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Symbol: EPC-DO: 23-389
LA-UR: 23-34161
Locates: N/A
Date: February 16, 2024

Shelly Lemon, Bureau Chief
New Mexico Environment Department
Surface Water Quality Bureau
1190 St. Francis Drive
P.O. Box 5469
Santa Fe, NM 87502

Subject: Use Attainability Analysis for Upper Sandia Canyon, Revision 1

Dear Ms. Lemon:

Attached is the updated Use Attainability Analysis (UAA) for Upper Sandia Canyon Assessment Unit (AU) NM-9000.A_47 in water quality segment 20.6.4.126 (126). This UAA supersedes the draft Upper Sandia Canyon UAA submitted to the New Mexico Environment Department (NMED) on October 21, 2021 (EPC-DO: 21-342) and has been revised based on comments received from the NMED, the Environmental Protection Agency, and the public. The UAA was prepared by the Department of Energy's National Nuclear Security Administration and Triad National Security, LLC (DOE-Triad) pursuant to requirements contained in 20.6.4.15 NMAC.

The Upper Sandia Canyon AU is listed in the NMED's 2022–2024 Integrated Report as impaired due to temperature exceedances and is assigned an IR Category of "5B," which indicates the need for review of the temperature water quality standard. The UAA was prepared in accordance with the work plan submitted by Triad on February 10, 2020 (EPC-DO: 20-040) and approved by NMED on April 9, 2020.

The purpose of the UAA is to determine the most protective aquatic life use attainable in the perennial portion of Sandia Canyon. The UAA findings include the following:

- Coldwater aquatic life use is attainable in the lower portion of the Sandia Canyon AU, from Sandia Canyon at Sigma Canyon to Sandia Canyon at Bedrock Road (formerly known as "Sandia at Crossing").
- Coldwater aquatic life use is not attainable in the upper portion of the AU, from Sandia Canyon at Bedrock Road to Outfall 001, because naturally occurring pollutant concentrations prevent the attainment of the use (40.CFR 131.10 (g)(1)).
- Coolwater aquatic life use is attainable in the upper portion of the AU and is the most protective aquatic life use for this portion of the AU.
- DOE-Triad propose to create a new coolwater segment for the upper portion of the AU, from Sandia at Bedrock Road to Outfall 001, with additional protection of a 6T3 standard of 25 °C.

The analyses in the UAA provide supporting data that the highest attainable use for the upper portion of the AU is the coolwater aquatic life use with a segment-specific 6T3 criterion of 25 °C. DOE-Triad recommend that the coldwater aquatic life use be retained for the lower portion of the AU and remain in segment 126.

The final UAA Revision 1 (Rev1) is provided to NMED in advance of DOE-Triad's completion of the Stakeholder Outreach and Public Engagement portion of the process. Triad intends to post this document for public comment on LANL's Electronic Public Reading Room and to publish notice of the UAA's availability in a local newspaper in accordance with the approved work plan.

In accordance with the approved work plan, the UAA will also be submitted to San Ildefonso Pueblo, Cochiti Pueblo, Jemez Pueblo, and Santa Clara Pueblo (Accord Pueblos); and the Northern New Mexico Citizen's Advisory Board. DOE/NA-LA/Triad have established an email address to receive comments and to answer questions specific to the Upper Sandia Canyon UAA: sandiacanyonuaa@lanl.gov.

Please contact Robert Gallegos at (505) 901-3824 or robert.gallegos@nnsa.doe.gov; or contact Tim Goering at (505) 350-6084 or goering@lanl.gov if you have any questions.

Sincerely,

SARAH HOLCOMB (Affiliate)
Digitally signed by SARAH HOLCOMB (Affiliate)
Date: 2024.02.09 08:38:43 -07'00'

Sarah S. Holcomb
Acting Group Leader
Environmental Compliance Programs
Triad National Security, LLC

Sincerely,

ROBERT GALLEGOS
Digitally signed by ROBERT GALLEGOS
Date: 2024.02.15 16:10:26 -07'00'

Robert A. Gallegos
Permitting and Compliance Program Manager
National Nuclear Security Administration
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Attachment(s): Use Attainability Analysis for Upper Sandia Canyon

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LA-UR-23-34161
Revision 1
February 2024

Use Attainability Analysis for Upper Sandia Canyon

Los Alamos
NATIONAL LABORATORY

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Caption: Sandia Canyon below Gage E123

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Acronyms and Abbreviations

Acronym	Definition
4T3	water temperature not to be exceeded for 4 or more consecutive hours in a 24-hour period on more than 3 consecutive days
6T3	water temperature not to be exceeded for 6 or more consecutive hours in a 24-hour period on more than 3 consecutive days
ALU	aquatic life use
ATEMP	average July air temperature
AU	assessment unit
AWTC	air-water temperature correlation
CFR	Code of Federal Regulations
DO	dissolved oxygen
DOE	U.S. Department of Energy
GCS	grade control structure
HMP	habitat management plan
IR	integrated report
LANL	Los Alamos National Laboratory
LANL MET	Los Alamos National Laboratory meteorological monitoring network
MCW	marginal coldwater
MCWAL	marginal coolwater
MWAT	maximum weekly average (water) temperature
NMAC	New Mexico Administrative Code
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
PCBs	polychlorinated biphenyls
PRISM	Parameter-Elevation Relationships of Independent Slopes Model
SSTEMP	stream segment temperature
SU	standard units
TA	technical area
TMAX	maximum water temperature
Triad	Triad National Security, LLC
UAA	use attainability analysis
USFWS	U.S. Fish and Wildlife Service
WQCC	Water Quality Control Commission
WQS	water quality standards
WY	water year

1 Introduction

This document presents a use attainability analysis (UAA) for the perennial segment of upper Sandia Canyon (Figure 1), which is located within Los Alamos National Laboratory (LANL) property near Los Alamos, New Mexico.[1] The NMED approved workplan for this UAA is provided in Appendix A. The perennial reaches of Sandia Canyon are currently classified as 20.6.4.126 New Mexico Administrative Code (NMAC) (NMED 2022b):

> 20.6.4.126 RIO GRANDE BASIN: Perennial waters within lands managed by the U.S. department of energy (DOE) within Los Alamos National Laboratory (LANL), including but not limited to: Cañon de Valle from LANL stream gage E256 upstream to Burning Ground spring, Sandia canyon from Sigma canyon upstream to LANL NPDES outfall 001, Pajarito canyon from 0.5 miles below Arroyo de La Delfe upstream to Homestead spring, Arroyo de la Delfe from Pajarito canyon to Kieling spring, Starmers gulch and Starmers spring and Water canyon from Area-A canyon upstream to State Route 501.
>
> A. Designated Uses: coldwater aquatic life, livestock watering, wildlife habitat and secondary contact.
>
> B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses. [20.6.4.126 NMAC - N, 5/23/2005; A, 12/1/2010; A, 4/23/2022]

The perennial waters of Sandia Canyon are currently listed as impaired for temperature, dissolved copper, polychlorinated biphenyls (PCBs), and total recoverable aluminum under the Clean Water Act 303(d)/305(b) integrated report 2022–2024. The reach was placed in Category 5B, which means that it is impaired for one or more pollutant, and water quality standards are not being met due to the impairment (NMED 2022a).

Title 40 Code of Federal Regulations (CFR) 131.10(g)(1) permits a state to remove a designated use that is not an existing use (as defined in 40 CFR 131.3) if a UAA demonstrates that naturally occurring pollutant concentrations prevent the attainment of the use or if physical conditions related to the natural features of the water body preclude the attainment of the aquatic life protection use. This UAA considers whether natural, physical conditions in upper Sandia Canyon, specifically air and/or water temperatures, prevent the designated aquatic life use (ALU) water temperature limits (i.e., coldwater) from being attained in the perennial segment.

Upon thorough examination of instream thermograph data and air-water temperature modeling, DOE-Triad recommend that the coolwater ALU is the most protective attainable use for the upper portion of Sandia Canyon—from Sandia Canyon at Bedrock Road to NPDES[2] Outfall 001. Additional protection for this coolwater assessment unit (AU) is proposed by including a new segment 20.4.6.141 with a

[1] Within this document, the terms "LANL" and "Laboratory" are used to distinguish between the organization and the physical area on the Pajarito Plateau controlled and operated by LANL, respectively.

[2] NPDES = National Pollutant Discharge Elimination System.

segment-specific criterion (6T3)[3] of 25 °C (77 °F). The downstream segment of Sandia Canyon—from Sandia Canyon at Sigma Canyon to Sandia Canyon at Bedrock Road (Figure 2)—will remain coldwater ALU.

The new standards for segment changes would read as follows (changes in red):

20.6.4.141 RIO GRANDE BASIN: Perennial waters within lands managed by the U.S. department of energy (DOE) within Los Alamos National Laboratory (LANL), Sandia canyon from Sandia canyon at Bedrock Road upstream to LANL NPDES outfall 001.

A. Designated uses: coolwater aquatic life, livestock watering, wildlife habitat and secondary contact.

B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criterion applies: a 6T3 of 25 °C (77 °F) or less.

[20.6.4.141 NMAC - N, X/XX/XXXX]

This segment description will require the following changes to segment 20.6.4.126:

20.6.4.126 RIO GRANDE BASIN: Perennial waters within lands managed by the U.S. department of energy (DOE) within Los Alamos National Laboratory (LANL), including but not limited to: . . . Sandia canyon at Sigma canyon upstream to Sandia Canyon at Bedrock Road . . .

A. Designated uses: coldwater aquatic life, livestock watering, wildlife habitat and secondary contact.

B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses.

[20.6.4.126 NMAC - N, 5/23/2005; A, 12/1/2010; A, 4/23/2022; A, X/XX/XXXX]

2 Watershed Description and History

Upper Sandia Canyon is one of several segments described by 20.6.4.126 NMAC (NMED 2022b). It is a perennial reach originating within the Laboratory and includes one AU, "NM-9000.A_47, from NPDES outfall 001 to Sigma Canyon" (hereinafter referred to as the upper Sandia Canyon AU; Figure 1). Outfall 001, located at LANL's Technical Area (TA) 3, discharges an average of 154,000 gallons per day (and a maximum of 333,000 gallons per day), creating a continuously flowing waterbody in upper Sandia Canyon (USEPA 2020). Most of the water comes from the co-generating power and steam plant, which generates heat, electricity, and steam used for LANL activities. Although Outfall 001 is the primary source of water flow to the upper Sandia Canyon AU, two other NPDES outfalls—Outfall 027 and Outfall 199—also discharge much smaller volumes of effluent to the AU. Both outfalls discharge cooling tower effluents. Information on outfalls and discharge can be found in the N3B Sandia Wetland Performance Report (2019).

[3] 6T3 = Water temperature not to be exceeded for 6 or more consecutive hours in a 24-hour period on more than 3 consecutive days.

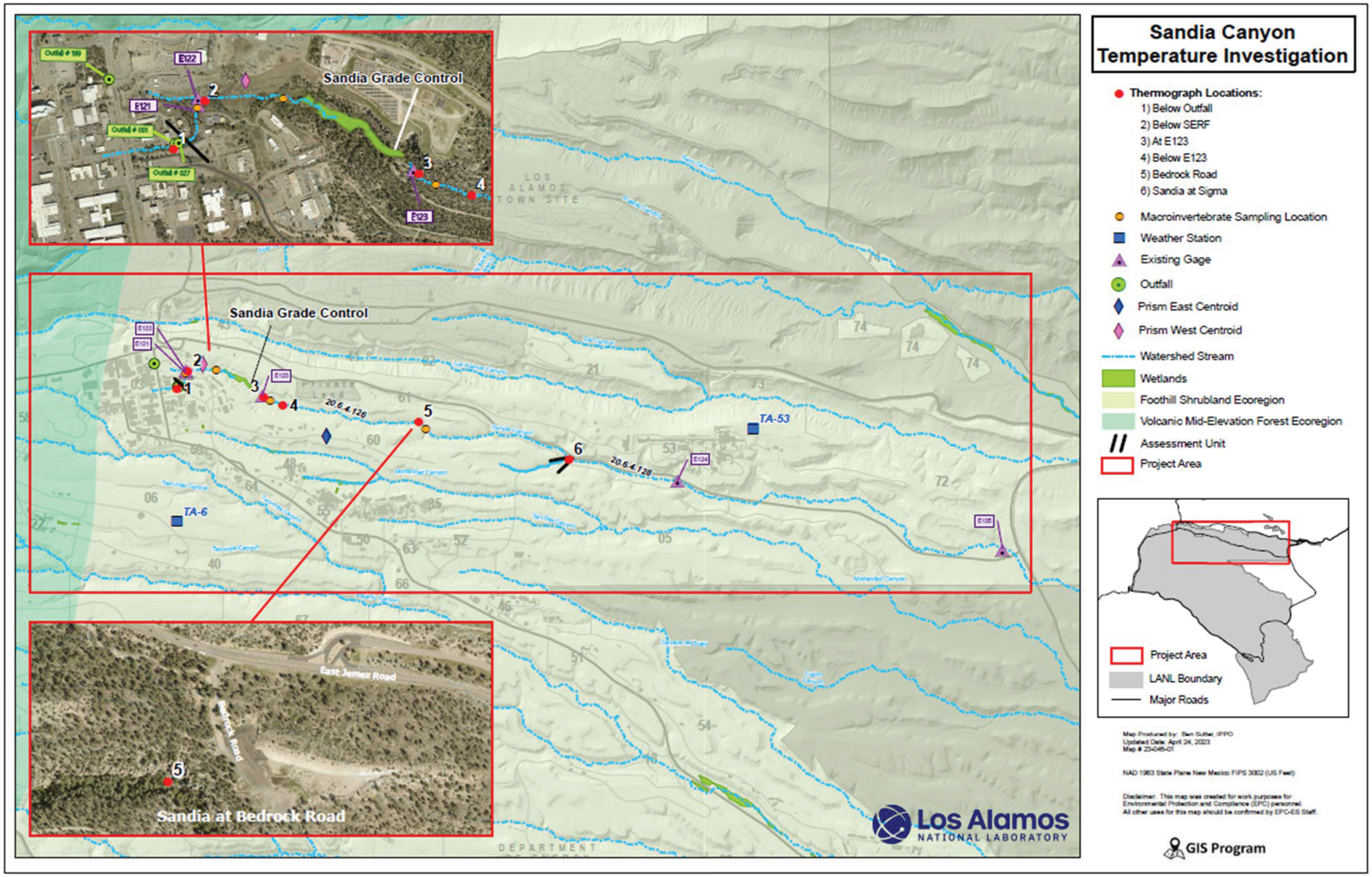

Figure 1. Upper Sandia Canyon assessment unit. GPS coordinates are provided in Appendix B.

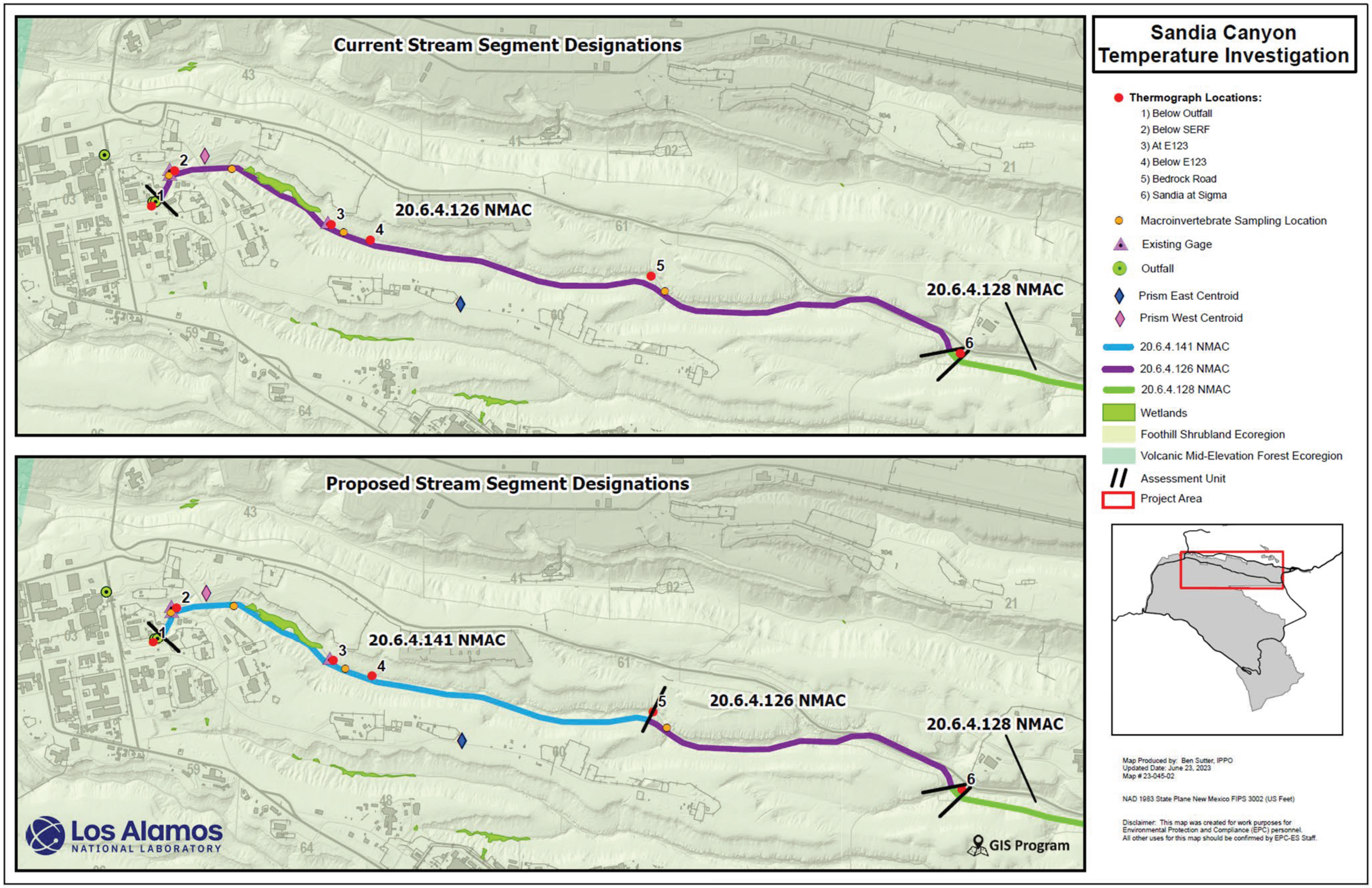

Figure 2. Proposed stream segment designations.

Upper Sandia Canyon is effluent dependent, meaning that without the point source discharge of wastewater, surface waters would be ephemeral (NMED 2020). Discharge into Sandia Canyon began in the 1950s (LANL 2008) and now supports a 3.65-acre wetland (Stanek et al. 2020) near the upper end of the upper Sandia Canyon AU, just downstream of the outfalls (Figure 1). Wetland sediments are underlain by the Bandelier Tuff, upon which alluvial groundwater is perched. Past investigations have shown little evidence of significant infiltration beneath the wetland (LANL 2013). For example, in a water balance study conducted between 2007 and 2008 (LANL 2008), only about 2 percent of the surface water entering the wetland infiltrated the underlying bedrock. Past comparisons of surface water chemistry results from above and below the wetland have demonstrated that baseflow has a short residence time and that there is little exchange between surface water and groundwater within the wetland (Iacona 2015).

Installation of a grade control structure (GCS) in 2013 reduced the rate of erosion at the downstream end of the wetland and created an impermeable barrier to subsurface flow, such that alluvial groundwater must now resurface before exiting the wetland. Given the impermeable nature of this barrier and the largely impermeable tuff that underlies the wetland, the wetland can conceptually be thought of like a bathtub that effectively holds water and slows down flow—excess water overflows from the wetland at the GCS. Annual evaluation of baseflow rates has confirmed this description, and rates entering and exiting the wetland (including transpiration losses) have been validated (N3B 2019).

LANL (2008) determined the water budget for sources of flow and loss throughout the canyon. The study concluded that the perennial segment of upper Sandia Canyon is a net-neutral or net-losing stream from the wetland to the end of the upper Sandia Canyon AU (Table 1); in other words, the amount of water in the stream is stable or decreases over its length as a result of evaporation, infiltration, or surface water loss to alluvial groundwater. Flow in alluvial well gages correlated with changes in outfall flow, as well as with precipitation events. Daily temperature swings in alluvial groundwater also correlated with air temperature fluctuations. These patterns indicate that the alluvial storage is minimal, and that the alluvium is recharged by Sandia Canyon surface water.

Table 1. Approximate Surface Water Budget in Upper Sandia Canyon from July 2007 to June 2008

Process and Area[a]	Estimated Gain or Loss (acre ft/yr)	Percent of Total
Discharge from outfalls	389	75
Runoff above E123	130	25
Evapotranspiration in wetland	−18	−3
Infiltration beneath wetland	−12	−2
Infiltration between wetland and D123.6	0	0
Surface water loss between D123.6 and D123.8	−119	−23
Surface water loss between 123.8 and E124	−334	−64
Surface water loss between E124 and E125	−36	−7

[a] E123, E124, and E125 are permanent surface water gage stations in upper Sandia Canyon. D123.6 and D123.8 were temporary gage stations for the water balance study (LANL 2008).

In 2005, the New Mexico Water Quality Control Commission (WQCC) adopted the upper Sandia Canyon segment as a classified water of the state, designating a use of coldwater aquatic life and a segment-specific temperature criterion of 24 °C. The decision to adopt the segment-specific temperature criterion was based on a 2002 U.S. Fish and Wildlife Service (USFWS) study (Lusk et al. 2002), which found that water temperatures within the upper Sandia Canyon AU exceeded 20°C but not the maximum summer temperature for the survival of brook trout (24 °C).[4] Time-averaged peak temperatures were not considered in that study because time-averaged criteria had not yet been adopted by the WQCC as part of the New Mexico water quality standards (WQS).

In 2010, as part of a revision of the New Mexico WQS, the WQCC eliminated and replaced the upper Sandia Canyon AU's site-specific criterion of 24 °C with the general coldwater aquatic life designated use temperature criterion (also 24 °C) from 20.6.4.900.H NMAC (NMED 2022). In a subsequent rulemaking proceeding, the WQCC adopted the 6T3 criterion[5] of 20 °C and made it applicable to the statewide coldwater designated use (Table 2). Attainability of the 6T3 criterion in the upper Sandia Canyon AU has not been previously analyzed.

Table 2. New Mexico Temperature Criteria for Aquatic Life Designated Uses

Designated ALU[a]	DO (mg/L)	4T3 (°C)	6T3 (°C)[b]	TMAX (°C)[b]	pH
High-Quality Coldwater	6.0	20	NA	23	6.6−8.8
Coldwater	6.0	NA	20	24	6.6−8.8
Marginal Coldwater[c]	6.0	NA	25[d]	29	6.6−9.0
Coolwater	5.0	NA	NA	29	6.6−9.0
Warmwater	5[e]	NA	NA	32.2	6.6−9.0
Marginal Warmwater	5	NA	NA	32.2	6.6−9.0
Limited Aquatic Life	NA	NA	NA	NA	NA

[a] These criteria are derived from the 4/23/2022 20.6.4 NMAC.
[b] Default criteria unless segment-specific criteria have been assigned.
[c] Based on the 2020 Triennial Review and technical support document, EPA determined that "marginal coldwater" in reference to ALU means that natural conditions severely limit maintenance of a coldwater aquatic life population during at least some portion of the year or historical data indicate that the temperature of the surface water of the state may exceed that which could continually support aquatic life adapted to coldwater [25 °C (77 °F)]." (USEPA, 2023b). Based on this updated definition of marginal coldwater, we believe that the marginal coldwater ALU would not apply to the perennial reach of upper Sandia Canyon because of the anthropogenic origin of the flow.
[d] With the exception of 20.6.4.114 NMAC, which contains a segment-specific 6T3 of 22 °C (NMED).
[e] Warmwater and marginal warmwater DO criterion has only one significant figure in 20.6.4 NMAC.
DO = dissolved oxygen.
4T3 = Water temperature not to be exceeded for 4 or more consecutive hours in a 24-hour period on more than 3 consecutive days.
TMAX = maximum water temperature.
NA = not applicable.

Temperature is one of the most common causes of water quality impairment in New Mexico. The upper Sandia Canyon AU is listed as impaired due to temperature exceedances, as discussed in the New Mexico Environment Department (NMED) 2022–2024 Integrated Report (IR) (NMED 2022), and is assigned an IR Category of "5B," indicating the need for review of the WQS.

2.1 Existing Use

In the intricate landscape of environmental compliance and use attainability, a fundamental concept lies in understanding the idea of "existing use," which is defined by the USEPA and NMED as "those uses

4 Sandia Canyon drains to the Rio Grande. The downstream end of the perennial reach is located approximately 8 miles upstream and 1,300 vertical feet above the Rio Grande. Aquatic life surveys of Sandia Canyon have found no fish (LANL 2017 and Lusk et al. 2002).
5 Water temperature not to be exceeded for 6 or more consecutive hours in a 24-hour period on more than 3 consecutive days.

actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards" (40 CFR 131.3, NMAC 20.6.4.7). In accordance with 40 C.F.R. 131.10(g), a designated use may be removed (and replaced with the highest attainable use) if it is not an existing use. Additionally, and pursuant to 40 C.F.R. 131.10(i), a designated use may not have criteria less stringent than the existing use. In the upper Sandia Canyon AU, DOE-Triad National Security, LLC (Triad) have conducted a comprehensive evaluation in upper Sandia Canyon to ensure that the proposed ALU not only complies with existing regulations but also is as stringent as the existing use.

Flow in upper Sandia Canyon is predominantly effluent from Outfall 001, with lesser quantities of effluent from Outfalls 199 and 027. Discharge from Outfall 001 is the primary factor that defines water quality in upper Sandia Canyon. Flow in upper Sandia Canyon is anthropogenic and primarily comprises effluent from the outfalls; however, under natural conditions (with no effluent), flow in upper Sandia Canyon would be ephemeral, with a limited aquatic life existing use. Perhaps more importantly, the water chemistry and characteristics of discharge from Outfall 001 have improved over the years (see Section 2.1.1), and the current attainable use is more protective than the limited aquatic life existing use.

Further details on the historical water quality and benthic macroinvertebrate data, which define the existing use for the segment, are presented in the following sections.

2.1.1 *Historical Water Quality Data*

Historical water quality data for upper Sandia Canyon from early Annual Site Environmental Reports (LANL 1978; LANL 1982) and macroinvertebrate studies in the 1990s (Bennett 1994; Cross 1994; and Cross 1995) indicate that the ALU for the reach has improved over time—concurrently with advancements in water treatment technology and improved detection capabilities for emerging contaminants. In the past, DO and pH data did not consistently meet criteria for marginal warmwater, and more protective ALUs (Lusk et al. 2002). Monthly grab samples conducted in upper Sandia Canyon in the 1990s measured DO below 5 mg/L and occasionally below 4 mg/L during the summer. In addition, pH values exceeding 9 standard units (SU) (and occasionally 10 SU) were measured. These water quality criteria did not meet New Mexico's ALU criteria for marginal warm water (MWWAL) of DO 5 mg/L or more and pH within the range of 6.6 to 9.0 SU.

2.1.2 *Historical Studies of Aquatic Life in Sandia Canyon*

LANL scientists, contract scientists, and NMED have studied the aquatic life of Sandia Canyon and surroundings since the early 1990s. Some of these studies were tied to spill events where macroinvertebrates were used as indicators of ecosystem health in response to these environmental stresses. These studies were not used to affirm attainable and existing use; however, it is important to acknowledge that the perennial section of upper Sandia Canyon—formed and influenced by treated effluent—hosts an aquatic community adapted to the historical and present water quality of the discharge.

2.1.3 *Absence of Fish*

In a study of intermittent streams on the plateau (Lusk et al. 2002), researchers scored fish habitat fitness as "low" for Sandia, owing to several factors:

- low stream discharge and velocity, cover, limited prey abundance and diversity, and excess nutrients in Sandia Canyon reduced potential trout habitat;

- stormflow scouring, erosion, and embedded substrates also reduce the quality of the habitat for benthic macroinvertebrates for this reach; and
- a test of caged fish exposures to Sandia waters (fathead minnows) showed some mortality, which was attributed to stormwater influences.

Perhaps the primary reasons that Pajarito Plateau waters are fishless are the poor habitat availability and—although hydrologic connectivity exists—the lack of migratory connection to waters with fish, owing to the steep drop-off to the Rio Grande at White Rock Canyon (Lusk et al. 2002).

2.1.4 *Benthic Macroinvertebrate Characteristics*

Upper Sandia Canyon, just below the discharge, supports an aquatic life community that is adapted to and less diverse than that found in the reference reach of Los Alamos Canyon (Schmid 1996). Los Alamos Canyon scored an EPT[6] Index of 6, whereas Sandia Canyon scored 0 in the upper reach in this study by NMED. The Biological Condition index of habitat fitness in Sandia Canyon was judged to be 40–50 percent of that in the reference reach, and the number of pollutant tolerant species was higher in upper Sandia Canyon (Schmid 1996). LANL studies have shown that improved diversity and abundance are noted the farther downstream in the perennial reach one goes (LANL 1994, 1995).

2.1.5 *Summary Based on Existing Use Evaluation*

Informed by a thorough examination of past studies and the environmental dynamics of this anthropogenic system, the proposed ALU of coolwater emerges as both attainable and in accordance with the existing use as characterized by discharge from the outfalls (40 CFR 131.3).

To further protect and enhance the water quality of the AU, we recommend the application of a segment-specific criterion of a 6T3 of 25 °C from Sandia Canyon at Bedrock Road to Sandia Canyon below Outfall 001. Concurrently we propose retaining the coldwater ALU for the lowermost segment of the reach—from Sandia Canyon at Sigma Canyon to Sandia Canyon at Bedrock Road. This approach not only aligns with regulatory standards but also reflects our proactive commitment to ensuring the resilience and health of our aquatic ecosystems.

2.2 Basis for Original Coldwater Aquatic Life Use Designation

The 2002 Lusk et al. study assessed Sandia Canyon and identified indicator species and habitat for a coldwater fishery. Based on the Lusk et al. findings, NMED (2007) classified upper Sandia Canyon as NMAC 20.6.4.128 (coldwater); however, chronic temperature monitoring and historical records from 2014 through 2018 led LANL to contest the erroneous application of the coldwater ALU to upper Sandia Canyon.

Significant differences—including elevation, vegetation, and water quality impairments—emerged when comparing Sandia Canyon with the reference site (Lusk et al. 2002) in upper Los Alamos Canyon. Sandia Canyon exhibited lower elevations, shallower canyon transects, piñon-juniper woodland (as opposed to spruce-fir), and impairments from contaminants such as aluminum, chromium, and PCBs. The benthic macroinvertebrate community in upper Sandia Canyon was moderately impaired, with a 30 percent degradation in water quality compared with the reference site from the Lusk study. The study also

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[6] EPT (ephemeroptera, plecopteran, and trichoptera) are generally pollutant-sensitive taxa and are used to investigate water quality.

predates NMED's chronic temperature-monitoring criterion, revealing that in 2002, Sandia Canyon might have failed to meet a coldwater ALU if a 6T3 were applied.

These distinctions underscore the importance of long-term datasets and the effect of specific environmental factors on source water quality. Given these findings, a proposed coolwater ALU for the upper portion of Sandia Canyon is recommended, with additional protection using a segment-specific criterion of 25 °C (77 °F). The downstream segment of Sandia Canyon will remain coldwater.

3 Ecoregion Setting

The Laboratory was built upon the Pajarito Plateau, which the U.S. Environmental Protection Agency (USEPA 2023a) characterizes as southern Rocky Mountain foothill shrub lands, volcanic mid-elevation forests, and north-central New Mexico valleys and mesas. The Pajarito Plateau slopes downward to the east-southeast, covering approximately 15 miles from the base of the Jemez Mountains (7,800 ft elevation) to the Rio Grande (5,400 ft elevation). Habitat on the Pajarito Plateau consists of irregular rolling hills and finger mesas composed primarily of the soft, erodible Bandelier Tuff.

The upper Sandia Canyon AU falls within ecoregion 21d, "Northwestern Forested Mountains-Western Cordillera-Southern Rockies-Foothill Woodlands and Shrubs" (Griffith et al. 2006). Ecoregion 21d, which extends from Wyoming through Colorado and into northern New Mexico, is characteristically dry Rocky Mountain habitat dominated by piñon-juniper and oak woodland forests at 6,000 to 8,500 ft of elevation (Griffith et al. 2006). The upper Sandia AU is located within a transitional zone between mountainous and xeric regions, and air and water temperatures reflect this transition. Section 7 provides information that supports that water temperatures warm along the transition from mountainous to transitional to xeric ecoregions.

4 Water Temperature Data Evaluation

This section provides a discussion of available water temperature measurements from the upper Sandia Canyon AU, including temperatures from Outfall 001, which is the dominant source of water in the AU. All water temperature data are provided electronically with this report in Appendix C. The measured water temperature presented in this section provide clear evidence to the unattainability of the coldwater ALU for the headwaters of upper Sandia Canyon. Furthermore, this section shows support for splitting the reach—from Bedrock Road to Outfall 001—into a coolwater designation with increased protections of a 6T3 criterion of 25 °C. A coldwater designation will remain in place downstream at Sigma Canyon to Bedrock Road (Figure 2).

4.1 Upper Sandia Canyon Thermograph Water Temperatures

Between 2014 and 2017, LANL strategically deployed five thermographs in the upper Sandia Canyon AU to directly monitor water temperatures. To enhance the dataset, a sixth thermograph was deployed in 2018 in Sandia Canyon at Bedrock Road (formerly "Sandia at Crossing"; see Figure 1). Some challenges arose because thermographs faced exposure to air temperature during storm events or low-flow conditions, which resulted in inaccurately high temperature readings that reached 61 °C. LANL identified and subsequently excluded these exposed periods when calculating 6T3 values and determining exceedances of criteria. Figure 3 shows the refined 2014–2018 thermograph data, illustrating temperature variations over time at different positions along the upper Sandia Canyon AU. Specific dates for which data were excluded are reported in Table 3.

Figure 3 shows that—the instantaneous water temperatures exceeded the 6T3 threshold (green dotted line) for coldwater (20 °C) at every thermograph location during the study period; however, when we look at Table 3 using NMED 6T3 calculations, we see that the 6T3 criterion for coldwater was not exceeded at Sandia Canyon or Sigma Canyon between 2016 and 2018, nor at Sandia Canyon at E123 in 2017. However, the 6T3 criterion for coldwater was exceeded at Sandia Canyon at E123 from 2014 to 2016, again at Sandia Canyon below E123 in 2016, and every year (2014 to 2017) at Sandia Canyon below Outfall 001 and Sandia Canyon below SERF. Sandia Canyon at Bedrock Road exceeded coldwater 6T3, but only 1 year of data supports this exceedance of 20.1 °C. The coldwater TMAX criterion (24 °C) was exceeded at Sandia Canyon below Outfall 001, Sandia Canyon below SERF, and Sandia Canyon at E123 at least once during the study period, whereas the criterion was not exceeded any year at Sandia Canyon below E123, Sandia Canyon at Bedrock Road, or Sandia Canyon at Sigma Canyon. Actual 6T3 values were calculated using NMED long-term data management spreadsheets found in Appendix D.

The results presented in this section, with a focus on Table 3, illustrate variability in water temperature statistics within the upper Sandia Canyon AU. These variations indicate instances where actual water temperatures deviate from predictions made by the air-water temperature correlation (AWTC) in Section 8. Values were derived using a regression model with inherent uncertainties, so modeled deviations from observed water temperatures were anticipated. TMAX predictions exhibited a consistent bias toward higher temperatures—with limited exceptions—when compared with actual values.

Lower-than-expected water temperatures, particularly at stations downstream of E123, could have resulted from shading in canyon bottoms and effluent discharged from Outfall 001 that was cooler than the modeled water temperature for the upper Sandia AU (see Section 4.2). It is essential to note that data from Parameter-Elevation Relationships of Independent Slopes Model (PRISM) and Los Alamos National Laboratory meteorological monitoring network (LANL MET) stations represent temperatures on top of the Pajarito Plateau rather than within Sandia Canyon, so possible effects of shading and microclimate (e.g., cooler, denser air settling in the canyon bottom) seem reasonable when comparing the air and water temperature lines of evidence (Table 3 and Table 4). The difference between modeled and observed water temperatures was greater downstream of E123 compared with upstream, indicating that microclimate and hydrologic cooling influences intensify as shading increases and as the canyon narrows and steepens downstream.

The observed cooling trend over time might be correlated with the installation of the GCS in 2013, resulting in increased water retention and enhanced vegetative growth in the 0.4-mile-long wetland above gage E123 (Figure 1). Vegetation within the wetlands plays a significant role in shading, potentially maintaining lower water temperatures throughout the day. A survey conducted between 2014 and 2017 indicated a high density of vegetation within the wetland, increased plant diversity and tree canopy, and an annual increase in the areal extent of the wetland (Gallegos 2021). The GCS's mechanism of resurfacing alluvial groundwater before its exit from the wetland further contributes to the potential cooling effect on water temperatures at E123.

Measured water temperatures and AWTC-modeled water temperatures indicate that, with the exception of some years and locations, the coolwater use is attainable across the entire AU. It is assumed that the cooling will be sustained and that a coolwater designated use is representative of future conditions.

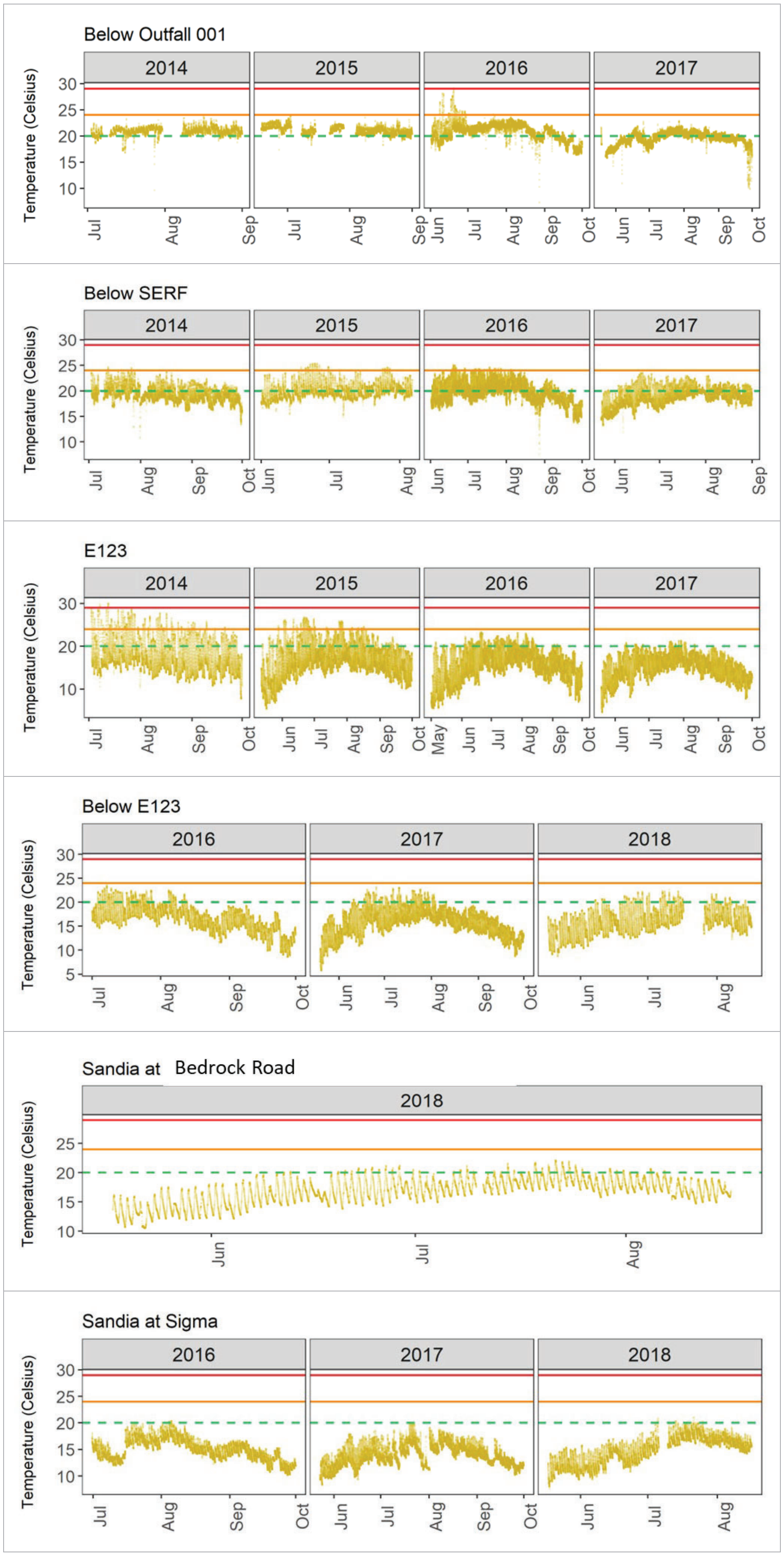

Figure 3. Water temperature in upper Sandia Canyon assessment unit 2014–2018. Source: LA-UR-18-28589. Sub-figures are organized in the direction of flow from below Outfall 001 to Sandia at Sigma. Horizontal lines represent temperature criteria associated with designated uses. Green dash = coldwater 6T3 (20 °C); orange solid = coldwater TMAX (24 °C); and red solid = coolwater TMAX (29 °C). High-quality coldwater TMAX of 23 °C not shown. Data were removed from thermograph datasets from periods when thermographs became exposed to air (Table 3).

Table 3. Measured and Predicted Water Temperature Thresholds[a] 2014–2018

Thermograph	Year	Actual TMAX (°C)	Actual 6T3[b] (°C)	AWTC TMAX (°C)	AWTC 6T3[b] (°C)	Designated Use Attained	Dates Exposed/Data Excluded
Sandia Canyon below Outfall 001	2014	23.9	21.6	27.4	22.6	Coolwater	7/7 to 7/9, 7/31 to 8/7
	2015	23.9	22.4	26.2	21.7	Coolwater	6/1 to 6/17, 7/3 to 7/7, 7/15 to 7/21, 7/29 to 8/3
	2016	29.1	23.4	30.8	26.2	Warmwater	None
	2017	22.9	21.0	28.5	24.0	Coolwater	None
Sandia Canyon below SERF	2014	24.7	21.5	27.4	22.6	Coolwater	7/7 to 7/9
	2015	25.4	22.5	26.2	21.7	Coolwater	None
	2016	25.2	22.8	30.8	26.2	Coolwater	None
	2017	23.6	21.0	28.5	24.0	Coolwater	None
Sandia Canyon at E123	2014	30.1	23.6	27.4	22.6	Warmwater	None
	2015	26.8	22.7	26.2	21.7	Coolwater	None
	2016	23.3	20.1	30.8	26.2	Coolwater	None
	2017	21.4	19.1	28.5	24.0	Coldwater	None
Sandia Canyon below E123	2016	23.5	20.7	30.8	26.2	Coolwater	None
	2017	23.2	19.7	28.5	24.0	Coldwater	None
	2018	22.6	18.9	28.9	24.4	Coldwater	7/17 to 7/25
Sandia Canyon at Bedrock Road	2018	22.1	20.1	28.9	24.4	Coolwater	7/10
Sandia Canyon at Sigma Canyon	2016	20.4	18.4	30.8	26.2	Coldwater	None
	2017	20.0	17.6	28.5	24.0	Coldwater	None
	2018	21.0	18.7	28.9	24.4	Coldwater	7/6 to 7/9

(orange)	Meets warmwater based on TMAX
(green)	Meets marginal coldwater based on TMAX and 6T3
(blue)	Meets high-quality coldwater based on TMAX and 4T3

[a] Predicted thresholds based on AWTC (Table 3, Equations 3 and 4).
[b] Actual 6T3 values were calculated using NMED long-term data management spreadsheets found in Appendix D.

Data Uncertainty

Uncertainties in thermograph data, PRISM air temperature data, and LANL meteorological station air temperature data are discussed in the following subsections.

Uncertainty in Thermograph Data

The thermographs used for the Sandia UAA were the HOBO Water Temp Pro (U22-001) logger, designed for long-term deployments in water. The thermographs have an accuracy of ±0.21 °C and a resolution of 0.021 °C at 25 °C.

Occasionally, DOE-Triad thermographs became exposed to the air due to storm events or low-flow conditions, leading to very high and inaccurate temperature readings in our records (up to 61 °C). DOE-Triad identified those periods when the thermographs became exposed, and those data were removed from consideration (e.g., when calculating 6T3 values and determining exceedances of criteria).

Uncertainty from PRISM Temperature Data

The PRISM Climate Group at Oregon State University provides estimated air-temperature data using PRISM. The accuracy of the model results depends on multiple factors, including the topography of the area modeled, the grid resolution, and the density of meteorological sensors that capture climate data to provide input for the model. Calculations used in this UAA for PRISM can be found in Appendix E.

A study published by S. Strachan and C. Daly (2017) tested 16 sites on open woodland slopes in California and Nevada to measure the accuracy of the PRISM air temperature model in semi-arid watersheds. Their study revealed high accuracy in the PRISM temperature data but systematic biases linked to topoclimatic (orographic) effects.

These biases may be apparent in the PRISM data set used with the NMED's AWTC model to predict water temperatures in upper Sandia Canyon, with predicted water temperatures biased high (Table 3). Both the PRISM and the LANL MET data represent temperatures on the Pajarito Plateau rather than within Sandia Canyon and do not reflect microclimate effects (e.g., cooler, denser air settling in the canyon bottom), or the increased shading in the lower part of the canyon. These microclimate cooling effects become greater as the canyon narrows and becomes steeper downstream (Table 3), with the greatest differences between predicted and actual water temperatures in the portion of the canyon downstream of E123.

Uncertainty in LANL Meteorological Station Air Temperature Data

Temperature data from LANL's meteorological stations introduce some minor uncertainty due to the accuracy of instruments used to measure air temperatures at the Laboratory. DOE has directed that the accuracies of the monitoring measurements should at least be consistent with the specifications set forth in either ANSI/ANS-3.11-2015 or EPA-454/R-99-005. In 2016, personnel at the Laboratory conducted an analysis of uncertainties in meteorological measurements (Dewart 2016) and determined that accuracy of the data is dominated by instrument uncertainty. The evaluation showed that uncertainties introduced by system components, such as the data logger and the data management system, are typically small. The instrument accuracy of air temperature data collected at LANL meteorological stations is ± 0.19 °C, well within the ANSI/ANS-3.11-2015 accuracy requirement (±) of ± 0.5 °C. LANL MET data used for this study can be found in Appendix E.

Additional uncertainty for the UAA modeled results using LANL meteorological data is introduced as a result of microclimate effects. The use of LANL meteorological data to predict the maximum water temperature (TMAX) in the perennial reach of Sandia Canyon introduces some bias toward higher predicted temperatures (versus actual temperatures in the water), as shown in Table 3; however, it must be considered that the source water is anthropogenic and potentially a blend of multiple origins.

This bias could reflect the fact that the LANL meteorological stations used for the Sandia UAA modeling of water temperature data in upper Sandia Canyon are located on the mesas of the Pajarito Plateau and not in the canyons. For this reason, temperature data from the meteorological stations do not accurately reflect microclimate influences of the canyon itself, particularly in the lower portion of Sandia Canyon at Sigma Canyon.

As Table 3 indicates, thermograph data from lower Sandia Canyon show significantly cooler in-stream temperatures than predicted using LANL MET data and the NMED's AWTC. In most cases, the maximum water temperature (TMAX) was higher than the predicted maximum temperature based on the air-water temperature correlation (AWTC TMAX), with the greatest differences in the lower part of Sandia Canyon, where the orographic microclimatological effects were most significant.

4.2 Maximum Weekly Average Water Temperatures

Maximum weekly average (water) temperature (MWAT) values were used to predict the attainable use based on the AWTC Model (NMED 2011a), discussed in Section 8. The NMED Surface Water Quality Bureau developed a statewide correlation in 2011 showing that average July air temperature (ATEMP) from PRISM data directly correlated to MWAT. According to the AWTC model, the attainable water MWAT equals ATEMP for locations where water temperature is controlled by ambient air temperature in streams that are not significantly influenced by groundwater (NMED 2011a). While MWAT proves valuable for predictions, DOE-Triad acknowledge the uncertainties with the model and emphasize thermograph data over modeled data. MWAT is considered a supplementary line of evidence in this context. MWAT calculations used for this study are provided in Appendix F.

As noted in Section 4.1, potential exists for microclimate effects in the upper Sandia Canyon AU, so the assumption that ATEMP equals MWAT may be invalid in this instance. Therefore, the equations from NMED (2011a) that rely on MWAT directly (Eq. 1 and 2) can be used instead of those that rely on ATEMP (and the assumption of its equivalency to MWAT). By inputting measured MWAT values into Equations 1 and 2, the 6T3 and TMAX values that should be observed in the upper Sandia Canyon AU can be more accurately estimated.

$$6T3 = 1.0346 \times MWAT + 1.3029 \quad \text{(Eq. 1)}$$

$$TMAX = 1.0661 \times MWAT + 4.9547 \quad \text{(Eq. 2)}$$

To calculate MWAT values for the six monitoring locations (listed in Table 4), 15-minute thermograph measurements were averaged over each day, and then 7-day rolling averages were calculated over each monitoring year. Data gaps exist where thermographs were exposed to the air (entire days; see Table 3) or when data were being downloaded (short periods during single days). Daily averages were calculated when small data gaps occurred during a day (from downloading data) but were not calculated for days when thermographs were exposed to air. Rolling averages were calculated for 7-day periods, so these values did not include data gaps. This approach led to significant uncertainty for the 2015 period for the thermograph at Sandia Canyon below Outfall 001, which was frequently exposed to the air; therefore, no MWAT was calculated for 2015. Table 4 reports the MWAT values, which vary spatially and temporally and range from 16.64 °C at Sandia Canyon at Sigma Canyon in 2017 to 22.35 °C at Sandia Canyon below Outfall 001 in 2016.

Table 4. Measured MWAT and Predicted 6T3 and TMAX Criteria Based on MWAT

Location	Year	Measured MWAT (°C)	Predicted 6T3 (°C)[a]	Predicted TMAX (°C)[a]	Predicted Attainable Use
Sandia Canyon below Outfall 001	2014	21.44	23.48	27.81	coolwater
	2015	nd[b]	nd[b]	nd[b]	nd[b]
	2016	22.31	24.20	28.55	coolwater
	2017	20.96	22.99	27.30	coolwater
Sandia Canyon below SERF	2014	20.67	22.69	26.99	coolwater
	2015	21.20	23.24	27.56	coolwater
	2016	21.18	23.22	27.53	coolwater
	2017	20.18	22.18	26.47	coolwater
Sandia Canyon at E123	2014	20.36	22.37	26.66	coolwater
	2015	19.35	21.32	25.58	coolwater
	2016	18.61	20.56	24.79	coolwater
	2017	17.87	19.79	24.01	coolwater
Sandia Canyon below E123	2016	19.29	21.26	25.52	coolwater
	2017	18.88	20.84	25.08	coolwater
	2018	17.62	19.53	23.74	coolwater
Sandia Canyon at Bedrock Road	2018	19.19	21.16	25.41	coolwater
Sandia Canyon at Sigma Canyon	2016	17.89	19.81	24.03	coolwater
	2017	16.63	18.51	22.68	coldwater
	2018	18.05	19.98	24.20	coolwater

[a] The 6T3 and TMAX values were predicted by inputting measured MWAT into Equations 1 and 2, respectively.
[b] nd = not determined; MWAT values were not determined for Sandia Canyon below Outfall 001 in 2015 because of frequent periods of exposure of the thermograph to air, which resulted in large data gaps and uncertainty in the MWAT calculation.

The attainable uses were predicted by inputting MWAT values into Equations 1 and 2 and then comparing the output to temperature criteria for designated uses (Table 2). Analysis of the MWAT data suggests that the coolwater ALU is attainable for the upper Sandia Canyon AU with a single exception: Sandia Canyon at Sigma Canyon in 2017 (Table 4). This analysis provides another line of evidence that supports a coolwater ALU, although—because it relies on modeling temperature criteria—it is not as strong a line of evidence as data presented in Section 4.1.

4.3 Outfall 001 Effluent Water Temperatures

Hourly Outfall 001 temperature data for the summer months of 2015–2018 (Gallegos 2018) reveal lower variability in effluent temperatures compared with instream temperatures. Table 5 displays observed TMAX and 6T3 values calculated for this period. The 6T3 was calculated using NMED long-term data management spreadsheets found in Appendix D. In 2016, TMAX exceeded the coldwater aquatic life criterion of 24 °C, and 6T3 exceeded the coldwater aquatic life criterion of 20 °C every year; the discharge from Outfall 001 did not exceed the coolwater criterion for TMAX (29 °C) during this time.

Table 5. Observed TMAX and Calculated 6T3 Outfall Temperatures

Year	TMAX (°C)	6T3 (°C)
2015	23.2	22.1
2016	24.6	23.7
2017	22.3	21.3
2018	22.5	21.8

Source: Gallegos 2018.

It is important to note that the outfall temperatures referenced in Table 5 were recorded before any artificial cooling or manipulation took place in later years to comply with NPDES requirements, indicating that natural air temperature is the primary factor that affects water temperatures in the canyon.

4.4 Protection of Downstream Waters

Under the proposed designated use change, downstream waters to upper Sandia Canyon will be protected and maintained in accordance with 40 CFR 131.10(b). Changes in the designated ALU for upper Sandia Canyon (Segment NM-9000.A_47) will not impact surface waters located downstream of the reach. These surface waters include the following (upstream to downstream):

- Sandia Canyon from Sigma Canyon to Bedrock Road in Water Quality Segment 20.6.4.126 (AU NM 9000.A_047). Perennial waters within lands managed by the U.S. Department of Energy (DOE) with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact.
- Sandia Canyon in Water Quality Segment 20.6.4.128 (AU NM-9000.A_047). Ephemeral and intermittent waters within lands managed by U.S. Department of Energy (DOE) with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact.
- Sandia Canyon below LANL Boundary 0.5-mile reach within Bandelier National Monument (presumably Water Quality Segment 20.6.4.98). Unclassified intermittent waters with designated uses of wildlife habitat, livestock watering, warmwater aquatic life, and primary contact.
- Sandia Canyon within San Ildefonso Pueblo.[7] Water quality standards not promulgated.
- Rio Grande in Water Quality Segment 20.6.4.114 (from Cochiti Pueblo boundary upstream to Rio Pueblo de Taos). Designated uses of irrigation, livestock watering, wildlife habitat, marginal coldwater aquatic life, warmwater aquatic life, primary contact, and public water supply. Segment-specific temperature criteria of 6T3-22 °C (instead of 25 °C for marginal coldwater [MCW]) and maximum temperature of 25 °C (instead of 29 °C). Note: Marginal

[7] Waters that originate or pass through sovereign Pueblo or Tribal lands are under the jurisdiction of those Pueblos or Tribes. A notable exception is joint jurisdiction held by the Pueblo de San Ildefonso and the State of New Mexico for portions of the Rio Grande in segment 20.6.4.114 NMAC.

coolwater (MCWAL) not attained (2022–2024 IR) in Rio Grande WQS 20.6.4.114 NMAC - AU NM-2111_00.

Amending water quality standards requires assessing downstream protections for Segments 126, 128, and 114. Figure 2 illustrates the current and proposed ALU designations for the upper Sandia Canyon AU. Shifting Sandia Canyon's upper segment (Bedrock Road to Outfall 001) from coldwater (Segment 126) to coolwater (Segment 141) remains protective because the system naturally cools downstream into Segment 126 waters (from Sandia Canyon at Sigma Canyon to Bedrock Road). Water quality of Sandia Canyon at Sigma Canyon will remain designated within Segment 126 because it currently meets the coldwater ALU.

Thermograph data from 2016 to 2018 for Sandia Canyon at Sigma Canyon (Table 3) indicate compliance with the current coldwater standard without active cooling measures at Outfall 001. Segment 128 and Segment 114 waters of lower Sandia Canyon are designated as Limited ALU, a less-protective use.

Changing the designated use for upper Sandia Canyon will not impact downstream ephemeral portions of the canyon to the Rio Grande (Segments 20.6.4.128 –20.6.4.114). Laboratory gaging stations indicate that flows from upper Sandia Canyon seldom reach the Lab's eastern boundary (Figure 4), approximately 3.3 miles below the end of perennial flows (Figure 1). It is even more rare for surface flows to reach the Rio Grande—approximately 9 miles below the perennial section—and unlikely for surface flows to affect temperatures at the confluence. The data confirm that amending upper Sandia Canyon's designated ALU from coldwater to coolwater will not impact water quality and supports the attainment and maintenance of downstream standards.

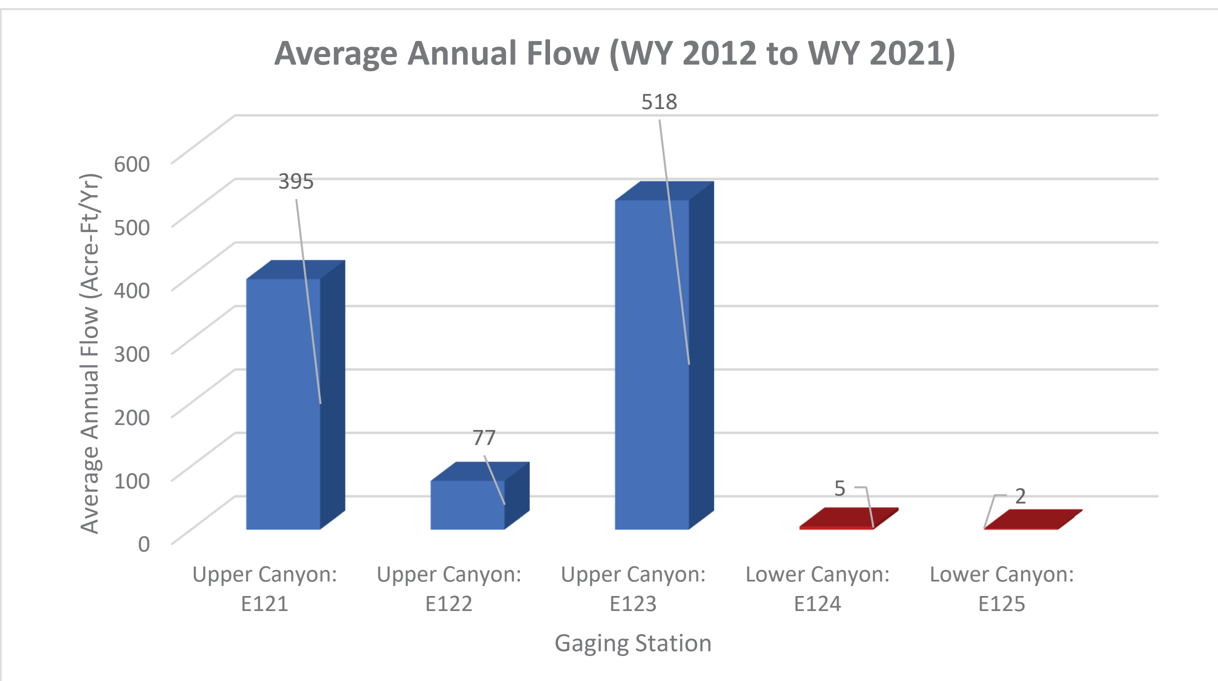

Figure 4. Average annual flow measured in Sandia Canyon gages during the period from October 1, 2011, through September 30, 2021.Period of record for Gage E124 spans only 8 years, from October 1, 2013, to September 30, 2021 (N3B 2022). WY = water year

5 Threatened and Endangered Species, Critical Habitat, and Aquatic Life

An evaluation was conducted of the potential impact of proposed water quality changes on Endangered Species Act–listed threatened and endangered species located within upper Sandia Canyon. Documentation of the presence or absence of threatened and endangered species and critical habitat in upper Sandia Canyon was analyzed in LANL's habitat management plan (HMP; (Hathcock, Keller, and Thompson 2017). The HMP is a comprehensive plan that balances current operations at the Laboratory and future development within the habitats of listed species. Three federally listed threatened or endangered species currently have site plans at the Laboratory: Mexican spotted owl (*Strix occidentalis lucida*), Jemez Mountains salamander (*Plethodon neomexicanus*), and southwestern willow flycatcher (*Empidonax trailii extimus*). The lower section of the upper Sandia Canyon AU is within delineated habitat for the Mexican spotted owl. Based on a review of the proposed work, the UAA work scope is within the framework of the HMP, so no further consultation is needed. Changes to the water quality designation are also within the framework of the HMP, requiring no further consultation.

Several aquatic life surveys have been conducted in Sandia Canyon (Hathcock, Keller, and Thompson 2017; LANL 2017). Fish have not been observed in the upper Sandia Canyon AU—despite attempts to survey them—which indicates that fish are not present. Aquatic life surveys have shown that benthic invertebrate species (macrofauna and meiofauna) are present: 86 taxa—the majority of the insects—were observed in 2017 (Appendix G)[8]; 35 percent were chironomid midges, and 19 percent were coleopterans (beetles), ephemeropterans (mayflies), or trichopterans (caddisflies). Small meiofaunal species (e.g., tardigrades) accounted for a limited portion of observed taxa. Observed taxa richness did not clearly increase with distance from Outfall 001 (Table 6).

Table 6. Count of Taxa Observed in Upper Sandia Canyon in 2017[a]

Reach	Reach Description	No. of Unique Taxa
1	Uppermost: near forks confluence (gages E121 and E122)	33
2	Upper: above wetland	59
3	Middle: below wetland (near E123)	37
4	Lower: midway between wetland and Sigma Canyon	47
All	Reaches 1, 2, 3, and 4	86

[a] The taxa observed in each reach are not mutually exclusive, so the sum of observed taxa is not equivalent to the total unique taxa observed among all reaches.

The benthic macroinvertebrate and meiofaunal species observed during the aquatic life surveys were compared with sensitive and protected species listed by the New Mexico Department of Game and Fish (NMDGF; BISON-M 2016) to determine if threatened or endangered species have been found in the upper Sandia Canyon AU. Review of the data revealed that no species listed as threatened or endangered by NMDGF and USFWS or discussed in Berryhill et al. (2020) were found within the upper Sandia Canyon AU during these surveys.

[8] Taxa overlap in some cases (e.g., "Annelida" was listed as a unique taxon in addition to Tubificidae, Enchytraeidae, and Lumbricina [among others], all of which are annelid taxa), so the total of 86 species may be an overestimation of species richness.

6 Evaluation of pH, Dissolved Oxygen

This section provides a discussion of other factors discussed in the UAA Work Plan (Gallegos 2020), provided in Appendix A, that may affect attainment of the coldwater aquatic life designated use.

In accordance with Gallegos 2020, DO and pH data from LANL's environmental surveillance gages E121, E122, and E123—located within the upper Sandia Canyon AU—were evaluated to determine whether DO and pH fell within acceptable levels during the monitoring period. The criteria applicable to the coldwater aquatic life designated use are DO ≥ 6.0 mg/L, pH between 6.6 and 8.8, 6T3 temperature < 20 °C, and maximum temperature < 24 °C (20.6.4.900.H(2) NMAC) (NMED 2022b).

DO and pH data were collected pursuant to LANL's interim facility-wide groundwater monitoring plan (LANL 2016) and provided in Appendix H. Data from 2016 through 2019 were downloaded from the Intellus New Mexico website (Intellus 2019). Sampling locations in the Intellus database that correspond with gages E121, E122, and E123 are "Sandia right fork at Pwr Plant," "South Fork of Sandia at E122," and "Sandia below Wetlands," respectively.

Figure 5 shows DO concentrations at E121, E122, and E123. During the period from 2016 to 2019, DO ranged from 6.26 to 11.23 mg/L, exceeding the criterion limit for coldwater designated use. DO concentrations vary seasonally, with the highest concentrations during winter months. The elevated DO concentrations in winter reflect the greater solubility of oxygen in cold water than in warmer summer water.

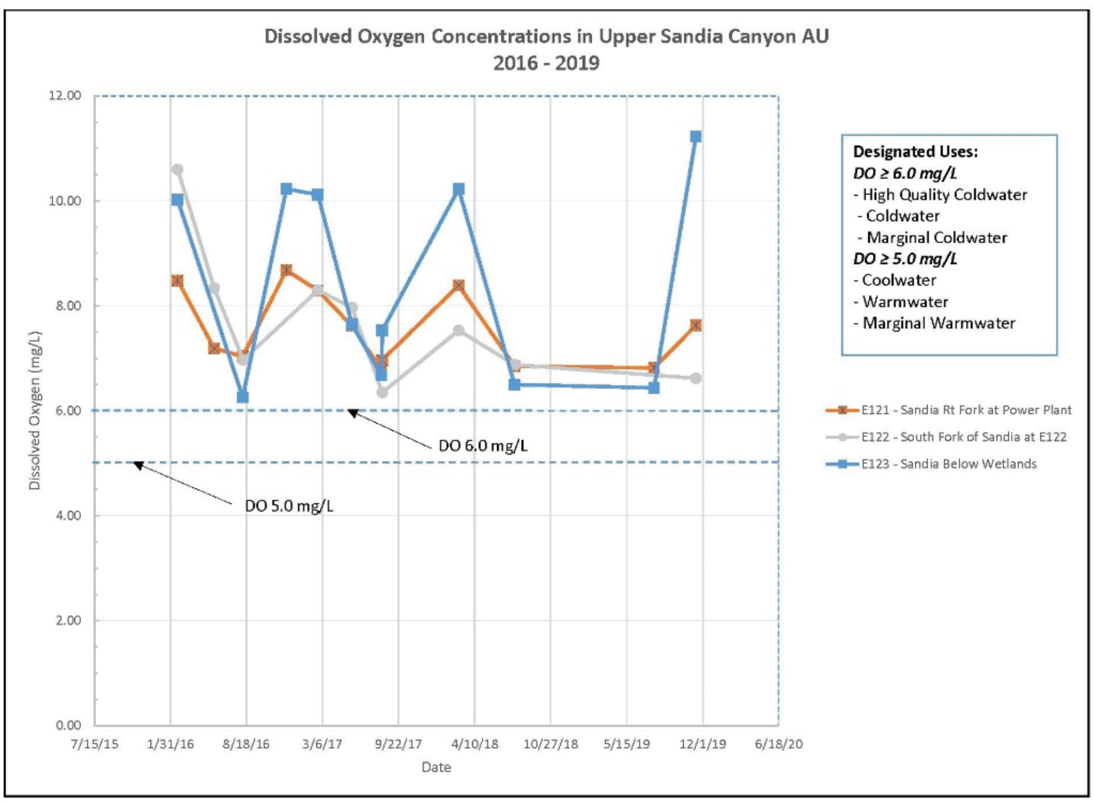

Figure 5. DO concentrations in upper Sandia Canyon assessment unit, 2016–2019.Coldwater aquatic life designated use criterion for DO is 6 mg/L.

Figure 5 shows the pH concentrations in the upper Sandia Canyon AU from 2016 to 2019. During this period, pH concentrations ranged from 7.43 to 8.80, remaining within the coldwater aquatic life designated use range of 6.6 to 8.8. The pH concentrations at E123 were observed to be slightly lower than those at E121 and E122.

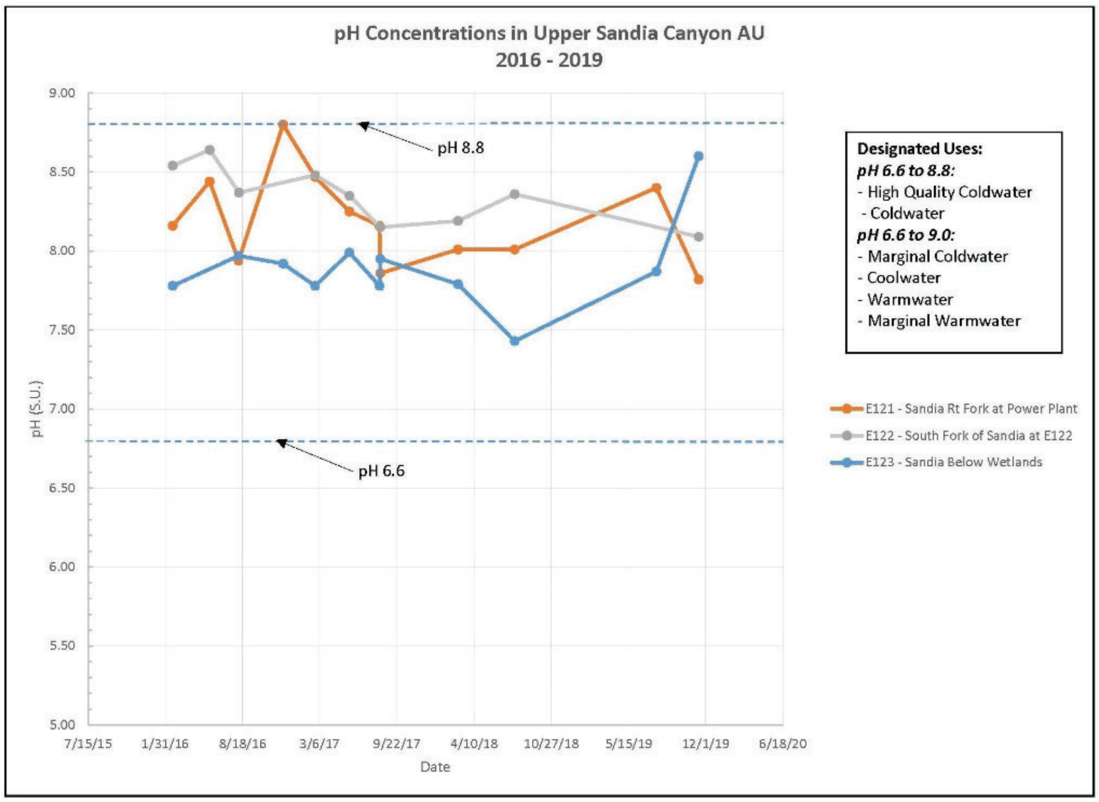

Figure 6. pH Concentrations in upper Sandia Canyon assessment unit 2016–2019.The coldwater aquatic life designated use criterion range for pH is 6.6 to 8.8.

In summary, DO and pH concentrations between 2016 and 2019 were entirely within acceptable levels for the coldwater aquatic life designated use. Therefore, DO and pH do not prevent attainment of the coldwater designated use.

7 Transitional Nature of Ecoregion 21d

Tetra Tech (2010), cited in the 2017 Tecolote Creek temperature UAA (NMED 2017), divided Level IV ecoregions in New Mexico into three sedimentation categories: mountain (21h), foothills (21d), and xeric (22h). This scheme recognizes the differences between high-elevation, steep-sloped, lush-vegetation mountain streams; lower and drier foothills streams; and flatter and still drier xeric streams. The Laboratory lies entirely within these three Level IV ecoregions, and upper Sandia Canyon falls within ecoregion 21d, which represents a transitional environment between 21h and 22h.

During the 2009 Triennial Review, NMED adopted the coolwater aquatic life designated use into its rulemaking process. The coolwater use criteria are intended to provide appropriate protection to aquatic species in transitional and coolwater areas between high-quality coldwater and coldwater use areas in mountainous streams and warmwater use areas in xeric streams (NMED 2009). Communities that live in naturally coolwater streams are tolerant of and adapted to coolwater conditions.

To illustrate how the concept of ecoregion relates to upper Sandia Canyon water temperatures, stream temperatures were measured in three perennial streams located within the Laboratory area: Water Canyon, upper Sandia Canyon, and lower Ancho Canyon. These streams are positioned in the mountains (21h), foothills (21d), and xeric (22h) landscapes, respectively, within the Laboratory area; therefore, they span the range of regional conditions for streams with comparable hydrologic regimes.

July water temperatures are plotted in Figure 7, which illustrates increasing temperatures from the mountain region in the west (Water Canyon) toward the xeric region in the east (lower Ancho Canyon) nearer the Rio Grande. Temperatures in upper Sandia Canyon are, on average, between those observed in the other two streams—consistent with expectations for the three ecoregions. Raw data are provided in Appendix I.

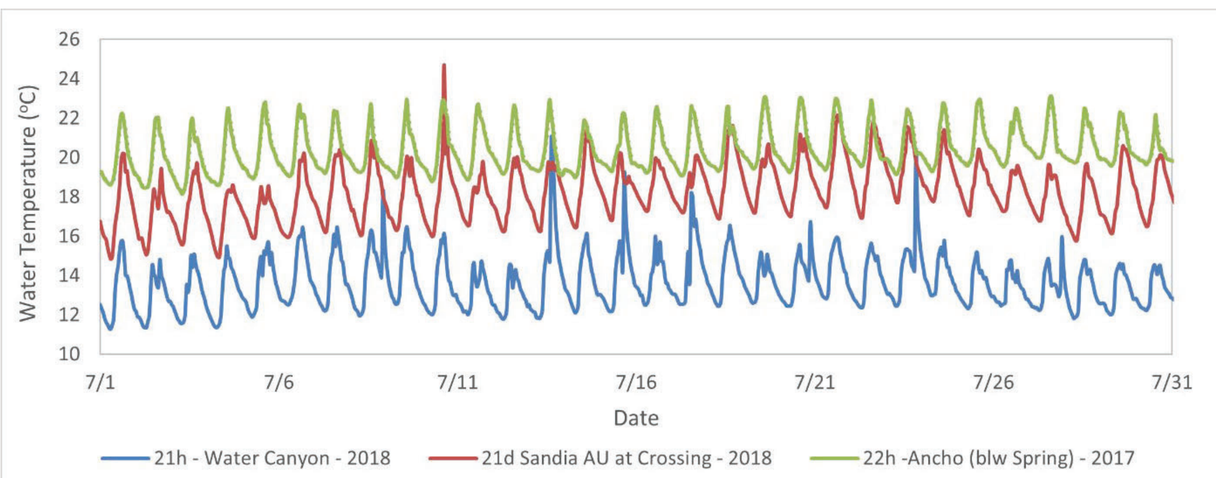

Figure 7. July 2017 and 2018 temperatures for perennial streams within ecoregions 21h, 21d, and 22h. Water Canyon, upper Sandia Canyon, and lower Ancho Canyon monitoring locations are located with ecoregions 21h (mountain), 21d (foothills), and 22h (xeric), respectively, and were sampled in 2018, 2018, and 2017, respectively. Foothills are transitional between mountain and xeric. The coldwater TMAX criterion (24 °C) was exceeded once during the 2018 monitoring period in upper Sandia Canyon; however, this period represents a time (7/10/2018) when the thermograph was exposed to the air (Table 5).

8 Air-Water Temperature Correlation Model

Air temperature and water temperature are highly correlated (NMED 2011a), so air temperature data can be used to understand what water temperatures can be attained in the upper Sandia Canyon AU. The NMED Surface Water Quality Bureau AWTC model has been used in past UAAs (e.g., NMED 2017, 2011b) to estimate water temperature statistics and substantiate which aquatic life designated uses are attainable. This UAA applies the same line of evidence, as described in this section. AWTC is considered a supplementary line of evidence, with greater emphasis placed on thermograph data. Data spreadsheets and calculations are provided in Appendix E.

8.1 Description of the AWTC

The statistics needed to determine attainable uses for the upper Sandia Canyon AU were the 6T3 and TMAX.[9] These statistics were estimated using the AWTC equations (Equations 3 and 4)[10] and then compared with New Mexico temperature criteria (Table 2) to estimate which aquatic life designated uses are likely attainable in the upper Sandia Canyon AU.

$$6T3 = 1.0346 \times ATEMP + 1.3029 \qquad \text{(Eq. 3)}$$

where:
ATEMP = average July air temperature in the upper Sandia Canyon AU.

$$TMAX = 1.0661 \times ATEMP + 4.9547 \qquad \text{(Eq. 4)}$$

where:
ATEMP = average July air temperature in the upper Sandia Canyon AU.

8.2 AWTC Model Application

Two datasets were used to generate independent ATEMP estimates:

- Near-surface air temperature data from the LANL meteorological monitoring network (LANL MET; LANL 2023).
- Parameter-Elevation Relationships of Independent Slopes Model (PRISM; Oregon State University 2023) daily mean air temperature data

[9] The 4T3 criterion (water temperature not to be exceeded for 4 or more consecutive hours in a 24-hour period on more than 3 consecutive days) applies only to the high-quality, coldwater designated use (Table 2). This UAA confirms that the coldwater designated use cannot be attained because of elevated water and air temperatures, so the 4T3 and high-quality coldwater designated use were generally not considered herein. An exception is found in Table 5.

[10] Equations 3 and 4 are the final equations reported by NMED (2011a), which assumed an approximate equivalency between ATEMP and the maximum weekly average (water) temperature (MWAT); the MWAT value was used to generate the slopes and intercepts in Equations 3 and 4, but then ATEMP was substituted for MWAT. This is relevant to the discussion in Section 10, which revisits the AWTC.

The upper Sandia Canyon AU comprises two PRISM grid cells, referred to hereinafter as upper Sandia AU-West [11] and upper Sandia AU-East. [12] Data for the two PRISM cells, along with the July average temperatures estimated from the PRISM data, are provided in Appendix E.

Two LANL MET stations, TA-6 and TA-53, are in close proximity to the upper Sandia Canyon AU. TA-6 is located near the head of Twomile Canyon, approximately 1 mile south and at approximately the same elevation as Outfall 001 (Figure 1). TA-53 is located on the narrow mesa between Sandia Canyon and Los Alamos Canyon, approximately 1 mile east of the lower extent of the upper Sandia Canyon AU, at an elevation of 6,990 ft. Daily minimum and maximum temperatures from the thermometer closest to the ground (height = 1.2 m) at each station were recorded from July 2014 through July 2018. These data were used to estimate a daily mean air temperature (as the midpoint between the daily minimum and the daily maximum) [13] and an average July air temperature (Appendix E, Tables A3 and A4).

Table 3 presents the average July air temperatures for upper Sandia Canyon (based on two PRISM cells and two LANL MET stations) from 2014 to 2018, the associated AWTC-predicted 6T3s, TMAXs, and the designated uses that could be attained at those levels. The attainable uses were determined by comparing the 6T3 and TMAX values to temperature criteria (Table 2) and summarized in Table 3 by year and among years. The highest attainable use among the sources of air temperature data and among years was selected as the projected attainable use (according to the air temperature line of evidence). Based on the summary provided in Table 3 and air temperature thresholds specified by NMED (2011a), the current coldwater ALU is unattainable. This modeling exercise found the coolwater and warmwater ALUs to have been attainable in the upper Sandia Canyon AU between 2014 and 2018, based on air temperature data analyzed using the AWTC model (NMED 2011). With the exception of 2016 and 2018, modeling approaches more frequently predicted that coolwater (rather than warmwater) was attainable; in 2018, based on modeling, the two uses were equally likely. Altogether, these results from AWTC modeling suggest that the coolwater use should be attainable in most years and that a coldwater ALU is not attainable.

[11] Centroid for PRISM cell is at latitude 35.8755, longitude 106.3181; elevation 7,582 ft.
[12] Centroid for PRISM cell is at latitude 35.8694, longitude 106.3073; elevation 7,149 ft.
[13] The use of a midpoint in place of the mean assumes that the temporal trend in temperatures for each day was sinusoidal and approximately symmetrical about the mean.

Table 7. Attainability Evaluation for Upper Sandia Canyon Assessment Unit Waters Based on Average July Air Temperature over Various Periods of Record (OSU 2023)

Year	Average July Air Temperature (°C)				6T3 (°C)				TMAX (°C)				Projected Attainable Use by Year by Metric				Projected Attainable Use by Year(s)
	PRISM		LANL MET		PRISM		LANL MET		PRISM		LANL MET		PRISM		LANL MET		
	Upper Sandia AU-West	Upper Sandia AU-East	TA-6	TA-53	Upper Sandia AU-West	Upper Sandia AU-East	TA-6	TA-53	Upper Sandia AU-West	Upper Sandia AU-East	TA-6	TA-53	Upper Sandia AU-West	Upper Sandia AU-East	TA-6	TA-53	
1991–2020 Normals	19.7	20.9	NA	NA	21.6	22.8	NA	NA	26.0	27.3	NA	NA	MCW[c] or Coolwater	MCW[c] or Coolwater	NA	NA	NA
1981–2010 Normals	19.0	20.2	NA	NA	20.9	22.1	NA	NA	25.3	26.6	NA	NA	MCW[c] or Coolwater	MCW[c] or Coolwater	NA	NA	NA
1991–2020 Normals: 800m Headwater Grid[a]	NA	20.4	NA	NA	NA	22.3	NA	NA	NA	26.8	NA	NA	NA	MCW[c] or Coolwater	NA	NA	NA
2014	20.7	21.6	20	21.5	22.7	23.7	22.0	23.5	27.0	28.0	26.3	27.9	Coolwater	Coolwater	Coolwater	Coolwater	Coolwater
2015	19.7	20.5	19.4	19.6[b]	21.7	22.5	21.4	21.6	26.0	26.8	25.6	25.9	Coolwater	Coolwater	Coolwater	Coolwater	Coolwater
2016	24	25.2	22.9	24.6	26.1	27.4	25.0	26.8	30.5	31.8	29.4	31.2	Warmwater	Warmwater	Warmwater	Warmwater	Warmwater
2017	21.3	22.3	21.4	23	23.3	24.4	23.4	25.1	27.7	28.7	27.8	29.5	Coolwater	Coolwater	Coolwater	Warmwater	Warmwater
2018	22.2	22.6	21.6	23.3	24.3	24.7	23.7	25.4	28.6	29.0	28.0	29.8	Coolwater	Warmwater	Coolwater	Warmwater	Warmwater

[a] 30-year Normals: At the end of each decade, average values for temperature and precipitation are computed over the preceding 30 years. The current set of 30-year normal covers the period 1991–2020. The 1991–2020 dataset, Version M4, was released in December 2022 and is the default 30-year normal dataset for the PRISM Data Explorer (https://prism.oregonstate.edu/explorer/). The 30-year average July air temperatures are reported for the 4 km grid, which includes several canyons (including Los Alamos Canyon) and several plateaus. Upper Sandia AU-West has several grid cells in upper Los Alamos Canyon—in more mountainous and deeply incised areas west of State Highway 501.

[b] Daily maximum air temperatures were not available for July 2015 at TA-53 (except for July 15). Instead, daily maximum temperatures were calculated using 15-minute interval air temperature data from the thermometer 1.2 m above the ground (or from the thermometer 11.5 m above the ground when data from the lower thermometer were not available).

[c] Marginal coldwater; applies only to natural conditions that limit a water body from attaining coldwater uses.

NA = Not Applicable

8.3 Uncertainty in the Air-Water Temperature Model

As with any model, there are uncertainties associated with understanding the complexities of temperature dynamics within a system. The AWTC dataset might not correlate precisely with the July average air temperatures for several reasons, including:

- local conditions that cause the water temperature to be unusually high or low;
- unrepresentative thermograph locations;
- inconsistent periods of record;
- microclimates—in particular, sunny or shady areas; and
- groundwater influences.

The LANL meteorological stations are more local sources to use when gathering air temperature data; however, they do not account for the temperature at every thermograph location, and minor errors can be associated with that as well. LANL acknowledges the uncertainties associated with these models and encourages readers to seek guidance from NMED on the development of the AWTC (NMED 2011a).

9 Stream Segment Temperature Model

In accordance with LANL (2020), the stream segment temperature (SSTEMP) model was used to simulate temperatures in the upper Sandia Canyon AU and estimate effects that result from potential changes in alluvial groundwater inflow and outflow (see Appendix J). The model was developed to predict minimum, mean, and maximum daily stream temperatures based on watershed geometry, hydrology, and meteorology (Bartholow 2004). Four different modeling scenarios were evaluated using 2007 and 2017 data from several stream gages (Table 8). These time periods were selected because they had continuous streamflow data.

Table 8. SSTEMP Estimates

Model Scenario	SSTEMP Model Temperature Estimate (˚C)			No. of Days with Continuous Flow Data	Estimated Use Attained[a]
	Minimum[b]	Mean[b]	Maximum[b]		
E121/E122 to E123	13.91	20.37	26.87	31 (July 2017)	Coolwater
E123 to E123.6	15.74	22.04	28.37	8 (July 23–30, 2007)	Coolwater
E123 to E123.8	16.72	22.55	28.38	8 (July 23–30, 2007)	Coolwater
E123.6 to E123.8	16.85	22.98	29.11	8 (July 23–30, 2007)	Warmwater

[a] Estimated use is based on the predicted maximum temperature compared to TMAX criteria for aquatic life designated uses (Table 2). Minimum and mean estimates are not comparable to criteria; therefore, no comparison of SSTEMP estimates can be made to 6T3 or 4T3 criteria.
[b] Value was estimated on a daily basis and averaged among all modeling days.

The temperatures summarized in Table 8 were derived under a variety of flow conditions. The purpose of evaluating multiple conditions was to determine if inflow from the surrounding alluvium influences stream temperature predictions. The sensitivity analysis generated by SSTEMP for each scenario indicated that mean air temperature had the greatest influence over estimated mean stream temperatures, whereas inflow temperature, relative humidity, wind speed, and possible insolation had lesser (but still significant) influences over predicted mean temperatures. The SSTEMP modeling results support the AWTC modeling results described in Section 4 and provide another line of evidence that coldwater aquatic life criteria in the upper Sandia Canyon AU are not attainable. The results in Table 8 also suggest that a coolwater use designation for the upper Sandia Canyon AU is appropriate.

Uncertainty in the Stream Segment Temperature Model

SSTEMP 2.0 addresses limitations by incorporating an uncertainty feature using the *Monte Carlo analysis*. Monte Carlo analysis is a method that introduces randomness into input values. Instead of relying on a single "most likely" estimate, the model runs multiple simulations with randomly chosen input values (Bartholow 2004). This randomness captures the inherent variability and inaccuracies in measurements, estimations, and the environment. The technique ensures a more comprehensive exploration of potential values, acknowledging the uncertainties within the system.

In the Monte Carlo analysis of SSTEMP, values are drawn randomly from distributions that reflect measurement errors, estimation uncertainties, and landscape variability. The software uses either a uniform or normal distribution for sampling, with precautions to avoid unrealistic values. Although SSTEMP does not account for correlation among variables, the random sampling method aids in estimating average temperature responses and assessing the overall spread of predicted temperatures (Bartholow 2004). The number of trials and samples per trial in this method influences the precision of the results and the confidence interval around the mean temperature.

10 Discussion and Conclusions

The current designated use for the upper Sandia Canyon AU is coldwater, with TMAX and 6T3 temperature criterion of 24 °C and 20 °C, respectively; a DO criterion of 6 mg/L; and a pH range criterion of 6.6 to 8.8. Our recommendation is based on a comprehensive examination of both measured and modeled results from the Sandia UAA. These findings consistently indicate that the current designation of coldwater for the upper Sandia Canyon AU is not supported. This misclassification arose from past studies that failed to account for chronic temperature measurements (4T3 and 6T3), the use of a mismatched reference section (Section 2.2), and the lack of a long-term data set. This analysis looks at temperature over a 5-year study period. Based on the data from the UAA, DOE-Triad recommend splitting the reach into a coolwater ALU segment for upper Sandia Canyon, from Sandia Canyon at Bedrock Road to Sandia Canyon below Outfall 001, with a segment-specific criterion for a 6T3 of 25 °C. The lower segment will retain the coldwater ALU from Sandia Canyon at Sigma Canyon to Sandia Canyon at Bedrock Road.

Measured temperature data analyzed in Section 4 highlight the incongruity of the current coldwater designation. Table 3 exemplifies how instream temperatures frequently surpass the coldwater 6T3 criterion at most thermograph locations during the study period. Likewise, the coldwater TMAX criterion was exceeded at three of six thermograph locations at various points during the study period. Importantly, the coolwater TMAX criterion (29 °C) was exceeded at two locations during this time.

In examining stream and Outfall 001 temperature data (Table 3 and Table 5), it is evident that air temperature predominantly drives instream temperature dynamics. The data indicate that artificial cooling of the effluent might not result in a corresponding reduction in downstream temperatures at the bottom of the AU. It is essential to recognize that intensified cooling results in higher energy use and an increased carbon footprint for LANL, which is not consistent with the Laboratory's sustainability goals to address climate change. The Laboratory's Sustainability Program is currently developing a plan to move the facility toward a zero-carbon future by increasing efficiency and transitioning away from carbon-based energy. Striking a balance between temperature control and environmental sustainability is a complex challenge that requires careful consideration.

A notable and encouraging observation is the cooling trend recorded in the TMAX and 6T3 values for E123 in 2016 and 2017, contrasting with values from 2014 and 2015. We hypothesize that this cooling effect relates to the installation of the GCS in 2013, leading to vegetative growth and altered alluvial groundwater hydrology. This result implies that a coolwater designated use is likely attainable throughout the AU, possibly due to shade generated by vegetation or shifts in groundwater dynamics. Microclimate effects, especially in the lower reach, also seem to contribute to the cooler-than-expected water temperatures.

Predicted TMAX and 6T3 temperatures from the AWTC model, based on air temperature data, concur with the notion that a coolwater designation could have consistently been met across most study years in upper Sandia Canyon. Section 9 delves further into results from the SSTEMP model—aligning with the coolwater ALU—after considering air temperature, watershed characteristics, hydrology, and meteorology. Sections 8 and 9, though model driven, reinforce the case for a coolwater designation by looking at multiple factors that can affect water temperature.

Regulatory guidelines, specifically 40 CFR 131.10(g) and 40 CFR 131.10(i), support the replacement of a designated use with the highest attainable use when the designated use is unattainable and necessitate that the proposed use be at least as stringent as the existing use. LANL data, shown in Table 3, illustrate that the existing use in the upper Sandia Canyon AU has not met and does not currently meet coldwater aquatic life uses; however, that existing use is met in the lower segment. These data informed LANL's recommendation to maintain the existing use/designated use requirements in the lower segment and to modify the upper segment to reflect the highest attainable use of coolwater aquatic life. In compliance with these regulations, DOE-Triad has meticulously evaluated the ALU in upper Sandia Canyon, affirming that the proposed coolwater ALU for Sandia Canyon from Sandia Canyon at Bedrock Road to Sandia Canyon below Outfall 001—with a segment-specific criterion of a 6T3 of 25 °C— meets the highest attainable use designation. We also find that the coldwater ALU from Sandia Canyon at Sigma Canyon to Sandia Canyon at Bedrock Road is an existing use and recommend that it be maintained. This conclusion aligns with the improvements in water quality observed over the years and acknowledges the unique nature of the effluent-dependent upper Sandia Canyon system.

11 References

Disclaimer: Links to and/or PDFs of LANL documents have been made available as requested by NMED; however, some non-LANL primary scientific literature that was cited in this UAA lacks Creative Commons licensing or Open Access features. LANL is unable to include this literature in the data package that supports the UAA. Supplemental PDFs of references from LANL are provided in Appendix K.

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Appendix A: UAA Work Plan

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Appendix B: GPS Data for Thermograph, Gage, and Outfall Locations

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Appendix C: Raw Thermograph and Outfall Water Temperature Data for 2014–2018

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Appendix D: Long-Term Data Management Spreadsheets for 6T3 Calculations

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Appendix E: AWTC, PRISM, and LANL MET Data

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Appendix F: MWAT Data, Tables, and Equations

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Appendix G: Habitat Management Plan and Aquatic Life Surveys

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Appendix H: Interim Facility-Wide Groundwater Monitoring Plans

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Appendix I: Transitional Nature of Ecoregions

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Appendix J: SSTEMP Data and Model Outputs

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Appendix K: Supplemental References from Los Alamos Unlimited Release Publications

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