White Sands Missile Range Watershed Resiliency Programmatic Environmental Assessment

Draft

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Prepared by:
Scout

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POC:
USARMYGarrisonWSMREnvironmentalAssessments@army.mil

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FINDING OF NO SIGNIFICANT IMPACT
White Sands Missile Range, New Mexico

NAME OF PROPOSED ACTION: White Sands Missile Range (WSMR) Watershed Resiliency Programmatic Environmental Assessment (EA)

DESCRIPTION OF THE PROPOSED ACTION: The action being proposed by WSMR includes restoration, replacement, and mitigation of existing watershed elements impacted by storm events. A variety of design solutions that serve as a menu of options for WSMR to consider and implement are analyzed under the proposed action. These design solutions include early warning systems, detention basins, levee improvements, cross/culvert improvements, retention and reuse, check dams, and erosion control measures.

PURPOSE AND NEED: The purpose of this project is to assess the potential environmental impacts associated with the restoration, replacement, and mitigation of existing watershed elements impacted by storm events at WSMR. The project is needed to mitigate and alleviate impacts of storm events on the watershed and military infrastructure at WSMR.

ENVIRONMENTAL CONSEQUENCES: The Draft Programmatic EA assessed potential environmental impacts associated with the no action alternative and the proposed action. The Programmatic EA analyzed biological resources; cultural resources; geological resources and soil erosion; human health and safety; infrastructure, facilities, and traffic/transportation; land use; socioeconomics; and water resources. No significant impacts on the environment have been identified for the proposed action and no significant cumulative impacts are expected. Mitigation measures and best management practices for avoiding or reducing potential impacts are described.

CONCLUSION: Based on the information and analysis presented in this Programmatic EA and on the guidelines for determining significance of proposed federal actions in 40 Code of Federal Regulations (CFR) 1508.27 and Army guidelines under 32 CFR 651, and review of public and agency comments submitted during the 30-day comment period, WSMR has concluded that implementation of the proposed action would not result in significant impacts on the quality of human and natural environments. In addition, all applicable federal, state, and local laws and regulations would be followed. For these reasons, a Finding of No Significant Impact (FONSI) is made, thereby making the preparation of an Environmental Impact Statement unwarranted.

DRAFT AVAILABILITY AND POINTS OF CONTACT: WSMR invites members of the public to comment on the Draft Programmatic EA and Draft FONSI. The Draft Programmatic EA and Draft FONSI are available digitally on the WSMR garrison website at: https://home.army.mil/wsmr/about/garrison/directorate-public-works-dpw/environmental under the “Environmental Documents” folder.

Hard copies are available to the public by sending a request using the contact information below, or at the following public libraries:

Alamogordo Public Library
920 Oregon Avenue
Alamogordo, NM 88310

Thomas Branigan Memorial Library
200 E Picacho Avenue
Las Cruces, NM 88001

White Sands Missile Range Library
Building 436 Dyer Ave
White Sands Missile Range, NM 88002

The Draft FONSI and a Notice of Availability announcing the public release of the Draft Programmatic EA/Draft FONSI will be published in a local area newspaper (Las Cruces Sun-News).

Comments must be postmarked and received within 30 days of the publication of the Draft Programmatic EA. Written comments concerning the Draft Programmatic EA/Draft FONSI should be directed to the following address:

U.S. Garrison, White Sands Missile Range
Attn: AMIM-WSP-E-CS
Re: WSMR Watershed Resiliency Programmatic EA Comments
Building 163, Springfield Avenue
White Sands Missile Range NM 88002
Email: USARMYGarrisonWSMREnvironmentalAssessments@army.mil

DEPARTMENT OF DEFENSE
UNITED STATES ARMY
DRAFT PROGRAMMATIC FINDING OF NO PRACTICABLE ALTERNATIVE FOR FLOOD CONTROL SOLUTIONS AT
WHITE SANDS MISSILE RANGE, NEW MEXICO

1 INTORDUCTION

The United States Army Garrison (USAG), White Sands Missile Range (WSMR), prepared and seeks approval of this Programmatic Finding of No Practicable Alternative (PFONPA) to support the construction and maintenance of flood control solutions that are assessed in the *Programmatic Environmental Assessment for Watershed Resiliency* (PEA). The focus of this PFONPA is to address watershed resiliency needs within Flood Impact Areas 2 (see Figure 1). It is essential to start to reduce potential flood hazards for approximately 6,000 civilian employees, 350 service members, 950 residents, elementary and middle school students along with administrative infrastructure located within the main cantonment of the installation.

WSMR is in south-central New Mexico, providing an environment for testing and developing weapon systems and equipment used for national defense programs (Figure 2). WSMR headquarters encompasses 1,530 acres at the base of the Organ mountains with steep, angular peaks exceeding 8,000 feet interlaced with rocky spires and narrow canyons. It is marked by a significant 230-meter (755 foot) elevation change. Runoff from these mountains flows eastward towards the main cantonment. Thirty-one percent of the area is within the 100-year floodplain hazard.

2 PROPOSED ACTION

WSMR proposes implementing flood control solutions analyzed in the PEA for the purpose of reestablishing hydraulic capacity in Impact Area 2. To date, there are no identified projects for the other Impact Areas, thus not considered in this PFONPA. Proposed actions include in this PFONPA involve improvements to the existing 3.55 km (2.2 mi) levee and culvert system, and constructing new ponding areas (i.e., detention, (bioengineered) retention, and rain gardens) with erosion controls (i.e., check dams), realigning existing arroyos to current drainage patterns, and directing waterflow away from existing infrastructure.

Flood control solutions would involve blading an area to remove vegetation and contouring soil. Vegetation and soil would be temporarily disturbed but stabilized post construction. Up to eight basins ranging in size of 4 to 8 acres. Check dams would average 500 square feet. Crossing/culvert improvements would average 57,000 square feet. Retention basins would average 500,000 square feet. Approximately 64 acres would be disturbance within Impact Area 2 including the design solution, access routes and staging areas. Implementation would occur over ten years, with approximately four being constructed in five years. Individual basins could take up to 18 months to construct.

Specific locations for flood control solutions would be determined using an environmental review process and siting criteria (i.e., completed cultural survey, cultural sites monitoring during construction, seasonal nesting bird surveys and occupied nest avoidance, vegetation, terrain and soil data. These best management practices allow for determining suitable and compatible locations and incorporation of low-impact development measures. Flood control solutions would be adjusted engineered using on information such as ground cover, precipitation, soils, hydrology and hydraulic data. Regular maintenance activities would be required to maintain the engineering design functionality. Each project would require access routes, staging areas for heavy equipment and materials during construction. Excess materials would be hauled off the installation and disposed of at approved locations.

Alternatives were considered include moving the cantonment infrastructure further away from the base of the Organ mountains. Constructing a new or extended levee was also considered but would be cost prohibitive. A FONPA for other Impact Areas was considered but lacked information about the base flood area.

3 FLOODPLAIN IMPACTS AND MITIGATION MEASURES

EO 11988, Floodplain Management, state that each agency shall take action to reduce the risk of flood loss, minimize the impact of flood on human safety, health and welfare, and restore and preserve the natural and beneficial values served by floodplains by evaluating the potential effects of any action it takes in a floodplain; to ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management and before taking an action evaluate through the National Environmental Policy Act of 1969. If the only practicable alternative requires siting in a floodplain, the agency shall, prior to acting, design or modify its action to minimize potential harm to or within the floodplain. It is the Department of Defense policy to minimize construction within floodplains. Installations are required to comply with local, state, and federal requirements for actions with the potential to impact local waters. The floodplain hazard within the main cantonment area of WSMR has been established by the US Army Corp of Engineers and WSMR Directorate of Public Works for Impact Area 2 and identified as the base flood or one percent annual chance of being flooded. The main cantonment lies entirely within the Tularosa Basin Watershed which is an enclosed basin. There is no discharge to the Waters of the United States, thus there is no need for a National Pollutant Discharge Elimination System (NPDES) permit nor jurisdictional wetlands.

In the short-term, the proposed action has the potential to cause minor to moderate adverse effects to adjacent resources, including floodplains during site preparation and construction of flood solutions due to the potential for increased soil turbidity. In the long- term, the proposed action has the potential for minor to moderate beneficial effects on facility assets within the main cantonment area, ground water recharge, reduced soil erosion and managed stormwater control. Movement of soil during the construction of flood control solutions will not diminish the net capacity for holding or storing stormwater. Flood control solutions incorporating best management practices, standard operating procedures for soil erosion and low-impact development measures that work with natural and man-made features reduce floodplain impacts. Flood control solutions will avoid measurable changes to the base flood elevation (highest flood level upstream or downstream) and safety of surrounding infrastructure or people.

Specific locations for flood control solutions would be determined using an environmental review process and siting criteria. Review of engineered flood control solutions by subject matter experts provides the opportunity to find suitable and compatible locations that protect local resources. Siting criteria allow for adaptive adjustments based on information such as cultural resources, wildlife, ground cover, precipitation, terrain, soil characteristics, and hydrology. Mitigation factors such as working with existing hydrologic patterns, placing flood control solutions where soils are less prone to erosion, working on lower slopes, being away from cultural resources, and considering wildlife would minimize impacts, and represent all practicable measures to minimize harm to floodplains and changes to floodplains. Regular maintenance activities would be required to maintain the engineering design functionality. Each project would require access routes, staging areas for heavy equipment and materials during construction. Excess materials would be hauled off the installation and disposed of at approved locations.

Building flood control solutions outside of the floodplain would be ineffective, disrupt current hydraulic functions and could cause more harm to neighboring resources. The purpose of the ponding areas would be to offset stormwater storage, providing an equal volume of flood storage at or adjacent to the main cantonment, diverting stormwater around facilities and increasing useable spaces for modernization. Best management practices used to avoid or minimize impacts are as follows:

Engineer with Nature:

- Encouraging water to slowly soak into the ground
- Use ponds with slow release to recharge underground water supplies
- Place features on lower slopes
- Avoid increased flood levels upstream or downstream
- Design ponds that keep people and wildlife safe by creating escape routes and varying depths
- Ensure designs handle the movement and settling of sand and dirt
- Use natural materials and native plants to build flood control

Maintenance for Long-term Effectiveness:

- Regularly clear away built-up dirt in ponds
- Control invasive plants
- Maintain safe wildlife passage
- Allow floodplains to flood naturally when arroyo levels are high
- Conduct effectiveness monitoring and apply adaptive management
- Incorporate best management practices to prevent stormwater pollution

Construction Impacts:

- Locate construction staging areas in existing disturbed
- Avoid removing native plants as much as possible
- Replant disturbed areas with native vegetation
- Use the best available hydraulic and hydrology data
- Use an environmental review process and sitting criteria
- Seasonal restrictions on vegetation removal to protect nesting migratory birds

The draft PFONPA along with the Draft PEA and Draft Finding of No Significant Impact (FONSI) were made were available for the WSMR Garrison Environmental website (https://home.army.mil/wsmr/index.php/about/garrison/directorate-public-works-dpw/environmental) on May 30, 2025 for 30 days for the public and coordinating agencies to review and provide comments. The PFONPA, and FONSI were published in local area newspaper (Las Cruces Sun News) and libraries (Thomas Branigan Memorial, White Sands Missile Range Post, and Alamogordo). Any substantive comments received during the public review period have been addressed prior to finalization.

4 FINDING OF NO PRACTICABLE ALTERNATIVE

During development of the Proposed Action, the WSMR Environmental Office worked proactively to ensure the purpose and need of the Proposed Action was met while also avoiding as many potential impacts to floodplains as practicable. It was determined that avoidance of floodplains to implement flood control solutions was not feasible; however, the Proposed Action minimizes potential impacts to the greatest degree practicable while also achieving the required results.

Attachments:

Figure 1. Flood Impact Areas
Figure 2. Installation Location
Figure 3. Flood Control Solutions, Impact Area 2

References:

EO 11988, Floodplain Management. 24 May 1977
Programmatic Environmental Assessment for Watershed Resiliency, White Sands Missile Range, New Mexico, May 2025.

Figure 1: Flood Impact Areas

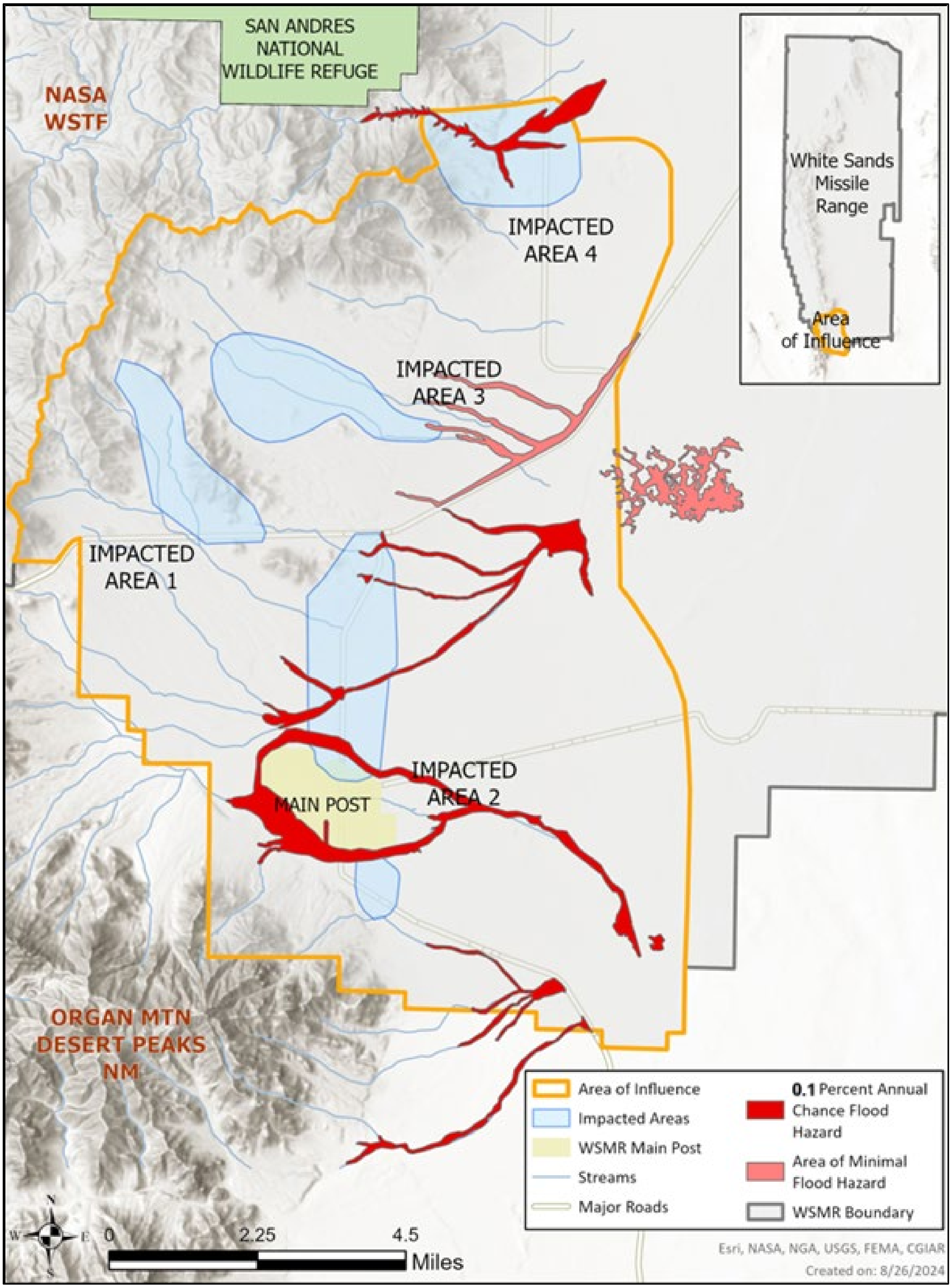


Figure 2: Installation Location

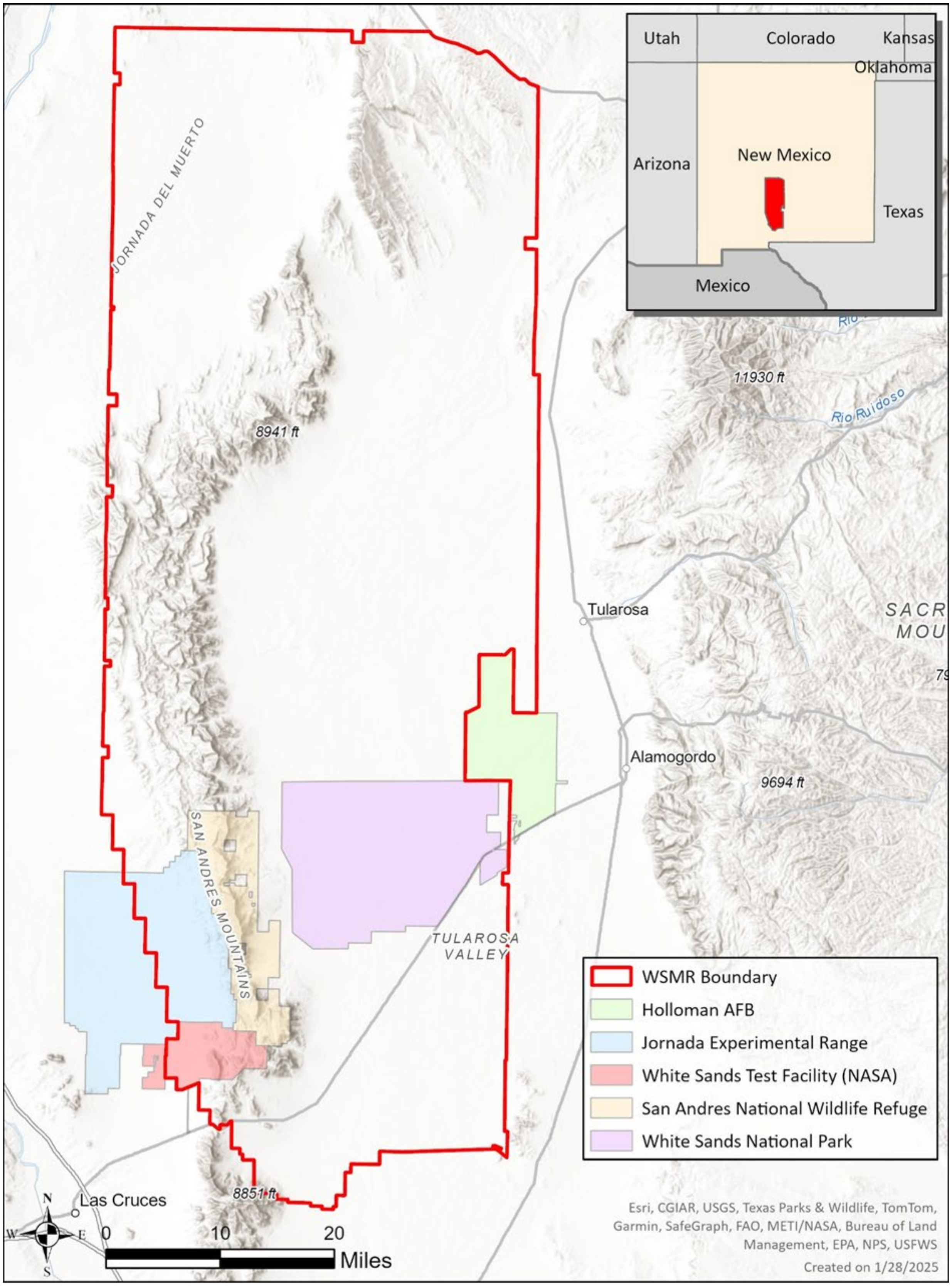
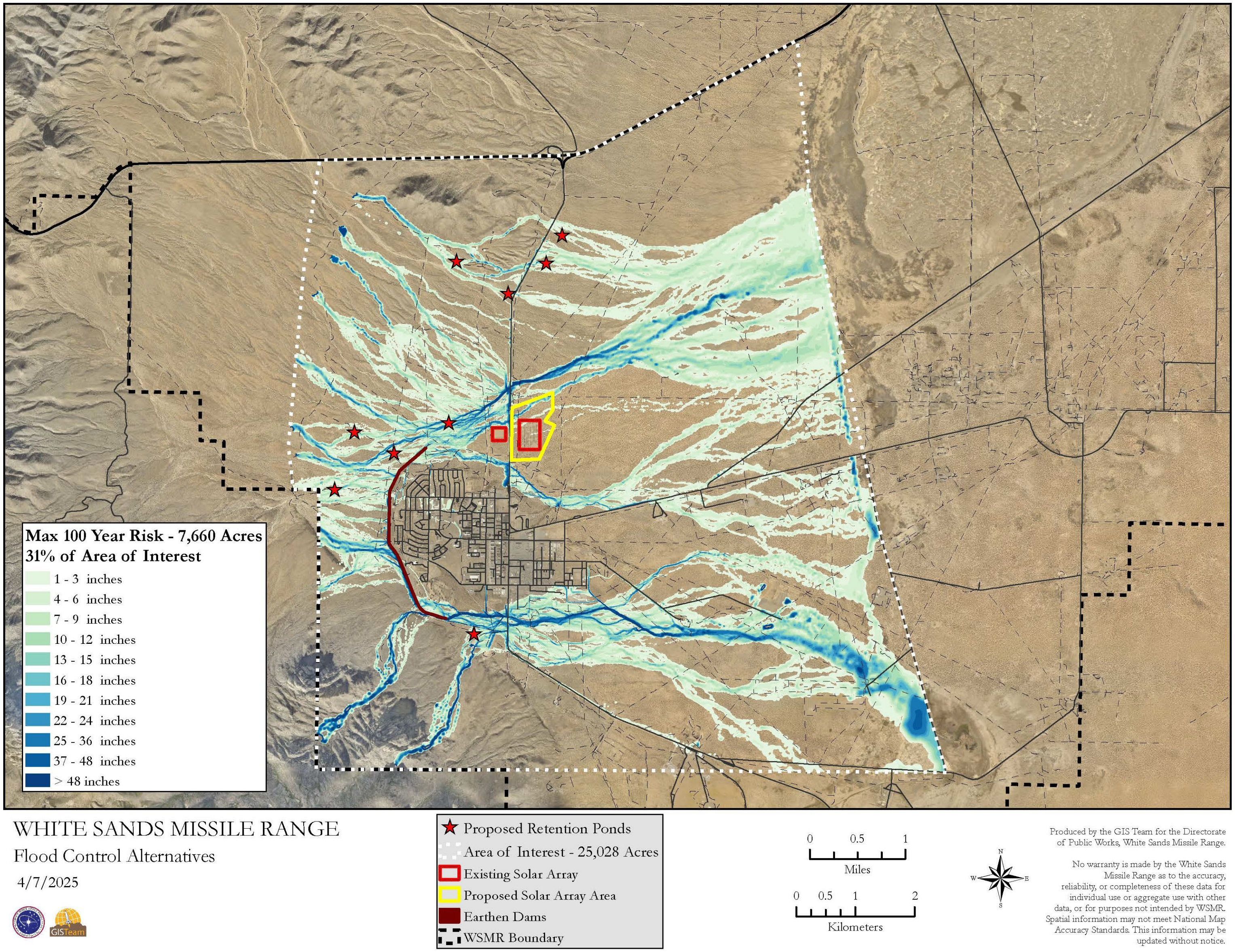


Figure 3: Flood Control Solutions, Impact Area 2



U.S. ARMY WHITE SANDS MISSILE RANGE, NEW MEXICO PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

Title: WHITE SANDS MISSILE RANGE WATERSHED RESILIENCY PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

PROPONENT:

ROBERT LOPEZ III, P.E. Chief, Engineering Services Division Directorate of Public Works	Date

REVIEWED:

BRIAN KNIGHT Chief, Environmental Division Directorate of Public Works	Date

CONCURRENCE:

DEAN ASH Director Directorate of Public Works	Date

APPROVED:

DONYEILL A. MOZER Colonel, LG Commanding	Date

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ABBREVIATIONS AND ACRONYMS

APE	Area of Potential Effect
AR	Army Regulation
BMP	Best Management Practice
CFR	Code of Federal Regulations
CRM	Cultural Resources Manager
CWA	Clean Water Act
DoD	Department of Defense
EA	Environmental Assessment
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FONSI	Finding of No Significant Impact
I	Interstate
ICRMP	Integrated Cultural Resources Management Plan
INRMP	Integrated Natural Resources Management Plan
IPaC	Information for Planning and Consultation
MBTA	Migratory Bird Treaty Act
MSS	Mission-sensitive species
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMBGMR	New Mexico Bureau of Geology and Mineral Resources
NMDA	New Mexico Department of Agriculture
NMDGF	New Mexico Department of Game and Fish
NRCS	Natural Resources Conservation Services
NRHP	National Register of Historic Places
NMRipMap	New Mexico Riparian Habitat Map
NWI	National Wetland Inventory
OSH	Occupational safety and health
PAD	Project Action Description
PIF	Partners in Flight
PPE	Personal protective equipment
ROI	Region of Influence
SGCN	Species of Greatest Conservation Need
SHPO	State Historic Preservation Office
SOPs	Standard Operating Procedures
SWCC	New Mexico Soil and Water Conservation Commission
SWCD	Soil and Water Conservation Districts
SWQB	Surface Water Quality Bureau
TRCI	Traditional Religious and Cultural Importance
U.S.	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VEC	Valued Environmental Component
UXO	Unexploded ordnance
WOTUS	Waters of the United States
WSMR	White Sands Missile Range

1 INTRODUCTION

This Programmatic Environmental Assessment (EA) evaluates the potential environmental effects associated with Watershed Resiliency Projects at the White Sands Missile Range (WSMR). This section states the purpose and need of the proposed action and outlines the scope of the environmental analysis for the considered alternatives.

This Programmatic EA has been prepared to fulfill the requirements of the National Environmental Policy Act (NEPA) (42 United States Code [USC] 4321 *et seq.*) in accordance with 32 CFR Part 651, (Army Regulation [AR] 200-2), Environmental Analysis of Army Actions (United States [U.S.] Army, 2002), and Army policy (U.S. Army, 2017).

The proposed action to implement Watershed Resiliency Projects does not meet Army screening criteria for a categorical exclusion as described in 32 CFR 651.29. Furthermore, using the NEPA process provides the public the opportunity to review and comment on proposed watershed resiliency projects. WSMR has a sustained commitment to avoiding impacts to natural and cultural resources as part of their overall environmental program; no aspect of the proposed action would reduce current levels of stewardship.

As the specific design and location of the projects have not yet been identified, this Programmatic EA evaluates the potential environmental impacts of a menu of potential watershed resiliency projects.

1.1 Background

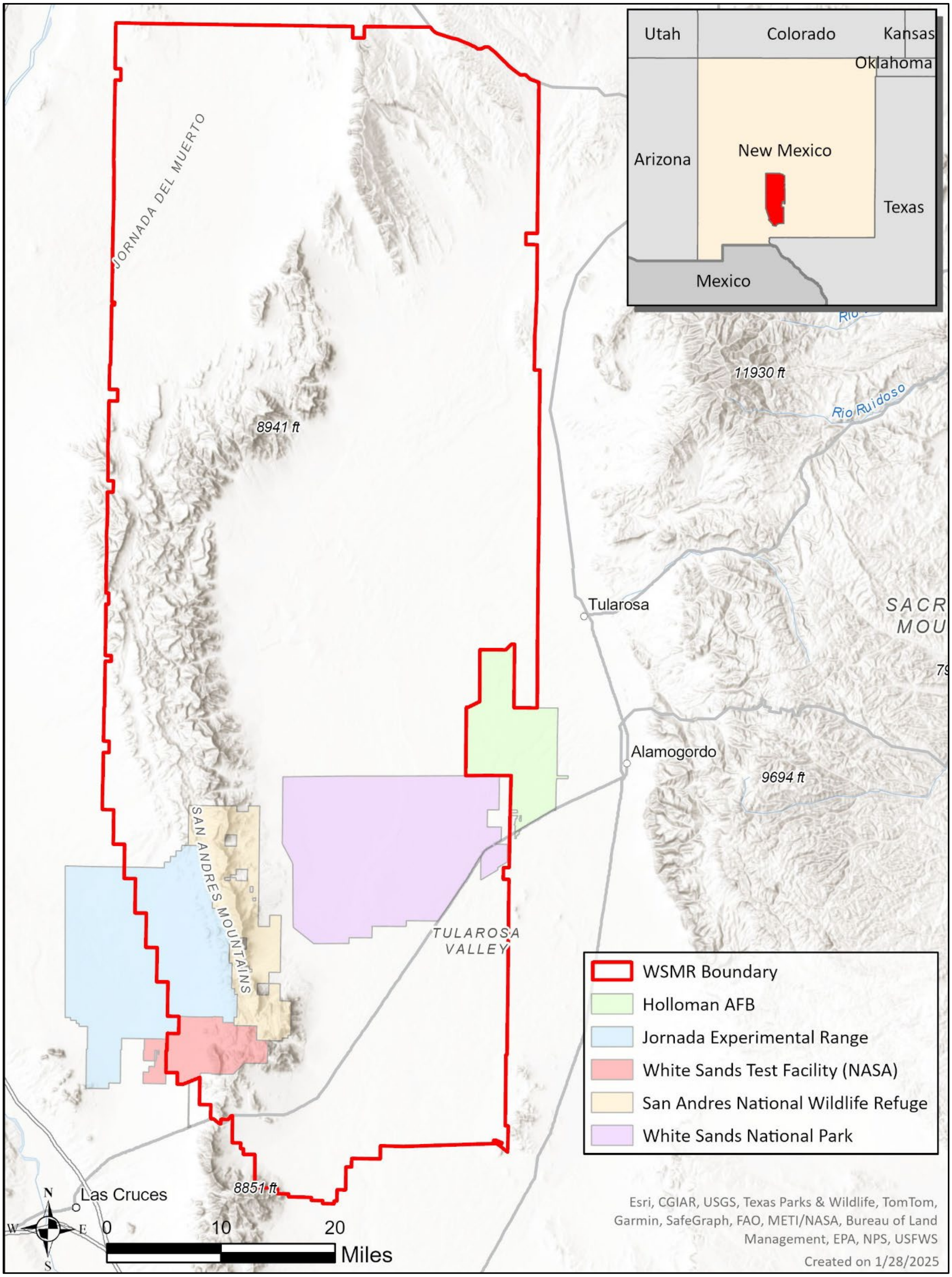
The Army's Installation Management Command manages WSMR. The air and ground space at WSMR are critical for weapon systems research, development, testing, and evaluation for the Army, Air Force, Navy, other Department of Defense (DoD) agencies, non-DoD governmental agencies, and private organizations.

WSMR is remotely located with expansive and varied terrain (Figure 1-1). The installation encompasses about 2.2 million acres within a contiguous boundary, extending approximately 40 miles from east to west, and 118 miles from north to south. This area spans five counties in New Mexico which include Socorro, Sierra, Doña Ana, Otero, and Lincoln. The elevation ranges from 3,887 feet above mean sea level to more than 8,500 feet above mean sea level (WSMR, 2010).

The largest populated communities near Main Post and the southern portion of WSMR, include Las Cruces and Alamogordo, New Mexico, and El Paso, Texas. Socorro, New Mexico is the largest community located on the north end of WSMR, also known as Stallion Range Camp.

WSMR can be separated into four functional geographic areas: Southern, Western Mountains, Northern, and Eastern Boundaries. Mountains on the western side of WSMR are rough, almost providing a natural barrier. Holloman Air Force Base and the White Sands National Park are to the east of WSMR. The northern portion of WSMR is adjacent to government and privately owned land.

Figure 1-1: Location of White Sands Missile Range



WSMR supports an abundance and wide variety of unique natural and cultural resources, many of which are potentially at risk due to training activities, infrastructure development, atmospheric change, high intensity catastrophic wildfire, and other perturbations of the biotic and abiotic physical environment. Watershed resiliency is essential for protecting the public from flood events and protecting WSMR resources.

In 1978 and 2021 there were extreme storm events that caused immense road damage and road closures. The extreme storm events were equivalent to 200-year and 500-year storm events.

The flooding which took place in August 1978 resulted in five casualties, including a family of four and a military police officer who attempted to rescue the family. The 1978 flooding also caused extensive road, infrastructure, and WSMR facility damage (Photographs 1-1, 1-2, and 1-3).

In July and August of 2021 heavy rains struck north of U.S. 70. The rains caused destructive flooding which caused the closure of U.S. 70, WSMR North access point, and Range Road 7 (Figure 1-2; Photographs 1-4, 1-5, 1-6, and 1-7).

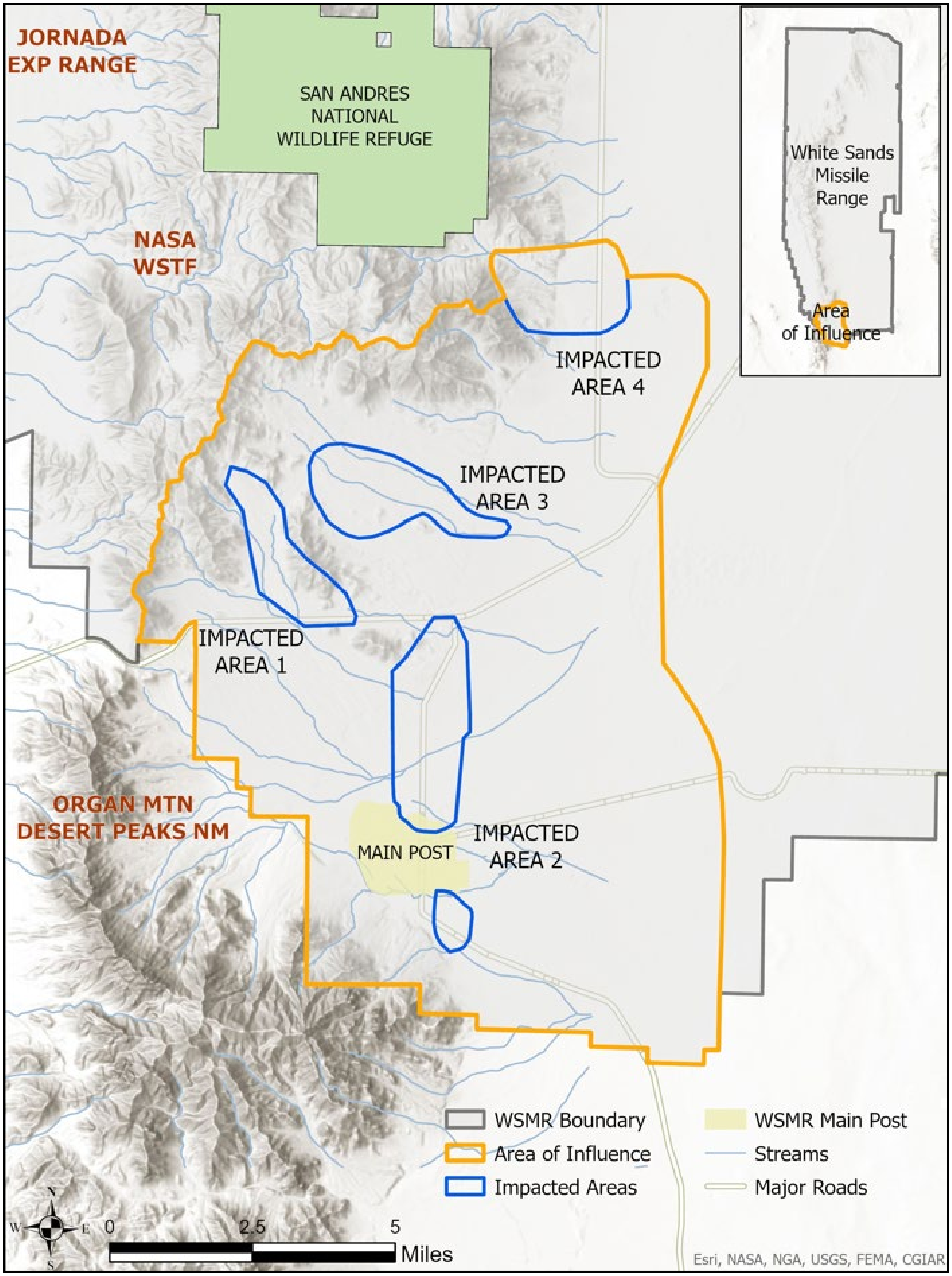
In addition to these extreme storm events, there have been lesser yet impactful storm events. In 2016, summer rains led to localized flooding and road damages.

Photo 1-1: 1978 Flood Event, WSMR Golf Course

Photo 1-2: 1978 Flood Event, WSMR El Paso Gate Access

Photo 1-3: 1978 Flood Event, WSMR Las Cruces Gate

Figure 1-2: 2021 WSMR Flooding Impact Areas



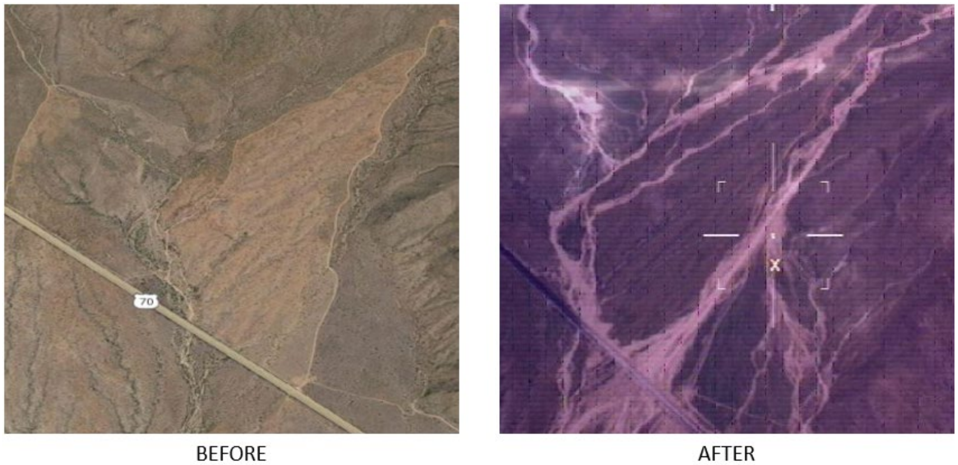


Photo 1-4: 2021 Flood Event Impact Area 1, North of U.S. 70

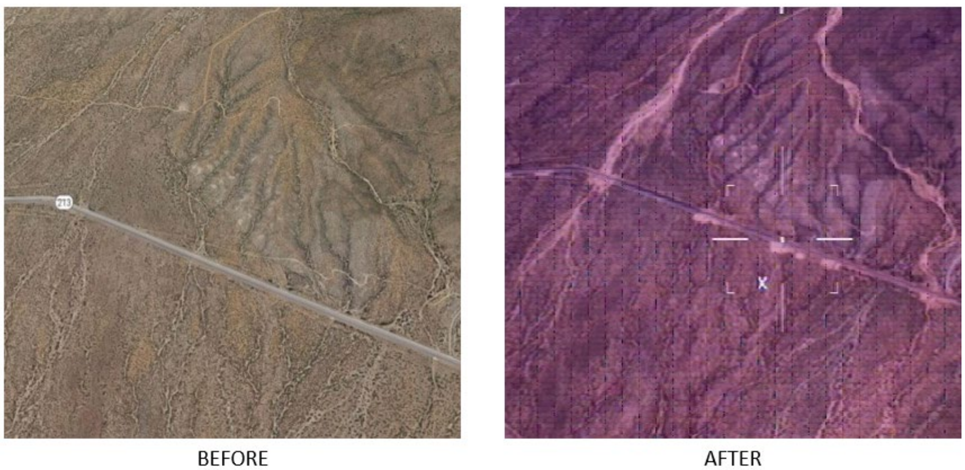


Photo 1-5: 2021 Flood Event Impact Area 2, Las Cruces Gate "Owens Road" Access Point

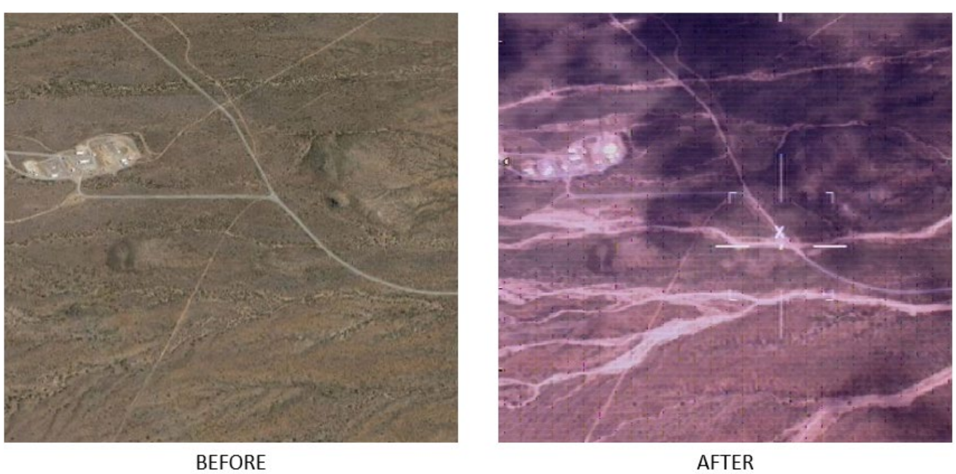


Photo 1-6: 2021 Flood Event Impact Area 3, WSMR Electro-Magnetic Radiation Effects Site

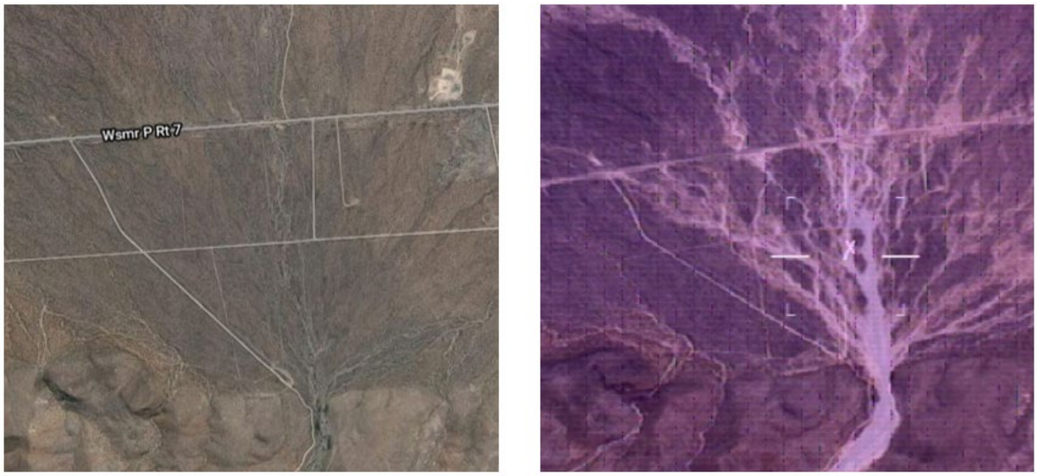


Photo 1-7: 2021 Flood Event Impact Area 4, WSMR Range Road 7

1.2 Related Environmental Documentation

The following previously prepared reports were used to inform this Programmatic EA as they are relevant to the proposed action:

- **Environmental Impact Statement for Development and Implementation of Range-Wide Mission and Major Capabilities.** In 2010, WSMR this Final Environmental Impact Statement (EIS) examining the environmental effects of developing new test and training capabilities to meet current and future mission requirements at WSMR (WSMR, 2010). The EIS serves as a comprehensive reference for multiple resource areas considered under this Programmatic EA.
- **White Sands Missile Range Integrated Cultural Resource Management Plan.** This plan updates the 2015-2019 Integrated Natural and Cultural Resources Management Plan and creates a standalone Integrated Cultural Resources Management Plan (ICRMP) and INRMP (WSMR, 2025).
- **Draft EA for the Implementation of the 2022-2027 White Sands Missile Range INRMP.** In 2023, WSMR released a Draft EA for the Implementation of the 2022-2027 WSMR INRMP. This plan updates the 2015-2019 Integrated Natural and Cultural Resources Management Plan and creates a standalone INRMP and Integrated Cultural Resources Management Plan.
- **White Sands Missile Range Thurgood Canyon Watershed.** This 2022 report analyzes Range Road 7 and establishes best management practices. The report analyzes if and how sensitive fish habitat are impacted by draining infrastructure, assesses the condition and sustainability of existing transportation infrastructure, and develops a comprehensive operation and management approach to achieve sustainable transportation on the Thurgood Canyon alluvial fan and mitigate any impacts to the sensitive habitat located at the base of the fan.

1.3 Purpose and Need

The purpose of this project is to conduct a Programmatic EA for the Watershed Resiliency Projects at WSMR, New Mexico. The project aims to assess the potential environmental impacts associated with the restoration, replacement, and mitigation of existing watershed elements impacted by storm events at WSMR. The Programmatic EA will analyze the proposed action alternative, which includes activities to enhance the resiliency of the watershed and protect critical infrastructure. Under the proposed action alternative, up to 150 cumulative acres of flood control improvements are proposed to be implemented within an area of influence targeting four distinct impacted areas (Figure 1-2). Additionally, the Programmatic EA will evaluate the no action alternative, which involves basic repairs without considering long-term watershed health or atmospheric factors.

The need for this proposed action arises from the impacts of storm events on the watershed and military infrastructure at WSMR. The existing watershed elements have been affected by sediment deposition, reduced hydraulic capacity, and damage to infrastructure due to storm events. These impacts pose risks to the ecological functions, natural and cultural resources, and military operations in the area. Therefore, there is a need to restore and enhance the watershed's resiliency to mitigate the potential risks associated with future storm events.

The proposed action alternative and the no action alternative will be thoroughly analyzed in the Programmatic EA, considering available data on hydrology modeling, hydraulic flow, and existing biological and cultural resource surveys. The Programmatic EA will identify and assess the potential environmental impacts of both alternatives, including any significant adverse effects on the environment, and will recommend measures to mitigate those impacts. The findings and recommendations of the Programmatic EA will provide a basis for informed decision-making regarding the potential Watershed Resiliency Projects at WSMR.

1.4 Scope of Environmental Analysis

This Programmatic EA considers the potential impacts of the proposed action and alternatives on the potentially affected environment and the degree of the effects of the action. Specifically, this Programmatic EA considers:

1. Direct effects, which are caused by the action and occur at the same time and place.
2. Indirect effects, which are caused by the action and are later in time or farther removed in distance but are still reasonably foreseeable.
3. Cumulative effects, which are effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (federal or non-federal) or person undertakes such other actions.

The Army’s decision is whether to implement the proposed action and alternatives (including the no action alternative). The Army would issue a Finding of No Significant Impact (FONSI) if the selected alternative would result in no significant impact to human or environmental health. If the selected alternative results in a significant impact, the Army would prepare an EIS.

A team of WSMR subject matter experts identified the Valued Environmental Components (VECs) for detailed evaluation in this Programmatic EA (see Chapter 3).

1.5 Public and Agency Participation

To facilitate the analysis and the decision-making process, the Army maintains a policy of open communication with interested parties and invites public participation. The Army urges all federal and state agencies, public and private organizations, and members of the public that have a potential interest in the proposed action, including minority, low-income, disadvantaged and Native American groups to participate in the Army's NEPA and decision-making processes, AR at 32 CFR Part 651.

The Draft Programmatic EA and Draft FONSI will be made available to federal, state, and local agencies, Native American tribes, and the public for review and comment for 30 days. WSMR will publish a Notice of Availability for the Draft Programmatic EA and Draft FONSI in the Las Cruces Sun-News newspaper. WSMR will also make the Draft Programmatic EA available for online viewing at https://home.army.mil/wsmr/about/garrison/directorate-public-works-dpw/environmental under the "Environmental Documents and Information" folder and at the following libraries:

- Thomas Branigan Memorial Library, 200 E. Picacho Avenue, Las Cruces, New Mexico 88001;
- White Sands Missile Range Post Library, Building 465, White Sands Missile Range, New Mexico 88002; and
- Alamogordo Public Library, 920 Oregon Avenue, Alamogordo, New Mexico 88310.

Following the 30-day review period, the Army will address all relevant comments received. If the Army identifies any significant impacts during the review of comments, the Army would prepare a Notice of Intent and commence the EIS process. If the Programmatic EA does not identify significant impacts, the Army would finalize the Programmatic EA and prepare and sign a FONSI.

WSMR has been actively coordinating with neighboring agencies and stakeholders, such as Bureau of Land Management, White Sands National Park, Doña Ana County Flood Commission, Natural Resources Conservation Service, and New Mexico Department of Transportation in regard to this proposed action. WSMR will continue to maintain active coordination with neighboring agencies and stakeholders after the completion of this Programmatic EA to promote and sustain watershed resiliency both within and beyond WSMR boundaries. This collaborative approach ensures that efforts to address watershed management are aligned across jurisdictions, fostering shared solutions to regional water resources challenges.

2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

This chapter describes the proposed action and the alternatives. This chapter also describes the location and area under consideration, as well as the timing of the proposed action. Additionally, this chapter provides the screening criteria used by the Army to develop the range of considered alternatives and concludes with identifying the decision the Army will make.

To address the purpose and need, this Programmatic EA analyzes two alternatives, one of which is the no action alternative (mandated in Environmental Analysis of Army Actions 32 CFR part 651.34). Section 2.1 describes the action alternatives, Section 2.2 describes the no action alternative, and Section 2.3 describes the alternatives WSMR considered but did not carry forward for analysis.

2.1 Background

To identify potential design solutions for the proposed action, a weather forecast model was developed (refer to Appendix A). This model helped in understanding the potential impacts of weather related impacts on the watershed and military infrastructure at WSMR. Based on the outcomes of this model, the next step was the development of a Flood Control Conceptual Design Solutions Report (refer to Appendix B). This report outlined conceptual designs for flood control measures to mitigate the impacts of storm events on the watershed and military infrastructure. The proposed action of potential design solutions is based on the findings and recommendations of Appendix B.

2.2 Screening Criteria

The selection of alternatives was based on several screening criteria to ensure that each alternative could effectively achieve the project objectives while minimizing potential environmental impacts. The following screening criteria were used:

- **Alignment with Project Objectives:** The alternatives were evaluated based on their ability to achieve the project's purpose and meet the identified needs. The screening criteria focused on determining whether each alternative could effectively address the goals and objectives outlined in the project proposal.
- **Feasibility:** The feasibility of each alternative was assessed in terms of technical, logistical, and economic considerations. This criterion aimed to identify alternatives that were practical and achievable within the project's scope, taking into account factors such as available resources, expertise, and potential constraints.
- **Environmental Impacts:** The potential environmental impacts associated with each alternative were carefully evaluated. This criterion considered the direct and indirect effects on natural resources, including land, water, air quality, wildlife, vegetation, and cultural resources. Alternatives that demonstrated a higher likelihood of significant adverse impacts were given lower priority.
- **Stakeholder Considerations:** The perspectives and concerns of stakeholders, including local communities, government agencies, and organizations, were taken into

account. This criterion considered the level of stakeholder engagement, public input, and the ability of each alternative to address their needs and interests.

- **Social and Economic Benefits:** The potential social and economic benefits associated with each alternative were evaluated. This criterion assessed the impacts on employment, local economy, public services, quality of life, and community resilience. Alternatives that demonstrated positive social and economic outcomes were given favorable consideration.
- **Regulatory and Legal Requirements:** Compliance with applicable laws, regulations, and permitting processes was a critical screening criterion. This criterion ensured that the alternatives were aligned with relevant environmental regulations, land-use policies, and other legal requirements.

Project Location Siting Criteria

- Completion or funding availability for a cultural survey
- Avoidance of areas with known cultural sites
- Promotion of ecological functions such as hydrology, hydraulic, and water table recharge
- Avoidance of downstream impacts to infrastructure
- Limitation of negative wildlife-human interactions
- Availability of maintenance funding

These screening criteria were used to evaluate the range of considered alternatives and to select the most appropriate option for achieving the project's purpose and need while minimizing potential environmental impacts.

2.3 Proposed Action

2.3.1 Overview

The proposed action includes one action alternative and one no action alternative. Descriptions of each action alternative follow.

2.3.2 Environmental Review Process

In order for missions/projects to be implemented on WSMR grounds, the mission proponent must first submit a project action description (PAD) to the Garrison Environmental Division, Customer Support Branch, who initiates an environmental review. A PAD contains sufficient critical details for the Customer Support Branch and other subject matter experts and internal stakeholders to determine if there are any potential environmental impacts. During the review process, subject matter experts can add conditions of use to prevent environmental impacts or alert the proponent to other environmental requirements. The review process also facilitates coordination between subject matter experts and the proponent. Comments received on a PAD provide information considered by the Customer Support Branch who determine if the proposed action meets the screening criteria for categorical exclusion. When a PAD meets the screening criteria for a categorical exclusion, such as those for construction and demolition (32 CFR 651 App B Sec II (c)) and cultural and natural resource management activities (32 CFR 651 App B Sec II (d)), the determination is documented in a Record of Environmental Consideration. When a categorical exclusion does not apply, the action may still fall within the scope of existing EAs, and would be documented in a Record of Environmental Consideration. However, if there are any extraordinary circumstances, then a more in-depth review may be required, which may mean completing an EA.

The Environment Division's Conservation Branch participates in the environmental review process in two ways. The Conservation Branch contains subject matter experts that provide input to the environmental review process, prescribing best management practices or mitigations to minimize impacts to natural resources and the human environment.

2.4 Action Alternatives

2.4.1 Alternative 1

Alternative 1 includes restoration, replacement, and mitigation of existing watershed elements impacted by storm events at WSMR. These activities would consider natural and cultural resources, ecological resources, weather related factors, bioengineering, and military infrastructure. Sediment, rock, and woody debris or other material may be relocated to reestablish the appropriate hydrologic capacity of arroyos and floodplains or protect critical infrastructure.

Environmental analysis will be focused on the impacts of installing up to 150 acres of conceptual flood control improvements within any of the four identified impact areas as illustrated in Figure 1-2. Additional supplemental environmental analysis will be required once the cumulative 150-acre threshold has been obtained, to determine effectiveness and impacts of existing flood control improvements implemented under this proposed action.

Engineering plans would reestablish desired hydraulic capacity and increase resilience for future storm events, as depicted in Figure 2-1 (see Appendix B: Flood Control Conceptual Design Solutions Report).

The designs presented in Figure 2-1 represent a menu of conceptual solutions, including:

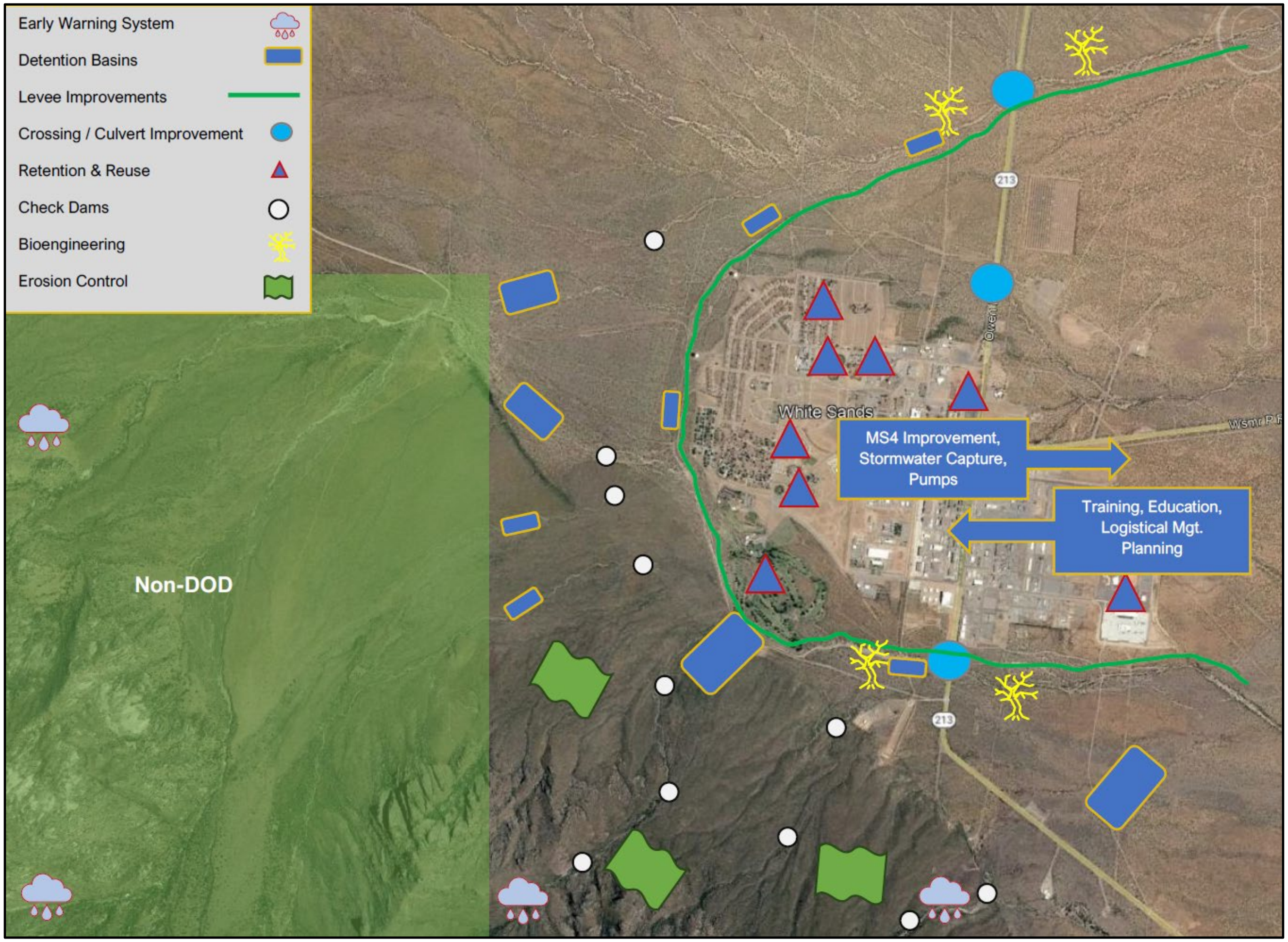
- Early warning systems[1];
- Detention basins;
- Levee improvements;
- Cross/culvert improvements;
- Retention and reuse;
- Check dams;
- Bioengineering; and
- Erosion control.

[1] Developing an early warning system could include close collaboration with the Doña Ana County Flood Commission. By working with both the Commission and the WSMR Meteorological group, it may be possible to leverage more predictive flood detection methods without the need for installing or maintaining equipment on WSMR or Bureau of Land Management lands.

It's important to note that solutions presented in Figure 2-1 represent a menu of conceptual solutions. Specific designs are not included in this Programmatic EA, as it is programmatic in nature, but rather general locations and types are considered.

Detailed calculations and potential maximum areas of flood control improvements are provided in Appendix C, which supports the conceptual solutions presented here.

Figure 2-1: Flood Control Conceptual Designs



This figure illustrates the conceptual designs focused on the main cantonment area. Please note that this representation does not encompass all impact areas analyzed under the proposed action (refer to Figure 1-2 for comprehensive impact areas).

2.4.2 No Action Alternative

The no action alternative is required pursuant to U.S. Army NEPA regulations and provides a baseline against which the proposed action can be compared. This comparison enables decision makers to examine the magnitude of environmental effects from implementing the action alternatives. Additionally, NEPA regulations recommend inclusion of the no action alternative in an EA to assess any environmental consequences that may occur if the proposed action is not implemented. Therefore, the no action alternative is carried forward for detailed analysis in this Programmatic EA.

Under the no action alternative, WSMR would implement basic repairs that provide immediate relief after a damaging flood event, never fully consider watershed health or weather factors influencing storm events that negatively impact military infrastructure, nor understanding the potential risks if design solutions are not adequate. Therefore, the no action alternative would not meet the purpose and need for the proposed action.

2.5 Alternatives Considered but Not Carried Forward

The purpose and need statement (see Section 1.3) served as a basis to identify potential alternatives to carry forward for environmental analysis.

In addition to the action alternative presented in this project, several alternatives were considered but not carried forward for further analysis. These alternatives were evaluated based on their ability to achieve the purpose of the project and address the identified needs, while also minimizing potential environmental impacts. However, after a thorough assessment, it was determined that these alternatives did not adequately meet the project objectives or were not feasible within the project scope. The alternatives considered but not carried forward are described below:

Alternative 2: Construction of New Flood Control Structures

This alternative involved the construction of new flood control structures, such as dams or levees, to mitigate the impacts of storm events and protect critical infrastructure at WSMR. However, at the time this Programmatic EA was developed, there was insufficient information to fully analyze the feasibility of new structures, and a programmatic EA would not be suitable for such a discrete project. Furthermore, the construction of new structures would require significant land acquisition, engineering, and construction costs. Potential impacts on natural and cultural resources, as well as the long-term maintenance and inspection of new flood control structures – which differs from the maintenance of existing levees – were also identified as prohibitive. Consequently, this alternative was not carried forward for detailed analysis.

Alternative 3: Relocation of Military Infrastructure

This alternative explored the option of relocating military infrastructure, including buildings and facilities, to areas outside of the flood-prone zones. While relocation could potentially reduce the vulnerability of infrastructure to storm events, it was determined that the costs and logistical challenges associated with relocating the existing infrastructure were not practical. The alternative would also require the identification of suitable alternative locations and potential impacts on surrounding communities.

After careful consideration, these alternatives were not carried forward for further analysis in the Programmatic EA. The selected action alternative, as described in the project proposal, was determined to be the most appropriate and feasible option for achieving the project's purpose and need while minimizing potential environmental impacts.

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter presents a description of the environmental resources and baseline conditions that could be affected from implementation of the alternatives. It also presents an analysis of the potential effects of each alternative to each environmental resource area. The affected environment has been determined using the criteria in NEPA and the Army NEPA Guidance Manual (U.S. Army, 2007).

3.1 Valued Environmental Component Analysis

This Programmatic EA applies a method described in the NEPA Analysis Guidance Manual used to rate VECs typically addressed in Army NEPA analyses (U.S. Army, 2007). This analytical process allows a level of consistency in evaluating impacts and comparing impacts across installations to help with Army-wide decision-making. It also advocates a process for focusing analysis on areas where impacts are most likely to occur, considering the type of actions involved in a geographic context. Participants included subject matter experts at WSMR who have extensive knowledge of the various resources on the installation.

Table 3-1 summarizes the degree to which each VEC would potentially be affected by the proposed action. Possible ratings for each VEC range from low, moderate, to high. VECs rated low indicate that potential impacts to those resource areas were considered to be negligible or nonexistent so they do not require further analysis. This Programmatic EA identified eight VECs with a rating of medium. No VECs were identified with a high rating. Therefore, this Programmatic EA evaluates the following eight VECs: Biological Resources; Cultural Resources; Geological Resources and Soil Erosion; Human Health and Safety, Infrastructure, Facilities, and Traffic/Transportation; Land Use; Socioeconomics; and Water Resources.

Table 3-1: Valued Environmental Components

VEC	*Rating*	*Rationale/Special Considerations*
Air Quality	L	The proposed action's impact on air quality would primarily stem from construction activities, such as dust generation. These impacts would be mitigated to a negligible level through the implementation of construction best management practices (BMPs). These BMPs include, but are not limited to, effective dust control measures (e.g., watering, and avoiding construction activities that generate dust during high winds and dry conditions) and vehicle emission controls.
Airspace	L	The proposed action would not involve any airspace operations nor impede existing airspace use or management. Therefore, no impacts to airspace would occur.
Biological Resources	M	Short- and long-term impacts to vegetation and wildlife.
Cultural Resources	M	Unsurveyed areas may contain cultural resources and therefore would have the potential to be impacted by the proposed action. There is potential for the inadvertent discovery of cultural resources during implementation of the various design solutions.
Geological Resources and Soil Erosion	M	Potential to alter the surface hydrology and groundwater recharge. Short-term surface soil disturbance may occur during construction activities.

VEC	Rating	Rationale/Special Considerations
Hazardous Waste and Hazardous Materials	L	Hazardous materials and waste would be limited to construction equipment and construction waste materials. Any petroleum, oils, and lubricants generated would be collected and stored in properly labeled, approved containers and recycled or disposed through the WSMR Hazardous Management Center in accordance with WSMR Regulation 200-1, Hazardous Waste Management. WSMR would also follow the respective installation Spill Prevention Plan. Watershed resiliency projects would not be implemented in known environmental restoration sites. Therefore, no impacts from hazardous materials or wastes would occur.
Human Health and Safety	M	Potential for child safety concerns, vector breeding, and UXO concerns requiring clearing prior to construction. Overall, implementation of the proposed action would enhance public safety by protecting people from dangerous flooding.
Infrastructure, Facilities, and Traffic/ Transportation	M	Implementation of the proposed action would enhance protection of infrastructure, facilities and traffic/transportation.
Land Use	M	Potential conflicts between operational and non-operational areas and conversion of open space to developed land.
Noise	L	Temporary and localized noise would be generated during construction and maintenance activities. These noise impacts would be localized and sporadic. These impacts would be mitigated to a negligible level through the implementation of BMPs. These BMPs include conducting noise generating construction and maintenance activities during daytime hours. Therefore, no impacts to the noise environment would occur.
Socioeconomics	M	Potential benefit to socioeconomics from reducing flood-related disruptions to commerce.
Water Resources	M	Potential impacts to floodplains and wetlands and hydrologic flow. The proposed action may occur within a floodplain, which triggers the requirements of EO 11988 *Floodplain Management* and may necessitate a Finding of No Practicable Alternative. If required, a Finding of No Practicable Alternative would be prepared upon completion of this Programmatic EA.

Legend: BMP=Best Management Practice; EO=Executive Order; WSMR=White Sands Missile Range; UXO=Unexploded Ordnance
Notes:
L rating = negligible or minor impact anticipated.
M rating = moderate impact anticipated (less than significant).
H rating = significant impact potential anticipated (likely to be mitigated to less than significant).

3.2 Biological Resources

Biological resources include native or naturalized plants and animals and the habitats in which they occur, and native or introduced species found in landscaped or disturbed areas. Protected species are defined as those listed as threatened, endangered, or proposed or candidate for listing by the U.S. Fish and Wildlife Service (USFWS) or New Mexico Department of Game and Fish (NMDGF). Federal species of concern and candidate species are not protected by the Endangered Species Act (ESA); however, these species could become listed, and therefore are given consideration when addressing impacts on biological resources. Section 7 of the ESA of 1973 requires all federal agencies to use their authorities to conserve endangered and threatened species in consultation with USFWS. The ESA gives the Secretary of the Interior the responsibility of deciding whether a species' survival has been so jeopardized that it warrants conservation actions. Authority for administering the ESA has been delegated to USFWS. Under the ESA, when a species is formally "listed" (i.e., added to the Federal List of Endangered and Threatened Wildlife and Plants) federal agencies are directed to use their legal authorities to carry out conservation programs to support continued survival of the species. The New Mexico Wildlife Conservation Act [17-2-40.1 New Mexico Statutes Annotated 1978] has similar provisions and covers species that are native to New Mexico. Sensitive habitats include those areas designated by the USFWS as critical habitat under the ESA and sensitive ecological areas as designated by state or federal rulings. Sensitive habitats also include wetlands/playas, plant communities that are unusual or of limited distribution, and important seasonal use areas for wildlife (e.g., migration routes, breeding areas, crucial summer/winter habitats). Further, the Army is responsible for the protection of migratory birds under the Migratory Bird Treaty Act (MBTA) and Executive Order (EO) 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*.

3.2.1 Affected Environment

WSMR encompasses one of the largest expanses of relatively undeveloped land remaining in the southwestern U.S., extending into parts of five New Mexico counties and encompassing the majority of two major mountain ranges, the San Andres and Oscura Mountains. White Sands National Park and the San Andres National Wildlife Refuge are located entirely within WSMR's boundaries.

3.2.1.1 Ecoregion

WSMR lies within the Chihuahuan Desert Ecoregion, which consists of a series of basins and mountain ranges, with a central highland that extends from Socorro southward into Mexico. Landforms include plains with low mountains consisting of gentle slopes and local relief of 1,000 to 3,000 feet, plains with high hills and local relief of 1,000 to 3,000 feet, open high hills with relief of 500 to 1,000 feet, and tablelands with moderate relief averaging from 100 to 300 feet (WSMR, 2024a). Weather in this ecoregion is characterized by abundant sunshine, low humidity, modest rainfall, and about 250 frost-free days a year at lower elevations. Fall, winter, and spring are typically mild, and summer is hot. Strong westerly winds are most dominant in the spring, and most precipitation occurs during thunderstorms in late summer. Daily and annual temperature and precipitation vary considerably, and weather patterns can be dynamic and difficult to predict. WSMR maintains an extensive surface meteorological data-collection system, referred to as the Surface Atmosphere Measuring System, administered by the Army Research Laboratory. The average annual precipitation at WSMR's Southern Basin Weather Station since 1962 is 10.1 inches. According to the weather station records, 2020 was the fifth driest year on record. Four of the five driest years on record have all occurred in the last two decades. Average annual precipitation in WSMR's arid desert basins is less than 10 inches, in semiarid foothills 10 to 16 inches, and highest mountain elevations are almost temperate (WSMR, 2023a). Average annual temperature has increased in the southern basin of WSMR from 1962 to 2020. Every year since 2011, temperatures at WSMR have been above average. The average low temperature in January is 29 degrees Fahrenheit and in July, the average high is 95 degrees Fahrenheit. Temperature extremes range from 112 degrees Fahrenheit (recorded at

Orogrande in June 1994) to -25 degrees Fahrenheit (recorded at White Sands National Park in January 1962) (WSMR, 2023a).

Vegetation

Several species of thorny shrubs are typical of the Chihuahuan Desert. They frequently grow in open stands, but sometimes form low thickets. They can also be associated with short grasses, such as grama (*Bouteloua sp*.). Extensive arid grasslands cover most of the high plains of the ecoregion. On deep soils, honey mesquite (*Prosopis glandulosa*) is often the dominant plant. Cacti are also abundant, particularly prickly pears (*Opuntia phaeacantha*). The desert is characterized by yuccas (*Yucca elata*) and Creosote bush (*Larrea tridentata*), the most abundant plant of the ecoregion, which is especially common on gravel fans. Species like agave (*Agave americana*) and common sotol (*Dasylirion wheeleri*) are also abundant. On rocky slopes, the ocotillo (*Fouquieria splendens*) can frequently be found. Vegetation types found on WSMR are depicted in Figure 3-1 and further described in Appendix D.

The USFWS Information for Planning and Consultation (IPaC) tool identified six federally listed plant species as potentially occurring at WSMR, including the Pecos sunflower (*Helianthus paradoxus*), Sacramento Mountains thistle (*Cirsium vinaceum*), Sacramento prickly poppy (*Argemone pleiacantha ssp. Pinnatisecta*), Sneed pincushion cactus (*Coryphantha sneedii var. sneedii*), Todsen's pennyroyal (*Hedeoma todsenii*), and Wright's marsh thistle (*Cirsium wrightii*) (USFWS, 2024). Only one of these species has been documented at WSMR, the Todsen’s pennyroyal. Todsen’s pennyroyal occurs in the San Andres Mountains and on the western slope of the Sacramento Mountains at elevations of 6,200 to 7,400 feet. There are 15 known populations of Todsen’s pennyroyal at WSMR (see Figure 3-2). The smallest population covers 0.1 acres and the largest covers 1.22 acres. Although habitat occurs on the installation, no known habitat occurs within the project area.

Todsen’s pennyroyal was originally listed as federally endangered, with critical habitat for two known populations, on January 19, 1981 (FR, 1981). New Mexico has also listed Todsen’s pennyroyal as endangered under the state program. The Todsen’s Pennyroyal Endangered Species Management Component was developed by WSMR to facilitate protection of this endangered species (WSMR, 2023a). The Endangered Species Management Component defines the conservation goals and management objectives, and it prescribes management actions for populations of Todsen’s pennyroyal at WSMR. Though the Todsen’s Pennyroyal is known to occur on WSMR it is not known to occur within the area of influence.

In addition to Todsen’s pennyroyal, three other plant species are state-listed: Mescalero milkwort (*Polygala rimulicola var. Escalerorum*), Night-blooming cereus (*Peniocereus greggii var.greggi*), and Organ Mountain pincushion cactus (*Escobaria sneedii organensis*) (WSMR, 2023a). Mescalero milkwort, and the Organ Mountain pincushion is not known to occur within the area of influence. The Night-blooming cereus has a low probability of occurring within the area of influence.

Figure 3-1: WSMR Vegetation Types

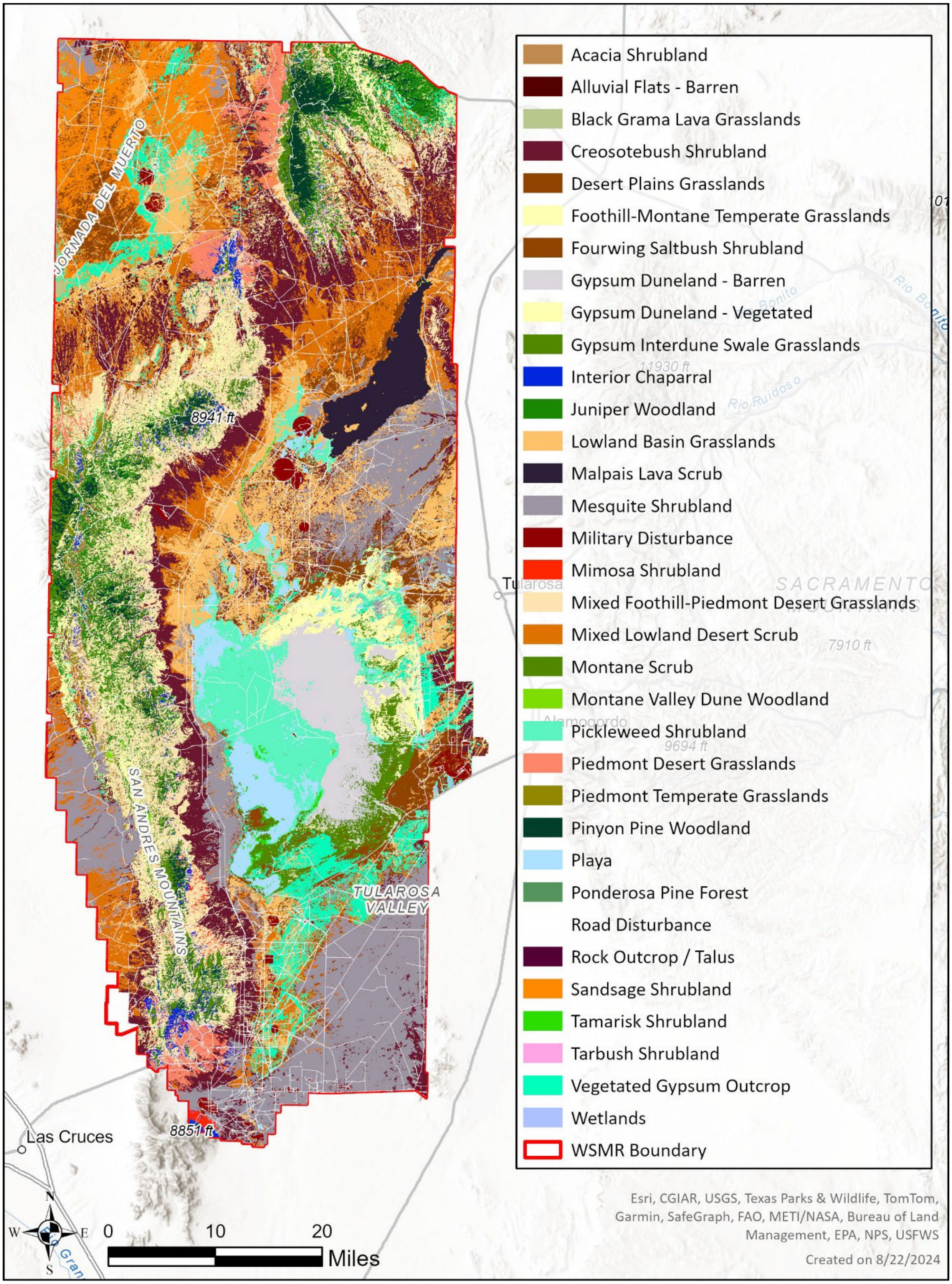
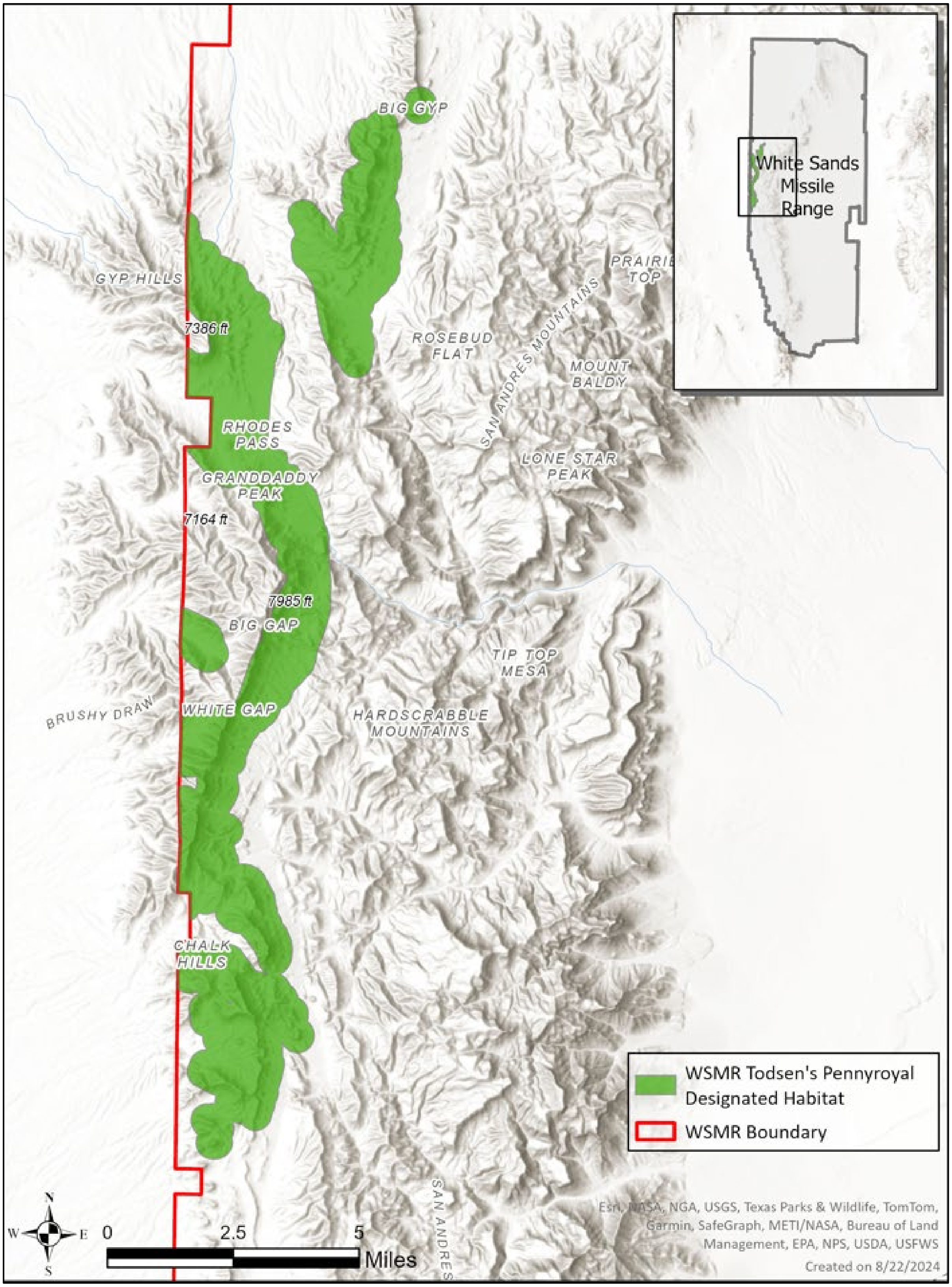


Figure 3-2: WSMR Todsen's pennyroyal Habitat



3.2.1.2 Wildlife

Complete lists of wildlife species present on WSMR can be found in the WSMR INRMP (WSMR, 2023a). Below is a brief description of each animal sub-group excerpted from the WSMR INRMP.

Invertebrates

While exact species are unknown, common insect orders that are thought to be present in the action area are Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Hymenoptera (ants, bees, and wasps), and Lepidoptera (butterflies and moths) (WSMR, 2023a). Not only are invertebrates an important source of food for many birds, mammals, fish, and reptiles, but they also benefit the ecosystem through decomposition, seed dispersal, soil aeration, and pollination (WSMR, 2009).

Insect surveys have been conducted in several different habitats throughout WSMR. Butterfly surveys and incidental encounters at WSMR have detected more than 100 butterfly species (WSMR, 2023a). Although there are no federal or state listed species of insects at WSMR, USFWS has determined that listing the monarch butterfly (*Danaus plexippus*) under the ESA is warranted but precluded at this time by higher priority listing actions. With this finding, the monarch becomes a candidate for listing. The monarch has been documented throughout WSMR. Investigators recommend further monitoring of the monarch and Poling's hairstreak (*Satyrium polingi*), which has a rare endemic subspecies (*S. p. organensis*) occurring at WSMR. The probable range of *S. p. organensis* appears to be restricted to a narrow montane corridor that starts in the Organ Mountains, extending along the San Andres Mountains and possibly the Oscura Mountains up to U.S. 380. At WSMR, this subspecies has only been recorded at two sites. As of January 2022, USFWS has proposed endangered listing for the Sacramento Mountain Checkerspot (*Euphydryas anicia cloudcrofti*). Surveys for this endemic subspecies had previously been conducted in 2005. While the Sacramento Mountain Checkerspot was not found at that time, the survey effort did find host and food plants for that species at several sites; consequently, Environmental Division personnel have proposed follow-up surveys to confirm presence/absence of this potential endangered species (WSMR, 2023a).

The Tularosa springsnail (*Juturnia tularosae*) is an endemic species to WSMR and is listed by NMDGF as a Species of Greatest Conservation Need (SGCN). Tularosa springsnails only occur along the Salt Creek drainage within WSMR. The USFWS IPaC tool identified two federally listed endangered snail species as potentially occurring at WSMR, including the Chupadera Springsnail (*Pyrgulopsis chupaderae*) and Socorro Springsnail (*Pyrgulopsis neomexicana*) (USFWS, 2024). However, neither of these species have been documented at WSMR.

Amphibians and Reptiles

WSMR contains habitat that supports a diverse array of herpetofauna, including seven species of amphibians and 48 species of reptiles. Possible species that may never be documented due to their secretive nature and scarcity include the New Mexico milk snake (*Lampropeltis gentilis*) and many-lined skink (*Plestiodon multivirgatus*). The nonnative Mediterranean gecko (*Hemidactylus turcicus*) was detected on Main Post in 2013 (WSMR, 2023a). The USFWS IPaC tool identified one federally listed amphibian species as potentially occurring at WSMR, the Chiricahua leopard frog (*Rana chiricahuensis*). However, this species has not been documented at WSMR. Additionally, NMDGF lists both the Banded Rock Rattlesnake (*Crotalus lepidus*) and Western Massasauga Rattlesnake (*Sistrurus catenatus*) (Western Massasauga Rattlesnake is not known to occur within the area of influence) as SGCN (WSMR, 2023a). Three reptiles on the Army Priority List of At-Risk Species (the little white whiptail lizard [*Aspidoscelis gypsi*], White Sands prairie lizard [*Sceloporus undulatus cowlesi*], and Desert tortoise [*Gopherus agassizii*]) have been documented at WSMR (WSMR, 2023a).

Fish

The White Sands Pupfish is the only native fish present at WSMR. The White Sands Pupfish naturally occurs in Salt Creek and Malpais Spring. Pupfish have been translocated to three locations on WSMR (South Mound Spring, North Mound Spring, and Main Mound Spring) as well as one location on Lost River (WSMR, 2023a).

Field surveys on WSMR have documented nonnative fish in ponds and springs. Largemouth bass (*Micropterus salmoides*), goldfish (*Carrasius auratus*), and mosquitofish (*Gambusia affinis*) were reported as occurring at Guilez and Barrel Springs. A population of bluegill (*Lepomis macrochirus*) was discovered in Martin Ranch Pond. Nonnative fish have since been eradicated at all locations on WSMR except at Guilez and Barrel Springs (WSMR, 2023a).

The USFWS IPaC tool identified two federally listed fish species as potentially occurring at WSMR, including the Rio Grande Cutthroat Trout (*Oncorhynchus clarkii virginalis*) and Rio Grande Silvery Minnow (*Hybognathus amarus*) (USFWS, 2024). However, neither of these species have been documented at WSMR.

Avifauna

Due to its wide diversity of habitats, New Mexico has recorded the second highest number of bird species of any non-coastal state in the U.S. (WSMR, 2024a). WSMR itself has documented 313 bird species (WSMR, 2023a). The USFWS IPaC tool identified five federally listed bird species as potentially occurring at WSMR, including the Mexican spotted owl (*Strix occidentalis lucida*), northern aplomado falcon (*Falco femoralis septentrionalis*), piping plover (*Charadrius melodus*), southwestern willow flycatcher (*Empidonax traillii extimus*), and yellowbilled cuckoo (*Coccyzus americanus*) (USFWS, 2024). Additionally, on August 17, 2023, it was announced that the piñon jay (*Gymnorhinus cyanocephalus*) is under review for listing with the USFWS.

Similarly, WSMR has documented 10 species with NMDGF listed status, including the northern aplomado falcon, southwestern willow flycatcher, bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), broad-billed hummingbird (*Cynanthus latirostris*), Costa's hummingbird (*Calypte costae*), Bell's vireo (*Vireo bellii*), gray vireo (*Vireo vicinior*), Baird's sparrow (*Centronyx bairdii*), and varied bunting (*Passerina versicolor*) (WSMR, 2023a). Thirteen bird species listed by NMDGF as SGCN have been documented at WSMR, including the Bendire's thrasher (*Toxostoma bendirei*), Black-chinned sparrow (*Spizella atrogularis*), burrowing owl (*Athene cunicularia*), Chestnut-collared longspur (*Calcarius ornatus*), flammulated owl (*Psiloscops flammeolus*), Loggerhead shrike (*Lanius ludovicianus*), long-billed curlew (*Numenius americanus*), Olive-sided flycatcher (*Contopus cooperi*), piñon jay, snowy plover (*Charadrius nivosus*), Virginia's warbler (*Leiothlypis virginiae*), and yellow-billed cuckoo (WSMR, 2023a).

The 1988 amendment to the Fish and Wildlife Conservation Act mandates the USFWS to identify species, subspecies, and populations of all migratory nongame birds that without additional conservation action are likely to become candidates for listing under ESA. The Birds of Conservation Concern distinction identifies migratory and non-migratory bird species (beyond those already designated as federally threatened or endangered) that represent the highest conservation priorities of USFWS. WSMR is located within USFWS Bird Conservation Region 35, which lists 30 bird species as Birds of Conservation Concern. Of these 30 species, 27 species may be present at WSMR at some time during their lifecycle.

DoD Partners in Flight (PIF) has identified, through a detailed technical analysis, 15 bird species occurring on lands throughout DoD that may be at risk of becoming listed under the federal ESA. DoD PIF designated these as "Mission-sensitive Species" (MSS) due to their high potential to impact the military mission should ESA listing be warranted. There are two bird species that occur at WSMR that are considered MSS, the burrowing owl and piñon jay (WSMR, 2024a). In addition to the MSS list, DoD PIF also categorized an additional 37 species as "Tier 2" species. Most of these species are experiencing long-term declines and have some potential relevance to future mission impacts if federally listed, but they are not considered highest priority based on DoD PIF's current review criteria. There are 14 Tier 2 species that occur at WSMR, the long-billed curlew, flammulated owl, golden eagle (*Aquila chrysaetos*), greater yellowlegs (*Tringa melanoleuca*), black-chinned sparrow, Kentucky warbler (*Geothlypis formosa*), olive-sided flycatcher, Sprague's pipit (*Anthus spragueii*), Virginia's warbler, loggerhead shrike, Lewis's woodpecker (*Melanerpes lewis*), gray vireo, chestnut collared longspur (*Calcarius ornatus*), and Baird's sparrow (*Centronyx bairdii*) (WSMR, 2024a).

Mammals

New Mexico has one of the most diverse mammal communities in the world, with 179 total mammal species documented (WSMR, 2023a). Seventy-five of these species have been recorded at WSMR. The USFWS IPaC tool identified three federally listed mammal species as potentially occurring at WSMR, including the Mexican gray wolf (*Canis lupus baileyi*), New Mexico meadow jumping mouse (*Zapus hudsonius luteus*), and Penasco Least chipmunk (*Tamias minimus atristriatus*) (USFWS, 2024). None of these species have been documented at WSMR (WSMR, 2023a). Nevertheless, populations of the Mexican gray wolf, a federal and state endangered listed species, have improved and continue to expand their range throughout the Mexican Wolf Experimental Population Area (USFWS, 2024).

The Mexican gray wolf is the rarest subspecies of gray wolf in North America and was listed as endangered in 1976. The USFWS began reintroducing Mexican gray wolves back into the wild within the Mexican Wolf Experimental Population Area in Arizona and New Mexico in 1998 (FR, 1998). WSMR is a federal cooperating agency for the introduction of the Mexican gray wolf under the 2015 10(j) rule, revision to the regulations for the nonessential experimental population (FR, 2015). WSMR is within management Zone 2 of the Mexican Wolf Experimental

Population Area (FR, 2022) and one Mexican wolf has been spotted in the northern portion of WSMR. Management Zone 2 is where Mexican wolves are allowed to naturally disperse into and occupy and where Mexican wolves may be translocated.

There are three NMDGF threatened mammal species that have been documented at WSMR, including the Organ Mountains Colorado chipmunk (*Neotamias quadrivittatus organensis*), Oscura Mountains Colorado chipmunk (*Neotamias quadrivittatus oscuraensis*), and spotted bat (*Euderma maculatum*). A single mammal, the Townsend's big-eared bat (*Corynorhinus townsendii*), is listed by NMDGF as a SGCN and has been documented at WSMR (WSMR, 2023a). One mammal on the Army Priority List of At-Risk Species (the Oscura Mountains Colorado chipmunk) has been documented at WSMR (WSMR, 2023a).

Large Mammal Management

Hunting is used for wildlife population control and recreation for the public (WSMR, 2009). WSMR and the NMDGF have partnered in managing hunting on WSMR since the 1950's. Currently, oryx (*Oryx gazella*), pronghorn antelope (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), mountain lion (*Puma concolor*), and javelina are managed through hunting programs on WSMR. Black bear (*Ursus americanus*) and Barbary sheep (*Ammotragus lervia*) populations are continually monitored to determine the need for establishing future hunting seasons for these species. Several upland game birds, waterfowl, furbearers, and non-protected species are hunted small game species. There is no fishing or sport trapping allowed at WSMR. It is prohibited to collect and/or kill reptiles and amphibians (WSMR, 2023a).

Livestock

Livestock grazing is prohibited on WSMR lands without authorization, although it still occasionally occurs at low levels from livestock intrusions. Overgrazing by cattle can remove herbaceous cover and result in sand sheets or dunes if not controlled (Milchunas, 2006). Domestic cattle (*Bos taurus*) do not occur on WSMR lands, with the exception of animals in some areas where there is no impediment to intrusion. Barbary sheep (*Aoudad*) are observed primarily in mountainous regions, the same habitat as bighorn sheep. Due to the potential threat the species poses to bighorn sheep, WSMR maintains a year-round kill permit for the species. No domestic or feral goats are known to occur on WSMR, but future immigration of feral goats into the area remains a possibility. Additionally, domestic sheep (*Ovis aries*), "wild-type" mouflon are occasionally raised on game ranches and can become naturalized. Potential intrusions may occur although there are no known sheep occurrences on the installation. The oryx is a naturalized exotic that is native to the deserts in the Kalahari region of southern Africa. The oryx is considered a game species and is hunted on WSMR (WSMR, 2023a).

3.2.2 Environmental Consequences

For the purposes of this Programmatic EA, the proposed significance criteria for biological resources include the following:

- The permanent loss or degradation of designated rare/sensitive plant species or introduction or increased prevalence of undesirable non-native species;
- Long-term loss or impairment of a substantial portion of local habitat (species dependent);
- Significant decline in MBTA populations or direct mortality or take;
- Direct mortality or other unpermitted take of threatened and endangered species;
- Jeopardize the continued existence of a species or result in an overall decrease in population diversity, abundance, or fitness; or
- Degradation of habitat quality or diminish species health.

To avoid and minimize a trend towards exceeding the significance criteria listed above, applicable best management practices (BMPs) and mitigation measures would be implemented under the alternative 1. In addition, WSMR would minimize potential impacts by assessing the project action area for sensitive biological resources through application of the WSMR environmental review process as explained in Section 2.3.2. In the event WSMR observes a shift towards species or ecosystem decline resulting from the proposed action, WSMR would reevaluate the BMPs and mitigation measures. Additionally, to address uncertainties surrounding a potential shift, an adaptive monitoring/management process would be implemented to integrate planning with additional monitoring/investigations to ensure that the most current information is available and used in the decision-making process.

3.2.2.1 Alternative 1

WSMR would assess each potential design solution action area for sensitive biological resources through application of the WSMR environmental review process as explained in Section 2.1.2. The area of potential effect encompasses 69,903 acres of land between the eastern base of the Organ Mountains and the southernmost portion of the installation where stormwater runoff has historically flooded the installation and surrounding roadways. The area of analysis for this resource area is the flooding impact area (see Figure 1-2) plus a 1,000-foot-wide buffer.

Vegetation Communities

Short- and long-term, direct and indirect, minor, adverse impacts on vegetation would occur. Short-term, direct effects on vegetation from removal and crushing and indirect effects from soil compaction and the potential for establishment of invasive species could occur. However, long-term, negligible, beneficial impacts would result from revegetation or landscaping of disturbed sites with native species supporting the native plant community on the installation.

Access to the action area would utilize existing roads and pullouts. New ingress or egress routes or staging areas would be created. If needed, temporary trails may be generated by transiting All-Terrain Vehicles/Utility Terrain Vehicles. In some areas, the terrain may be inaccessible by vehicles and materials may need to be hauled in on foot. The proposed alternative would be sited to avoid or reduce direct impacts to the greatest extent feasible.

Construction activities would result in short-term disturbance to vegetation. Permanent impacts would result from the construction of a variety of design solutions. Vegetation that is tall enough to impede construction would be sheared off near ground-level with a brush-beater or with hand labor in isolated locations. The soil surface and root systems would be left intact, when feasible. Surveys for any listed species with the potential to occur within the project area would be completed prior to any construction activities.

Vegetation would be removed where construction of detention basins, levee improvements, cross/culvert improvements, and other design solutions would require excavation. Depending on the design solution and location excavation would be done by hand, truck-mounted auger, and or heavy machinery. The overall effect on species composition and forage production would likely be negligible. Since the exact locations and designs are not yet determined, additional analysis may be necessary once design solutions and site selections are finalized.

To reduce the chance of invasive plants affecting the action area, the project proponent would coordinate with the WSMR Integrated Pest Management Coordinator regarding invasive weed management. Preventative and control measures would include, but are not limited to, an Employee Environmental Awareness Program; vehicle and equipment entry cleaning; and treatment methods including manual, mechanical, and herbicidal. These measures would limit the infestation of invasive plant species from altering the ecological function of the action area. In addition, detention basins could become desirable places for wildlife to nest, bed down, and construct burrows. Regular inspection and maintenance of these areas would prevent the detention basins from becoming enticing habitat.

Long-term impacts would include reduced vegetative cover where animal trails are created in order to access or avoid potential design solution. Design solutions such as retention ponds may be used as a watering hole for local wildlife. Animal trails would be expected leading up to and around these design features. The installation of water resilient infrastructure and design solutions would alter habitat in and around these features. Design features that capture or slow the movement of water would alter the adjacent vegetative community. These design features would create more longer lasting ephemeral wetland habitat more suitable for riparian vegetation.

Wildlife

Short- and long-term, minor, adverse impacts on wildlife species and their habitats would occur. Construction and training activities would result in both permanent (due to new construction footprint) and temporary (due to disruption from construction and maintenance activities), minor degradation of habitat. To help mitigate these impacts, WSMR would conduct surveys for listed species prior to any construction and have a monitor onsite during construction when necessary. The need for surveys would be a condition of use and determined through the environmental review process. Additionally, the presence of monitors would be species/habitat driven. An updated species list from USFWS would be required to be obtained within 90 days of starting any construction activities.

Mobile wildlife would be temporarily displaced during construction and maintenance activities. Long-term effects on wildlife would relate primarily to how the new design solutions may influence seasonal movements. No matter how well designed, new design solutions could still result in increased animal stress and energy loss, and occasionally mortality should animals become trapped in them or become separated from their herd and become more prone to predation. Additionally, potential detention ponds located near roads may attract larger wildlife, such as deer and oryx, which could pose safety concerns for vehicular traffic in the area. To mitigate these risks, measures such as fencing and enhanced signage could be implemented to minimize the likelihood of wildlife-vehicle collisions and ensure the safety of both motorists and wildlife.

Individuals of smaller, less-mobile species could be inadvertently killed or injured during ground disturbing activities or transportation of equipment and personnel. Burrowing animals, such as rodents and reptiles, could be impacted. However, vehicles associated with construction activities would be used primarily on the established roads, which limits the potential for impacts on burrowing species.

BMPs that could be implemented include employing seasonal avoidance measures during construction and training activities as well as non-disturbance buffer zones around occupied nests during the nesting period. Preconstruction surveys would be conducted during the breeding season, and if found, one of the following mitigation activities would be conducted (1) seasonal avoidance measures would be implemented until birds have vacated the affected nests (i.e., construction activities would not occur during the breeding season of March 1 to September 30); (2) spatial buffers of at least 0.25 mile from construction activities would be implemented; or (3) relocation activities would be implemented using USFWS-recommended relocators. Additionally, WSMR requires personnel to participate in Environmental Awareness Training prior to beginning activities at WSMR.

Although the design solutions may preclude transboundary migration patterns of animals, especially larger mammals (e.g., mule deer), and thus fragment habitat within the action area, these impacts would be considered minimal. Habitat fragmentation typically affects species with small population sizes or those that are dependent upon migration to obtain spatially or temporally limited resources (Gilpin and Hanski, 1991). Prior to construction, WSMR would undergo an environmental review process to evaluate design alternatives.

Ultimately, the type of design solutions would be selected based on a site-specific design and would be consistent with the White Sands Missile Range Watershed Level Flood Control Conceptual Design Solutions (Appendix B).

Standing water associated with water resilient infrastructure and design solutions would potentially attract mosquitoes and facilitate breeding. In order to manage mosquito populations, WSMR staff would follow the mosquito management strategy described in 8.1.3 of the Integrated Pest Management Plan (WSMR, 2021a).

Properly designed and maintained water resilient infrastructure would reduce the risk of flooding while having minimal detrimental effects on wildlife. The infrastructure would slow and trap water, making water more accessible for local wildlife. The infrastructure would be designed in order to reduce the possibility of wildlife entrapment.

Threatened and Endangered Species

Short-term, negligible, adverse impacts on threatened and endangered species, SGCN and other species of interest could occur with the construction and maintenance of water resilient design solutions. Key habitat for threatened and endangered species is not known to occur within the project area. In the short-term, alternative 1 has the greatest potential to affect, but not adversely affect threatened or endangered species or critical habitat for those species during site preparation and construction actions associated with prescribed design solutions. Potential disturbances may include ground-disturbing activity and noise associated with construction equipment. In the long-term, alternative 1 has the potential for minor to moderate beneficial effects to protected species and habitat based on a potential to reduce erosion, remove noxious weeds, increase riparian habitat, and reduce the risk of flooding. Additionally, WSMR would use BMPs and incorporate all permit conditions applicable to minimizing effects to protected species and habitat.

Potential impacts to the endangered Todsen's pennyroyal would be avoided as specific design solution projects would undergo an environmental review, screening and decision process prior to implementation. As a result, avoidance and minimization measures include species-specific surveys prior to construction activities within potential habitat to ensure avoidance. Additionally, a qualified biological monitor (approved by the WSMR Environmental Division) would be onsite during construction activities within potential habitat to ensure no direct impact to the species. The Todsen's pennyroyal habitat does not occur within the area of influence, as such impacts are not anticipated.

There is approximately 200,000 acres of suitable breeding and foraging habitat on WSMR for the northern Aplomado falcon within the northwest corner of the installation (FR, 2006). Because the exact locations and design plans are not known at this time the permanent disturbance of foraging habitat cannot be currently quantified, but is anticipated to be minimal. Additionally, construction activities would occur outside of the migratory bird nesting season (March through August), which coincides with the species breeding season.

Gray vireo habitat does not occur within the area of influence, as such impacts are not anticipated. Regardless, construction activities and vegetation removal would occur outside of the migratory bird nesting season from March through August, which coincides with the gray vireo's breeding season.

Other Protected Species

Suitable nesting and foraging habitat for SGCN species occurs within the action area. Short-term disturbance may displace the birds temporarily.

Of note, the burrowing owls' use of burrows makes them susceptible to impacts from ground disturbing activities. Construction activities may temporarily displace wintering owls, but breeding owls would not be impacted because the proposed action would not occur during the nesting season (March through August) and burrows would be avoided.

Various plant species of interest have the potential to occur within the action area. A full list of floral state species of concern and WSMR special interest is located in the INRMP (WSMR, 2023a). Thus, the WSMR Environmental Division would perform an environmental review of the proposed design solution projects prior to implementation. Potential habitat for any species of interest identified during the review process would require presence and absence surveys to be performed by an approved qualified botanist. Avoidance of species of interest would occur to the maximum extent possible and BMPs and mitigation measures would be implemented.

In addition, to addressing species listed under the ESA and state SGCN, WSMR must also comply with the MBTA. Because construction activities do not qualify for the Military Readiness Exemption under the MBTA, any actions taken would follow applicable MBTA requirements to avoid and minimize impacts to migratory birds. As a result, project planning and execution would incorporate measures, such as avoiding construction activities during nesting season, to reduce disturbance and potential harm to migratory bird populations.

Summary

Implementation of alternative 1 would result in negligible direct impacts to vegetation and some wildlife. Indirect impacts to vegetation and wildlife would also occur. With the implementation of the minimization and mitigation measures listed above the impacts to biological resources, including listed species, would be avoided or reduced. The construction, operation, and maintenance of the proposed design solutions would alter the hydrologic setting in order to reduce flooding, however, the design solutions would be designed and maintained to emulate the natural hydrologic setting. Therefore, implementation of alternative 1 would not result in significant impacts to biological resources.

3.2.2.2 No Action Alternative

Under the no action alternative, WSMR would continue to carry out only basic repairs to provide immediate relief following a damaging flood event, without implementing design solutions to enhance flood protection. Biological resources would remain unchanged. Therefore, there would be no impacts to biological resources under the no action alternative.

3.3 Cultural Resources

Archaeological resources consist of the material remains of prehistoric and/or historic human activity. The Archaeological Resources Protection Act of 1979 defines archaeological resources as “pottery, basketry, bottles, weapons, weapon projectiles, tools, structures or portions of structures, pit houses, rock paintings, rock carvings, intaglios, graves, human skeletal materials, or any portion or piece of any of the foregoing items” (16 USC 470bb).

Architectural resources also include manmade structures including, but not limited to, standing buildings, dams, bridges, and canals. Under the National Historic Preservation Act of 1966 (NHPA) (16 USC 470 et seq.), only architectural resources older than 50 years are considered for protection; however, younger structures can be afforded the same protection under special circumstances.

Traditional cultural properties may include archaeological resources, architectural resources, topographic features, plant and animal habitat, and any other inanimate object deemed essential to the continuance of a traditional culture by Native Americans and other groups.

The NHPA provides for establishment of the National Register of Historic Places (NRHP), an official list of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, and culture. Section 106 of the NHPA requires federal agencies with jurisdiction over a proposed federal project to take into account the undertaking's effect on cultural resources listed or eligible for listing in the NRHP and affords the State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation opportunity to comment with regard to the undertaking. NRHP eligibility criteria have been defined by the Secretary of the Interior's Standards for Evaluation (36 CFR 60). Cultural resources are NRHP-eligible if they display the quality of significance in American history, architecture, archaeology, engineering, and culture present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, workmanship, feeling, and association, and meet at least one of the following criteria:

- Criterion A: The resources are associated with the events that have made a significant contribution to the broad patterns of American history;
- Criterion B: The resources are associated with the lives of persons significant in our past;
- Criterion C: The resources embody the distinctive characteristic of a type, period, or method of construction, or represent the work of a master, or possess high artistic value, or represent a significant or distinguishable entity whose components may lack individual distinction;
- Criterion D: The resources have yielded or may likely yield information important in prehistory or history.

The process of agency review and assessment of the effect of an undertaking on cultural resources is set forth in the implementing regulations formulated by the Advisory Council on Historic Preservation (36 CFR 800, Protection of Historic Properties). Other applicable laws and guidelines include:

- EO 11593, *Protection and Enhancement of Cultural Environment* (16 USC 470 [Supp. 1, 1971]);
- Native American Graves Protection and Repatriation Act (25 USC 3001 – 3013);
- Determination of Eligibility for Inclusion in the NRHP (36 CFR 63);
- Recovery of Scientific, Prehistoric, and Archaeological Data (36 CFR 66);
- Curation of Federally Owned and Federally Administered Archaeological Collections (36 CFR 79); and
- DoD Directive 4710.1, Archeological and Historic Resources Management.

Section 101(d)(6)(B) of the NHPA requires federal agencies to consult with Indian tribes that attach religious or cultural significance to historic properties. Compliance with 36 CFR 800.2, which implements consultations with Native Americans, may be conducted by federal agencies as part of a government-to-government undertaking. In accordance with Section 101(b)(3) of the

Act, SHPOs advise and assist federal agencies in carrying out their Section 106 responsibilities and assist agencies, organizations, and individuals to ensure that historic properties are taken into consideration at all levels of planning and development. In New Mexico, the State Historic Preservation Officer is the director of the New Mexico Historic Preservation Division of the Department of Cultural Affairs. Consultation between WSMR and SHPO is an ongoing process for undertakings at WSMR.

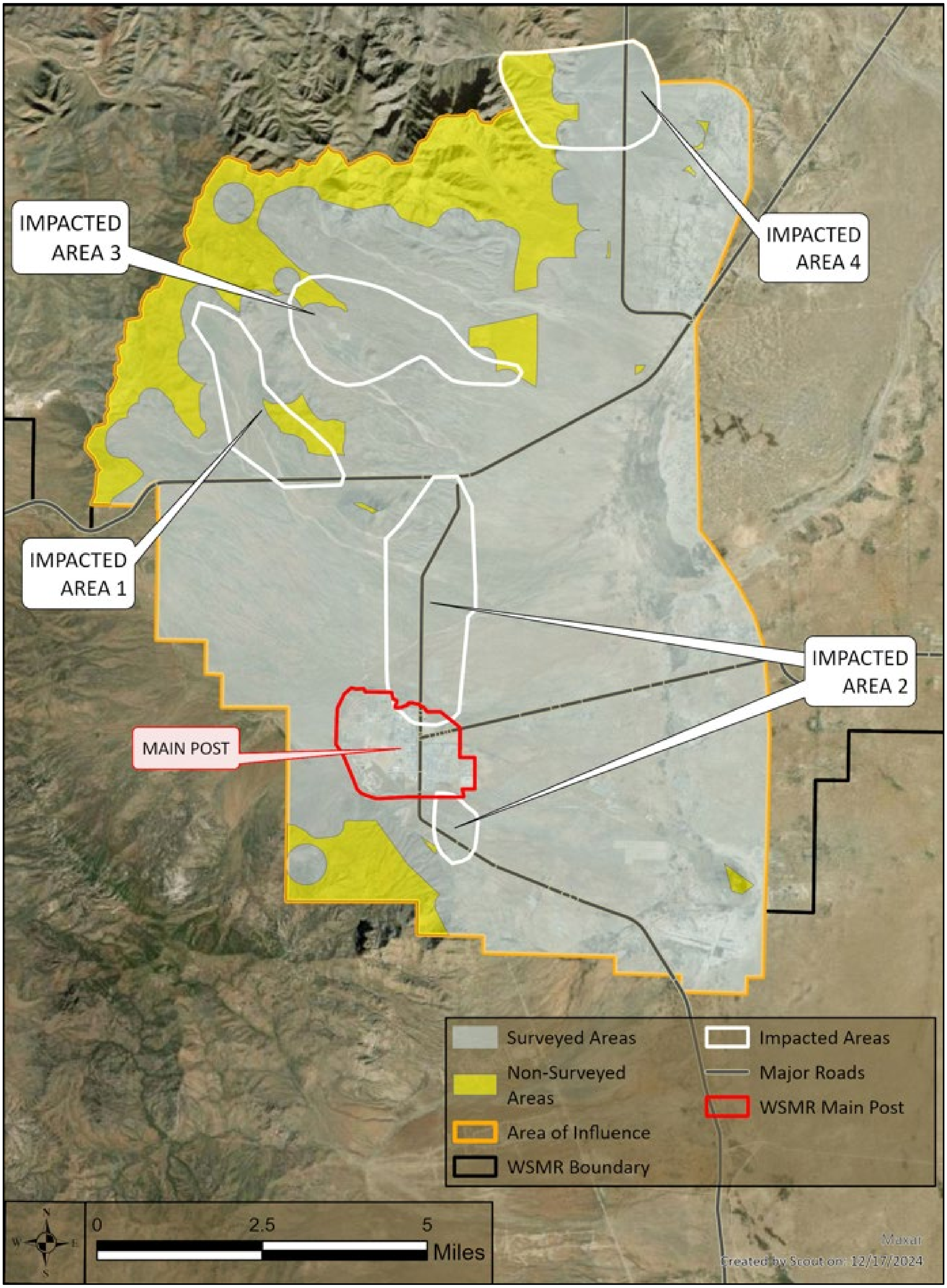
The management of cultural resources falls within the objectives identified in the WSMR ICRMP (WSMR, 2025). All activities on WSMR are informed by the Programmatic Memorandum of Agreement among the Department of the Army, White Sands Missile Range, the State Historic Preservation Officer, and the Advisory Council on Historic Preservation (U.S. Army, 1985).

3.3.1 Affected Environment

The area of potential affect (APE) for cultural resources consists of 66,253 acres of land between the northeast base of the Organ Mountains and southwest portion of the installation where stormwater runoff has historically flooded the installation and surrounding roadways. The actual footprint of temporary and permanent construction activities is smaller than the analysis area (1,000-foot-wide buffer).

The vast size of the WSMR holdings means that there are large areas of WSMR and the APE that have not been surveyed. Approximately 25 percent of WSMR's 2.2 million acres have been surveyed for the presence of cultural resources (see Figure 3-3). These efforts have demonstrated at least 10,000 years of human occupation in the area. Sample surveys conducted in the 1980s and 1990s established a baseline of various sites that occur in the areas of low activity. Another tool used to evaluate cultural resources potential is the application of a predictive model using data from both WSMR and Fort Bliss. For a comprehensive treatment of the WSMR historic context and documented cultural resources, see the WSMR ICRMP (WSMR, 2025).

Figure 3-3: Cultural Survey Areas Within the Area of Influence



3.3.2 Environmental Consequences

The WSMR ICRMP (2025) lays out standard operating procedures (SOPs) for the identification of historic properties and cultural resources and BMPs to avoid adverse effects to these resources. For each proposed conceptual design, a site-specific evaluation of potential impacts to cultural resources would be conducted using the WSMR Environmental Review process. Based on the outcome of that review, it would be determined which SOPs apply, and if necessary, actions may proceed under Section 106 consultation, site mitigation requirements, and coordination with Native American tribes. These SOPs include:

SOP #1: Identifying Undertakings

- Following proper procedures to determine if an action is an undertaking subject to Section 106 review, and having the cultural resources manager (CRM) review all undertakings for potential to affect historic properties.
- Ensuring that the following activities have coordination with Cultural Resources Program prior to the implementation of a project, all new construction, all building demolitions, any ground-disturbing activity, or all activities affecting properties at WSMR that are evaluated as historic or could be considered historic.

SOP #4: Identifying and Evaluating Historic Properties

- Identify properties that are eligible for inclusion in the NRHP or that are identified as Properties of Traditional Religious and Cultural Importance (TRCI) by federally recognized Tribes and manage them to maintain the historic or cultural characteristics that qualify them for inclusion in the NRHP or important as TRCIs.
- All sites, until determined not eligible for NRHP listing, are considered TRCIs and are subject to the ICRMP guidelines.
- Potentially conducting archaeological survey if determined necessary.
- Properly recording and documenting sights and isolated occurrences.

SOP #5: Assessing Effects

- If the CRM finds that there are historic properties that may be affected by the undertaking, the CRM shall apply the criteria of adverse effect to historic properties within the APE.

Impacts could be considered significant to cultural resources if they cause alteration or to the characteristics that could qualify a property for inclusion on the NRHP. This could include physical destruction, damage, alteration, removal, change in use or character within the setting, and negligence causing deterioration, transfer, lease or sale. Alteration to properties or to the access of properties that are of religious or cultural significance to Native American Tribes would also be considered significant.

3.3.2.1 Alternative 1

Under alternative 1, WSMR would implement restoration, replacement, and mitigation of existing watershed elements impacted by storm events. Cultural resources would be considered before any activities would take place. As such, prior to the implementation of this project, and any of the proposed design solutions, engineering plans, or relocation of sediment, rock, or other debris, WSMR CRM would follow Section 106 review and procedure.

The WSMR CRM would determine whether pre-test, site-specific cultural resource studies, or consultation would be required prior to implementing these potential solutions or activities in their respective areas. Any cultural resource consultations would happen prior to implementing these activities.

The areas containing known sensitive cultural resources would be avoided through site selection during the planning process or through a cultural resources monitor directing the placement of these proposed solutions to avoid damage to any historic buildings, sites, or other cultural resources.

There is potential for the inadvertent discovery of cultural resources during the implementation of the various design solutions. In the event of inadvertent discovery, WSMR would follow the inadvertent discovery policy and processes specified in the ICRMP (WSMR, 2025).

Therefore, implementation of alternative 1 would result in no adverse effects to cultural resources.

3.3.2.2 No Action Alternative

Under the no action alternative, WSMR would continue to carry out only basic repairs to provide immediate relief following a damaging flood event, without implementing design solutions to enhance flood protection. WSMR would continue to implement the measures in the ICRMP and manage historic properties in accordance with the ICRMP. Therefore, implementation of the no action alternative would not result significant impacts to cultural resources.

3.4 Geological Resources and Soil Erosion

Geologic resources include the geology, topography, and geologic hazards of a given area. The geology of an area includes surface and bedrock materials, its orientation and faulting, and natural resources such as mineral deposits, petroleum reserves, and fossils. Topography is the elevation, slope, aspect, and surface features found within a given area. Potential geologic hazards include the seismicity (the relative frequency of earthquakes) and the existence or potential for landslides, sinkholes, and liquefaction, as well as the potential for seismic events to pose a risk to people and property.

Soil consists of unconsolidated materials that lie on the surface, overlying bedrock, or other parent material. Soil erosion is the process by which the upper layer of soil is removed or displaced, often due to natural forces such as water, wind, ice, or gravity. This process can lead to the degradation of land, reducing its fertility and affecting its ability to support vegetation. The loss of soil can have significant environmental impacts, including reduced agricultural productivity, increased sedimentation in waterways, and loss of biodiversity. The effects of soil erosion within any given area are influenced by the interplay of geology, soils, topography, weather, and vegetative cover.

Soil taxonomy, developed by the U.S. Department of Agriculture (USDA), is a system for classifying soils based on their properties and characteristics. It helps soil scientists, agronomists, and land managers describe and manage soils across different environments. In this system, soils in an area can be categorized as either a "complex" or an "association." A soil association consists of distinct soil series that consistently occur together in predictable patterns, allowing for separate mapping. In contrast, a soil complex involves intermixed soils that cannot be mapped separately due to unpredictable boundaries (USDA, 2018).

Slope gradient is the angle of the land surface relative to a flat, horizontal plane. Often referred to as simply "slope", it is calculated by dividing the vertical rise by the horizontal run, then multiplying by 100. A steeper slope means water flows with more energy, leading to increased erosion and a greater capacity to carry sediment. It also means that water moves through the soil more quickly, reducing the time that water remains in the soil (USDA, 2018).

The regulatory framework that governs the management and conservation of soil and geology includes the State of New Mexico's Soil and Water Conservation District Act. The purpose of the Soil and Water Conservation District Act is to:

1. Control and prevent soil erosion,
2. Prevent floodwater and sediment damage,
3. Further the conservation, development, beneficial application, and proper disposal of water,
4. Promote the use of impounded water for recreation, propagation of fish and wildlife, irrigation and for urban and industrial needs, and
5. By the application of these measures, conserve and develop the natural resources of the state, provide for flood control, preserve wildlife, protect the tax base, and promote the health, safety, and general welfare of the people of New Mexico (New Mexico Department of Agriculture [NMDA], 2024).

A total of 47 Soil and Water Conservation Districts (SWCDs), spanning six geographic regions are organized and perpetuated under the Soil and Water Conservation District Act. The SWCDs are independent subdivisions of the New Mexico state government. The general and specific powers of the SWCDs are set out in the New Mexico Statutes Annotated (73-20-44 and 73-20-45) and generally reflect a range of actions that meet the purpose of the Act (NMDA, 2024).

The SWCDs work together with the New Mexico Soil and Water Conservation Commission (SWCC), under the New Mexico Department of Agriculture, Agricultural Programs and Resources Division. The 12-member SWCC is comprised of six district supervisors, appointed by the governor to represent the six SWCD regions. The SWCC serves as the state entity providing guidance and policy direction to the local SWCDs. The SWCC advises the New Mexico Department of Agriculture concerning any matter that has a significant impact on or otherwise substantially affects soil and water conservation; and promulgates rules to carry out the provisions of the Act (NMDA, 2024).

3.4.1 Affected Environment

The area subject to potential direct impacts to soil erosion consists of 69,903 acres of land between the eastern base of the Organ Mountains and the southernmost portion of the installation where stormwater runoff has historically flooded the installation and surrounding roadways. The area of analysis for this resource area is the flooding impact area (see Figure 1-2) plus a 1,000-foot-wide buffer.

Geology

WSMR is located within the southeasternmost portion of the Basin and Range Physiographic Province (Hawley, 1986), a regional area typified by uplifted fault blocks forming mountains and downthrown blocks forming basins. Erosion of the uplifted fault blocks and deposition of the eroded sediments have resulted in thick sequences of alluvial materials accumulating within the basins (Natural Resources Conservation Service [NRCS], 2017 as cited in WSMR 2021c). The WSMR terrain consists of rugged mountain peaks and canyons, rolling grass-covered hills, sand dunes, lava flows, semi-arid yucca and grassland basins, and large playas with scattered springs and ponds (Muldavin et al., 2000a and 2000b).

Topography

The topography of the project areas exhibits a range of topographic relief depending on the specific project area. Elevation ranges from approximately 3,900 (Condron Airfield) to 7,900 (North Oscura Peak) feet above mean sea level (Google Earth, 2024).

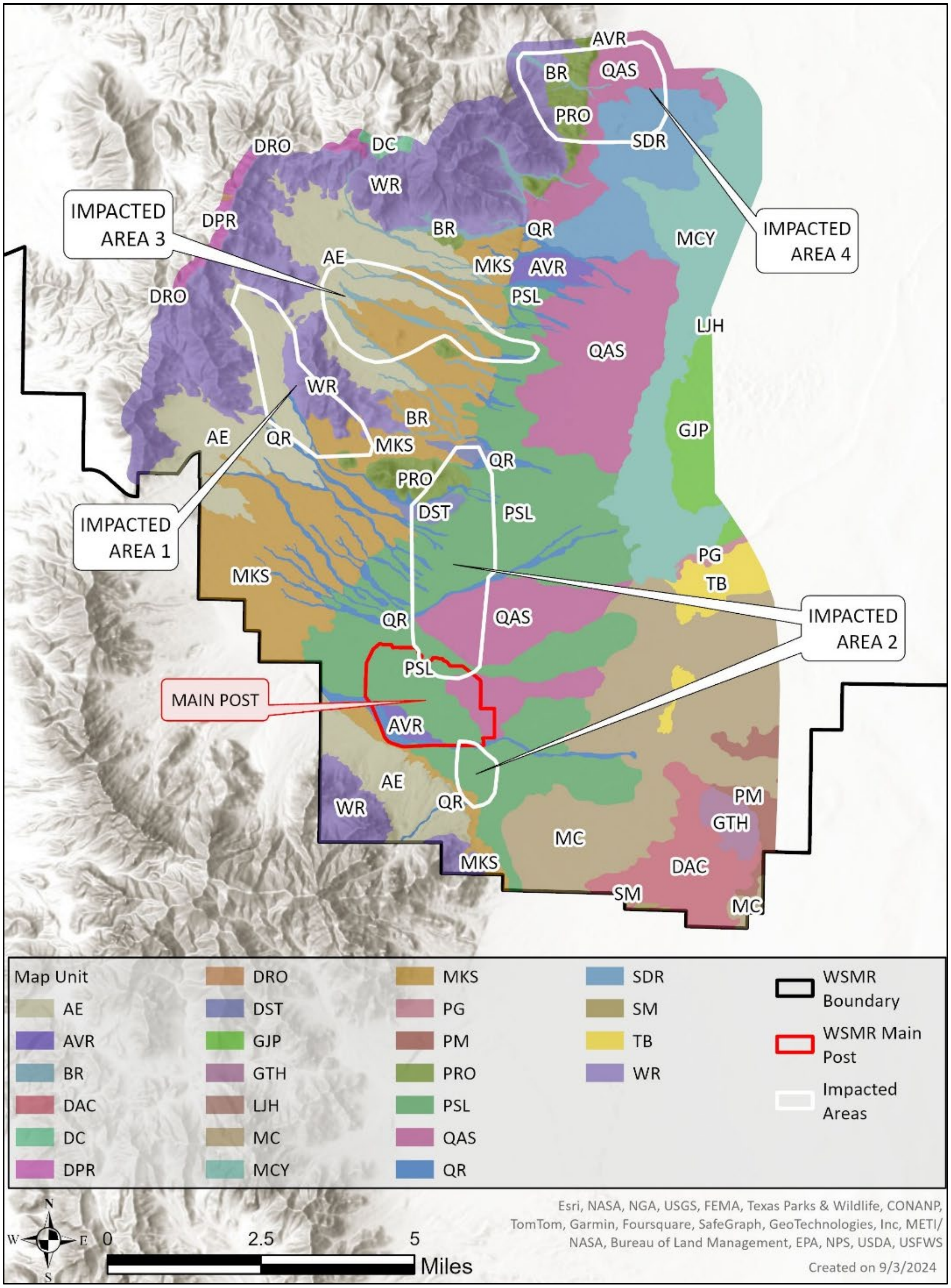
Soils

The NRCS has completed a soil survey of WSMR, and soil maps are available on the USDA NRCS Web Soil Survey [https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm] (NRCS, 2024). For a complete description of soil series represented on WSMR—including horizon and diagnostic characteristics—please reference the NRCS Soil Series Classification Database on the Web Soil Survey[https://soilseries.sc.egov.usda.gov/scname.aspx]. Soils in the region are generally dry and erode easily. Large, red dune fields spread across basin floors, occasionally interrupted by small, desert grasslands and dry lakebeds (or playas). Deep, eroded arroyos have cut into lower mountain slopes, carrying runoff from seasonal rains at high speeds to lower basins, where water rapidly soaks into the ground to resupply a shallow freshwater table. Within the last five years, multiple storm events have caused sediment flows that have resulted in damaged infrastructure (WSMR, 2023a).

The dominant soil orders in the area are Aridisols and Entisols and, at the higher elevations, Mollisols. The soil temperature regime in most of the Major Land Resource Area is typic aridic thermic grading into ustic aridic and aridic ustic thermic as elevation increases. Ustic aridic and aridic ustic mesic regimes are in the San Andres and Organ Mountains and the Sierra de las Uvas. Soil mineralogy is dominantly mixed, with carbonatic mineralogy in limestone-derived soils and gypsic and hypergypsic mineralogies in the Tularosa and Jornada Basins. Soils are generally very deep and nongravelly, except where they have petrocalcic horizons on the valley floor, basins, and piedmonts. Soils are generally shallow and very gravelly in the hills and mountains. Soils with high water tables and aquic conditions mainly occur in the Rio Grande Valley and in the hypergypsic dune areas in the Tularosa Basin (NRCS, 2022).

The results of the NRCS soil survey show that there are 24 distinct soil types within the region of influence (ROI). Figure 3-4 depicts the locations of these soil types in relation to the Main Post area and Flooding Impact Areas (see section 1.1). Table 3-2 provides an alphabetized list of soil names and the corresponding percent slope, soil characteristics, total acreage of the soil type, and rank according to total acreage.

Figure 3-4: WSMR ROI Soil Survey Map



Source: NRCS, 2024

Table 3-2: Soil Survey Characteristics

Map Unit	*Soil Name*	*Percent Slope*	*Soil Characteristics*	*Acreage[1] (cumulative[2])*	*Rank (size)*
AVR[3]	***Agustin-Vado-Riverwash complex***	***1 to 10***	***Very gravelly sandy loam; somewhat excessively drained***	***518***	***16***
AE	***Aladdin-Eppenauer family-Petrocalcic Paleustolls complex***	***1 to 60***	***Gravelly sandy loam; somewhat excessively drained***	***7,104***	***6***
BR	Bodecker-Riverwash complex	0 to 20	Very gravelly sand; somewhat excessively drained.	951	13
DPR	***Deama-Penagua-Rock outcrop complex***	***35 to 90***	***Very cobbly loam, well drained***	***453***	***18***
DRO	***Deama-Rock outcrop complex***	***30 to 90***	***Very gravelly loam; well-drained.***	***57***	***23***
DST	Delnorte-Stagecoach-Turney complex	0 to 15	Very gravelly loam; well-drained to moderately well-drained.	343	19
DC	Desario-Cuate complex	5 to 35	Very gravelly loam to clay loam; well drained	127	20
DAC	Doña Ana-Chutum complex	1 to 10	Loamy fine sand to sandy loam; well drained	1,876	10
GJP	***Globe-Jato-Peligro complex***	***0 to 20***	***Clay; poorly to moderately well-drained.***	***1,231***	***12***
GTH	***Globe-Typic Haplocalcids complex***	***0 to 1***	***Clay; moderately well-drained.***	***464***	***17***
LJH	Loki-Jato-Hermes complex	0 to 5	Loamy over coarse gypsum; well-drained.	6	24
MKS	***Mallet-Kimrose-Stronghold complex***	***5 to 20***	***Gravelly fine sandy loam; somewhat excessively drained***	***7,523***	***4***
MC	Mcnew-Copia complex	1 to 15	Sandy to loamy fine sand; excessively drained	7,384	5
MCY	Mimbres-Chutum-Ybar complex	0 to 5	Fine to silty loam; moderately well-drained.	4,818	7
PSL	***Pajarito sandy loam***	***0 to 9***	***Loamy fine sand to fine sandy loam; well drained***	***10,986***	***1***
PM	Pajarito-Mcnew complex	1 to 8	Loamy fine sand; well drained	581	15
PRO	***Pantak-Rock outcrop-Lithic Ustic Torriorthents complex***	***15 to 70***	***Loamy, gravelly; well-drained to excessively drained.***	***1,381***	***11***
PG	Peligro gypsiferous sandy loam	0 to 15	Coarse, sandy loam; well-drained.	108	21

Map Unit	Soil Name	Percent Slope	Soil Characteristics	Acreage[1] (cumulative[2])	Rank (size)
QAS	***Queencreek-Agustin-Stagecoach complex***	***0 to 14***	***Very to extremely gravelly sand; excessively drained***	***8,029***	***3***
QR	***Queencreek-Riverwash complex***	***0 to 5***	***Extremely gravelly sand; excessively drained***	***2,073***	***9***
SDR	***Stagecoach-Delnorte-Riverwash association***	***0 to 35***	***Loamy gravel; well-drained.***	***2,658***	***8***
SM	Stronghold-Mallet complex	1 to 16	Coarse loam; well-drained.	59	22
TB	Talos-Basso complex	0 to 4	Fine to fine-loamy; well-drained.	910	14
WR	***Woodcutter-Rock outcrop complex***	***30 to 90***	***Very gravelly loamy sand to sandy clay loam; well drained***	***10,300***	***2***

Source: NRCS, 2024

Notes:

1. Acreage is approximate and has been rounded to the nearest whole number.
2. The cumulative acreage represents the total area of the soil type within the ROI, not across all of WSMR.
3. ***Bold and italicized*** rows indicate soils located in the impact areas (or Main Post) that are either discussed in the text or identified as optimal for the proposed design solutions in Table 3-3.

The most abundant soil type in the ROI (rank 1) is Pajarito sandy loam, a well-drained sandy loam with a slope of 0 to 9 percent, covering 10,986.1 cumulative acres. This soil dominates the Main Post area and most of Impacted Area 2. The third most abundant soil, the Queencreek-Agustin-Stagecoach complex (excessively drained, extremely gravelly sand, slope 0 to 14 percent), also occupies parts of Impacted Area 2 and Main Post, along with the Agustin-Vado-Riverwash complex (very gravelly sandy loam; somewhat excessively drained).

Impacted Area 1 features an equal distribution of the Queencreek-Riverwash complex, Woodcutter-Rock outcrop complex, and Mallet-Kimrose-Stronghold complex. The second most abundant soil in the ROI, the Woodcutter-Rock outcrop complex, consists of well-drained, very gravelly loamy sand to sandy clay loam with a high slope of 30 to 90 percent, indicating significant erosion potential.

In Impacted Area 3, the dominant soils are the Mallet-Kimrose-Stronghold complex (gravelly fine sandy loam; somewhat excessively drained, slope 5 to 20 percent) and the Aladdin-Eppenauer family-Petrocalcic Paleustolls complex (gravelly sandy loam; somewhat excessively drained, slope 1 to 60 percent). Impacted Area 4 is primarily composed of the Queencreek-Agustin-Stagecoach complex, Pantak-Rock outcrop-Lithic Ustic (loamy, gravelly; well-drained to excessively drained, slope 15 to 70 percent), and the Stagecoach-Delnorte-Riverwash association (loamy gravel; well-drained, slope 0 to 35 percent).

Geologic Hazards

Rockfalls, sinkholes, and minor earthquakes are common in New Mexico. Exposed rock outcrops are subject to these gravity-driven geologic hazards. Sinkholes are commonly form due to the dissolution of minerals underground. In all parts of New Mexico, carbonate strata and interbedded salts are dissolved over time, which can lead to sinkholes. There are sinkholes on the eastern portion of WSMR, adjacent to Holloman Air Force Base. Earthquakes can happen when rock strata on either side of a geologic fault move relative to one another. While earthquakes are common in New Mexico they are generally minor and rarely cause serious structural damage to buildings (New Mexico Bureau of Geology and Mineral Resources [NMBGMR], 2023).

3.4.2 Environmental Consequences

Protection of unique geological features, minimization of soil erosion, and the design and siting of facilities in relation to potential geologic hazards are considered when evaluating potential impacts of a proposed action on geological resources. Generally, adverse impacts can be avoided or minimized if proper techniques, erosion-control measures, and structural engineering design are incorporated into project development. Impacts on geology and soils would be adverse if they would alter the lithology (i.e., the character of a rock formation), stratigraphy (i.e., the layering of sedimentary rocks), and geological structures that dictate groundwater systems; change the soil composition, structure, or function within the environment; or increase the risk of geological hazards. Additionally, the scarification of soils and damage resulting from the removal of vegetation can take up to 15 to 30 years for recovery. As weather patterns change and shift, the rate of soil recovery may take longer. Geological resources may become more vulnerable to erosion as soil humidity declines and high wind and rainstorm events increase in intensity.

3.4.2.1 Alternative 1

Regional Geology

Long-term, negligible to minor, adverse impacts on geology would be expected from the proposed action. WSMR is an area with a history of flooding. Activities associated with the proposed construction and maintenance of alternative 1 would slightly alter the surface hydrology to slow down, trap, and divert floodwaters. The proposed construction and maintenance of alternative 1 design solutions would control or impact the aquifers and confining beds in the ROI. To minimize impacts to the local geology the design solutions would be constructed using BMPs and designed to emulate and blend into the natural preexisting hydrologic features. Features that trap and/or slow water would be designed to allow for the continued recharge of local aquifers.

Topography

Short-term, negligible, adverse impacts on topography would be expected from earthmoving and grading activities during construction. The topography would be mildly altered to provide flat surfaces for the proposed access roads. Impacts would be negligible where the site is generally level and earthmoving and grading would not be required for maintenance and operations. Design solutions proposed in substantially steep slopes would avoid altering the local topography to the greatest extent possible. Additionally, the design solutions would be designed to emulate and blend into local natural topography therefore, no impacts on topography would be expected from these activities post-construction.

Soils

Short and long-term, significant but mitigable, adverse impacts could occur due to soil erosion and drainage issues. The results of the NRCS soil survey (described in section 3.4.1) indicate that the potential impacts of the proposed action at WSMR would vary depending on the specific soil types in the impact areas selected for the design solutions. The survey highlights several key considerations including soil drainage and erosion potential, hydrologic capacity and infrastructure protection, and resilience to future storm events.

Pajarito sandy loam, the most abundant soil, is well-drained with a relatively low slope, suggesting it may be less prone to erosion but could still require careful management during restoration and mitigation activities. The Woodcutter-Rock outcrop complex, with its high slope (30 to 90 percent) and well-drained, gravelly texture, presents a significant erosion risk. Any disturbance in areas with this soil type, particularly during storm events, could lead to increased erosion, necessitating proposed erosion control measures such as check dams or bioengineering.

Soils like the Queencreek-Agustin-Stagecoach complex, with its excessively drained, gravelly sand, and the Aladdin-Eppenauer family-Petrocalcic Paleustolls complex, which is also gravelly and somewhat excessively drained, may influence the reestablishment of hydraulic capacity in arroyos and floodplains. These soils might require specific design considerations for detention basins or levee improvements to ensure that relocated sediment and materials maintain the desired hydrologic capacity. The presence of well-drained soils with varying slope percentages across the ROI suggests that bioengineering solutions, erosion control measures, and other infrastructure improvements would need to be carefully tailored to each soil type. Soils with higher erosion potential may need more robust design solutions to increase resilience against future storm events. Table 3-3 depicts the soil types that best align with the proposed design solutions. This proposed alignment leverages the soil characteristics to enhance the effectiveness of each design solution, ensuring that the proposed actions are tailored to the specific challenges presented by the different soil types.

Table 3-3: Optimal Soil Types by Design Solutions for Watershed Restoration at WSMR

Proposed Design Solution	*Optimal Soil Type Present in ROI*	*Map Unit*	*Rational*
Early Warning Systems	Woodcutter-Rock outcrop complex (30 to 90% slope)	WR	Given its high erosion potential, early warning systems would be critical for areas with this soil to anticipate and respond to erosion risks.
Detention Basins	Globe-Jato-Peligro complex (0 to 20% slope)	GJP	Poorly to moderately well-drained clay soils like these are suitable for detention basins to manage water retention and control runoff.
Levee Improvements	Pantak-Rock outcrop-Lithic Ustic Torriorthents complex (15 to 70% slope)	PRO	The well-drained to excessively drained, loamy, gravelly soil is ideal for levee improvements to manage water flow and prevent erosion.
Cross/Culvert Improvements	Mallet-Kimrose-Stronghold complex (5 to 20% slope)	MKS	With gravelly fine sandy loam that is somewhat excessively drained, cross/culvert improvements would help manage water flow in these areas to prevent flooding and erosion.
Retention and Reuse	Globe-Typic Haplocalcids complex (0 to 1% slope):	GTH	The moderately well-drained clay soil is suitable for retention and reuse systems to capture and store water for later use.
Check Dams	Queencreek-Agustin-Stagecoach complex (0 to 14% slope)	QAS	This extremely gravelly, excessively drained sand would benefit from check dams to slow water flow and reduce erosion.
Bioengineering	Deama-Rock outcrop complex (30 to 90% slope)	DRO	Bioengineering solutions would help stabilize this very gravelly loam and reduce erosion in steep areas.
Erosion Control	Deama-Penagua-Rock outcrop complex (35 to 90% slope)	DPR	Erosion control measures would be essential for this very cobbly loam with a high slope to prevent significant soil loss.

The variety of soil types across the ROI suggests that a one-size-fits-all approach is not feasible. In general, accelerated erosion of soils would be temporary, during construction activities, and minimized by appropriately siting and designing facilities, taking into consideration soil limitations, employing construction and stabilization techniques appropriate for the soil and weather, and implementing BMPs and erosion control measures. Construction contractors would adhere to soil erosion control BMPs as outlined in State of New Mexico, WSMR, U.S. Environmental Protection Agency (USEPA), the U.S. Forest Service guidance and regulations. Such BMPs could include the installation of silt fencing and sediment traps, application of water to disturbed soil to reduce dust, and revegetation of disturbed areas immediately following ground disturbance, as appropriate. Construction materials would be appropriately stabilized and covered using temporary erosion control measures during construction, and with long-term measures and BMPs. Impacts would be localized to the proposed disturbance area due to the implementation of these measures and BMPs.

The need for site-specific mitigation strategies indicates that while the potential for significant impacts exists, they can be reduced to a less-than-significant level through careful planning and BMP implementation. Therefore, while the potential for significant impacts exists, the use of tailored mitigation strategies as described, can effectively manage and reduce these impacts, making them significant but mitigable.

Geologic Hazards

Short- and long-term, negligible, adverse impacts could occur due to geological hazards. While earthquakes are common in New Mexico, they are generally minor and rarely cause structural damage to buildings (NMBGMR, 2023). The proposed facilities would meet all building requirements outlined in applicable state and local building codes to minimize potential impacts from earthquakes.

New construction would generally occur on level terrain; however, some design solutions may occur on highly sloped areas. Implementation of BMPs and erosion control measures, as well as other appropriate preventative measures identified by federal, state, and local agencies, would be implemented where applicable to minimize potential impacts from rockfalls. These preventative measures could include regular drain and culvert inspection and maintenance, drainage ditch and channel inspection and maintenance, vegetation maintenance, and implementation of roadside stabilization measures.

Summary

Implementation of alternative 1 would result in negligible minor long-term impacts on geology, mainly due to surface hydrology alterations for flood control, with BMPs employed to protect aquifers and retain the natural hydrologic and topographic setting. Minor short-term impacts on topography are expected from grading for roads, but post-construction impacts would be negligible. Soils could experience significant, yet mitigable, erosion, especially in areas with steep slopes or certain soil types, requiring tailored erosion control measures and BMPs. Geologic hazards like earthquakes and rockfalls pose minimal risks, and new construction would adhere to codes and preventative measures to minimize these impacts. Therefore, implementation of alternative 1 would not result in significant impacts to geologic resources.

3.4.2.2 No Action Alternative

Under the no action alternative, WSMR would continue to carry out only basic repairs to provide immediate relief following a damaging flood event, without implementing design solutions to enhance flood protection. Implementation of the no action alternative could result in significant and long-term impacts on the area's geological and soil resources. Without comprehensive watershed management, the existing soil erosion issues would likely worsen over time. Basic repairs would only address immediate damage rather than preventing future degradation, leading to continued loss of topsoil, particularly in areas with high erosion potential. Without considering watershed health and atmospheric factors, the hydrologic capacity of arroyos and floodplains would remain compromised. This could result in more frequent and severe flooding, leading to further erosion, sediment displacement, and degradation of soil structure.

As the no action alternative does not fully consider the long-term effects of storm events, military infrastructure could be at increased risk from both geological hazards and compromised soil stability. This could lead to repeated damage and the need for ongoing repairs, which would further disturb soil and geological resources. The failure to implement design solutions like erosion control, bioengineering, and levee improvements would leave the landscape vulnerable to future storm events. Over time, this could result in significant, irreversible damage to soil resources, reduced land stability, and an overall decline in the ecological health of the area.

In summary, the no action alternative would likely lead to the deterioration of geological and soil resources, resulting in significant long-term impacts that could undermine both the environmental and operational sustainability of WSMR.

3.5 Human Health and Safety

A safe environment is one in which there is no, or an optimally reduced, potential for death, serious bodily injury or illness, or property damage. Human health and safety address workers' and public health and safety during and following construction, demolition, and training activities.

Site safety requires adherence to regulatory requirements imposed for the benefit of employees and the public. Site safety includes the implementation of engineering and administrative practices that aim to reduce risks of illness, injury, death, and property damage. The health and safety of onsite military and civilian workers are safeguarded by numerous DoD and military branch-specific requirements designed to comply with standards issued by federal Occupational Safety and Health Administration, USEPA, and state occupational safety and health (OSH) agencies. These standards specify health and safety requirements, the amount and type of training required for workers, the use of personal protective equipment (PPE), administrative controls, engineering controls, and permissible exposure limits for workplace stressors.

Health and safety hazards can often be identified and reduced or eliminated before an activity begins. Necessary elements for an accident-prone situation or environment include the presence of the hazard itself, together with the exposed (and possibly susceptible) population or public. The degree of exposure depends primarily on the proximity of the hazard to the population. Hazards include transportation, inspection, maintenance, and repair activities, the creation of a noisy environment, a potential fire hazard, or the risk of flash floods. Flash floods pose a significant risk, as they can occur suddenly and with little warning, leading to dangerous conditions that threaten human health and safety. The swift and unpredictable nature of flash floods can result in rapid inundation of populated areas, compromising evacuation efforts and endangering lives.

The proper operation, inspection, maintenance, and repair of vehicles and equipment carry Important safety implications. Any facility or human-use area with potential explosive or other rapid oxidation process creates unsafe environments due to noise or fire hazards for nearby populations. Noisy environments can also mask verbal or mechanical warning signals such as sirens, bells, or horns.

The Army's policies, responsibilities, and procedures to protect Army personnel and property are contained in AR 385-10. This regulation provides for operational safety, safe and healthy workplaces, and ensures compliance with applicable laws and regulations. It also advocates for the safety of children by establishing safety protocols that impact family housing areas, schools, and childcare facilities on military installations. Furthermore, AR 385-10 aligns with the principles of EO 13045, *Protection of Children from Environmental Health and Safety Risks,* which emphasizes the protection of children from environmental health and safety risks. In addition to these provisions, installations are required to comply with the Occupational Safety and Health Act of 1970 as implemented in EO 12196, *Occupational Safety and Health Programs for Federal Employees*, DoD Instruction 6055 Series, and AR 385-10.

3.5.1 Affected Environment

Construction Personal Safety

All personnel performing construction and demolition activities are responsible for following federal and state safety regulations and are required to conduct activities in a manner that does not increase risk to workers or the public. A Health and Safety Plan detailing how safety requirements would be met prior to beginning work would be required.

New Mexico is one of several states that administer their own OSH program according to the provision of the federal OSH Act of 1970, which permits a state to administer its own OSH program if it meets all federal requirements regarding the program's structure and operations. The New Mexico Occupational Health and Safety Bureau has the responsibility of enforcing OSH regulations within the state. Its jurisdiction includes all private and public entities such as city, county, and state government employees. Federal employees are excluded as they are covered by federal Occupational Safety and Health Administration regulations.

OSH programs address the health and safety of people at work. OSH regulations cover potential exposure to a wide range of chemical, physical, and biological hazards, and ergonomic stressors. The regulations are designed to control these hazards by eliminating exposure to the hazards via administrative or engineering controls, substitution, or use of PPE. Occupational health and safety is the responsibility of each employer, as applicable. Employer responsibilities are to review potentially hazardous workplace conditions; monitor exposure to workplace chemical (e.g., asbestos, lead, hazardous substances), physical (e.g., noise propagation, falls), and biological (e.g., infectious waste, wildlife, poisonous plants) agents, and ergonomic stressors; recommend and evaluate controls (e.g., prevention, administrative, engineering, PPE to ensure exposure to personnel is eliminated or adequately controlled; and ensure a medical surveillance program is in place to perform occupational health physicals for those workers subject to the use of respiratory protection or engaged in hazardous waste, asbestos, lead, or other work requiring medical monitoring.

The nearest major hospital that offers emergency room services and inpatient care for the general public, including construction contractor personnel, is the MountainView Regional Medical Center in Las Cruces, New Mexico. MountainView Regional Medical Center also provides general medical care, specialty care, and urgent care (MountainView Regional, 2024).

Military and Civilian Personnel Safety

The WSMR health and safety program operates in compliance with all applicable federal, state, DoD, and Army instructions, laws, and regulations. These regulations have guided the development of SOPs which all installation users are required to follow. Additionally, WSMR provides mission-focused training and guidance to its personnel (WSMR, 2014).

The nearest major hospital that offers emergency room services and inpatient care for military personnel is the William Beaumont Army Medical Center in El Paso, Texas. For regular health care services, the McAfee Health Clinic at WSMR provides daily appointments and offers immunizations and general medical care. The nearest major hospital that offers emergency room services and inpatient care for the general public, including civilian personnel, would be the same as those described for construction personnel.

Public Safety

WSMR has its own Range Control, Safety, Fire Department, and Environmental Division offices that all play key roles in safety planning, training, oversight, and response activities. WSMR also participates in the Emergency Operations Plan with other federal, state, and local agencies as part of an extended response network for emergencies (fires, hazardous material spills, mishaps, or multi-hazard events) which requires an expanded team of trained responders, whether on a local or broader regional level.

WSMR lands are generally restricted from public access and public use due to potential safety hazards. For missions that may pose risks to the public outside the installation, WSMR can enact local highway closures and evacuation of certain private lands. WSMR established a Memorandum of Understanding with the New Mexico Department of Transportation to allow closures of up to 1 hour on U.S. 54 and U.S. 70 (up to 80 minutes in an emergency) and up to two hours on U.S. 380, with 48 hours prior notice.

3.5.2 Environmental Consequences

Impacts on health and human safety would be considered significant if a substantial additional risk to human health or safety would be attributable to the proposed action, including direct human exposure to hazardous conditions or a substantial increase in conditions that adversely affect public health.

3.5.2.1 Alternative 1

Alternative 1 includes restoration, replacement, and mitigation of existing watershed elements impacted by storm events at WSMR. Figure 2-1 in section 2.4.1 represents a menu of design solutions including early warning systems, detention basins, levee improvements, cross/culvert improvements, retention and reuse, check dams, bioengineering, and erosion control.

Implementing an early warning system at WSMR, consisting of a network of rain and stream gauges, could significantly enhance human health and safety by providing critical advance notice of approaching floodwaters. In desert environments, where flooding can occur with little to no rainfall on the desert floor due to runoff from surrounding mountains, personnel may be caught unaware of the impending danger. An early warning system would enable the timely dissemination of alerts, giving base personnel the opportunity to prepare and implement necessary hazard mitigation measures. This increased lead time could reduce the risk of injury, prevent damage to infrastructure, and ensure a safer environment for all those on the base.

The installation of detention basins, along with levee and cross-culvert improvements, at WSMR could enhance human health and safety by effectively managing and mitigating the impact of sudden flood events. In an environment prone to rapid runoff and flash flooding, detention basins would help to temporarily store and control the flow of floodwaters, while improved levees would provide additional protection for the base. Conversely, detention ponds located near roads may attract larger wildlife, such as deer and oryx, potentially creating safety concerns for vehicular traffic in the area. To address these risks, mitigation measures such as fencing and improved signage could be employed to reduce the chances of wildlife-vehicle collisions and enhance the safety of both motorists and wildlife. Cross-culvert enhancements would further improve water management by ensuring that floodwaters are channeled safely and efficiently away from critical areas, reducing the likelihood of overflow and infrastructure damage. Together, these measures would reduce the volume and speed of water reaching the base, thereby lowering the risk of flooding and associated hazards.

By slowing down and redirecting water, detention basins, levees, and cross-culverts would also provide additional time for early warning systems to activate and for personnel to implement protective measures, significantly enhancing WSMR's resilience against flooding and safeguarding both infrastructure and lives. However, it is crucial to recognize that these flood management features could also pose safety risks, particularly for children who may be attracted to these structures. Additionally, detention basins could create potential health risks by providing breeding grounds for mosquitoes, increasing the risk of mosquito-borne diseases on the base. Mitigation measures such as secure wildlife compatible fencing around detention basins, childproof barriers at cross-culverts, clear signage, community awareness programs, and regular inspection and maintenance to prevent standing water accumulation would be essential to protect the safety and health of both children and other vulnerable individuals. These steps would ensure that these infrastructure improvements do not inadvertently create new hazards.

An additional safety concern is the potential for unexploded ordinances (UXOs), particularly those north of U.S. 70. The approximate locations of UXOs are known to the installation and have been mapped accordingly. If planners install any design solutions near these known areas, mitigation measures may be necessary. Mitigation measures such as UXO clearing, public brochures, and/or signage can ensure the safety of military and civilian personnel on post

In conclusion, the implementation of alternative 1, which includes restoration, replacement, and mitigation of existing watershed elements at WSMR, along with the adoption of the described early warning systems, detention basins, levee and cross-culvert improvements, and other flood management measures, could significantly enhance the safety and resilience of the base against flood-related hazards. While these infrastructure improvements could introduce certain risks, such as those associated with mosquito breeding and child safety, the incorporation of targeted mitigation measures—including secure, wildlife compatible fencing, childproof barriers, regular inspection and maintenance, and UXO clearing—could effectively minimize these risks. Therefore, with these mitigation measures in place, the potential impacts on human health and safety are expected to be less than significant.

3.5.2.2 No Action Alternative

Under the no action alternative, WSMR would continue to carry out only basic repairs to provide immediate relief following a damaging flood event, without implementing design solutions to enhance flood protection. Under the no action alternative, WSMR would continue to carry out only basic repairs that provide immediate relief after a damaging flood event, never fully consider watershed health or weather factors influencing storm events that negatively impact military infrastructure, nor understanding the potential risks if design solutions are not adequate.

Under this alternative, the potential for negative impacts on human health and safety at WSMR would increase due to the likelihood of more severe flood events. Basic repairs, while addressing immediate damage, would not fully account for the overall condition of the watershed or the atmospheric factors that contribute to storm events. This approach could leave the infrastructure vulnerable to future flooding, potentially leading to unsafe conditions, damage to critical infrastructure, and risks to personnel and residents. The absence of comprehensive mitigation measures could result in increased exposure to hazards and interruptions to essential services. Therefore, the no action alternative would not meet the purpose and need for the proposed action.

3.6 Infrastructure, Facilities, and Traffic/Transportation

Infrastructure and facilities consist of the man-made systems and physical structures that enable a population in a specified area to function. Facility components to be discussed in this section include the facilities on the Main Post and designated training areas. Infrastructure components to be discussed in this section include transportation elements, utilities, and stormwater infrastructure. Utilities generally include electrical supply, natural gas/propane supply, solid waste management, water supply, and sanitary sewer and wastewater. Transportation includes land, air, and sea routes with the means of moving passengers and goods.

3.6.1 Affected Environment

Facilities

The affected environment for facilities includes WSMR, buildings, temporary facilities, training areas, and adjacent properties. The majority of WSMR facilities are located on the Main Post, with some facilities that support training activities scattered throughout the training areas. Main Post facilities include residential, industrial, commercial, administrative, and other support buildings.

Utilities

The utility systems at WSMR are comprehensive and varied. Electricity is generated off-site and distributed across the installation via overhead and underground transmission lines, with semipermanent portable generators available for remote sites. Natural gas is supplied to the Main Post by the Public Service Company of New Mexico, while other, more remote, facilities use tank-fed propane. Solid waste management includes five landfills (two or which are now closed) on WSMR, which are predominantly used for construction and demolition materials disposal. Municipal waste from the Main Post is disposed of off-installation. WSMR's potable water is sourced entirely from groundwater, drawn from six well fields, while wastewater is treated at multiple facilities on installation, all meeting regulatory standards (WSMR, 2023a; WSMR, 2021b).

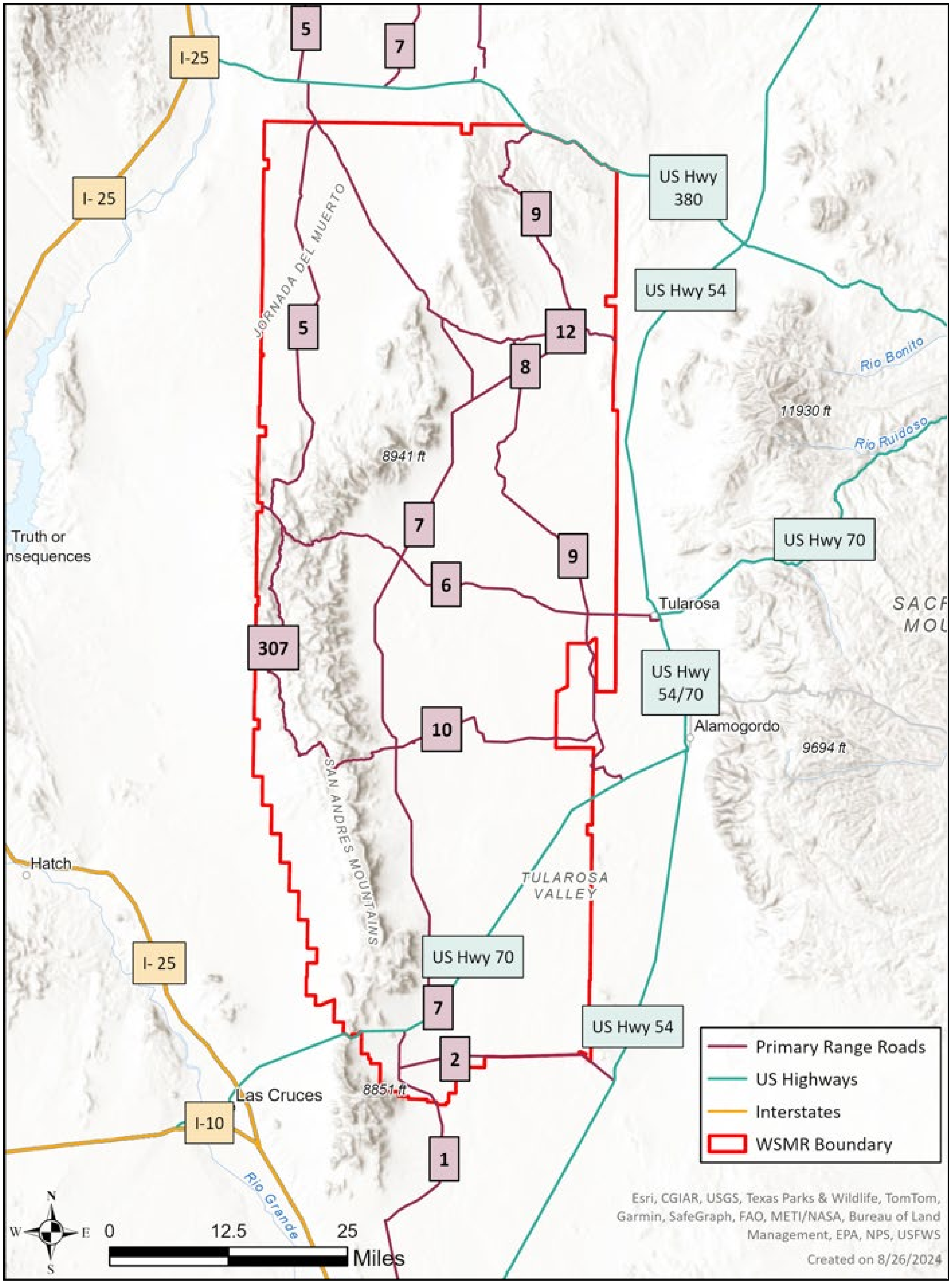
Stormwater Infrastructure

WSMR lies mostly within the Tularosa Basin, which has an average of 10 inches of rainfall per year. Main Post is most affected by runoff due to the large areas of impervious surface. In 1968, a levee was built along the western edge of the Main Post to divert stormwater drainage north and south of the Main Post. Storm pipes, inlets, and culverts provide drainage assistance in sections of the northern housing area and the administrative area between Headquarters Avenue and Dryer Street. Stormwater runoff control measures are covered under the Environmental Protection section of the general specifications for contracts supporting military construction projects assigned to U.S. Army Corps of Engineers (USACE) at WSMR (WSMR, 2009). During major storm events, the existing stormwater infrastructure can become overwhelmed, which has led to flooding throughout WSMR. These floods have resulted in damage to WSMR facilities, infrastructure, and roads.

Traffic and Transportation

Interstate (I) 10 and I-25 are the primary interstate highways in the vicinity of WSMR. I-10 generally traverses in an east-west direction and passes approximately 50 miles south of WSMR Main Post, with exits to WSMR at El Paso, Texas and Las Cruces, New Mexico. I-25 provides a north-south interstate connection to WSMR, with local exits at San Antonio and Las Cruces. Major highways serving WSMR include U.S. 380, U.S. 70, and U.S. 54 (see Figure 3-5).

Figure 3-5: Roadway Network on and Surrounding WSMR



WSMR is traversed by an extensive network of county-maintained and WSMR-maintained paved and unpaved roads. WSMR's road network spans over 3,680 miles of paved and unpaved roads. Private roads extend from these main routes to reach more remote areas. WSMR manages access through a comprehensive system of major and secondary range roads, connecting most areas within the installation. Major range roads are two-laned paved or graded surfaces, while all secondary roads are unpaved. The WSMR road network includes 1,338 miles of major range roads, 596 miles of secondary roads, 1,490 miles of bladed trails, and an undetermined length of remote two-track, four-wheeled-vehicle trails. WSMR has approximately 700 miles of roads within the WSMR transportation network that are not meant for heavy equipment use, with an additional 15,840 square yards of tank trails located south of U.S. 70. The installation is accessed through six primary access gates, with the Las Cruces and El Paso gates serving as the main control points for entry and exit to the Main Post area.

Flooding and mudslides from major storm events have significantly impacted road infrastructure both within and around the installation. These events have, at times, necessitated temporary road closures and extensive repairs to affected roadways. A notable example occurred in July 2021, when a severe thunderstorm forced the closure of U.S. 70 from NASA Road to the WSMR entrance. The storm inundated the highway with water, mud, and debris, resulting in the closure of the WSMR Las Cruces gate for four days (Romero, 2021a; Romero, 2021b). The flood also deposited mud and debris onto Owens Road and washed out a culvert. The extent of the damage caused by this event is depicted in Photo 3-1.

Photo 3-1: July 2021 U.S. 70 Flood Damage

Source: NMDOT as cited in Romero, 2021a

Within the installation, recurring seasonal weather events – such as heavy rainfall or flash flooding – often result in temporary road closures. These closures can hinder access to essential areas, interrupt daily operations, and limit emergency response capabilities. In addition, internal drainage issues frequently exacerbate these problems, particularly along Range Road 7, where heavy rain events can cause culvert blockages and further restrict access.

3.6.2 Environmental Consequences

Impacts to infrastructure, facilities, and traffic/transportation would be considered significant if the proposed action significantly disrupts access to facilities, disrupts utility service, and/or significantly increases traffic volume.

3.6.2.1 Alternative 1

Implementation of alternative 1 would have a beneficial impact on facilities, infrastructure, and traffic/transportation. By implementing a variety of the design solutions that account for the potential increase in rain events due to weather changes, this alternative would decrease the likelihood of destructive flooding and minimize damage to WSMR buildings and roads during major storm events.

At WSMR, stormwater infrastructure can become overwhelmed during extreme storm events, leading to potential inundation and flooding. Implementing the design solutions proposed in alternative 1 would enhance the current stormwater management system, creating a more resilient and efficient network. These improvements would provide stronger protection for WSMR and its assets against the risks of flash flooding. The design solutions would also address the potential increase in precipitation rates and extreme storm events due to weather change. These measures would protect WSMR, its assets, and surrounding infrastructure from larger and more frequent storms, while also maintaining protection against current storm levels.

Roadways both on and off WSMR are frequently damaged and often need to close for repairs following major storm events. These closures disrupt commuting for those around WSMR and interfere with training activities on the installation. Implementing alternative 1 would reduce roadway damage and closures in and around WSMR, thereby enhancing traffic flow.

If excavation becomes necessary, WSMR will collaborate with the White Sands Technical Center Range Operations–Infrastructure Management to obtain precise cable location data in order to safeguard the integrity of existing communication infrastructure.

Construction and excavation debris such as asphalt or concrete waste would be disposed of in coordination with Compliance, Solid Waste Management. Waste will be diverted from the landfill and recycled. If any material could not be diverted, it will be disposed of in accordance with federal, state, and WSMR regulations.

Any spilled material will be collected, cleaned up, immediately reported to the Storm Water Manager, and taken to the Hazardous Waste Management Center 1870.

Each design solution would have distinct inspection and maintenance requirements to ensure its continued effectiveness. Once a solution is selected, WSMR would develop tailored maintenance and inspection plans and conduct the necessary inspections and maintenance to preserve the functionality of the selected design solutions. Proper maintenance of the selected design solutions would ensure continued protection of people, facilities, and infrastructure from flooding during major storm events. Therefore, implementation of alternative 1 would have a beneficial impact to infrastructure, facilities, and traffic/transportation.

3.6.2.2 No Action Alternative

Under the no action alternative, WSMR would continue to carry out only basic repairs to provide immediate relief following a damaging flood event, without implementing design solutions to enhance flood protection. Facilities, infrastructure, and traffic/transportation would remain unchanged. Consequently, flooding would remain a concern, and larger flood events would continue to pose risks and cause damage to WSMR facilities and infrastructure. Therefore, implementation of the no action alternative would have minor to significant adverse impacts, depending on the severity of the storm event, to infrastructure, facilities, and traffic/transportation.

3.7 Land Use

Land use describes the way the natural landscape has been modified or managed to provide for human needs. In developed and urbanized areas, land uses typically include residential, commercial, industrial, utilities and transportation, recreation, open space, and mixes of these basic types. Other uses such as mining, extractive activities, agriculture, forestry, and specially protected areas (such as larger monuments, parks, and preserves) are usually found on the fringes of or outside of urbanized areas. Plans and policies guide how land resources are allocated and managed to best serve multiple needs and interests. Federal, state, and local statutes, regulations, plans, programs, and ordinances define specific limitations on uses.

Federal statutes and regulations that govern land use at military installations include NEPA, Federal Land Policy and Management Act, Resource Conservation and Recovery Act, Comprehensive Environmental Response, Compensation, and Liability Act, and the ESA. NEPA processes such as this Programmatic EA are required for land use planning and any significant changes in land use at military installations. The Federal Land Policy and Management Act governs the management of public lands, including those managed by the DoD and requires consideration of land use planning and multiple-use management. DoD policies and regulations, such as those found in the Unified Facilities Criteria, guide planning, design, construction, and sustainment for facilities located on military installations the Resource Conservation and Recovery Act influences land use through disposal and storage requirements for waste management and remediation. The Comprehensive Environmental Response, Compensation, and Liability Act can impose restrictions such as land use controls to identify and prevent exposure to contaminated lands. The ESA requires the protection of endangered species and their habitats, which can limit land use activities on military installations.

State statutes, rules, and regulations include the New Mexico Environment Department's regulations, which govern environmental protection, air and water quality standards, waste management, and land reclamation. The New Mexico Land Use Regulations establish state-level policies on zoning and development, potentially affecting areas adjacent to and near WSMR. Additionally, the New Mexico Department of Game and Fish oversees wildlife and habitat protection, which may impact land use and development decisions adjacent to and on WSMR.

Land management on WSMR is guided by several regulations including AR 210-20, *Real Property Master Planning for Army Installations,* AR 350-19, *The Army Sustainable Range Program*, and AR 200-2, *Environmental Efforts of Army Actions*. AR 210-20 defines the Army real property master planning process, which integrates goals and objectives for installation development with natural, cultural, and other land use constraints. AR 350-19 provides policy and guidance on the Range and Training Land Program and the Integrated Training Area Management Program. The WSMR Integrated Training Area Management program facilitates the integration of mission requirements and environmental constraints. AR 200-2 defines the Army methodology for assessing the environmental impacts of Army actions. On WSMR Main Post, a Real Property Planning Board reviews and approves facility siting plans, as per the requirements of AR 210-20. This review process integrates facility operational requirements with environmental constraints and other land use planning considerations. Once a project passes the Real property Planning Board, the Garrison Commander submits it to the Installation Management Command -West Region Director for formal siting review and approval. Additionally, the WSMR INRMP outlines the management of natural resources on the installation, balancing military mission requirements with environmental stewardship.

When evaluating a proposed action, assessing its potential impacts on both the project site(s) and the surrounding land uses is essential. Potential impacts to land use can result from actions that (1) change the suitability of a location for its current or planned use (e.g., noise exposure in residential areas), (2) cause conditions that are unsafe for range and training area usage and the public welfare, (3) conflict with the current and planned use of the area based on current zoning, amendments, agreements, regulatory restrictions, management, and land use plans, or (4) displace a current use with use that does not meet the goals, objectives, and desired use for an area. The degree of land use effects (negligible, minor, moderate, or significant) is based on the level of land use sensitivity in areas affected by a proposed action, the magnitude of change, and the compatibility of a proposed action with existing or planned land uses

3.7.1 Affected Environment

Installation Land Use Overview

WSMR developed a Land Use Classification system to assist in planning range use. The classifications primarily reflect the administrative status of land areas and overlying airspace and the associated limitations on use. The 2009 WSMR Final EIS lists 17 discrete Land Use Classifications involving combinations of land status and airspace designation at WSMR shown in Table 3-4 below.

Table 3-4: WSMR Land Use Classifications

Land Use Classification	***Title***
A	Primary Test Zone
B	Range Centers and Built-Up Areas
C	Augmented Test Zone
D	Impact Area
E	Lava Flows
F	Jornada Experimental Range
G	White Sands National Monument Co-Use Area
H	Conservation/Protected Area
I	Dedicated Use Area
J	Special Call-Up Area (within Restricted Area airspace)
K	General Call-Up Area (within Restricted Area airspace)
L	Ground Only Call-Up Area (outside Restricted Area airspace)
M	Restricted Area Airspace Only (overlying DoD land outside WSMR and call-up areas – from surface)

N	Restricted Area Airspace Only (overlying non-DoD land and outside call-up areas – from surface)
O	High Altitude Restricted Area Airspace (outside DoD land and call-up areas)
P	Unrestricted Airspace (with approval)
Q	Non-Contiguous WSMR Land

Legend: WSMR = White Sands Missile Range, DoD = Department of Defense.
Source: WSMR, 2009

Military Land Use

The mission of WSMR is to provide comprehensive support for testing, training, research, and development of various military technologies and systems. As a premier testing facility, WSMR offers a wide range of capabilities, including missile testing, weapons systems evaluation, electronic warfare testing, and aerospace research. WSMR's mission takes place primarily in four areas: main range, operational test areas, call-up areas, and annexes. The ROI of this Programmatic EA is limited to the area of influence (see Figure 1-2) in the main range—the area within WSMR's formal boundaries (WSMR, 2023a). The area of influence lies within land use areas B (Range Centers and Built-Up Areas) and C (Augmented Test Zone).

The main range is used for tests and evaluations of tri-service missile systems, high-energy laser, and directed energy systems, air defense fire-distribution systems, space systems, and surface-to-surface missile systems. Specialized test beds, laboratories, and facilities located throughout WSMR include special target areas. Numerous locations across the range include Aerial Cable, penetrator warhead tunnels, and impact areas. Other facilities involve chemicals and materials, information operations laboratories, climatic and environmental, dynamic, electromagnetic, electronic warfare, High Energy Laser Systems Test Facility, launch, nuclear effects, and warhead test facilities. On the main range, structures are scattered individually or situated in small clusters of sites with local area names (e.g., C-Station). There are currently 564 site names listed in the real property inventory. Individual sites occupy anywhere from a few to several thousand acres. The Main Post area is within this area, including residential neighborhoods, services, a museum, parks, office buildings, and other support facilities (WSMR, 2023a).

Operational Test Areas

Several areas have been established on WSMR to support off-road requirements associated with testing weapons systems in a tactical setting. These areas support the need for maneuver "space" and have been evaluated for the presence of sensitive fauna/flora, UXO, cultural resources, and soil erosion potential to demonstrate suitability of these sites for use as maneuver and operational testing areas.

Four maneuver and operational test areas have been established: Yucca North (Southern Range Area), Sierra (Northern Range Area), Otero (Northern Range Area), and Thurgood West (Northern Range Area) (WSMR, 2023a).

General Land Use Constraints

There are several land use constraints recognized on WSMR, such as jurisdictional (i.e., White Sands National Park, San Andreas National Wildlife Refuge, and Jornada Experimental Range), environmental (e.g., Special Natural Areas, springs, Todsen's pennyroyal and White Sands pupfish habitats), and operational constraints (e.g., impact areas, specialized areas, UXO areas) that restrict activities on WSMR. Most of these areas support some type and level of activity—except the Todsen's pennyroyal Critical Habitat and the White Sands Pupfish essential habitat areas, which are off-limits to all surface activity (WSMR, 2023a). The area around the main cantonment area (Main Post) is a non-operational area.

3.7.2 Environmental Consequences

Considering the ROI for this Programmatic EA is primarily on military lands (see Figure 1-2), impacts to land use would be considered significant if the land use were incompatible with existing military land uses and designations (including recreation) and or sufficient land is not available. These impacts could conflict with Army land use plans, policies, regulations, or with land use off post.

3.7.2.1 Alternative 1

Implementing alternative 1 at WSMR could have significant impacts on land use, particularly if the proposed restoration, replacement, and mitigation activities are incompatible with existing military land uses and designations. Additionally, if sufficient land is not available for these activities, it could create challenges in accommodating the proposed solutions without disrupting current land use practices. This might lead to conflicts with both on-post military operations and nearby land use off-post, potentially affecting overall mission readiness and land management objectives.

Specific identified issues regarding the action alternatives' impact on land use include potential conflicts between operational and non-operational areas. The area around the main cantonment area (Main Post) is classified as non-operational, where proposed design solutions may be installed. While retention and design solutions can facilitate an expansion of the main cantonment area, it could result in the conversion of open space to developed land, leading to internal land use conflicts particularly a reduction in available training lands. Additionally, one of the proposed locations for a retention pond is in an area currently used for cattle grazing. This could disrupt ongoing agricultural activities and create further land use conflicts.

To reduce the potential impact of implementing this alternative, several mitigation techniques could be employed. These mitigation techniques include strategies such as avoidance of high-value areas. Careful selection of locations for detention basins, levee improvements, and other infrastructure to avoid areas of high operational, ecological, or recreational value. For example, placing these structures in areas that do not interfere with key training grounds or designated wildlife habitats. Where possible, proposed design solutions should try to utilize areas that have already been disturbed by previous development or are less critical to military operations. Additionally, following the Joint Land Use Study approach described in the INRMP can help mitigate conflicts. Cooperative planning with nearby landowners and stakeholders may further reduce conflicts. Establishing new buffer zones, wildlife compatible fencing, and signage are also potential mitigation techniques that can minimize the impact on land use.

Given that WSMR is a large installation with ample land for training, impacts on land use would be significant if the proposed activities conflicted with existing military land uses or designations (including recreation) or if they limited the availability of land for training. The proposed design solutions may by planned for areas around the Main Post, classified as Land Use Classification B (non-operational), indicating that the land is not currently used for training. However, the exact locations of these solutions are not yet determined, so it is unclear if they might conflict with other military uses. Since the exact locations and designs are not yet determined, additional analysis may be necessary once design solutions and site selections are finalized. By applying the listed mitigation techniques, potential impacts can be effectively mitigated and kept below significant levels. This approach ensures alignment with Army land use plans, policies, and regulations while preserving the operational integrity of both on-post and off-post land use. Therefore, under the assumption that mitigative actions are taken, the impacts to land use are less than significant.

3.7.2.2 No Action Alternative

Under the no action alternative, WSMR would implement basic repairs that provide immediate relief after a damaging flood event, never fully consider watershed health or weather factors influencing storm events that negatively impact military infrastructure, nor understand the potential risks if design solutions are not adequate. However, existing land uses and designations would continue as is, therefore there would be no impact on land use under the no action alternative.

3.8 Socioeconomics

Socioeconomics describes the local economic and social conditions in an area. Socioeconomic indicators, such as population, housing, and regional economic activity inform the assessment of socioeconomics and are used to understand the community potentially affected by the proposed action.

3.8.1 Affected Environment

WSMR encompasses five counties in New Mexico including Socorro, Sierra, Doña Ana, Otero, and Lincoln. The ROI includes areas that are generally considered the geographic extent to which the majority of the installation's soldiers, Army civilians, and contractor personnel and their families reside. As such, this analysis focuses on the three largest populated cities near WSMR: Socorro, Alamogordo, and Las Cruces.

The estimated population total for the ROI in 2023 was 154,537, including 8,361 for Socorro, 31,284 for Alamogordo, and 114,892 for Las Cruces. The ROI experienced a cumulative population increase of 0.5 percent between 2020 and 2023, including Socorro's population decrease of 3.9 percent, Alamogordo's increase of 1.2 percent and Las Cruces's increase of 3.2 percent (U.S. Census Bureau, 2023).

The total on-post population for WSMR is 19,651 as of September 2023. This includes 2,033 service members, 2,775 active-duty family members, 1,957 military retirees and 6,725 family members of retirees. Additionally, 1,624 army civilian employees and 1,963 other department of defense civilian employees. And lastly, 1,290 contractors, 417 reserve component members from all branches, and 867 family members of reserve component members (Military Installations, 2024).

This Programmatic EA highlights the distribution of race and poverty in areas potentially impacted by the implementation of the proposed action. The minority population (excluding two or more races) make up 59.2 percent of the population in the city of Socorro, 44.6 percent in Alamogordo, and 68.6 percent in Las Cruces (see Table 3-5) in 2023. In comparison, the non-White population in New Mexico was approximately 63.2 percent for the same period. There are pockets of low-income and minority populations within areas adjacent to WSMR with these three cities having about 20 percent of their population in poverty (U.S. Census Bureau, 2023).

Table 3-5: Demographic Statistics for Socorro, Alamogordo, and Lac Cruces Cities, New Mexico, 2023

Race/Origin	*Percent of the Population in Socorro*	*Percent of the Population in Alamogordo*	*Percent of Population in Las Cruces*
White Only	65.7	70.8	62.0
Black or African American Only	1.7	5.5	2.8
Native American and Alaskan Only	3.9	1.9	1.6
Asian Only	3.6	2.1	1.8
Native Hawaiian or Other Pacific Islander	0.0	0.0	0.3
Hispanic or Latino*	47.1	32.3	61.7
Two or more races	18.0	15.1	17.3

Note: *Hispanic or Latino is not a race but an origin.
Source: U.S. Census Bureau, 2023

WSMR provides a substantial contribution to the ROI economy, producing around $10.3 million daily and $3.7 billion annually in Las Cruces and the region bordering the missile range. Furthermore, its military spending contributes to 30 percent of wages in Southern New Mexico and employs approximately 6,000 civilians, 350 servicemembers from the Army, Air Force, and Navy, 950 housing residents, and 3000 middle school and elementary school students (WSMR, 2024b).

The ROI 2022 annual average civilian labor force aged 16 and over was 45.4 percent for Socorro, 49.1 percent for Alamogordo, and 59.2 percent in Las Cruces (U.S. Census Bureau, 2023). Educational services, professional, scientific, and technical services, and health care and social assistance were the three most common employment sectors for Socorro in 2022 (Data USA, 2024a). Health care and social assistance, retail trade, and public administration were the most common employment sectors for Alamogordo in 2022 (Data USA, 2024b). Lastly, the most common employment sectors for Las Cruces in 2022 were health care and social assistance, educational services, and retail trade (Data USA, 2024c). The state of New Mexico had an unemployment rate of 3.8 percent in May of 2024, a 0.3 percent decrease from two years prior (U.S. Bureau of Labor Statistics, 2024). The average per capita income of the ROI was $27,732 in 2022. For comparison, the per capita income of New Mexico was $32,667 (U.S. Census Bureau, 2023).

3.8.2 Environmental Consequences

Impacts to socioeconomics would be considered significant if the proposed action were to cause substantial changes to sales volume, income, employment, or population (including housing and schools).

3.8.2.1 Alternative 1

Under the action alternative, the socioeconomics of the WSMR region could experience benefits due to the implementation of proactive flood mitigation measures, including the construction of detention basins, levees, cross-culverts, and early warning systems. These improvements would reduce the risk of flash floods causing road closures and damage, particularly on critical routes like U.S. 70, ensuring that essential transportation corridors remain open and minimizing disruptions to shipping, travel, and commerce. The uninterrupted operation of internal roads and main thoroughfares within WSMR would also support the smooth flow of personnel and resources, maintaining efficient and cost-effective military and civilian activities.

Additionally, if local construction crews are employed to carry out these infrastructure projects, the action alternative could provide a minor boost to the local economy. Utilizing local labor and businesses for construction could create jobs, increase household incomes, and stimulate economic activity within the community. This infusion of economic activity would not only support the construction sector but also benefit other local businesses, from suppliers to service providers, creating a positive economic ripple effect throughout the region. In the long term, by reducing the risk of flood-related disruptions, the action alternative could sustain economic stability, support local businesses, and enhance the quality of life for residents and workers, making the WSMR region more resilient and economically robust.

In summary, alternative 1 may offer short-term benefits to local employment, sales volume, and income. Additionally, this alternative could reduce flood-related disruptions in the long term. However, it is unlikely to have any significant short- or long-term effects on the WSMR population. As a result, the socioeconomic impacts of this alternative are considered less than significant.

3.8.2.2 No Action Alternative

Under the no action alternative, WSMR would implement basic repairs providing immediate, short-term relief in response to damaging flood events. Implementing short term repairs means that WSMR would not implement permanent flood control solutions and storm events would continue to negatively impact military infrastructure and impact the local economic and social conditions in the area.

Under the no action alternative, the socioeconomics of the WSMR region could be adversely affected due to the risk of flash floods, which can carry silt and debris over essential roadways such as U.S. 70. The potential for closure or damage to U.S. 70 may have significant ripple effects on the local and regional economy. Delays in shipping and travel disruptions could hinder commerce, affecting businesses that rely on timely deliveries and access to markets. Additionally, road closures or damage to internal roads and main thoroughfares within WSMR could disrupt daily operations, impede the movement of personnel, and delay critical missions. The economic impact could extend to the broader community, as prolonged road closures could limit access to essential services, increase transportation costs, and reduce the overall quality of life for residents and workers in the area. Not implementing alternative 1 may increase socioeconomic challenges which could become more frequent with severe, potential negative impacts on both the short and long-term economic health of the region. Therefore, there could be significant impacts on socioeconomics under the no action alternative.

3.9 Water Resources

Water resources are natural and man-made sources of water that are available for use by, and for the benefit of, humans and the environment. Water resources relevant to WSMR in New Mexico include groundwater, surface water, wetlands, and floodplains.

The Clean Water Act (CWA), the Safe Drinking Water Act, the Wild and Scenic Rivers Act, and EOs 11988 *Floodplain Management* and EO 11990 *Protection of Wetlands* are the federal regulatory drivers applicable to the evaluation of water quality considered in this Programmatic EA. The effects of alternative 1 are evaluated in accordance with applicable statues and EOs. The primary focus of this Programmatic EA with respect to water resources is the potential effects on watersheds, groundwater, water quality, and the actions proposed to protect the resource. Water resources in New Mexico are governed by multiple, often overlapping federal, state, and tribal regulatory boundaries.

As administered by the New Mexico Environment Department Surface Water Quality Bureau (SWQB), operates under a variety of state statutes, rules, and federal regulations to ensure compliance with state regulations and permits, pertaining to water resources. The SWQB protects New Mexico's watersheds through managing non-point source pollution. The SWQB also administers the New Mexico Wetlands Program, that facilitates the development of comprehensive plans for wetlands restoration and protection in New Mexico watersheds, through Wetland Action Plans. Wetland Action Plans are a guide for the planning and implementation of projects and activities essential to the understanding, conservation, protection, restoration, and management of wetlands in a planning area. As previously stated, the USEPA is the CWA Section 402 permitting authority in New Mexico and the USACE is the CWA Section 404 permitting authority. The Office of the State Engineer is charged with administering the state's water resources. The State Engineer has authority over the supervision, measurement, appropriation, and distribution of all surface and groundwater in New Mexico, including streams and rivers that cross state boundaries, under New Mexico Statutes Chapter 72, known as New Mexico's Water Law. 40 Section 72-9-1 of the New Mexico Statutes gives the State Engineer authority to regulate reservoirs, canals, pipelines, or other works, such as acequias, and the water rights of the owners thereof.

The NMDGF, in collaboration with the U.S. Forest Service, New Mexico University, and other partners, have developed a map resource to support the conservation and management of New Mexico's riparian habitats. The New Mexico Riparian Habitat Map (NMRipMap) provides a comprehensive, fine-scale spatial view of the composition, cover, and structure of riparian and wetland vegetation along New Mexico's perennial streams and rivers.

Groundwater

Groundwater is water that exists in the saturated zone beneath the Earth's surface that collects and flows through aquifers and is used for drinking, irrigation, and industrial purposes. Groundwater typically can be described in terms of depth from the surface, type of aquifer, well capacity, recharge rates, and water quality.

Surface Water

Surface water includes natural, modified, and man-made water confinement and conveyance features above groundwater that may or may not have a defined channel and discernable water flow. Stormwater control systems are an important component of surface water management systems due to the impact of storm water on sediment load and movement of contaminants that may degrade surface water systems, such as lakes, rivers, and streams. The Energy Independence and Security Act Section 438 (42 USC 17094) regulates federal facility development projects and requires that the project include appropriately designed stormwater systems when the project is greater than 5,000 square feet. Under these requirements, predevelopment site hydrology must be maintained or restored to the maximum extent technically feasible with respect to temperature, rate, volume, and duration of flow.

Wetlands

Wetlands are considered Waters of the U.S. (WOTUS) if they are determined to be jurisdictional by USACE. USFWS maintains the National Wetland Inventory (NWI) for public use, which provides maps of current status, extent, characteristics, and functions of wetland, riparian and deepwater habitats. A ruling instituted by USACE revised the definition of WOTUS protected under the CWA. The ruling came into effect on March 20, 2023. Under the 2023 Rule, WOTUS include: (1) traditional navigable waters, the territorial seas, and interstate waters; (2) impoundments of qualifying waters; (3) tributaries to qualifying waters; (4) wetlands adjacent to qualifying waters; and (5) certain intrastate lakes and ponds, streams, and wetlands.

Floodplains

Floodplains are areas of low, level ground present along rivers, stream channels, or coastal waters that are subject to periodic or infrequent inundation because of rain or melting snow. Flood potential is evaluated by the Federal Emergency Management Agency (FEMA), which defines the 100-year floodplain as an area within which there is a 1 percent chance of inundation by a flood event in a given year, or a flood event in the area once every 100 years. EO 11988, *Floodplain Management*, requires federal agencies to determine whether a proposed action would occur within a floodplain and to avoid floodplains to the maximum extent possible wherever there is a practicable alternative. More specifically, it requires agencies to determine specific federal building or project dimensions (i.e., how high, wide, and expansive a building or project should be) in order to manage and mitigate any current or potential flood risks. Additionally, Directive-type Memorandum 22-003, *Flood Hazard Area Management for DoD*

Installations, directs the DoD to avoid development within a flood hazard area to the maximum extent practicable.

3.9.1 Affected Environment

WSMR lies mostly within the Tularosa Valley Watershed. This watershed is an enclosed basin with no external outlet and is part of the Rio Grande Rift. Consequently, there are no jurisdictional wetlands within the area of influence. A playa known as Lake Lucero represents the remains of the Pleistocene Epoch Lake Otero. The northeast portion of WSMR is contained within the Jornada del Muerto Watershed, which is a closed basin with no flow into the Rio Grande. Most drainages of the northern Jornada del Muerto Basin empty into or terminate at the edge of the basin (WSMR, 2023a).

Natural water sources on WSMR include over 183 ephemeral and perennial springs, seeps, streams, lakes, ponds, and wetlands, though there are no sensitive resources found within the area of influence. Recent surveys determined that regional drying over the past three decades has resulted in the reduction of available surface water as well as shrinking riparian patch size with changing riparian species composition at most springs on WSMR (WSMR, 2023a).

The southwest experiences a wide range of weather events, including droughts, heat waves, and floods. Notable wet periods in the last 115 years include 1940–1941 and the 1980s and 1990s. Region-wide severe droughts occurred in 1900, the mid-1950s, and early 2000s. Recent surveys determined that regional drying over the past three decades has resulted in the reduction of available surface water as well as shrinking riparian patch size and changing riparian species composition at most springs on WSMR (WSMR, 2023a).

The 2023 Gridded Precipitation Scaling for Future Conditions study (Appendix A) found that future extreme precipitation is expected to increase alongside increasing extreme temperature. When considering the design of new infrastructure, for a design life of less than or greater than 50-years, a minimum change factor of 10 percent should be applied to adequately account for future conditions. How these increases in precipitation would translate to runoff volumes and discharges is not directly clear. This uncertainty is due to unknown soil moisture conditions at the time of future rainfall events, along with unknown changes in landcover over time due to factors such as urban sprawl, forest fires, and woodland growth. However, there is consensus within the scientific community that precipitation increases for the more extreme storm events (i.e., 25, 50, and 100 Average Return Interval) would translate to increases in runoff volume and discharge (WSMR, 2023b).

Groundwater

Most of the water used at WSMR is used on Main Post. Water is supplied to Main Post via 15 groundwater wells. Data indicates average groundwater usage per year at WSMR between 2007 and 2014 was 446 million gallons per year. However, average water usage has decreased since 2013 with water conservation efforts. A hydrogeological and groundwater assessment determined the groundwater aquifers used by the Main Post water supply system have a safe long-term yield of 645 million gallons per year. Water usage peaks in the summer months (WSMR, 2024a).

Groundwater recharge rates in the region are highly variable due to weather patterns, and precipitation rates. Precipitation in the San Andres and Oscura Mountains recharge the aquifer through infiltration. Precipitation on Main Post does not recharge the aquifer. The sub-basin (Sotol Creek), which feeds the WSMR supply wells receives approximately 14 inches of precipitation annually, of which only 4-5 percent is estimated to become groundwater. 143,000 cubic meters per day of recharge is estimated to enter the basin-fill aquifer from subbasins that rim the Tularosa Basin (WSMR, 2024a).

Well and test hole observations on Main Post and adjacent areas of WSMR determined a continuous decline of the water table has occurred since production began in 1949 (WSMR, 2024a).

Surface Water

The only major perennial stream on WSMR is Salt Creek. Water flow in Salt Creek is maintained by spring and seep discharge from the basin-fill aquifer in the Tularosa Basin). Ground water input occurs throughout the reach of Salt Creek from headwaters downstream to the vicinity of a head-cut waterfall. Tularosa Creek and Three Rivers have water flows that occasionally reach WSMR during periods of high precipitation and runoff from the Sacramento Mountains. Most perennial ponds on WSMR are near the Mound Springs Complex and Malpais Spring. There are seven perennial ponds associated with various springs around the Mound Springs Complex: the most notable of these being Main Mound Spring, North Mound, and South Mound. Groundwater discharge from Malpais Spring provides water to a large, inundated marsh area and associated ponds. Barrel Spring and Guilez Spring are southeast of Malpais Spring near the eastern boundary of WSMR (WSMR, 2023a).

Lake Lucero occasionally contains water following large rain events that produce significant runoff. Brazel Lake is the terminus of Tularosa Creek. Water is depleted from these areas due to drought and diversion of water east of the WSMR boundary and due to percolation of water to the subsurface, evaporation, and evapotranspiration. Davies Tank, approximately five miles southeast of the Main Post, is a naturally occurring ephemeral lake located in the southern portion of WSMR. Davies Tank has been extensively manipulated by human use, functioning as a holding site for effluent from the WSMR Main Post wastewater treatment facility since 1986 This inflow of water over many years has contributed to the growth of riparian species, such as willows, cottonwood trees, cattails, rushes, and sedges—as well as other facultative and obligate wetland vegetation that would not otherwise persist at this playa lake (WSMR, 2023a).

Wetlands

The NWI indicates that two mapped wetlands are located within the area of influence as presented in the proposed project areas (NWI, 2024). These wetlands are not considered jurisdictional because the watershed is within an enclosed basin. The wetlands are associated with and adjacent to Davies Tank and West Dry Lake Tank. Both these areas have been heavily manipulated and disturbed.

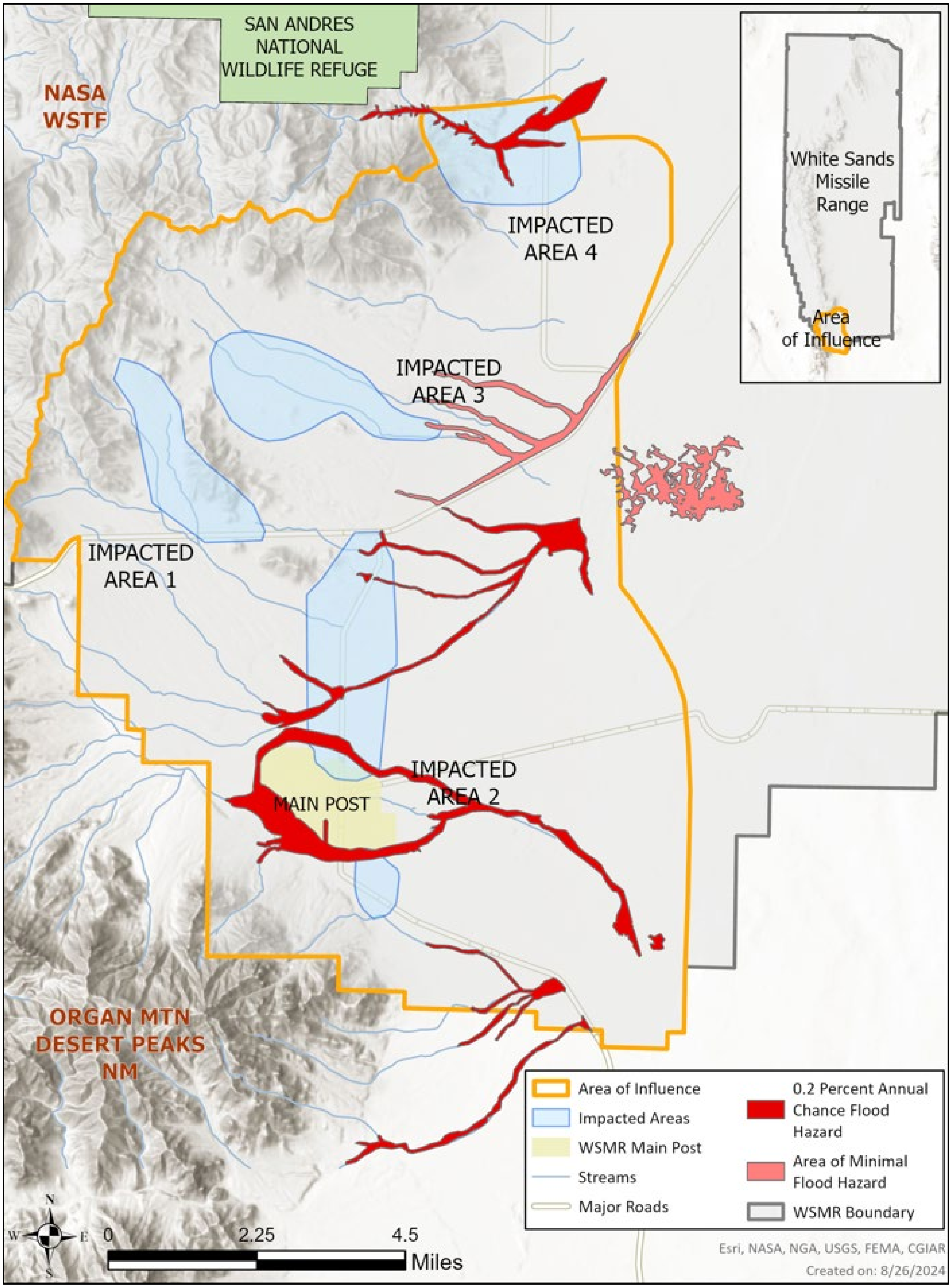
Floodplains/Stormwater

The proposed project areas are located within the 500-year floodplain and are also determined within 1 percent and 0.2 percent annual chance floodplain (FEMA, 2023). Figure 3-6 depicts the 0.2 percent annual chance floodplain and areas of minimal flood hazard.

WSMR occasionally experiences sudden and heavy rainfall. These intense storm events can dump large amounts of water in a short period of time. High rates of precipitation overwhelm the ground's ability to absorb excess water causing water runoff. In the mountains around WSMR deep eroded arroyos have cut into lower slopes, carrying runoff from seasonal rains at high speeds to lower basins, where water rapidly soaks into the ground to resupply a shallow freshwater table (WSMR, 2023a). Flooding from large storm events can cause damages to WSMR facilities, infrastructure, and transportation. Floods also pose as a danger to human health and safety.

Extreme storm events in 1978 and 2021 caused significant road damage and closures, with rainfall levels equivalent to 200-year and 500-year storms. The August 1978 flooding resulted in five fatalities, including a family of four and a military police officer attempting their rescue. It also severely damaged roads, infrastructure, and WSMR facilities. Similarly, heavy rains in July and August 2021 led to flooding that closed U.S. 70, the WSMR North access point, and Range Road 7. Additionally, smaller but impactful storm events, such as summer rains in 2016, caused localized flooding and road damage.

Figure 3-6: FEMA Flood Map



3.9.2 Environmental Consequences

The ROI consists of the water resources that are within and downstream or downgradient of the footprint of operations related to the design and construction of stormwater and flash flood prevention infrastructure and design solutions.

3.9.2.1 Alternative 1

Alternative 1 presents a range of watershed resiliency design solutions designed to reduce the risk of loss of life and property caused by the effects of flooding associated with New Mexico monsoon cycles. The proposed design solutions and the associated specific environmental consequences and mitigation measures are listed in Table 3-6. WSMR anticipates some projects identified under this Programmatic EA could be located in a floodplain. For any project tiered from this Programmatic EA that is determined to be within a floodplain, a Finding of No Practicable Alternative would be required, consistent with EO 11988.

Table 3-6: Proposed Design Solutions and Associated Environmental Consequences

Proposed Design Solutions	***Environmental Consequences***	***Minimization and Mitigation Measures***
Early Warning Systems	Early warning systems are generally small and minimally intrusive. However, any system sited on or near Bureau of Land Management lands must comply with Bureau of Land Management's environmental requirements and the Proclamation for the Organ Mountains-Desert Peaks National Monument. Although the construction and operation of these systems can have environmental consequences, employing non-intrusive methods—such as weather forecasting and real-time Doppler radar—could further minimize ground-disturbing activities, thereby reducing potential impacts in sensitive areas.	*Design*: Coordinate with neighboring agencies (such as Bureau of Land Management) to ensure the most effective and nonintrusive early warning systems are implemented. *Maintenance*: Coordinate with neighboring agencies to ensure early warning systems are regularly inspected and maintained to ensure the early warning systems remain functional.

Proposed Design Solutions	***Environmental Consequences***	***Minimization and Mitigation Measures***
Detention Basins	Detention basins can disrupt natural hydrological cycles, reduce groundwater recharge, and alter local hydrologic ecosystems. If improperly managed water could become stagnant, which can foster invasive species or promote mosquito breeding. Detention basins could positively impact the environment improve water quality by allowing sediments and pollutants to settle before water is released downstream.	*Design:* Detention basins would be designed to promote gradual water infiltration, facilitate groundwater recharge and mimic natural hydrological processes. Additionally, integrating wildlife-friendly features, such as shallow slopes and varied water depths, can create habitats for aquatic and terrestrial species while minimizing negative ecological effects. *Maintenance:* Regular inspection and maintenance, such as removing accumulated sediment and controlling invasive species, ensures the basin functions properly and reduces the risk of stagnant water.
Levee Improvements	The construction and operation of levees could alter the local hydrology. Levees could change the natural flow of streams, reduce sediment deposition, and alter groundwater recharge.	*Design:* Habitat corridors would be incorporated into levee designs to help reduce the impact on wildlife. Levees would be designed to allow the controlled flooding of floodplains during high-flow periods to maintain natural hydrology and ecosystems. *Maintenance:* WSMR would develop strategies to manage sediment transport and deposition to mitigate downstream erosion and maintain habitat health.
Cross/Culvert Improvements	The construction and operation of Cross/Culverts could alter the local hydrology. Culverts could change the natural flow of streams, reduce sediment deposition, and alter groundwater recharge.	*Design:* Habitat corridors would be incorporated into culvert designs to help reduce the impact on wildlife. Culverts would be designed to allow the controlled flooding of floodplains during high-flow periods to maintain natural hydrology and ecosystems. *Maintenance:* WSMR Directorate of Public Works would develop strategies to manage sediment transport and deposition to mitigate downstream erosion and maintain habitat health.

Proposed Design Solutions	***Environmental Consequences***	***Minimization and Mitigation Measures***
Retention and Reuse	Retention and reuse could disrupt natural hydrological cycles, reduce groundwater recharge, and alter local hydrologic ecosystems. If improperly managed water could become stagnant, which could foster invasive species or promote mosquito breeding. Retention and reuse could positively impact the environment improve water quality and reduce water demand.	*Design:* Flood retention and reuse systems would be designed to integrate with natural landscapes, preserving wetlands and enhancing groundwater recharge. Where feasible, these designs would incorporate native vegetation to aid in surface water absorption through evapotranspiration. These systems would also promote sustainable water management by reducing reliance on natural water sources during dry periods. *Maintenance:* Regular inspection and maintenance, such as removing accumulated sediment and controlling invasive species, would be performed to ensure the basin functions properly and reduces the risk of stagnant water.
Check Dams	Check dams could alter natural water flow, disrupt sediment transport, and affect aquatic habitats. Over time, check dams could lead to sediment buildup upstream, potentially reducing water quality and altering local ecosystems.	*Design:* Check dams would be designed to allow controlled water flow and sediment passage *Maintenance:* Regular inspection and maintenance, such as removing accumulated sediment and controlling invasive species, would be performed to ensure the dam functions properly and reduces the risk of stagnant water.
Bioengineering	Bioengineering projects could disrupt local ecosystems, alter natural watercourses, and promote nonnative species.	*Design:* Bioengineering projects would integrate these systems into existing ecosystems, prioritizing the use of native or otherwise approved vegetation, in accordance with the Directorate of Public Works Environmental Division. Materials and plant species would be selected to enhance the local biodiversity and ensure alignment with installation-specific requirements. *Maintenance:* Invasive species would be managed according to the Integrated Pest Management Plan.
Erosion Control	Erosion control measures could disrupt natural landscapes, alter water flow, and reduce habitat quality for wildlife.	*Design:* Erosion control measures would prioritize natural solutions like vegetation planting and the use of permeable materials, which would allow water infiltration while stabilizing soil.

Legend: WSMR = White Sands Missile Range

WSMR anticipates some projects identified under this Programmatic EA could be located in wetlands. Because the proposed action is located within an enclosed basin, no wetlands are considered jurisdictional. As such, USACE wetland delineation and/or National Pollutant Discharge Elimination System permitting would not be required. Since the exact locations and designs are not yet determined, additional analysis to determine potential impacts to wetlands may be necessary once design solutions and site selections are finalized.

Adverse effects with respect to the CWA are not anticipated through actions evaluated in this Programmatic EA. Because the proposed action is located within an enclosed basin a 404 and/or National Pollutant Discharge Elimination System permit would not be required by USACE or USEPA. Adverse effects with respect to drinking water are not anticipated. The range of design solutions does not involve storage or transport of toxic, or pathogenic materials such as solvents, road salt, manure, petroleum products or sewage in quantities that would adversely impact groundwater, if inadvertently released. Further, the installation of injection wells is not proposed under alternative 1.

The design solutions proposed under alternative 1 are intended to restore, replace, and mitigate existing watershed elements impacted by storm events at WSMR. This action would not increase water usage from the aquifer. Contaminated runoff into the aquifer used for potable water on WSMR is possible as runoff from the Main Post supplies the aquifer along with runoff from the San Andres and Oscura Mountains. BMPs would be implemented to decrease or eliminate potential adverse impacts on groundwater resources from the construction of any design solutions. Detention/retention ponds and other design solutions involving the capture of water would negligibly alter the groundwater recharge areas. Detention and retention ponds would implement a design that would allow water to permeate the ponds to recharge groundwater thus, the impacts to groundwater recharge would be minor. No major impacts on groundwater are anticipated from alternative 1.

In the short-term, the proposed action alternative has the potential to cause minor to moderate adverse effects to water resources, including wetlands and floodplains during site preparation and construction of design solutions due to the potential for increased turbidity at project sites. In the long-term, alternative 1 has the potential for minor to moderate beneficial effects to water resources based on the proposed design solutions potential to reduce erosion, control and manage stormwater runoff and the potential for flooding from storm events, and protect the quality and quantity of drinking water aquifers.

WSMR would use BMPs and incorporate all permit conditions applicable to minimizing effects to water resources.

In summary, the design solutions under alternative 1 aim to restore and protect watershed elements affected by storms, with minimal impacts on groundwater recharge. The proposed action or other projects tiered off of this Programmatic EA may occur within a floodplain, which triggers the requirements of EO 11988 and may necessitate a Finding of No Practicable Alternative. If required, a Finding of No Practicable Alternative would be prepared upon completion of this Programmatic EA or prior to any construction. Construction may cause minor to moderate short-term effects on water resources, BMPs and permit conditions would be applied to minimize adverse effects. Long-term benefits include improved stormwater management, reduced erosion, and protection of drinking water aquifers. Therefore, implementation of alternative 1 would result in less than significant impacts to water resources.

3.9.2.2 No Action Alternative

Under the no action alternative, WSMR would continue to carry out only basic repairs to provide immediate relief following a damaging flood event, without implementing design solutions to enhance flood protection. However, water resources would remain unchanged. Therefore, there would be no impact on water resources under the no action alternative.

4 CUMULATIVE IMPACTS

Cumulative effects analysis assesses the combined effects of the proposed action and those of other past, present, and reasonably foreseeable future projects that would reasonably be expected to affect the same resource areas regardless of what entity is implementing the other projects.

In this chapter, the Army has identified past, present, and reasonably foreseeable future actions in the region of WSMR. This analysis also evaluates reasonably foreseeable future actions that are in the planning phase in this region.

This chapter provides decision makers with the cumulative effects of the proposed action at WSMR, as well as the incremental contribution of past, present, and reasonably foreseeable actions.

Table 4-1 summarizes past, present, and reasonably foreseeable future actions within the region that could interact with implementation of the proposed action at WSMR. Table 4-1 briefly describes each identified action, presents the proponent or jurisdiction of the action and the timeframe (e.g., past, present/ongoing, future).

Past activities are those actions that occurred within the geographic scope of cumulative effects that have shaped the current environmental conditions of the project area. For resources, the impacts of past actions are now part of the existing environment and are incorporated into the description of the affected environment in Chapter 3. Present/ongoing activities encompass all projects currently under construction or development within the geographic region of WSMR at the time of this Programmatic EA's publication. Reasonably foreseeable future actions include those actions that are likely (or probable) to occur or be implemented within the area affected by cumulative impacts.

Table 4-1: Past Present, and Reasonably Foreseeable Actions Within the Region of Influence

Action	*Proponent / Location*	*Timeframe*	*Description*
Military Actions			
Replacement and Modernization of Main Cantonment Access Gates	WSMR	Present, Future	Replacement and modernization of the WSMR main cantonment access gates.
Replacement and Modernization of Fire Stations	WSMR	Present, Future	Replacement and modernization of the Main Post, Stallion, Nike Avenue, HELSTF, and Mid-Range fire stations.
Las Cruces Substation Upgrade	WSMR	Future	Upgrade existing Las Cruces substation to increase reliability and maintainability.
Address Energy Readiness	WSMR	Future	Expand existing six MW solar PV system on the Main Post by adding a 20 MW solar PV system, install microgrid systems designed to incorporate carports and ground-level and rooftop PV panels at the Stallion Range Center and other locations, install energy storage systems and additional generators powered by natural gas, propane, or diesel, and install electric vehicle charging stations within disturbed areas near existing facilities.
Expansion and Repair of Stallion Army Airfield Runway	WSMR	Future	Expand and repair the Stallion Army Airfield runway.
3D Printed Transient Training Barracks	WSMR	Present, Future	Construct 3D printed transient training barracks (400 bed)
UHP Barracks	WSMR	Present, Future	Construct UHP barracks (200 bed)
Central Wash Rack/Tank Wash Rack/ GSA Vehicle Car Wash	WSMR	Present, Future	Construct central wash rack, tank wash rack, and GSA vehicle car wash.
Transient Training Barracks	WSMR	Present, Future	Construct transient training barracks.
Increase Weapon Impact Areas	WSMR	Present, Future	Increase in the number of weapon impact areas used to support Research, Development, Test, an Evaluation of weapon systems. Expand the size of Lee and Yucca Impact Areas.
Local Actions			
U.S. 70 Roadway Rehabilitation	NMDOT	Past	Rehabilitation of U.S. 70 from milepost 143 (I-10/U.S. 70 interchange) to milepost 161 (Organ).
U.S. 70 Rehabilitation Project West of Las Cruces	NMDOT	Present, Future	Rehabilitation of U.S. 70 from Del Rey Boulevard (milepost 150.95) to NASA Road (milepost 161.43) just east of Las Cruces. This project includes removing and replacing outdated guardrails, curbs, and gutters from NASA Road to Las Cruces and repaving.

Legend: WSMR = White Sands Missile Range, HELSTF = High Energy Laser Systems Test Facility, PV = photovoltaic, MW = megawatt, 3D = three dimension, UHP = Unaccompanied Housing Program, GSA = Government Services Administration, U.S. = United States, NMDOT = New Mexico Department of Transportation
Source: City of Las Cruces, 2023; NMDOT, 2024; U.S. Army, 2024a; U.S. Army, 2024b, U.S. Army, 2024c

4.1 Cumulative Effects Analysis

This section evaluates the cumulative effects from past, present, and reasonably foreseeable future actions (see Table 4-1) relative to the implementation of the proposed action.

4.1.1 Biological Resources

Cumulative impacts on human health and safety would occur if the proposed action, in conjunction with past, present, or reasonably foreseeable actions resulted in a substantial additional risk to biological resources. Construction, operation and maintenance of the design solutions proposed under alternative 1, as well as present and reasonably foreseeable future projects on the installation and within the surrounding areas, would result in impacts on vegetation crushing/removal and soil compaction/removal during ground-disturbing activities, which could result in establishment of invasive species.

Adverse impacts on vegetation would be minimized with implementation of appropriate minimization and mitigation measures and BMPs, such as cleaning equipment prior to entering the project area, and measures would be implemented to help prevent and control dissemination of invasive plant species during ground-disturbing activities. Revegetation of disturbed sites with native vegetation would further reduce the establishment of invasive species. Project activities that require heavy equipment could cause mobile mammals, amphibians, reptiles, and birds, including breeding migratory birds, to temporarily relocate to nearby similar habitat. These disturbances are expected to be minor, and it is assumed that displaced wildlife would return to areas that had not been improved soon after activities conclude or would move to adjacent areas of similar habitat. Adverse impacts on wildlife would be minimized with appropriate minimization and mitigation measures as well as BMPs, such as conducting surveys prior to any construction activities taking place and scheduling project activities to occur outside of the nesting season of March 1 to September 30 to reduce impacts on migratory birds. Although growth and development could be expected to continue outside of WSMR and within the surrounding natural areas, significant adverse impacts on these resources would not be expected. Therefore, the proposed action, when combined with past, present, and reasonably foreseeable future actions would not result in a significant impact on biological resources.

4.1.2 Cultural Resources

Cumulative impacts to cultural resources would occur if the proposed action, in conjunction with past, present, or reasonably foreseeable future actions resulted in significant alteration of NRHP listed and eligible properties or by altering, inhibiting access to properties of religious or cultural significance to Tribes. At WSMR, the first approach to cultural resource management is to avoid sensitive areas whenever possible. Nevertheless, ground disturbing activities, blocking access to sacred sites, and inadvertently affecting previously unidentified cultural resources have the potential to cause cumulative effects. Implementation of BMPs and, when necessary, mitigation measures would reduce these effects to less than significant. In addition, SOPs detailed in the WSMR ICRMP (WSMR, 2025) provide guidance for identifying historic properties and establishes BMPs to avoid or reduce adverse effects. Therefore, cumulative impacts to cultural resources resulting from implementation of the proposed action in addition to the past, present, and reasonably foreseeable future actions at WSMR and in the surrounding region would be less than significant.

4.1.3 Geological Resources and Soil Erosion

Cumulative impacts on geologic resources and soil erosion would primarily result from construction activities, such as vegetation clearing, grading, and the creation of impervious surfaces. These activities could alter topography and soils and lead to excessive stormwater runoff. Implementation of mitigation measures and BMPs, including revegetation, erosion control measures, and the emulation of natural topography would minimize the severity. Overall, the cumulative impacts on geological resources and soil erosion in combination with other past, present, and reasonably foreseeable future actions are expected to be less than significant.

4.1.4 Human Health and Safety

Cumulative impacts on human health and safety would occur if the proposed action, in conjunction with past, present, or reasonably foreseeable actions resulted in a substantial additional risk to human health or safety including direct human exposure to hazardous conditions or a substantial increase in conditions that adversely affect public health.

The implementation of alternative 1, could significantly enhance the safety and resilience of the base against flood-related hazards. While these infrastructure improvements could introduce certain risks, such as those associated with mosquito breeding and child safety, the incorporation of targeted mitigation measures—including secure, wildlife compatible fencing, childproof barriers, regular inspection and maintenance, and UXO clearing—could effectively minimize these risks. Therefore, with these mitigation measures in place, the potential impacts on human health and safety are expected to be less than significant

The projects listed in Table 4-1 also show potential benefits to human health and safety such as the replacement and modernization of fire stations, infrastructure upgrades, and the rehabilitation of U.S. 70. Cumulative impacts on human health and safety resulting from the implementation of the proposed action in conjunction with past, present, and reasonably foreseeable future actions at WSMR and in the surrounding region would be beneficial and less than significant

4.1.5 Infrastructure, Facilities, and Traffic/Transportation

Cumulative impacts on infrastructure, facilities, and traffic/transportation would occur if the proposed action, in conjunction with past, present, and reasonably foreseeable future actions, leads to increased traffic volumes, road degradation, restricted access to facilities, deterioration of facilities, or prolonged interruptions to utility connectivity. The construction and renovations of multiple facilities on the installation, listed in Table 4-1 would result in long-term minor adverse impacts on the infrastructure due to the increase in consumption of utilities, although the addition of the proposed action is not anticipated to significantly contribute to this increase. To further mitigate potential adverse impacts from increased energy and water use, the incorporation of sustainable design principles, such as Net Zero Polices or Leadership in Energy and Environmental Design standards, could be considered during planning and construction. Conversely, a variety of the cumulative projects, such as the Main Post access gate, substation upgrade, and the U.S. 70 improvement projects, would improve upon existing infrastructure, facilities, roadway networks, and improve traffic flow. These projects in combination with the proposed action would benefit infrastructure, facilities, and traffic/transportation. The proposed action when combined with past, present, and reasonably foreseeable future actions are expected to have a less than significant impact on infrastructure, facilities, and traffic/transportation.

4.1.6 Land Use

Cumulative impacts to land use would occur if the proposed action, in conjunction with past, present, or reasonably foreseeable actions resulted in land use that is incompatible with existing military land uses and designations (including recreation) and or sufficient land is not available. These impacts could conflict with Army land use plans, policies, and regulations, or with land use off post.

Under the assumption that mitigative actions are taken, the impacts on land use caused by the action alternative are less than significant. The potential land use changes caused by the projects listed in Table 4-1 are likely to be compatible with existing land uses and designations. Through adequate consultation with Real Property Management, potential land use changes would not conflict with Army land use plans, policies, regulations, or off-post land use. Cumulative impacts on land use resulting from the implementation of the proposed action in conjunction with past, present, and reasonably foreseeable future actions at WSMR and in the surrounding region would be less than significant.

4.1.7 Socioeconomics

Cumulative impacts to socioeconomics would occur if the proposed action, in conjunction with past, present, or reasonably foreseeable future actions would cause substantial changes to sales volume, income, employment, or population levels, or if they caused substantial disproportionate impacts on minority or low-income populations. The proposed action may slightly affect socioeconomic resources such as employment, sales volume, and income. These impacts are expected to be slightly beneficial at local levels and to be short term. The actions listed in Table 4-1 would have nominal effects on socioeconomics and the overall impacts to the local communities, on and off the installation, would be positive, although the level of impact would vary by area and project size. Cumulative impacts to socioeconomics resulting from the implementation of the proposed action in conjunction with past, present, and reasonably foreseeable future actions at WSMR and in the surrounding region would be less than significant.

4.1.8 Water Resources

Cumulative impacts on geologic resources and soil erosion would occur if the proposed action, in conjunction with past, present, or reasonably foreseeable actions resulted in a substantial additional alteration of water resources. Alternative 1, when combined with other present and reasonably foreseeable future actions occurring in the surrounding area, may result in short-and long-term, minor, cumulative impacts on water resources. Other projects would include construction of buildings and increased impervious surface area, thus increasing potentially contaminated runoff volume into surface water bodies. Additionally, compounded projects could increase the need for water during construction and induce competition for a limited number of water pipe stands. However, BMPs would be implemented which would minimize potential impacts. The construction, operation and management of the proposed design solutions would aim to restore and protect watershed elements affected by storms, with minimal impacts on groundwater recharge. Construction may cause minor to moderate short-term effects on water resources, BMPs and permit conditions would be applied to minimize adverse effects. Long-term benefits include improved stormwater management, reduced erosion, and protection of drinking water aquifers. Therefore, implementation of alternative 1 when combined with past, present and reasonably foreseeable future actions at WSMR and in the surrounding region would not result in a significant cumulative impact on water resources.

5 SUMMARY OF POTENTIAL IMPACTS AND MEAUSRES TO AVOID, MINIMIZE, OR MITIGATE IMPACTS

This chapter summarizes the potential impacts for the resource areas analyzed in detail. For each resource area, Table 5-1 identifies applicable BMPs that WSMR would implement to avoid or minimize impacts of the proposed action.

BMPs are standard practices that are implemented as part of the proposed action to minimize or avoid adverse impacts. Mitigation measures are specific actions that would rectify or compensate for unavoidable adverse environmental effects that could be significant without mitigation. No mitigation measures have been currently identified.

The no action alternative would represent no change in the current operational environment of WSMR. Therefore, no impacts to the resource areas analyzed would be expected.

Table 5-1: Impact Summaries and Best Management Practices

Impact Summary	***BMP***
Biological Resources	
Less than significant	• Support vehicles would use existing roads to the fullest extent possible. • Off-road travel would be limited to designated areas only and when necessary, use a single path in and out. Personnel would be informed of restricted areas per the guidance of the Environmental Awareness Training. • Staging areas would be located in previously disturbed areas, where possible, and kept as small as possible. • Avoid construction activities during nesting season (March through September). • Surveys for migratory birds would be conducted seven days before construction activities occur during nesting season. Survey personnel would be required to meet the standards and qualifications of the Environmental Division Conservation Program. • All openings, inside and outside of buildings and structures that allow wildlife (e.g., rodents, birds, snakes, etc.) entry would be blocked. • Workers would be instructed to not harass, collect, possess, harm, disturb, or destroy wildlife or their parts to include, but not limited to, snakes, bats, birds, nests, eggs, or nestlings. • Workers would be made aware of local wildlife species that have potential for negative interactions and instructed not to feed wildlife, water wildlife, or leave food or trash in areas that may attract wildlife. In areas with potential bear issues, the trash receptacles would be required to be bearproof. • Workers would be instructed to report to the Environmental Division any injured or dead birds or active nests with eggs or nestlings discovered at the project sites.

Impact Summary	BMP

	• Removal or modification of vegetation would be conducted outside bird nesting season (March through September).
	  o When vegetation removal or modification must be conducted during bird nesting season, surveys would be conducted by qualified biologists and coordinated with the Environmental Division; and
	  o The Environmental Division would be contacted for any issues regarding migratory birds, raptors, lizards, snakes, or other wildlife species of concern.
	• Disturbed areas would be restored to the fullest extent feasible, and native vegetation would be allowed to reseed naturally as approved by the Environmental Division.
	• If bird nests are found during surveys, the Environmental Division would be consulted to determine actions to be taken.
	• The Environmental Division would consult with the USFWS regarding MBTA and ESA issues.
	• The Environmental Division would coordinate with the NMDGF regarding SGCN and state-listed or game species when needed.
	• Eagle biologists (via the Environmental Division) would monitor the eagle nests at or adjacent to each project and activity area to determine which nests are active during a given breeding season.
	• Human and vehicle activity would remain outside of the 0.5-mile buffer area for any active eagle nest throughout the nesting season of mid-January through July and outside of the 0.25-mile buffer area for any active burrowing owl habitats.
	• WSMR requires all personnel to participate in Environmental Awareness Training prior to beginning activities.
	• LED lighting would be installed in accordance with Unified Facilities Criteria 3-530-01, including fully shielded luminaires and lights pointing down (at a 0-degree tilt) straight at ground.
	• When possible, trenching would occur within previously disturbed areas and during the cooler months (i.e., October to March). Concurrent trenching, pipe- or cable-laying, and backfilling would occur whenever possible, and crews would be kept as close together as possible to minimize the amount of open trench at any given time. When trenching activities are temporarily halted, wildlife would be protected from accessing any open trench prior to backfilling.
	• Water would be diverted around construction sites whenever possible.

Impact Summary	*BMP*
	• Natural areas within the project site would be preserved. WSMR would strive to maintain the natural drainage system of the site, including natural stream channels, wetlands, and floodplains. The site would be designed, constructed, and maintained to protect the natural hydrology. • If erosion control blankets are used following construction, blankets would not include fused mesh corners (e.g., use woven mesh) to reduce the chances of unintentional entanglement of wildlife, and blanket edges would be buried. Erosion control blankets would be regularly checked after placement to identify and release any wildlife that should become entangled. Properly engineered drainage swales and other vegetated channel systems would be used instead of storm sewers, lined channels, curbs, and gutters. Vegetated swales would be gently sloped (4:1) so that small wildlife would be able to maneuver them.
Cultural Resources	
Less than significant	• During the site selection and planning process, areas containing sensitive cultural resources would be avoided as the primary measure to protect these resources. • Following the WSMR environmental review process and site evaluation, use cultural resource monitors approved by the WSMR Environmental Division, as appropriate. • Any activity that would occur in areas where cultural resource surveys have not been completed or where NHPA Section 106 consultation that is not complete would be subject to a site-specific cultural resource survey and/or evaluation, including Tribal Historic Preservation Officer consultation if determined necessary through the environmental review process. • Construction would adhere to the WSMR inadvertent discovery policy and process specified in the ICRMP. • The projects would implement SOPs and BMPs identified in the ICRMP.
Geological Resources and Soil Erosion	
Less than significant	• Appropriately design and site design solutions to consider soil limitations. • Ensure design solutions emulate and blend into natural preexisting hydrologic features and allow for continued recharge of local aquifers. • Adhere to all WSMR, State of New Mexico, USEPA, and U.S. Forest Service soil erosion control guidance and regulations. • Implement soil erosion techniques during construction to reduce dust (such as, watering and revegetation) • Regularly maintain all design solutions to minimize the potential of rockfalls.

Impact Summary	***BMP***
Human Health and Safety	
Less than significant	• Construct wildlife compatible fencing, childproof barriers, and signage around design solution as necessary. • Develop and implement community awareness programs. • Implement SOPs and BMPs as outlined in the WSMR Integrated Pest Management Plan to manage mosquitos. • Develop and implement maintenance and inspection plans to minimize standing water and mosquito breeding. • Conduct UXO surveys and clearing as necessary.
Infrastructure, Facilities, and Traffic/Transportation	
Beneficial impact	• Develop and implement maintenance and inspection plans to preserve the functionality of the selected design solutions.
Land Use	
Less than significant	• Avoid high-value areas, including areas of high operational, ecological, or recreational value. • Implement cooperative planning with nearby landowners and stakeholders. • Establish new buffer zones, wildlife compatible fencing, and signage as necessary.
Socioeconomics	
Less than significant	• None identified
Water Resources	
Less than significant	• Design detention basins to promote gradual water infiltration, facilitate groundwater recharge and mimic natural hydrologic processes. Integrate wildlife friendly features such as shallow slopes and varied water depths. • Regularly maintain detention basins by removing accumulated sediment and controlling invasive species. • Incorporate habitat corridors into levee designs to reduce impacts to wildlife. • Levees would be designed to allow the controlled flooding of floodplains during high flow periods in order to maintain natural hydrology and ecosystems. • Maintain levees to manage sediment transport and deposition to mitigate downstream erosion and maintain habitat health. • Design cross/culverts to incorporate habitat corridors to reduce the impact to wildlife. • Culverts would be designed to allow for the controlled flooding of floodplains during high-flow periods in order to maintain natural hydrology and ecosystems. • Maintain cross/culverts to manage sediment transport and deposition in order to mitigate downstream erosion and maintain habitat health. • Design flood retention and reuse systems to integrate with natural landscapes, preserving wetlands and enhancing groundwater recharge. • Regularly maintain flood retention and reuse systems by removing accumulated sediment and controlling invasive species.

Impact Summary	***BMP***
	• Design check dams to allow for controlled water flow and sediment passage. • Regularly maintain check dams by removing accumulated sediment and invasive species. • Bioengineering projects would integrate into existing systems and prioritize native plants and materials that enhance local biodiversity. • Utilize erosion control measures that prioritize natural solutions such as vegetation planting and the use of permeable materials.

Legend: USFWS = United States Fish and Wildlife Service, MBTA = Migratory Bird Treaty Act, ESA = Endangered Species Act, NMDGF = New Mexico Department of Game and Fish, SGCN = Species of Greatest Conservation Need, WSMR = White Sands Missile Range, NHPA = National Historic Preservation Act, ICRMP = Integrated Cultural Resources Management Plan, SOPs = Standard Operating Procedures, BMPs = Best Management Practices, USEPA= Untied States Environmental Protection Agency, U.S. = United States, UXO = unexploded ordinance, INRMP = Integrated Natural Resources Management Plan

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7 LIST OF PREPARERS

Scout prepared this Programmatic EA under the direction of White Sands Missile Range. The following contractor staff contributed to the preparation of this document:

Melanie Hernandez, JD, CEP, Scout, NEPA Program Manager, J.D., specializing in Environmental Law, 24 years of experience

Roxanne Beasley, Scout, Technical Editor, B.S., Business, 16 years of experience

Kari McCollum, Scout, NEPA Planner, M.S., Environmental Studies, 4 years of experience

Caidy Riggs, Scout, NEPA Planner, B.S., Environmental Science, 1 year of experience

Evan Reider, Scout, NEPA Planner, B.S. Environmental Science and Management, 2 years of experience

Becky Diaz, Scout, NEPA Planner/GIS Analyst, B.A., Child Development, Certificate of Achievement in Environmental Studies and GIS, 2 years of experience

Megan Beasley, Scout, Cultural Resources Specialist, B.A., Anthropology, 1 year of experience

Appendix A WSMR Gridded Precipitation Scaling for Future Conditions – Summary Report

SUMMARY REPORT

GRIDDED PRECIPITATION SCALING FOR FUTURE CONDITIONS - FINAL

Prepared by Michael Baker International
for The White Sands Missile Range (WSMR)

December 2023

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1. Introduction

Michael Baker International (MBI) partnered with Scout Environmental, Inc to perform gridded precipitation scaling for future conditions within the White Sands Missile Range (WSMR) in New Mexico. Like many regions in the world, New Mexico has experienced increases in extreme rainfall events over the past few decades, exacerbating stormwater challenges throughout developed portions of the State, including WSMR. Historical annual rainfall within this region averages over ten inches in the basin and seventeen inches at elevations around 8,000 feet (Jacobs et., al., 2009). While the desert climate has sparse annual rainfall, the regional climate is dominated by pronounced summer monsoonal season in July with runoff from the mountains and occasional heavy rains. Runoff from storms during these summer periods have been noted to inundate poorly drained lowland basin grasslands for days to even several weeks (Chloeta Fire et.al., 2021).

The Department of Defense (DoD) is interested in accounting for future climate conditions in their operations and infrastructure. This project aims to provide future precipitation change factors for that purpose. Currently the Department of Defense (DoD) utilizes a Climate Assessment Tool (DCAT) for assessing the exposure of military sites to climate change. DCAT uses climate data from General Circulation Models (GCMs) in the Coupled Model Intercomparison Project Phase 5 (CMIP5) set to provide relative ranking scores useful for comparative analysis and strategic planning between multiple sites. While the DCAT provides useful insight into evaluating relative risks posed by climate change, this study brings the added advantages of leveraged the latest information (CMIP6) and enabling future precipitation estimates that can be applied to engineering design or construction activities (e.g., how should a levee with a 50-year lifespan be designed considering future climate scenarios). Some of the enhancements and changes introduced in CMIP6 compared to CMIP5 include scenario-based methodology, more than double the number of participating models, higher spatial resolution, more realistic future land use and land cover, additional earth system components and processes, and an extended historical period.

This summary report provides highlights and key information pertaining to this study and is accompanied by a detailed report with further elaboration and analysis.

2. Climate Data Sources

In estimating future climate conditions, a set of assumptions must be made in the models about the level of greenhouse gases, their accumulation, and changes in land use and land cover. These assumptions are groups in emission-producing scenarios known as Shared Socio-Economic Pathways (SSPs) (Eyring et al., 2016). SSPs are an enhancement of CMIP6 upon CMIP5 and include four Tier 1 and four Tier 2 scenarios. This project evaluated data across all four of the Tier 1 climate change scenarios: SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 (Figure 1). While each scenario has inherent uncertainty as to what the future climate may be, together these four climate scenarios capture a realistic envelope of uncertainty for future climate conditions that can be used to provide a range of values guiding planning and design efforts.

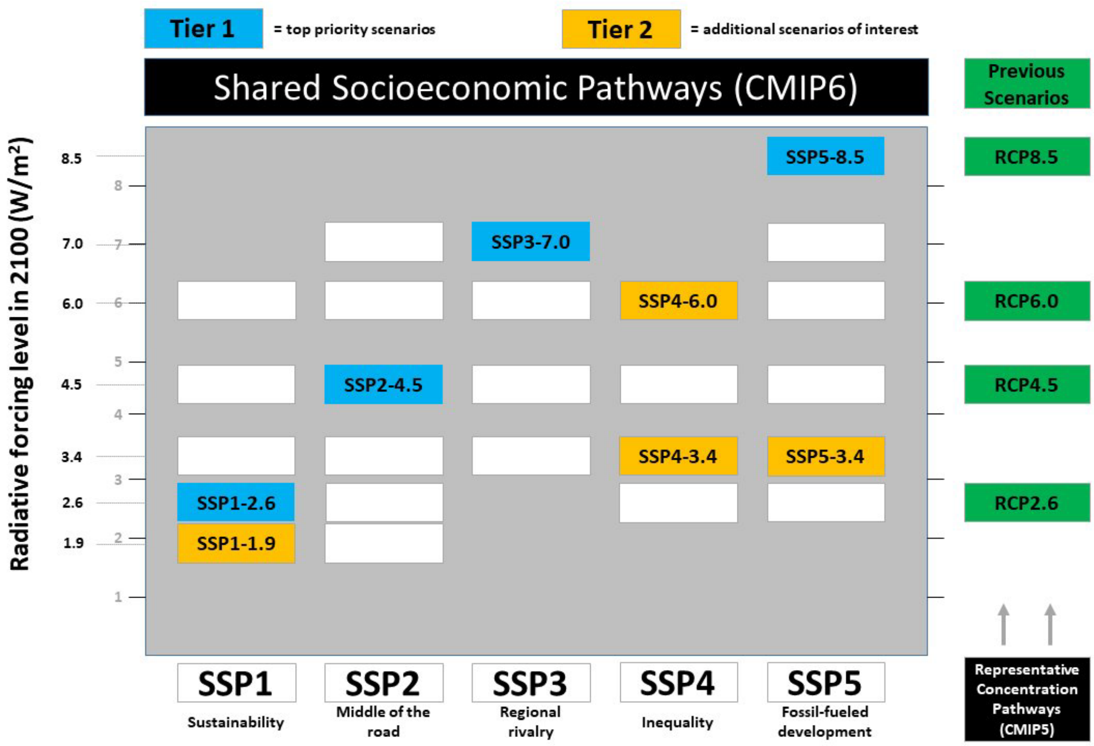

Figure 1. Future climate scenarios available in the CMIP6 dataset (O’Neill et al., 2016)

Each of the climate projections includes daily average variables for the periods from 1950 through 2014 (“historical period”) and from 2015 to 2100 (“future scenarios”). Data for and after 2015 is regarded as future because this modeling project began in 2014 and the first predicted (future) year was 2015. Global Climate Models (GCMs), also referred to as General Circulation Models (GCMs), are spatial datasets that typically adopt relatively coarse-resolution grid spacing (e.g., 100-km x 100-km), which neglects effects from regional topography and climate (Maraun et al., 2010; Bhaskaran et al., 2012). Downscaling of the coarse-resolution GCM variables to a regional scale is essential for better representation of regional climate, especially when there is significant topographic variation within the region. Therefore, this effort utilized the NASA Exploration CMIP6 Global Daily Downscaled Projections (NEX-CMIP6-GDDP) dataset (Thrasher et. al., 2021, 2022), which follows a 0.25-degree resolution.

3. Data Processing and Analysis

Of the variables provided by the GCMs, a frequency analysis was performed on the 24-hr total precipitation depth and the 24-hr average atmospheric temperature. Figure 2 shows an example comparison of shifting distributions from frequency analysis performed over different periods at a single location. This shift in Figure 2 illustrates that the statistical properties are changing with time (e.g., non-stationarity) and demonstrates the need to consider future climate analysis when designing infrastructure.

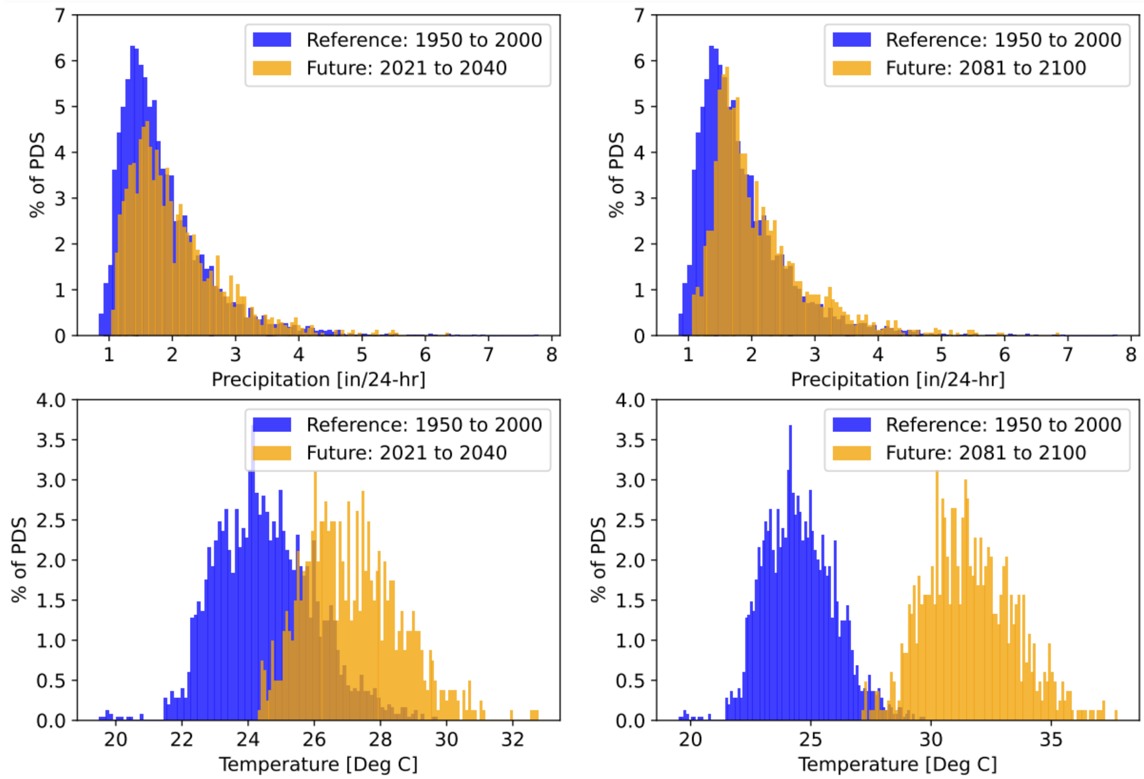

Figure 2. Example of shifting distributions under SSP5-8.5 at a single grid point near WSMR

The shift in distributions were then analyzed at six annual recurrence intervals (ARI) (i.e., 50%, 20%, 10%, 4%, 2%, and 1%) across four timescales (i.e., years 2021-2040, 2041-2060, 2061-2080, and 2081-2100) for the four future climate scenarios (i.e., SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). This resulted in a total of 96 paired scenarios for each of the 80 grid points covering WSMR. The estimated precipitation depths from this frequency analysis of the GCM projections were then divided by precipitation depths from the GCM historical period to result in a change factor, as shown below. The change factor calculation is carried out for each grid cell, ARI, future time period, GCM, and SSP within the study area. Because change factors are essentially a scalar between the modeled historic period and the modeled future period of interest, these values can be directly multiplied by the design precipitation depths from existing datasets (e.g., NOAA Atlas 14) for the respective recurrence interval to obtain the climate adjusted intensity duration frequency (IDF) curves.

$$Change\ Factor_{ARI} = \frac{Future\ Modeled\ Precip_{ARI}}{Historical\ Modeled\ Precip_{ARI}}$$

$$Future\ Precip_{ARI} = Atlas\ 14_{ARI} * Change\ Factor_{ARI}$$

It is recommended that future change factors for ARIs greater than the 100-year either adopt the same values as the 100-year, or develop a frequency curve trend line at each grid point location within the desired area of interest.

4. Results

The spatial distribution of future precipitation change factors is illustrated in Figure 3 for the more extreme (25, 50, 100-year) ARIs. From left to right the recurrence intervals increase, while from top to bottom the future projected time periods shift in 20-year windows from 2021 to 2100. The range of change factors is spread from 0.9 to 1.3, with values greater than 1 indicating future conditions that are wetter than historic. HUC-8 and WSMR boundaries are shown in black and red, respectively (Figure 3).

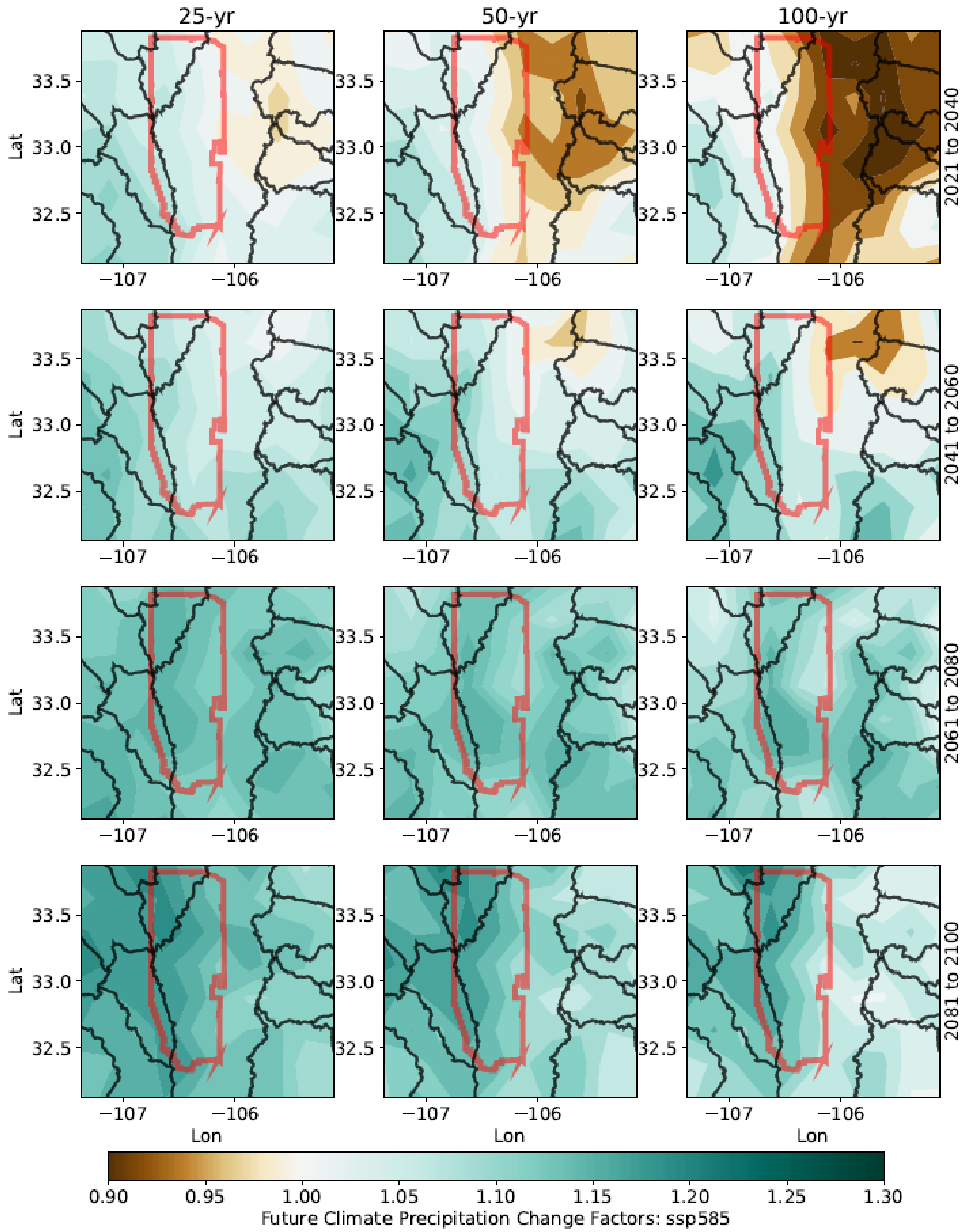

Figure 3. Spatial variability of future precipitation change factors over time (SSP5-8.5)

Example future IDF curves are shown in Figure 5 when applying the calculated future precipitation change factors to NOAA Atlas 14 design precipitation depths at a single grid point location for SSP5-8.5. Similar information can be analyzed at any grid point across WSMR for any of the four scenarios, four time periods, and six recurrence intervals and can be viewed via this online dashboard.

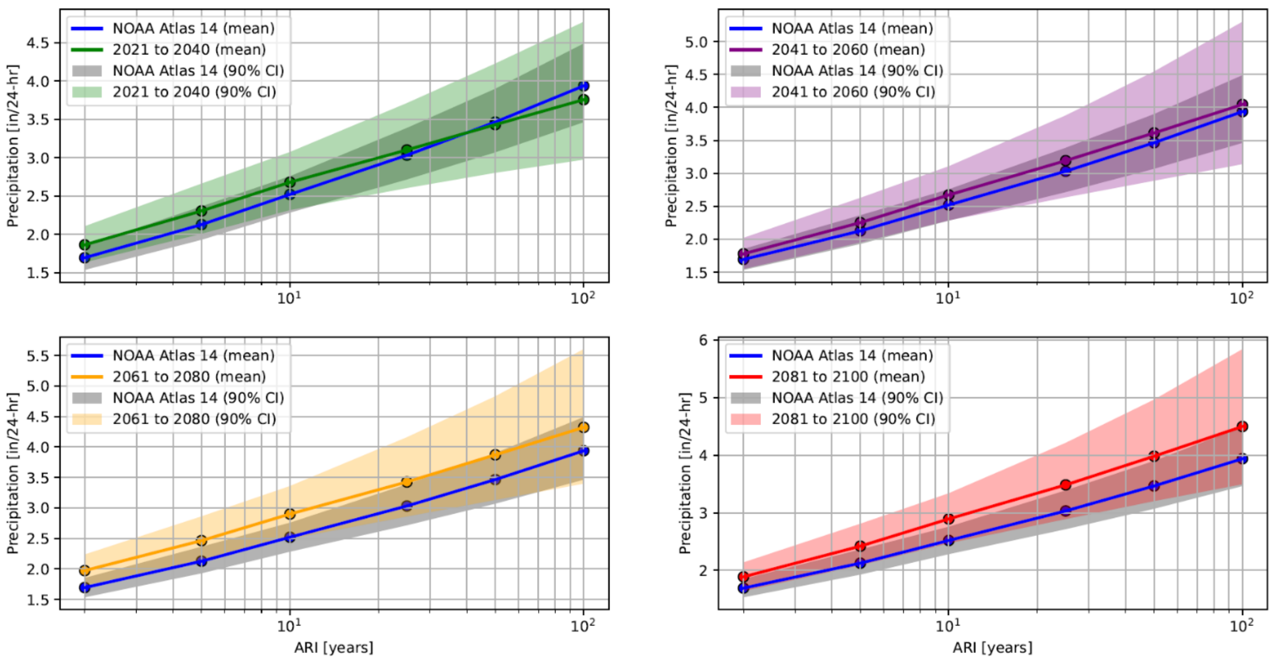

Figure 4. Example future design precipitation depths (SSP5-8.5 near north end of WSMR)

5. Conclusions

This study developed gridded future precipitation change factors for WSMR using the latest state-of-the-art future projections from CMIP6 and can now be readily leveraged in subsequent studies to assess future conditions in hydrologic analysis. These change factors are provided in four 20-year future periods and for four assumed scenarios to provide a flexible design period selection for planning.

The main finding from this study is that future extreme precipitation is expected to increase alongside increasing extreme temperature. When considering the design of new infrastructure, for a design life or less than or greater than 50-years, a minimum change factor of 10% should be applied to adequately account for future conditions. How these increases in precipitation will translate to runoff volumes and discharges is not directly clear. This uncertainty is due to unknown soil moisture conditions at the time of future rainfall events, along with unknown changes in landcover over time due to factors such as urban sprawl, forest fires, and woodland growth. However, there is consensus within the scientific community that precipitation increases for the more extreme storm events (i.e., 25, 50, and 100 ARI) will translate to increases in runoff volume and discharge. This is due to the intensity of the storm exceeding the basin's ability to modulate the runoff response. Therefore, the design of future infrastructure (e.g., culverts, building siting, levees, etc.) should consider modeling with increased precipitation to account for these changes. The results from this study can be readily accessed via the online dashboard, which also provides options to download a CSV and shapefile of the gridded data for further analysis.

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Appendix B WSMR Watershed Level Flood Control Conceptual Design Solutions

Note: Appendices of the WSMR Watershed Level Flood Control Conceptual Design Solutions report, including the fact sheets, are omitted from this document due to file size but are available upon request.

WHITE SANDS MISSLE RANGE WATERSHED LEVEL FLOOD CONTROL CONCEPTUAL DESIGN SOLUTIONS

November 9, 2023

FMF Pandion

Prepared by:
FMF Pandion
2235 Encinitas Blvd, Suite 107
Encinitas, CA 92024
(760) 405-6805

Submitted to:
White Sands Missile Range

IMPORTANT NOTICE

Executive Summary

White Sands Missile Range (WSMR) is a United States Army base located in Southern New Mexico south of Albuquerque, NM and to the northeast of Las Cruces, NM (Bell et al 2018). The climate is predominantly high steppe/dessert, which is classified as arid which is typical of the southwestern United States. Winds circulate from over the Gulf of Mexico and are the primary source of moisture for eastern New Mexico. Storms originating in the Pacific Ocean typically provide moisture to the San Andres Mountains. Winter is generally the dry season with light precipitation. The precipitation during the rainy season on WSMR is typically from July to September. Severe thunderstorms frequently produce significant rainfall. The White Sands Post does not have perennial stream flows in the area. However, the threat of flash flooding of the arroyos is possible (Jacobs 2009). This report focuses primarily on the White Sands Post areas (e.g., built up areas) (hereinafter referred to as "White Sands Post").

White Sands Post is located in an area susceptible to flooding from severe rainfall events over the Organ Mountains. Runoff flows easterly and is diverted around White Sands Post via a North and a South Arroyo (Bell et al, 2018). The area has sparse annual rainfall with a defined summer monsoonal season in July. The most significant known storm for the area occurred on August 19, 1978. This storm produced ten inches of precipitation over a five-hour period. Storms of this nature can make the arroyos surrounding White Sands Post unpredictable and dangerous (Jacobs 2009). Several major floods have occurred over the past few decades, most recently in 2021.

This report recommends BMPs to control, minimize, or adapt to flood risks and mitigate erosion on WSMR. Flood Control BMP recommendations vary based on site / location specific factors. This document is not intended to limit available flood control BMPs. It presents a high-level approach for flood control BMPs to consider. Actual implementation is recommended to occur on a site-by-site basis while taking into account flood control across the entire base.

Mitigating flood control risks should be conducted using a holistic approach. The entire White Sands Post, and surrounding areas that either impact the Post, or the base may impact (including but not limited to communities, highways, National Parks, Refuges, and Monuments, and Holloman AFB), should be considered. Improvements should not be implemented in isolation. What solves a problem in one area may create or worsen a problem in another area.

This report further seeks to apply an approach that will allow improvements selected based on current conditions to continue to function during future conditions. Predicting the weather two weeks out is challenging enough. The effects climate change will ultimately have on WSMR remain unknown and can only be hypothesized. What effect modified global weather will have on selected locations in the future will likely vary considerably. However, increased rainfall amount and intensity along with hotter and drier average conditions is one possible outcome. This report assumes that rainfall amount and intensity will increase in future years in combination with hotter and drier conditions. This has the likely potential to affect vegetation cover and soil moisture conditions. This combination may lead to increased storm runoff with higher sediment loads along with increased wildfire risk.

While emergency measures may be required to mitigate immediate flood risks, this report is not intended to be used to determine emergency measures.

Current flood control improvements are being implemented based on recommendations and conceptual designs completed in 2017 (Northwind 2017). These improvements include the following activities:

- Extend and increase the levee height on the west, south, and north side of White Sands Post.
- Install four retention ponds on the north (2), west (1), and south (1) sides of White Sands Post.
- Increase the size of the north and south arroyo crossings.

The improvements currently being undertaken are generally designed to provide end of the line protection to White Sands Post. They are designed to protect against storm flows coming down from the Organ Mountains. These improvements are generally in line with the recommendations of this report to protect the immediate camp area.

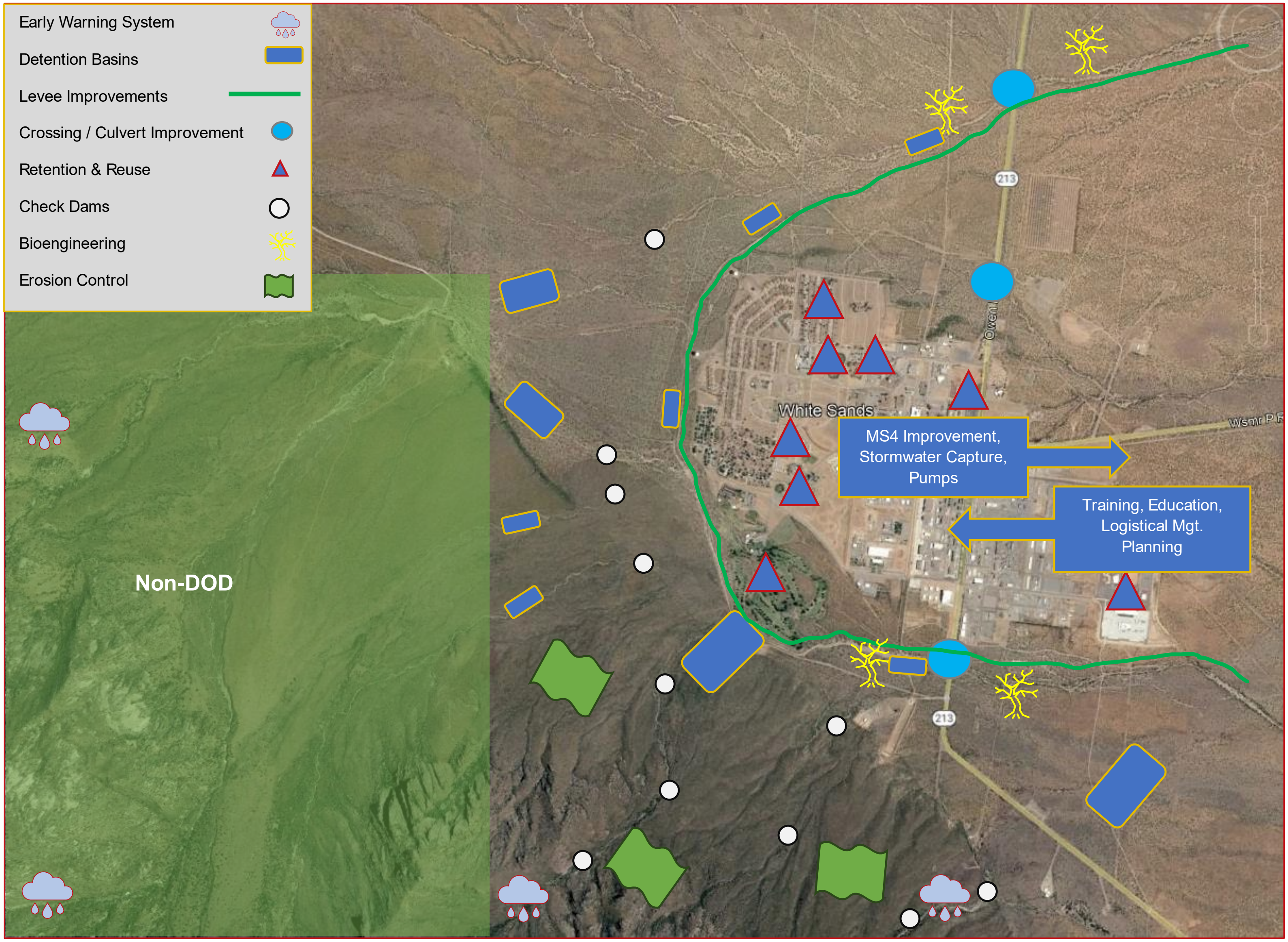
BMPs must be maintained. While the set it and forget it approach has long been sought, it remains unrealistic. Buildings, roads, vehicles, military gear and a wide range of other items require periodic routine and sometimes emergency maintenance to perform properly. BMPs also require periodic routine and emergency maintenance. A critical component of the approach outlined in this report is that funding and scheduling of BMP maintenance should be implemented at the same time BMP design and installation / implementation occurs. Maintenance standard operating procedures (SOPs) should be developed parallel to BMP design.

Modeling hydrologic conditions based on current conditions is the general historical approach to selecting and sizing BMPs. However, potential impacts from climate change may alter runoff in future years. The following should be taken into account related to future flow and sediment load conditions:

- Increased Rainfall Amount and Intensity
- Drier Soils
- Altered Vegetation Communities
- Increased Wildfires

The White Sands Post is located at the base of the Organ Mountains as described in Section 1. Higher rainfall amounts at higher elevations in the Organ Mountains flow down the mountains and onto the bajadas, which the White Sands Post borders. Flooding near bajadas can occur with little or no rainfall at the lower elevations. Storm flows from rainfall at higher elevations can sometimes surprise anyone at lower elevations who has not received any rainfall. The Watershed level concept presented in this report moves from higher elevations to lower elevation. Figure 0-1 illustrates this approach.

Figure 0-1.Flood Control Conceptual Design



Details regarding each of the BMPs presented in Figure 0-1 are presented within this report.

Non-structural recommendations include but are not limited to planning updates, logistical preparation, and conducting exercises in advance of flood conditions to improve response times during actual flood events.

This report presents conceptual options to mitigate flood risks to White Sands Post. A high-level concept along with a summary of potential improvements is presented. It is important to note that this report is conceptual in nature. Additional studies are recommended to be completed to determine future activities.

While the 2017 improvements are being implemented, it is recommended that an early warning system be given strong consideration. Additionally, the non-structural recommendations are also recommended to be implemented.

Hydrologic modeling utilizing the updated climate model along with the factors presented in this report are also recommended. Updated future forecasted flow conditions are considered a critical step in identifying, sizing, and siting, additional flood control improvements to implement.

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Appendixes

Acronyms

Acronym	Definition
BMP	best management practice
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
SOP	standard operating procedure
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
WSMR	White Sands Missile Range

Crosswalk

Scope of Work Requirement	Report Section
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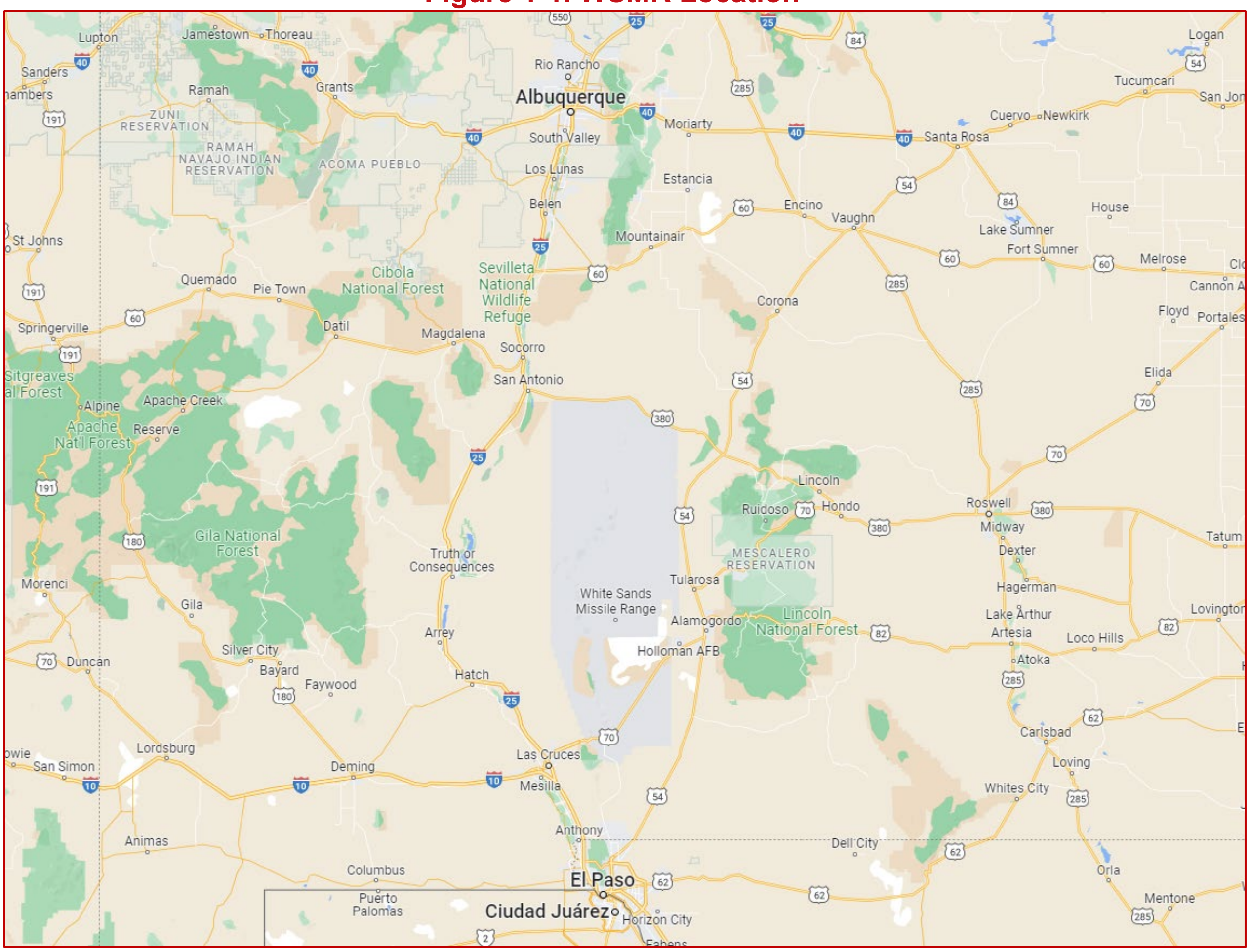
1 Introduction

1.1 WSMR

1.1.1 Location

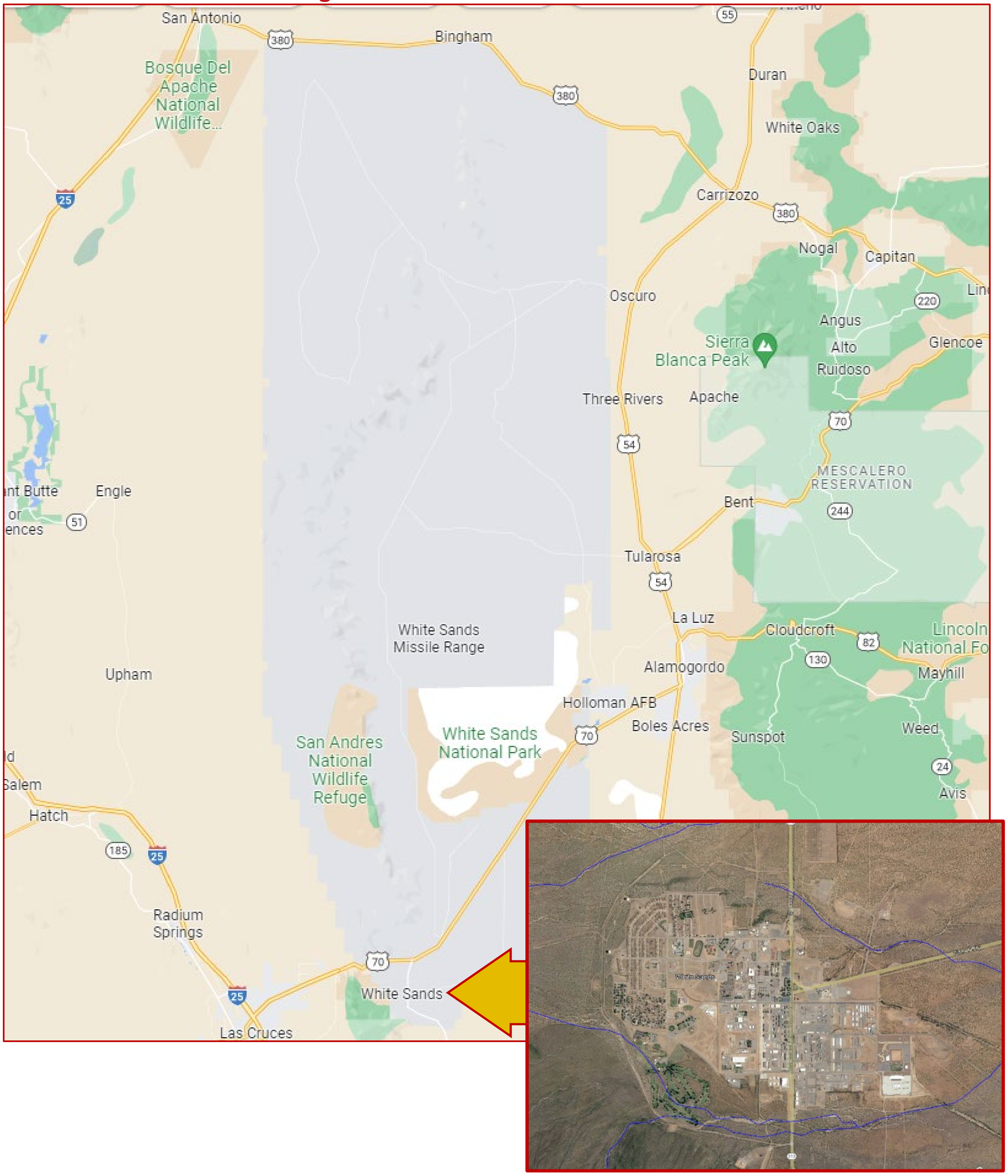
White Sands Missile Range (WSMR) is a United States Army base located in Southern New Mexico south of Albuquerque, NM and to the northeast of Las Cruces, NM (Bell et al 2018). The base is approximately 100 miles north to south and at 40 miles at its widest point from west to east. The majority of WSMR lies within the Tularosa Basin and is generally low lying landscape with the San Andres, Organ, and Oscura Mountains to the west and the Sacramento Mountains to the east. The White Sands Post is at elevation of approximately 4,250 feet (Jacobs 2009). Salinas Peak is the highest point at 8,967 ft.[1] Figure 1-1 illustrates WSMR location. Figure 1-2 illustrates White Sands Post.

Figure 1-1. WSMR Location[2]



[1] https://en.wikipedia.org/wiki/Salinas_Peak accessed on November 9, 2023.
[2] Image courtesy of https://www.google.com/maps.

Figure 1-2. White Sands Post Area[3]



[3] Images courtesy of https://www.google.com/maps.

1.1.2 Physical Description

The higher mountain area has sparse vegetation limited to areas of soil or to cracks and fissures in the rock. Vegetation includes grasses, mountain-mahogany, pinon pine, on-seed juniper and Gambel oak. The foothill area between the Post and the mountain slopes consists of gravelly sandy sediments on alluvial fans that have been incised by small ephemeral arroyos. Mid and short grass, chamiza, soaptree yucca, mesquite, broom snakeweed and annuals make up the vegetation in this area (Jacobs 2009).

The climate is predominantly high steppe/dessert, which is classified as arid. Which is typical of the southwestern United States. Abundant sunshine, relatively low humidities, slight rainfall, and a wide range in daily temperature variations are common. The area is classified by moderately severe, semi-arid high desert, continental, with summers having hot, dry days and moderate nights and typically cool winters. Annual rainfall averages approximately ten inches in the basin and seventeen inches at higher elevations (8,000 feet) (Jacobs 2009).

Winds circulate from over the Gulf of Mexico and are the primary source of moisture for eastern New Mexico. Storms originating in the Pacific Ocean typically provide moisture to the San Andres Mountains. Winter is generally the dry season with light precipitation (Jacobs 2009).

The precipitation during the rainy season on WSMR is typically from July to September. Severe thunderstorms frequently produce significant rainfall. The White Sands Post does not have perennial stream flows in the area. However, the threat of flash flooding of the arroyos is possible (Jacobs 2009).

This report focuses primarily on the White Sands Post as shown in Figure 1-2. However, the solutions proposed in this report should be considered for flood control across the entire WSMR base where applicable.

1.1.3 Flood Risk

White Sands Post is located in an area susceptible to flooding from severe rainfall events over the Organ Mountains. Runoff flows easterly and is diverted around White Sands Post via a North and a South Arroyo (Bell et al, 2018). The area has sparse annual rainfall with a defined summer monsoonal season starting in July and ending in October. This coincides with the Atlantic Ocean hurricane season. The most significant known storm for the area occurred on August 19, 1978. This storm produced ten inches of precipitation over a five-hour period. Storms of this nature can make the arroyos surrounding White Sands Post unpredictable and dangerous (Jacobs 2009). Several major floods have occurred over the past few decades, most recently in 2021. The road leading into WSMR is named Owens Road. This road is named after Private First Class Marvin Owen who tragically lost his life during a 1978 flood while attempting to rescue a family of four[4]. This road now stands as a reminder of the risks flooding possess at WSMR. Figure 1-3 illustrates the tributary area around White Sands Post. Figure 1-4 illustrates the Tularosa Hydrologic Unit which WSMR lies primarily inside.

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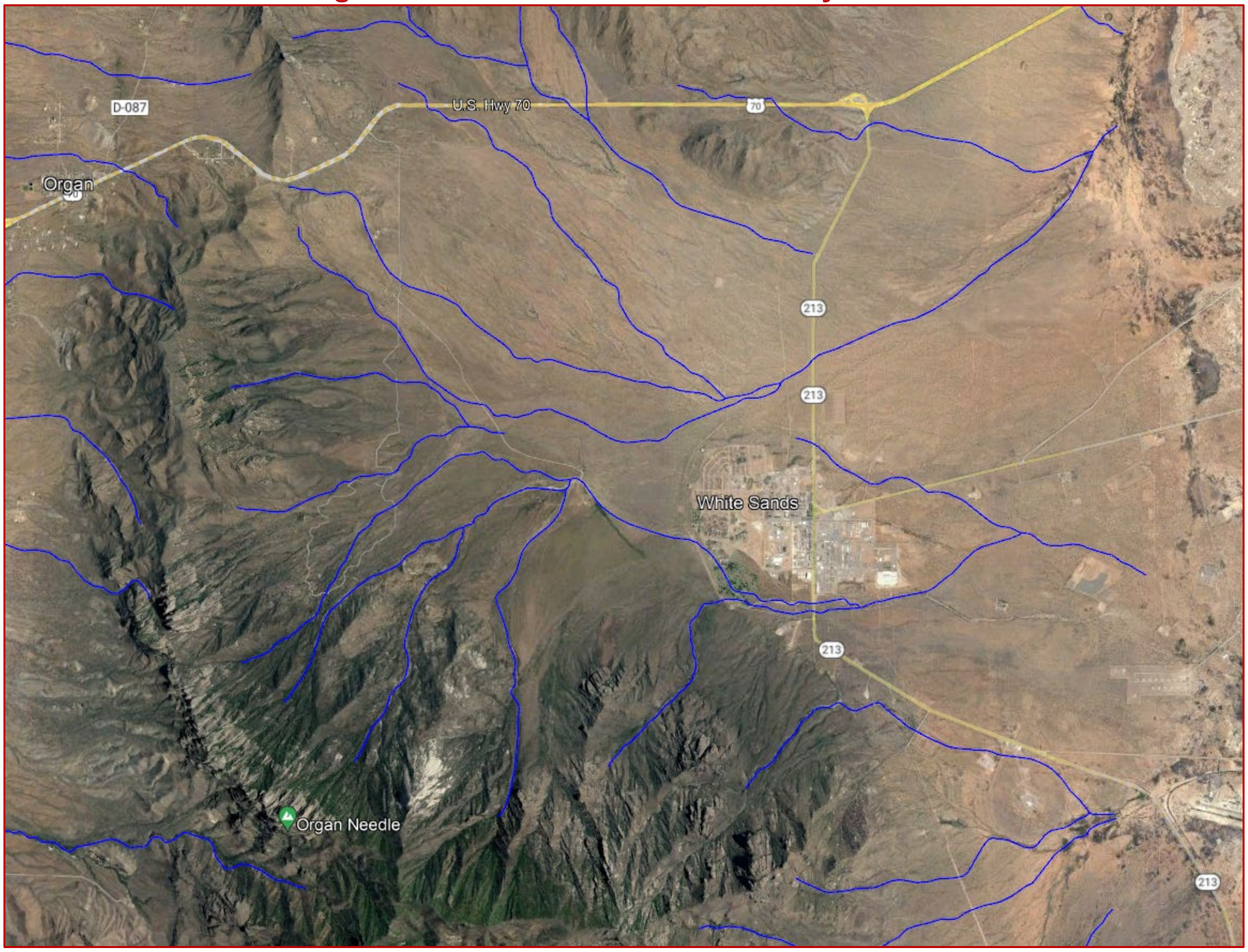
[4]https://www.lcsun-news.com/story/news/local/community/2021/07/14/wsmrs-owen-road-has-history-flooding-army-base-white-sands-missile-range-thunderstorm-mudslide-us-70/7972339002/ accessed 7/17/2023.

Figure 1-3. White Sands Post Tributary Area[5]

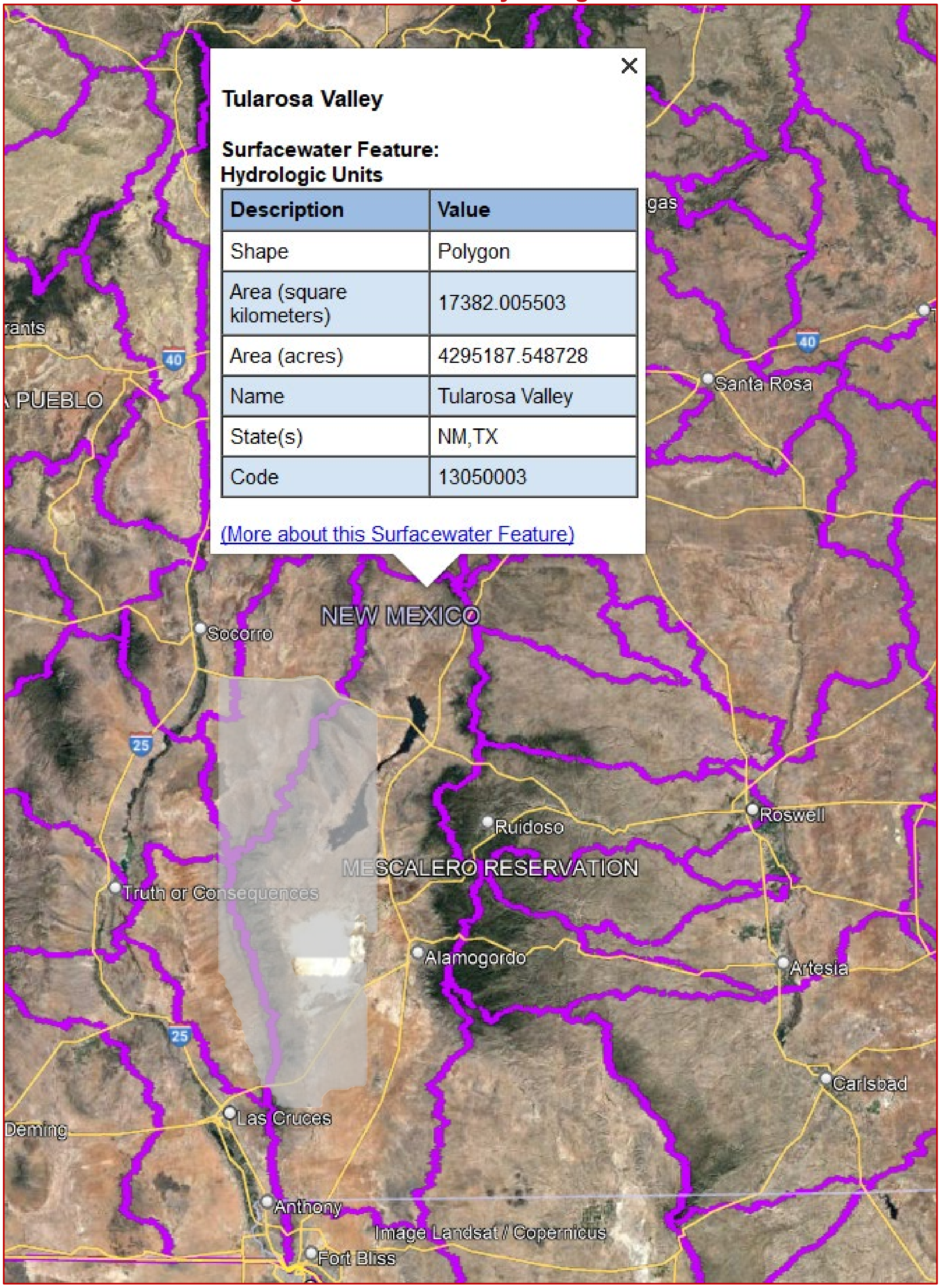


Tributaries, catchments, and other water features can be viewed in more detail using Google Earth Pro in combination with the Environmental Protection Agency (EPA) WATERS Data layer. This information is provided for informational purposes only and it does not represent an endorsement by either FMF Pandion or this report. Links to Google Earth Pro and the EPA WATERS Data layer are presented below. These links are valid as of August 3, 2023.

- https://www.google.com/earth/about/versions/#download-pro
- https://www.epa.gov/waterdata/viewing-waters-data-using-google-earth

[5] https://www.epa.gov/waterdata/viewing-waters-data-using-google-earth accessed 8/1/2023.

Figure 1-4. WSMR Hydrologic Unit[6]



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[6] https://www.epa.gov/waterdata/viewing-waters-data-using-google-earth accessed 8/1/2023.

1.2 Report Context

This report is intended to function as a toolbox of ideas related to managing flood control risks. This report uses best management practices (BMPs) and improvements interchangeably. BMPs can be either structural (detention basin) or non-structural (planning / education) while improvements are typically structural in nature (levees). This report is not intended to be exhaustive, nor does this report seek to limit the range of available options to decision makers to the BMPs presented in this report. This report is intended to be a starting point in this process. Site specific criteria must be taken into account when ultimately selecting the appropriate BMP of the proper size to place in the correct area.

1.3 Report Intention and Limitations

This report recommends BMPs to control, minimize, or adapt to flood risks and mitigate erosion on WSMR. Flood Control BMPs have recommended areas for location. This document is not intended to limit available flood control BMPs. It presents a high-level approach for flood control BMPs to consider. Actual implementation is recommended to occur on a site-by-site basis while taking into account flood control across the entire base. Flood Control BMPs should not be implemented in isolation of each other. What may fix a risk in one area may increase risk in another area. Consideration of impacts to upstream, downstream, and surrounding areas should be undertaken prior to implementing a BMP.

This report also seeks to maintain natural stream, wetland, and flood plain functions. Channelizing the streams as they cross WSMR while effective, would be costly, and would result in loss of significant natural river functions and habitat area. This was a popular approach in previous decades. However, this led to an understanding of the importance of maintaining geomorphologic function and habitat in stream systems both for water quality, flood control, and biodiversity.

Permitting is assumed to be completed on a project-by-project basis and is not addressed in this report.

Mitigation for projects is assumed to completed on a project-by-project basis and is not addressed in this report.

This report breaks BMPs into two types, structural and non-structural. Structural solutions must be built, while non-structural solutions are primarily related to planning and education.

This report further breaks BMPs into two categories, flood control, and erosion control (including post fire erosion control).

Example drawings, schematics, and / or figures are presented in this report. However, they are not intended to be utilized during the actual conceptual design phase. Site specific factors including but not limited to hydrology, hydraulics, geology, sediment load, habitat impacts, permitting requirements, available space, and surrounding area should be taken into account for each flood control improvement before ultimately implemented. Appendix A also provides publicly available BMP fact sheets that can be further used by WSMR.

1.4 Report Approach

This report recommends an approach be adopted that seeks to proactively mitigate flood risks, not a reactive one which considers the immediate impacts based on current conditions. This report proposes a proactive approach to mitigate flood risk that includes the following two main factors:

1.4.1 Holistic Approach

Mitigating flood control risks should be conducted using a holistic approach. The entire White Sands Post, and surrounding areas that either impact the Post, or the base may impact (including but not limited to communities, highways, National Parks, Refuges, and Monuments, and Holloman AFB), should be considered. Improvements should not be implemented in isolation. What solves a problem in one area may create or worsen a problem in another area.

1.4.2 Generational Approach

This report further seeks to apply an approach that will allow improvements selected based on current conditions to continue to function during future conditions. Predicting the weather two weeks out is challenging enough. The effects climate change will ultimately have on WSMR remain unknown and can only be hypothesized. What effect modified global weather will have on selected locations in the future will likely vary considerably. However, increased rainfall amount and intensity along with hotter and drier average conditions is one possible outcome. This report assumes that rainfall amount and intensity will increase in future years in combination with hotter and drier conditions. This has the likely potential to affect vegetation cover and soil moisture conditions. This combination may lead to increased storm runoff with higher sediment loads along with increased wildfire risk. This report seeks to incorporate planning for this potential outcome into currently planned and future improvements.

1.4.3 Emergency Measures

While emergency measures may be required to mitigate immediate flood risks, this report is not intended to be used to determine emergency measures. Longer term solutions should be identified and implemented to replace emergency measures once the immediate risk has passed. Similarly, emergency measures should not be relied upon for long term mitigation of flood risks.

1.4.4 Summary

In summary, flood control should be addressed looking at the entire Post and/or base and surrounding communities holistically while also assuming increased rainfall amount and intensity along with higher sediment loads due to drier and hotter average conditions.

2 Currently Planned Improvements

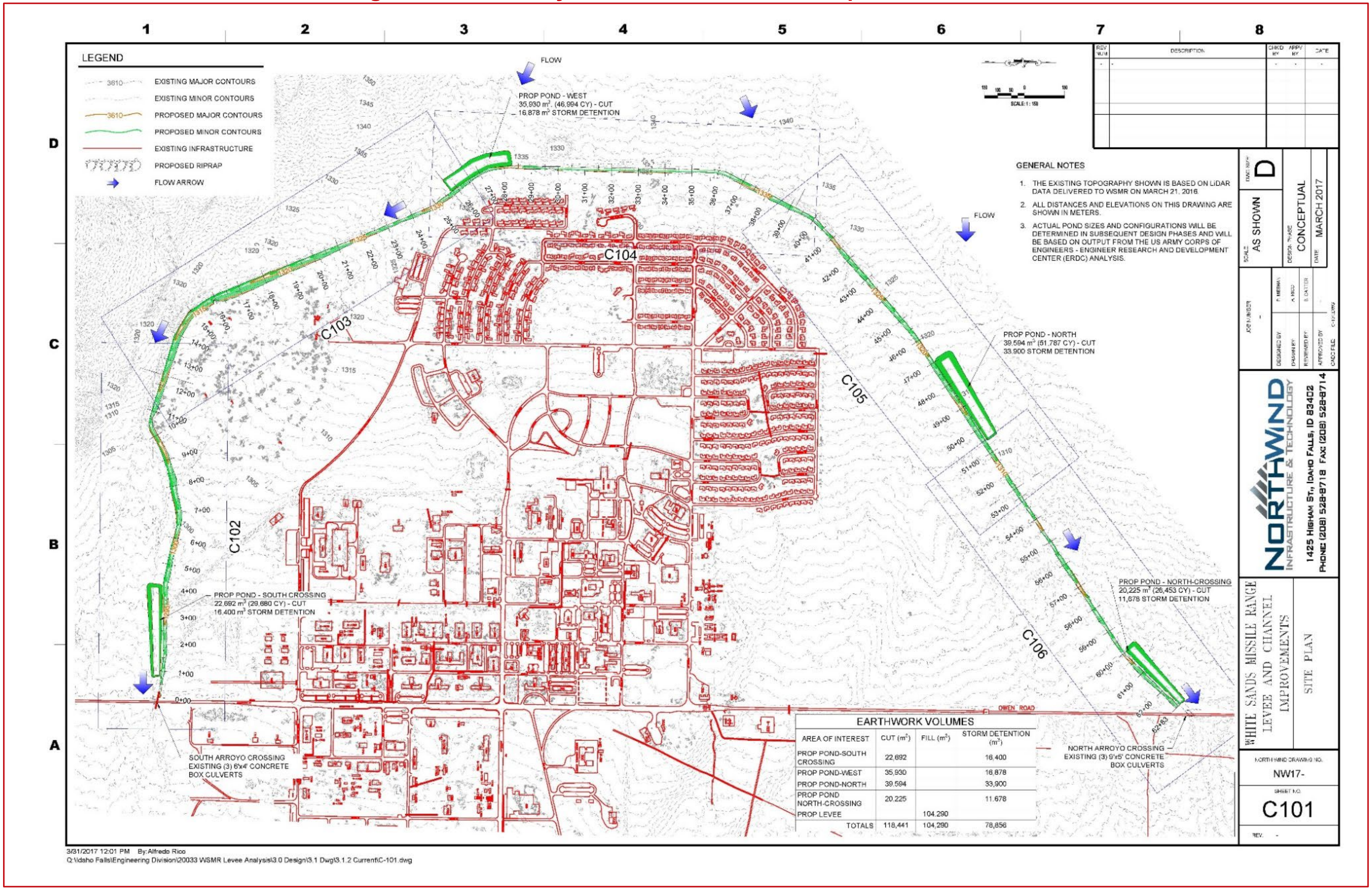
This is a summary of known currently planned flood control improvements. It is not intended to be exhaustive.

Current flood control improvements are being implemented based on recommendations and conceptual designs completed in 2017 (Northwind 2017). These improvements include the following activities:

- Extend and increase the levee height on the west, south, and north side of White Sands Post.
- Install four retention ponds on the north (2), west (1), and south (1) sides of White Sands Post.
- Increase the size of the north and south arroyo crossings.

The improvements currently being undertaken are generally designed to provide end of the line protection to White Sands Post. They are designed to protect against storm flows coming down from the Organ Mountains. These improvements are generally in line with the recommendations of this report to protect the immediate camp area. This report provides additional recommendations to slow and reduce water and sediment volume prior to flood waters reaching the currently planned improvements and also additional recommendations within the camp itself. Figure 2-1 illustrates the currently planned improvements.

Figure 2-1. Currently Planned Flood Control Improvements



3 Maintenance Consideration

BMPs must be maintained[7]. While the set it and forget it approach has long been sought, it remains unrealistic. Buildings, roads, vehicles, military gear and a wide range of other items require periodic routine and sometimes emergency maintenance to perform properly. BMPs also require periodic routine and emergency maintenance.

BMPs typically have recommended maintenance intervals. Often, these recommended maintenance intervals are based on best case scenarios tested in laboratory settings. They do not take into account site specific factors and / or factors not accounted for in laboratory settings.

A critical component of the approach outlined in this report is that funding and scheduling of BMP maintenance should be implemented at the same time BMP design and installation / implementation occurs. Maintenance standard operating procedures (SOPs) should be developed parallel to BMP design. It is recommended that the required maintenance funding be programmed into annual workplans to cover the maintenance costs for projects.

Tracking and scheduling of BMP locations and maintenance should be conducted. BMPs in remote locations may be easily forgotten. Maintenance may become a task that is easy to defer. However, BMPs that are not properly maintained may exacerbate existing flood risks. A system that produces reminders for BMP inspections and maintenance is recommended.

Additionally, the same BMP in different areas often requires a different maintenance cycle. Initial increased observations / inspections of BMPs to gauge proper maintenance cycles is critical to maintaining BMP functionality. A detention basin in one area may have limited sediment influx and require maintenance on a longer timeline than one in an area with sediment rich storm flows. This applies to both proprietary and non-proprietary BMPs. A proprietary solution will come with a manufacturer's recommended maintenance schedule. However, it is recommended that this be considered as an initial guideline and observations / inspections should be conducted to develop a maintenance schedule that is specific to that BMP at that site.

Maintenance recommendations stated in this document should be considered starting points only and performance observations should be conducted to determine site and/or BMP specific maintenance schedules[8]. Even bio engineering style BMPs require maintenance, typically on a longer cycle[9].

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7 https://www.epa.gov/npdes/stormwater-maintenance accessed 8/1/2023.
8 https://landstudies.com/hows-whys-stormwater-bmp-maintenance/ accessed 8/1/2023.
9 https://extensionpublications.unl.edu/assets/html/g1307/build/g1307.htm accessed 8/1/2023.

4 Hydrologic Modeling Considerations

Modeling hydrologic conditions based on current conditions is the general historical approach to selecting and sizing BMPs. However, potential impacts from climate change may alter runoff in future years. This section presents several hypothetical conditions that may occur in future years that may lead to increased runoff amount and intensity. It is recommended that these potential conditions are taken into account when hydrologic modeling is conducted to select and size BMPs. While this will likely result in BMPs oversized for current conditions, it will hedge future BMP performance in the event runoff amount and intensity increase. While this may result in increased costs, the cost to replace an undersized BMP in the future would be significantly higher.

4.1 Potential Increased Future Runoff

Several factors that may increase runoff volume are presented below. These factors are not intended to be an exhaustive list. They are intended to be the primarily identified potential drivers of increased runoff. It is also important to consider that the factors presented below would likely have a synergistic affect creating greater runoff amount together than individually.

4.1.1 Increased Rainfall Amount and Intensity

Climate change may increase both rainfall amount and intensity[10]. This may occur on an individual and / or annual basis. Hotter and drier conditions may occur leading to less rain annually. However, when rain does occur, it may potentially have greater than current average amount and intensity. While rainfall amount is often focused on, rainfall intensity is critical in proper BMP design sizing. BMPs typically are designed for a selected flow rate. This flow rate may be based on average storm amount over an average storm time period. However, if either amount or intensity increase, they have the potential to turn a BMP that is appropriately sized for current conditions into an undersized BMP.

- To account for this factor, outputs from a climate change model are recommended to be used. Additionally, rainfall intensity observed during past flood events is recommended to be considered when sizing BMPs.

4.1.2 Drier Soils

Water retention in terrestrial ecosystems is expected to be lower as climate change impacts increase[2]. Soils that are subject to hotter and drier conditions have reduced soil moisture. While some soils may increase absorption due to this, soils with high clay content may form a hard surface layer that can initially lead to increased runoff during the early stages of a storm event. This is known as soil crusting[11] Soils with lower soil moisture may also be easier to be transported in runoff waters due to reduced binding to hold them together. Wind may also remove drier soils. Over time, more absorbent surface soils may be removed and underlying soils or bedrock may have limited ability to absorb runoff. This in turn leads to increased runoff.

- To account for this, using a higher runoff coefficient when modelling is recommended. Additionally, selection of BMPs amenable to high sediment loads is recommended.

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[10] https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019EF001398 accessed 8/1/2023.
[11] https://www.ndsu.edu/agriculture/ag-hub/ag-topics/crop-production/soil-health/aggregation-erosion/soil-crusting accessed on 8/1/2023.

4.1.3 Altered Vegetation Communities

Vegetation communities are typically determined by temperature, moisture, soil type, elevation and other factors. Recently, record breaking heat in Arizona has resulted in the death of cactus that are adapted to live in hot dry climates[12]. While this is an anecdotal observation based on recent events, it is also an indication that even plants adapted for hot dry climates are likely to be affected by hotter drier conditions that climate change may cause. Soils rely on the vegetation communities above them to slow the impact of rain drops, and vegetation roots to hold them together. Climate change may result in the loss of vegetation cover or change in vegetation community. In these scenarios, soil may be exposed to greater erosion risk which in turn would result in higher sediment loads in runoff water and increased runoff water volume.

- To account for this, using a higher runoff coefficient when modelling is recommended. Additionally, selection of BMPs amenable to high sediment loads is recommended.

4.1.4 Increased Wildfires

Potential hotter and drier conditions would likely increase the risk of wildfires. Vegetation communities may die or become drier than current conditions. While wildfire is currently a risk throughout the southwest, it varies each year in number of wildfires and area burned. Anecdotally, drier conditions lead to increased risk of wildfire. If climate change leads to hotter and drier conditions on WSMR, then the risk of wildfire would likely increase. Wildfire removes vegetation from the soils surface exposing it to greater erosion potential and increased runoff potential. Wildfires also change the soil moisture content depending on severity.[13]

- To account for this, using a higher runoff coefficient when modelling is recommended. Additionally, selection of BMPs amenable to high sediment loads is recommended.

[12] https://weather.com/news/weather/video/iconic-saguaro-cactus-cant-take-the-phoenix-heat accessed 8/1/2023.
[13] https://acsess.onlinelibrary.wiley.com/doi/10.2136/vzj2018.05.0099 accessed 8/1/2023.

4.2 Potential Increased Future Sediment Load

Each of the factors listed in section 4.1 also have the ability to lead to increased sediment load in runoff waters. Drier soils, altered vegetation, wildfires, and increased rainfall amount and intensity each have the ability to contribute more sediment load to runoff waters[14]. Together, they may have a synergistic affect and increase sediment load together more than they could individually.

Climate change also has the potential ability to alter predominant winds on WSMR. This may involve a shift in wind direction, or stronger winds. Increases in wind strength or changes in direction possess the ability to increase available sediment load within the watershed.

- To account for this factor, it is recommended that BMPs able to trap or pass anticipated sediment volumes be selected.
- Increased sediment load within the runoff waters will also likely require a more frequent BMP maintenance interval if rainfall conditions do become more intense.
- Consideration should be given to not select BMPs that may become inundated with sediment and thus ineffective.

[14] https://www.nature.com/articles/s41598-021-97574-z accessed 8/1/2023.

5 Watershed Level Concept

The White Sands Post is located at the base of the Organ Mountains as described in Section 1. Higher rainfall amounts at higher elevations in the Organ Mountains flow down the mountains and onto the bajadas, which the White Sands Post borders. Flooding near bajadas can occur with little or no rainfall at the lower elevations. Storm flows from rainfall at higher elevations can sometimes surprise anyone at lower elevations who has not received any rainfall. The Watershed level concept presented in this section moves from higher elevations to lower elevation. Table 5-1 presents the watershed level concept proposed by this report. Figure 5-1 illustrates this approach.

Table 5-1. Watershed Level Concept

Location	Recommended BMP
Organ Mountains, Bajada, White Sands Post	Rain gauge network for early warning of rainfall at high elevation
Organ Mountains, Bajada, White Sands Post	Stream gauge network for early warning of elevated stream flows
Bajada	Detention basins to slow and reduce flow prior to reaching White Sands Post
Stream Channels with Flood Plains	Improve flood plain connection through grading, bioengineering, or use of dam structures that do not inhibit low flows to reduce flow prior to reaching White Sands Post
Stream Channel upstream of Crossings	Bioengineering to protect crossings from scour
Post	Improved levees to protect the Post and lengthen to protect entire Post
Post	MS4 pump system in the event levees are breached
Post	Underground retention storage to reduce flows and reuse for irrigation
Civilian and Military Base Personal	Education and training related to flood risks
WSMR and Surrounding Agencies	Multiple agency flood response coordination ahead of time to speed response times during an emergency
WSMR	Development and redevelopment planning to locate structures out of flood risk areas
Organ Mountains, Bajada, White Sands Post	Temporary and permanent erosion control management due to wildfires and / or climate change impacts to minimize sediment load in storm flows

Figure 5-1. Watershed Level Concept[15]

[15] Base imagery Google Earth.

6 Flood Control Toolbox

This section presents general BMPs / improvements for consideration. This is not intended to be an exhaustive list of BMPs. BMPs presented in this section should be compared against each other and new technology / methods or existing BMPs not detailed in this section. Site specific evaluation is considered critical to implementing the correct BMP in the correct location.

6.1 Structural BMPS

Structural BMPs are required to be built or if prefabricated, emplaced. Space available to place or construct a BMP can often be a limiting factor in determining which BMP to select and also the capacity of that BMP.

6.1.1 Conveyance / Hydraulic Capacity

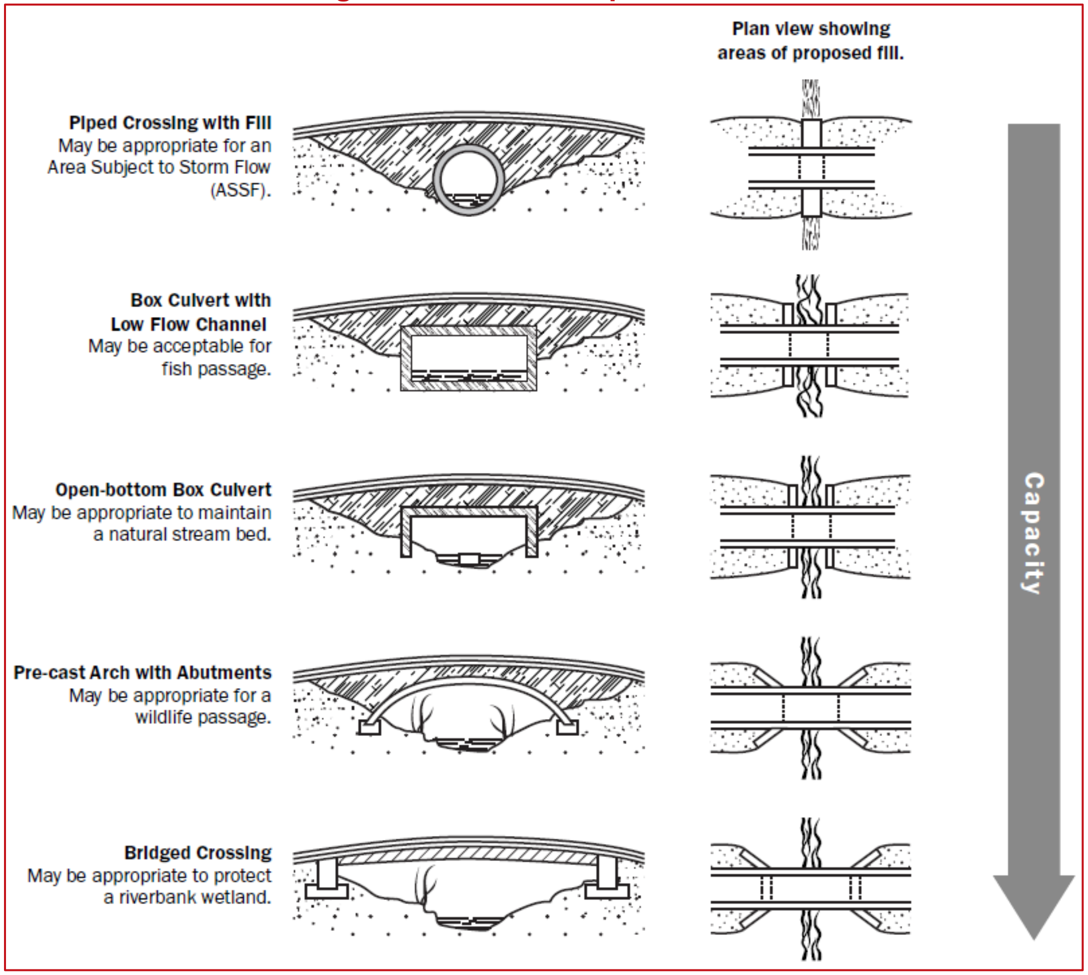
This section presents BMPs designed to increase the hydraulic capacity of the arroyos.

Table 6-1. Culvert Size Increase

Description	Replace existing culverts with larger culverts to increase hydraulic capacity.
Benefits	1. Increased hydraulic capacity. 2. Improved chance road to remain passable during floods.
Disadvantages	1. Sediment accumulation can reduce capacity. 2. Undersized replacements provide limited increased benefit. 3. Road closure during construction
Target Location	Channel crossings with existing undersized or no culvert(s).
Estimated Cost	$$ - $$$
Geographic Scale	Site specific.
Ecological Impact	Temporary during construction. Sites with current undersized culverts may experience improvement in ecological conditions due to less restricted flow. Sites that do not currently have a culvert may experience ecological impact due to restriction of stream channel.
Maintenance Requirements	Minimal once installed. Generally, no routine maintenance required if properly installed. Emergency maintenance due to erosion or infill by sediment may be required.
Notes	Care should be taken so that sedimentation of the culvert is minimized to maintain hydraulic capacity. Increased downstream scour potential should be mitigated using bioengineering techniques during installation. Bioengineering techniques should also be utilized upstream to prevent upstream scour.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1,000,000 - $10,000,000; $$$$$ = $10,000,000 - $100,000,000

Figure 6-1. Culvert Improvement[16]



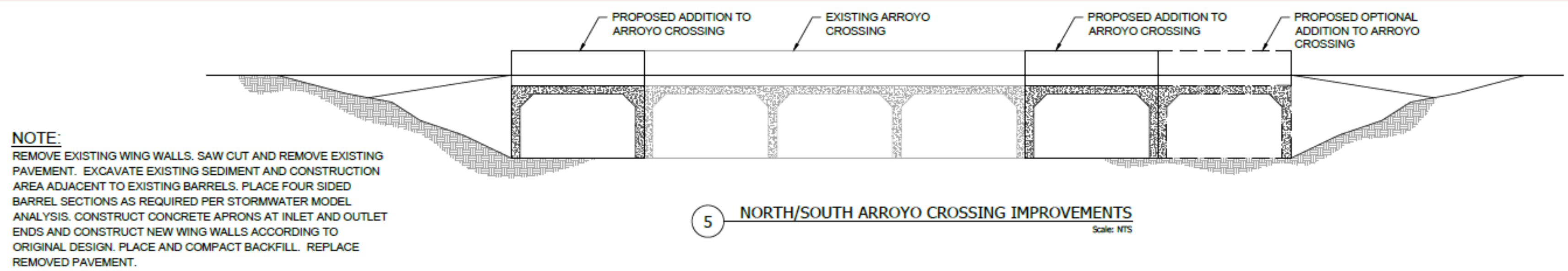
[16] Image courtesy of https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-1-3-drainage-culverts.pdf accessed 08/17/2023.

Table 6-2. Crossing / Bridge Improvement

Description	Widen existing bridges to increase hydraulic capacity.
Benefit	1. Increased hydraulic capacity. Improved chance road to remain passable during floods.
Disadvantages	1. Sediment accumulation can reduce capacity. 2. Undersized replacements provide limited increased benefit. 3. Road closure during construction
Target Location	Channel crossings with existing undersized bridge(s).
Estimated Cost	$$$$ - $$$$$
Geographic Scale	Site specific.
Ecological Impact	Temporary during construction. Sites with current undersized crossings may experience improvement in ecological conditions due to less restricted flow. Sites that do not currently have a crossing may experience ecological impact due to restriction of stream channel.
Maintenance Requirements	Minimal once installed. Generally, no routine maintenance required if properly installed. Emergency maintenance due to erosion or infill by sediment may be required within the stream channel. Structural repair may be required over time.
Notes	Care should be taken so that sedimentation of the crossing is minimized to maintain hydraulic capacity. Increased downstream scour potential should be mitigated using bioengineering techniques during construction. Bioengineering techniques should also be utilized upstream to prevent upstream scour of banks.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-2. Crossing Improvement[17]



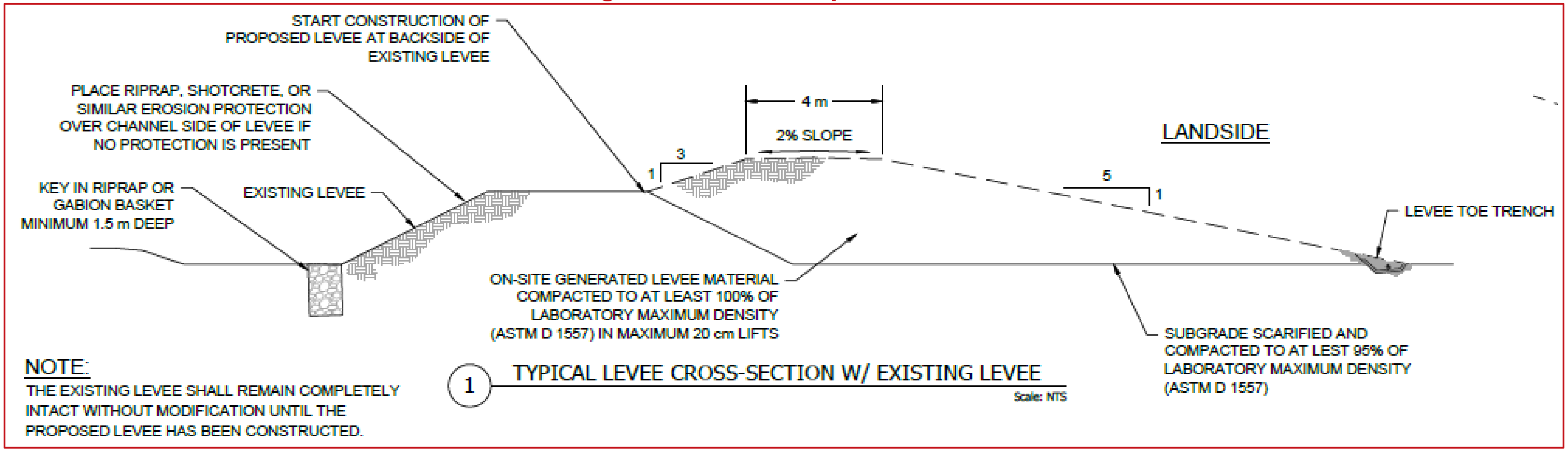
[17] Northwind, White Sands Missile Range Levee and Channel Improvements, 2017.

Table 6-3. Levees

Description	Implement new dykes and levees or increase the size and length of existing dykes and levees.
Benefit	1. Either channelizes water or shields one bank to protect urban areas. 2. May increase connection to floodplain on adjoining bank if only present on one side.
Disadvantages	1. Decrease flood plain area available to slow waters. 2. Loss of floodplain habitat. 3. Potential increase water velocity. 4. Potential increased channel incising. 5. If breached, they may act as a barrier to trap water in the urban areas they are meant to protect.
Target Location	Stream channels near built environment.
Estimated Cost	$$$ - $$$$$
Geographic Scale	Stream reach to watershed scale.
Ecological Impact	Potential significant ecological impact due to construction and alteration of stream morphology. Alteration of flow, potential channel incision, loss of flood plain.
Maintenance Requirements	Routine inspections to assess levee structural soundness. Repairs as needed based on routine inspections.
Notes	Levees are currently be heightened and lengthened around White Sands Post.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-3. Levee Improvement[18]



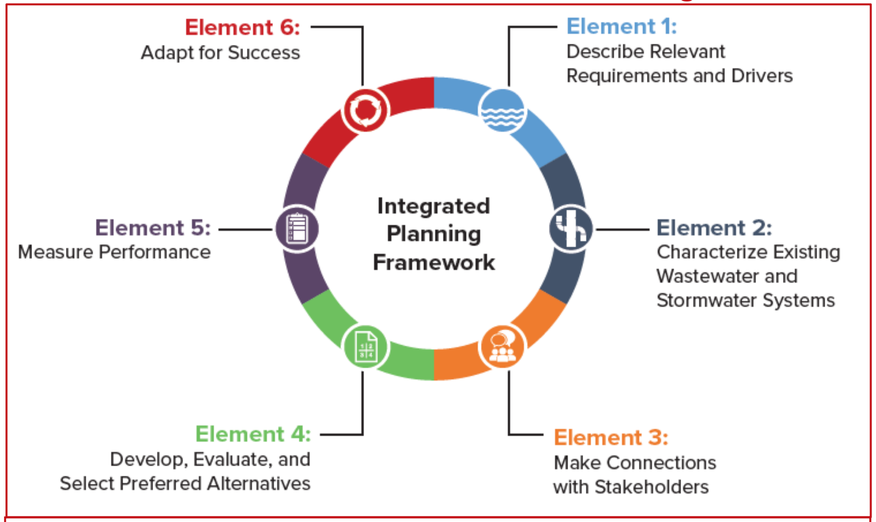
[18] Northwind, White Sands Missile Range Levee and Channel Improvements, 2017.

Table 6-4. Post MS4 Improvement

Description	The municipal sanitary storm sewer system (MS4) should be assessed to determine if existing pipe and drainage capacity is sufficient. Improvements should be undertaken to increase hydraulic capacity of White Sands Post MS4 if it is determined to be undersized for current conditions. Additionally, it is recommended that a pump system be installed with the capability to expedite storm flows out of White Sands Post. This is considered critical in the event that the levee system was breached.
Benefit	1. Minimize risk of street flooding during severe storms within White Sands Post. 2. Reduce risk of Post flooding in the event the levee is breached.
Disadvantages	1. Potential disruptions to Post area during construction. 2. Required maintenance of pumps. 3. Downstream effects of pump system.
Target Locations	White Sands Post
Estimated Cost	$$$$-$$$$$
Geographic Scale	Limited to built areas that require a municipal sanitary storm sewer system.
Ecological Impact	Limited due to area already being urbanized. Potential for increased flow from the built area.
Maintenance Requirements	Routine inspections. Cleaning and repairs based on routine inspection results.
Notes	Reducing the risk of flooding within White Sands Post should be considered critical. While current improvements seek to keep flood waters out of the Post area, consideration should also be given to severe storms causing flooding within the Post area itself. Climate change may increase this risk. Also, planning for levee failure is generally a reactionary undertaking. This report proposes that levee failure be planned for proactively by installing a pump system with the capabilities to quickly clear flood waters from the Post.

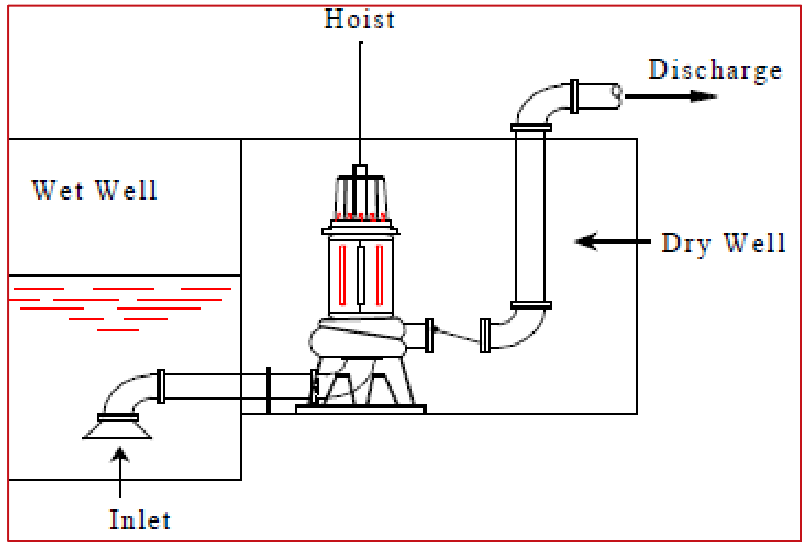
$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-4. MS4 Improvement[19]



Graphic from EPA integrated planning process for clean water. It also can be applied to flood control.

1. Mitigate flooding of White Sands Post.
2. What is the existing White Sands Post storm drainage network?
3. Connect civilian and military personnel who rely on the storm drainage network.
4. Select improvement options and construct or implement.
5. Evaluate short and long term efficiency.
6. Modify or adjust improvements based on performance.



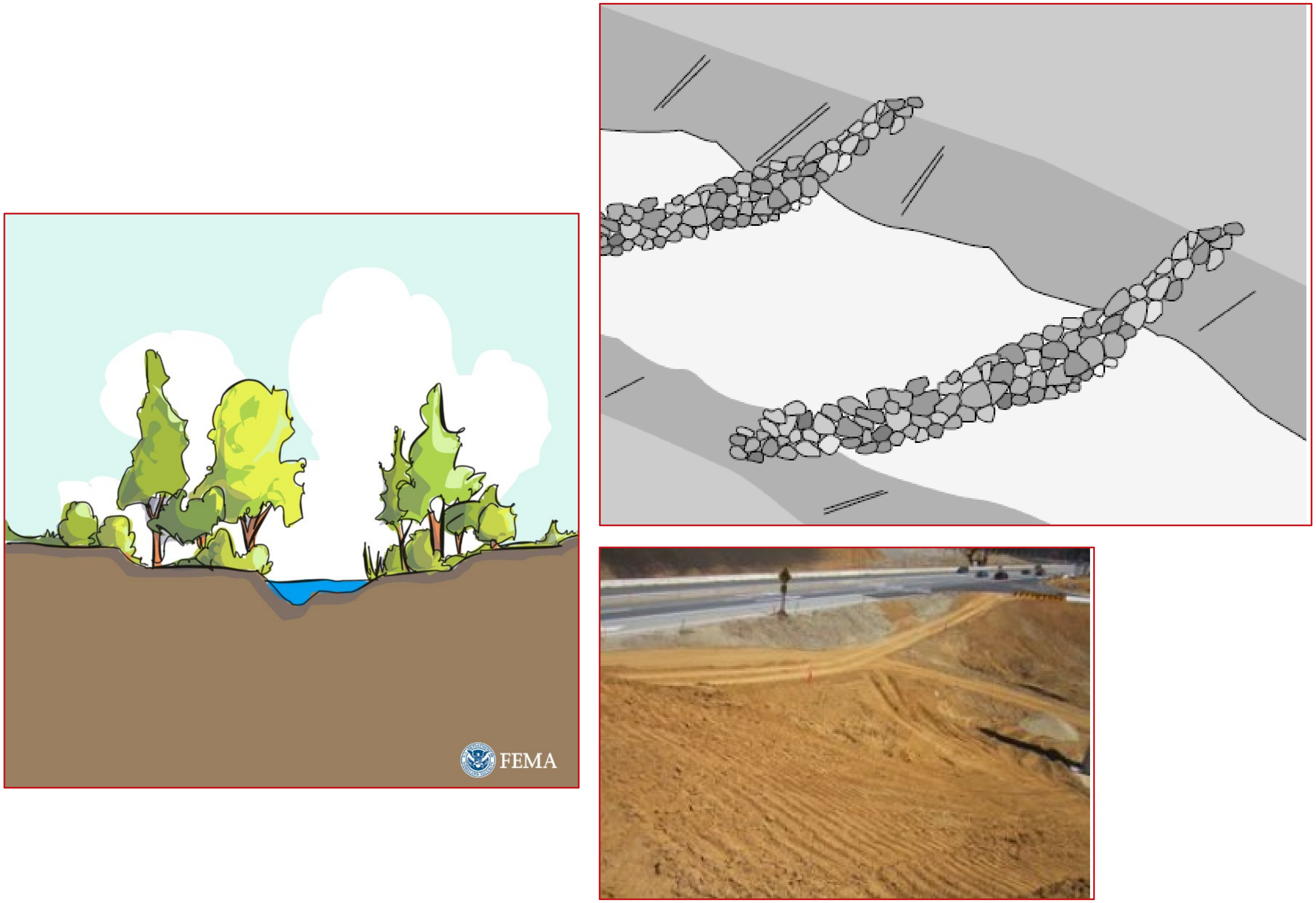
[19] Images courtesy of https://www.epa.gov/system/files/documents/2021-12/ip-facsheet_thebasics-2.pdf and https://www3.epa.gov/npdes/pubs/sewers-lift_station.pdf accessed 08/16/2023.

Table 6-5. Floodplain Connection

Description	Use either bioengineering or grading where possible to connect arroyo flows to surrounding floodplain area. Grading where the arroyo is shallow to increase connection to surrounding floodplain area. Bioengineering utilizing check dams that allow lower flows to pass uninhibited but elevate higher flows and connect them to the surrounding flood plain to spread and slow flows.
Benefit	1. Flood plains slow and infiltrate water. 2. Downstream flows reduced. 3. Potential downstream scour reduction.
Disadvantages	1. Permitting (e.g. stream alteration). 2. Potential downstream scour increase. 3. Potential sediment load increase.
Target Locations	Where stream and floodplain elevation are conducive to connection. Deeply incised areas are not considered conducive.
Estimated Cost	$$$-$$$$
Geographic Scale	Site to watershed in scale.
Ecological Impact	Short term potentially significant impact. Construction requires stream channel alteration to reconnect incised channels to flood plains. Revegetation or restoration likely also required. Long term benefits to habitat and wildlife.
Maintenance Requirements	Initial erosion control and revegetation. Long term maintenance of vegetation and stream channel until established.
Notes	Bioengineering techniques should be used. Check dams will act as weirs. Water will flow at 90 degrees from the weir and thus they must be angled properly to avoid unintended downstream scour. Water returning from the flood plain area may carry sediment and may incise channel banks. Care should be taken to protect channel banks in these areas using bioengineering techniques. This BMP involves work directly in the stream channel. Permitting may be difficult to obtain during non-emergency times. Emergency conditions may allow for a more streamlined permitting process. Thus, designing, planning, and identifying amenable site locations in advance is recommended. Cultural resource mitigation and UXO surveys may also be required due to excavation requirement.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-5. Floodplain Connection[20]



[20] Images courtesy of https://www.fema.gov/node/floodplain-restoration accessed, https://www.epa.gov/system/files/documents/2021-11/bmp-land-grading.pdf, and https://sswm.info/sites/default/files/reference_attachments/CASQA%202003%20Check%20Dams.pdf accessed on 08/17/2023.

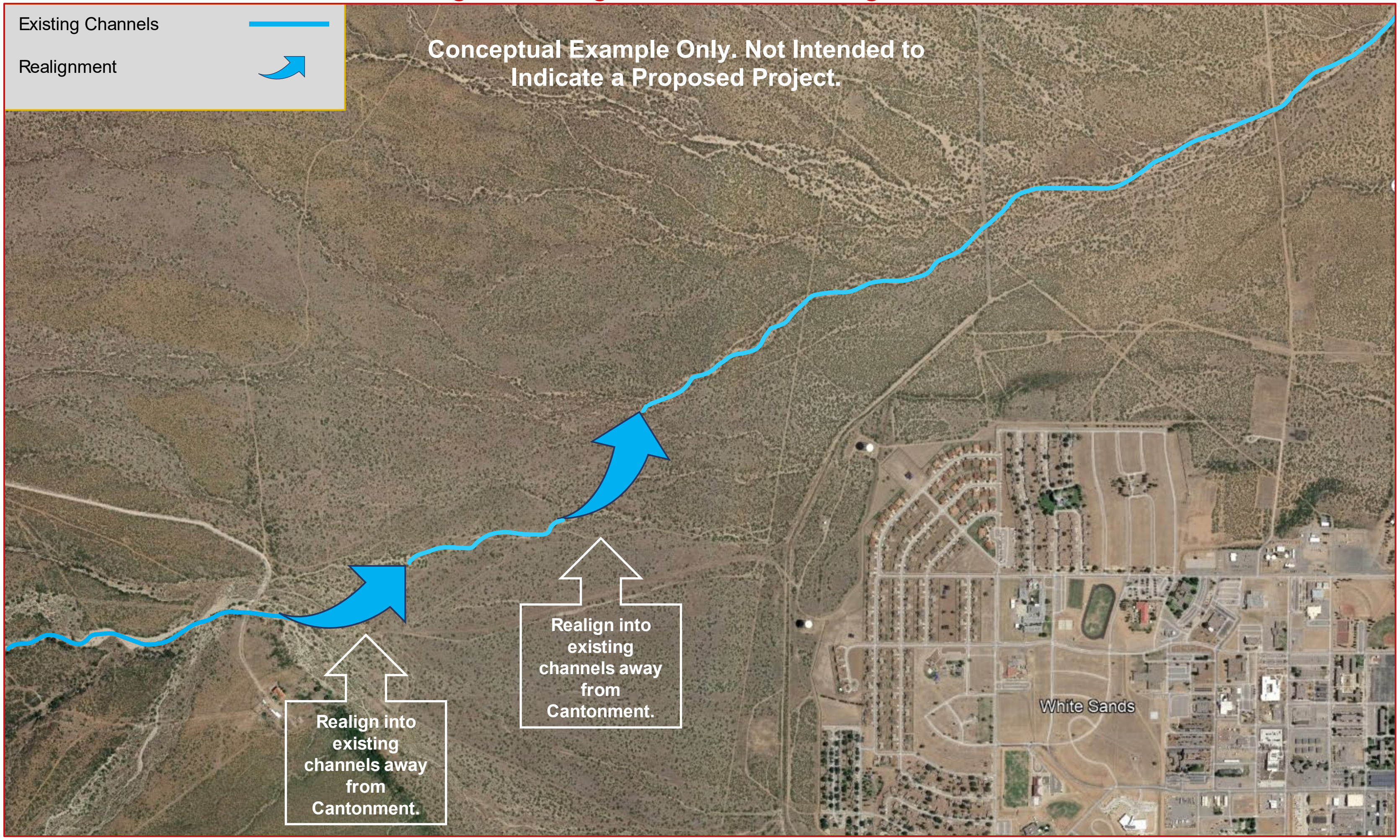
Table 6-6. Engineered Channel Realignment

Description	Streams migrate to different channels through time. Flood events can change the preferred channel for a stream. This is a naturally occurring process. The Colorado River serves as an example of this[21]. Through time, it has switched back and forth from flowing to the Gulf of California to the Salton Sea. Humans caused this channel migration once in the past. Based on satellite imagery, it appears that ranges in the area surrounding White Sands Post have undertaken significant excavation when constructed. Engineering a channel migration of the north and south arroyo that pass on the borders of White Sands Post would likely require less excavation than these ranges required to create. While the north and south arroyos that pass by White Sands Post would still carry storm flows. The volume could be reduced significantly by engineering a channel migration in the bajada area before the flows reach White Sands Post.
Benefit	1. Significantly reduced storm flows near the Post.
Disadvantages	1. Permitting. 2. Flow increase in diverted channel. 3. Increased incision in diverted channel. 4. Failure of the engineered diversion could result in significant flooding of the Post. 5. Neighbor agency coordination. 6. Cultural resource survey and possible site mitigations. 7. Wildlife habitat modifications.
Target Locations	Upstream of the Post in the bajada where a historic channel can be reconnected to.
Estimated Cost	$$$$-$$$$$
Geographic Scale	Watershed scale.
Ecological Impact	Potentially significant. Short term construction impacts. Long term results in lower flows and available water in channel aligned away from, higher flows in channel aligned to. Increased water in channel aligned to may result in incision, require culvert and/or crossing upgrades, and significant channel bioengineering to stabilize.
Maintenance Requirements	Similar to ecological impact. Significant maintenance required in channel aligned to. Channel grading, culvert and/or crossing upgrades, and significant channel bioengineering.
Notes	Permitting is likely not to be approved for this improvement. Flood conditions may result in the channel diverting back to the current channel. Significant mitigation of scour would need to be undertaken in the channel flows were diverted to.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

[21] https://scripps.ucsd.edu/news/flooding-ancient-salton-sea-linked-san-andreas-earthquakes accessed on 8/3/2023.

Figure 6-6. Engineered Channel Realignment[22]



22 Base Imagery Google Earth.

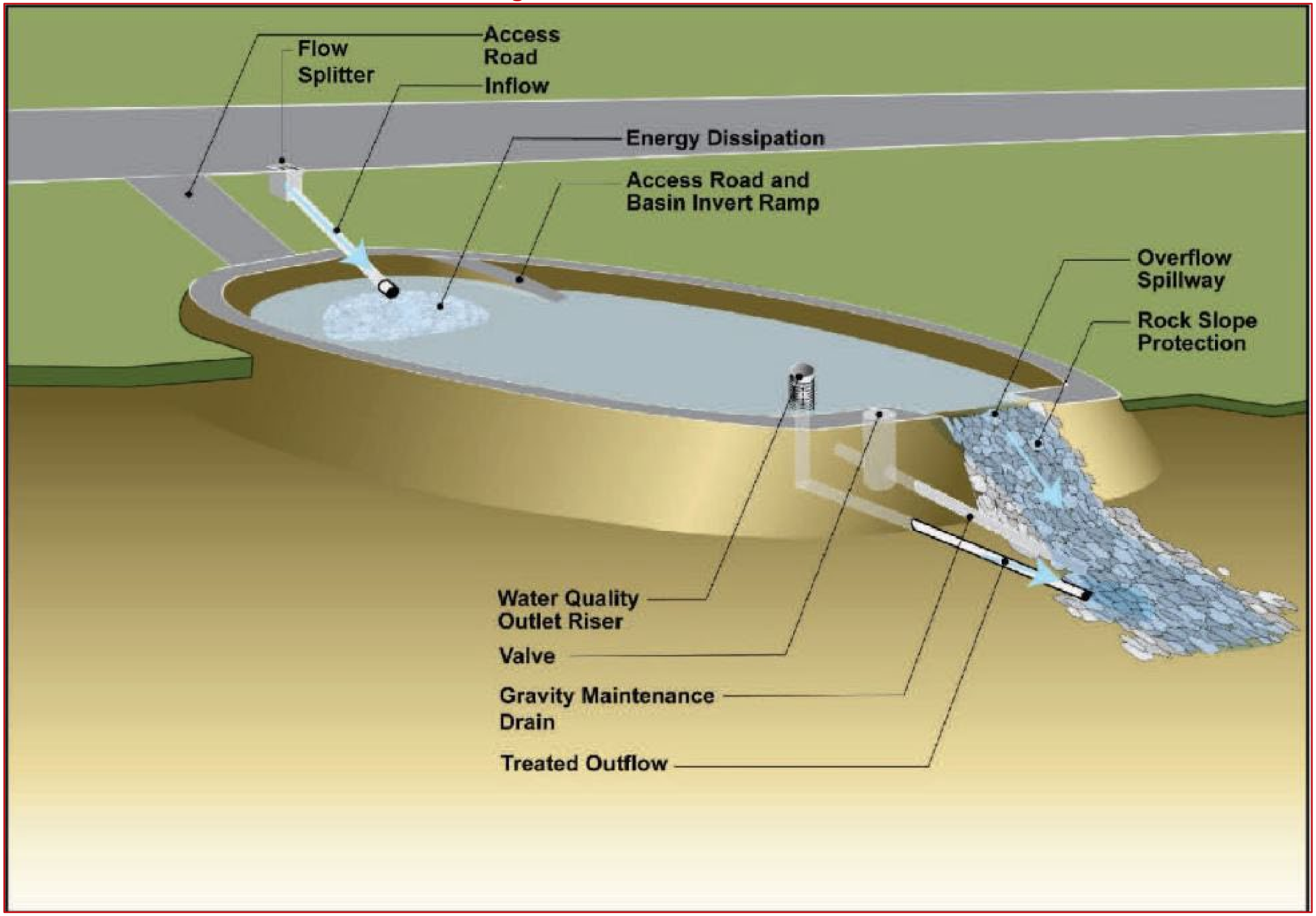
6.1.2 Detention

Table 6-7. Detention Basin

Description	Detention basins allow flows to enter and then are released at a slower rate. It is recommended that as stream gradient flattens out as flows move from steeper mountain to flatter bajadas that offline detention basins be installed. Flows would be diverted from the channel into the detention basin. In stream diversion of flows would be determined on a site-specific basis and could include check dams, riser pipes, and traditional MS4 style inlets.
Benefit	1. Reduce downstream flows. 2. Remove sediment load from storm flows.
Disadvantages	1. Need to be implemented in an area water can be gravity diverted into them. 2. Difficult to install within the stream channel. 3. Heavy sediment loads can reduce capacity.
Target Locations	Bajada and White Sands Post
Estimated Cost	$$$-$$$$
Geographic Scale	Site specific.
Ecological Impact	Significant during construction. May require stream channel alteration to connect. Long term impacts based on design. Concrete or lined basins permanently reduce habitat. Vegetated basins may function to support wildlife but require maintenance of vegetation, so they do not become overgrown.
Maintenance Requirements	Routine inspections required. Sediment removal based on inspection results.
Notes	Detention basins can be developed in shapes and depths to fit specific available areas. Often detention basins are undersized due to space required for them. However, as this report seeks to mitigate flood risks downstream, undersized basins aid in reducing downstream flows consistent with their size. Thus, a battery of smaller detention basins could be used to achieve a similar effect to fewer larger detention basins.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-7. Detention Basin[23]



[23] Image courtesy of https://dot.ca.gov/-/media/dot-media/programs/design/documents/4_dg-detention-basins_ada.pdf accessed on 08/13/2023.

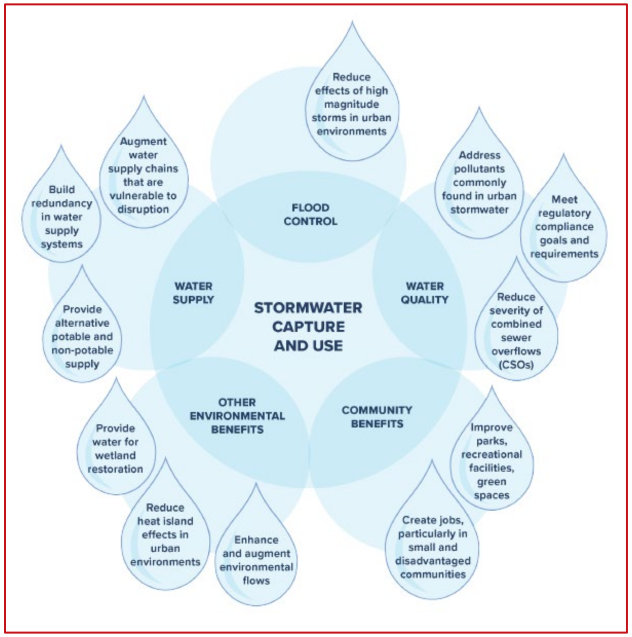
6.1.3 Underground Retention

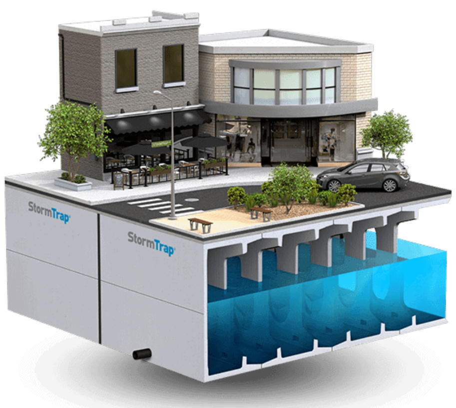
Table 6-8. Underground Retention

Description	Underground retention basins can either hold water for reuse or allow it to infiltrate. They collect water similar to a detention basin, but do not discharge the water. There are prefabricated proprietary versions that can be purchased or non-proprietary versions can be designed specific to a site.
Benefit	1. Reduce downstream flow. 2. Water can be reused for irrigation. 3. Not typically visible above ground. 4. Limit evaporation compared to above ground storage.
Disadvantages	1. Areas not available for use during construction. 2. Infiltration versions may clog over time. Thus, pretreatment is recommended to remove sediment from infiltration versions (e.g., cartridge filters or hydrodynamic separators).
Target Locations	Golf course, sports fields, and parks in White Sands Post
Estimated Cost	$$$-$$$$
Geographic Scale	Site specific.
Ecological Impact	Minimal since only proposed in already urbanized locations.
Maintenance Requirements	Routine inspections. Sediment removal based on inspection results. Pretreatment filters or separators may reduce sediment removal interval. Would require maintenance on a routine basis of pretreatment filters or separators.
Notes	This report primarily seeks to mitigate flood waters during severe rainfall event. However, rainfall should also be viewed as a resource. This is especially true in desert climates. Underground cisterns have been used in arid climates for thousands of years. Modern underground retention of stormwater either for infiltration or reuse is still in its infancy. Irrigation occurs for golf course, sports fields, and parks in the and around the Post area. As water is becoming a more precious resource, consideration should be given to collecting runoff into underground retention areas and then reusing for irrigation of public green spaces.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-8. Underground Retention[24]





Type of Flood Storage Area/Reservoir	Description
Online	Both dry and wet weather flows pass through the flood storage area
Offline	Dry and first-flush wet weather flows pass through the flood storage area. Larger flows bypass the facility
Dry	The flood storage system is kept essentially dry due to infiltration and evapotranspiration
Wet	The flood storage area contains water under all flow conditions
Wet/Dry	Part of the flood storage area contains water and part is dry during various flow conditions

[24] Image courtesy of https://www.epa.gov/system/files/documents/2022-03/wrap-pure-potential-report.pdf, https://www.fema.gov/sites/default/files/documents/fds_fact_sheet_feb2017.pdf accessed on 08/16/2023. https://stormtrap.com/wp-content/uploads/2016/04/infiltration-2.png accessed on 09/25/2023. Example only and does not represent an endorsement of Storm Trap products.

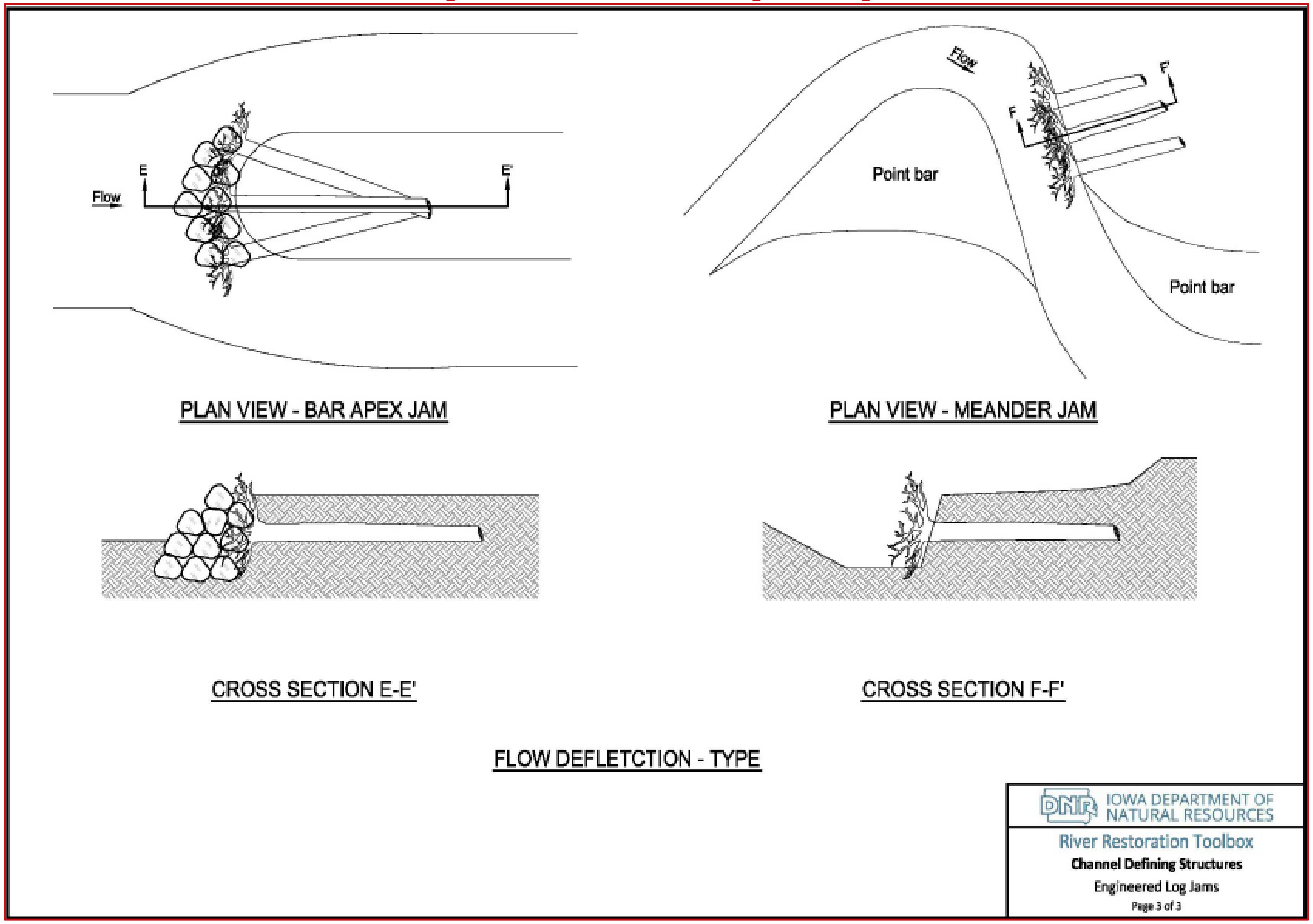
6.1.4 Stream Bioengineering

Table 6-9. Stream Bioengineering

Description	Nature-based and biologically inspired mitigation measures such as bank stabilization using natural materials and re-vegetation in combination with hard armoring. Examples include watershed restoration and mitigation including channel shaping or re-profiling, floodplain construction, overflow channel construction, riparian re-vegetation, and in-stream habitat improvement. These methods are recommended for stream channel stabilization projects.
Benefit	1. Can be used to mitigate a wide variety of stream issues including but not limited to scour, incision, head cuts, and bank erosion. 2. Solutions can be better blended into native habitat. 3. Native Fauna are generally better able to utilize these structures than rip rap or concrete alone.
Disadvantages	1. Permitting. 2. Timbers used will need replaced over time.
Target Locations	Throughout entire watershed. Especially upstream and downstream of crossings to protect them from scour.
Estimated Cost	$$-$$$$
Geographic Scale	Site specific to watershed scale depending on chosen method.
Ecological Impact	Potentially significant during construction. Requires stream channel alteration. Long term potential benefits to stream channel morphology and habitat.
Maintenance Requirements	Limited once completed. Longer term maintenance cycle compared to other methods. Routine inspections required. Maintenance based on inspection results.
Notes	One of the most important factors to understand when designing and implementing bioengineering BMPs is to understand what your stream is capable of moving, and then using rock and tree that exceed the streams ability to move them. However, climate change may result in increased storm amounts and/or intensity. Thus, it is critical to factor this into design. Over engineering based on present conditions to account for future conditions is recommended. Since this is trying to maintain the natural setting of the area, care should be taken to perform bioengineering with resources similar to the surrounding area. At higher elevations timbers may be the best option in areas with pine trees. At lower elevations, large boulders may be a better option in scrub environments that do not have surrounding trees. Also, consideration should be give to not use preserved or treated timbers as these my pose an environmental contamination risk to soil and water and create toxicity for wildlife. Several agencies have produced manuals detailing stream bioengineering methods. Links are provided below to three example manuals. **Federal Emergency Management Agency (FEMA)** https://www.fema.gov/pdf/about/regions/regionx/Engineering_With_Nature_Web.pdf **Bureau of Reclamation (USBR)** https://www.usbr.gov/tsc/techreferences/mands/mands-pdfs/A-BankStab-final6-25-2015.pdf **Army Corps of Engineers (USACE)** https://www.engr.colostate.edu/~bbledsoe/CIVE413/Bioengineering_for_Streambank_Erosion_Control_report1.pdf Additionally, as of the writing of this report, valuable USACE stream bioengineering presentations are also available at the following address: https://dirttime.tv/downloads/#free_downloads_stormcon_presentions

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 6-9. Stream Bioengineering[25]



25 Images courtesy of https://www.iowadnr.gov/Portals/idnr/uploads/RiverRestoration/toolbox/channel-definition/Practice%208_Channel_Definition_Strucures_Full_Chapter.pdf accessed on 08/16/2023.

6.2 Hazard Mitigation (Non-Structural BMPs)

Non-structural BMPs presented in this report primarily consist of planning, education, and logistical consideration.

6.2.1 Early Warning System

Table 6-10. Early Warning System

Description	A network of rain gauges and stream gauges at various elevations upstream of White Sands Post.
Benefit	1. Can provide early warning of severe weather at elevation. 2. Can provide early warning of elevated flows approaching White Sands Post.
Disadvantages	1. Maintenance. 2. Must be monitored. 3. Permitting. 4. Coordination with neighboring agencies/land owners. 5. Means lag to implementation. 6. Education on use and when to respond in a timely manner to save lives
Target Locations	Mountains, arroyo, White Sands Post.
Estimated Cost	$$-$$$$
Geographic Scale	Watershed to Regional Scale.
Ecological Impact	Minimal for rain gauges. Depending on stream gauge type, minimal (pressure transducer only) to significant (concrete weir installation).
Maintenance Requirements	Routine cleaning and calibration of rain gauges. Routine checks of equipment communications and data logging. Routine clearing of stream flow site.
Notes	In desert environments with surrounding mountains flooding can occur with little to no rainfall in the desert floor itself. Thus, personnel may be unaware of approaching flood waters. An early warning network of rain and stream gauges could provide crucial time to warn base personal of approaching floods and implement other hazard mitigation options prior to the arrival of flood waters. A remote rain gauge network is considered more cost effective and easier to implement as there are several remote weather monitoring station options that could be purchased and installed. A remote stream gauge network required more intensive permitting and greater effort to both install and maintain. While ideally both rain and stream gauges would be installed as the stream gauges would indicate the magnitude of flow approaching White Sands Post, if sufficient funds are not available, it is recommended that a rain gauge network be installed first. It is not the intention of this report that both rain and flow gauges must be installed at the same time. Either rain or flow gauges may be installed independently of each other.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

6.2.2 Transportation Management

Table 6-11. Transportation Management

Description	Proactive closure of roads and / or bridges during severe weather events.
Benefit	1. Eliminates reactive need to close roads when flooding is actively occurring. 2. Warns drivers not to cross potentially flooded areas.
Disadvantages	1. Flooding may not occur, thus the road closures may be unnecessary. 2. Staff diverted from standard duties to close roads. 3. May impact emergency services.
Target Locations	Roads on WSMR.
Estimated Cost	$-$$
Geographic Scale	Site specific to regional scale.
Ecological Impact	None anticipated.
Maintenance Requirements	Regular inspections of road closure signs and barriers to ensure they are functional when needed.
Notes	Closure of roads may include also closing Post areas to traffic leaving and WSMR base to traffic entering. Closing roads, bridges, Post areas, and WSMR base proactively prior to flood events based on weather forecast data may be met with skepticism and difficult to implement. Alternatively, to manually placing closure signs, barriers that can be remotely triggered could be installed to prevent travel into low lying flood prone areas during severe weather. (e.g.' rail road crossing style barriers are envisioned)

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

6.2.3 Field Training Logistics

Table 6-12. Field Training Logistics

Description	Reviewing the weather forecast is typically undertaken prior to field exercises. However, military personal may be prone to pushing forward even when severe weather is forecast. This hazard mitigation strategy envisions setting forecast based criteria that would automatically result in cancelation of field training exercises if triggered. The goal of this hazard mitigation strategy is to prevent personal from becoming isolated by flood waters in remote areas of WSMR. Decision makers would rely less on interpreting weather forecasts themselves and instead would have set criteria to defer to in order to continue with, delay, or cancel field training.
Benefit	1. Weather forecast based standard threshold criteria to be followed would remove gray area of personal interpretation by decision makers.
Disadvantages	1. Weather forecasts are often incorrect. Thus field training may be canceled when it did need to be. Conversely, field training may commence and severe weather occur that was not forecast. 2. Likely difficult to agree on set criteria.
Target Locations	WSMR
Estimated Cost	$-$$
Geographic Scale	Regional scale.
Ecological Impact	None anticipated.
Maintenance Requirements	None anticipated.
Notes	This hazard mitigation strategy is intended primarily for key decision makers who plan field training exercises.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

6.2.4 Flood Risk Training

Table 6-13. Flood Risk Training

Description	Introductory or annual safety training is often performed for many civilian and military jobs. This hazard mitigation strategy proposes WSMR specific flood awareness training for all civilian and military personal. This will provide a baseline understanding of flood risks on WSMR (where flooding is likely), actions to be undertaken during flood conditions (turn around, don't drown), and emergency response methods in place (who to notify).
Benefit	1. Base personal will have a basic understanding of flood risks on WSMR and actions to take during flood events.
Disadvantages	1. Cumbersome to train all base personal. 2. Tracking who has had training and who has not on a military base as staff come and go from other installations is difficult.
Target Locations	WSMR
Estimated Cost	$$
Geographic Scale	Site / personal specific.
Ecological Impact	None anticipated.
Maintenance Requirements	Production of and updating of training materials.
Notes	This training could be performed simply by completing a technical memorandum that is emailed to all personal and tracked by each civilian or military personal acknowledging via a response or website that they have reviewed and understand the document. This training may be best implemented at the department / unit level.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

6.2.5 Planning / Zoning

Table 6-14. Planning / Zoning

Description	Military installations are often undergoing constant change. Older buildings are being renovated or replaced while new buildings are being constructed. This hazard mitigation strategy proposes that flood risks are reviewed during planning and zoning for renovation and new construction. Planning should take into account potential future conditions due to climate change, not just current conditions. Additionally, low impact development (LID) techniques should be used to reduce runoff from rainfall within White Sands Post.
Benefit	1. Proper planning incorporating flood areas should result in buildings located in safer areas. 2. Reduction of runoff flow from White Sands Post.
Disadvantages	1. Increased planning time.
Target Locations	WSMR
Estimated Cost	$-$$$
Geographic Scale	Regional scale.
Ecological Impact	Project specific. Potentially none to significant.
Maintenance Requirements	Updating of zoning ordinance.
Notes	As an example, the levee is currently being extended to Owen Road. However, downstream of Owen Road a levee system is not in place to protect areas east of Owen Road. Further development in this area of White Sands Post should not be placed near the arroyos. Extending the levee to protect the entire Post should be considered in future planning. Examples of LID techniques from the EPA may be found at the following link. https://www.epa.gov/nps/urban-runoff-low-impact-development

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

6.2.6 Emergency Response Planning

Table 6-15. Emergency Response Planning

Description	Exercises should be conducted on a routine basis of reactions to a flood event. Military units often train against an imaginary enemy on military basis to prepare for actual combat. This recommendation is similar in nature to that training. Training against an imaginary flood should be routinely conducted to assess operational readiness in the event of a real flood. What happens if pumps fail? What happens if troops in a remote area of the base are cut off due to road or bridge washout? These and similar questions should be strategized during these exercises so reaction times during actual flood events is improved. Additional resources available to WSMR should be analyzed during these exercises. Coordinating with Federal, State, and Local resources that may be available to support flood emergencies. The National Park Service, the adjoining USAF base, city of Los Cruces, and the State of New Mexico along with counties and other agencies each have a vested interest in the health and wellbeing of WSMR as it supports local economies and provides conservation.
Benefit	1. Proactive planning can provide crucial time during actual flood events. 2. Understanding and planning for what may go wrong will increase reaction times during flood events when things do go wrong. 3. Interagency coordination provides additional resources.
Disadvantages	1. Potentially costly. 2. Neighboring agencies may not support. 3. Disparate nature of flooding may push this hazard mitigation strategy to the back burner. 4. Supporting agencies likely to expect support for their areas of responsibility from WSMR.
Target Locations	WSMR and surrounding locations / agencies
Estimated Cost	$$-$$$
Geographic Scale	Regional scale.
Ecological Impact	None anticipated. Virtual exercise.
Maintenance Requirements	Updating of operating procedures and contact information.
Notes	Contingency plans should be developed to manage floods. Historic flood patterns can be used to determine the effects of potential future floods. These plans should be regularly updated based on changing base conditions and improved methods. Inclement weather is when power is most likely to be lost. Thus, the BMPs recommended in this report should assume that power can be lost. Contingencies should be included in planning and implementation. As an example, if an early warning system of rain and stream gauges is implemented, a backup power source should be included based on the assumption the primary power source may fail. Similarly, pumps to remove water from the camp area should have backup generators. Backup systems should be routinely tested to ensure they are functional.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

7 Erosion Control Toolbox

This section presents potential BMP options to minimize sediment and / or debris flows. These BMPs may be required following a fire, landslide, or construction. If the climate becomes hotter and drier on average due to climate change, these BMPs may also be potential options to control increased sediment load in storm flows due to less vegetation and lower soil moisture content.

Two categories of erosion control BMPs are presented in this report. The first are temporary BMPs that may be required immediately following a fire or other ground cover disturbance activity to temporarily stabilize the soil surface until more permanent BMP solutions can be implemented. Permanent ground cover stabilization BMPs are the second category or erosion control BMPs presented in this report.

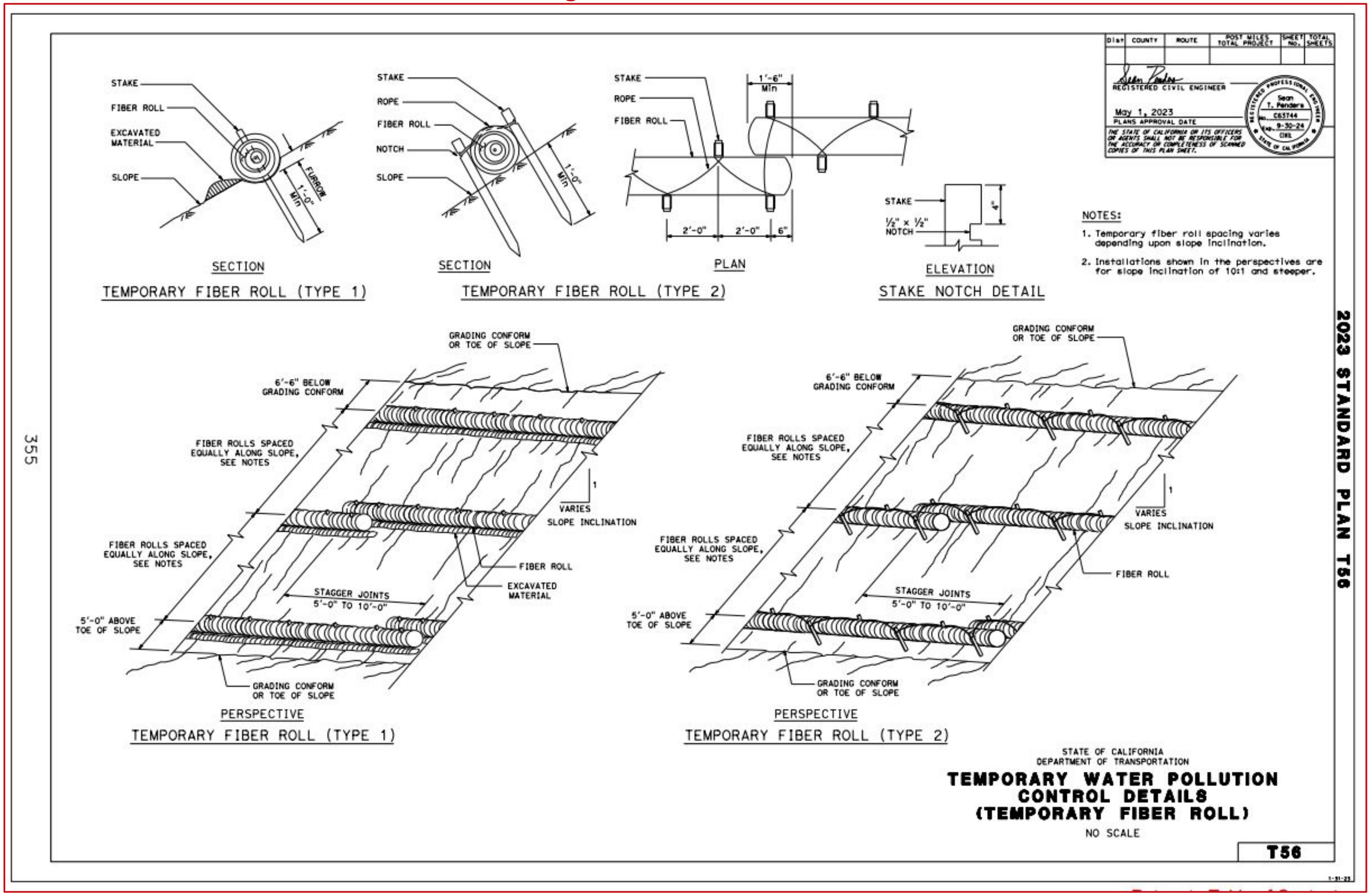
7.1 Temporary Solutions

Table 7-1. Fiber Rolls

Description	Fiber rolls are similar to what they sound like. They are long round bundles of fiber typically transported in a roll. They vary in thickness and material. Wooden or metal stakes are typically used to secure them in place. Sufficient stakes should be used to ensure water is not able to pass under the fiber roll. Once installed, the fiber roll acts like a berm to slow runoff water and allow sediment to settle out. Fiber rolls must be maintained on a regular basis. Sediment builds up against them which must be removed or runoff water will be able to pass over the fiber roll. Checks to ensure water is not passing under the fiber roll should be conducted. Additionally, on longer term installations fiber rolls may break down and require replacement.
Benefit	1. Easy and expeditious to install. 2. Reduce runoff volume. 3. Reduce sediment load. 4. Relatively inexpensive.
Disadvantages	1. Can be short circuited either over or under. 2. Break down over time. 3. Wildlife can be trapped in plastic netting common to fiber rolls.
Target Locations	Recent wildfire areas and areas with high erosion potential.
Estimated Cost	$$
Geographic Scale	Site specific.
Ecological Impact	Minimal impact anticipated. Potential habitat improvement due to reduced erosion.
Maintenance Requirements	Initial installation. Routine maintenance to re-stake as required and replace as necessary.
Notes	Fiber rolls are an expeditious method to create a berm. A berm of compressed soil may also be used to achieve similar results to fiber rolls. Soil may be subject to greater erosion potential if the berm is not properly constructed. Fiber rolls are not a permanent solution. Planning should be conducted to implement a permanent solution in areas they are installed.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-1. Fiber Rolls[26]



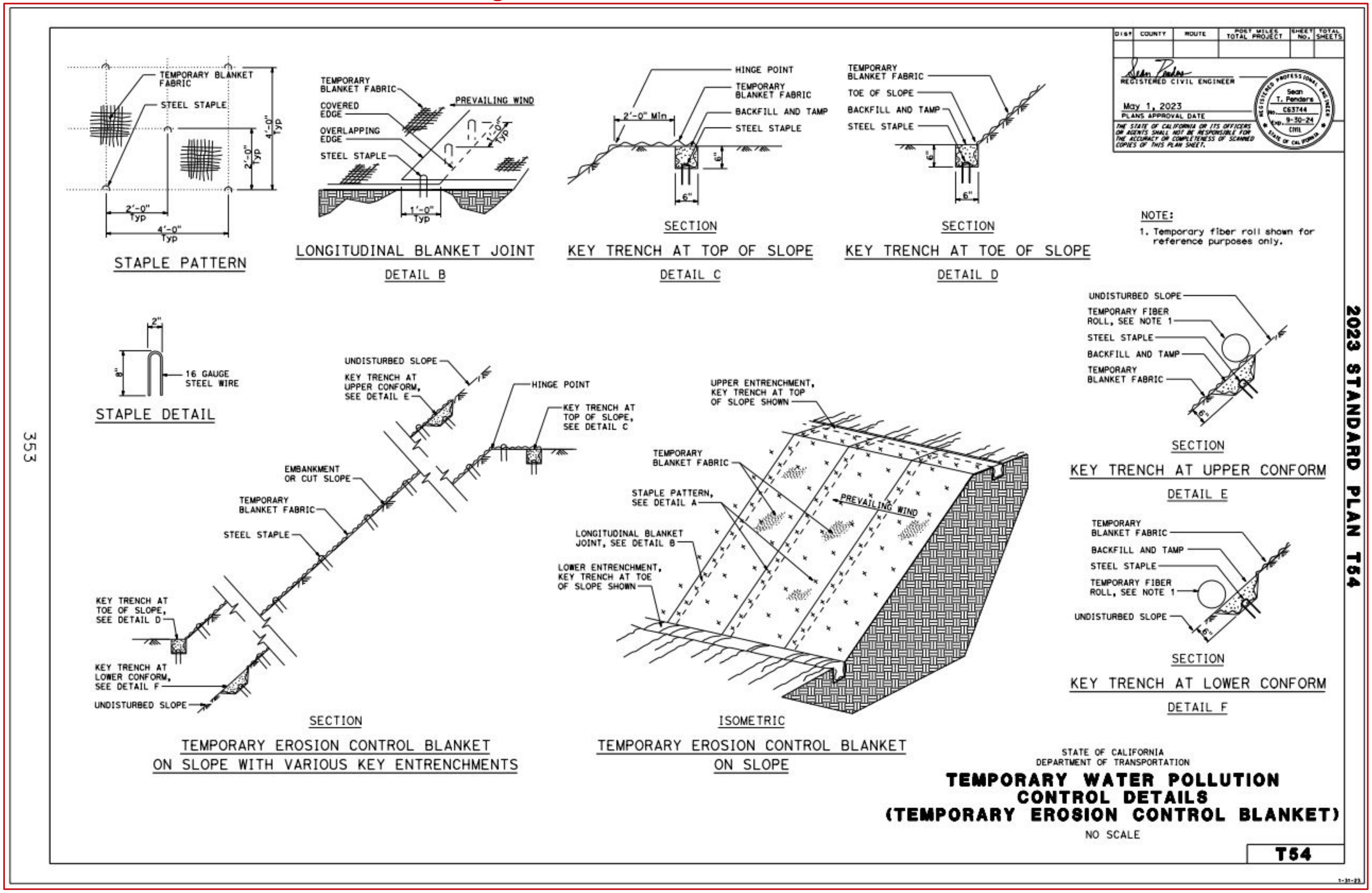
[26] Image courtesy of Caltrans 2023 Standard Plans – T56 – Temp Water Pollution Control Details – Temporary Fiber Roll

Table 7-2. Erosion Control Blankets

Description	Erosion Control blankets are large woven fabric pieces typically made of jute or other natural material. Soil blankets are designed to cover large areas. They are typically shipped in rolls. They can be used to cover large areas and secured with wooden or metal stakes.
Benefit	1. Stabilize large areas quickly. 2. Natural fibers break down over time as vegetation grows. 3. Provide stabilization for vegetation growth.
Disadvantages	1. Break down over time. 2. May be impractical on large areas.
Target Locations	Recent wildfire areas and areas with high erosion potential.
Estimated Cost	$$-$$$
Geographic Scale	Site specific.
Ecological Impact	Minimal impact anticipated. Potential habitat improvement due to reduced erosion.
Maintenance Requirements	Initial installation. Routine maintenance to re-stake as required and replace as necessary.
Notes	Soil blankets present an expeditious method to cover large areas of ground relatively inexpensively. They are presented in this report as a temporary method, but may also be used to stabilize the ground for permanent revegetation or restoration efforts.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-2. Erosion Control Blankets[27]



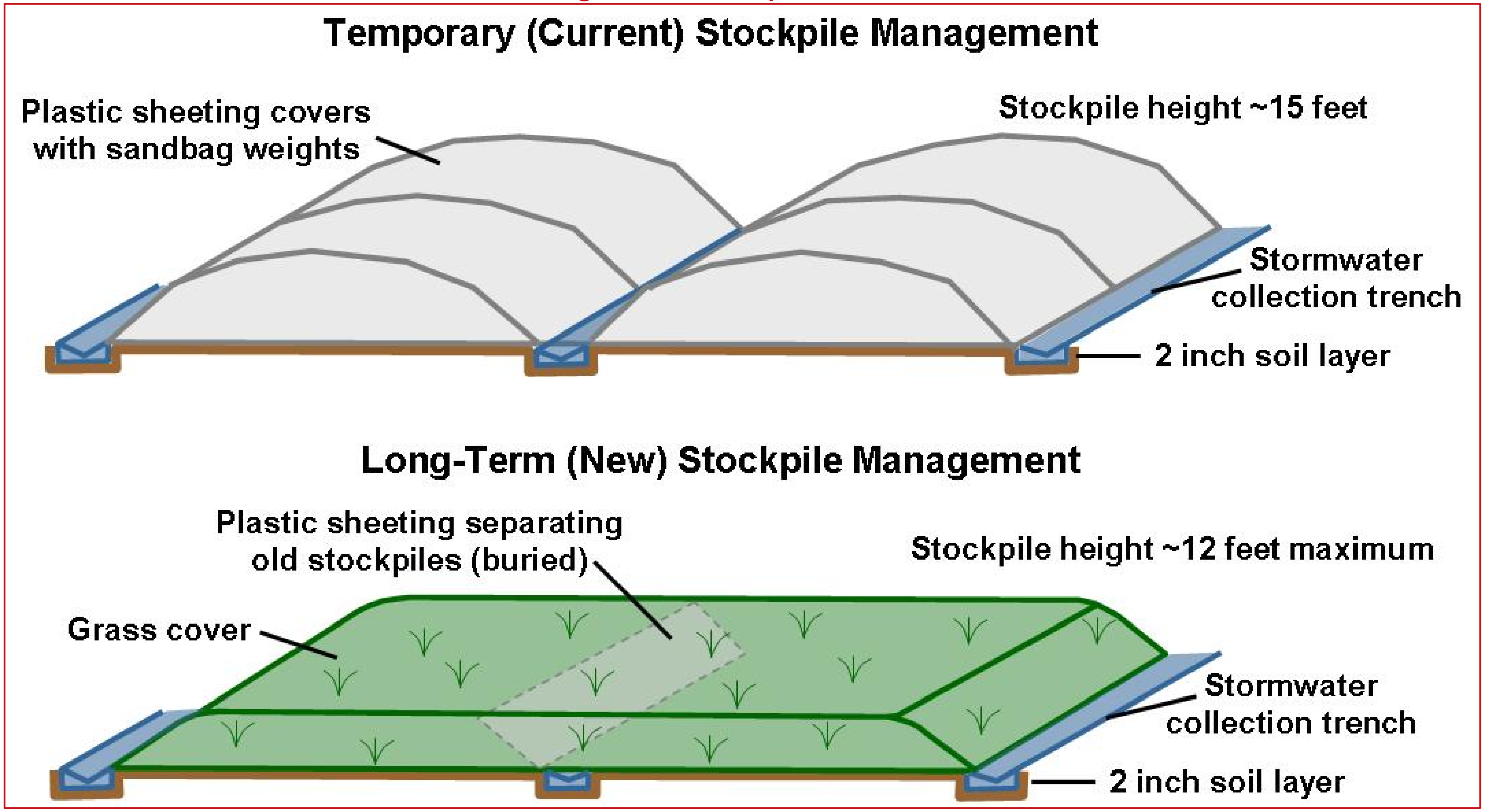
[27] Image courtesy of Caltrans 2023 Standard Plans – T54 – Temp Water Pollution Control Details – Temporary Erosion Control Blanket

Table 7-3. Stockpile Covers

Description	Stockpile covers are large typically synthetic tarps or sheets that are anchored around the edges by weights or stakes. They are designed to cover soil stockpiles temporarily due to rain or wind events.
Benefit	1. Protects loosely compacted soil stockpiles from erosion due to rain or wind.
Disadvantages	1. Synthetic covers tend to break down over time and must be disposed of in a landfill. 2. Rain runs off of the synthetic cover.
Target Locations	Construction areas, stream dredging.
Estimated Cost	$$-$$$
Geographic Scale	Site specific.
Ecological Impact	Minimal impact anticipated. Main impact would be from construction activities that result in creation of the stockpile.
Maintenance Requirements	Initial installation. Routine maintenance to re-stake as required and replace as necessary.
Notes	Stockpile covers are typically required on construction sites. Natural non-synthetic versions may be available. Ideally construction would not occur during the rainy season and stockpile covers would not be required.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-3. Stockpile Covers[28]



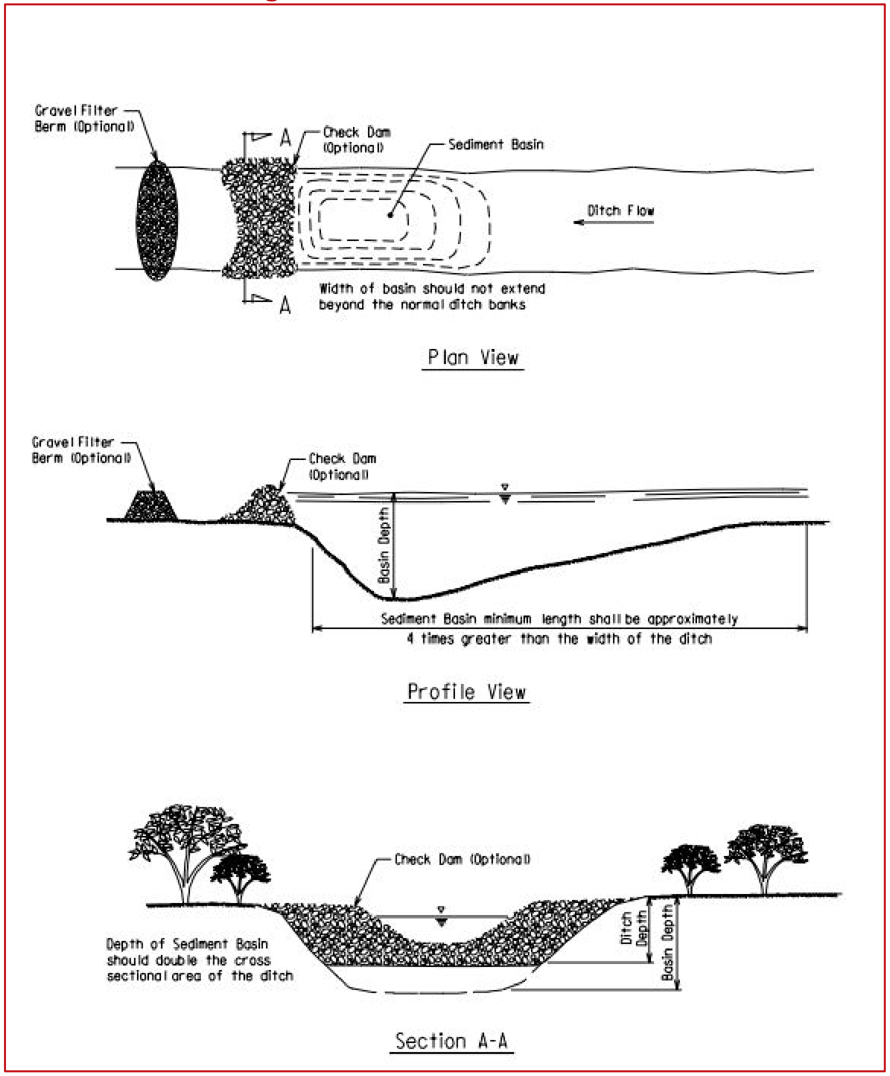
[28] Image courtesy of Ecology Washington
http://1.bp.blogspot.com/-vWYr7v5zXI0/Ug5_171evTI/AAAAAAAAACE/FgT2t9_NnQc/s1600/Stockpile+covers.jpg accessed 08/16/2023.

Table 7-4. Sediment Basins

Description	Sediment basins are small basins created to trap sediment as runoff water passes through the basin. They are typically either rock or poly lined to provide stabilization and so that the basins themselves do not contribute to erosion. These basins are used in smaller areas of disturbance. They may also be used in a series of several basins if space for one larger basin is not available.
Benefit	1. Reduce sediment load from smaller areas. 2. Typically expeditious to install.
Disadvantages	1. Designed for small disturbance areas. 2. Hold water which may present a vector hazard.
Target Locations	Small areas of soil disturbance on WSMR.
Estimated Cost	$$
Geographic Scale	Site to watershed scale.
Ecological Impact	Typically placed in areas already disturbed. Thus, impact is considered minimal.
Maintenance Requirements	Routine inspections. Removal of sediments based on inspection results.
Notes	These basins are small dugout depressions in the flow path from disturbed areas. They are not meant to be in the stream channel.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-4. Sediment Basins[29]



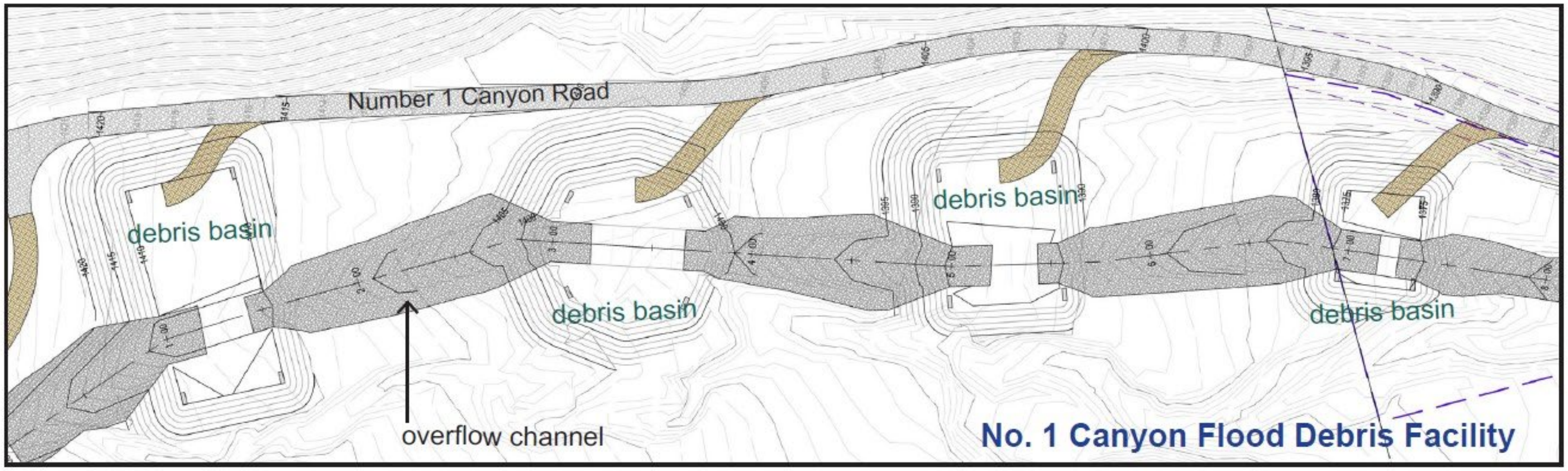
29 Image courtesy of Michigan SESC Manual 2006 – Sediment Basin

Table 7-5. Debris Basins

Description	Larger disturbed area, cross between a sediment trap and detention basin. Often has baffles in it to help settle out sediment (gabion). Debris basins are structures that temporarily detains runoff water carrying sediment loads. They generally consist of an earth embankment and a perforated pipe principal spillway. Runoff water slows upon entering the impoundment allowing sediment to settle out. Water is drawn out through a principal spillway. Debris basins are similar to permanent detention basins, but temporary in nature. They often also include a series of baffles (e.g., gabion) to aid in settling out sediment.
Benefit	1. Able to treat larger disturbed areas. 2. Reduce runoff. 3. Reduce sediment load.
Disadvantages	1. Sediment should be cleaned out as needed to maintain capacity. 2. Construction time. 3. Require space to meet volume runoff requirements.
Target Locations	Large areas of soil disturbance on WSMR.
Estimated Cost	$$-$$$
Geographic Scale	Site to watershed scale.
Ecological Impact	Typically placed in areas already disturbed. Thus, impact is considered minimal.
Maintenance Requirements	Routine inspections. Removal of sediments based on inspection results.
Notes	Consideration should be given to using debris basins below large wildfire burn areas and other large areas with increased sediment risk to capture heavily sediment laden debris flows to reduce available sediment prior to flows reaching downstream improvements.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-5. Debris Basins[30]



[30] Image courtesy of https://www.co.chelan.wa.us/files/flood-control-zone-district/images/debris%20basins_graphic.jpg accessed 08/16/2023.

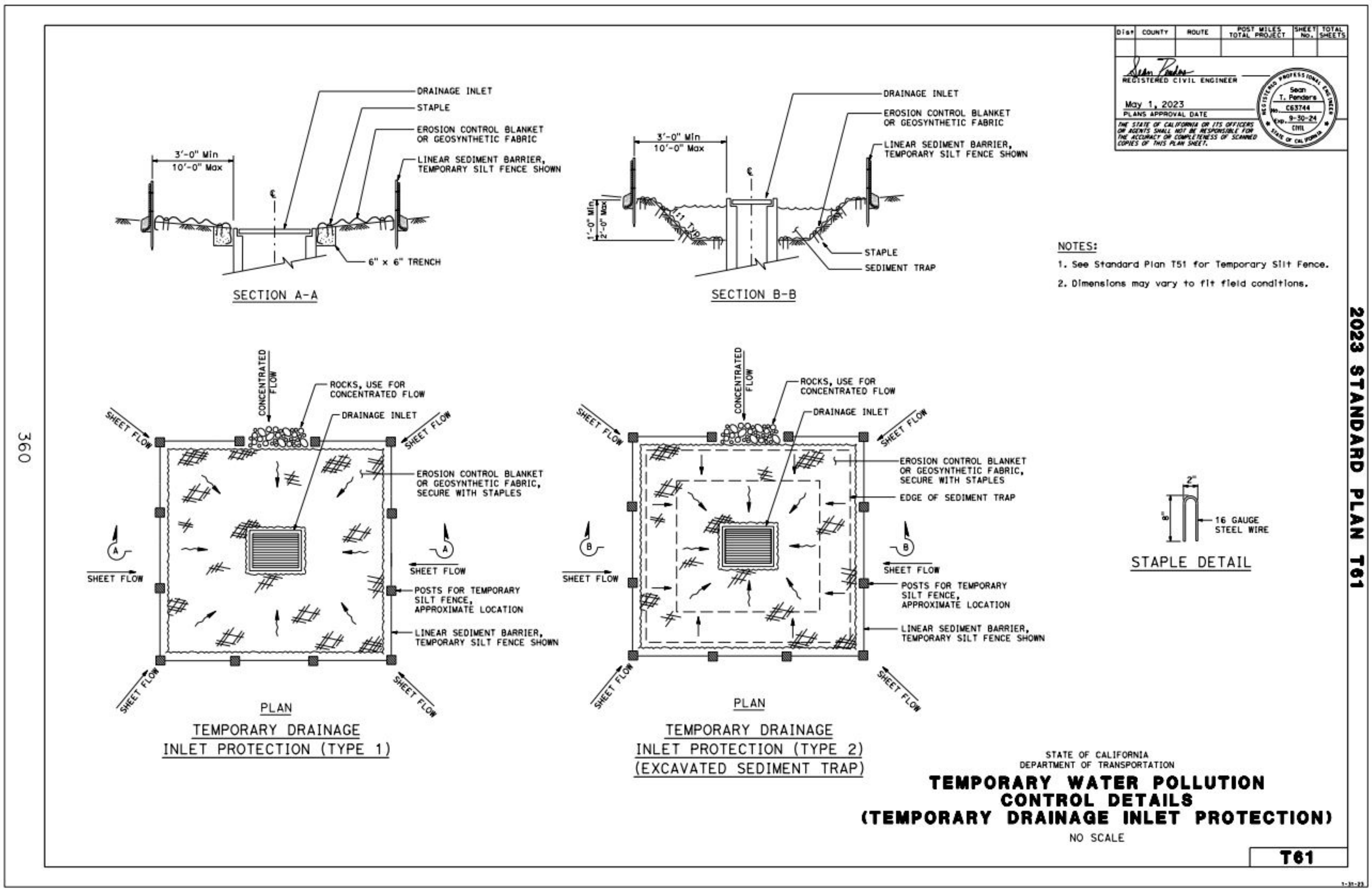
7.2 Permanent Solutions

Table 7-6. Inlet Debris Protectors

Description	Inlet debris protectors can prevent a wide range of debris from entering a treatment or MS4 system ranging from large organic debris to silt. Inlet debris protectors can be used both temporally (e.g., construction) or permanently (e.g., MS4 capacity protection). Inlet debris protectors should be used in concert with street sweeping to collect debris they prevent from entering an inlet. A wide variety of inlet debris protectors are available with numerous options available. Some provide filtration treatment for oil and grease as well as other potential chemicals.
Benefit	1. Reduce sediment load from construction sites. 2. Maintain MS4 capacity. 3. Relatively easy to maintain.
Disadvantages	1. Installation is inlet specific. 2. Maintenance.
Target Locations	White Sands Post
Estimated Cost	$$-$$$
Geographic Scale	Urban areas / built environment.
Ecological Impact	None anticipated.
Maintenance Requirements	Routine inspections. Cleaning based on inspection results.
Notes	Filter fabric and sandbags can be used downstream of construction or erosion prone areas to create temporary inlet debris protectors. A wide variety of inlet protectors are available which may increase decision making difficulty.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-6. Inlet Protection[31]



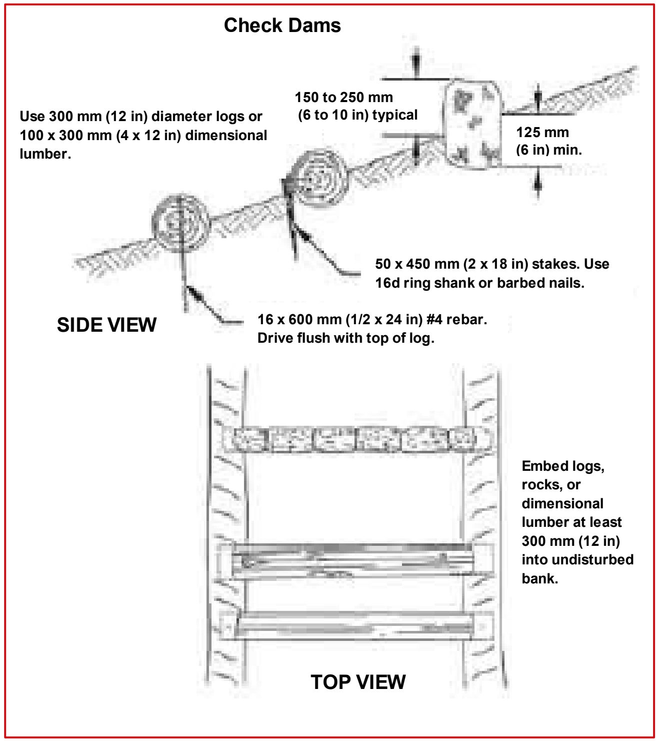
[31] Image courtesy of Caltrans 2023 Standard Plans – T61 – Temp Water Pollution Control Details – Temporary Drainage Inlet Protection

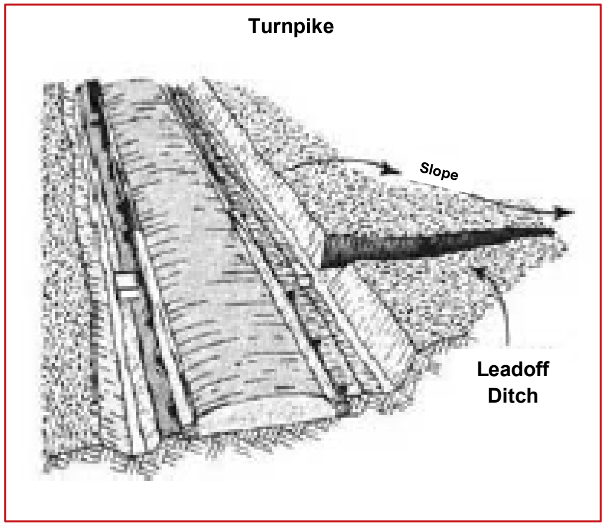
Table 7-7. Timber Structures

Description	Timber structures typically involve the use of timbers placed into the ground and held in place with metal stakes to stabilize erosion prone areas. An example of this is the wood you often see crossing hiking trails. This was placed there to help prevent erosion on the trail. Timber structures may also be used to stabilize small rills and prevent them from eroding further while allowing runoff water to still be transported along the same pathway.
Benefit	1. Work well to stabilize erosion prone areas. 2. Typically, long lasting.
Disadvantages	1. Intensive labor effort to install. 2. Typically, heavy to move timbers to remote areas.
Target Locations	Erosion prone areas of WSMR.
Estimated Cost	$$-$$$
Geographic Scale	Site specific.
Ecological Impact	Minimal since typically placed in a disturbed area. Potential habitat improvements due to reduced erosion.
Maintenance Requirements	Routine inspections. Maintenance of erosion areas based on inspections.
Notes	Consideration should be given to not use preserved or treated timbers as these may pose an environmental contamination risk to soil and water and create toxicity for wildlife.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-7. Timber Structures[32]





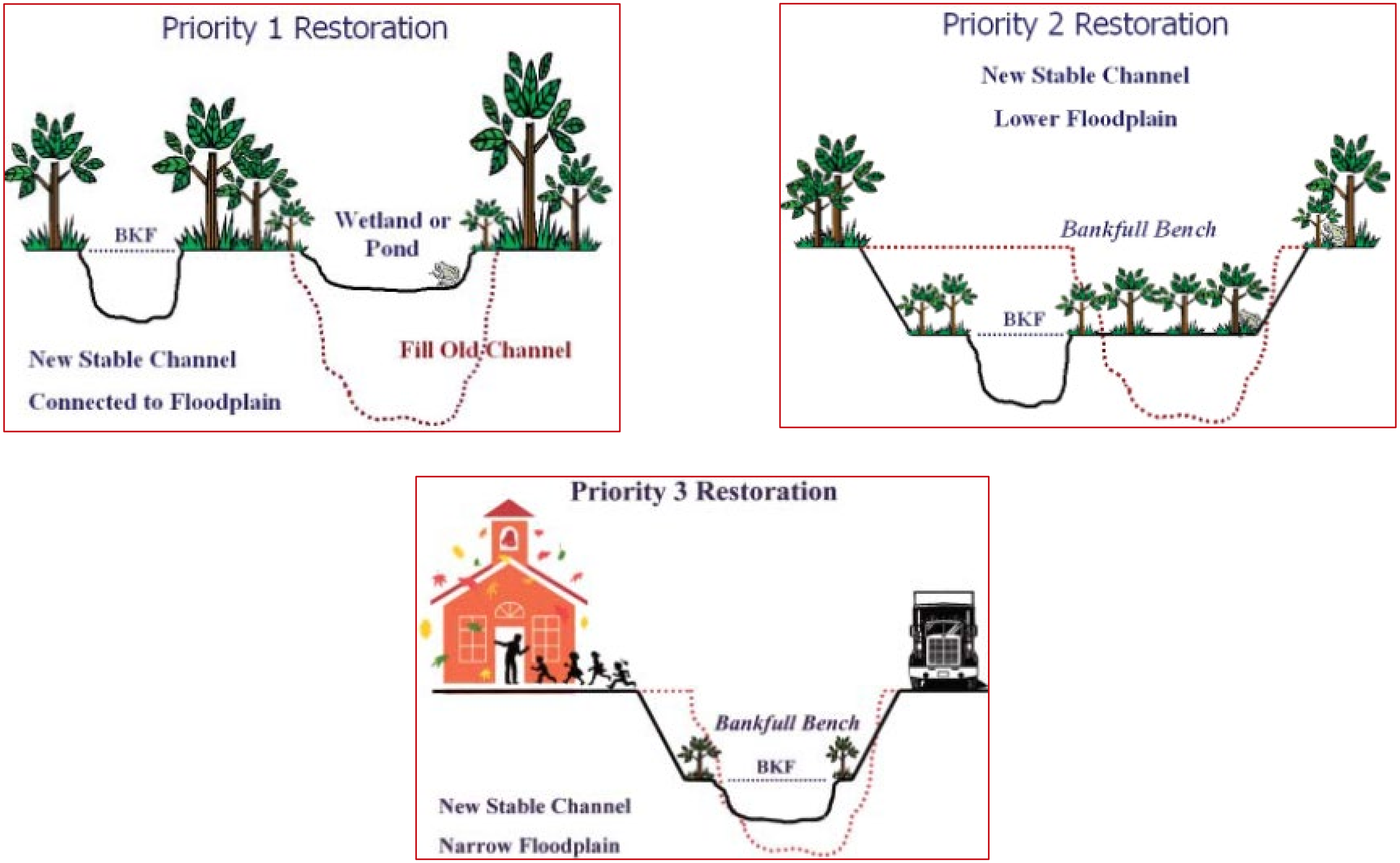
32 Images courtesy of https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5343897.pdf accessed 08/17/2023.

Table 7-8. Revegetation and Restoration

Description	Following a wildfire or other large soil disturbance that creates a significant erosion risk consideration should be given to revegetation or restoration. Revegetation may be undertaken by hydroseeding an erosion prone area with a native seed mix. Specific plantings may be undertaken by hand to complete the plant community. Revegetation is recommended in areas that soil remains relatively intact and there are indications that it will be successful. Restoration is considered significantly more involved. Target areas may require design, permitting, grading, stabilization, planting, temporary irrigations, and long-term monitoring. Restoration is recommended in areas were significant erosion or large wildfires have occurred. Restoration may include other options presented in this report under its umbrella.
Benefit	1. Return habitat to native state more expeditiously. 2. Reduce erosion potential longer term. 3. Aesthetically more pleasing than man-made solutions.
Disadvantages	1. Typically, expensive. 2. Labor intensive. 3. Replanting and / or restoration may fail. 4. May require temporary irrigation to establish plants. 5. Environmental analysis preparation (cultural resource survey/UXO. survey/etc. possibly NEPA process). 6. Extensive and in the short term not aesthetic until established. 7. Seeds not germinating due to heat. 8. Seed loss to wind and insects.
Target Locations	Post wildfire and erosion prone areas of WSMR.
Estimated Cost	$$$-$$$$$
Geographic Scale	Site to watershed scale.
Ecological Impact	Potentially significant during construction. Often requires stream channel alteration. Habitat improvement once established.
Maintenance Requirements	Initial establishment of vegetation. Erosion control until established. Ongoing vegetation maintenance.
Notes	As the climate changes the plant communities may change. Erosion may be caused by current plant communities dying and being replaced. Investigations should be conducted based on current and future conditions to select plant communities to be used during revegetation or restoration activities.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-8. Restoration[33]



[33] Images courtesy of https://semspub.epa.gov/work/01/554360.pdf accessed on 08/17/2023.

Table 7-9. Soil Amendment Cover

Description	In areas where vegetation is unlikely to grow, soil crusting is possible, and erosion risk is considered high, the use of soil amendment covers may be considered. Soil amendment covers include a range of things from straw and hay along with other crop residues. They may also include topsoil from off site and animal dropping based fertilizers. These can be used as a temporary or permanent solution. When used on a temporary basis they are left on the ground surface and break down. When used on a permanent basis they should be tilled or plowed into the soil surface in sufficient quantities to change the soil characteristics and allow for improved chance of plant growth and reduced chance of soil crusting.
Benefit	1. Alter the soil makeup to be more amenable to plant growth and less amenable to soil crusting.
Disadvantages	1. Labor intensive. 2. Impractical in remote areas. 3. Amendments could change carbon dates on historic cultural artifacts. 4. PFAS may be an emerging issue for some amendments. 5. Expensive.
Target Locations	Large areas of erosion prone soil with little to no plant growth potential.
Estimated Cost	$$$-$$$$
Geographic Scale	Site specific.
Ecological Impact	Potentially significant due to altering soil or ground cover.
Maintenance Requirements	Minimal. May require repeated applications to achieve long term results.
Notes	This option is considered unlikely with the exception of near or in Post areas. It is likely impractical in remote areas. It is also impractical and unnecessary in primarily sandy soils.

$ = $1,000 - $10,000; $$ = $10,000 - $100,000; $$$ = $100,000 - $1,000,000; $$$$ = $1m - $10m; $$$$$ = $10m - $100m

Figure 7-9. Soil Amendment Covers[34]

[34] Image courtesy of https://www.epa.gov/system/files/documents/2021-11/bmp-mulching.pdf accessed 08/17/2023.

8 Summary and Recommendations

8.1 Summary

White Sands Post located in the southwest corner of White Sands Missile Range has a history of significant flood events. These significant flood events impact access to and from the Post area and have the potential to cause emergency situations with White Sands Post.

Flood control improvements developed in 2017 are currently being implemented. These flood control improvements include levee improvements around White Sands Post, detention ponds, and bridge widening. These activities generally fit with the recommendations of this document. These flood improvements that have been or are planned to be implemented have been limited in scope and consist of a reused of existing borrow pit for a detention pond, and the bridge is currently being repaired from flood damages but not yet widened.

Additional improvements prior to storm flows reaching White Sands Post are recommended. The 2017 improvements currently being implemented are considered “end of the line” improvements as they are in the immediate White Sands Post area (no improvements slow, reduce, or redirect storm flows until the Post area). Improvements to slow and reduce storm flows prior to reaching White Sands Post will aid the 2017 improvements effectiveness. Implementation of projects has been limited in scope as mentioned above. An environmental assessment will open possibilities of moving into a larger project scope.

Recommended additional improvements include but are not limited to additional detention ponds, check dams, bioengineering, and an early warning network of rain and stream gauges.

Non-structural recommendations include but are not limited to planning updates, logistical preparation, and conducting exercises in advance of flood conditions to improve response times during actual flood events.

8.2 Recommendations

This report presents conceptual options to mitigate flood risks to White Sands Post. A high-level concept along with a summary of potential improvements has been presented. It is important to note that this report is conceptual in nature.

1. Additional site-specific studies are recommended to be completed to determine design plans.
2. Within White Sands Post a network of stormwater capture and reuse is recommended.
3. While the 2017 improvements are being implemented, it is recommended that an early warning system be given strong consideration.
4. The non-structural recommendations are also recommended to be implemented.
5. Updated future forecasted flow conditions are considered a critical step in identifying, sizing, and siting, additional flood control improvements to implement. Hydrologic

modeling utilizing the updated climate model along with the factors presented in this report are also recommended.

9 References

Bell, Gary; Sharp, Jeremy; Lewis, James; Savant, Gaurav; McAlpin, Jennifer. Hydraulic Modeling of Extreme Flows for the White Sands Missile Range Using Adaptive Hydraulics (AdH). 2018

Jacobs, Huitt Zollars. 2009 Infrastructure Report Storm Water Drainage Study for BCT (Heavy). 2009.

Northwind. Levee and Channel Improvements Conceptual Design. 2017.

Appendix A. Publicly Available BMP Fact Sheets

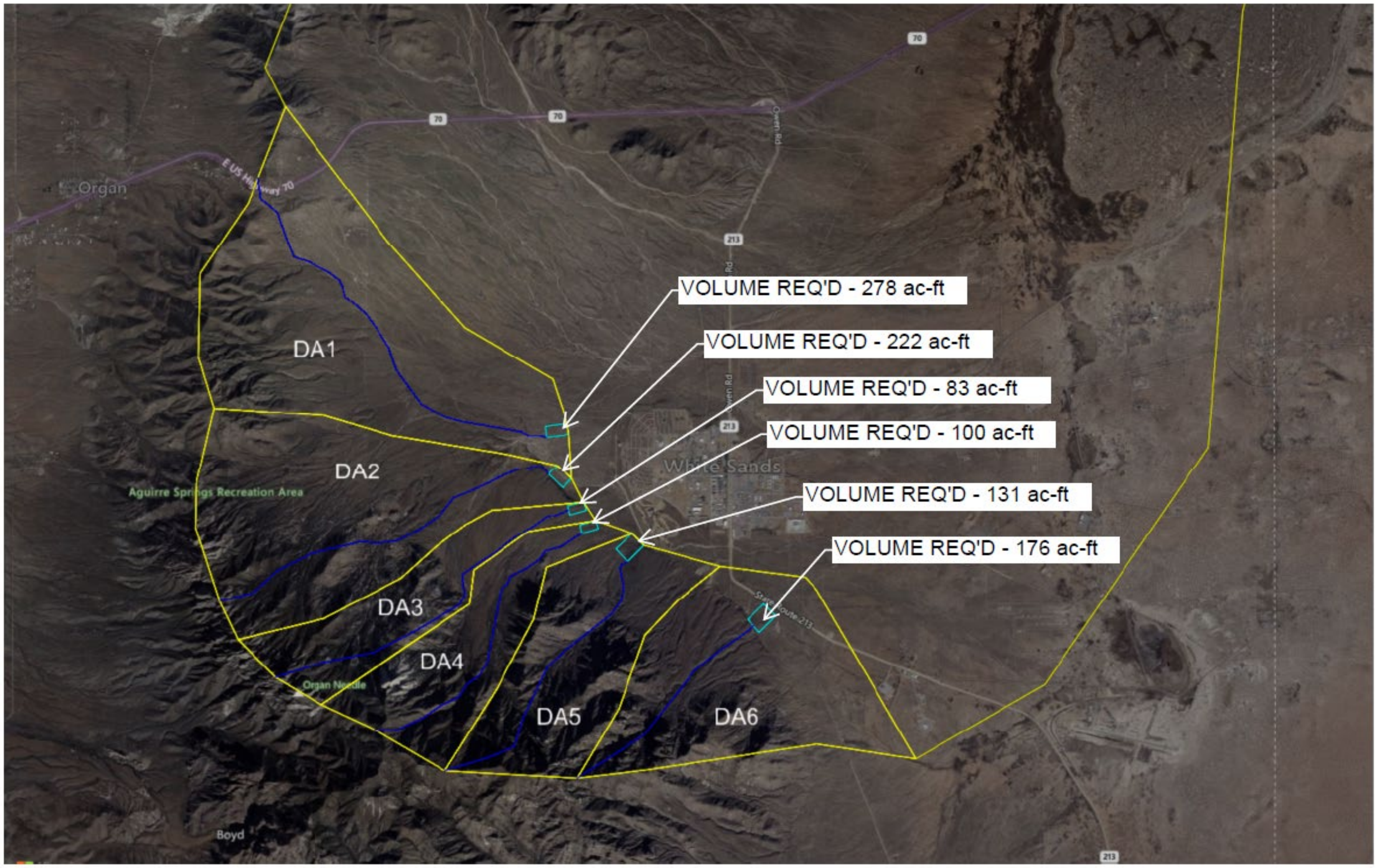
Appendix C WSMR Watershed Level Flood Control Improvements Estimated Maximum Areas

The following calculates the potential maximum areas of each of the flood control improvements presented in White Sands Missile Range Watershed Level Flood Control Conceptual Design Solutions (see Appendix B).

Flow runoff modeling was conducted for each of six drainage areas to the west of WSMR. Each of these six drainage areas produces runoff which ultimately impact either WSMR or Highway 213, which runs north to south, to and from WSMR. TR-55 hydrologic model was used in each of these six drainage areas. Modeling was conducted using the 500-year storm to determine extreme rainfall event runoff. Total flow indicated by the runoff modeling is presented in acre-feet. The resulting flow volume is presented to gain an understanding of the area potential detention basins may require if they were selected as a viable option. A figure is attached which presents the runoff modeling estimates for each drainage area (Figure C-1). Additionally, several other structural flood control improvements were proposed. Areas for each of these is presented in the attached table (Table C-1).

Subsequently, impacted area basin figures were developed to illustrate the potential detention basins. These figures and basins are not to scale and are provided as example graphics only (Figure C-2).

Figure C-1: WSMR Runoff Modeling Estimates for Each Drainage Area



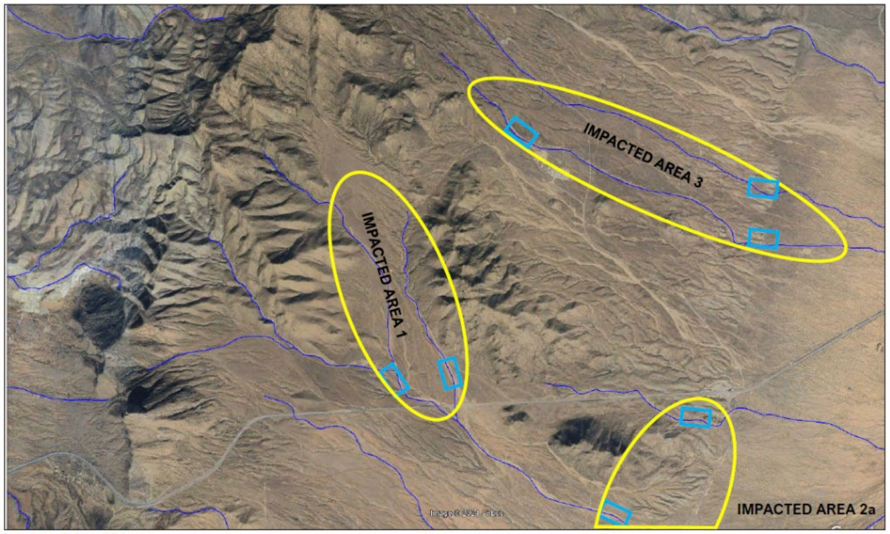
	Q (cfs)	Drainage Area (sq mi)	Rainfall Data (I - 500yr) (in)
DA1	694	7.88	4.9
DA2	835	6.28	4.9
DA3	413	2.34	4.9
DA4	529	2.85	4.9
DA5	713	3.71	4.9
DA6	1332	5	4.9

Table C-1: WSMR Flood Control Improvements Estimated Maximum Areas

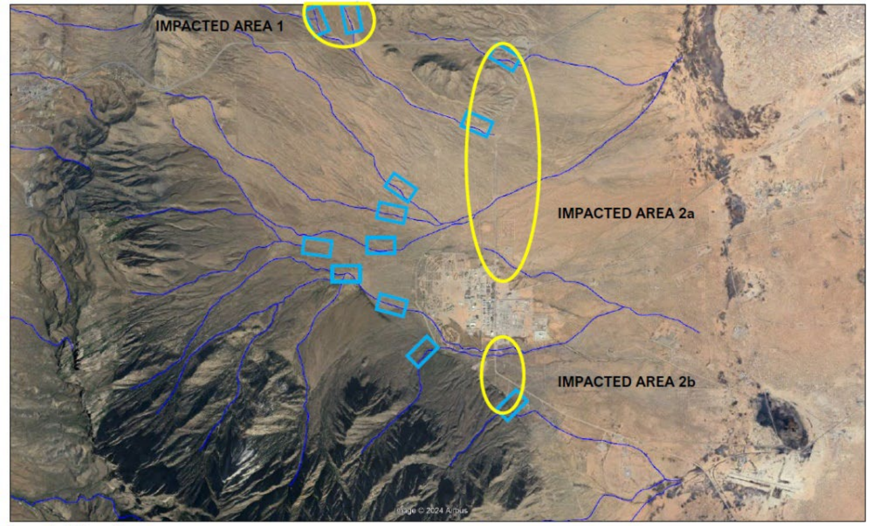
Improvement	Number	Estimated Size	Estimated Total Area Each	Total Estimated Area
Check Dams (Berms)	11	100'x5' (Average)	500 ft^2	5,500 ft^2
Crossing Improvements	3	250'x150', 150'x150', 750'x150'	37,500 ft^2, 22,500 ft^2, 112,500 ft^2	172,500 ft^2
Early Warning System (flow and rain)	4	2'x100' (each)	200 ft^2	800 ft^2
Early Warning System (rain only)	4	2'x2' (each)	4 ft^2	16 ft^2
Berm Extension East of Highway 213	2	75'x650' (each)	48,750 ft^2	97,500 ft^2
Bio Engineering (protect crossings)	2	200'x1,000' (each)	200,000 ft^2	400,000 ft^2
Underground Retention	8	500'x225', 350'x700', 350'x700', 700'x400', 350'x700', 400'x400', 2,000'x2,000', 300'x500'	112,500 ft^2, 245,000 ft^2, 245,000 ft^2, 280,000 ft^2, 245,000 ft^2, 160,000 ft^2, 4,000,000 ft^2, 150,000 ft^2	5,437,500 ft^2
Erosion Control	Event Based	Largest recorded NM wildfire was 2022 Hermits Peak/Calf Canyon Fire	300,000 acres	300,000 acres

Figure C-2: WSMR Impact Area Basin Figures

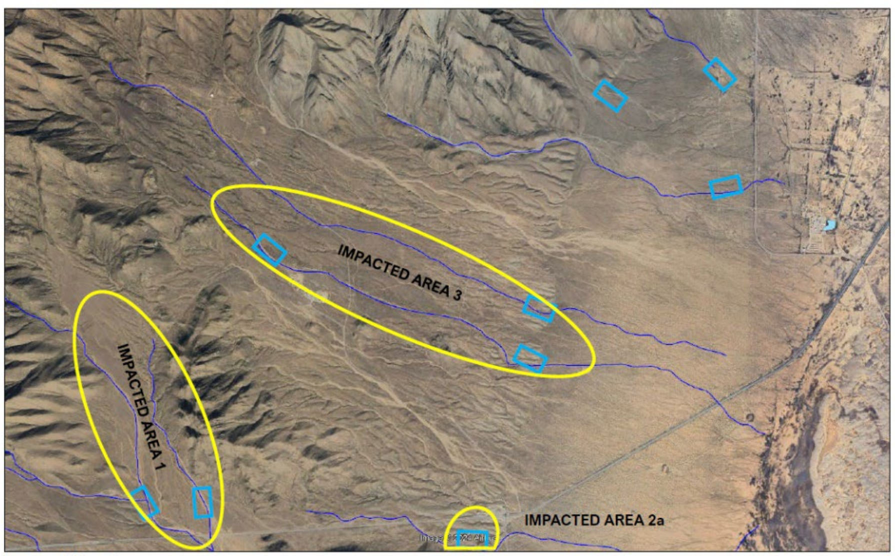
Note: Figures not to scale. Basins not to scale. Example graphic only.



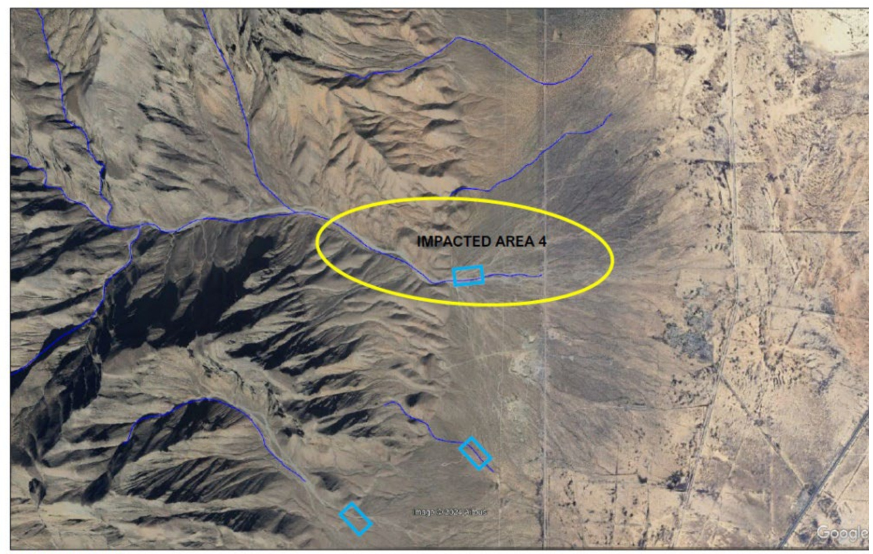
Impacted Area 1



Impacted Area 2



Impacted Area 3



Impacted Area 4