



## **Record of Decision**

### **Armament and Automotive Area/Aerospace Ground Equipment Shop**

Final

### **Buckley Air Force Base**

Prepared By

### **United States Air Force**

### **Aurora, Colorado**

July 2018

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## Acronyms

AAA	Armament and Automotive Area
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
AGES	Aerospace Ground Equipment Shop
Air Force	United States Air Force
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BiRD	biogeochemical reductive dehalogenation (or dechlorination)
CAG	Community Advisory Group
CBSG	Colorado Basic Standard for Ground Water
CCR	Code of Colorado Regulation
CD	compact disc
CDI	chronic daily intake
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Civil Engineering Squadron
C.F.R.	Code of Federal Regulations
CIA	Central Industrial Area
CIP	Community Involvement Plan
COC	chemical of concern
CRP	Compliance Restoration Program
CSEVR	Colorado Soil Evaluation Value - residential
CSM	conceptual site model
DCE	dichloroethene
DERP	Defense Environmental Restoration Program
EAB	enhanced anaerobic bioremediation
EPC	exposure point concentration
ERP	Environmental Restoration Program
ESD	Explanation of Significant Difference
Fe <sub>x</sub> S <sub>y</sub>	iron sulfides
FS	Feasibility Study
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IDP	Installation Development Plan
IR	Information Repository
IRIS	Integrated Risk Information System
ISCR	in situ chemical reduction
LTM	long-term monitoring
LUC	land use control
MCL	Maximum Contaminant Level
mg/kg-day	milligrams per kilogram-day

## Acronyms (continued)

mg/m <sup>3</sup>	milligrams per cubic meter
MY568	Aerospace Ground Equipment Shop
MY570	Armament and Automotive Area
NA	not applicable
NCP	National Contingency Plan
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PCA	1,1,2,2-tetrachloroethane
PRB	permeable reactive barrier
RAO	remedial action objective
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RMA-Insight	RMA-Insight Joint Venture
ROD	Record of Decision
RSL	Regional Screening Level
RSLR	Regional Screening Level – residential
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
SI	Site Inspection
TBC	to be considered
TCE	trichloroethene
TFA	Truck Fueling Area
UCL	upper confidence limit
U.S.	United States
U.S.C.	United States Code
URS	URS Group, Inc.
USEPA	United States Environmental Protection Agency
UU/UE	unlimited use and unrestricted exposure
Versar	Versar, Inc.
VOC	volatile organic compound
ZVI	zero-valent iron
µg/L	micrograms per liter
µg/m <sup>3</sup>	micrograms per cubic meter
95% UCL	95 percent upper confidence limit of the mean

## **1.0 Declaration**

### **1.1 Site Name and Location**

Facility Name: Buckley Air Force Base (AFB)  
Location: 18500 East 6th Avenue, Aurora, Colorado, 80011  
USEPA ID: CO9570025644  
Operable Unit/Site: Compliance Restoration Program (CRP) Armament and Automotive Area (MY570)/ Aerospace Ground Equipment Shop (MY568)

### **1.2 Statement of Basis and Purpose**

This Record of Decision (ROD) presents the Selected Remedy for the Armament and Automotive Area (AAA)/Aerospace Ground Equipment Shop (AGES) site, in Aurora, Colorado. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (42 United States Code [U.S.C.] §§ 9601-9675), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA, Public Law 99-499), and to the extent practicable, the National Contingency Plan (NCP, 40 Code of Federal Regulations [C.F.R.] Part 300). This decision is based on information contained in the Administrative Record (AR) for this site.

This document is issued by the United States (U.S.) Air Force (Air Force), as the lead agency. The Air Force is managing the remediation at the AAA/AGES site in accordance with CERCLA as required by the Defense Environmental Restoration Program (DERP, 10 U.S.C. §§ 2701-2711). Buckley AFB is not on the National Priorities List; therefore, in accordance with Executive Order 12580 (1987), the lead agency responsibilities have been delegated from the U.S. Environmental Protection Agency (USEPA) to the Air Force.

As the lead agency, the Air Force has selected the final remedy for the site. The USEPA has been given the opportunity to review this document and has chosen to defer to the Colorado Department of Public Health and Environment (CDPHE) for regulatory oversight of the Environmental Restoration Program (ERP) at Buckley AFB. CDPHE, as the lead regulatory agency, concurs with the selected remedy.

### **1.3 Assessment of Site**

The remedial action selected in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Until the implementation of the selected remedy is complete, areas within the AAA/AGES site cannot support unlimited use and unrestricted exposure (UU/UE) due to hazardous substances remaining in place. Land use controls (LUCs) are required as part of this remedial action to limit receptors' use of and exposure to contaminated resources on the site. The LUCs will be maintained until concentrations of hazardous substances in the groundwater are at levels allowing for UU/UE.

The Air Force is committed to implementing, monitoring, maintaining, and enforcing all components of the selected remedy to ensure that it remains protective of human health and the environment.

## **1.4 Description of Selected Remedy**

Remedial alternatives for the AAA/AGES site were developed and evaluated through a feasibility study (FS) and presented in the *Final Feasibility Study Report for Central Industrial Area – Armament and Automotive Area (MY570)/Aerospace Ground Equipment Shop (MY568), Buckley Air Force Base, Colorado* (RMA-Insight Joint Venture [RMA-Insight] and Versar, Inc. [Versar] 2017a). Based on the results of the FS, the Air Force developed a Proposed Plan (Air Force 2017) that identified the preferred alternative to cleaning up the contaminated groundwater at the sites and the rationale for this recommendation. After making the Proposed Plan available for public review and comment, the Air Force selected in situ treatment of trichloroethene (TCE) contaminated groundwater and long-term monitoring (LTM) with LUCs for both TCE and 1,4-dioxane as the preferred alternative for the AAA/AGES site. The treatment is designed to treat TCE; 1,4-dioxane is not targeted for treatment because in situ, effective technologies to treat the levels of 1,4-dioxane in groundwater at the site have not been fully evaluated or proven. However, the LUCs described below will protect human receptors from unacceptable risks that might arise from these contaminants. The major components of the selected groundwater remedy include:

- In Situ Chemical Reduction (ISCR) for the TCE plume;
- LTM; and
- LUCs.

LUCs are engineering or institutional controls that protect human health and the environment by controlling access and exposure to contaminants. LUCs will be applied to the AAA/AGES site to control current and future use and access of groundwater, and control any new construction over the TCE plume. Another LUC will protect the LTM network of groundwater monitoring wells and remedial injection wells from disturbance.

The LUCs shall be added to the Buckley AFB Installation Development Plan (IDP), which provides long-range projections for land use that fulfill the military vision for the base.

A full description of LUCs chosen for the AAA/AGES site is included in Section 2.12.2.

## **1.5 Statutory Determinations**

The selected remedy for the AAA/AGES site is protective of human health and the environment, and complies with promulgated federal and state applicable or relevant and appropriate requirements (ARARs) to the remedial action. The selected remedy is cost-effective and uses permanent solutions to the maximum extent practicable.

Because this remedy will result in hazardous substances remaining on site above levels that allow for UU/UE for more than 5 years, the Air Force will conduct a review at least every 5 years after initiation of remedial action to ensure that the remedy continues to be protective of human health and the environment.

In addition to the in situ groundwater treatment remedy, LTM and LUCs will also be applied to ensure continued protection of human health and the environment.



## **1.6 Data Certification Checklist**

The following information is included in Section 2.0.

- Chemicals of concern (COCs) and their respective concentrations (Section 2.5.7).
- Baseline risk represented by the COCs (Section 2.7).
- Cleanup levels established for COCs and the basis for these levels (Section 2.8 and Section 2.12.4).
- Principal threat wastes (Section 2.11).
- Current and reasonably anticipated future land use assumptions, and current and potential future beneficial uses of groundwater (Section 2.6 and Section 2.7).
- Potential land and groundwater use that will be available at the site as a result of the selected remedy (Section 2.6.1 and Section 2.6.2).
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs; discount rate; and number of years over which the remedy cost estimates are projected (Section 2.10.7).
- Key factors that led to selecting the remedy (Section 2.10 and Section 2.12).

Additional information can be found in the Information Repository (IR) for the AAA/AGES site at the Aurora Public Library, Central Branch.

Aurora Public Library  
Central Branch  
14949 E. Alameda Parkway  
Aurora, CO 80012  
Phone: (303) 739-6600  
Hours:  
Monday-Thursday – 8 a.m. to 10 p.m.  
Friday – 8 a.m. to 8 p.m.  
Saturday – 8 a.m. to 6 p.m.  
Sunday – 10 a.m. to 6 p.m.

In addition, final documents that form the basis for the selection of the site response can be accessed via the U.S. Air Force Civil Engineer Center (AFCEC) AR website by going to <http://afcec.publicadmin-record.us.af.mil/Search.aspx>; selecting Buckley AFB, CO; and clicking on “Search.”


## 1.7 Authorizing Signatures

This signature sheet documents the United States Air Force approval of the remedy selected in this Record of Decision for the AAA/AGES site, Buckley Air Force Base, Aurora, Colorado.

  
\_\_\_\_\_  
ROBERT J. BACKLUND, P.E., GS-14, DAF  
Deputy Director, Environmental Management Directorate  
Air Force Civil Engineer Center

9/14/18  
\_\_\_\_\_  
Date

The undersigned representative concurs with the Record of Decision for the AAA/AGES site, Buckley AFB, Aurora, Colorado.

  
\_\_\_\_\_  
JENNIFER OPILA  
Director, Hazardous Materials and  
Waste Management Division  
Colorado Department of Public Health and Environment

11/2/18  
\_\_\_\_\_  
Date

## **2.0 Decision Summary**

The Decision Summary identifies the selected remedy, explains how the remedy fulfills statutory and regulatory requirements, and provides a substantive summary of the AR file that supports the remedy selection decision.

### **2.1 Site Name, Location, and Description**

Buckley AFB occupies 3,287 acres (Buckley AFB 2014) east of Denver, Colorado, as shown in Figure 1. The closest population center is located just west of the base and is in the city of Aurora, a suburb of Denver. Land use around Buckley AFB includes industrial and agricultural to the north, commercial and residential to the west, residential and agricultural to the south, and primarily agricultural to the east.

The AAA/AGES site is defined as the full extent of TCE and 1,4-dioxane groundwater contaminant plumes that underlie and extend beyond the original boundaries for the AAA and AGES sites (CRP sites MY570 and MY568, respectively) (Figure 2). The AAA/AGES site is located in the central area of Buckley AFB, within a CRP investigation area known as the Central Industrial Area (CIA).

As the lead agency for remedial activities, the Air Force has conducted environmental restoration investigations at the AAA and AGES sites in accordance with CERCLA under the DERP which was established by Section 211 of SARA of 1986. CDPHE provides primary regulatory oversight of the environmental restoration actions. In addition, the Air Force is supported by the Tri-County Health Department, the city of Aurora, and Arapahoe County.

### **2.2 Site History and Enforcement Activities**

This section provides background information and summarizes the series of previous site activities and investigations that led to the ROD. It describes the CERCLA activities undertaken at the AAA/AGES site.

The Department of the Army opened this facility as Buckley Field in 1942 to train the Army Air Corps. By 1945, Army training activities declined, and operation of the facility transferred to the Department of the Navy. The facility subsequently became known as the Naval Air Station, Denver. The Navy deactivated the facility in 1959, and the license from the Air Force to use and act as the host of the property was given to the State of Colorado. Under the State of Colorado, the base became known as Buckley Air National Guard Base and was used for military aviation and support activities for the Colorado Air National Guard.

Effective October 1, 2000, the license was revoked by the Air Force and the 821st Space Group became the host group. The base was reassigned from the Air National Guard to the Air Force Space Command and renamed Buckley AFB. In October 2001, the 460th Air Base Wing was established at Buckley AFB and assumed control of the installation. The Wing supports the Air Force mission by providing space-based missile warning data, space communication data, and data relay operations, as well as sustaining related base support functions. On August 19, 2004, the Wing accepted several additional missile warning missions from the 21st Space Wing,

located at Peterson Air Force Base, Colorado. With a full operational mission, the 460th Air Base Wing was re-designated the 460th Space Wing.

Operations in the AAA and AGES sites began in the early 1940s. The AAA site has included an armament and electronic maintenance building, automotive maintenance shop, automotive repair building, armament storage building, a road oil pump house, a paint shop, a maintenance shop, and contained at least two underground storage tanks. Activities at only one of these buildings, Building 940 (automotive maintenance shop) constructed in 1971 in the central area of the site, continue today (Figure 3). The AGES site has consisted of facilities used to support aerospace ground equipment. Building 814, the Aerospace Ground Equipment Shop, has been present on the site since 1971 and is still operational (Figure 3).

TCE was first detected in groundwater above state and federal standards in the AAA site during a 2005 investigation of an adjacent fuel oil storage site (Site 9). The AAA and AGES sites were initially evaluated in the Basewide Preliminary Assessment which recommended investigation of soil and groundwater (URS Group, Inc. [URS] 2007). These investigations were conducted under the Basewide Site Inspection (SI), which was completed in March 2010 and recommended further investigation to determine the nature and extent of contamination (URS 2010).

The Remedial Investigation (RI) for the AAA and AGES sites, and ten other CIA sites (12 total sites), was completed in December 2012 (RMA-Insight and Versar 2012). In 2013, CDPHE, USEPA, and the Air Force administratively and technically agreed AAA and AGES were the source sites for the TCE groundwater contamination (RMA-Insight and Versar 2013). The 1,4-dioxane groundwater contamination was identified later, under the FS. An FS for the AAA/AGES site was completed in March 2017 (RMA-Insight and Versar 2017a). The FS included field investigations and developed and evaluated remedial action alternatives for the TCE and 1,4-dioxane plumes. Laboratory treatability testing and field pilot studies were also performed during the FS for the TCE plume. Another FS and Proposed Plan has been completed for one CIA site, the Truck Fueling Area (TFA) (Figure 3), to address petroleum contamination associated with an underground storage tank north of the TCE and 1,4-dioxane plumes. No Action RODs have been approved for the nine other CIA sites included in the RI (Air Force 2013, 2014, and 2015).

The only known remaining environmental concerns for the AAA/AGES site that warrant remedial action are the TCE and 1,4-dioxane groundwater plumes that are the subjects of this ROD. The investigation results for the AAA and AGES sites are documented in the following reports, which can be found in the Buckley AFB IR at the Aurora Public Library, Central Branch, or in the online AFCEC AR website at <http://afcec.publicadmin-record.us.af.mil/Search.aspx>.

- *Final Feasibility Study Report for Central Industrial Area – Armament and Automotive Area (MY570)/Aerospace Ground Equipment Shop (MY568), Buckley Air Force Base (RMA-Insight and Versar 2017a) (AR #869.1 and #869.2)*

- *Final Compliance Restoration Program Central Industrial Area Remedial Investigation Report, Buckley Air Force Base* (RMA-Insight and Versar 2012) (AR #573.1 through #573.10)
- *Final Basewide Site Inspection Report, Buckley Air Force Base* (URS 2010) (AR #369.1 and #369.2)
- *Final Basewide Preliminary Assessment Report, Buckley Air Force Base* (URS 2007) (AR #39)

There have been no enforcement activities at the AAA/AGES site.

## **2.3 Community Participation**

The Air Force has prepared and implemented a Community Involvement Plan (CIP) in accordance with CERCLA requirements. The CIP describes community involvement activities that the Air Force will undertake during remedial activities at Buckley AFB. The Air Force has followed the CIP requirements, including holding public meetings and providing the opportunity for public comment.

The Preliminary Assessment, Basewide SI, RI, and FS reports for the AAA/AGES site and other documents related to the site were made available to the public in the IR and in the online AR. The AAA/AGES site has been discussed at Buckley AFB Community Advisory Group (CAG) meetings and included in Buckley AFB ERP Site Status Reports that are distributed to the public. The CAG meetings and distribution of Site Status Reports were changed from a quarterly basis to a semi-annual basis starting in April 2013.

Final Proposed Plans, Semi-annual Site Status Reports, and final documents that form the basis for the selection of the site response can be accessed via the AFCEC AR website by going to <http://afcec.publicadmin-record.us.af.mil/Search.aspx>; selecting Buckley AFB, CO; and clicking on "Search". All final documents that form the basis for the selection of the site response, as well as information related to the CAG, can be accessed through the IR compact discs (CDs) or hard copies that are at the Central Aurora Public Library. The library is located at 14949 E. Alameda Parkway, Aurora, Colorado; current hours and other information can be obtained by calling the library at (303) 739-6600.

The Proposed Plan presented the Air Force's preferred remedy for the AAA/AGES site (Air Force 2017). In accordance with 40 C.F.R. § 300.430(f)(3), a notice of availability was published in the *Aurora Sentinel* on November 2, 2017 (Attachment 1). A public comment period for the Proposed Plan was held from November 2 to December 3, 2017. A summary of the Proposed Plan for the AAA/AGES site was presented during the CAG meeting on November 16, 2017. Community members, in addition to representatives from the Air Force and its contractors, CDPHE, city of Aurora, and Arapahoe County, attended the meeting. As described in the Responsiveness Summary in Section 3 of this ROD, no written or verbal comments regarding the remedy evaluation were received from the public.

## **2.4 Scope and Role of Operable Unit or Response Action**

The AAA/AGES site is included in the Buckley AFB CRP. Activities for this and other CRP sites have been and are currently being performed in accordance with the CERCLA remedial process and, to the extent practicable, the NCP. Future investigations, remedy selection, and closure for other CRP sites are pending; however, these activities do not impact the closure of the AAA/AGES site.

This ROD selects a remedial action for the full extent of groundwater contamination assigned to the AAA/AGES site at Buckley AFB.

## **2.5 Site Characteristics**

### **2.5.1 Physiography and Climate**

The Buckley AFB climate is characterized by low relative humidity, abundant sunshine, and large daily and seasonal temperature variations. For the city of Aurora (based on the Stapleton Station), the average daily temperature is a high of 64.4 degrees Fahrenheit with a low of 36.6 °F, and the average annual precipitation is approximately 15.37 inches (<http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?co2220>).

### **2.5.2 Geology**

Buckley AFB is located within the shallow, bowl-shaped Denver Basin (Basin) that covers an area of approximately 6,700 square miles. The Basin has been filled with sedimentary rocks associated with erosion processes occurring to the west in the Rocky Mountains. The sedimentary rocks deposited in the Basin are comprised of six geologic formations including the following in descending stratigraphic order: Castle Rock Conglomerate; Dawson Arkose; Denver, Arapahoe, and Laramie Formations; and the Fox Hills Sandstone. The Fox Hills Sandstone is underlain by the relatively impermeable Pierre Shale Formation.

Buckley AFB is situated on the Denver Formation as the Castle Rock Conglomerate and Dawson Arkose Formations are not present. At Buckley AFB, the Denver Formation is approximately 850 feet thick. The Denver Formation is an approximately 600 to 1,000-foot thick sequence of variably consolidated, interbedded shale, claystone, siltstone, and sandstone occurring in poorly defined discontinuous layers. Approximately 70% of the Denver Formation is composed of thick sequences of shale and claystone. Approximately 30% is composed of coarser grained sediments that are irregularly dispersed in discontinuous layers that range from a few inches to as much as 50 feet thick. The Denver Formation is characterized by its olive, green-gray, brown, and tan colors. Additional characteristics include thin lignite seams.

The thickness of the Denver Formation is expected to inhibit the potential environmental impact to underlying geological units (i.e., Arapahoe and Laramie Formations and Fox Hills Sandstone). Overlying the Denver Formation is a thin mantle of windblown loess and fine sand ranging from 8 to 15 feet thick. However, the mantle is generally less than 10 feet thick. Alluvial deposits derived from the relatively recent erosion of the Denver Formation are located in stream valleys. Specifically, the alluvial deposits are located along Sand Creek, East Toll Gate Creek, and tributaries in the Buckley AFB vicinity. Sand Creek is located north and northeast of Buckley AFB. East Toll Gate Creek is within and south and west of Buckley AFB.

Soils encountered at the AAA/AGES site are characteristic of the Denver Formation and overlying alluvial and windblown deposits described above. The geology underlying the AAA/AGES site consists of unconsolidated alluvial and windblown deposits, primarily silt and silty clay, typically to about 5 to 10 feet below ground surface (bgs). The Denver Formation underlying the site is composed of variably weathered interbedded gray to tan to brownish yellow claystone, clayey siltstone, sandy siltstone, clayey sandstone, silty sandstone, and sandstone with minor gravel and pebbles. The unweathered Denver Formation includes a blue-gray claystone and siltstone locally known as the “Denver Blue” that was observed in two wells within the plume at initial depths of 54 to 54.5 feet bgs. The “Denver Blue’s” upper surface is not a stratigraphic horizon, but rather an irregular weathering and/or alteration zone that is often transitional.

### **2.5.3 Hydrogeology**

Bedrock aquifers of the Denver, Arapahoe, and Laramie-Fox Hills Formations underlying Buckley AFB are identified as part of the Denver Basin aquifer system. Depth to groundwater at Buckley AFB is generally between 15 and 50 feet bgs, primarily in the weathered Denver Aquifer. The claystone within the Denver Formation impedes the hydraulic flow both vertically and horizontally within the aquifer. Because of the conditions noted above, unconfined (i.e., water table) and confined conditions exist within the Denver Aquifer. Generally, unconfined conditions exist within the weathered Denver Aquifer or overlying surficial deposits, as at Buckley AFB; in the deeper zones of the unweathered Denver Aquifer, confined conditions exist. Confined conditions generally are present in the Denver Aquifer in the south and central portions of the Denver Basin outside of Buckley AFB where the Dawson Formation overlies the Denver Formation.

Recharge to the Denver Formation occurs in outcrop areas by direct infiltration of precipitation or irrigation water, and downward leakage from alluvial aquifers in the upland reaches of stream and river valleys. Groundwater discharge occurs primarily in the form of seepage and evapotranspiration where the formation crops out. At Buckley AFB, regional groundwater flow is to the northwest toward the South Platte River, which serves as a groundwater divide within, and a major discharge area for, the aquifer. Within the base, groundwater flows away from the bedrock high area along the northwest-southeast main runway, generally either toward Sand Creek or East Toll Gate Creek.

Depth to groundwater within the AAA/AGES plume is approximately 28 to 45 feet bgs, with depth generally increasing in the northwestern portion of the plume. The groundwater flow direction is primarily to the west in the vicinity of the AAA and AGES sites; downgradient from this area, the groundwater flow direction includes a more northwesterly component. Estimated groundwater flow velocities are approximately 0.006 to 0.3 foot per day across the site, with the possibility that groundwater may flow at higher velocities locally (RMA-Insight and Versar 2012).

### **2.5.4 Surface Water Hydrology**

Sand Creek and East Toll Gate Creek exist along the northeast and southwest sides of Buckley AFB, respectively (Figure 2). Both drainages originate in the high plains east of Buckley AFB. The AAA/AGES site lies between the two drainages, and is more than 3,000 feet from either

drainage. Surface water drainage is controlled by land surface topography, which in general slopes to the north and west at the Base. A water storage reservoir, Lake Williams, exists within the boundaries of the Base in the Sand Creek drainage and is about 3,500 feet upgradient (northeast) from the AAA/AGES site (Figure 2).

No surface water bodies or wetlands are on the AAA/AGES site.

### **2.5.5 Ecology**

The ecological conditions at Buckley AFB were researched during completion of the Integrated Natural Resource Management Plan (Buckley AFB 2015). Native habitat within and adjacent to Buckley AFB includes short grass prairie rangelands and a riparian strip along East Toll Gate Creek. These range lands support numerous non-game species of animals that include ground-nesting birds and small mammals.

A diversity of habitats is found in the open grass prairies, riparian corridors, and open water at Lake Williams, which is located on the northeastern part of the base. Wildlife found in these areas is typical of the high plains of Colorado. Fishery resources found at Buckley AFB are limited to Lake Williams and the small ponds along East Toll Gate Creek.

Several species of birds protected under federal and state of Colorado statutes have been observed at Buckley AFB, including:

- Mature and immature bald and golden eagles;
- Several breeding pairs of western burrowing owls;
- Loggerhead shrike; and
- Ferruginous hawks.

There are no federal or state listed endangered or threatened species present on Buckley AFB (Buckley AFB 2015). No sensitive ecological populations nest or forage on the AAA/AGES site. In addition, there is no sensitive habitat or natural resources at or immediately adjacent to the AAA/AGES site.

Buckley AFB contains several areas designated by the U.S. Fish and Wildlife Service as wetlands that qualify for protection under Section 404 of the Clean Water Act. These areas are found along the riparian corridors and are designated as bottomland meadow or cottonwood/willow associations. None of these areas are within or adjacent to the AAA/AGES site.

### **2.5.6 Previous Site Characterization Activities**

As noted in Section 2.2, various environmental investigations were conducted at the AAA/AGES site between 2008 and 2016, after TCE was detected above state and federal standards in the AAA site during a 2005 investigation of an adjacent fuel oil storage site (Site 9). The subsections below describe the primary investigations for the AAA/AGES groundwater contaminant plume and briefly summarize their findings.

#### **2.5.6.1 Basewide SI**

The Basewide SI, conducted in 2008 and 2009, investigated soil and groundwater at the AAA and AGES sites for potential releases of petroleum products, solvents, and metals (URS 2010).



The investigation at the AAA site included installation of two monitoring wells, analysis of soil and groundwater samples from these two wells, analysis of soil samples from four borings, and inspection of soil from four borings near potential source areas. The investigation at the AGES site included installation of one monitoring well and analysis of soil and groundwater samples from this well. Based on the results for these and other sites in the central portion of the base, the Basewide SI Report (URS 2010) identified a TCE plume beneath the AAA, AGES, and four other sites, and recommended that volatile organic compounds (VOCs), semivolatile organic compounds, petroleum hydrocarbons, and metals in soil and groundwater be further investigated.

#### 2.5.6.2 Central Industrial Area CRP RI

The AAA and AGES sites, in addition to 10 other CIA sites, were investigated in 2011 during the CRP RI (RMA-Insight and Versar 2012). Chemicals of potential concern in soil and groundwater for the AAA and AGES sites were VOCs, polycyclic aromatic hydrocarbons (PAHs), and metals, including hexavalent chromium. Field activities were performed during two phases of work to characterize soil and groundwater, and identify the source areas and extents of the contamination found in groundwater. In the AAA site, soil samples were collected from 10 soil borings, monitoring wells were installed in these borings, and groundwater samples were collected from these 10 new wells and 4 existing wells. In the AGES site, soil and groundwater samples were collected from two soil borings that were drilled and completed as monitoring wells. Throughout the CIA, a total of 80 soil borings were drilled and sampled, with 58 of these completed as monitoring wells; a total of 172 soil samples and 75 groundwater samples were analyzed.

RI sampling results were evaluated against soil and groundwater screening levels established in the Basewide SI and CIA RI. Soil data were compared to Colorado Soil Evaluation Values – residential (CSEVRs) (CDPHE 2011a, 2011b), and USEPA Regional Screening Levels – residential (RSLRs) (USEPA 2011). During the RI, only one chemical of potential concern was detected in soil at a concentration greater than the CSEVR (CDPHE 2011a) or USEPA RSLR (USEPA 2011) at either the AAA or AGES sites. This chemical, benzo(a)pyrene, a PAH, was detected in one shallow soil sample collected from the ground surface to 0.5 foot bgs at the AAA site. However, based on the results of the RI, the benzo(a)pyrene detection was determined to be unrelated to historical site activities, and likely attributable to asphalt components from the adjacent parking lot.

In the RI, groundwater data were compared to Colorado Basic Standards for Groundwater (CBSGs) (CDPHE 2009) and Federal Drinking Water Maximum Contaminant Levels (MCLs) (USEPA 2009), and the data confirmed a TCE groundwater plume was present. TCE in groundwater at both the AAA and AGES sites was detected above its CBSG and MCL of 5 micrograms per liter ( $\mu\text{g/L}$ ). In addition, at the AAA site, 1,1,2,2-tetrachloroethane (PCA) and two PAHs (benzo[a]anthracene and chrysene) were detected slightly above their CBSGs (less than two times) in one well each. The PCA concentration was less than the risk-based screening level; therefore, it was not identified as a COC for the FS. These two PAHs did not exceed CSEVRs or RSLRs in soil from the site and, therefore, the sites are not considered a source of the PAHs in the groundwater. In one of the other CIA sites that overlies the TCE plume, 1,4-dioxane was analyzed in groundwater samples from one well but the detection was below the CBSG at the time ( $3.2 \mu\text{g/L}$ ). Other chemicals were detected in groundwater above CBSGs

within the other CIA sites; however, these were not identified as COCs based on their association with treated water (e.g., chloroform, bromodichloromethane, and dibromochloromethane), or not attributable to activities at the site (e.g., other PAHs including benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene).

The RI Report concluded the only COC in groundwater at the site is TCE; the highest concentration of TCE (27 µg/L) was detected in groundwater in the AAA, which is the farthest upgradient site. At the time of the 2012 RI, the detected concentration of 1,4-dioxane was below the existing CBSG. The contamination occurs in shallow groundwater in the weathered Denver Formation bedrock, in a zone that is within about 57 feet of the ground surface. No soil COCs were identified in either the AAA or AGES sites. The RI Report recommended an FS for the TCE plume, which was initiated in 2012 and completed in 2017 as described below. In 2013, CDPHE, USEPA, and the Air Force administratively and technically agreed AAA and AGES were the source sites of the TCE groundwater contamination (RMA-Insight and Versar 2013).

#### 2.5.6.3 AAA/AGES FS

As part of the AAA/AGES FS, four separate phases of field investigations, including two phases of TCE characterization, were conducted from 2013 through 2016 (RMA-Insight and Versar 2017a). In 2013, six monitoring wells were installed and sampled to further delineate the TCE plume. In 2014, five additional monitoring wells were installed and sampled to delineate the downgradient end of the TCE plume; indoor air screening was also conducted in a building near the downgradient end of the TCE plume under a vapor intrusion pathway investigation by AFCEC (AFCEC Environmental Directorate 2014). In 2016, groundwater sampling for 1,4-dioxane was conducted to determine its extent above the 2013 CBSG because its CBSG was made more stringent in 2013. In addition, laboratory studies and field pilot studies were conducted in 2013 through 2014 to evaluate potential technologies to clean up TCE in the plume. The laboratory and pilot studies were not designed to evaluate cleanup of 1,4-dioxane because 1,4-dioxane had not yet been identified as a COC at the site. Technologies that treat 1,4-dioxane are different than those typically used to treat chlorinated solvents.

The results of the FS characterization investigations were as follows:

- No soil contamination was identified based on comparison to residential soil screening levels (2011 CDPHE CSEVRs and USEPA 2011 RLSRs) and CDPHE (2014) groundwater protection levels.
- Higher TCE concentrations were detected in the source area in the AAA site than previously detected (e.g., maximum of 210 µg/L versus 27 µg/L during the RI), which confirmed the source of the plume is in the AAA.
- Two changes to the RI TCE plume boundary were made based on detections above CBSGs in new monitoring wells: 1) the TCE plume was confirmed to be contiguous from AAA downgradient to the west through the AGES, TFA, and Space Warning Squadron Area sites; and 2) the plume narrows and extends farther downgradient (by about 700 feet) compared to the RI interpretation of the plume extent.

- 1,4-Dioxane was identified as a COC based on its presence above the CBSG of 0.35 µg/L, at a maximum concentration of 0.94 µg/L, in five of seven wells that were sampled. The extent of the 1,4-dioxane plume was inferred to be similar to the TCE plume. Further delineation of the 1,4-dioxane plume is planned under remedial design field work.

Under the Air Force's 2014 indoor air screening for TCE and its degradation products (1,2-dichloroethene and vinyl chloride) at the Space Warning Squadron Area site in Building 401 (Figure 3), no detectable concentrations were found in the indoor or ambient air samples at the 2013 or 2014 USEPA Regional Screening Levels (RSLs) for industrial air (AFCEC Environmental Directorate 2014).

In the laboratory studies initiated in 2013, AAA groundwater and soil from the saturated zone near the source area of the plume were used to test three technologies that could be effective at treating the TCE – zero-valent iron (ZVI), biogeochemical reductive dehalogenation (BiRD), and enhanced anaerobic bioremediation (EAB). These technologies are described in Section 2.9.

The field pilot studies in the AAA/AGES plume consisted of injecting ZVI in 2013 in three separate areas, including the AAA, AGES, and TFA sites. At the AAA site, ZVI was injected at four locations from 29 to 45 feet bgs. At the AGES site, ZVI was injected at five locations from 24 to 40 feet bgs. At the TFA site, ZVI was injected at five locations from 30 to 42 feet bgs. After injections, seven wells were monitored for 6 months. Overall, the results of the pilot studies indicated the ZVI created a groundwater environment that could degrade (breakdown) TCE to nontoxic chemicals.

### **2.5.7 Nature and Extent of Contamination**

The AAA/AGES site contamination consists of two overlapping dissolved-phase plumes of contaminants in groundwater above CBSGs (CDPHE 2013): a TCE plume and an inferred 1,4-dioxane plume. TCE and 1,4-dioxane were detected up to concentrations of 210 µg/L and 0.94 µg/L, respectively.

Figure 2 shows the plume areas based on COCs above CBSGs (CDPHE 2013). The plumes originate in the AAA site, and extend west through the AGES site and to the northwest beginning in and downgradient from the TFA site. The areal extent of the TCE plume is 3,450 feet long, and ranges from 75 to 550 feet wide. The inferred 1,4-dioxane plume is similar in length to the TCE plume and is wider (e.g., about 450 feet versus 300 feet in one area of the plume based on data for two crossgradient wells). The inferred 1,4-dioxane plume boundary will be further refined in the remedial design phase. The plumes do not extend off base, and the downgradient end of the plumes are about 0.5 mile from the west base boundary. Groundwater levels in the plume area in 2013-2014 ranged from about 28 to 45 feet bgs.

No site-related COCs have been detected in soil at concentrations above residential screening levels or groundwater protection levels within the footprint of the plume during any of the previous investigations, as described in Section 2.5.6. Although no soil samples were analyzed for 1,4-dioxane, no exceedances of 1,4-dioxane soil screening levels would be expected based on the lack of exceedances of screening levels of other COCs and the higher propensity of 1,4-dioxane to migrate to groundwater rather than sorb to soil (RMA-Insight and Versar 2017a).

Groundwater contamination above the CBSGs is within “shallow groundwater”, which is thought to be a single hydrogeologic unit or hydrostratigraphic unit, correlating with the weathered Denver Formation and aquifer. The water-bearing zone, consisting of weathered sandstones, siltstones, and claystones, is less than 57 feet bgs.

It is uncertain how the chemicals resulting in the groundwater contamination were released to the environment; no remaining sources of contamination have been found. TCE is a cleaning and degreasing solvent (chlorinated solvent), 1,4-dioxane was commonly used as a solvent stabilizer, and both of these contaminants are likely associated with maintenance or similar activities conducted at the AAA site. The data indicate 1,4-dioxane was a component of the TCE release in the source area. It is uncertain when the contaminants were released, but it was most likely between 1945 and 1975.

### **2.5.8 Conceptual Site Model**

A conceptual site model (CSM) was developed in the CIA RI (RMA-Insight and Versar 2012) to depict the potential relationship or exposure pathway between chemical sources and receptors. An exposure pathway describes the means by which a receptor can be exposed to contaminants in environmental media. These pathways, as presented in Figure 4, are based upon current and potential future land uses and the potential beneficial use of groundwater at the AAA/AGES and other CIA sites. A conceptual model for the sites indicates runoff, leaks, and spills of maintenance and industrial materials during historical activities could have impacted surface soil, subsurface soil, and groundwater (Figure 4). Potential exposure media include surface soil (0-0.5 foot bgs), combined soil (0-10 feet bgs), deep groundwater (deeper than 10 feet bgs), and indoor and ambient air.

Groundwater at the AAA/AGES site occurs primarily in the weathered Denver Aquifer, which is an unconfined aquifer generally at more than 10 feet bgs; from a hydrogeological perspective, the groundwater at this site is considered shallow (Figure 4). However, from a risk assessment perspective as indicated on Figure 4, the groundwater at this site is considered to be “deep” because it is more than 10 feet bgs; for risk assessment purposes, groundwater is categorized as shallow if it is at depths of 10 feet bgs or less. Exposure to surface soil is possible at the site. Exposure to subsurface soil could occur during future site excavation work. Direct exposure to groundwater will not occur during excavation work, because the depth to groundwater at the AAA/AGES site is at least 28 feet bgs and excavation will not be this deep. Although on-base groundwater production wells exist, groundwater at Buckley AFB is not currently used as a source of drinking water, nor is future use anticipated. VOCs from groundwater can enter indoor air via vapor intrusion in areas that have buildings.

Based on current and reasonably anticipated future land use scenarios, full-time commercial/ industrial workers (either current or potential future), and potential future construction workers were evaluated for the CIA sites in the human health risk assessment (HHRA) (RMA-Insight and Versar 2012). In addition, a hypothetical residential scenario (including domestic use of groundwater) was evaluated for this site. Future residential use at the AAA/AGES site is considered unlikely; however, a hypothetical residential scenario was considered in the HHRA to determine whether the site’s land and groundwater would be suitable for UU/UE and to establish requirements for LUCs, as described within this ROD.

## **2.6 Current and Potential Future Land Use and Resource Uses**

### **2.6.1 Land Use**

The current land use of the AAA/AGES site is as industrial/administrative according to the Buckley AFB IDP (Buckley AFB 2014). The most likely future land use of the AAA/AGES site is also as industrial/administrative and mixed use (e.g., retail, housing, and administration) according to the Buckley AFB IDP (Buckley AFB 2014).

The current land use of adjacent and surrounding land beyond the base boundary to the west is primarily residential and commercial. The future use of adjacent and surrounding land is expected to remain the same over the foreseeable future.

The federal government maintains both surface and subsurface ownership of the on-base land affected by the AAA/AGES site. As discussed in later sections, LUCs will be implemented for the AAA/AGES site to ensure exposure to impacted groundwater is prevented.

### **2.6.2 Ground and Surface Water Beneficial Uses**

The aquifer beneath and in the vicinity of the AAA/AGES site is the Denver Aquifer as described in Section 2.5.3. No site-specific groundwater classifications or site-specific water quality standards exist for the Buckley AFB area. The shallow groundwater that has been the subject of the investigations is considered a single water-bearing geologic unit, correlating with the weathered Denver Formation and aquifer. As described in Section 2.5.7, the Denver Aquifer is affected by the AAA/AGES site contamination, based on TCE and 1,4-dioxane concentrations above CBSGs.

Although on-base groundwater production wells exist, currently, groundwater at Buckley AFB is not used for drinking water or irrigation, and future use is not anticipated. Drinking water for Buckley AFB is supplied by the city of Aurora. No surface water exists on the site.

## **2.7 Summary of Site Risks**

This section summarizes the human health and ecological risk assessments that have been performed for the CIA, focusing on the AAA and AGES sites and the six other sites that overlie the TCE groundwater plume. The six other sites overlying the TCE plume include the Communication Facility Area, Building 815 Area, Aqua Gas System Area, Naval Motor Pool Area, TFA, and Space Warning Squadron Area. The risk assessment was conducted to determine whether chemicals detected in groundwater or soil pose a threat to human health. The COCs associated with unacceptable site risk are identified, as well as the potentially exposed populations and exposure pathways of primary concern. A summary of the findings of the ecological risk assessment is also presented.

### **2.7.1 Summary of Human Health Risk Assessment**

The baseline risk assessment conducted during an RI estimates what risks the site poses if no action were taken. It provides an understanding of the actual and potential risks to human health, which is useful in determining whether remedial action is warranted. This section of the ROD summarizes the approaches used and the results of the HHRA for the CIA and specifically for the sites that overlie the TCE groundwater plume, as presented in the RI Report for the CIA sites (RMA-Insight and Versar 2012) and reevaluated in the FS Report (RMA-Insight and Versar

2017a). The results and conclusions of the RI HHRA for groundwater exposure pathways (for the eight sites overlying the TCE groundwater plume) were reevaluated for current commercial/ industrial workers in the FS, because higher TCE concentrations were detected in groundwater at the source area during the FS as compared to the RI. In addition, in one building within the Space Warning Squadron Area site (Building 401), the Air Force also conducted indoor air screening in 2014 to further evaluate risk.

The HHRA is divided into the following sections: identification of COCs (hazard assessment), exposure assessment, toxicity assessment, and risk characterization. Potential risks for both current and potential future (both reasonably anticipated and hypothetical) site occupants are discussed. Key assumptions and uncertainties associated with the HHRA are also identified. The chemicals, exposure pathways, and populations associated with unacceptable risk are highlighted. The HHRA separately evaluated each of the sites for groundwater exposure pathways; however, for soil exposure pathways, soil data from all 12 CIA sites were combined.

#### 2.7.1.1 Identification of Chemicals of Concern

In the RI HHRA, maximum detected concentrations of chemicals in groundwater were compared to the USEPA RSLs for Chemical Contaminants table (tapwater) (USEPA 2011) to identify COCs for domestic use of groundwater. To identify COCs for the vapor intrusion pathway, the maximum detected concentrations of chemicals in groundwater were compared to USEPA target groundwater concentrations for protection of vapor intrusion into indoor air (USEPA 2002). Maximum detected concentrations of chemicals in soil were compared to the lower of the USEPA (2011) RSLR or the CDPHE (2011a) CSEVR, and then, for arsenic in soil, to Colorado background (CDPHE 2011b). Chemicals with concentrations exceeding human health screening levels based on a target cancer risk of  $1 \times 10^{-6}$  or a hazard index (HI) of 0.1 were retained in the risk assessment. Data used in the risk assessment were of sufficient quality for risk assessment purposes.

For evaluating the COCs in the HHRA, the 95% upper confidence limit (UCL) of the mean of the chemical concentrations in groundwater were used as the exposure point concentrations (EPCs) when 10 or more samples were collected, such as for TCE; the maximum concentration for 1,4-dioxane, which was only sampled at one location, was used as the EPC. To evaluate the vapor intrusion pathway in the RI HHRA, indoor air concentrations were modeled using the Johnson and Ettinger analytical solution (USEPA 2004), site-specific model input parameters, and groundwater EPCs (95% UCLs). In 2014, to further evaluate risk to industrial workers from the vapor intrusion pathway, AFCEC conducted indoor air screening in one building overlying the TCE plume and compared the concentrations to USEPA (2013a, 2014) RSLs for industrial air.

The risk characterization, which incorporates the exposure and toxicity assessment described in the following sections, identified COCs representing the primary contributors to the cancer risk and/or noncancer adverse effects. Based on the HHRA and evaluation of site-derived chemicals, TCE (indoor air and groundwater use) and 1,4-dioxane (groundwater use) were the only chemical risk drivers determined to be COCs for the AAA/AGES site in the FS. TCE and 1,4-dioxane were identified as groundwater COCs because they generated a cancer risk that exceeded  $1 \times 10^{-6}$  or an HI that exceeded 1. In the RI HHRA, other chemicals were quantitatively evaluated in the risk assessment and detected above CBSGs, as described in

Section 2.5.6.2, but were not considered COCs for further evaluation in the AAA/AGES FS due to sporadic detection (PCA); association with treated water (e.g., chloroform, bromodichloromethane, and dibromochloromethane); or not attributable to activities at the site (i.e., PAHs) or, for the TFA site, the portion of the site associated with the TCE plume (excludes the TFA petroleum contamination).

Table 2-1 presents the range of detected concentrations, detection frequency, EPCs, and screening concentrations for the groundwater COCs at the AAA/AGES site, as evaluated during the RI HHRA. For the purposes of this table, although groundwater exposure pathways were evaluated separately by site, this summary represents the range of concentrations and highest EPCs from the RI HHRA for the eight sites that overlie the TCE and 1,4-dioxane groundwater plumes. No COCs were identified for soil.

**Table 2-1  
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations**

Media/ Exposure Pathway	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration <sup>1</sup>	Screening Concentration <sup>2</sup>
		Min	Max				
<b>Groundwater</b>							
Ingestion, Dermal Contact	1,4-Dioxane <sup>3</sup>	0.81 <sup>3</sup>	1.4 <sup>3</sup>	µg/L	1/2 <sup>3</sup>	<b>1.4<sup>3</sup></b>	0.67
	TCE	0.17	27 <sup>4</sup>	µg/L	various <sup>4</sup>	<b>22<sup>4</sup></b>	0.26
Vapor Intrusion <sup>5</sup>	TCE	0.17	27 <sup>4</sup>	µg/L	various <sup>4</sup>	<b>22<sup>4</sup></b>	5
		NA	NA	µg/m <sup>3</sup>	NA	<b>5.01 (resident) 1.04 (industrial)<sup>4</sup></b>	0.43 (resident) 3.0 (industrial)
<sup>1</sup> <b>Bolded</b> EPCs exceed a screening concentration. <sup>2</sup> The screening levels in the RI were the USEPA (2011) tap water RSLs based on a cancer risk of 1 x 10 <sup>-6</sup> or hazard index of 0.1 and, for the vapor intrusion pathway, USEPA target groundwater concentrations for protection of vapor intrusion into indoor air (residential use scenario) (USEPA 2002). In addition, the 2014 indoor air screening for Building 401 used USEPA (2013a and 2014) regional screening levels for industrial air; for comparison purposes, the resident level is also presented in this table. <sup>3</sup> In 2016 during the FS, seven wells were sampled for 1,4-dioxane. Concentrations ranged from 0.49 to 0.94 µg/L with the maximum concentration detected in the same well that was sampled during the RI (which had a concentration of 1.4 µg/L; the well was within the Building 815 Area site). <sup>4</sup> The maximum TCE concentration was detected in the AAA site; the highest EPC was for the adjacent Communication Facility Area site. In 2013 during the FS baseline sampling, the maximum TCE concentration was 170 µg/L, detected in the AAA site. <sup>5</sup> The exposure point concentrations that are identified in units of µg/m <sup>3</sup> were modeled indoor air concentrations, based on the groundwater exposure point concentration; these were used in the RI HHRA.  NA - not applicable (Indoor air concentrations were modeled in the RI using the Johnson & Ettinger Model [USEPA 2004] and groundwater EPCs.) µg/L - micrograms per liter µg/m <sup>3</sup> - micrograms per cubic meter							

### 2.7.1.2 Exposure Assessment

This section documents the populations and exposure pathways that were quantitatively evaluated in the HHRA. A CSM was developed to aid in determining reasonable exposure scenarios and pathways of concern; this CSM is shown on Figure 4. As described in this section, both current and future populations have been evaluated based on current and reasonably

anticipated and hypothetical future land use. The contaminated media to which people may be exposed is also discussed. In addition to land use, other potentially impacted resources were evaluated, including groundwater.

Chemical releases at the AAA/AGES site have resulted in contaminated groundwater, the primary contaminated media at the site. Exposures to groundwater and soil were evaluated, although groundwater is not a current exposure medium at the site, as described in Section 2.6.2, and soil COCs were not identified at the AAA/AGES site. Exposures to indoor air of buildings via vapor intrusion of VOCs from groundwater were also evaluated.

The source area of the TCE plume is southwest of the AAA automotive maintenance shop (Building 940) on undeveloped land within a west-trending (dry) drainage. The other areas overlying or adjacent to the AAA/AGES TCE and 1,4-dioxane plumes include roads, parking areas, and six commercial and light industrial buildings (Figure 3).

Current and future exposure scenarios that were evaluated included commercial/industrial workers. A construction worker scenario was also evaluated for potential exposure to contaminated soil; however, no soil contamination was identified at the AAA/AGES site. In addition, although reasonably anticipated future land use at the AAA/AGES site does not include residential use, hypothetical future residents were evaluated for risk management purposes. The potential exposure routes for these commercial/industrial and residential scenarios are described below.

The commercial/industrial scenarios that were considered included a current or potential (future) commercial/industrial worker who could work in a building over the plumes. This worker could inhale VOCs such as TCE in indoor air that migrated from groundwater through vapor intrusion. They could also come into contact with contaminated surface soil; however, no soil COCs were identified at the AAA/AGES site.

A hypothetical future residential scenario was evaluated to estimate health effects that could result from domestic use of contaminated groundwater (i.e., ingestion, skin contact, and inhalation of vapors from water used during showering and bathing), in addition to inhalation of VOCs in indoor air due to vapor intrusion from groundwater.

Major assumptions about exposure frequency, duration, and other exposure factors that were included in the exposure assessment are included in the RI (RMA-Insight and Versar 2012).

### 2.7.1.3 Toxicity Assessment

This section describes the carcinogenic and noncarcinogenic toxicity criteria used to calculate the potential risk for each COC. Carcinogenic toxicity is the tendency of a chemical to cause cancer. Noncarcinogenic toxicity includes all other adverse health effects of a chemical. Toxicity data for carcinogens is presented in Table 2-2 and for noncarcinogens in Table 2-3. When available, separate toxicity criteria are listed for ingestion (oral intake, swallowing), inhalation (breathing into the lungs), and dermal (absorption through the skin) routes of exposure.

For carcinogenic COCs, the toxicity criteria are a numerical slope factor (for oral and dermal routes of exposure) or unit risk (for inhalation routes of exposure), which when multiplied by the daily dose of the chemical, yields the expected incidence of cancer in a population. The weight of evidence/cancer guideline description, usually provided by the USEPA, classifies the degree of confidence that the chemical is a human carcinogen. Slope factors, unit risks, and weight of



evidence/cancer guideline descriptions are listed in Table 2-2 along with the source of each slope factor or unit risk and date of publication (most recent update). Although the most recent update for the 1,4-dioxane slope factor is after the RI was published, the factor is the same as used in the RI HHRA.

For noncarcinogenic chemicals the toxicity criteria are the reference dose (RfD) (for oral and dermal routes of exposure) or reference concentration (RfC) (for inhalation routes of exposure). The RfD or RfC is the maximum daily dose of the chemical that is not expected to cause any adverse effect on human health. The RfD and RfC are derived from animal or human data and incorporate uncertainty factors to address limitations of the data set. RfDs and RfCs are listed in Table 2-3 for each pathway-specific COC along with the target organ of the toxicity, and the sources of each RfD and RfC and date of publication (most recent update).

**Table 2-2  
Cancer Toxicity Data Summary**

<b>Pathway: Ingestion, Dermal</b>				
<b>Chemical of Concern</b>	<b>Oral (Dermal) Cancer Slope Factor (kg-day/mg)</b>	<b>Weight of Evidence/Cancer Guideline Description</b>	<b>Source<sup>1</sup></b>	<b>Date<sup>1</sup></b>
1,4-Dioxane	1.0 x 10 <sup>-1</sup>	Likely to be carcinogenic to humans	IRIS	2013
TCE	4.6 x 10 <sup>-2</sup>	Carcinogenic to humans	IRIS	2011
<b>Pathway: Inhalation</b>				
<b>Chemical of Concern</b>	<b>Unit Risk (m<sup>3</sup>/µg)</b>	<b>Weight of Evidence/Cancer Guideline Description</b>	<b>Source<sup>1</sup></b>	<b>Date<sup>1</sup></b>
TCE	4.1 x 10 <sup>-6</sup>	Carcinogenic to humans	IRIS	2011
<sup>1</sup> As identified for the USEPA May 2013 Regional Screening Level (USEPA 2013b); date corresponds to most recent IRIS update; value was used in RI HHRA. IRIS – Integrated Risk Information System kg-day/mg – kilogram-day per milligram m <sup>3</sup> /µg – cubic meters per microgram				

**Table 2-3  
Noncancer Toxicity Data Summary**

<b>Pathway: Ingestion, Dermal</b>				
<b>Chemical of Concern</b>	<b>Oral (Dermal) RfD (mg/kg-day)</b>	<b>Primary Target Organ</b>	<b>Source<sup>1</sup></b>	<b>Date<sup>1</sup></b>
1,4-Dioxane	3.0 x 10 <sup>-2</sup>	Liver	IRIS	2010
TCE	5.0 x 10 <sup>-4</sup>	Heart	IRIS	2011
<b>Pathway: Inhalation</b>				
<b>Chemical of Concern</b>	<b>Inhalation RfC (mg/m<sup>3</sup>)</b>	<b>Primary Target Organ</b>	<b>Source<sup>1</sup></b>	<b>Date<sup>1</sup></b>
TCE	2.0 x 10 <sup>-3</sup>	Heart	IRIS	2011
<sup>1</sup> As identified for the USEPA May 2013 Regional Screening Level (USEPA 2013b); date corresponds to most recent IRIS update.  IRIS – Integrated Risk Information System mg/kg-day – milligram per kilogram-day mg/m <sup>3</sup> – milligram per cubic meter RfC – reference concentration RfD – reference dose				

#### 2.7.1.4 Risk Characterization

This section of the risk assessment combines the results of the exposure assessment with the toxicity criteria identified for the COCs and pathways. Carcinogenic risks and noncarcinogenic impacts for each COC are presented for all populations and media of interest, including both current and future land and other resource use settings. Cumulative risks, including all COCs and pathways, for all relevant pathways and populations are also described.

The major uncertainties affecting the risk assessment are also presented in this section, including uncertainties related to the use of maximum concentrations for screening and the use of 95% UCLs for EPCs, sampling and analysis, chemical fate and transport (e.g., assumption that COC concentrations remain the same over time), the use of default exposure assumptions, and those associated with the toxicity criteria.

For carcinogens, risks are generally expressed as the incremental probability of an individual's likelihood of developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

Where:

Risk = a unitless probability (e.g.,  $2 \times 10^{-5}$ ) of an individual's likelihood of developing cancer

CDI = chronic daily intake, averaged over 70 years (mg/kg-day)

SF = slope factor, expressed as (mg/kg-day)<sup>-1</sup>

These risks are probabilities that are usually expressed in scientific notation (e.g.,  $1 \times 10^{-6}$ ). An excess lifetime cancer risk of  $1 \times 10^{-6}$  indicates that an individual has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. Under CERCLA, cleanup is generally not required when risks are below one-in-one-million ( $10^{-6}$ ), and cleanup is generally required when risks are greater than one-in-ten-thousand ( $10^{-4}$ ). USEPA considers the range of  $10^{-6}$  to  $10^{-4}$  as an acceptable risk management range, while  $10^{-6}$  is a CDPHE target cancer risk (i.e., acceptable risk to human health) (CDPHE 2012).

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with an RfD derived for a similar exposure period. An RfD represents a daily individual intake (i.e., exposure) over a lifetime that is not expected to cause any adverse effect. The ratio of site-related daily intake to the RfD is called a hazard quotient (HQ).

The HQ is calculated as follows:

$$\text{Noncancer HQ} = \text{CDI}/\text{RfD}$$

Where: CDI = chronic daily intake

RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

The HI is generated by adding the HQs for all COCs and pathways at a site that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which an individual may reasonably be exposed. An HI less than or equal to 1 indicates that adverse effects are unlikely from additive exposure to site chemicals. An HI greater than 1 indicates that site-related exposures may present a risk to human health. A higher HI does not indicate a greater probability of health effects.

### **Summary of Human Health Risks**

Cancer risks and noncancer hazards were calculated under baseline conditions (i.e., based on existing, current site data) and used reasonable maximum exposure assumptions. Tables 2-4 and 2-5 present the cancer and noncancer COC-specific risk estimates, respectively, for each COC and exposure route for the receptors with estimated cancer risks above  $10^{-6}$  or an HI greater than 1 (i.e., residents) for each of the eight sites that overlie the TCE and 1,4-dioxane plumes. As described in Section 2.7.1.1, other chemicals were quantitatively evaluated in the risk assessment and some contributed to cancer risks above  $1 \times 10^{-6}$ , but they are not site-derived contaminants and are not COCs.

For the current commercial/industrial worker and the reasonably anticipated future construction worker scenarios, site-related chemicals do not pose unacceptable threats to human receptors. For the current commercial/industrial scenario, cumulative excess cancer risks were below  $10^{-6}$ , and the noncancer hazard indices were below the threshold of 1. The highest cumulative excess cancer risk for the commercial/industrial scenario was  $3 \times 10^{-7}$  and the highest noncancer hazard index was 0.1. For the construction worker scenario, no COCs were identified. Therefore, risk assessment results for these receptors are not presented in Tables 2-4 or 2-5. The Air Force's indoor air screening data obtained in Building 401 within the Space Warning Squadron Area site (Figure 3) provide an additional line of evidence that significant vapor intrusion is not occurring in the building overlying this portion of the TCE plume. In this building, all 58 indoor sampling locations were nondetect for TCE and degradation products below the USEPA RSLs for industrial air (AFCEC Environmental Directorate 2014).

The RI HHRA also determined site-related chemicals do not pose unacceptable threats to future commercial/ industrial workers. However, the potentially complete and significant pathway that was evaluated quantitatively in the RI HHRA and could change based on different groundwater concentrations during the FS is the inhalation of VOCs in indoor air via vapor intrusion from groundwater. The FS determined that the RI risk/hazard calculations and conclusion remain protective of human health based on current exposure scenarios because the differences between the RI and FS TCE concentrations are negligible where buildings currently overlie the plumes. However, under a hypothetical future commercial/ industrial worker scenario for a new building constructed over the source area of the TCE plume, TCE could pose an unacceptable threat to future full-time occupants. This is because higher TCE concentrations were detected in groundwater in this area of the AAA in the FS as compared to the RI.

For hypothetical future residents – a scenario that is not reasonably anticipated for this area – the cumulative excess cancer risk was within or below the USEPA risk management range for all eight sites for the site COCs (TCE and 1,4-dioxane), as shown in Table 2-4. The noncancer hazard index exceeded the threshold of 1 for five sites for the site COCs (TCE and 1,4-dioxane) (Table 2-5). All excess cancer risks above  $1 \times 10^{-6}$  and hazard indices above 1 for the site COCs were from hypothetical use of groundwater for all uses including drinking, and inhalation of

TCE in indoor air due to vapor intrusion from groundwater. The pathway contributing the majority of the cancer risk and noncancer hazard from TCE was ingestion of groundwater. Both TCE and 1,4-dioxane contributed to the excess cancer risk above  $1 \times 10^{-6}$  for this pathway.

**Table 2-4  
Risk Characterization Summary for Hypothetical Future Resident – Carcinogens**

Site	Media	Chemical of Concern <sup>1</sup>	Pathway-Specific Carcinogenic Risk			Exposure Routes Total
			Ingestion	Dermal Contact	Inhalation <sup>2</sup>	
AAA	Groundwater	TCE <sup>1</sup>	$8.28 \times 10^{-6}$	$5.69 \times 10^{-7}$	$1.02 \times 10^{-5}$	$1.90 \times 10^{-5}$
	Indoor air	TCE	NA	NA	$2.49 \times 10^{-6}$	$2.49 \times 10^{-6}$
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>2 \times 10^{-5}</math></b>
Communication Facility Area	Groundwater	TCE <sup>1</sup>	$1.51 \times 10^{-5}$	$1.03 \times 10^{-6}$	$1.85 \times 10^{-5}$	$3.46 \times 10^{-5}$
	Indoor air	TCE	NA	NA	$8.44 \times 10^{-6}$	$8.44 \times 10^{-6}$
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>4 \times 10^{-5}</math></b>
AGES	Groundwater	TCE <sup>1</sup>	$1.16 \times 10^{-5}$	$7.99 \times 10^{-7}$	$1.43 \times 10^{-5}$	$2.68 \times 10^{-5}$
	Indoor air	TCE	NA	NA	$5.48 \times 10^{-6}$	$5.48 \times 10^{-6}$
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>3 \times 10^{-5}</math></b>
Building 815 Area	Groundwater	TCE <sup>1</sup> 1,4-Dioxane <sup>1</sup>	$1.23 \times 10^{-5}$ $2.08 \times 10^{-6}$	$8.46 \times 10^{-7}$ $3.96 \times 10^{-9}$	$1.52 \times 10^{-5}$ --	$2.83 \times 10^{-5}$ $2.09 \times 10^{-6}$
	Indoor air	TCE <sup>1</sup>	NA	NA	$5.07 \times 10^{-6}$	$5.07 \times 10^{-6}$
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>4 \times 10^{-5}</math></b>
Naval Motor Pool Area	Groundwater	TCE <sup>1</sup>	$1.09 \times 10^{-5}$	$7.52 \times 10^{-7}$	$1.35 \times 10^{-5}$	$2.52 \times 10^{-5}$
	Indoor air	TCE	NA	NA	$3.71 \times 10^{-6}$	$3.71 \times 10^{-6}$
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>3 \times 10^{-5}</math></b>
Aqua Gas System Area	Groundwater	TCE <sup>1</sup>	$1.03 \times 10^{-6}$	$7.05 \times 10^{-8}$	$1.26 \times 10^{-6}$	$2.36 \times 10^{-6}$
	Indoor air	NA <sup>1</sup>	NA	NA	NA	NA
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>2 \times 10^{-6}</math></b>
TFA	Groundwater	TCE <sup>1</sup>	$2.68 \times 10^{-6}$	$1.84 \times 10^{-7}$	$3.29 \times 10^{-6}$	$6.16 \times 10^{-6}$
	Indoor air	TCE <sup>1</sup>	NA	NA	$8.54 \times 10^{-7}$	$8.54 \times 10^{-7}$
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>7 \times 10^{-6}</math></b>
Space Warning Squadron Area	Groundwater	TCE <sup>1</sup>	$3.35 \times 10^{-7}$	$2.30 \times 10^{-8}$	$4.13 \times 10^{-7}$	$7.71 \times 10^{-7}$
	Indoor air	NA <sup>1</sup>	NA	NA	NA	NA
	<b>COC Risk Total<sup>3</sup>:</b>					<b><math>8 \times 10^{-7}</math></b>

<sup>1</sup>Other chemicals contributed to risk above  $1 \times 10^{-6}$  but were determined not to be site-related COCs.  
<sup>2</sup>Indoor vapor inhalation pathway was evaluated in the RI by using modeled indoor air concentrations based on groundwater concentrations.  
<sup>3</sup>The COC risk total was rounded to one significant digit.  
NA – not applicable  
-- – not calculated (not a COC)

**Table 2-5  
Risk Characterization Summary for Hypothetical Future Resident – Noncarcinogens**

Site	Media	Chemical of Concern	Pathway-Specific Noncarcinogenic Hazard Quotient			Exposure Routes Total
			Ingestion	Dermal Contact	Inhalation <sup>1</sup>	
AAA	Groundwater	TCE	0.851	0.0577	2.90	3.81
	Indoor air	TCE	NA	NA	0.710	0.710
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>5</b>
Communication Facility Area	Groundwater	TCE	1.55	0.105	5.27	6.93
	Indoor air	TCE	NA	NA	2.40	2.40
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>9</b>
AGES	Groundwater	TCE	1.20	0.0811	4.08	5.35
	Indoor air	TCE	NA	NA	1.56	1.56
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>7</b>
Building 815 Area	Groundwater	TCE	1.27	0.0859	4.32	5.67
		1,4-Dioxane	0.00164	0.00000308	--	0.00164
	Indoor air	TCE	NA	NA	1.44	1.44
<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>7</b>	
Naval Motor Pool Area	Groundwater	TCE	1.13	0.0763	3.84	5.04
	Indoor air	TCE	NA	NA	1.05	1.05
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>6</b>
Aqua Gas System Area	Groundwater	TCE	0.105	0.00716	0.360	0.472
	Indoor air	NA	NA	NA	NA	NC
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>0.5</b>
TFA	Groundwater	TCE <sup>3</sup>	0.275	0.0187	0.938	1.23
	Indoor air	TCE <sup>3</sup>	NA	NA	0.243	0.243
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>1</b>
Space Warning Squadron Area	Groundwater	TCE	0.0345	0.00234	0.117	0.154
	Indoor air	NA	NA	NA	NA	NA
	<b>COC Hazard Index Total<sup>2</sup>:</b>					<b>0.2</b>

<sup>1</sup>Indoor vapor inhalation pathway was evaluated in the RI by using modeled indoor air concentrations based on groundwater concentrations.  
<sup>2</sup>The COC risk total was rounded to one significant digit.  
<sup>3</sup>Other chemicals contributed to a hazard index above 1 but were determined not to be site-related COCs.  
NA – not applicable  
-- -- not calculated (not a COC)

### 2.7.2 Summary of Ecological Risk Assessment

The AAA site (but not the AGES site) was determined to have ecological habitat to support some of the ecological receptors (plants, soil invertebrates, and wildlife, including birds and mammals) and was carried through the Ecological Risk Assessment in the CIA RI (RMA-Insight and Versar 2012). Risks for ecological receptors at this site were below levels of concern.

### 2.7.3 Basis for Action

It is the Air Force’s current judgment that the response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment from the AAA/AGES site. CDPHE concurs with the response action for this site. Groundwater at the AAA/AGES site, without treatment, does not support UU/UE because it contains TCE and 1,4-dioxane at concentrations greater than levels considered protective of human health and the environment. The response action is warranted based on unacceptable cancer risks and noncancer hazards and exceedances of ARARs (i.e., CBSGs).

## **2.8 Remedial Action Objectives**

Remedial action objectives (RAOs) provide a general description of what the cleanup will accomplish. These goals typically serve as the design basis for the remedial alternatives that are presented in the next section.

The RAOs for the AAA/AGES site are:

- Protect human health by preventing exposure to groundwater containing contaminants exceeding CBSGs until concentrations have been reduced to levels that allow UU/UE.
- Achieve regulatory requirements of preventing migration of groundwater containing contaminants exceeding CBSGs beyond the point of compliance.

A point of compliance, such as a monitoring well or wells, will be established at some specified distance downgradient of the groundwater contaminant plume. The purpose of a point (or points) of compliance at this site is to determine if unacceptable levels of COCs are migrating beyond the LUC boundaries, identified on Figure 5.

These RAOs were developed based on a hypothetical future land use (residential), which is the most protective and allows UU/UE, and the potential beneficial use of groundwater as described in Section 2.6.2. These RAOs address the risks identified in the risk assessment by preventing potential ingestion and other potential domestic uses of contaminated groundwater and inhalation of VOCs in indoor air due to vapor intrusion from groundwater until UU/UE is achieved. The quantitative cleanup levels for groundwater COCs that need to be met to achieve the RAOs (CBSGs) are presented below.

- TCE: 5 µg/L
- 1,4-Dioxane: 0.35 µg/L

Concentrations of potential degradation products of the COCs must also meet their CBSGs to achieve the RAOs, including cis-1,2-dichloroethene (DCE) (70 µg/L), trans-1,2-DCE (100 µg/L), and vinyl chloride (2 µg/L). These TCE degradation products do not currently exceed CBSGs.

## **2.9 Description of Alternatives**

The Air Force considered five remedial alternatives to address groundwater at the AAA/AGES site as documented in the Final AAA/AGES FS Report (RMA-Insight and Versar 2017a) and as summarized in Table 2-6. One alternative, Alternative 5, is applicable only to the 1,4-dioxane plume. Each alternative evaluated is described in more detail, including remedy components, common elements and distinguishing features, and expected outcomes, in the following sections.

**Table 2-6  
Summary of Remedial Alternatives for Groundwater, AAA/AGES Site**

<b>Alternative</b>	<b>Components</b>	<b>Description</b>	<b>Estimated Cost/Timeframe</b>
<b>1 – No Action</b> <i>No action, no monitoring, and no restrictions.</i>	None	No action	No cost or time
<b>2 – Chemical Reduction using Zero Valent Iron (ZVI), LUCs, and LTM</b>  <i>Uses reactive iron to degrade TCE to nontoxic chemicals by an abiotic process.</i>	Injection of ZVI	Injection of ZVI at three permeable reactive barriers (PRBs) (injections in the PRBs about 20 feet apart), and up to 4 secondary treatments about 4 years apart.	Capital: \$956,639 Annual O&M*: \$62,400 Present Worth: \$2,513,964 Construction time: 2 months Time to Achieve RAOs: 21 years
	Groundwater monitoring	Periodic groundwater monitoring and reporting.	
	LUCs	LUCs to prohibit use of groundwater and disturbing the groundwater monitoring network, and limit construction over the TCE plume.	
<b>3 – Biogeochemical Reductive Dehalogenation (BiRD), LUCs, and LTM</b>  <i>Uses naturally present concentrations of iron and sulfate at the site to reduce TCE to nontoxic chemicals, primarily as an abiotic process</i>	Injection of carbon, sulfate, and other amendments as needed (e.g., iron, bacteria)	Injection of BiRD substrates at three PRBs (injections in the PRBs about 30 feet apart), and up to 5 secondary treatments about 3 years apart.	Capital: \$536,246 Annual O&M*: \$62,400 Present Worth: \$1,459,960 Construction time: 2 months Time to Achieve RAOs: 18 years
	Groundwater monitoring	Periodic groundwater monitoring and reporting.	
	LUCs	LUCs to prohibit use of groundwater and disturbing the groundwater monitoring network, and limit construction over the TCE plume.	
<b>4 – Enhanced Anaerobic Bioremediation (EAB), LUCs, and LTM</b>  <i>Modifies subsurface environment to stimulate bacteria and enhance biological degradation of TCE to nontoxic chemicals.</i>	Injection of carbon substrate and bacteria	Injection of carbon substrate and bioaugmentation culture at three PRBs (injections in the PRBs about 24 feet apart), and up to 5 secondary treatments about 3 years apart.	Capital: \$803,896 Annual O&M*: \$62,400 Present Worth: \$2,330,619 Construction time: 2 months Time to Achieve RAOs: 21 years
	Groundwater monitoring	Periodic groundwater monitoring and reporting.	
	LUCs	LUCs to prohibit use of groundwater and disturbing the groundwater monitoring network, and limit construction over the TCE plume.	
<b>5 – LUCs and LTM (1,4-Dioxane)</b>  <i>Monitors 1,4-dioxane concentrations to determine whether 1,4-dioxane above its CBSG is migrating beyond a point of compliance.</i>	Groundwater monitoring	Periodic groundwater monitoring and reporting.	Capital: \$317,262 Annual O&M*: \$50,700 Present Worth: \$949,209 Construction time: 1 month Time to Achieve RAOs: 30 years
	LUCs	LUCs to prohibit use of groundwater and disturbing the groundwater monitoring network.	

\*Total O&M and periodic costs are not presented; refer to Table 2-8 for additional cost detail.

### 2.9.1 Description of Remedy Components

One of the five alternatives developed to address remediation at the AAA/AGES site (Alternative 1) is a no action alternative required to be considered in all remedy comparisons; each of the other alternatives has distinct components and features, as indicated in Table 2-6. This section provides a summary overview of the components of those alternatives, including a general description of the components that are similar between alternatives, followed by a discussion of the technology features of each of the alternatives evaluated in the FS.

- **In situ groundwater treatment:** Placement of materials (i.e., amendments) in injection points or wells, throughout the saturated zone, from the groundwater table to the maximum depth of groundwater containing COCs above their CBSGs. These injection points or wells are arranged in lines perpendicular to the plume flow path. Each line of injection points or wells would be considered a simulated permeable reactive barrier (PRB). The PRB transects would be at each of the three ZVI pilot test areas within the TCE plume, which allows use of the existing injection wells, and addresses the central core of the plume (i.e., TCE above 10 µg/L).

None of the treatment alternatives target 1,4-dioxane because in situ, effective technologies to treat the levels of 1,4-dioxane in groundwater at this site have not been fully evaluated or proven. Under Alternative 5, which is applicable only to the 1,4-dioxane plume, groundwater treatment is not included. However, the LUCs will protect human receptors from unacceptable risks that might arise from this contaminant.

Periodic restoration of the in situ groundwater treatment zone at the PRBs will be performed, and include repeat delivery of amendments or expansion of treatment areas, as well as potential adjustments to amendment composition. The purpose of these additional treatment activities would be to address plume areas where COC concentrations are not decreasing as planned by the treatment and optimize effectiveness of the treatment. These optimization activities are also intended to address residual COCs outside the treatment areas if degradation in the fringes of the plume, combined with active treatment are not sufficiently reducing COC concentrations. These scalable features will be implemented to optimize the remedy during LTM.

- **LTM:** Collecting groundwater data to monitor groundwater conditions and evaluate the effectiveness of the remedy (increasing or decreasing concentration trends, ability to achieve the cleanup levels) until UU/UE is achieved.
- **LUCs:** LUCs are institutional or engineering controls that limit the uses of resources or restrict receptors' exposure to contaminants to protect human health and the environment. The LUCs for Alternatives 2 through 5 include: no use of impacted groundwater, other than for environmental monitoring or testing; no disturbing any components of the groundwater monitoring network or any other engineered component of the remedy; and all proposed construction over any part of the TCE plume shall be reviewed by the 460th Civil Engineering Squadron (CES) for potential hazards or risks posed by contaminated groundwater. The Air Force is responsible for implementing, maintaining, monitoring, reporting and enforcing all on-base LUCs. LUCs will be maintained until concentrations of hazardous substances in groundwater are at levels allowing UU/UE.

Alternative 1: No Action. Evaluation of a no action alternative is required as a baseline for comparison to the other alternatives. No action would leave affected groundwater in place and untreated. No mechanisms would be in place to prevent or control exposure to contaminated groundwater.

Alternative 2: Chemical Reduction using ZVI, LUCs, and LTM. Under Alternative 2, ZVI would be placed in injection points or wells at three PRBs in the TCE plume. The ZVI (solid granules) would be mixed with water and injected throughout the saturated zone using nitrogen



gas at low pressures. This technique, which was used in the pilot study, is referred to as atomized liquid injection. The ZVI would form a zone of reactive material. As groundwater flows through the reactive ZVI mineral zone, the TCE is reduced to its degradation compounds, expected to be primarily ethene, ethane, and methane, via an abiotic process.

Alternative 3: BiRD, LUCs, and LTM. Alternative 3 uses concentrations of iron, sulfate, and sulfate-reducing bacteria that are naturally present at the site and supplements site conditions with carbon, sulfate, and other amendments (e.g., iron and/or bacteria), as needed, to transform the COCs to chloride, hydrogen, or carbon substances. Under this alternative, the substrate would be placed in injection points or wells at three PRBs in the TCE plume. The BiRD substrates, either dissolved in water, in an aqueous slurry, or as a non-aqueous emulsion, would be delivered by direct injection or other techniques that could enhance distribution. Reduction of COCs would primarily occur by an abiotic process, as the groundwater flows through a reactive zone of enriched iron sulfide minerals. This type of abiotic process minimizes generation of DCE and vinyl chloride and other potential COC degradation products.

Alternative 4: EAB, LUCs, and LTM. Alternative 4, EAB, involves modification of the subsurface environment to stimulate bacteria and enhance biological degradation of the COCs. A carbon substrate, such as emulsified vegetable oil or dairy whey, and bioaugmentation culture would be placed in injection points or wells at three PRBs in the TCE plume. A bioaugmentation culture is needed because testing during the FS showed that the key group of bacteria involved with the reductive biological degradation of TCE were not present in the groundwater.

Alternative 5: LUCs and LTM (1,4-dioxane only). Under Alternative 5, groundwater monitoring would be conducted to demonstrate sufficient reduction of 1,4-dioxane in groundwater via natural attenuation processes to meet the CBSG.

## **2.9.2 Common Elements and Distinguishing Features of Each Alternative**

Table 2-6 provides a summary of the elements common to each alternative and features that distinguish one alternative from another. All alternatives, with the exception of Alternative 1 (No Action), have LTM and LUCs in addition to installation and sampling of new monitoring wells, as common elements in the design. PRBs are a common element of Alternatives 2 through 4. Other features that are similar between Alternatives 2 through 4 include the ability to meet ARARs both during implementation and after completion, long-term reliability, and estimated time for design and construction. All alternatives, except the “no action” alternative, are expected to attain the RAOs.

Distinguishing features between Alternatives 2 through 4 include estimated time frame to reach remediation goals and alternative costs, as indicated on Table 2-6. Alternative 5, which is applicable only to the 1,4-dioxane plume, does not include any groundwater treatment. A distinguishing feature of Alternative 3 is that BiRD is considered an innovative technology. The Air Force has demonstrated it at pre-commercialization stage at numerous sites that have varying characteristics (Earth Sciences Division 2004, Interstate Technology and Regulatory Council 2008, Kennedy et al. 2006, Parsons 2012). Since 2012, the patented technology has been applied commercially, and numerous sites are at various stages of implementation across the U.S.,

including implementation in 2016 at Buckley AFB for the Site 11 PCE (tetrachloroethene) Plume (RMA-Insight and Versar 2017b).

### **2.9.3 Expected Outcome of Each Alternative**

Table 2-6 provides a summary of the outcomes of each alternative. All alternatives except Alternative 1 (No Action) are expected to attain UU/UE upon achieving RAOs. For Alternatives 2 through 5, the LUCs would be maintained until concentrations of hazardous substances in the groundwater are at levels allowing for UU/UE. For Alternative 3, this time frame for TCE is estimated as 18 years; for Alternatives 2 and 4, this time frame is estimated as 21 years. Under Alternative 5 for 1,4-dioxane, the time frame is estimated as 30 years.

## **2.10 Summary of Comparative Analysis of Alternatives**

In accordance with the NCP, the alternatives for the AAA/AGES site were evaluated using the nine criteria described in Section 121(a) and (b) of CERCLA and 40 C.F.R. Section 300.430 (e) (9) (iii) as cited in NCP §300.430(f)(5)(i). These criteria are classified as threshold criteria, balancing criteria, and modifying criteria.

**Threshold criteria** are standards that an alternative must meet to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—the alternative must meet them or it is unacceptable. The following are classified as threshold criteria:

- Overall protection of human health and the environment; and
- Compliance with, or an applicable waiver of ARARs.

**Balancing criteria** weigh the tradeoffs between alternatives. These criteria represent the standards upon which the detailed evaluation and comparative analysis of alternatives are based. In general, a high rating on one criterion can offset a low rating on another balancing criterion. Five of the nine criteria are considered balancing criteria:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

**Modifying criteria** which may be considered to the extent that information is available during the FS, but can be fully considered only after public and regulator comments, are as follows:

- Community acceptance; and
- State/support agency acceptance.

This section summarizes how well each alternative satisfies each evaluation criterion and indicates how it compares to the other alternatives under consideration. A summary of the evaluation is presented in Table 2-7.

**Table 2-7  
Comparative Analysis of Remedial Alternatives for AAA/AGES Site Groundwater**

Evaluation Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5 <sup>2</sup>
	No Action	ISCR using ZVI <sup>1</sup>	BiRD <sup>1</sup>	EAB <sup>1</sup>	LUCs, LTM
Threshold Criteria					
Overall Protection of Human Health and the Environment	○	●	●	●	●
Compliance with ARARs	○	●	●	●	●
Primary Balancing Criteria					
Long-Term Effectiveness and Permanence	○	◎	◎	◎	◎
Reduction of Toxicity, Mobility, or Volume through Treatment	○	●	●	●	○
Short-Term Effectiveness	○	◎	◎	◎	◎
Implementability	●	◎	●	◎	●
Cost	●	◎	●	◎	●
Modifying Criteria					
Regulatory Acceptance	○	◎	●	◎	●
Community Acceptance	○	◎	●	◎	●

● = Meets Criteria    ◎ = Partially Meets Criteria    ○ = Does Not Meet Criteria

<sup>1</sup>Alternatives 2, 3, and 4 also include LUCs and LTM; treatment under these alternatives does not target 1,4-dioxane.

<sup>2</sup>Alternative 5 is applicable only to the 1,4-dioxane plume.

ARARs = Applicable or Relevant and Appropriate Requirements

BiRD = Biogeochemical Reductive Dehalogenation

EAB = Enhanced Anaerobic Bioremediation

ISCR = In situ Chemical Reduction

LTM = Long-term Monitoring

LUCs = Land Use Controls

NA = Not Applicable

ZVI = Zero-Valent Iron

### **2.10.1 Overall Protection of Human Health and the Environment**

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, and/or LUCs.

All of the alternatives, except Alternative 1 (No Action), are protective of human health and the environment through implementation of LUCs until UU/UE is achieved, in addition to LTM, and, for Alternatives 2 through 4, treatment of groundwater contaminants. The protectiveness of Alternatives 2 through 4 are similar because they all include permanent solutions to treat the groundwater contamination.

### **2.10.2 Compliance with Applicable or Relevant and Appropriate Requirements**

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as “ARARs,” unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are “those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site” (40 C.F.R. 300.5). State standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements are “those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not ‘applicable’ to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate” (40 C.F.R. 300.5).

Alternative 1 (No Action) is the only alternative that would not meet the chemical-specific ARARs because groundwater is currently not in compliance with state standards and exposure to groundwater contaminants could occur before concentrations would be naturally reduced below standards. Under Alternatives 2 through 5, it is expected that these standards would be met in 18 to 30 years.

All alternatives meet the location-specific and action-specific ARARs applicable to all alternatives. Location-specific ARARs are related to wildlife. Action-specific ARARs are related to monitoring well requirements.

### **2.10.3 Long-Term Effectiveness and Permanence**

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once

cleanup levels have been met. This criterion includes the consideration of residual risk that will remain on site following remediation and the adequacy and reliability of controls.

Alternative 1 (No Action) would not provide long-term effectiveness and permanence because of potential excess risk associated with groundwater exposure, although potable use of groundwater and inhalation of vapors from impacted groundwater are unlikely.

Alternatives 2 through 4 would provide similar levels of long-term effectiveness and permanence because they all include permanent destruction of TCE over an estimated period of 18 to 21 years. For 1,4-dioxane, although Alternative 5 would rely on LUCs for a longer period of time to manage the potential risk (30 years) and has some uncertainty associated with the time, after cleanup levels are met, the alternative would provide a similar level of long-term effectiveness and permanence. For Alternatives 2 through 5, LUCs and LTM will ensure protectiveness until COC concentrations have been reduced to levels that allow UU/UE.

#### **2.10.4 Reduction of Toxicity, Mobility, or Volume Through Treatment**

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternative 1 (No Action) does not reduce the toxicity, mobility, or volume of the COCs.

Alternatives 2 through 4 would provide comparable reductions in the toxicity, mobility, and volume of groundwater contamination. Under Alternatives 2 through 4, concentrations of TCE in groundwater would be reduced to its CBSG through in situ groundwater treatment (none of the alternatives include treatment for 1,4-dioxane). Alternative 5 does not meet the criteria because no active treatment for 1,4-dioxane is performed; it relies on natural processes to achieve the reduction goal.

#### **2.10.5 Short-Term Effectiveness**

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternative 1 (No Action) has no short-term impacts because no action is taken.

Alternatives 2 through 5 are expected to be implemented within the same general length of time and have similar risks during implementation because they all involve field work using drilling rigs. Under Alternatives 2, 3, and 4, primarily nonhazardous or inert substances are injected into the subsurface.

#### **2.10.6 Implementability**

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Alternative 1 (No Action) has no technical implementability or administrative feasibility considerations because no action is undertaken.

Alternative 3 is expected to be easier to implement than Alternatives 2 and 4 because the site soil and groundwater are naturally conducive to BiRD. Alternative 3 would not require as significant a transformation of the subsurface environment, to either a strongly reducing environment (Alternative 2) or to a reducing environment where specific COC-reducing bacteria are continuously present in sufficient amounts (Alternative 4). In addition, Alternative 2 is less implementable than Alternative 3 because Alternative 2 relies on emplacement of solid ZVI by atomized liquid injection, whereas Alternative 3 primarily uses soluble amendments that can be placed using more traditional injection techniques, such as low pressure or gravity feed.

Alternative 4 is less implementable than Alternative 3 because Alternative 4 relies heavily on specific bacteria in the subsurface that are not naturally present, and successful introduction (bioaugmentation) and establishment of these COC-degrading bacteria in the plume is susceptible to failure considering the site conditions.

Alternative 5 is easily implemented because it consists of routine groundwater sampling and analysis technologies. Administrative feasibility would be similar for Alternatives 2 through 5.

### 2.10.7 Cost

The assumptions for the cost estimates were presented in detail in the AAA/AGES FS Report (RMA-Insight and Versar 2017a). Appendix A contains the detailed construction, annual O&M, and periodic costs for the alternatives, in addition to the calculated present worth based on these three types of costs. A discount rate of 7% was used to estimate the total present worth for Alternatives 2 through 5, as included in the cost summary in Table 2-8.

**Table 2-8  
Summarized Cost Estimates for the AAA/AGES Site Remedy Alternatives**

Alternative	1	2	3	4	5 (1,4-dioxane only)
Capital cost	\$0	\$956,639	\$536,246	\$803,896	\$317,262
Total O&M (not discounted)	\$0	\$1,248,000	\$1,060,800	\$1,248,000	\$1,470,300
Total Periodic Costs (not discounted)	\$0	\$1,803,034	\$594,916	\$1,635,762	\$25,000
Period of analysis (years)	50	21	18	21	30
Total Present Worth (discounted cost)	\$0	\$2,513,964	\$1,459,960	\$2,330,619	\$949,209

### 2.10.8 State/Support Agency Acceptance

CDPHE concurs with the Air Force's selected remedial action of Alternative 3 for TCE and Alternative 5 for 1,4-dioxane. CDPHE comments on the Draft Final ROD are in Appendix B.

### 2.10.9 Community Acceptance

During the public comment period, no verbal or written comments were received from the community on the recommended remedial action, Alternative 3 for TCE and Alternative 5 for 1,4-dioxane.

## **2.11 Principal Threat Wastes**

The NCP expects that treatment that reduces the toxicity, mobility, or volume of the principal threat wastes will be used to the extent practicable. The principal threat concept refers to the source materials at a CERCLA site considered to be highly toxic or highly mobile that generally cannot be reliably controlled in place or present a significant risk to human health or the environment should exposure occur. A source material is material that contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or that acts as a source for direct exposure.

No source material has been identified as a principal threat waste at the AAA/AGES site.

## **2.12 Selected Remedy**

The selected remedy for the AAA/AGES site, a combination of Alternative 3 for TCE, which includes treatment using the BiRD technology in addition to LUCs and LTM, and Alternative 5 for 1,4-dioxane, which includes LUCs and LTM, was selected based upon its ability to achieve both threshold criteria, as well as the implementability and cost effectiveness criteria. This section describes the selected remedy and the expected outcomes for the selected remedy.

The remedy selection is based on the detailed evaluation of remedial alternatives presented in the Final AAA/AGES FS Report (RMA-Insight and Versar 2017a).

Buckley AFB expects this remedy will remain in effect and be protective of human health and the environment until such time as the concentrations of TCE and 1,4-dioxane decrease to, or below, applicable cleanup levels. LUCs will remain in effect for as long as site conditions pose an unacceptable risk to human health (i.e., concentrations of COCs remain above CBSGs). The Air Force is responsible for implementing, maintaining, and monitoring the remedial action identified herein for the duration of the remedy selected in this ROD. The Air Force will exercise this responsibility in accordance with CERCLA and the NCP. Review, comment, and approval by CDPHE are required for any modification of the remedy that requires a modification of the ROD.

### **2.12.1 Summary of the Rationale for the Selected Remedy**

The selected remedial alternative for the AAA/AGES site is a combination of Alternative 3 (BiRD, LUCs, and LTM) for TCE and Alternative 5 (LUCs and LTM) for 1,4-dioxane. The Air Force and CDPHE believe that the selected remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria (Section 2.10). A brief summary of the rationale for selecting this remedy and rationale for not selecting the other remedies follows.

This alternative is recommended because it is expected to achieve substantial risk reduction by treating the highest concentrations of COCs in groundwater and it provides measures to prevent future exposure to currently contaminated groundwater and potential indoor air contamination until COC concentrations are reduced to levels that allow UU/UE.

Alternative 3 is more easily and reliably implemented compared to the other treatment alternatives, because the site conditions are naturally conducive to this technology. It also has a lower cost than the other alternatives that include treatment. Alternative 5 for 1,4-dioxane, which was only compared against the no action alternative, is easily implemented.

### 2.12.2 Description of the Selected Remedy

The selected remedy for the AAA/AGES site includes the following components:

- ISCR for TCE plume – Reagent injection creating reducing conditions under sulfate and iron-enriched conditions to rapidly generate or restore a solid-phase reactive mineral zone (BiRD), at vertical PRB transects positioned along the length of the plume;
- LTM – Sampling and analysis of monitoring wells; and
- LUCs – Implementation of LUCs until concentrations of hazardous substances in the groundwater are at levels that allow for UU/UE.

These components are described further in the following paragraphs. It is important to note that the remedy may change somewhat as a result of the remedial design and construction processes. Changes to the remedy as described in this ROD will be documented in the form of a memorandum in the AR, an explanation of significant difference (ESD), or a ROD amendment, depending on the magnitude of the change. CDPHE concurrence would be required on any such ROD modification.

#### **ISCR (BiRD)**

Concentrations of iron, sulfate, and sulfate-reducing bacteria that are naturally present at the site will be supplemented with carbon, sulfate, and other amendments (e.g., iron and/or bacteria), as needed, to transform the COCs to chloride, hydrogen, or carbon substances. The substrate will be placed in injection points or wells at three simulated PRBs in the TCE plume. These injection points or wells are arranged in lines perpendicular to the plume flow path. The PRBs are expected to be at each of the three ZVI pilot test areas within the plume, which allows use of the existing injection wells. Injection locations within the PRBs are expected to be from 20 to 30 feet apart. Placement of materials (i.e., amendments) will be throughout the saturated zone, from the groundwater table to the maximum depth of groundwater containing COCs above their CBSGs.

For the initial treatment, 10 new injection points are estimated for the TCE plume PRBs. BiRD substrates (e.g., carbon, sulfate, and iron) will be applied at the 6 existing injection wells and in 10 new injection points, and the subsurface reactions will transition so that BiRD is the dominant treatment process. The BiRD substrates, either dissolved in water, in an aqueous slurry, or as a non-aqueous emulsion, will be delivered by direct injection or other techniques that could enhance distribution. Reduction of COCs will primarily occur by an abiotic process, as the groundwater flows through a reactive zone of enriched iron sulfide ( $\text{Fe}_x\text{S}_y$ ) minerals. This type of abiotic process minimizes generation of DCE and vinyl chloride and other potential COC degradation products.

It is assumed there will be up to five secondary BiRD treatments at the three PRBs after initial remedial action construction, each approximately 3 years apart. Contingent and scalable actions include expansion of the initial treatment areas if COC concentrations are not being sufficiently reduced.



## LTM

A LTM program will be used to monitor groundwater conditions and evaluate the effectiveness of the remedy (increasing or decreasing concentration trends, ability to achieve the cleanup levels) and progress towards achieving the RAOs. LTM is considered an O&M component. The program details will be determined in the LTM plan to be prepared for the AAA/AGES site, with concurrence from CDPHE. The program is expected to include groundwater field parameter measurements, groundwater sample collection for laboratory analysis of COCs and their degradation products at a minimum, and depth to groundwater measurements. The details of the groundwater monitoring network, sampling frequency, and analytical parameters will be developed during the remedial design and refined after the remedy is implemented and as it is optimized. The Air Force will re-evaluate the monitoring program at a minimum during each 5-year review until UU/UE is achieved.

## LUCs

The LUC boundaries are shown on Figure 5 and encompass the TCE and 1,4-dioxane groundwater plumes. The groundwater plumes are where COCs are above CBSGs.

LUCs are kept in place until UU/UE can be allowed. The Air Force is responsible for implementing, maintaining, monitoring, reporting, and enforcing all on-base LUCs.

Here are the LUCs for the AAA/AGES site:

1. Prohibit the use of impacted groundwater, other than for environmental monitoring or testing. The Buckley AFB digging permit system requires all entities to file a form with the Customer Service Section of Base Civil Engineering that must be approved before ground below 6 inches is disturbed. This system will prevent drilling of any groundwater production wells and, therefore, any use of groundwater within the boundary of the AAA/AGES site.
2. Prohibit disturbing any components of the groundwater monitoring network or any other engineered component of the remedy. Any construction action that might damage or interfere with the proper operation or maintenance of any engineered component of the remedy, including monitoring or remediation wells, will not be permitted. The Buckley AFB digging permit system requires all entities to file a form with the Customer Service Section of Base Civil Engineering that the 460<sup>th</sup> CES must approve before ground below 6 inches is disturbed. This form will activate formal utility and infrastructure clearance procedures.
3. All proposed construction over any part of the TCE plume shall be reviewed by the 460<sup>th</sup> CES for potential hazards or risks posed by contaminated groundwater. The Buckley AFB construction review process, triggered by submittal of a Base Civil Engineer Work Request form, and the Buckley AFB digging permit system will prevent construction before review. The 460<sup>th</sup> CES will require additional investigation (e.g., updated groundwater or soil vapor data) or analysis of hazard and risk for the TCE plume to determine if there is an unacceptable risk to human health or the environment. If unacceptable risk is identified, the 460<sup>th</sup> CES will require new construction to include engineering controls to protect human health and the environment.

4. The base environmental impact analysis process will assess the potential environmental impact of any action proposed at the site, to include compliance with LUCs for the site. The environmental impact analysis process is implemented by the 460<sup>th</sup> CES, Installation Management Flight, Environmental Element (460 CES/CEIE).
5. All ROD use limitations and exposure restrictions shall be entered in the Base Installation Development Plan and the Geographical Information System by the Base Community Planner within 30 days after ROD signature.
6. The Air Force is responsible for implementing, maintaining, monitoring, reporting and enforcing all on-base LUCs.
7. The Air Force shall inform, monitor, enforce, and bind, where appropriate, authorized lessees, tenants, contractors, and other authorized occupants of the site regarding the LUCs affecting the site.
8. The Air Force will notify CDPHE as soon as practicable, but no longer than ten (10) days after discovery, of any activity that is inconsistent with the land use control objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs. The Air Force will include in such notice(s) a list of corrective actions taken or any planned, and associated dates, to address such deficiency or failure.
9. The Air Force must provide notice to CDPHE at least six (6) months prior to any transfer or sale of property containing LUCs, including federal-to-federal transfers of property accountability, so that CDPHE can be involved in discussions to ensure that appropriate provisions are included in the transfer or conveyance documents to maintain effective LUCs. If it is not possible to notify CDPHE at least 6 months prior to any transfer or sale, then the facility will notify the state as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to LUCs.
10. The Air Force shall not modify or terminate LUCs, modify land uses that might impact the effectiveness of the LUCs, take any anticipated action that might disrupt the effectiveness of the LUCs, or take any action that might alter or negate the need for LUCs without 45 days prior to the change seeking and obtaining approval from CDPHE of any required ROD modification.
11. The Air Force will monitor and inspect all site areas subject to LUCs at least annually.
12. The Air Force will report annually to CDPHE on the frequency, scope, and nature of LUC monitoring activities, the results of such monitoring, any changes to the LUCs, and any corrective measures resulting from monitoring during the time period.

With the exception of the LUC addressing engineering controls (item 3 above), which only applies to the TCE plume, these LUCs apply in plume areas where groundwater concentrations exceed CBSGs, as highlighted on Figure 5.

### **2.12.3 Summary of Estimated Remedy Costs**

A summary of the costs is presented in Appendix A, and complete detailed cost estimates were prepared for the AAA/AGES FS. The total present net worth cost of the selected remedy (Alternative 3 at \$1,459,960 and Alternative 5 at \$949,209) is \$2,409,169. The major cost

components of the remedy are the initial injections of substrate materials and periodic injections of substrate materials, and groundwater monitoring.

The information in the cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur based on new information and data collected during the engineering design of the remedial alternative. Changes will be documented in the form of a memorandum in the AR, an ESD, or a ROD amendment, depending on the magnitude of the change. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 percent to -30 percent of the actual project cost.

#### **2.12.4 Expected Outcomes of Selected Remedy**

The expected outcome for the selected remedy for the AAA/AGES site will allow for UU/UE following completion of the remedy by reducing COC concentrations in groundwater to the CBSGs. Until UU/UE is achieved, the LUCs will reduce risks to human health to acceptable levels by preventing human exposure to the AAA/AGES site groundwater contaminants. The current land use of industrial/administrative can continue under the selected remedy; however, the LUCs limit construction over the TCE plume and prohibit disturbance of the components of the groundwater monitoring system for both the TCE and 1,4-dioxane plumes.

In situ groundwater treatment, including initial and periodic injections of substrates, is expected to reduce TCE concentrations to or below its CBSG within approximately 18 years. No 1,4-dioxane specific treatment is included, and it is estimated to take about 30 years to naturally attenuate below the CBSG. Periodic groundwater monitoring will be implemented to validate these timeframes and optimize treatment as necessary.

The CBSGs (CDPHE 2013) are the groundwater cleanup levels for the AAA/AGES site COCs and their potential degradation products. These numerical cleanup levels serve as the basis for determining whether UU/UE is achieved. The numerical cleanup levels to be achieved by the selected remedy were presented in Section 2.8 and are also listed below in Table 2-9. The cleanup levels are based on the CBSGs for the COCs; most of the CBSGs are based on each COC's USEPA MCL, in compliance with 5 Code of Colorado Regulation (CCR) 1002-41:41.5's Table A. However, the CBSG for 1,4-dioxane is a health-based standard because there is no USEPA MCL for this chemical. Treatment will be monitored to ensure that these cleanup levels are achieved. This site is expected to be available for UU/UE as a result of the remedy.

**Table 2-9  
Groundwater Cleanup Levels for the AAA/AGES Site**

<b>Contaminant</b>	<b>Current COC<sup>1</sup></b>	<b>Cleanup Level<sup>2</sup> (µg/L)</b>
cis-1,2-DCE		70
1,4-Dioxane	X	0.35 <sup>3</sup>
trans-1,2-DCE		100
TCE	X	5
Vinyl chloride		2
<sup>1</sup> Above CBSG (cleanup level) <sup>2</sup> CBSG is the USEPA MCL except as noted <sup>3</sup> Health-based CBSG (not a USEPA MCL) CBSG – Colorado Basic Standard for Groundwater (CDPHE 2013) µg/L – micrograms per liter		

### **2.13 Statutory Determinations**

Under CERCLA §121 (as required by NCP §300.430(f)(5)(ii)), the lead agency must select a remedy that is protective of human health and the environment, complies with ARARs, is cost-effective, and uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, periodic 5-year reviews will be conducted because hazardous substances will remain in place above levels allowing for UU/UE following remedy implementation. CERCLA also includes: 1) a preference for remedies that employ treatment that permanently and significantly reduces the toxicity, mobility, or volume of principal threat wastes; and 2) a bias against offsite disposal of untreated wastes. However, no source material has been identified as a principal threat waste at the AAA/AGES site, as described in Section 2.11. The following sections discuss how the selected remedy meets these statutory requirements.

#### **2.13.1 Protection of Human Health and the Environment**

The selected remedy will protect human health and the environment through treatment of groundwater contaminants, LTM, and LUCs to prevent unacceptable exposures during remedy implementation until CBSGs are achieved (i.e., until groundwater meets UU/UE).

#### **2.13.2 Compliance with ARARs**

Remedial actions must comply with both federal and state ARARs. ARARs are legally applicable or relevant and appropriate requirements, standards, criteria, or limitations of federal and state environmental laws and regulations.

ARARs fall into three categories: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs are health-based or risk-management-based numbers that provide concentration limits for the occurrence of a chemical in the environment at agreed-upon points of compliance. Location-specific ARARs restrict activities in certain sensitive environments. Action-specific ARARs are activity-based or technology-based, and typically control remedial activities that generate hazardous wastes (such as with those covered under the Resource Conservation and Recovery Act). Criteria to be considered, or TBCs, are non-promulgated

advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances, TBCs are considered along with ARARs.

Table 2-10 summarizes the ARARs for the selected remedy at the AAA/AGES site and describes how the selected remedy addresses each one at agreed-upon points of compliance.

The selected remedy complies with the chemical-specific, location-specific, and action-specific ARARs. The implementation of the remedy is required to meet the substantive portions of these requirements at agreed-upon points of compliance and is exempt from administrative requirements such as permitting and notifications.

**Table 2-10  
Description of ARARs**

Type	Authority	Medium	Description of Standard, Requirement, Criteria or Limitation	ARAR Status	Status	Action to be Taken to Attain Requirement
National Primary and Secondary Drinking Water Standards for community and non-transient, non-community water systems (Chemical Specific)	40 CFR Part 141.61, Subpart G	Groundwater	Sets maximum contaminant levels (MCLs) for organic contaminants, including TCE.	Applicable	One organic chemical in groundwater (TCE) exceeds the standard specified in 40 CFR Part 141, Subpart G, §141.61. In the future, three other chemicals (cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) that are degradation or daughter products may exceed standards.	The remedial action is expected to reduce concentrations of TCE to below the MCL. AAA/AGES being a CERCLA site, federal MCLs are considered the applicable chemical-specific ARARs which would be used in establishing the preliminary remediation goals for the AAA/AGES site.
Colorado Basic Standards for Ground Water (CBSG) (Chemical Specific)	5 CCR 1002-41, Section 41.5, including Table A	Groundwater	Sets Colorado statewide standards for groundwater. These standards include the narrative standards of Section 41.5(A)(1) and the numeric standards for organic chemicals, including the COCs, of Section 41.5(C). The regulations at Section 41.5(B) explain which standards apply and how to measure them. The current CBSG are identified in the text of this document.	Applicable	TCE and 1,4-dioxane in groundwater currently exceed the CBSG threshold. In the future, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, and degradation or daughter products of 1,4-dioxane may exceed CBSG thresholds also.	The remedial action is expected to reduce 1,4-dioxane concentrations to below the CBSG. Since there is no MCL for 1,4-dioxane, the CBSG will be considered the applicable chemical-specific ARAR and will be used in establishing the preliminary remediation goal for 1,4-dioxane at the AAA/AGES site.
Migratory Bird Treaty Act (Location Specific)	16 U.S.C. § 703	Wildlife	Prohibits the unlawful taking, possession or sale of any migratory bird native to the United States or its territories.	Applicable	The remedy may require construction activity while migratory birds are present. Migratory birds known to inhabit Buckley AFB include, but are not limited to, bald eagles, ferruginous hawks, and burrowing owls.	Avian surveys will be completed approximately two weeks prior to the initiation of any remedial action construction or other fieldwork activities.
Bald and Golden Eagle Protection Act (Location Specific)	16 U.S.C. § 668(a)	Wildlife	Prohibits the unlawful taking of bald and golden eagles including their parts, nests, or eggs.	Applicable	Construction activities may be required while bald and/or golden eagles are present.	Avian surveys will be completed approximately two weeks prior to the initiation of any remedial action construction or other fieldwork activities.
Colorado Regulations Pertaining to Fugitive Dust and Opacity (Action Specific)	5 CCR 1001-3, Sections II.A.1 and II.A.2	Air	Establishes regulations concerning the generation of odors, fugitive emissions from construction activities, storage and stockpiling activities, discharges from point sources to the air.	Applicable	Construction activities will need to control pollutant emissions into the air.	Dust suppression and other actions during construction activities will be taken as necessary to fulfill regulatory requirements for smoke and opacity.
Well Permit Requirements (Action Specific)	Colorado Water Well and Pump Installation Contractors Act 2 CCR 402-2:13, 2 CCR 402-2:14, 2 CCR 402-2:16	Groundwater	Establishes requirements relating to the sampling, construction, and abandonment of water wells.	Applicable	Additional wells may need to be installed at the Site as part of the remedy.	Although CERCLA exempts federal facilities from obtaining permits for on-site remedial actions, the Air Force will comply with the substantive requirements of these regulations.
Underground Injection Control Regulations (Action Specific)	40 CFR Part 146 Subpart F	Groundwater	Establishes regulations for subsurface injections for protection of groundwater used for drinking water.	Relevant and Appropriate	The active groundwater remedial alternatives with subsurface injection will inject substrates through Class V wells into a non-drinking water aquifer. Class V well regulations are administered by USEPA and not CDPHE. As the groundwater is not used for drinking water, this subpart is considered Relevant and Appropriate.	Although CERCLA exempts federal facilities from obtaining permits for on-site remedial actions, the Air Force will comply with the substantive requirements of these regulations.
Colorado Regulations Pertaining to Solid Waste Sites and Facilities (Action Specific)	6 CCR 1007-2, Part I, Appendices B and I	Waste	Establishes requirements for activities meeting regulatory definition of "solid waste disposal" including the storage, utilization, processing, or final disposal of solid wastes.	Applicable	Implementation of remedy will require the management and disposal of solid waste.	Wastes generated during construction and operation of the remedy will be managed and disposed of in accordance with this regulation.
Colorado Hazardous Materials and Waste Management Division - Air Screening Concentrations Table (Chemical Specific)	CDPHE, Hazardous Materials and Waste Management Division, Air Screening Concentrations Table, as amended January 15, 2016	Air	Specifies indoor air remediation goals and action levels for VOCs, including for TCE, for sites where vapor intrusion may be a concern.	To Be Considered	Because volatile compounds (e.g., TCE) have been detected in groundwater, vapor intrusion may be a concern at the Site.	The Air Force will consider the remediation goals and action levels specified for COCs in this table.
Colorado Hazardous Materials and Waste Management Division - Hazardous Waste (Action Specific)	6 CCR 1007-3 Parts 261.20(a), 261.30(a), and 262.34(a), (c), (d), and (g)	Waste	Describes how to determine if a solid waste is a hazardous waste and the temporary storage requirements of hazardous waste.	Applicable	The potential for generating hazardous waste during remedial actions exists.	This regulation is applicable to the groundwater alternatives that include installing a new well or boring or sampling groundwater as the drill cuttings or purge water may be characteristic hazardous waste. Buckley AFB is responsible for the characterization and temporary storage requirements of the hazardous wastes.

AAA = Armament and Automotive Area  
 AFB = Air Force Base  
 AGES = Aerospace Ground Equipment Shop  
 ARAR = Applicable or Relevant and Appropriate Requirement  
 CBSG = Colorado Basic Standard for Ground Water  
 CCR = Code of Colorado Regulation

CDPHE = Colorado Department of Public Health and Environment  
 CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act  
 CFR = Code of Federal Regulation  
 cis-1,2-DCE = cis-1,2-dichloroethene  
 COC = chemical of concern  
 MCL = maximum contaminant level

TCE = Trichloroethene  
 trans-1,2-DCE = trans-1,2-dichloroethene  
 U.S.C. = United States Code  
 USEPA = United States Environmental Protection Agency  
 VOCs = volatile organic compounds

### **2.13.3 Cost Effectiveness**

Overall effectiveness was compared to costs to determine cost-effectiveness. A remedy is cost-effective if the remedy's cost is proportional to its overall effectiveness. More than one cleanup alternative can be cost-effective, and CERCLA does not mandate the selection of the most cost-effective cleanup alternative. The selected remedy's cost is proportional to its overall effectiveness. The overall effectiveness of the selected remedy for the AAA/AGES site was demonstrated in the comparative analysis of alternatives (Section 2.10).

The budgetary cost estimate summary for the selected remedy is included in Appendix A. Capital costs include all costs that are required to initially implement the remedy, including establishing baseline groundwater conditions, injecting substrates at both plumes, and initial process monitoring and reporting. Long-term costs associated with groundwater monitoring and periodic injections of substrate (i.e., restoration of treatment zone) are included in the total project cost. These periodic sampling and injection costs are adjusted for present worth at a 7% discount factor.

The estimated capital and total project costs of the selected remedy (Alternatives 3 and 5 combined) are:

Capital Cost:	\$ 853,508
Total Project Cost (present value):	\$2,409,169

### **2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies**

The selected remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable for the AAA/AGES site. The selected remedy of in situ treatment of TCE-contaminated groundwater with LUCs and LTM provides for protection of human health and the environment, long-term effectiveness, implementability, and is cost effective. Based on treatability testing that used Buckley AFB soil and groundwater, the site conditions are naturally conducive to the BiRD in situ technology, and use of naturally present amounts of iron, sulfate, and sulfate-reducing bacteria to treat the groundwater COCs will minimize use of additional materials and resources.

### **2.13.5 Five-Year Review Requirements**

The selected remedy will result in UU/UE, but not within 5 years from when the cleanup system is constructed and operational. Therefore, pursuant to Air Force policy, the Air Force will conduct a review within 5 years after initiation of the remedial action to verify that the remedy is, or will be, protective of human health and the environment. Five-year reviews will be conducted until UU/UE levels are achieved.

The initiation, or trigger date for the 5-year review, will be the date that the construction phase of the groundwater treatment commences at the AAA/AGES site after the ROD is signed.

## **2.14 Documentation of Significant Changes**

The Proposed Plan for the AAA/AGES site was released for public comment on November 2, 2017, and identified Alternative 3 (for TCE) and Alternative 5 (for 1,4-dioxane) as the preferred alternative for this site (Air Force 2017). The Proposed Plan did not identify any actions that were not protective of human health and the environment. No comments were submitted during

the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.



### **3.0 Responsiveness Summary**

This section provides a summary of the public comments regarding the Proposed Plan for remedial action at the AAA/AGES site, Buckley AFB, Aurora, Colorado, and the Air Force response to comments. At the time of the public review period, the Air Force had selected Alternative 3 (BiRD) for TCE and Alternative 5 (LUCs and LTM) for 1,4-dioxane for the AAA/AGES site groundwater.

No written or verbal comments on the proposed remedy were received during the public comment period.

#### **3.1 Stakeholder Comments and Lead Agency Responses**

As the lead regulatory agency, CDPHE has worked closely with Buckley AFB throughout the investigation and decision-making process.

CDPHE reviewed the Proposed Plan and concurs with the selected remedy for the AAA/AGES site. A letter from CDPHE documenting their review of the Draft Final version of this ROD is included in Appendix B. CDPHE concurs with this ROD.

#### **3.2 Technical and Legal Issues**

No technical or legal issues were identified during the public review period of the Proposed Plan.

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## 4.0 References

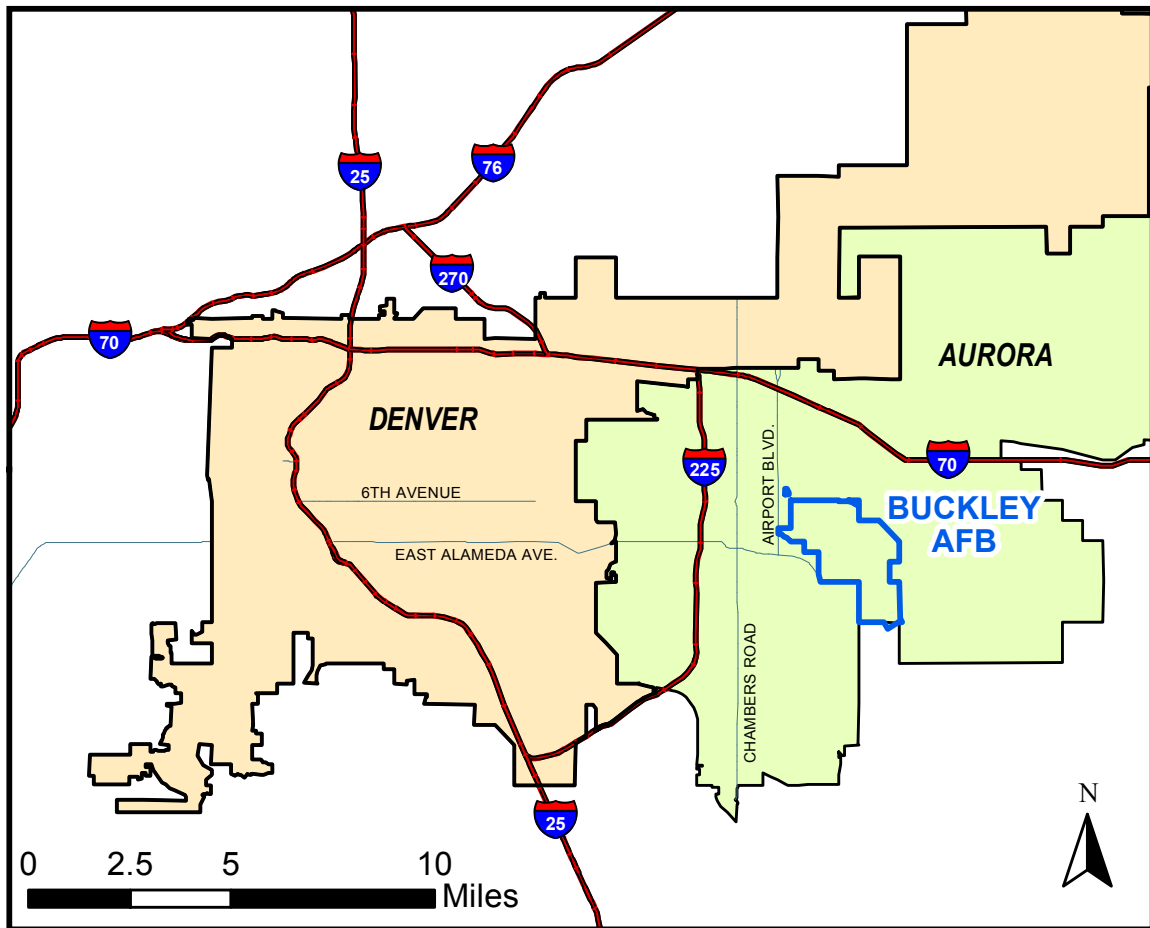
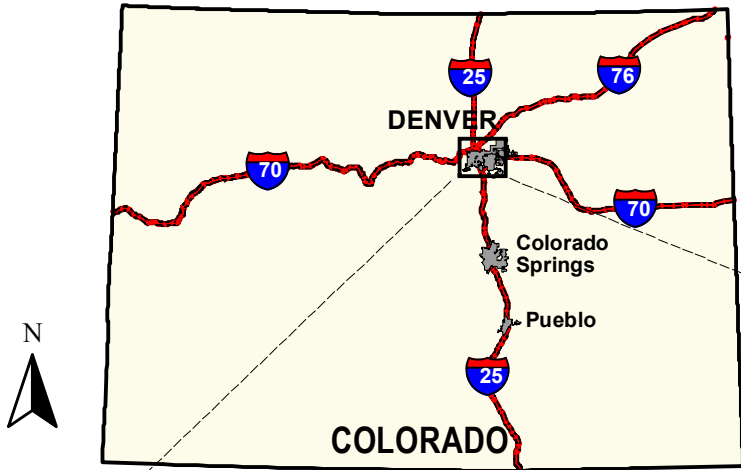
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## **Figures**



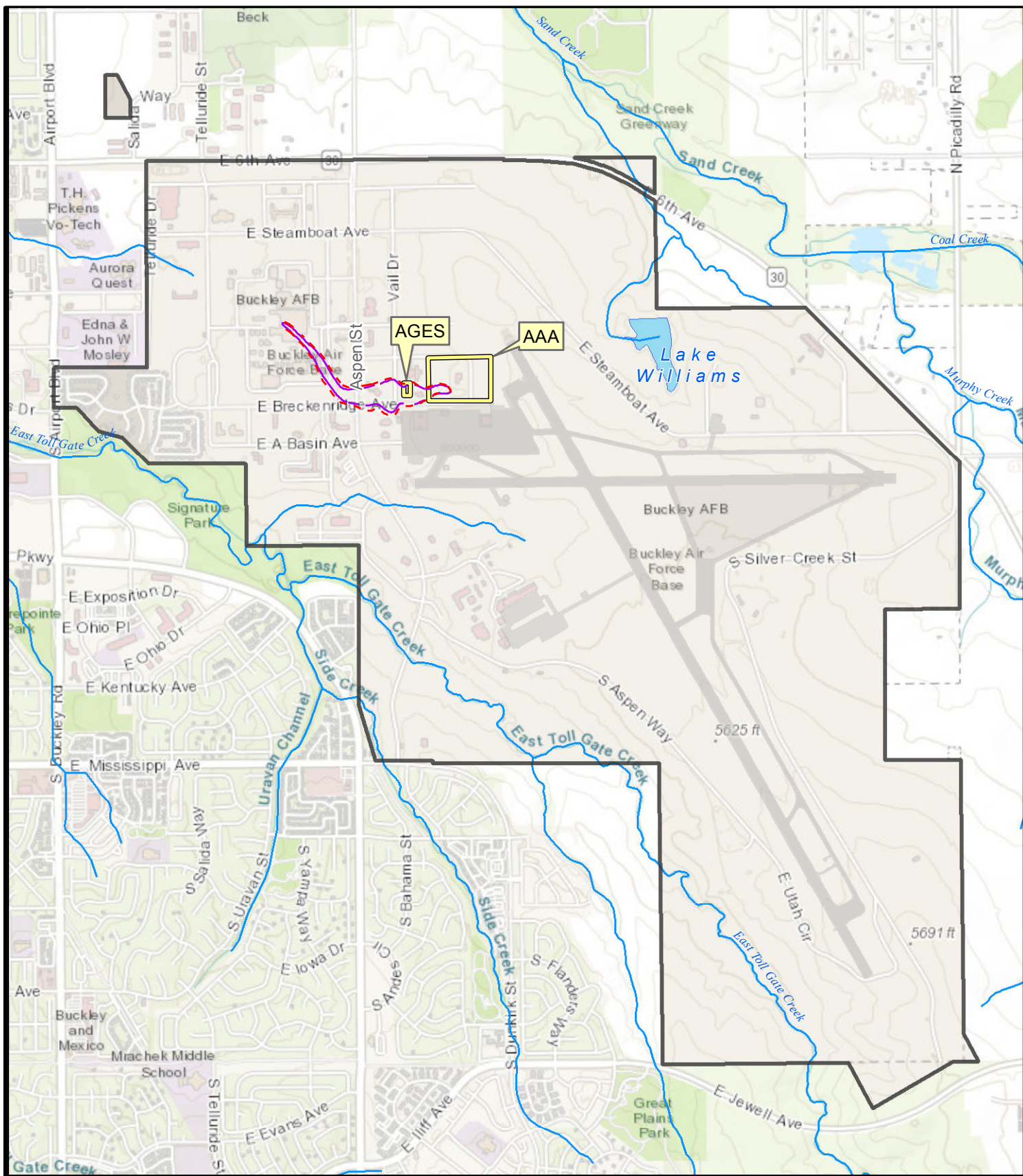
**Legend**





-  Major Highway
-  Installation Boundary
-  Denver
-  Aurora

**Figure 1**

Buckley AFB Regional Map  
 Armament and Automotive Area/Aerospace  
 Ground Equipment Shop Site  
 Record of Decision  
 Buckley Air Force Base - Aurora, Colorado





-  Original Site Boundary
-  Buckley Air Force Base
-  Trichloroethene Isoconcentration Contour (5 ug/L), dashed where inferred
-  1,4-Dioxane Isoconcentration Contour (0.35 ug/L), dashed where inferred

AAA = Armament and Automotive Area  
 AGES = Aerospace Ground Equipment Shop  
 ug/L = micrograms per liter (or parts per billion)

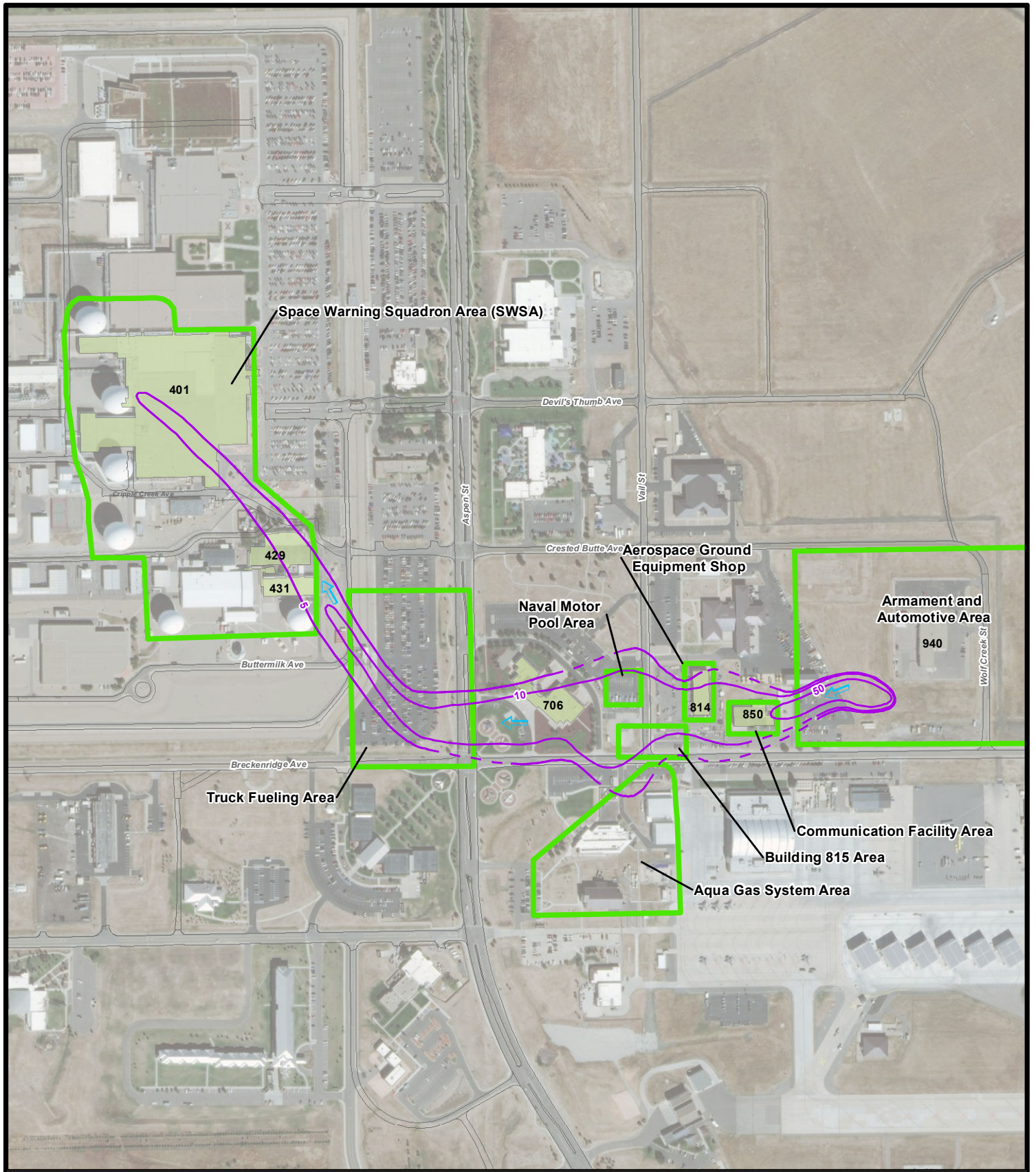


**Figure 2**





AAA/AGES Site Location Map

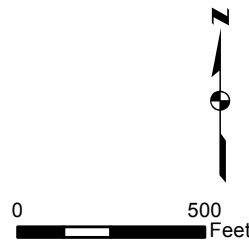
AAA/AGES Site  
 Record of Decision

Buckley Air Force Base - Aurora, Colorado



**Legend**

-  Groundwater Flow Direction
  -  Trichloroethene Isoconcentration Contour (5, 10, and 50 ug/L), dashed where inferred
  -  Building Overlying Plume and Associated Building Number
  -  Original Boundary of Central Industrial Area Site
- ug/L = micrograms per liter

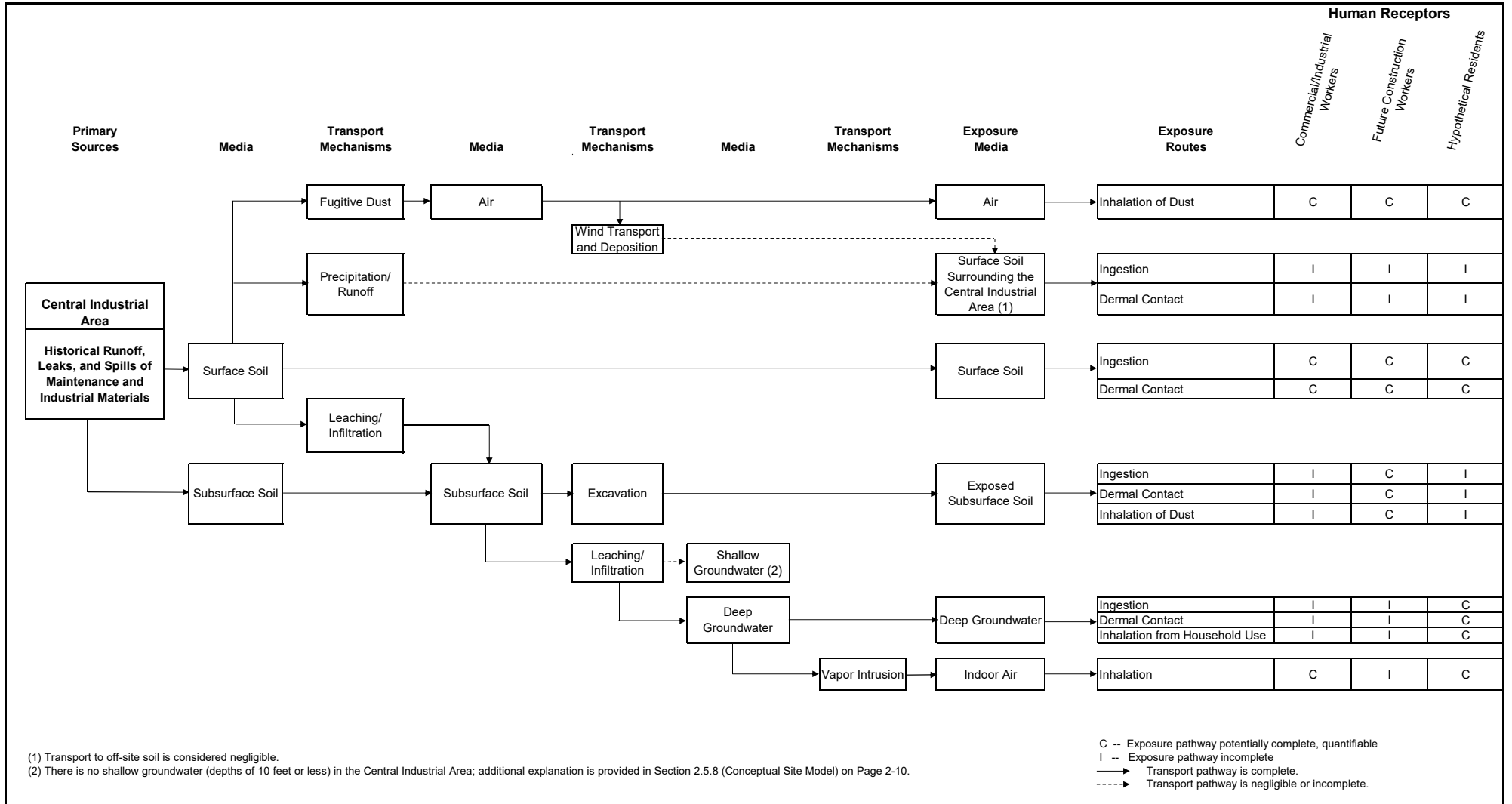


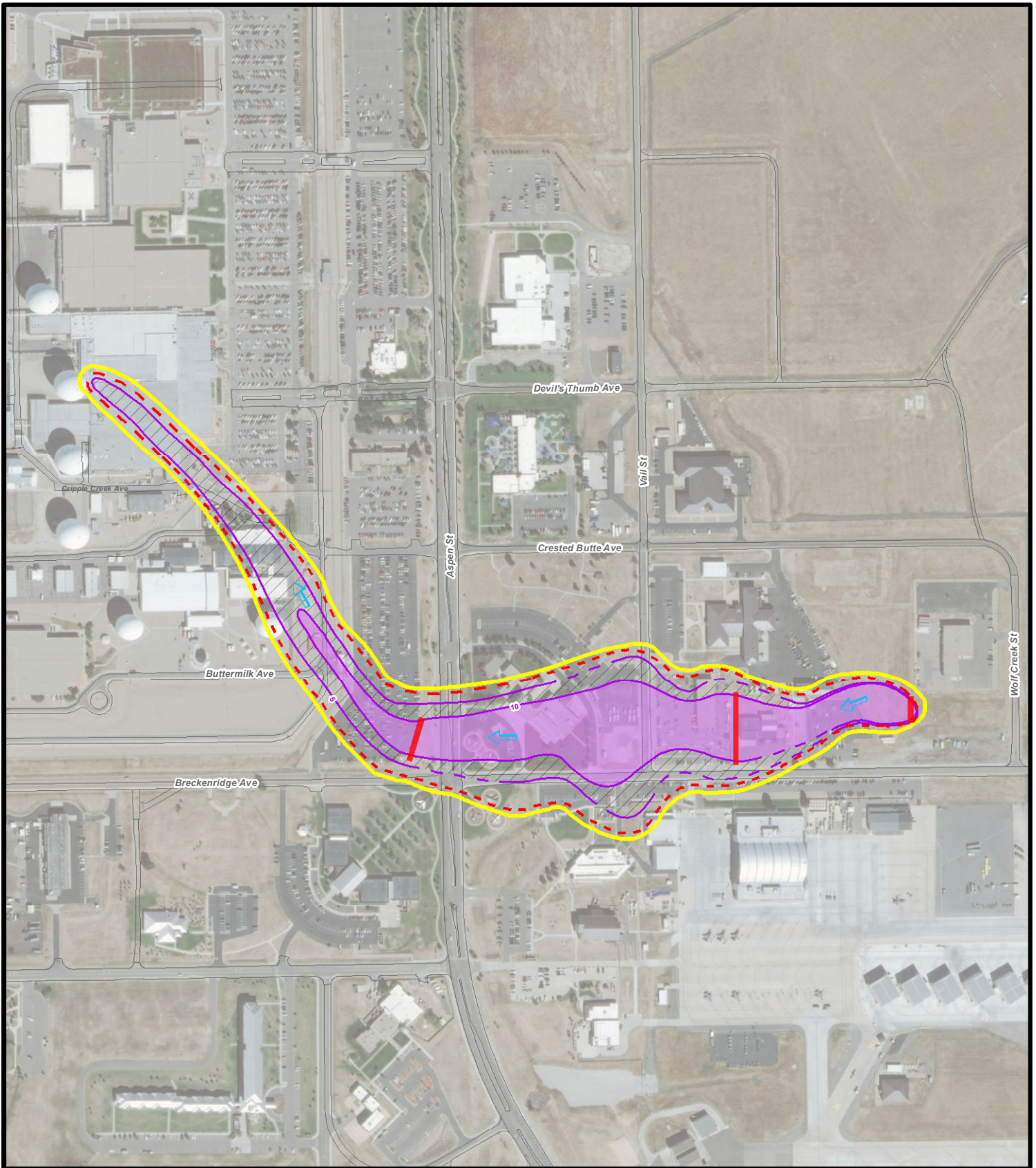
**Figure 3**  
 Central Industrial Area Remedial Investigation Sites and Buildings Overlying the Trichloroethene Plume

AAA/AGES Site  
 Record of Decision  
 Buckley Air Force Base - Aurora, Colorado








Figure 4

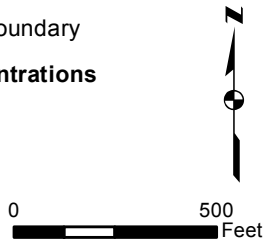
Human Health Conceptual Site Model  
 Central Industrial Area  
 CRP Site Remedial Investigation  
 Buckley Air Force Base, Colorado





**Legend**

-  Groundwater Flow Direction
-  Trichloroethene Isoconcentration Contour, dashed where inferred
-  Inferred 1,4-Dioxane Isoconcentration Contour (0.35 ug/L)
-  Permeable Reactive Barrier (Biogeochemical Reductive Dehalogenation [BiRD])
-  Land Use Control Boundary
- Trichloroethene Concentrations**
-  5 - 10 ug/L
-  > 10 ug/L
- ug/L = micrograms per liter



**Figure 5**  
 Preferred Alternatives 3 and 5 for the  
 AAA/AGES Plumes  
 AAA/AGES Site  
 Record of Decision  
 Buckley Air Force Base - Aurora, Colorado

**APPENDIX A**  
**Alternative Estimated Cost Summary**

Appendix A  
 Cost Estimate for Remedial Alternatives  
 Central Industrial Area Feasibility Study  
 Buckley Air Force Base, Colorado

**PRB Construction Capital Costs - Year 1**

Item Description	Units	Unit Cost	Quantity			Total Cost		
			Alt 2	Alt 3	Alt 4	Alt 2	Alt 3	Alt 4
<b>1.0 Mobilization</b>								
1.1 Purchase Chemical Products (ZVI) and Ship To BAFB	LS	\$ 59,169	1	0	0	\$ 59,169	\$ -	\$ -
1.2 Purchase Chemical Products (Carbon and Sulfate) and Ship To BAFB	LS	\$ 5,027	0	1	0	\$ -	\$ 5,027	\$ -
1.3 Purchase Chemical Products (EVO and Carbon) and Ship To BAFB	LS	\$ 75,537	0	0	1	\$ -	\$ -	\$ 75,537
1.4 Purchase Bioaugmentation Amendments (DHC) and Ship To BAFB	LS	\$ 28,119	0	0	1	\$ -	\$ -	\$ 28,119
1.5 Mob Drilling/Mixing/Injection Equipment, Supplies, and Personnel to BAFB	LS	\$ 13,700	1	1	1	\$ 13,700	\$ 13,700	\$ 13,700
			<b>Task Subtotal:</b>			\$ 72,869	\$ 18,727	\$ 117,356
<b>2.0 Drilling, Injection and Monitoring Well Installation/Development</b>								
2.1 Injection Well Installation	Ea.	\$ 5,400	15	10	13	\$ 81,000	\$ 54,000	\$ 70,200
2.2 Monitoring Well Installation	Ea.	\$ 5,400	3	3	3	\$ 16,200	\$ 16,200	\$ 16,200
2.3 Well Development	Ea.	\$ 750	3	3	3	\$ 2,250	\$ 2,250	\$ 2,250
2.4 Surveying	Ea.	\$ 250	18	13	16	\$ 4,500	\$ 3,250	\$ 4,000
2.5 IDW/Waste Management	LS	\$ 5,000	1	1.3	1.6	\$ 5,000	\$ 6,500	\$ 8,000
			<b>Task Subtotal:</b>			\$ 108,950	\$ 82,200	\$ 100,650
<b>3.0 Baseline Sampling and Analysis</b>								
3.1 Groundwater Sampling Event	Ea.	\$ 11,200	1	1	1	\$ 11,200	\$ 11,200	\$ 11,200
3.2 Laboratory Analysis and Data Validation	Ea.	\$ 10,200	1	1	1	\$ 10,200	\$ 10,200	\$ 10,200
3.3 IDW/Waste Management	Ea.	\$ 2,000	1	1	1	\$ 2,000	\$ 2,000	\$ 2,000
3.4 Reporting	Ea.	\$ 15,000	1	1	1	\$ 15,000	\$ 15,000	\$ 15,000
			<b>Task Subtotal:</b>			\$ 38,400	\$ 38,400	\$ 38,400
<b>4.0 Injectate Mixing and Emplacement</b>								
4.1 Chemical Emplacement (ZVI)	Ea.	\$ 11,516	15	0	0	\$ 172,740	\$ -	\$ -
4.2 Chemical Emplacement (Carbon and Sulfate)	Day	\$ 6,000	0	7.5	0	\$ -	\$ 45,000	\$ -
4.3 Chemical Emplacement (EVO, Carbon, and DHC)	Day	\$ 6,000	0	0	10.1	\$ -	\$ -	\$ 60,750
			<b>Task Subtotal:</b>			\$ 172,740	\$ 45,000	\$ 60,750
<b>5.0 Process Monitoring</b>								
5.1 Groundwater Sampling Event	Ea.	\$ 11,200	2	2	2	\$ 22,400	\$ 22,400	\$ 22,400
5.2 Laboratory Analysis and Data Validation	Ea.	\$ 10,200	2	2	2	\$ 20,400	\$ 20,400	\$ 20,400
5.3 IDW/Waste Management	Ea.	\$ 2,000	2	2	2	\$ 4,000	\$ 4,000	\$ 4,000
5.4 Reporting	Ea.	\$ 15,000	2	2	2	\$ 30,000	\$ 30,000	\$ 30,000
			<b>Task Subtotal:</b>			\$ 76,800	\$ 76,800	\$ 76,800
<b>6.0 Implement Land Use Controls</b>								
6.1 Update Buckley AFB Installation Development Plan	Ea.	\$ 5,000	1	1	1	\$ 5,000	\$ 5,000	\$ 5,000
			<b>Task Subtotal:</b>			\$ 5,000	\$ 5,000	\$ 5,000
<b>Subtotal of Year 1 Capital Costs:</b>						\$ 474,759	\$ 266,127	\$ 398,956
<b>Contingency</b>			%			30%	30%	30%
						\$ 142,428	\$ 79,838	\$ 119,687
<b>Subtotal Including Contingency:</b>						\$ 617,187	\$ 345,965	\$ 518,642
<b>Project Management</b>			%			10%	10%	10%
						\$ 61,719	\$ 34,597	\$ 51,864
<b>Technical Support</b>			%			15%	15%	15%
						\$ 92,578	\$ 51,895	\$ 77,796
<b>Remedial Design</b>			%			15%	15%	15%
						\$ 92,578	\$ 51,895	\$ 77,796
<b>Construction Management</b>			%			15%	15%	15%
						\$ 92,578	\$ 51,895	\$ 77,796
<b>Total Capital Costs - Year 1:</b>						\$ 956,639	\$ 536,246	\$ 803,896
<b>Annual Operation and Maintenance - Years 2+</b>								
Item Description	Units	Unit Cost	Quantity			Total Cost		
			Alt 2	Alt 3	Alt 4	Alt 2	Alt 3	Alt 4
<b>7.0 Groundwater Monitoring</b>								
7.1 Groundwater Sampling Event	LS	\$ 11,200	1	1	1	\$ 11,200	\$ 11,200	\$ 11,200
7.2 Laboratory Analysis and Data Validation	LS	\$ 10,200	1	1	1	\$ 10,200	\$ 10,200	\$ 10,200
7.3 IDW/Waste Management	LS	\$ 2,000	1	1	1	\$ 2,000	\$ 2,000	\$ 2,000
7.4 Reporting	LS	\$ 15,000	1	1	1	\$ 15,000	\$ 15,000	\$ 15,000
<b>Subtotal of Years 2+ Operation and Maintenance Costs (per year):</b>						\$ 38,400	\$ 38,400	\$ 38,400
<b>Contingency</b>			%			30%	30%	30%
						\$ 11,520	\$ 11,520	\$ 11,520
<b>Subtotal Including Contingency:</b>						\$ 49,920	\$ 49,920	\$ 49,920
<b>Project Management</b>			%			10%	10%	10%
						\$ 4,992	\$ 4,992	\$ 4,992
<b>Technical Support</b>			%			15%	15%	15%
						\$ 7,488	\$ 7,488	\$ 7,488
<b>Total Operation and Maintenance Costs (per year) - Years 2+:</b>						\$ 62,400	\$ 62,400	\$ 62,400
<b>Periodic Costs</b>								
Item Description	Units	Unit Cost	Quantity			Timing		
			Alt 2	Alt 3	Alt 4			
<b>8.0 Five-Year Review Support</b>								
<b>9.0 Restoration of Treatment Zone Capacity</b>			Ea.			\$ 5,000		
						3		
						2022, 2027, 2032		
9.1 Alternative 2 - Additional ZVI	Ea.	\$ 447,008	4	0	0	2021, 2025, 2029, 2033		
9.2 Alternative 3 - Additional Carbon and Sulfate	Ea.	\$ 115,983	0	5	0	2020, 2023, 2026, 2029, 2032		
9.3 Alternative 4 - Additional EVO, Carbon, DHC	Ea.	\$ 324,152	0	0	5	2020, 2023, 2026, 2029, 2032		

See last page for notes.

Appendix A  
 Cost Estimate for Remedial Alternatives  
 Central Industrial Area Feasibility Study  
 Buckley Air Force Base, Colorado

**Alternative 5 Construction Capital Costs - Year 1**

Item Description	Units	Unit Cost	Quantity	Total Cost
			Alt 5	Alt 5
<b>1.0 Mobilization</b>				
1.1 Purchase Chemical Products (ZVI) and Ship To BAFB	LS	\$ 59,169	0	\$ -
1.2 Purchase Chemical Products (Carbon and Sulfate) and Ship To BAFB	LS	\$ 5,027	0	\$ -
1.3 Purchase Chemical Products (EVO and Carbon) and Ship To BAFB	LS	\$ 75,537	0	\$ -
1.4 Purchase Bioaugmentation Amendments (DHC) and Ship To BAFB	LS	\$ 28,119	0	\$ -
1.5 Mob Drilling/Mixing/Injection Equipment, Supplies, and Personnel to BAFB	LS	\$ 13,700	0.5	\$ 6,850
			<b>Task Subtotal:</b>	\$ 6,850
<b>2.0 Drilling, Injection and Monitoring Well Installation/Development</b>				
2.1 Injection Well Installation	Ea.	\$ 5,400	0	\$ -
2.2 Monitoring Well Installation	Ea.	\$ 5,400	3	\$ 16,200
2.3 Well Development	Ea.	\$ 750	3	\$ 2,250
2.4 Surveying	Ea.	\$ 250	3	\$ 750
2.5 IDW/Waste Management	LS	\$ 5,000	1	\$ 5,000
			<b>Task Subtotal:</b>	\$ 24,200
<b>3.0 Baseline Sampling and Analysis</b>				
3.1 Groundwater Sampling Event (40 wells)	Ea.	\$ 20,200	1	\$ 20,200
3.2 Laboratory Analysis and Data Validation	Ea.	\$ 6,000	1	\$ 6,000
3.3 IDW/Waste Management	Ea.	\$ 4,000	1	\$ 4,000
3.4 Reporting	Ea.	\$ 25,000	1	\$ 25,000
			<b>Task Subtotal:</b>	\$ 55,200
<b>4.0 Injectate Mixing and Emplacement</b>				
4.1 Chemical Emplacement (ZVI)	Ea.	\$ 11,516	0	\$ -
4.2 Chemical Emplacement (Carbon and Sulfate)	Day	\$ 6,000	0	\$ -
4.3 Chemical Emplacement (EVO, Carbon, and DHC)	Day	\$ 6,000	0	\$ -
			<b>Task Subtotal:</b>	\$ -
<b>5.0 Process Monitoring</b>				
5.1 Groundwater Sampling Event (20 wells)	Ea.	\$ 11,200	1	\$ 11,200
5.2 Laboratory Analysis and Data Validation	Ea.	\$ 3,000	1	\$ 3,000
5.3 IDW/Waste Management	Ea.	\$ 2,000	1	\$ 2,000
5.4 Reporting and LTM Planning	Ea.	\$ 50,000	1	\$ 50,000
			<b>Task Subtotal:</b>	\$ 66,200
<b>6.0 Implement Land Use Controls</b>				
6.1 Update Buckley AFB Installation Development Plan	Ea.	\$ 5,000	1	\$ 5,000
			<b>Task Subtotal:</b>	\$ 5,000
<b>Subtotal of Year 1 Capital Costs:</b>				\$ 157,450
<b>Contingency</b>		%	30%	\$ 47,235
<b>Subtotal Including Contingency:</b>				\$ 204,685
<b>Project Management</b>		%	10%	\$ 20,469
<b>Technical Support</b>		%	15%	\$ 30,703
<b>Remedial Design</b>		%	15%	\$ 30,703
<b>Construction Management</b>		%	15%	\$ 30,703
<b>Total Capital Costs - Year 1:</b>				\$ 317,262
<b>Annual Operation and Maintenance - Years 2+</b>				
Item Description	Units	Unit Cost	Quantity	Total Cost
<b>7.0 Groundwater Monitoring</b>				
7.1 Groundwater Sampling Event (20 wells)	LS	\$ 11,200	1	\$ 11,200
7.2 Laboratory Analysis and Data Validation	LS	\$ 3,000	1	\$ 3,000
7.3 IDW/Waste Management	LS	\$ 2,000	1	\$ 2,000
7.4 Reporting	LS	\$ 15,000	1	\$ 15,000
<b>Subtotal of Years 2+ Operation and Maintenance Costs (per year):</b>				\$ 31,200
<b>Contingency</b>		%	30%	\$ 9,360
<b>Subtotal Including Contingency:</b>				\$ 40,560
<b>Project Management</b>		%	10%	\$ 4,056
<b>Technical Support</b>		%	15%	\$ 6,084
<b>Total Operation and Maintenance Costs (per year) - Years 2+:</b>				\$ 50,700
<b>Periodic Costs</b>				
Item Description	Units	Unit Cost	Quantity	Timing
<b>8.0 Five-Year Review Support</b>				
9.0 Restoration of Treatment Zone Capacity				
9.1 Alternative 2 - Additional ZVI	Ea.	\$ 447,008	0	-
9.2 Alternative 3 - Additional Carbon and Sulfate	Ea.	\$ 115,983	0	-
9.3 Alternative 4 - Additional EVO, Carbon, DHC	Ea.	\$ 324,152	0	-

See last page for notes.

Appendix A  
 Cost Estimate for Remedial Alternatives  
 Central Industrial Area Feasibility Study  
 Buckley Air Force Base, Colorado

Present Value of Capital, Operation and Maintenance, and Periodic Costs

Year	Present Value Adjustment	Alternative 2			Alternative 3			Alternative 4			Alternative 5			Adjusted Total			
		Capital	O&M	Periodic	Capital	O&M	Periodic	Capital	O&M	Periodic	Capital	O&M	Periodic	Alt 2	Alt 3	Alt 4	Alt 5
2016	1.000	\$ 956,639	\$ -	\$ -	\$ 536,246	\$ -	\$ -	\$ 803,896	\$ -	\$ -	\$ 317,262	\$ -	\$ -	\$ 956,639	\$ 536,246	\$ 803,896	\$ 317,262
2017	0.935	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 58,318	\$ 58,318	\$ 58,318	\$ 47,383
2018	0.873	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 54,503	\$ 54,503	\$ 54,503	\$ 44,283
2019	0.816	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 50,937	\$ 50,937	\$ 50,937	\$ 41,386
2020	0.763	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ 115,983	\$ -	\$ 62,400	\$ 324,152	\$ -	\$ 50,700	\$ -	\$ 47,605	\$ 136,088	\$ 294,899	\$ 38,679
2021	0.713	\$ -	\$ 62,400	\$ 447,008	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 363,201	\$ 44,490	\$ 44,490	\$ 36,148
2022	0.666	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 50,700	\$ 5,000	\$ 44,911	\$ 44,911	\$ 44,911	\$ 37,115
2023	0.623	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ 115,983	\$ -	\$ 62,400	\$ 324,152	\$ -	\$ 50,700	\$ -	\$ 38,860	\$ 111,088	\$ 240,725	\$ 31,573
2024	0.582	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 36,317	\$ 36,317	\$ 36,317	\$ 29,508
2025	0.544	\$ -	\$ 62,400	\$ 447,008	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 277,084	\$ 33,941	\$ 33,941	\$ 27,577
2026	0.508	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ 115,983	\$ -	\$ 62,400	\$ 324,152	\$ -	\$ 50,700	\$ -	\$ 31,721	\$ 90,681	\$ 196,504	\$ 25,773
2027	0.475	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 50,700	\$ 5,000	\$ 32,021	\$ 32,021	\$ 32,021	\$ 26,463
2028	0.444	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 27,706	\$ 27,706	\$ 27,706	\$ 22,511
2029	0.415	\$ -	\$ 62,400	\$ 447,008	\$ -	\$ 62,400	\$ 115,983	\$ -	\$ 62,400	\$ 324,152	\$ -	\$ 50,700	\$ -	\$ 211,386	\$ 74,023	\$ 160,406	\$ 21,039
2030	0.388	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 24,200	\$ 24,200	\$ 24,200	\$ 19,662
2031	0.362	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 22,617	\$ 22,617	\$ 22,617	\$ 18,376
2032	0.339	\$ -	\$ 62,400	\$ 5,000	\$ -	\$ 62,400	\$ 120,983	\$ -	\$ 62,400	\$ 329,152	\$ -	\$ 50,700	\$ 5,000	\$ 22,831	\$ 62,118	\$ 132,632	\$ 18,868
2033	0.317	\$ -	\$ 62,400	\$ 447,008	\$ -	\$ 62,400	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 161,266	\$ 19,754	\$ 19,754	\$ 16,050
2034	0.296	\$ -	\$ 62,400	\$ -	Estimated Achievement of TCE RAOs			\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 18,462	\$ -	\$ 18,462	\$ 15,000
2035	0.277	\$ -	\$ 62,400	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 17,254	\$ -	\$ 17,254	\$ 14,019
2036	0.258	\$ -	\$ 62,400	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 62,400	\$ -	\$ -	\$ 50,700	\$ -	\$ 16,125	\$ -	\$ 16,125	\$ 13,102
2037	0.242	Estimated Achievement of TCE RAOs			\$ -	\$ -	\$ -	Estimated Achievement of TCE RAOs			\$ -	\$ 50,700	\$ 5,000	\$ -	\$ -	\$ -	\$ 13,452
2038	0.226	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 11,444
2039	0.211	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 10,695
2040	0.197	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 9,995
2041	0.184	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 9,341
2042	0.172	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ 5,000	\$ -	\$ -	\$ -	\$ 9,591
2043	0.161	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 8,159
2044	0.150	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 7,625
2045	0.141	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 50,700	\$ -	\$ -	\$ -	\$ -	\$ 7,127
2046	0.131	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	Estimated Achievement of 14D RAO			\$ -	\$ -	\$ -	\$ -
<b>Total:</b>														\$ 2,513,964	\$ 1,459,960	\$ 2,330,619	\$ 949,209

- Notes:
1. Estimate based on *A Guide to Preparing and Documenting Cost Estimates during the Feasibility Study*. EPA 540-R-00-002.1 (USEPA, 2000).
  2. Unit costs are based in 2014 dollars.
  3. Present value adjustment made based on discount rate of 7.0% and inflation rate of 0.0%.
  4. Cost estimate is based on the best information available regarding the anticipated remedial alternative. Changes in the cost elements may occur as a result of new information (data) that become available over time.

14D = 1,4-Dioxane  
 RAO = Remedial Action Objective  
 TCE = Trichloroethene (and degradation products)



**APPENDIX B**  
**Agency Reviews of Draft Final Record of Decision**

**RESPONSES TO COMMENTS**  
**March 2018 Draft Final Record of Decision for Armament and Automotive Area**  
**(MY570)/Aerospace Ground Equipment Shop (MY568)**  
**Buckley Air Force Base (AFB), Colorado**

**April 2018**  
**Colorado Department of Public Health and Environment**  
**Principal Reviewer: Lee Pivonka**

**Specific Comments**

1. Section 1.7 (Authorizing Signatures) on Page 1-4: Gary Baughman plans to retire at the end of July 2018, so please keep the Division informed regarding the likely schedule for ROD execution, as the Division’s signature block will change around or after July 2018.

***Response:** Comment noted; the Air Force will keep the Division informed.*

2. Section 2.1 (Site Name, Location, and Description) on Page 2-1: Please add Arapahoe County to the end of the third paragraph of this section, to be accurate and consistent with the content of the fourth paragraph in Section 2.3 (Community Participation) on Page 2-3.

***Response:** This change has been made.*

3. Section 2.2 (Site History and Enforcement Activities) in the first full paragraph on Page 2-2: Because Building 940 (automotive maintenance shop) is referenced in the first full paragraph on Page 2-2, it would be useful to identify Building 940 on Figure 3.

***Response:** This change has been made.*

4. Section 2.2 (Site History and Enforcement Activities), the two bullet references at the bottom of Page 2-2 and the two bullet references at the top of Page 2-3: Please provide the Administrative Record Numbers in parentheses (i.e., (AR# ?????)), at the end of each of these four references.

***Response:** These Administrative Record Numbers have been added.*

5. Section 2.5.3 (Hydrogeology) on Page 2-5: Given the title of this section, the multiple references to weathered and/or unweathered “Denver Formation” in the first paragraph of this section should probably be changed to “Denver Aquifer.”

***Response:** These changes have been made.*

6. Section 2.5.8 (Conceptual Site Model), first and second paragraph of this section on Page 2-10: Should the word “...groundwater...” in the last line of the first paragraph of this section be “...deep groundwater...”?

**Response:** Yes, “deep” and “(greater than 10 feet bgs)” have been inserted in the sentence.

Please reference “(Figure 4)” in the third line of the second paragraph of this section after the word “...shallow.”

**Response:** This change has been made.

7. Section 2.12.1 (Summary of the Rationale for the Selected Remedy), Line 2 of first paragraph of section on Page 2-29: Please add “...and LUCs and LTM...” after the acronym “...(BiRD)...” in Line 2 of the first paragraph of this section.

**Response:** The terms LUCs and LTM have been added after “(BiRD).”

8. Section 2.12.4 (Expected Outcomes of Selected Remedy), third to last line in the third paragraph of this section on Page 2-33: Please replace “...health-based levels...” with “...health-based standards...” or “...health-based ARARs...”

**Response:** The change has been made to use "health-based standard."

9. Table 2-10 (Description of ARARs): Please add rows 1, 5, 6, 8, 9, and 10 from Table 6-1 from the February 2018 Site 10 Draft Final Focused Feasibility Study (FS) to Table 2-10 from the AAA/AGES ROD. Additionally, please see Comment 18 from the Division’s April 13, 2018 comments on the Site 10 FS, as it relates to Table 2-10 on Page 2-36 of the AAA/AGES ROD. While the LUCs currently contemplated for the AAA/AGES will likely involve BAFB’s internal LUCs and not a Colorado restrictive notice or Colorado environmental covenant, we are including Row 6 from Table 6-1 in the list above from the Site 10 FS, for completeness and/or discussion purposes.

**Response:** Rows 1 (EPA MCLs), 5 (Colorado Fugitive Dust Control), 8 (Underground Injection Control Regulations), 9 (CDPHE Air Screening Concentrations table), and 10 (Colorado Hazardous Waste determinations) from Table 6-1 of the February 2018 Site 10 Draft Final FS have been added to Table 2-10 and modified as needed to be relevant to the AAA/AGES site versus Site 10. In addition, a new line has been added for Colorado Regulations Pertaining to Solid Waste Sites and Facilities. As the Air Force discussed with CDPHE on 2 July 2018, and in accordance with the voicemail left by CDPHE, Row 6 has not been added. Row 6 (Colorado Statutes regarding notices of environmental use restrictions) has not been added because an environmental covenant and restrictive notice are not expected to be needed and therefore not applicable; the plume is on base and about 0.5 mile from the downgradient base boundary.

10. Section 4.0 (References) on Pages 4-1 and 4-2: Please revise CDPHE. 2013 and add the CDPHE, 2016 reference, as follows:

“CDPHE. 2013. Water Quality Control Commission. *The Basic Standards for Groundwater. 5CCR 1002-41, Regulation No. 41.* Effective January 31, 2013, as amended.”

“CDPHE. 2016. Water Quality Control Commission. *The Basic Standards for Groundwater.*

5CCR 1002-41, Regulation No. 41. Effective December 30, 2016, as amended.

**Response:** *These changes have been made.*

11. Figure 3 Legend: Please delete “...(or parts per billion)” in the Figure 3 legend.

**Response:** *This change has been made.*

12. Figure 4 (Human Health Conceptual Site Model): Please indicate in Footnote (2) on Figure 4 that “...additional explanation is provided in Section 2.5.8 (Conceptual Site Model) on Page 2-10.”

**Response:** *This change has been made.*

13. Figure 5 Legend: Please clarify the purple solid line represents the TCE isoconcentration contour (5 ug/L) and the red line, which should be dashed, represents the 1,4-dioxane inferred isoconcentration contour (0.35 ug/L). Clarification of the TCE and 1,4-dioxane isoconcentration contour symbols may be most easily accomplished by placing each set of symbols and explanations into two separate boxes, within the legend. Following (Biogeochemical Reductive Dehalogenation), please provide the acronym “(BiRD).” Also, delete “(or parts per billion)” from the Figure 5 legend.

**Response:** *These changes have been made.*

**ATTACHMENT 1**  
**Notice of Availability**

# SAFETY IN NUMBERS

## Aurora touts 'safest large' Colorado city distinction, an honor it bestows upon itself

BY BRANDON JOHANSSON  
Staff Writer

In a statement oozing with pride, Aurora police and city officials announced last week that Aurora is once again, "the safest large city in Colorado."

The moniker means that when compared to the state's two larger cities of Denver and Colorado Springs, Aurora saw less crime per-capita in 2016, same as it did in 2015, 2014 and 2013.

When compared to other cities around the nation with at least 250,000 people, Aurora, with 366,477 people, ranked No. 25.

"Our ranking as the safest large city in Colorado, and as one of the safest major cities in the country would not be possible without the dedication and hard work of every member of the Aurora Police Department," Aurora police Chief Nick Metz said in a statement announcing the ranking. "Our success in keeping Aurora safe would not be possible without the partnerships we have established with the members of the community

we serve, and by working closely and collaboratively with the Mayor and Councilmembers of the City of Aurora."

Focus on Aurora's crime rate comes from years of consternation at city hall with how local media reports Aurora crime. Past city officials have appealed to newspapers and television stations about how the word "Aurora" makes its way into broadcast and print headlines, but usually the word "Denver" and other communities do not.

Mayor Steve Hogan and others have said that the result has been the public perception that there's more crime in Aurora than there actually is.

City officials regularly say that much of the public is unaware of how large Aurora really is, and that the real gauge of public safety is the rate of crime, not the number of times media report incidents. So for the last several years, Aurora officials have focused on what they say are earmarks of a safe community.

The "safest large city" designation announced last week doesn't come from some outside agency.

Instead, it is bestowed on Aurora by Aurora officials based on statistics from the FBI and calculations by Aurora police crime analysts.

Aurora police spokesman Officer Bill Hummel said the department compares Aurora only to other cities with a minimum of 250,000 residents and only to those cities that report major crime data to the FBI.

That data covers murders, rapes, robbery, aggravated assault, burglary, larceny, motor vehicle theft and arson.

Not all cities contribute to the FBI statistics. Arvada and Centennial, for example, are not included in this year's FBI statistics.

Even when compared to other Colorado cities with 100,000 people or more, Aurora still ranks fairly high.

The city's crime rate of 35.89 trails Fort Collins, with a rate of 26.58, and Boulder with a rank of 32.35. The city also trails Thornton, but just barely as that north-metro suburb comes in with a crime rate of 35.07.

Aurora ranks ahead of smaller Colorado towns including Gree-



A member of the Aurora Police Gang Unit asks a driver about gang ties on Thursday June 22, 2017 in Aurora. Police and city officials say crime statistics show Aurora is the safest large city in Colorado, defining large city as that larger than 250,000 people. File Photo by Gabriel Christus/Aurora Sentinel

ley, Westminster, Lakewood and Pueblo.

Still, the designation comes as crime in Aurora — and in cities around the country — has been rising in recent years. From 2015 to 2016, Aurora saw about an 8-per-

cent spike in major crime, though the stats show Aurora still has less crime than it did a decade ago when 50,000 fewer people called the city home. The crime rate in Aurora in 2006, for example, was 40.40.

### Air Force Proposes Soil and Groundwater Cleanup for Truck Fueling Area Site, and Groundwater Cleanup for Armament and Automotive Area/Aerospace Ground and Equipment Shop Site

The United States Air Force (USAF), in cooperation with the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA), announces the public comment period for the Proposed Plans for two sites, the Truck Fueling Area site, and the Armament and Automotive Area/Aerospace Ground and Equipment Shop site at Buckley Air Force Base, Aurora, Colorado. The USAF has conducted multiple environmental investigations at these sites. The investigations and risk evaluations are complete.

The USAF has determined that response actions for the Truck Fueling Area site soil and groundwater, and Armament and Automotive Area/Aerospace Ground and Equipment Shop site groundwater are warranted. The Proposed Plans identify the Preferred Alternative (remedy) for cleaning up the contaminated soil and/or groundwater. CDPHE and EPA concur with the recommendations for these sites.

The Proposed Plans for each site summarize the site history and background, site characteristics, site risks, and the proposed cleanup remedies. Copies of the Proposed Plan documents for these sites have been placed in the Information Repository located at the Aurora Public Library, Central, and are available for public review and comment.

The USAF welcomes the public's comments on the Plans. The formal public comment period for the sites is 30 days and ends on December 3, 2017. Upon timely receipt of a request (i.e., received by December 3, 2017), the public comment period may be extended 15 additional days. The USAF will choose the final remedies after the comment period ends and after taking comments into account.

Copies of the Proposed Plans for the Truck Fueling Area site and the Armament and Automotive Area/Aerospace Ground and Equipment Shop site are available for review at:

Aurora Public Library, Central  
14949 E. Alameda Pkwy.  
Aurora, CO 80012  
(303) 739-6600

Monday-Thursday	8 a.m. to 10 p.m.
Friday	8 a.m. to 8 p.m.
Saturday	8 a.m. to 6 p.m.
Sunday	10 a.m. to 6 p.m.

The Proposed Plans are also available via the U.S. Air Force Civil Engineer Center Administrative Record website by going to <http://afcec.publicadmin-record.us.af.mil/Search.aspx>; selecting "Buckley AFB, CO"; clicking search; then selecting "TA564 Truck Fueling Area", "MY570 Armament and Automotive Area", or "MY568 Aerospace Ground Equipment Shop", and clicking search. The Proposed Plan for each site will be one of the first few documents in the list at the bottom of the page.

#### Public Comment Period

November 2 through December 3, 2017

The USAF will accept written comments on the Proposed Plans during the public comment period. Buckley Air Force Base operates a Community Advisory Group that meets on a semiannual basis to discuss environmental cleanup projects at the base. The Proposed Plans for the Truck Fueling Area site and the Armament and Automotive Area/Aerospace Ground and Equipment Shop site will be summarized during the November 2017 Community Advisory Group meeting. At the meeting, you will be able to state your views about the sites. The meeting will be:

November 16, 2017  
6:00 p.m.

at  
Aurora Chamber of Commerce  
14305 East Alameda Avenue, Suite 300,  
Aurora, Colorado 80012

For more information, contact the Buckley Public Affairs Office at 720-847-9431.

For further information or to submit written comments, please contact:

Mr. Scott Wilson  
Restoration Program Manager  
Phone: (720) 847-7159  
Fax: (720) 847-6159  
Scott.Wilson.7@us.af.mil

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