION

The Administrative Record for this proposed remedy selection consists of this Fact Sheet/ Statement of Basis (FS/SOB), a Public Notice, the April 29, 2004 Compliance Order on Consent (Consent Order), the Current Conceptual Model and Corrective Measures Evaluation (CCM/CME) Report, and associated investigation reports, monitoring reports, work plans, correspondence, and other referenced supporting documents. The Administrative Record may be reviewed, with prior appointment, at the following location during the public comment period.

NMED - Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone: (505) 476-6000
Monday – Friday: 8:00 a.m. to 5:00 p.m.
Contact: Naomi Gonzalez

The Administrative Record Index, Public Notice, FS/SOB, CCM/CME Report and Consent Order are also available on the NMED website at https://www.env.nm.gov/hazardous-waste/sandia-national-laboratories/#SNLTAG. To obtain a copy of the Administrative Record or a portion thereof, please contact Ms. Naomi Gonzalez at (505) 476-6000, or at address given above. NMED will provide copies, or portions thereof, of the Administrative Record at a cost to the requestor.

NMED issued this public notice on **August 5, 2022**, to announce the beginning of a 60-day comment period that will end at **5:00 p.m. MDT October 4, 2022**. Any person who wishes to comment on this action or request a public hearing should submit written or electronic mail (email) comments with the commenter's name and address to the address below. Only comments received on or before **5:00 p.m. MDT October 4, 2022** will be considered.

Dave Cobrain, Program Manager
Hazardous Waste Bureau - New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
(505) 476-6000
Email: dave.cobrain@state.nm.us
Reference: SNL TAG Remedy Selection

Written comments must be based on reasonably available information and include, to the extent practicable, all referenced factual materials. Documents in the administrative record need not be re-submitted if expressly referenced by the commenter. Requests for a public hearing shall provide: (1) a clear and concise factual statement of the nature and scope of the interest of the person requesting the hearing; (2) the name and address of all persons whom the requestor represents; (3) a statement of any objections to this action, including specific references to any conditions being addressed; and (4) a statement of the issues that the commenter proposes to raise for consideration at the hearing. Written comment and requests for a public hearing must be filed with Mr. Dave Cobrain on or before **5:00 p.m. MDT October 4, 2022**. NMED will provide a minimum thirty (30) day notice of a public hearing, if scheduled.

IV. NEXT STEPS

NMED must ensure that the selected remedies are consistent with the Hazardous Waste Act (HWA), the Hazardous Waste Management Regulations (HWMR), and the Consent Order. All written comments submitted on this matter will become part of the administrative record. NMED will consider all written comments in formulating a final decision, and it may select a different remedy based on public comments. NMED will respond in writing to all written public comments received during the public comment period. This response will specify which provisions, if any, have been changed in the final decision and the reasons for the changes; and briefly describe and respond to all public comments raised during the public comment period. All persons presenting written comments or who requested notification in writing will be notified of the decision by mail. These responses will also be posted on the NMED website.

After consideration of all the written public comments received, NMED will select the appropriate remedy for each site based on information in the administrative record. In all cases, the Respondents will be provided by certified mail a written notice in accordance with the Consent Order. NMED will make the notice available to the public.

Arrangements for Persons With Disabilities

Any person with a disability requiring assistance or auxiliary aid to participate in this process should contact Tina Montoya at the following address: New Mexico Environment Department, P.O. Box 5469, 1190 St. Francis Drive, Santa Fe, New Mexico, 87502-6110, (505) 372-9569. TDD or TDY users please access Ms. Montoya's number via the New Mexico Relay Network at 1 (800) 659-8331.

Non-Discrimination Statement

NMED does not discriminate on the basis of race, color, national origin, disability, age or sex in the administration of its programs or activities, as required by applicable laws and regulations. NMED is responsible for coordination of compliance efforts and receipt of inquiries concerning non-discrimination requirements implemented by 40 C.F.R. Part 7, including Title VI of the Civil Rights Act of 1964, as amended; Section 504 of the Rehabilitation Act of 1973; the Age Discrimination Act of 1975, Title IX of the Education Amendments of 1972, and Section 13 of the Federal Water

Pollution Control Act Amendments of 1972. If you have any questions about this notice or any of NMED's non-discrimination programs, policies or procedures, you may contact:

Kathryn Becker, Non-Discrimination Coordinator
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87502
(505) 827-2855
NMED.NDC@state.nm.us

If you believe that you have been discriminated against with respect to a NMED program or activity, you may contact the Non-Discrimination Coordinator identified above or visit our website at https://www.env.nm.gov/non-employee-discrimination-complaint-page/ to learn how and where to file a complaint of discrimination.

V. TIJERAS ARROYO GROUNDWATER (TAG) AREA OF CONCERN (AOC)

The TAG AOC is a perched aquifer located in the north-central portion of KAFB, located beneath three SNL/NM technical areas (TAs), TA-I, TA-II, and TA-IV. The TAG AOC encompasses approximately 1.82 square miles and is analogous with the previous terms "Sandia North" and "TAG Area of Responsibility (AOR)" (SNL August 2005). The focus of the TAG AOC investigation is the perched groundwater system, which is a thin, partially natural, dissipating water-bearing unit. This water-bearing unit formed because of historical anthropogenic surface and shallow subsurface discharges that occurred between approximately 1928 and 1992. These discharges may have undergone mixing with naturally occurring residual saturation as the waters percolated through the subsurface (SNL 2018a).

The perched groundwater system and the regional aquifer are separated by over 200 feet of unsaturated sediments. In the TAG AOC, groundwater in the perched groundwater system is present at depths as shallow as approximately 269 feet (ft) below ground surface (bgs), while groundwater in the regional aquifer system is present at depths of approximately 440 ft bgs. The estimated thickness of the perched groundwater system ranges from approximately 7 to 20 ft across the northern and central portions of the TAG AOC. In the southeast corner of the TAG AOC, the aquifer thickness ranges up to 40 ft. There are no production wells screened in the perched groundwater system. A series of discontinuous yet overlapping lenses of unsaturated Santa Fe Group alluvial fan sediments serve as the Perching Horizon beneath the perched groundwater system. Across the TAG AOC, the Perching Horizon has an estimated thickness ranging from 4 to 11 ft (SNL 2018a).

V.A. BACKGROUND AND HISTORY OF TAG AOC

Groundwater quality has been evaluated as part of the overall investigation of the regional aquifer beneath the Facility beginning in 1992 with the installation of three groundwater monitoring wells. During this initial investigation, the perched groundwater system was discovered at a depth of approximately 320 ft bgs. The regional aquifer was observed approximately 500 ft bgs. The perched groundwater system is contained within the Santa Fe Group alluvial fan facies and covers approximately 4.43 square miles. The lateral extent of the perched groundwater system was determined using numerous boreholes that were drilled for characterizing the two water-bearing units across the northern portion of KAFB. An abrupt edge of the limit of saturation is recognizable along nearly the entire lateral limit except at the southeast corner of the TAG AOC. The southeast edge is gradational because the perched groundwater system merges with the regional aquifer near Powerline Road and the Tijeras Arroyo Golf Course. This merging zone may result from groundwater migrating downward along the buried West Sandia Fault (SNL 2018a). The subsurface expression of this fault roughly parallels Powerline Road, which parallels the eastern boundary of the TAG AOC. The merging zone may also result from groundwater migrating downward through a localized sequence of more permeable sediments. Figure 1 presents a visualization of the TAG conceptual site model.

The perched groundwater system formed because of historical anthropogenic surface and shallow subsurface discharges that occurred between approximately 1928 and 1992 (SNL 2018a).

The TAG investigation groundwater monitoring activities are not associated with a single SWMU but have a broader scope. Remediation responsibility within the historical TAG area was assigned to three separate potentially responsible parties: DOE/ SNL, the City of Albuquerque, and KAFB. The sources of recharge were:

- The former KAFB sewage lagoons,
- Leaking water-supply lines in KAFB base housing and operational areas,
- Subsurface flow within a buried ancestral channel of Tijeras Arroyo,
- Surface water recharge from Tijeras Arroyo and Arroyo del Coyote on KAFB,
- Irrigation at the Tijeras Arroyo Golf Course,
- Watering of base housing lawns near the Gibson and Wyoming gates,
- Irrigation of the Parade Grounds (a grassy park),
- Infiltration from the Tijeras Arroyo Golf Course Main Pond,
- Leaking sewer lines in base housing and operational areas,
- Sewer line break (1994) and associated ponding on the floodplain,
- The Acid Waste Line Outfall (SWMU 46),
- TA-II personnel shower (SWMU 165), and
- TA-II wastewater outfalls (SWMUs 227 and 229).

The constituents of concern in groundwater at the TAG AOC are nitrate and trichloroethylene (TCE). The EPA's maximum contaminant level (MCL) for TCE is 5 micrograms per liter (µg/L). TCE has not exceeded the MCL in the perched groundwater system since March 2002, except at upgradient background monitoring well WYO-4 (SNL 2018b). This well is screened in the perched groundwater system near the western edge of the TAG AOC.

The MCL for nitrate is 10 milligrams per liter (mg/L). NMED has specified 4 mg/L as the maximum approved background value for nitrate at KAFB, including SNL/NM (Dinwiddie 1997). Nitrate concentrations in the perched groundwater system only exceed the MCL in the southeast corner of the AOC. The elevated nitrate concentrations in the perched groundwater system are primarily derived from domestic wastewater (sanitary waste). There are multiple sources of nitrate contamination. Details for these sites are discussed below.

V.A.1 SWMU 46 (Old Acid Waste Line Outfall)

During 1947 to 1974, an estimated 1.3 billion gallons of wastewater from six TA-I buildings discharged sequentially into three outfall ditches (SWMU 46) at the southern end of a buried 8-inch diameter sewer line (SWMU 226) (SNL 2005). The line extended approximately 700 ft to the north of the arroyo rim in a relatively flat area. Initially, one ditch was used, but the ditch was prone to become clogged with weeds and windblown sand, so two additional ditches were constructed. Each ditch was about 3-ft deep, 5-ft wide, and 700-ft long.

The amount of water that discharged from the wastewater line was not metered or routinely documented. *The Comprehensive Environmental Assessment and Response Program Phase I: Installation Assessment* (DOE 1987) is the only historical document that cites a wastewater discharge rate. The cited rate was 130,000 gallons of acid wastewater per day and presumably applies to the last year of operation (DOE 1987). Assuming this rate is applicable for the entire 27 years of operation, the cumulative discharge could have been as high as 1.3 billion gallons of wastewater. This value conservatively assumes that the daily rate is applied to each day of each year of operation, subtracting weekends and holidays. Field inspections and review of historical aerial photography have not identified a significant amount of erosion where the line discharged. However, the amount of water was sufficient to support vegetation that extended for approximately 1,400 feet to the south and southwest of the ditch end points, as depicted in Figure 2 (SNL 2018a).

The wastewater may have contained nitric and other acids from chemistry laboratories and possibly nitrate from inadvertent plumbing cross-connects between the buried SWMU 226 line and nearby sanitary sewer lines in TA-I. The disposal of large amounts of TA-I water containing nitrate at SWMU 46 is possible, but not supported by direct evidence. The disposal of significant amounts of sanitary sewage into open ditches was unlikely to have occurred because of obvious odor and health issues. However, inadvertent cross-connects at various sewer lines have been uncovered in TA-I (SNL 2018a). Similar cross-connects may have led to sanitary waste entering the Acid Waste Line (SWMU 226) and thus discharging at SWMU 46. The wastewater may have contained dilute concentrations of nitric acid. However, nitric acid would likely not have been persistent at SWMU 46. Nitric acid is photosensitive and exposure to sunlight in the outfall ditches would have degraded the acid. The surface soils in the TAG AOC vicinity are alkaline with caliche layers, which may have neutralized the acid solutions to some degree (SNL 2018a).

V.A.2 Multiple SWMUs at TA-II

From 1947 to 1992, several leach fields, seepage pits, and dry wells were used at TA-II to dispose of sanitary sewage and wastewater. The water was derived from a variety of operations including a shower/laundry facility, restrooms in several buildings, small research laboratories, and a machine shop. These releases occurred prior to installation of a sanitary sewer collection system in 1993. TA-II had seven wastewater disposal sites and six septic disposal sites (SNL 1994). The TA-II septic systems were excavated to confirm the locations of distribution boxes and leach fields (SNL 2018a). Figure 2 depicts a triangular area that contains all of the disposal sites.

SWMUs 48 and 136 were designed to handle more water than other TA-II systems. Instead of only being connected to buried disposal components (leach fields, seepage pits, and/or dry wells), these two SWMUs also discharged into open ditches. The disposal ditches were used only for wastewater, not sanitary sewage, because of the obvious odor and health problems inherent in exposure to sanitary waste (SNL 2005).

During the Cold War, the 45-acre, diamond-shaped fenced area contained about 25 structures consisting of small research laboratories, storage yards, warehouses, office trailers, and shipping facilities. A few hundred workers were employed at TA-II during this era (SNL 2018a). Several phases of soil removal were conducted at TA-II as part of voluntary corrective measures including the excavation of two small landfills (the Radioactive Waste Landfill - SWMU 1, and the Classified Waste Landfill - SWMU 2). Debris was also removed to the east of TA-II at SWMUs 50 and 228. NMED previously made corrective action complete (CAC) determinations for these SWMUs.

No SNL testing or disposal activities involving high explosive (HE) material are suspected of releasing nitrate to the environment. The potential for HE to degrade to nitrate in this area is low because of the lack of detected HE compounds in soil samples collected at TA-II SWMUs (for example, SWMUs 113 and 114). Furthermore, plastic explosives do not typically contain nitrate-based compounds. All TA-II sites have NMED-approved CAC status.

V.A.3 TA-I Sanitary Sewer System (SWMU 187)

Construction of the TA-I sanitary sewer system (SWMU 187) began in 1948. The sanitary sewer system is connected to numerous buildings in TA-I and is tied into the KAFB sewer system that discharged at the sewage lagoons from 1966 to 1987 before being connected to the Albuquerque-Bernalillo County Water Utility Authority (ABCWUA) system. Over the years, the TA-I sanitary sewer system has been expanded and upgraded. However, the buried lines may have leaked sanitary sewage in the subsurface and may possibly have had inadvertent plumbing cross-connects with wastewater lines (SNL 2018a). Numerous soil samples were collected at locations along the buried lines. No significant contamination was identified concerning potential groundwater contamination. CAC status for SWMU 187 was approved in June 2006 (NMED 2006).

V.A.4 Federal SWMUs and Municipal Sites with Potential for Creating Groundwater Contamination

There is an ABCWUA sanitary-sewer interceptor line that crosses the TAG AOC (Figure 2). This 24-inch concrete line trends along the arroyo floor and passes near monitoring wells TA2-W-19 and TJA-6. To the west of the TAG AOC, this line has experienced three known structural failures (1994, 2003, and 2013) where the line diameter is 96 inches (KAFB 2014).

In 1994, approximately 100 million gallons spilled from a line break and created ponding on the floodplain (Figure 3) (Montgomery Watson 2000). Some portion of the sewage was pumped back into the sewer system, but an unknown volume evaporated or infiltrated into the ground. Deposits consisting of sewage sludge were 2 to 3 feet thick in some places. Inspection of the sewer line revealed that leakage may have occurred for a prolonged period of time before the pipe ruptured.

A sewer-line break in 2003 also caused ponding, and a 2013 break created sinkholes, but no ponding (KAFB 2014). In a 2009 letter, KAFB requested that the ABCWUA supply their “sewage line inspection reports” because of the Air Force’s concern that leaking lines were contaminating groundwater (KAFB 2009). To date, this ongoing concern has not been addressed by the ABCWUA.

The KAFB Sewage Lagoons and the KAFB Golf Course Main Pond, together comprising SWMU WP-26, are a potential nitrate source. The two sewage lagoons depicted in Figure 3 are adjacent to each other and cover approximately 14 acres combined; they are located approximately 0.9 miles west of the TAG AOC. In the 1980s, nitrate was detected in water that was discharged to both the

KAFB Sewage Lagoons and the Golf Course Main Pond. Nitrate was detected in sediment samples from the lagoons and golf course pond (KAFB 2015).

During the irrigation season (April through October), approximately 330 million gallons of raw sewage were "handled" at the sewage lagoons over 25 years of use (KAFB 2015). KAFB operated the lagoons, which received untreated sewage from both KAFB and SNL, through an interconnected sanitary sewer system. The lagoons were used seasonally during the golf course irrigation season as settling basins for the untreated (raw) sewage (Montgomery Watson 2000). Over a period of 25 years, the estimated discharge rate would equate to 8.3 billion gallons. The volume of wastewater, which included mostly domestic sewage with some industrial wastewater, that percolated into the soil is not known. Some fraction evaporated, and some fraction was diverted from the lagoons to the golf course. SNL's modeling results indicate that approximately half (3.8 of the 8.3 billion gallons) of the "handled" volume of wastewater infiltrated through the upper vadose zone (SNL 2018a).

The 15-inch diameter pipeline that linked the former sewage lagoons with the golf course Main Pond ruptured in 1983 and released approximately 110,000 gallons of sanitary sewage near the Pennsylvania Street Bridge (KAFB 2004). This release site is tracked as KAFB SWMU 6-14. The pipeline had a length of 2.5 miles and was taken out of service in 1987. As part of a KAFB nitrate abatement plan, pumping of nitrate contaminated groundwater from production well KAFB-7 through a pipeline to the golf course began in September 2002 (KAFB 2002). After refurbishment in 2015, the pipeline was returned to service for transferring treated groundwater from the Bulk Fuel Facility spill remediation system to the golf course.

V.B. PREVIOUS INVESTIGATIONS AT TAG AOC

Groundwater monitoring associated with the TAG AOC has been conducted since 1992. In 2004, the Consent Order became effective (NMED 2004). The Consent Order identifies the TAG AOC as an area of groundwater contamination requiring further characterization and corrective action. In response to the Consent Order, DOE/Sandia submitted the TAG Corrective Measures Evaluation (CME) Work Plan to NMED in July 2004 (SNL 2004). NMED approved the work plan in October 2004 (NMED October 2004). After fulfilling the requirements of the CME Work Plan, DOE/SNL submitted the CME Report to NMED (SNL 2005a). The December 2016 CCM/CME Report superseded the 2005 CME Report (SNL 2018a).

NMED identified the TAG AOC in the Consent Order because nitrate and TCE concentrations in groundwater exceeded their respective MCLs. When the Consent Order was issued, nitrate and TCE were specified as constituents of concern (COCs) because the perched groundwater system contained concentrations of nitrate and TCE that exceeded the corresponding MCLs and the regional aquifer contained nitrate concentrations that exceeded the MCL. No exceedances of the MCL for TCE have been detected in the regional aquifer (SNL 2018b). TCE has not exceeded the MCL in the perched groundwater system since March 2002, except at upgradient background monitoring well WYO-4. This well is screened in the perched groundwater system near the western edge of the TAG AOC. The perched groundwater system has been gradually declining and the water level in well WYO-4 has declined to the point where collecting a representative sample is no longer feasible (SNL 2016).

DOE/NTESS and NMED discussed the status of monitoring well WYO-4 in an August 2017 meeting. In the meeting, NMED stated that the well is no longer the responsibility of DOE/SNL for groundwater sampling or remediation purposes. Responsibility for well WYO-4 was transferred to the KAFB Environmental Restoration Program.

The potential release sites for nitrate-impacted waters were evaluated in the Tijeras Arroyo Groundwater Investigation Report (SNL 2005b). Forty-seven SWMUs are located in the TAG AOC, all of which have achieved CAC status (NMED 2015). A corrective action complete determination requires that a site is not an ongoing source or potential source of contamination. Therefore, none of the SNL SWMUs are suspected of being an ongoing source of groundwater contamination. In addition, groundwater at the TAG AOC is addressed separately in accordance with the Consent Order (NMED 2004).

Currently, SNL samples 20 monitoring wells at the TAG AOC. KAFB samples an additional 10 monitoring wells in the vicinity including SNL monitoring well TJA-5. The City of Albuquerque Environmental Health Department also samples four nearby monitoring wells. Each well is sampled at a frequency (either quarterly, semiannually, or annually) in accordance with a variety of approved work plans. (SNL 2018b).

Figure 4 presents a 18-year time-series plot of nitrate concentrations in groundwater samples collected from SNL monitoring wells. The annual groundwater monitoring reports provide complete analytical data results and discussions.

For 2015, the maximum nitrate concentrations per well ranged from 3.56 to 27.8 mg/L in the perched groundwater system at the TAG AOC. Detected nitrate concentrations in nearby KAFB perched aquifer monitoring wells ranged up to 70 mg/L (KAFB 2016). The maximum historical concentration of nitrate reported for the perched groundwater system within the TAG AOC is 27.8 mg/L, which was obtained from monitoring well TA2-SW1-320 in January 2007 (SNL 2008). Due to casing integrity issues, this well was replaced by well TA2-W-28 in December 2014. A maximum nitrate concentration of 27.8 mg/L also was detected in replacement well TA2-W-28. This maximum was detected in November 2015 (SNL 2016).

Except for well TJA-4, the detected nitrate concentrations in the regional aquifer ranged from 1.15 to 4.03 mg/L in 2015. These concentrations are below the nitrate MCL (10 mg/L) and within the range of natural nitrate background concentrations (Moats 1995). Monitoring well TJA-4 is located in the extreme southeast corner of the TAG AOC, and based on its intermediate groundwater elevations, it is believed to be screened in a zone where the perched and regional aquifers merge and is not representative of the regional aquifer. The maximum nitrate concentration of 33.0 mg/L was detected in Well TJA-4 in 2015 (SNL 2016). Nitrate concentrations did not change significantly between 2015 and 2020 (SNL 2021).

Monitoring wells TA2-W-19, TA2-SW1-320/TA2-W-28, TJA-2, and TJA-7 are screened in the perched groundwater system and have consistently exceeded the MCL. Groundwater elevations are consistently declining while nitrate trends are either relatively stable or are slightly increasing. No correlation is apparent between trends in groundwater elevations and nitrate concentrations (SNL 2018b).

Nitrate concentrations in the perched groundwater system are expected to decrease as a result of natural groundwater transport mechanisms (advection, dispersion, and diffusion). The declining thickness (dewatering) of the perched groundwater system is the result of three factors: 1) anthropogenic recharge has been nearly eliminated, 2) perched groundwater is slowly percolating downward through the underlying low conductivity layer, and 3) perched groundwater is slowly migrating to the southeast. Dewatering indicates that the volume of available water in the perched groundwater system is decreasing along with a corresponding mass of nitrate. There is no geochemical indication that groundwater flowing downward through the perching horizon has reached the regional aquifer, except in the merging zone southeast of the TAG AOC (SNL 2018b).

Production wells completed in the regional aquifer of the Albuquerque Basin present the only potential exposure points for elevated nitrate in groundwater to reach human receptors. SNL's groundwater modeling demonstrates that elevated nitrate concentrations in the perched groundwater system will not affect production wells for at least 130 years. (SNL 2016a). Furthermore, the nitrate concentrations in groundwater that will arrive at the production wells are conservatively estimated to be 0.24 mg/L, which is almost two orders of magnitude below the nitrate MCL of 10 mg/L. The production wells are operated by KAFB, the Veterans Administration, and ABCWUA. No production wells are located within the TAG AOC (KAFB 2018b).

Paving, continuous industrial activities, lack of habitat, and fences have reduced the presence of animals in most of the TAG AOC. No wetlands are present. Therefore, there are no significant ecological or biological receptors of concern to the nitrate-impacted groundwater in the TAG AOC (SNL 2018a).

V.C. TAG AOC CORRECTIVE MEASURES EVALUATION SUMMARY

The Respondents submitted the CCM/CME Report for the TAG AOC to NMED on November 30, 2016 (SNL 2016a). After conducting a review of the CCM/CME Report, NMED sent comments to the Respondents in a notice of disapproval dated May 18, 2017 (NMED 2017). The Respondents submitted a revised CCM/CME Report on February 14, 2018 (SNL 2018a).

V.C.1. Corrective Measures Alternatives Evaluated by SNL for TAG AOC

The Respondents evaluated five corrective measure alternatives for the TAG AOC; one containment alternative, three groundwater treatment alternatives, and one natural attenuation alternative. They include 1) Monolithic Confinement; 2) Phytoremediation; 3) In-Situ Bioremediation; 4) Groundwater Extraction and Treatment; and 5) Monitored Natural Attenuation. A general description of each alternative considered in the CME is provided below (SNL 2018a).

Alternative 1– Monolithic Confinement
Under this alternative, barriers to groundwater flow are constructed by digging a trench and backfilling it with cement or clay. Monolithic confinement is used in remedial actions to confine groundwater contamination by sealing it from the outside environment or to manipulate the flow of groundwater to avoid contaminant transport through advection. Although monolithic confinement can slow or prevent contaminant migration, the contaminants in groundwater behind the barrier would not be remediated. The Respondents proposed removing this technology from consideration because the remedy is not practical due to the length of barrier that would be required in the TAG AOC (over 14,000 linear feet) and the depth to groundwater (over 300 ft bgs) (SNL 2018a).

Alternative 2 – Phytoremediation
Under this alternative, plants would be used to remove contaminants from soil or groundwater. The term phytoremediation is used to describe a number of biochemical interactions that may occur among plants, microbes living on plant roots, and contaminants, that ultimately reduce contaminant concentrations. The Respondents proposed removing this technology from consideration because: (1) it is only applicable to relatively shallow contamination, and (2) it is not effective for large, dilute groundwater contaminant plumes (SNL 2018a).

Alternative 3 – In-Situ Bioremediation
Under this alternative, nitrate concentrations in all TAG AOC groundwater would be reduced to below the MCL within 20 years by implementing an in-situ bioremediation remedy. The Respondents propose installing multiple closely spaced injection wells creating a series of Permeable Reactive Barriers (PRB) throughout the area where nitrate exceeds the MCL. The Respondents propose injecting an electron donor (such as ethyl lactate) into the injection wells to induce subsurface conditions conducive to nitrate degradation (denitrification) by enhancing the population of indigenous microbes. Denitrification results in the conversion of nitrate to nitrogen gas (SNL 2018a).

The Respondents assert that nine PRBs would be created by installing 575 injection wells spaced 50 feet apart. Multiple PRBs are needed due to the slow groundwater velocity (24 feet/year). The length of the proposed PRBs would range from 1,700 to 4,150 feet, each with 33 to 83 injection wells depending on the PRB length. Each PRB would be oriented perpendicular to the groundwater flow direction, with a spacing corresponding to no more than 20 years of groundwater travel time between each PRB. The spacing between each PRB would be 300 to 500 feet, depending on the groundwater flow rate (SNL 2018a).

The Respondents propose injecting an average of 20,000 gallons of substrate-amended potable water into each injection well. The volume injected into each well would be dependent on the saturated thickness, hydraulic conductivity, and porosity of the perched groundwater system at each location. The Respondents estimate that a 25-ft diameter biological denitrification treatment area would be created around each injection well, providing 50 percent lateral treatment coverage along the length of the PRBs. The average nitrate concentration would be reduced to below the MCL downgradient of each PRB because of the in-situ mixing of treated and untreated groundwater as it moves downgradient (SNL 2018a).

The Respondents propose that the bioremediation substrate mixture would consist of potable water, an electron donor (e.g., ethyl lactate), biological nutrients, buffering agents, and tracers. In addition to ethyl lactate, a complementary electron donor such as vegetable oil may be added to the substrate mixture to create a longer-lasting denitrification zone. The Respondents state that the bioremediation substrate amendments would be mixed with potable water and injected under a Discharge Permit issued by the NMED Ground Water Quality Bureau (SNL 2018a).

The Respondents propose to install twenty-five remedy performance monitoring wells. Fourteen of the wells would be installed between selected PRBs along the groundwater flow path to evaluate the effectiveness of treatment downgradient of the PRBs. The wells would be placed in consideration of groundwater travel time between the PRBs (1-year, 2-year, 5-year, 10-year, and 15-year travel times). The Respondents propose to install eleven monitoring wells at strategic locations throughout the nitrate plume for additional remedy performance monitoring. The depth of the monitoring wells would be approximately 300 ft bgs and screened across the full-saturated thickness of the perched groundwater system. Figure 5 depicts locations of the performance monitoring wells. The Respondents state that existing monitoring wells would also be incorporated into the performance-monitoring network (SNL 2018a).

The Respondents state that the injection wells would be re-dosed as necessary with smaller volumes of substrate mixture (500 gallons per well) to maintain denitrifying conditions in the PRBs. For cost purposes, it is assumed re-dosing would be performed every two years for the duration of the remedy, beginning in the third year after the initial injections (SNL 2018a).

The Respondents state that the conceptual locations of the PRBs are designed solely to reduce nitrate concentrations in groundwater to below the MCL within 20 years after active remedy implementation; adverse and interfering logistics (buildings, infrastructure, steep topography, and other natural features) were not considered (SNL 2018a).

Remedy Performance Monitoring, Maintenance, and Closure

The Respondents propose to initially sample the perched groundwater system monitoring wells and selected injection wells on a quarterly basis to confirm treatment and adjust bioremediation substrate dosing parameters and to transition to semiannual sampling after two years. Analysis and associated quality control would include nitrate, anions (bromide, chloride, fluoride, nitrite, sulfate), dissolved metals (arsenic, calcium, iron, magnesium, manganese, potassium, sodium), orthophosphate as P, and total organic carbon. The Respondents propose to implement electronic logging of water levels and parameter measurements in selected monitoring and injection wells. Regional aquifer wells would be sampled semiannually (SNL 2018a).

Groundwater from each monitoring well would be sampled annually for constituents required under the sanitary sewer discharge permit that is currently used for purge water and equipment decontamination water disposal (SNL 2018a).

The Respondents propose to perform post-remediation verification monitoring in the perched groundwater system wells on a quarterly basis after the cleanup standard is reached to detect any rebound (increase) in nitrate concentrations and restoration of naturally occurring conditions such as a decrease in localized metals concentrations. In addition, annual remedy performance reviews would be conducted that would identify any necessary modifications or optimization measures for the remedy (SNL 2018a).

The Respondents' Contingency Plan states that groundwater wells will be redeveloped, repaired, or replaced as needed. Well Installation Work Plans will be submitted to NMED within one year of a well with measured water levels that are unsuitable for injection or sampling purposes. The Respondents propose to plug and abandon wells completed in the perched groundwater system after remediation is complete and verified; monitoring wells completed in the regional aquifer will be transferred to the DOE Long Term Stewardship program (SNL 2018a).

Land Use Controls

The Respondents propose to implement and maintain land use controls to mitigate potential exposure to contaminated groundwater. The Respondents state that most of these controls are already in place and include maintaining existing SNL site access controls. Land use controls would be reviewed annually and modified if necessary. The Corrective Measures Implementation Plan would include a Land Use Control Implementation Plan that would be amended if site conditions change (SNL 2018a).

Timeframe

The Respondents state that the estimated total timeframe for Alternative 3 is 27 years. This includes:

- 5 years to design the remedy, obtain permits, install injection and monitoring wells, and perform initial bioremediation substrate injections,
- 20 years of performance monitoring, and periodic bioremediation substrate re-dosing, and
- 2 years of quarterly post-remediation verification monitoring after the MCL cleanup standard is met.

Cost

The Respondents state that the estimated Total Cost of the In-Situ Bioremediation Alternative (in 2021 dollars) is $186,285,000. Because of the increasing inflation rate and adverse and interfering logistics (buildings, infrastructure, steep topography, and other natural features) are not considered, the cost may be higher.

Alternative 4 – Groundwater Extraction and Treatment

Under this alternative, multiple groundwater extraction wells will be installed, pumping groundwater to a nitrate treatment system in order to remove nitrate from extracted groundwater by sorption onto ion-exchange resin. The Respondents propose the use of the ion-exchange resin followed by granular activated carbon (GAC) to remove any volatile organic compounds (VOCs) potentially present in the extracted groundwater prior to discharge. The Respondents propose to pump treated groundwater into a reinjection well in the regional aquifer. All TAG AOC groundwater with a nitrate concentration exceeding the MCL will be removed within 20 years (SNL 2018a).

Implementation

The Respondents state that a minimum of 73 groundwater extraction wells and associated infrastructure (pipelines) would need to be installed to capture all groundwater in the TAG AOC with a nitrate concentration exceeding the MCL within a pumping period of 20 years. The extraction wells would be completed approximately 300 ft bgs and screened across the full thickness of the perched groundwater system (SNL 2018a).

The Respondents propose pumping groundwater from extraction wells and then conveying it to a treatment facility via a network of buried double-contained piping (approximately 3.6 miles in total length) and above-ground transfer tanks. The total extraction rate is estimated to be approximately 100 gallons per minute (gpm). Individual extraction well yields are estimated to be 0.5 to 2 gpm and are dependent on lateral variability in hydraulic conductivity and saturated thickness (SNL 2018a).

The Respondents propose treating the extracted water with strong base anion ion-exchange resin to reduce nitrate concentrations to below the 10 mg/L MCL, then discharging the treated water to a reinjection well located on the west side of Wyoming Boulevard screened in the highly transmissive ancestral Rio Grande sediments of the regional aquifer. Figure 6 shows the proposed locations of the extraction wells, pipelines, transfer tanks, treatment facility, and reinjection well. The Respondents state that ion-exchange resin would be regenerated off-site and spent GAC would be disposed offsite in accordance with applicable waste disposal requirements (SNL 2018a).

The Respondents state that the conceptual locations of the extraction wells are designed solely to achieve complete removal of all nitrate-contaminated groundwater exceeding the MCL within 20 years after active remedy implementation; adverse and interfering logistics (buildings, infrastructure, steep topography, and other natural features) were not considered (SNL 2018a).

The Respondents propose to install eleven additional monitoring wells at strategic locations throughout the nitrate plume for additional remedy performance monitoring. The depth of the monitoring wells would be approximately 300 ft bgs and screened across the full-saturated thickness of the perched groundwater system. Existing monitoring wells would also be incorporated into the performance-monitoring network (SNL 2018a).

Remedy Performance Monitoring, Maintenance, and Closure

The Respondents propose to initially sample the perched groundwater system monitoring wells within the remediation area and selected extraction wells for nitrate on a quarterly basis, and transition to semiannual sampling after two years. Electronic logging of water levels would be implemented in selected monitoring and extraction wells. Regional aquifer wells would be sampled semiannually (SNL 2018a).

The Respondents propose to sample the groundwater treatment system at required points, including influent, mid-stream, and effluent of treatment prior to discharge in accordance with a Discharge Permit issued by the NMED Ground Water Quality Bureau. For cost estimation purposes, it is assumed that samples would be collected monthly at these points during system operation and analyzed for nitrate, VOCs, Target Analyte List metals plus uranium, anions (bromide, chloride, fluoride, and sulfate). Field measurements would be collected for other parameters (e.g., pH, temperature, conductivity).

The Respondents propose to perform quarterly post-remediation verification monitoring in the perched groundwater system wells after the cleanup standard is reached to detect any rebound (increase) in nitrate concentrations. Annual remedy performance reviews will be conducted that would identify any required modifications or optimization measures for the remedy (SNL 2018a).

The Respondents' Contingency Plan states that groundwater wells will be redeveloped, repaired, or replaced as needed. Well installation work plans will be submitted to NMED within one year of a well containing water columns that are unsuitable for extraction or sampling purposes. The Respondents propose to plug and abandon wells completed in the perched groundwater system after remediation is complete and verified; monitoring wells completed in the regional aquifer will be transferred to the DOE Long Term Stewardship program (SNL 2018a).

<u>Land Use Controls</u>

The Respondents propose to implement and maintain land use controls to mitigate potential exposure to contaminated groundwater. Land use controls would be reviewed annually and modified if necessary. The Corrective Measures Implementation Plan would include a Land Use Control Implementation Plan that would be amended if site conditions change (SNL 2018a).

<u>Timeframe</u>

The Respondents state that the estimated total timeframe for Alternative 4 is 27 years. This includes:

1. 5 years to design the remedy, obtain permits, install extraction, reinjection, and monitoring wells, and construct the pipelines and treatment facility,
2. 20 years of active groundwater extraction and treatment, and
3. 2 years of quarterly post-remediation verification monitoring after the MCL cleanup standard is reached (SNL 2018a).

<u>Cost</u>

The Respondents estimate that the Total Cost of the Groundwater Extraction and Treatment Alternative (in 2021 dollars) is $66,380,000.

Alternative 5 – Monitored Natural Attenuation

Monitored natural attenuation relies on natural processes to decrease concentrations of contaminants in soil and groundwater. These processes may include biodegradation, sorption, dispersion, dilution, evaporation, and chemical reactions. The Respondents propose to monitor the concentrations and extent of contaminants and prevent potential exposure throughout the duration of the remedy until remedial objectives are met or the perched groundwater system naturally dewaters. This technology requires no removal, treatment, or storage of groundwater other than the minor volumes generated during monitoring well sampling (SNL 2018a).

Implementation

The Respondents propose to sample monitoring wells completed in the perched groundwater system within the TAG AOC semiannually for nitrate until remedial objectives are met, or the perched groundwater system has naturally dewatered. Select regional aquifer wells would be sampled annually for nitrate. Figure 7 depicts the conceptual monitoring well field and sampling frequency for each well in the TAG AOC during remedy implementation. Table 1 shows the anticipated changes to the sampling program as the remedy progresses, taking into account when water levels in the perched groundwater system are anticipated to fall below the screened interval in each well (SNL 2018a).

The Respondents propose to measure groundwater elevations semiannually in monitoring wells completed in the perched groundwater system and the underlying regional aquifer. Wells where the water level has declined below the bottom of the screened interval would be checked to determine if groundwater rises into the well screen (SNL 2018a).

Remedy Performance Monitoring, Maintenance, and Closure

The Respondents propose to conduct annual remedy performance reviews and identify any required modifications or optimization measures for the remedy. A review of land use controls would also be incorporated into this process.

The Respondents' Contingency Plan states that groundwater wells will be redeveloped and repaired as needed. The need for replacing a monitoring well where the water level has dropped below the bottom of the screen will be determined on a case-by-case basis, depending on the progress of the remedy, and will take into account the remaining saturated thickness below the well screen, local nitrate concentrations, and the need for water level and water quality data (SNL 2018a).

Replacement wells will be screened down to the top of the perched horizon. The Respondents state that work plans will be used for obtaining NMED approval of proposed field tasks. A well installation work plan will be submitted to NMED within one year of a well having a water level unsuitable for sampling purposes. The Respondents propose to plug and abandon wells completed in the perched groundwater system after remediation is complete and verified. Monitoring wells completed in the regional aquifer will be transferred to the DOE Long Term

Stewardship program (SNL 2018a).

Land Use Controls

The Respondents propose to implement and maintain land use controls to mitigate potential exposure to contaminated groundwater. The Respondents state that most of these controls are already in place and include maintaining existing SNL site access controls. The Corrective Measures Implementation Plan would include a Land Use Control Implementation Plan that could be amended if site conditions change (SNL 2018a).

Timeframe

The estimated timeframe to achieve remedial objectives for this alternative (or for most of the perched groundwater system to naturally dewater) is estimated to be approximately 38 years, assuming remedy implementation in 2021. The Respondents state that groundwater in the immediate vicinity of well TJA-5 and the adjacent deeper well TJA-4 in the farthest southeast portion of the TAG AOC may be affected by recharge and contaminant sources outside of the TAG AOC and is not included in this timeframe estimate (SNL 2018a).

Cost

The estimated Total Cost of the Monitored Natural Attenuation Alternative (in 2021 dollars) is $8,383,000.

V.C.2. Corrective Measures Recommended by Respondents for TAG AOC

The Respondents recommended Alternative 5 for the TAG AOC: Monitored Natural Attenuation. The Respondents state that the recommended alternative would effectively address the following objectives:

1. Protective of Human Health and the Environment: There is no potential for human or ecological receptors to be exposed to nitrate at concentrations of concern.
2. Attain Media Cleanup Standard: The nitrate MCL cleanup standard would be attained by dispersion, dilution, and advection.
3. Control the Source of Releases: The original SNL sources of nitrate contamination (sanitary waste and wastewater discharges) have been eliminated. No discharges have been observed since 1992.
4. Comply with Standards for Management of Wastes: The alternative would comply with all standards for the management of wastes (SNL 2018a).

The Respondents assert that groundwater elevations in the perched groundwater system have been declining steadily for over 20 years because of cessation of recharge from the infiltration of wastewater discharges. This decline is anticipated to continue. No elevated risks would remain after the perched groundwater system has naturally dewatered. Land use controls would be maintained during the course of the remedy. A Contingency Plan would be developed identifying measures to be taken if the remedy does not proceed as anticipated (SNL 2018a).

The Respondents assert that although monitored natural attenuation would not reduce the toxicity, mobility, or volume of nitrate, there is no risk to human health or the environment, even if no degradation occurred. No hazardous byproducts would be produced during the remedy implementation. The mass of dissolved nitrate in the perched groundwater system would decline proportionately to the decrease in groundwater volume (SNL 2018a).

The Respondents assert that no risks to human health or the environment have been identified for the TAG AOC nitrate plume and that there would be no risk of worker exposure to contaminants during remedy implementation that cannot be easily managed. No additional risks would be incurred by this approach (SNL 2018a).

The Respondents assert that this alternative is feasible and easily implemented, as the monitoring network is already in place (SNL 2018a).

V.C.3. Corrective Measures Criteria Evaluation by NMED for TAG AOC

Alternative 1 – Monolithic Confinement and Alternative 2 – Phytoremediation

These two alternatives were not rated by NMED because they are not feasible to implement and were removed from consideration.

Alternative 3 – In-Situ Bioremediation

1. *Long-Term Reliability and Effectiveness*
   Alternative 3 would be fairly reliable and effective over the long-term as the contamination in the perched aquifer would degrade over time and as the aquifer dissipates. Monitoring would continue until after the nitrate plume no longer exists. Therefore, Alternative 3 rates high for this criterion.

2. *Reduction of Toxicity, Mobility, or Volume*
   Alternative 3 would provide a reduction in toxicity, mobility, or volume because nitrate would be converted to nitrate gas by biologic activity and, therefore, rates moderately high for this criterion.

3. *Short-Term Effectiveness*
   Alternative 3 would require approximately 27 years' time to implement. Short-term risks include increased greenhouse gas emissions, higher emissions from vehicles, and a higher injury risk. Therefore, Alternative 3 rates moderately low for this criterion due to the relatively long timeframe required and increased short-term risk.

4. *Implementability*
   Alternative 3 rates very low due for this criterion due to the high amount of infrastructure required, including 575 injection wells and 24 additional monitoring wells, even before consideration of possible interfering logistics.

5. *Cost*
   Alternative 3 would cost $186,285,000 in 2021 dollars. Therefore, Alternative 3 rates very low for this criterion.

Alternative 4 – Groundwater Extraction and Treatment

1. *Long-Term Reliability and Effectiveness*
   Alternative 4 would be fairly reliable and effective over the long-term as contaminated water would be removed from the perched aquifer and treated. This would also enhance the timeframe for natural desiccation of the perched aquifer; monitoring would continue until the nitrate plume no longer exists. Therefore, Alternative 4 rates high for this criterion.

2. *Reduction of Toxicity, Mobility, or Volume*
   Alternative 4 would provide a reduction in toxicity, mobility, or volume because nitrate would be removed from the perched aquifer and treated and, therefore, rates moderately high for this criterion.

3. *Short-Term Effectiveness*
   Alternative 4 would require approximately 27 years' time to implement. Short-term risks include increased greenhouse gas emissions, higher emissions from vehicles, highest electrical usage due to the operation of extraction pumps, higher injury risk and the highest accident risk due to the transportation of ion-exchange resin to a regeneration facility. Therefore, Alternative 4 rates moderately low for this criterion due to the relatively long timeframe required and increased short-term risk.

4. *Implementability*
   Alternative 4 rates very low due for this criterion due to the high amount of infrastructure required, including extraction wells, pipelines, transfer tanks, treatment facility, a reinjection well, and additional monitoring wells.

5. *Cost*
   Alternative 4 would cost $66,380,000 in 2021 dollars. Therefore, Alternative 4 rates low for this criterion.

Alternative 5 – Monitored Natural Attenuation

1. *Long-Term Reliability and Effectiveness*
   Alternative 5 would be fairly reliable and effective over the long-term because the perched aquifer is naturally dissipating due to the lack of a source of recharge. Monitoring would continue until after the nitrate plume no longer exists. Therefore, Alternative 5 rates moderately high for this criterion.

2. *Reduction of Toxicity, Mobility, or Volume*
   Alternative 5 would provide a reduction in toxicity, mobility, or volume as the perched aquifer naturally desiccates and, therefore, rates moderately high for this criterion.

3. *Short-Term Effectiveness*
   Alternative 5 would require many years' time to complete, however, there would be no short-term risks from construction or transportation of contaminants. Therefore, Alternative 5 rates moderately low for this criterion.

4. *Implementability*
   Alternative 5 would not require any further implementation as the monitoring network and plan is already in place; therefore, it rates very high for this criterion.

5. *Cost*
   Alternative 5 is estimated to cost $8,383,000 in 2021 dollars and would not increase the cost above current ongoing monitoring activities. Therefore, Alternative 5 rates high for this criterion.

V.C.4. Corrective Measures Selected by NMED for TAG AOC

NMED believes that Alternative 5 – Monitored Natural Attenuation is the corrective measure for TAG AOC that would best meet the evaluation criteria of the Consent Order, would be protective of public health and the environment, and would attain cleanup standards because of natural degradation of nitrate contamination and the ongoing reduction in the perched aquifer due to the elimination of the sources of recharge. The following is a summary of the rational for this proposed remedy selection.

Alternative 5, Monitored Natural Attenuation, is rated lower for short-term effectiveness, but it rates high for long-term reliability and effectiveness and reduction of toxicity, mobility, or volume, and rates highest on implementability and cost.

While Alternative 3, In situ Bioremediation, rates the highest for both long-term reliability and effectiveness and reduction of toxicity, mobility, or volume, it also rates the lowest for short-term effectiveness, implementability, and cost.

NMED did not select Alternative 3 because the implementation of this alternative is very costly and complex and increases risk to workers and the community with little decrease in completion time (38-27 = 11 years). The implementability of this alternative is not fully confirmed; the location of some of the injection wells would likely need to be modified due to existing buildings and infrastructure, in addition to geographic/topologic access constraints for well installation. The need to modify the locations of multiple injection wells due to access limitations will further increase the amount of time for completion.

Similarly, while Alternative 4, Groundwater Extraction and Treatment, rates the highest for both long-term reliability and effectiveness and reduction of toxicity, mobility, or volume, it also rates the lowest for short-term effectiveness, implementability, and cost.

NMED did not select Alternative 4 because the implementation of this alternative is very costly and complex and increases risk to workers and the community with little decrease in completion time (38-27 = 11 years). The implementability of this alternative is not fully characterized; the location of some of the extraction wells would likely need to be modified due to existing buildings and infrastructure, in addition to geographic/topologic access constraints for well installation. The need to modify the locations of multiple extraction wells will also increase the amount of time for completion. The installation of an extensive pipeline network would also be affected by existing buildings and infrastructure. Additionally, removal of nitrate from extracted groundwater would generate a large quantity of waste (regeneration brine) that would require on-site management and off-site disposal.

The difference in the estimated timeframes for remedy completion is not sufficient to justify the selection of an active remedy based on the evidence that water levels in the perched aquifer have been steadily declining for over two decades. The perched aquifer is anticipated to continue to be depleted due to the lack of recharge and ultimately cease to exist as an interconnected saturated zone. The perched aquifer is not anticipated to be a viable water supply source in the future due to the continuing reduction in saturated thickness.

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TABLES

Table 1. Sampled Wells Per Time Period

Period (Years from 2018)	Number of Sampled Wells		Sampling Frequency
	PGWS	Regional Aquifer	
1 – 3	12	9	Semiannual – PGWS Annual – Regional Aquifer
4 – 7	10	9	
8 – 10	9	9	
11 – 17	8	9	
18 – 23	7	9	
24 – 26	6	9	
27 – 28	4	9	
29 – 32	3	9	
33 – 41	2	9	

PGWS = Perched groundwater system.

FIGURES

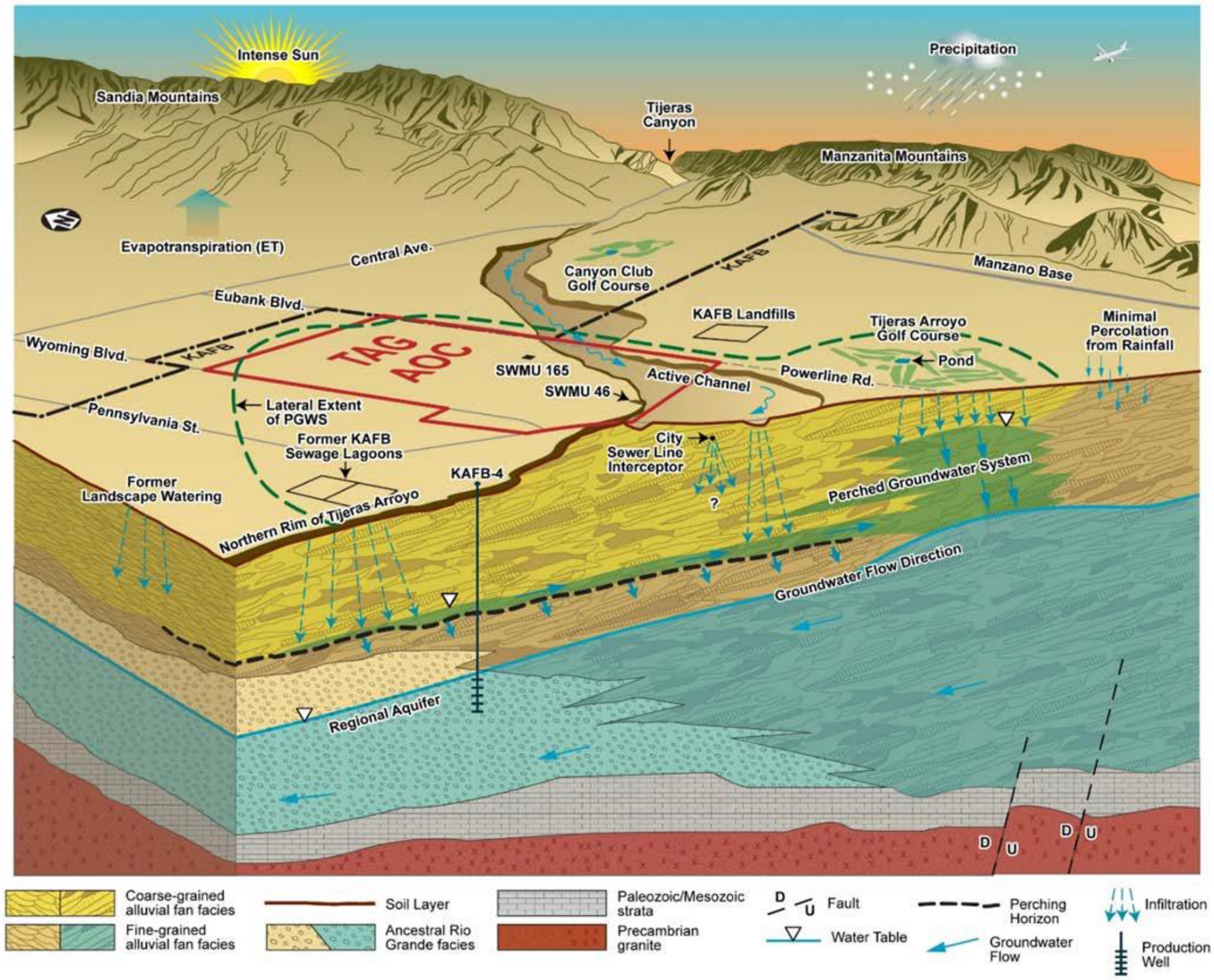

Figure 1. TAG Conceptual Site Model (SNL 2018b).

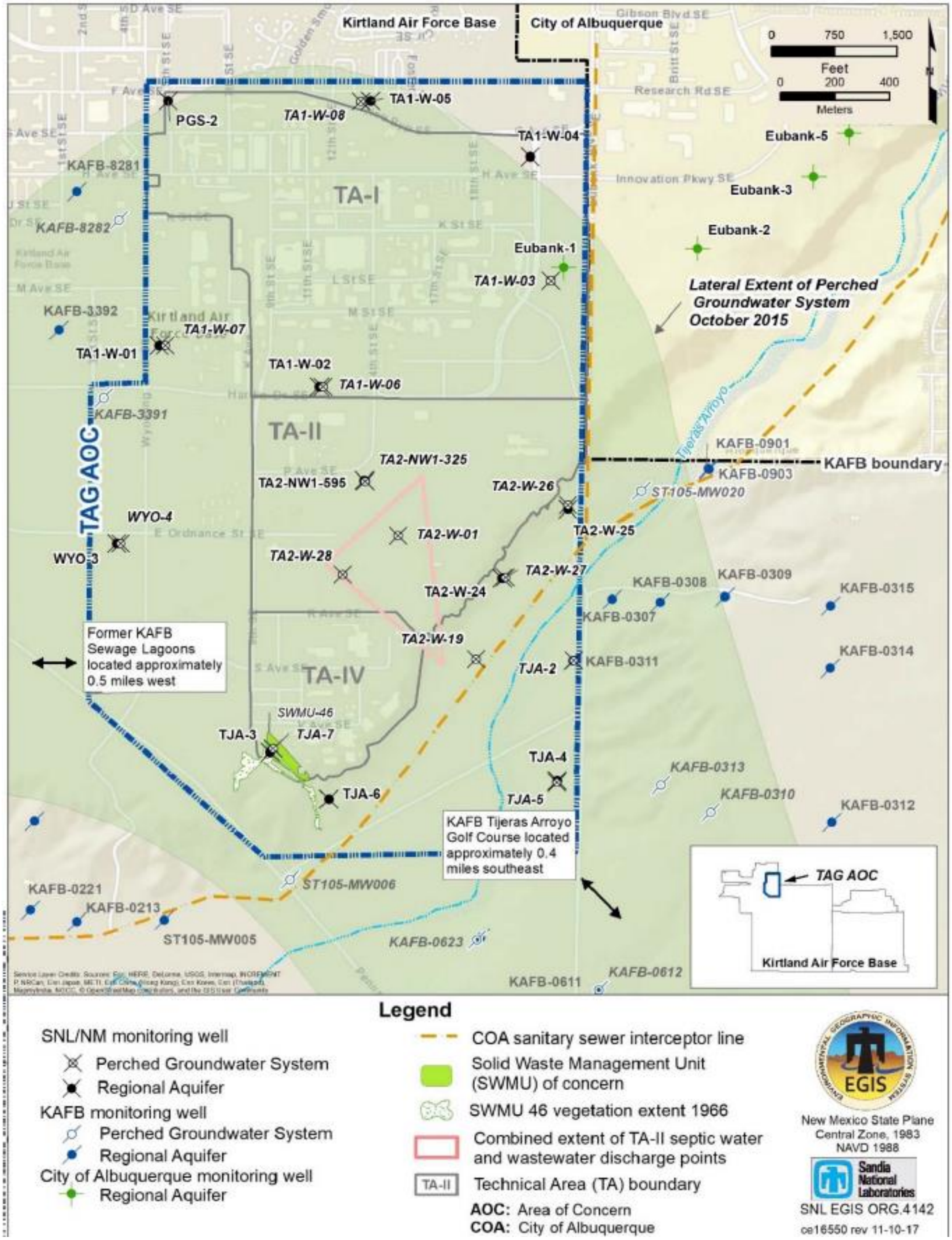

Figure 2. Potential Nitrate Release Sites in the TAG AOC (SNL 2018a).

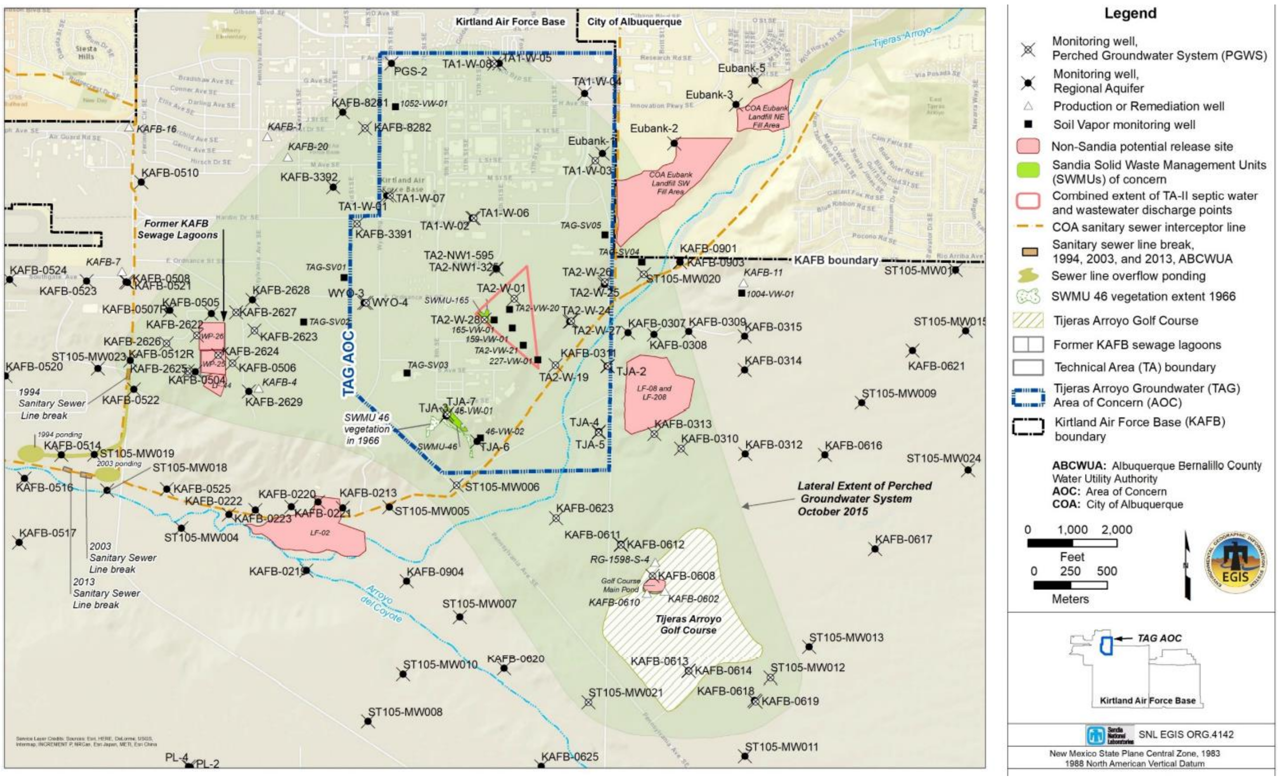

Figure 3. Monitoring Wells and Potential Nitrate Release Sites near the TAG AOC (SNL 2018a).

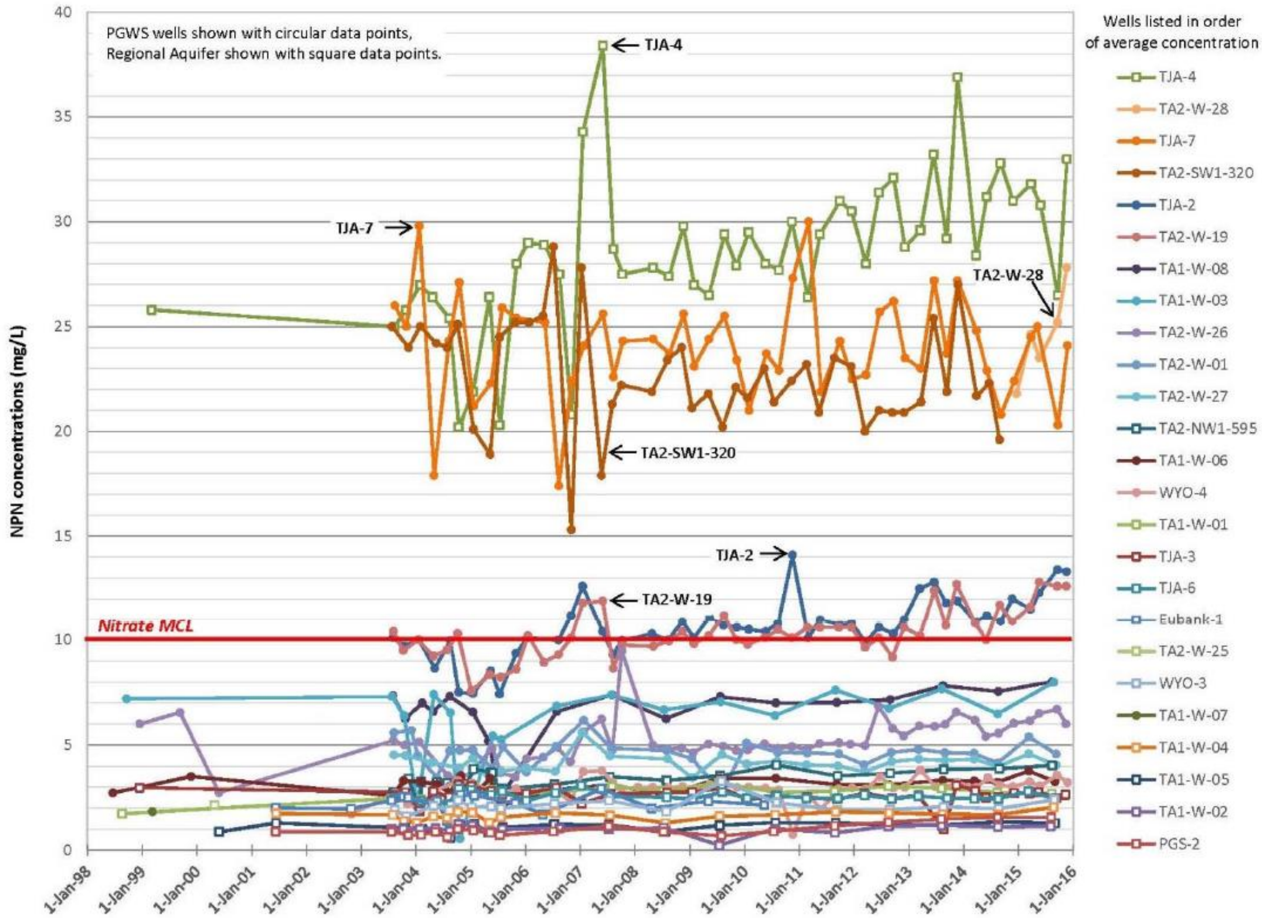

Figure 4. Time-Series Plot of Nitrate Concentrations in Groundwater (SNL 2018a).

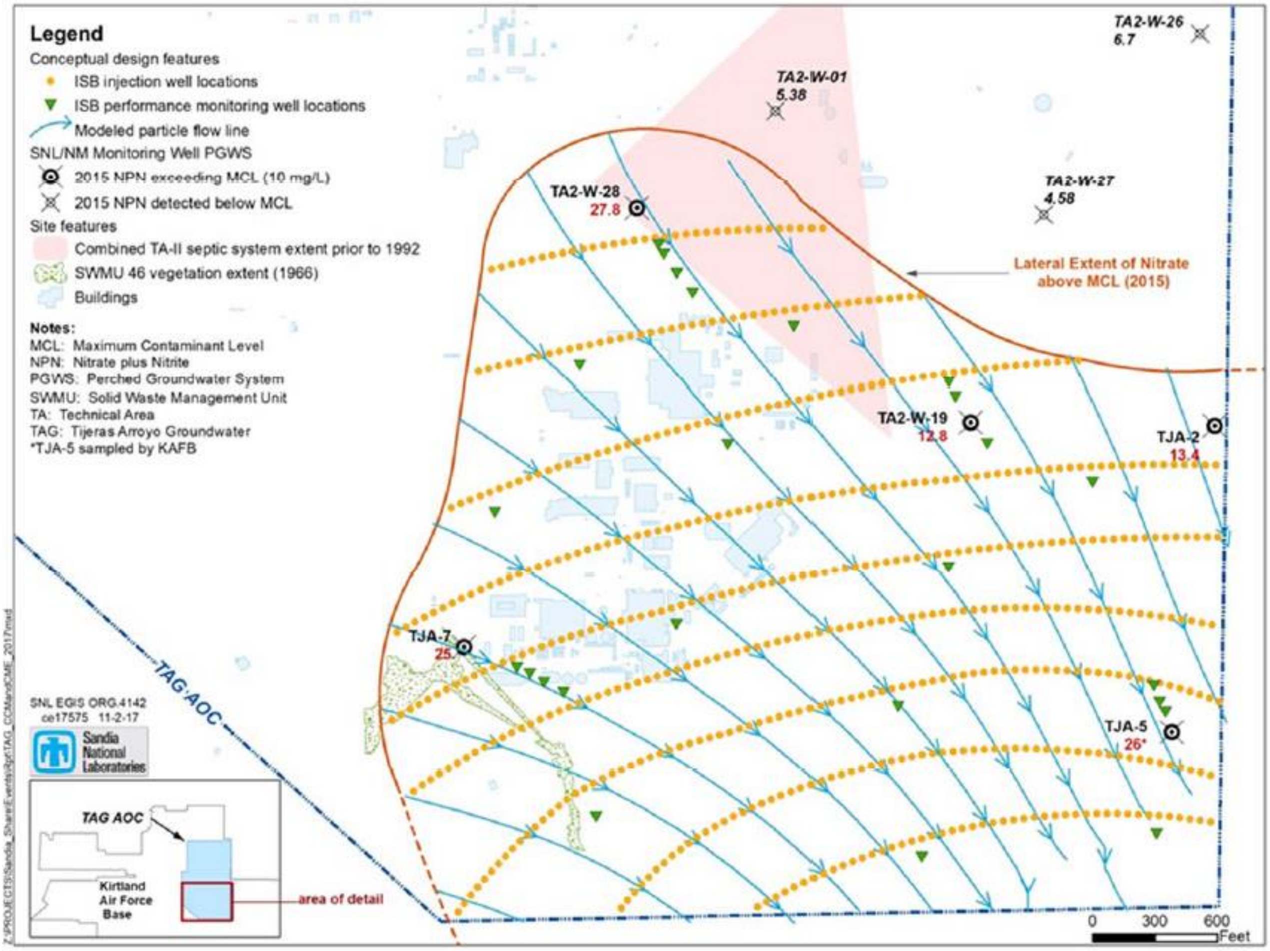

Figure 5. Conceptual Design for Remedial Alternative 3: In-Situ Bioremediation (SNL 2018a).

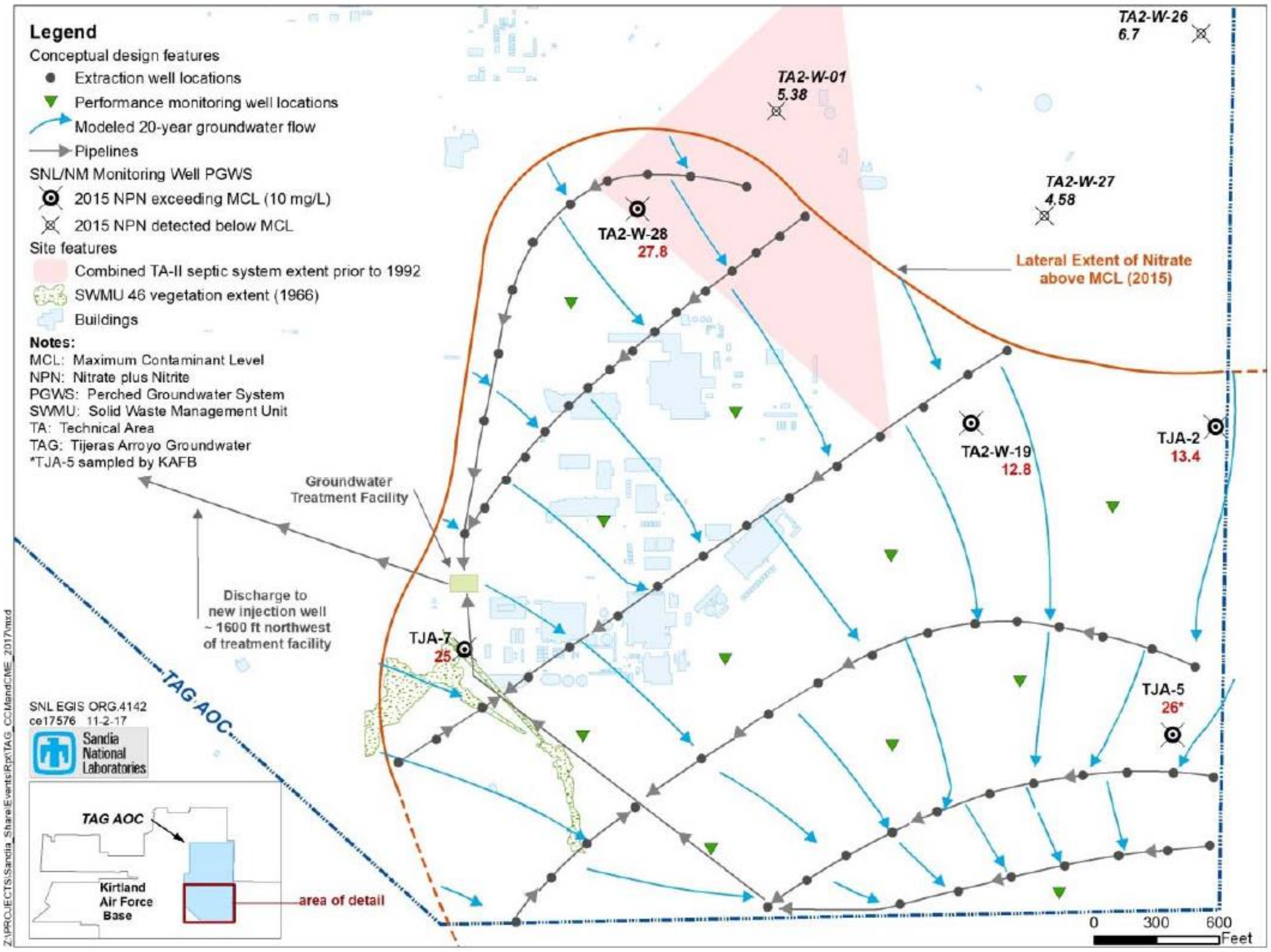

Figure 6. Conceptual Design for Alternative 4: Groundwater Extraction and Treatment (SNL 2018a).

Figure 7. TAG AOC Monitoring Wells with Sampling Frequency; Water Levels Measured Annually (SNL 2018a).