Air Force Civil Engineer Center

Cannon AFB PFAS Public Update

14 November 2023

Battle Ready…Built Right!

Agenda

- AFFF PFAS Investigation
- South-East Engineering Evaluation/Cost Analysis – Pilot Study
- North Playa Engineering Evaluation/Cost Analysis – Pilot Study
- Due Diligence for Supplemental PFAS Sources
- Going Forward
- Additional Information
- Common Acronyms

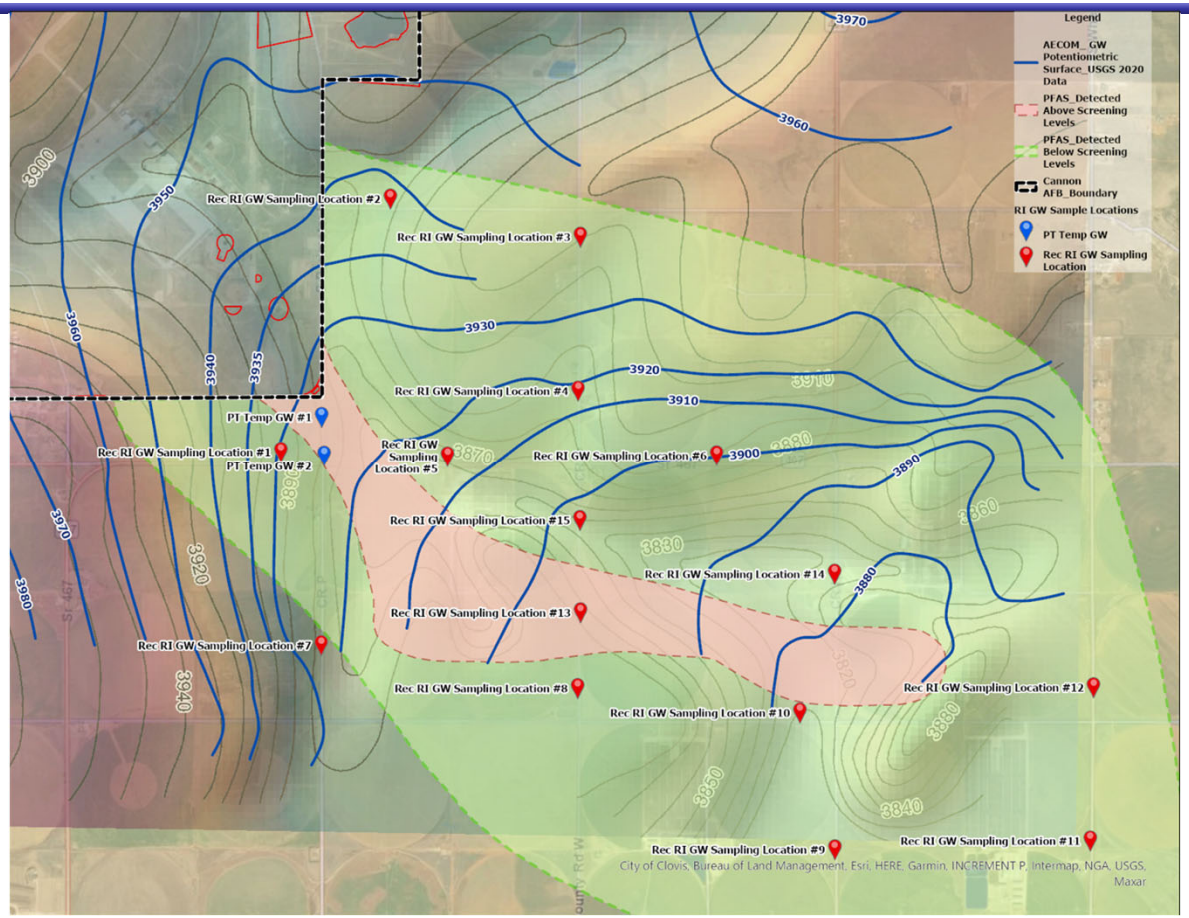
AFFF PFAS Investigation

- Preliminary Assessment (PA) – Completed October 2015
- Site Inspection (SI) – Completed August 2018
- Off Base SI – Completed September 2018
- Remedial Investigation (RI) – In progress
- Feasibility Study
- Public Participation/Record of Decision
- Remedial Design/Remedial Action
- Remedial Action Completion Report/Response Complete

AFFF PFAS Remedial Investigation

- **Remedial Investigation Status**
  - **August 2020 RI Contract awarded**
  - **June 2021 RI Work Plan/QAPP sent to the New Mexico Environmental Department (NMED) & the Environmental Protection Agency (EPA) for 30 Day courtesy regulatory review; review period 23 June – 23 July 2021**
  - **Work Plan completed – September 2021**
  - **November 2023 RI work completed to date:**
    - **Soil samples: on Base 1,526 – off Base 34**
    - **Sediment samples: on Base 12**
    - **Surface Water Samples: on Base 12**
    - **Groundwater samples: on Base 19 – off Base 34**
    - **Continuing installation of 16 new monitoring wells on base; 14 installed**
    - **Preparing to install 15 new off base monitoring wells; agreement with County finalized**

AFFF PFAS Remedial Investigation



South-East Engineering Evaluation/Cost Analysis– Pilot Study

- Award COMPLETED – 27 May 2021
- Initial Site Visit COMPLETED – 2 June 2021
- Kick-Off Meeting COMPLETED – 8 June 2021
- Sampling Event COMPLETED – 14 June 2021
- Treatability Study COMPLETED – December 2021
- Aquifer Test COMPLETED – December 2021
- Design/Work Plan COMPLETED– June 2023
- Construction IN PROGRESS – July 2023
- Operation Start – July 2024
- EE/CA Final – June 2025
  - (30-day NMED/EPA/Public comment period)

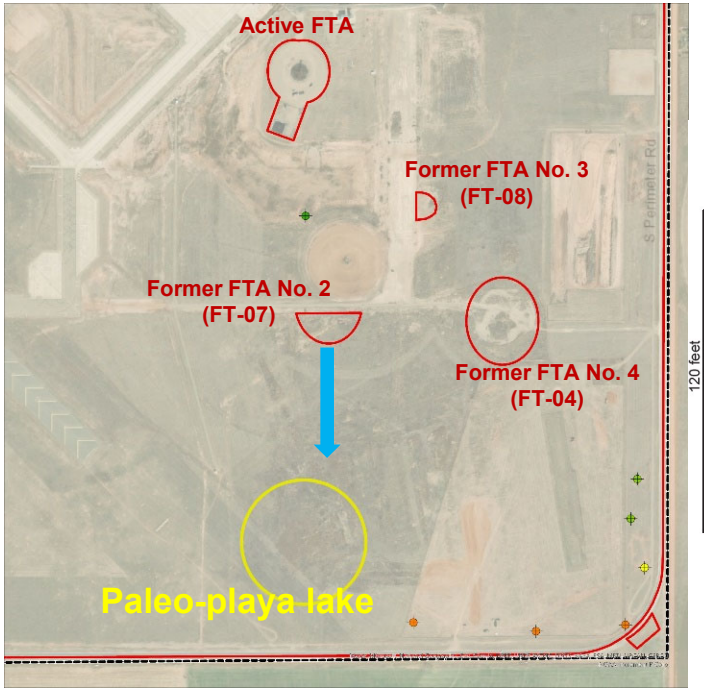
South-East Engineering Evaluation/Cost Analysis– Pilot Study

South-East Engineering Evaluation/Cost Analysis– Pilot Study

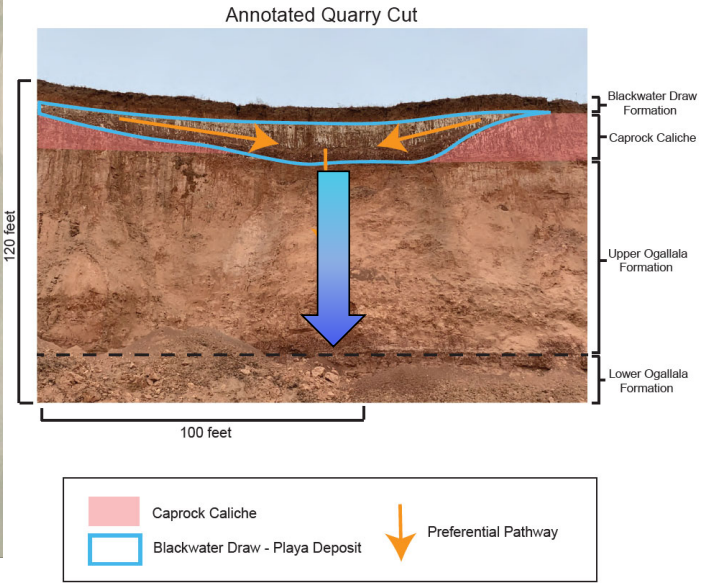
- Preliminary Assessment (PA) - Completed in 2015
- Site Inspection Report (SI) - Completed August 2018
- Identified Sites with Impacted with Emerging Contaminants
- Remedial Investigation (RI) awarded August 2020
- Anticipated Completion Date Summer 2025
- Environmental Sequence Stratigraphy – Completed September 2020
- Design Team engaged February 2021.
- Awarded the May 2021
- Initial Design Completed February 2022
- Optimized the Design July 2022 – Cannon AFB Workshop
- Construction Has Begun July 2023
- System Commissioning July 2024

South-East Engineering Evaluation/Cost Analysis– Pilot Study

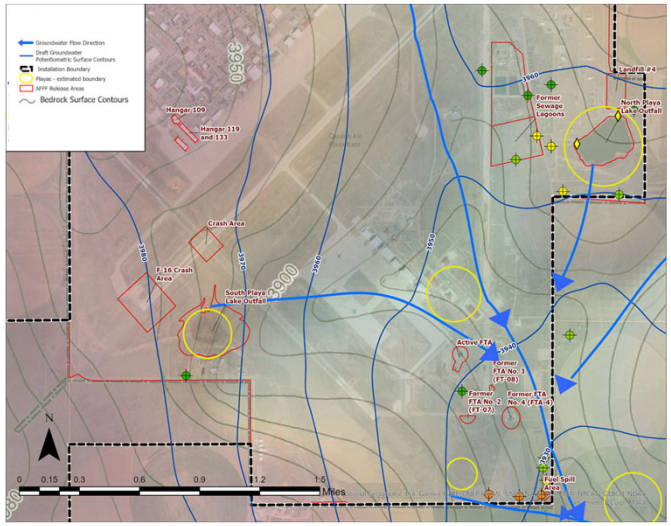
1. Surface Water Flow



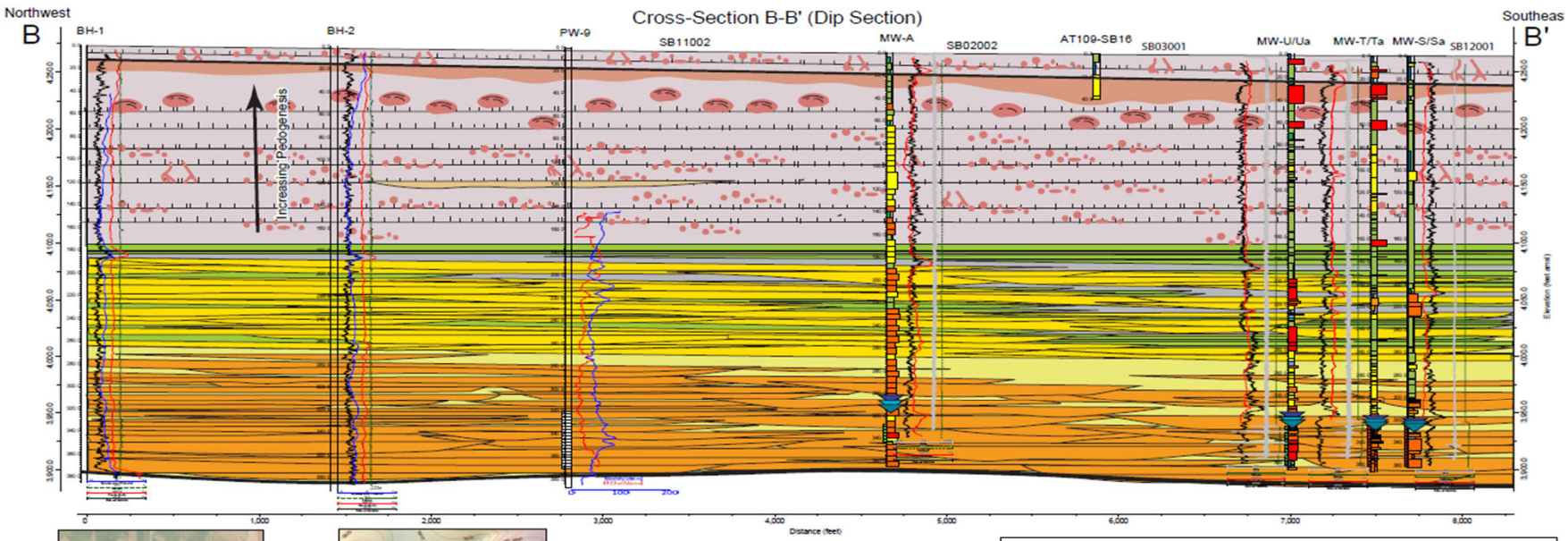
2. Infiltration into Groundwater



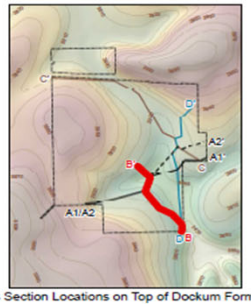
3. Groundwater Flow



South-East Engineering Evaluation/Cost Analysis– Pilot Study

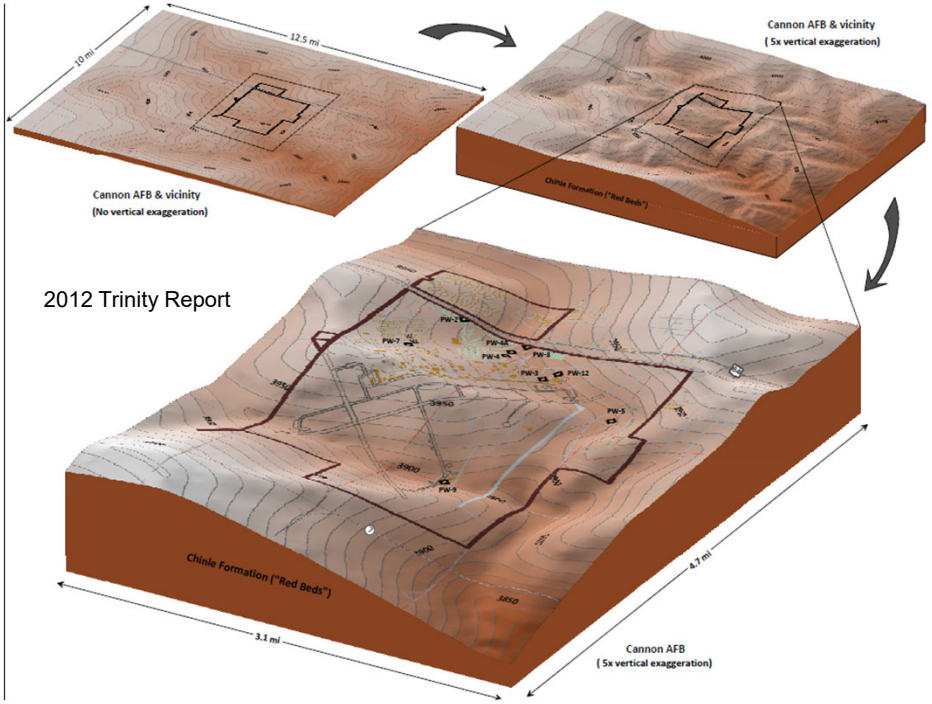


Cross Section Locations on Aerial Imagery

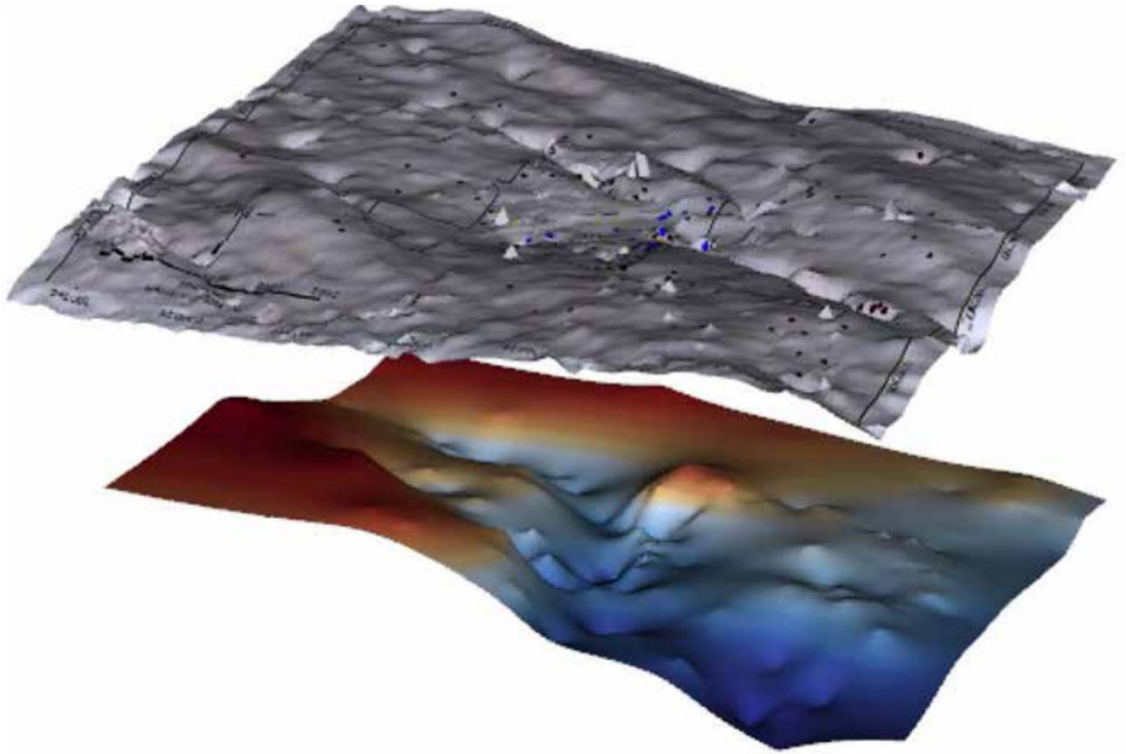


Cross Section Locations on Top of Dockum Formation

Cannon AFB
Groundwater Moves Into & Through Channel



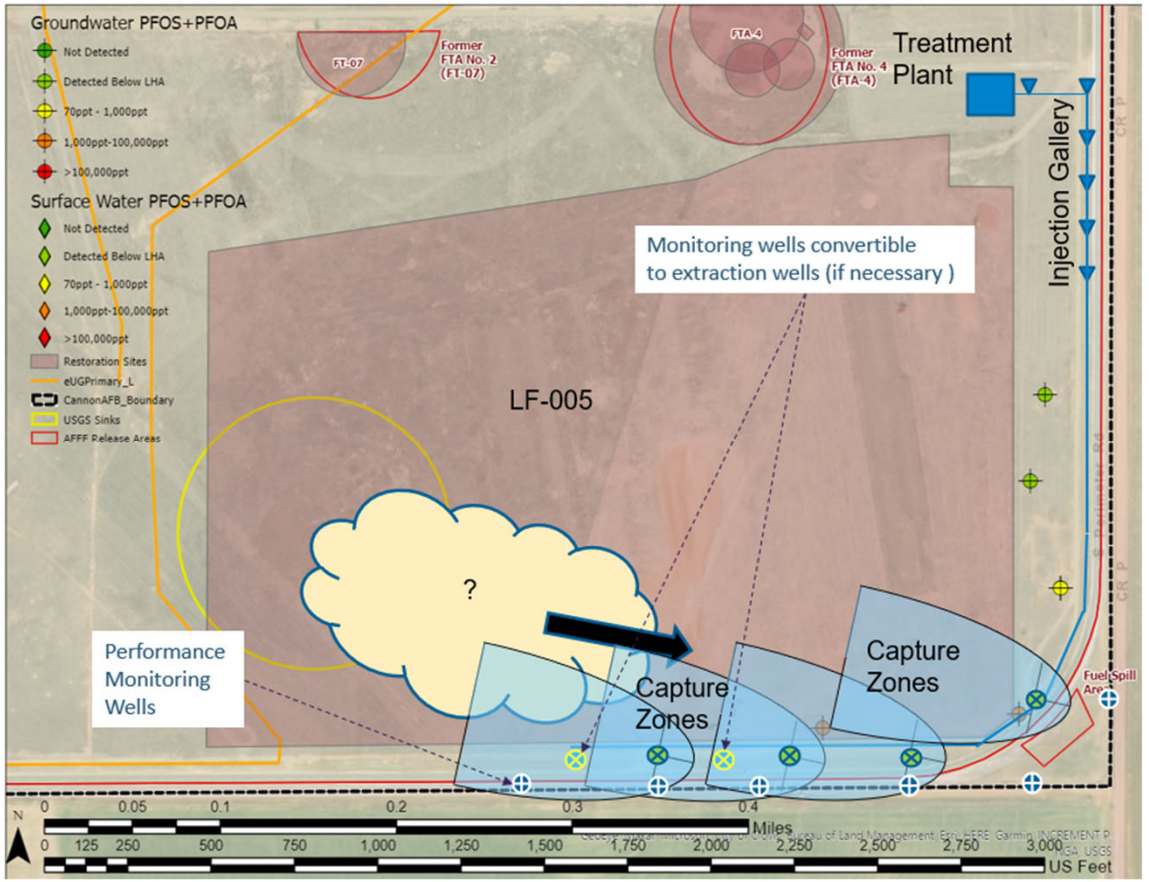
2012 Trinity Report



Update: Mapping the Altitude of the Top of the Dockum Group and Paleochannel Analysis Using Surface Geophysical Methods On and Near Cannon Air Force Base in Curry County, New Mexico, Scientific Investigations Report 2022-5050 Prepared in cooperation with the Air Force Civil Engineer Center

South- East Engineering Evaluation/Cost Analysis– Pilot Study

- Extraction wells
  - 4 extraction wells with pumps
  - 2 extraction wells with no pumps used as monitoring wells
- 6 Injection wells



Capture Zone Analysis

Analytical Model for Estimation of Steady-State Capture Zones of Pumping Wells in Confined and Unconfined Aquifers

by Stuart Grubb[a]

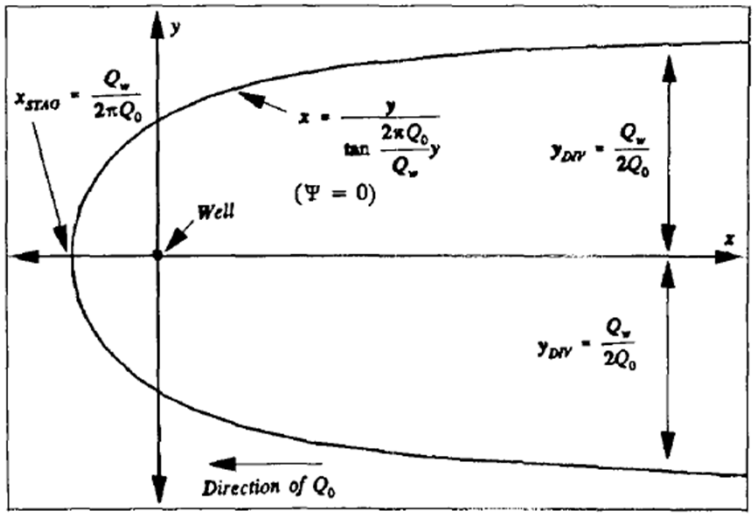
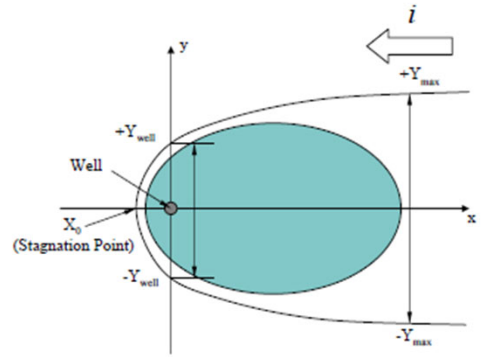


Fig. 1. Stagnation point, upgradient divide, and dividing streamline at infinite time (steady state).

Capture Zone Width Calculation, One Extraction Well

Assumptions:

- homogeneous, isotropic, confined aquifer of infinite extent
- uniform aquifer thickness
- fully penetrating extraction well(s)
- uniform regional horizontal hydraulic gradient
- steady-state flow
- negligible vertical gradient
- no net recharge, or net recharge is accounted for in regional hydraulic gradient
- no other sources of water introduced to aquifer due to extraction (e.g., from rivers or leakage from above or below)



$$x = \frac{-y}{\tan\left(\frac{2\pi Ti}{Q}y\right)} \quad -or- \quad y = \pm\left(\frac{Q}{2Ti}\right) - \left(\frac{Q}{2\pi Ti}\right)\tan^{-1}\left(\frac{y}{x}\right)$$

$$X_0 = -Q/2\pi Ti \quad ; \quad Y_{max} = \pm Q/2Ti \quad ; \quad Y_{well} = \pm Q/4Ti$$

(must use consistent units, such as "ft" for distance and "day" for time)

Where:

Q	=	extraction rate
T	=	transmissivity, $K \cdot b$
K	=	hydraulic conductivity
b	=	saturated thickness
i	=	regional (i.e., pre-remedy-pumping) hydraulic gradient
X_0	=	distance from the well to the downgradient end of the capture zone along the central line of the flow direction
Y_{max}	=	maximum capture zone width from the central line of the plume
Y_{well}	=	capture zone width at the location of well from the central line of the plume

Treatment System Efficiency

Anticipated effluent concentration from the Lead IX vessel - results consistent with US EPA treatment system database

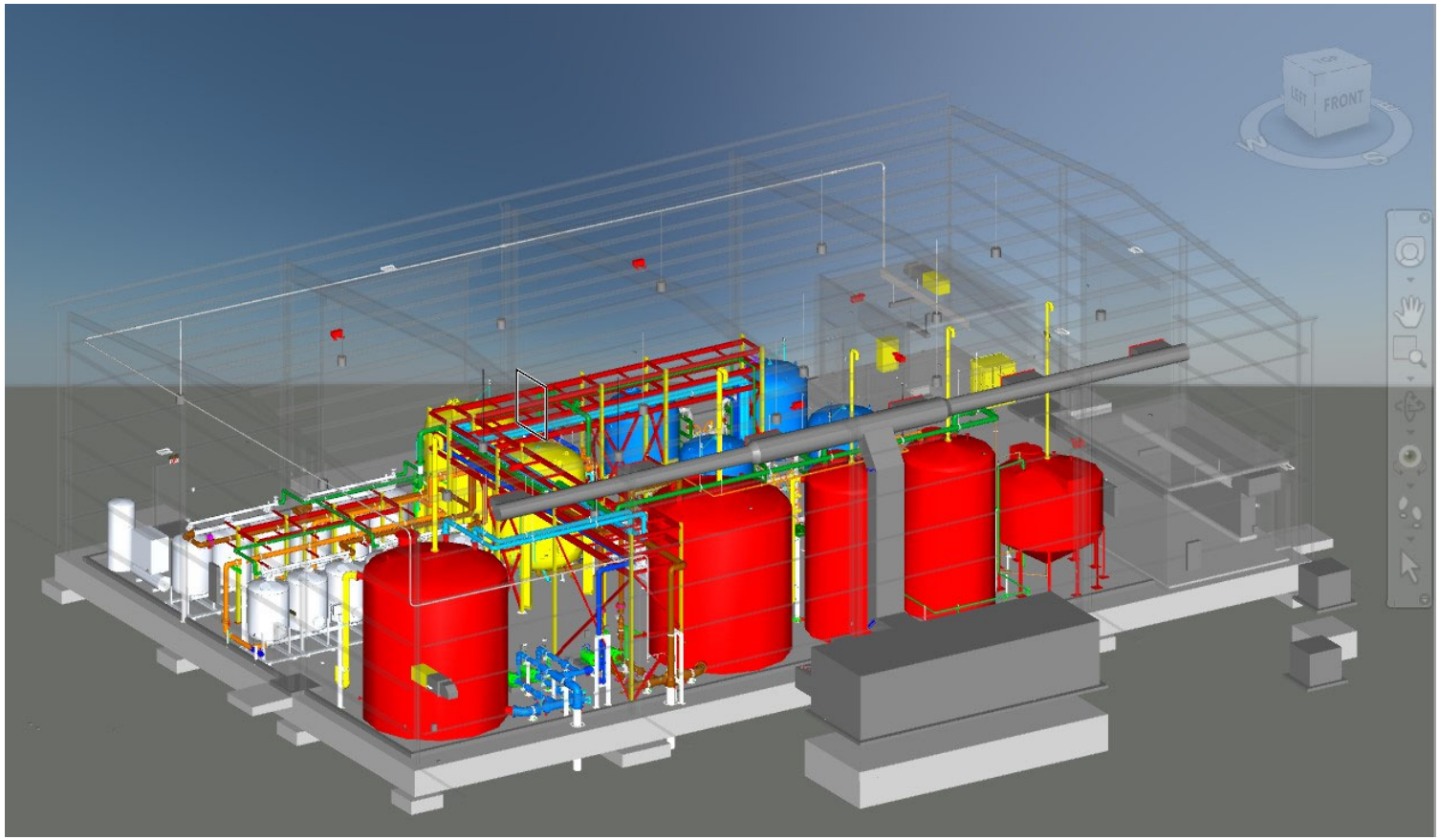
Contaminant of Concern	Specified Influent (ng/L)	Specified Effluent (ng/L)	Estimated lead vessel effluent at changeout (ng/L)	Estimated lag vessel effluent at changeout (ng/L)	Estimated mass removed per lead vessel at changeout (g)	
PFOS	20,767	4	0	0	5,446	
PFHxS	6,800	39	0	0	1,783	
PFOA	1,883	6	19	0	482	
PFBS	578	600	0	0	152	
PFNA	43.2	39.0	0	0	11	
				Total:	7,874	(g) of the 5 target contaminants

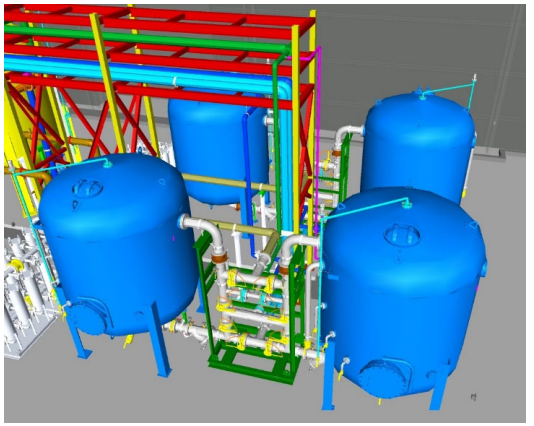
Notes:

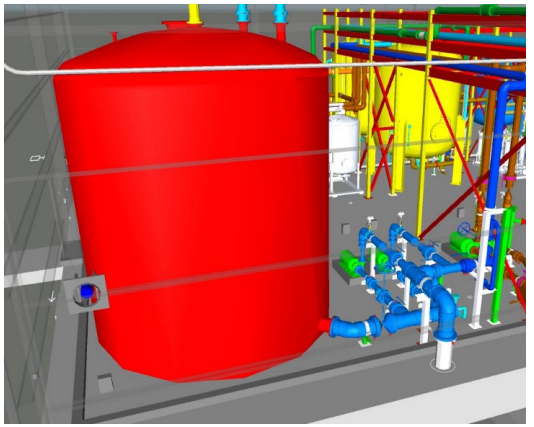
1. Zeros used where values are expected to be below level of detection for method of analysis
2. Results based on the design system flow rate of 1,200 gpm and the specified influent and treatment goals
3. PFOA is expected to breakthrough first and drive the resin changeout point
4. Results are based on resin capacity for the lead vessel only
5. Resin capacity is an estimate and may differ based on actual operation conditions (flow, water quality and influent PFAS concentrations)

Anticipated effluent concentration from the Lag IX vessel

SE Pilot Study Treatment System Layout







Cannon AFB SE Pilot Study Treatment System Operational Performance Based on Bench Scale Testing

ANALYTE NAME	ANALYTE ACRONYM	UNITS	AVERAGE RESULT OF TRIPLICATE SAMPLES	STANDARD DEVIATION
Perfluorooctanesulfonic acid	PFOS	ng/L	20,767	2,219
Perfluorohexanesulfonic acid	PFHxS	ng/L	7,343	405
6:2 Fluorotelomer sulfonate acid	6:2 FTS	ng/L	4,600	142
Perfluorohexanoic acid	PFHxA	ng/L	3,210	98
Perfluoropentanoic acid	PFPeA	ng/L	3,033	124
Perfluorooctanoic acid	PFOA	ng/L	1,883	90
Perfluoroheptanoic acid	PFHpA	ng/L	961	52
Perfluoroheptanesulfonic acid	PFHpS	ng/L	838	122
Perfluorobutyric acid	PFBA	ng/L	831	26
Perfluoropentanoicsulfonic acid	PFPeS	ng/L	639	43
Perfluorobutanesulfonic acid	PFBS	ng/L	578	35
4:2 Fluorotelomer sulfonate acid	4:2 FTS	ng/L	90	7.6
Perfluorononanoic acid	PFNA	ng/L	33	2.0
8:2 Fluorotelomer sulfonic acid	8:2 FTS	ng/L	33	2.2
n-Ethyl perfluorooctane-sulfonamidoacetic acid	NEtFOSAA	ng/L	15	9.2
n-Methyl perfluorooctane-sulfonamidoacetic acid	NMeFOSAA	ng/L	15	9.2
Perfluorononanesulfonic acid	PFNS	ng/L	13	8.1
Perfluorooctanesulfonamide	FOSA	ng/L	13	0.4
Perfluorodecanoic acid	PFDA	ng/L	11	6.9

Cannon AFB SE Pilot Study Treatment System Operational Performance Based on Bench Scale Testing

Table 13 RSSCT Predictions Using Isotherm Parameters vs Actual Observations

PARAMETER	SYMBOL (EQUATION 2)	UNITS	PFOA AS THE LIMITING FACTOR				
			BITUMINOUS GAC	SINGLE-USE IXR 1	SINGLE-USE IXR 2	SINGLE-USE IXR 3	REGENERABLE IXR
Average influent concentration	C_0	ng/L	1,506	1,506	1,506	1,506	1,506
Freundlich parameter, *K*	*K*	L/mg sorbent	1.04	0.71	0.85	0.88	0.54
Freundlich parameter, *n*	*n*	-	2.72	1.99	2.31	2.18	3.18
Adsorption capacity in equilibrium with C_0	q^*	ng/mg sorbent	15	28	20	25	5
Sorbent bed mass	B	mg	1849	876	692	951	1100
Water flowrate	Q	L/min	6.69E-03	5.65E-03	6.24E-03	5.05E-03	5.65E-03
Bed saturation	ζ	-	1	1	1	1	1
Breakthrough concentration	C_B	ng/L	20	20	20	20	20
Time to breakthrough	t_B	min	2831	2908	1497	3181	702
Volume to breakthrough	V_B	L	18.9	16.4	9.3	16.0	4.0
Predicted Treatable Bed Volumes	B_B	-	**6,185**	**11,430**	**8,089**	**10,217**	**2,195**
Actual RSSCT Treatable Bed Volumes	$B_{B,RSSCT}$	-	**26,100**	**50,000**	**47,500**	**50,000**	**43,100**

Notes:
For definitions, refer to the Acronyms and Abbreviations section.
*Calculated value using Freundlich isotherm parameters.

- **IXR1 produced the**
- **greatest adsorption**
- **capacity at 28 ng/mg.**
- **Actual RSSCT Bed Volume**

Cannon AFB SE Pilot Study Treatment System Operational Performance Based on Bench Scale Testing

RSSCT Metals and Inorganic Species

		Influent		Single-Use IXR 1		
		Initial	Endpoint	Initial	Midpoint	Endpoint
Analyte	Units	Avg 0 days	Avg 16.4 days	0.08 days	4.4 days	9.05 days
Arsenic	ug/L	4.1	4.245	3.42	4.22	4.17
Barium	ug/L	86.4	91.6	92.2	87.7	87.8
Cadmium	ug/L	1	0.5	0.5	0.5	0.5
Calcium	ug/L	43133	43050	42600	42500	42800
Chromium	ug/L	1	0.71	0.5	0.84	0.81
Iron	ug/L	50	50	50	50	50
Lead	ug/L	1	0.5	0.26	0.5	0.5
Magnesium	ug/L	40267	40400	37400	37900	39400
Manganese	ug/L	3	2.5	4.07	1.92	1.49
Selenium	ug/L	2	2.545	0.5	2.56	2.52
Silver	ug/L	1	0.5	0.5	0.5	0.5
Calcium, dissolved	ug/L	40033	40200	40600	40900	38900
Iron, dissolved	ug/L	50	50	50	50	50
Magnesium, dissolved	ug/L	36000	37350	36400	37100	34700
Manganese, dissolved	ug/L	3	2.5	3.71	2.5	1.93
Mercury	ug/L	0	0.15	0.15	0.15	0.15
Calcium	ug/L	43133	43050	42600	42500	42800
Magnesium	ug/L	40267	40400	37400	37900	39400
Hardness	mg/L CaCO3	274	273.5	260	262	269
Bicarbonate Alkalinity	mg/L CaCO3	282	282	302	295	281
Total Dissolved Solids(TDS)	mg/L	345	413	358	385	358
Total Suspended Solids	mg/L	5	5	5	5	5
Chloride	mg/L	27	27.48	30.3	29.2	17
Nitrate	mg/L-N	2	2.545	0.15	2.61	2.54
Sulfate	mg/L	37	42.15	42.1	37.2	41.7

Notes:
µg/L – micrograms per liter
Avg – average
CaCO3 – calcium carbonate
GAC – granular activated carbon
mg/L – milligrams per liter
mg/L-N – miligrams per liter as nitrogen

- ✓ No significant impact on metal concentrations in the effluent samples
- ✓ No significant impact on chloride, nitrate, sulfate, hardness, alkalinity, and TDS did not change significantly in any of the effluent
- ✓ pH and EC (µS/cm) were stable in the effluent samples
- ✓ ORP measurements showed an increase in all effluent samples from 150 to 350 meV.
- ✓ No VOCs or SVOCs were detected in the baseline groundwater samples. PCBs and radionuclides were not tested.

Cannon AFB SE Pilot Study Treatment System
Anticipated Effluent Water Quality - Based on Bench Scale Testing

Contaminants	Contaminants	
	Incoming (Influent)	Final (Effluent)
Nitrate as Nitrogen (NO_3-N, mg/L)[1]	2	No Significant Change
Total Kjeldahl Nitrogen (TKN, mg/L)[1]	NS	No Significant Change
Total Dissolved Solids (TDS, mg/L)[1]	345	No Significant Change
Chloride (Cl, mg/L)[1]	27	No Significant Change
Total Suspended Solids (TSS, mg/L)[2]	24	Reduced by 90%
Biochemical Oxygen Demand (BOD, mg/L)[2]	NS, None Anticipated	Zero
Fecal Coliform Bacteria (CFU/100 mL)[2]	NS, None Anticipated	Zero
pH[3]	7.5	Stable
Metals (attach list)[3]	No Significant Change, Radionuclides not sampled	
Organic Compounds (attach list)[3]	No VOC or SVOCs Detected, PCBs not sampled	

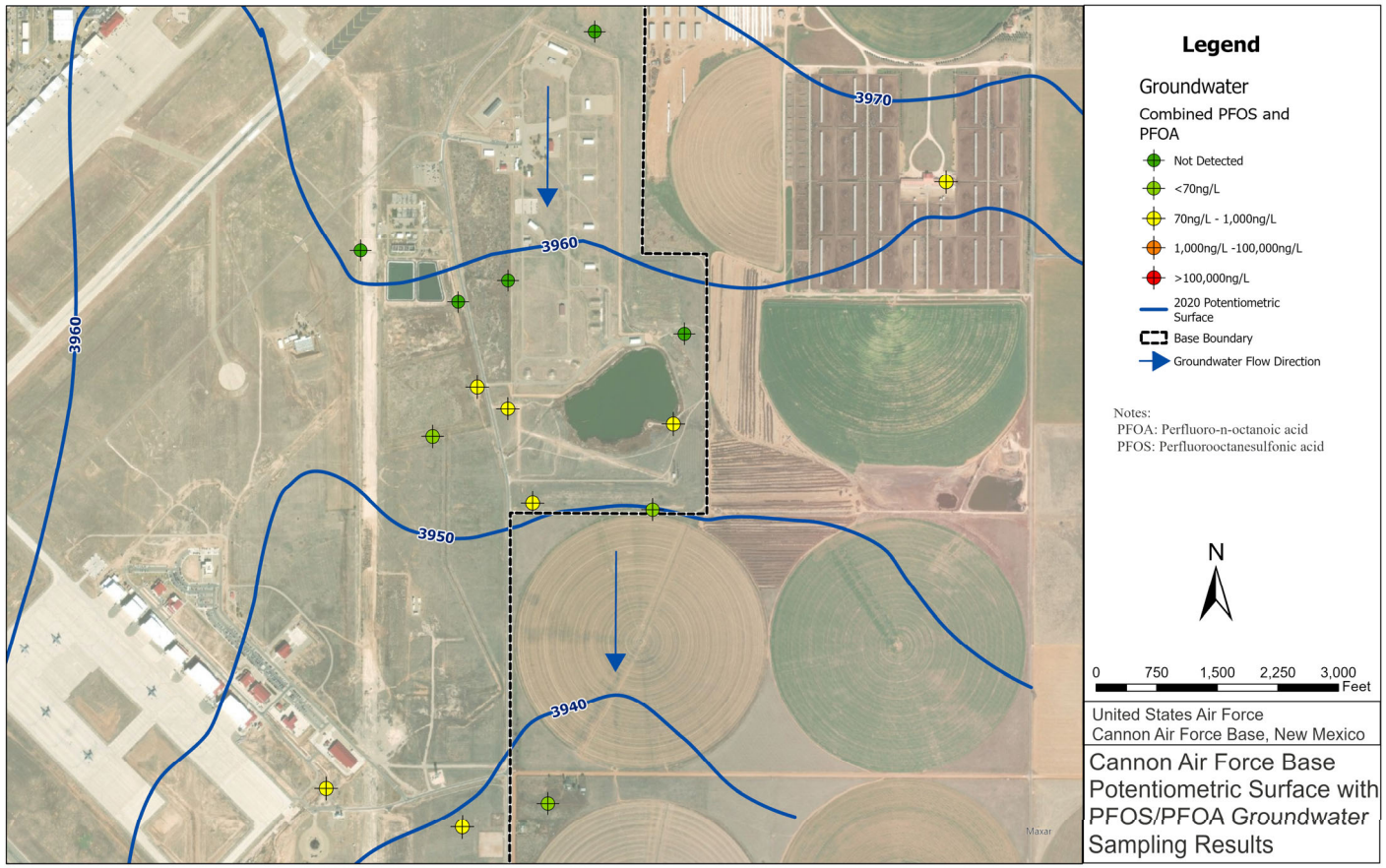
Cannon AFB SE Pilot Study Summary

- Rapid deployment from the drawing board to field implementation was achieved within one year utilizing the Non-Time-Critical Removal Actions (NTCRA) process under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
- Combination of Environmental Sequence Stratigraphy, synoptic groundwater measurements, and contaminant data accelerated the remedial approach.
- Beneficial impacts to off-base receptors should be realized within the first five years of treatment system operations.
- Treatment system will not exacerbate decreasing groundwater elevations at Cannon AFB.

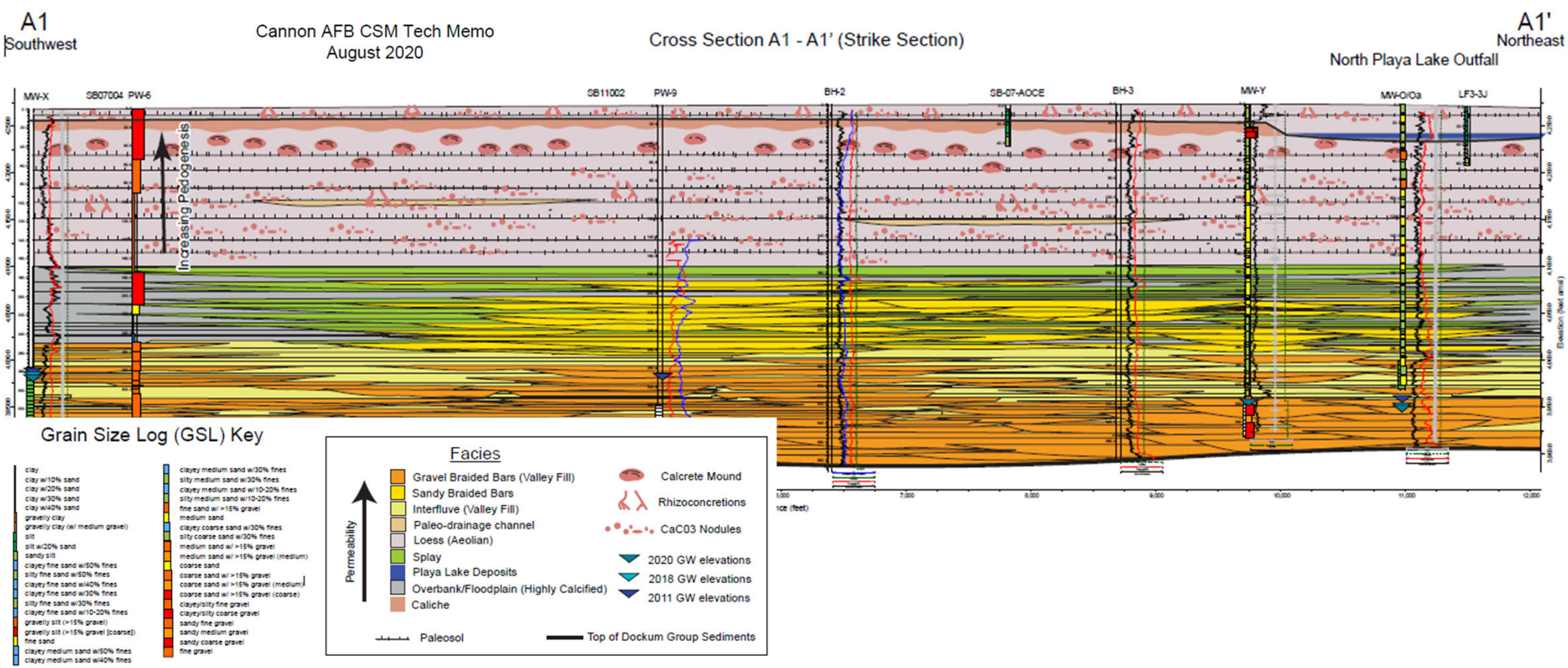
North Playa Engineering Evaluation/Cost Analysis– Pilot Study

- Contract Awarded – 26 September 2023
- Kick-Off Meeting COMPLETED – 4 October 2023
- Sampling Event – TBD
- Treatability Study – TBD
- Design/Work Plan – TBD
  - (30-day NMED/EPA comment period)
- Construction Start – TBD
- Operation Start – TBD
- EE/CA Final – TBD
  - (30-day NMED/EPA/Public comment period)

Potentiometric Surface 2020



Transect A1 to A1' for MW-Y and MW-Oa

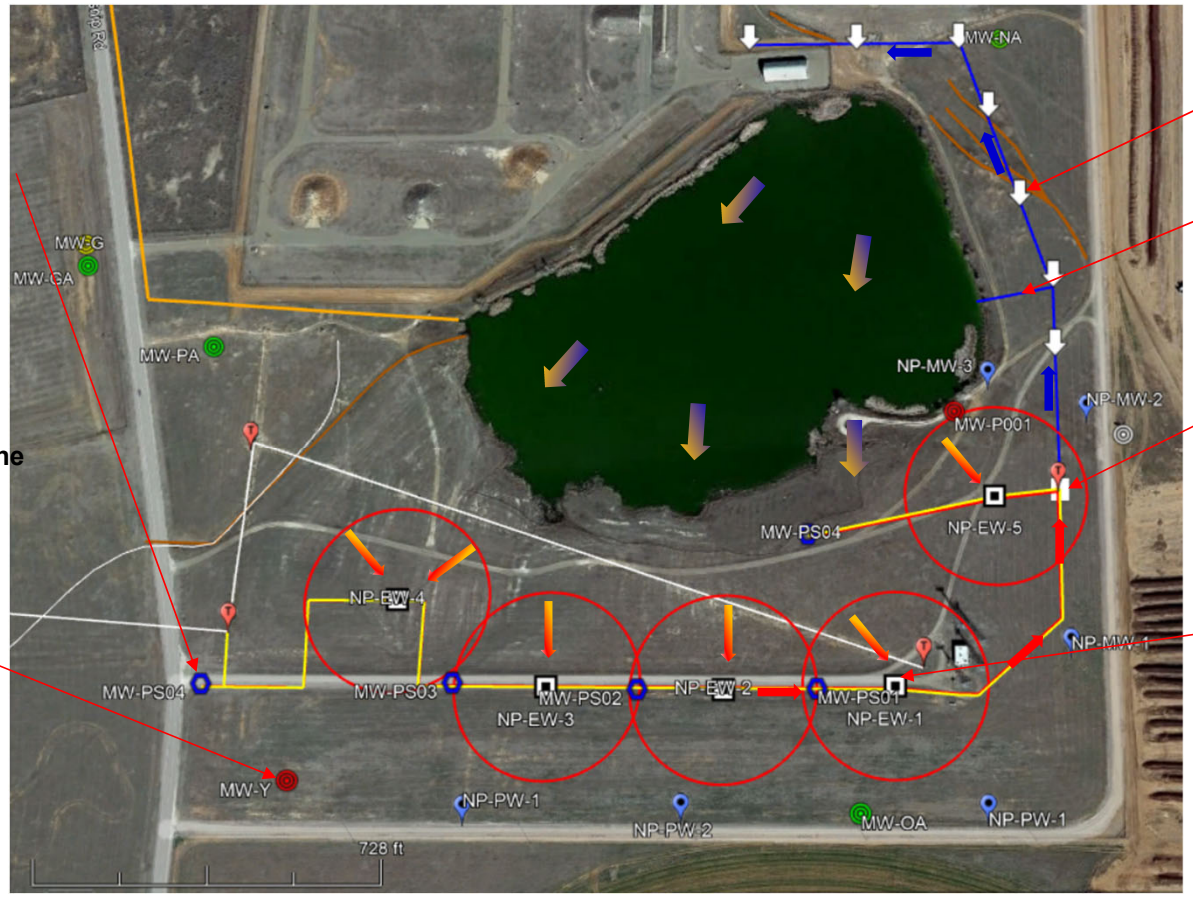


Closed Loop Groundwater Recirculation North Playa Lake Pilot Study Treatment System Design Layout

Additional extraction wells without pumps operating as monitoring wells increases system efficiency and flexibility In case future groundwater extraction capacity is necessary

Existing monitoring well network will be augmented with capture zone performance monitoring wells to ensure compliance along the base Perimeter

100% water recycled on-base



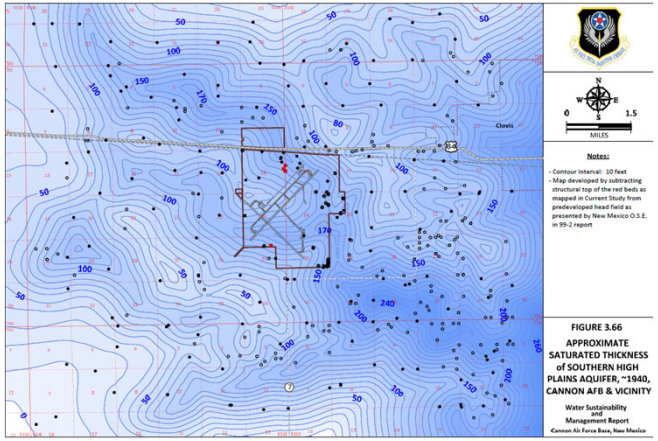
Groundwater reinjection following treatment

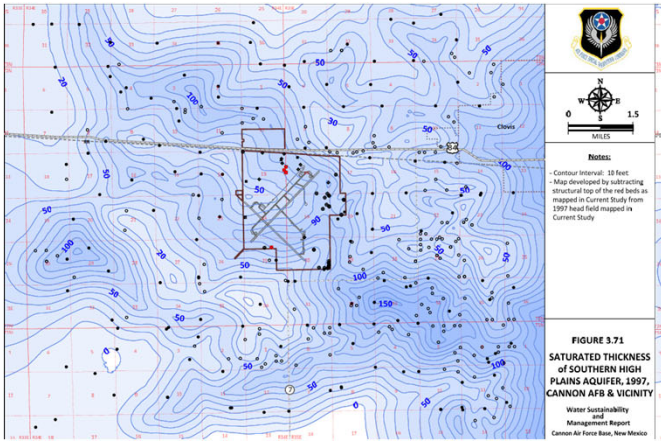
Bypass allows for future flexibility (if necessary)

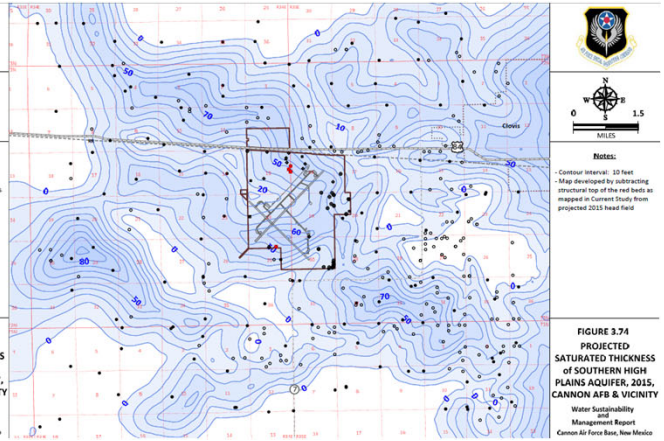
1000 gallon per minute groundwater treatment in a lead lag configuration Using 56,000 ion exchange resin, LGAC pretreatment

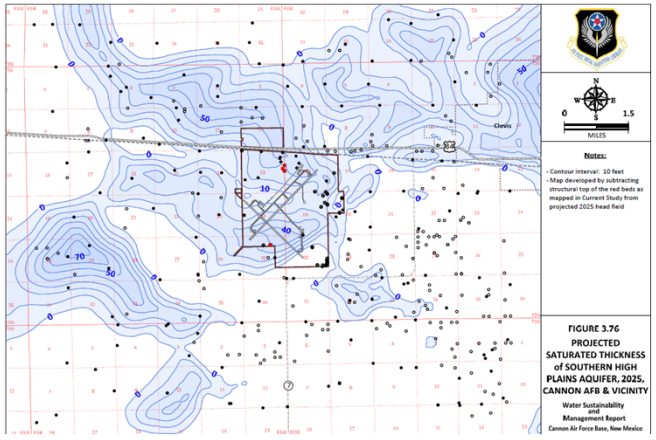
5 Grundfos 6 (230S400-10, 40 Hp, VFDs) extraction wells operating at 200 gpms per well. VFDs Optimal balancing to environmental conditions

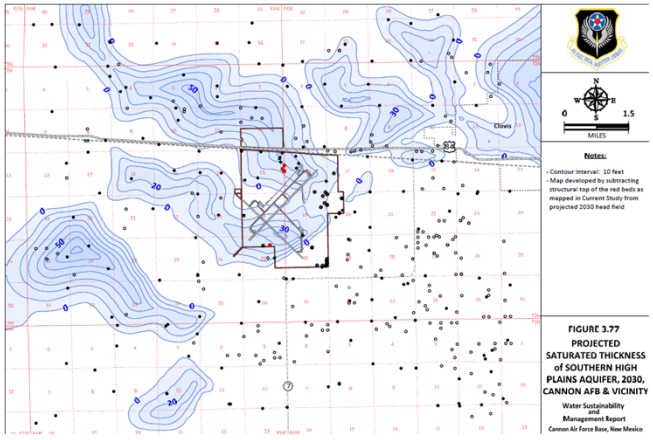
Cannon AFB Groundwater Declination

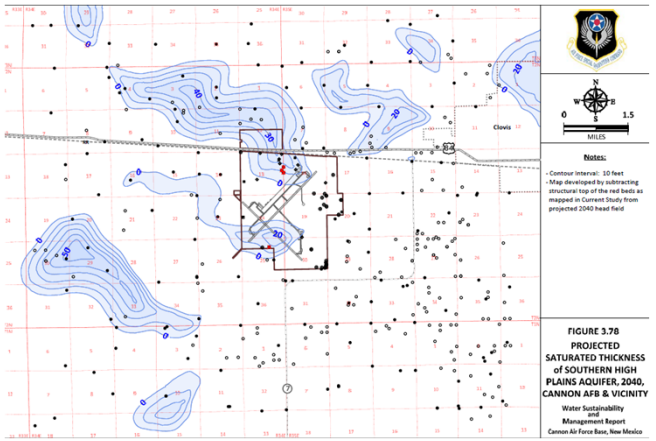












Due Diligence for Supplemental PFAS Sources

- Due Diligence for Supplemental PFAS Sources – In Progress
  - Contract Awarded September 2022
  - Site Kick-off meeting February 2023
  - Work plan completed April 2023
  - Draft report expected November 2023
- Any additional sites identified through this assessment will be added to the existing Remedial Investigation

Due Diligence for Supplemental PFAS Sources

- Work will consist of data collection and review to determine any locations that are potential areas requiring further investigation. Any sites selected for further investigation will move to the Remedial Investigation phase
- Examples of areas that will be investigated:
  - Biosolids, Carwashes, Automotive/Hobby Shops/Motor Pool, Warehouses and other storage (if stored materials in question), Landfills, Medical Clinics/facilities (x-ray film), Landscaping Sheds, Herbicides/Pesticides/insecticides, Sewers/Storm water runoff, Gas Pumps

PFAS Response Spending to Date

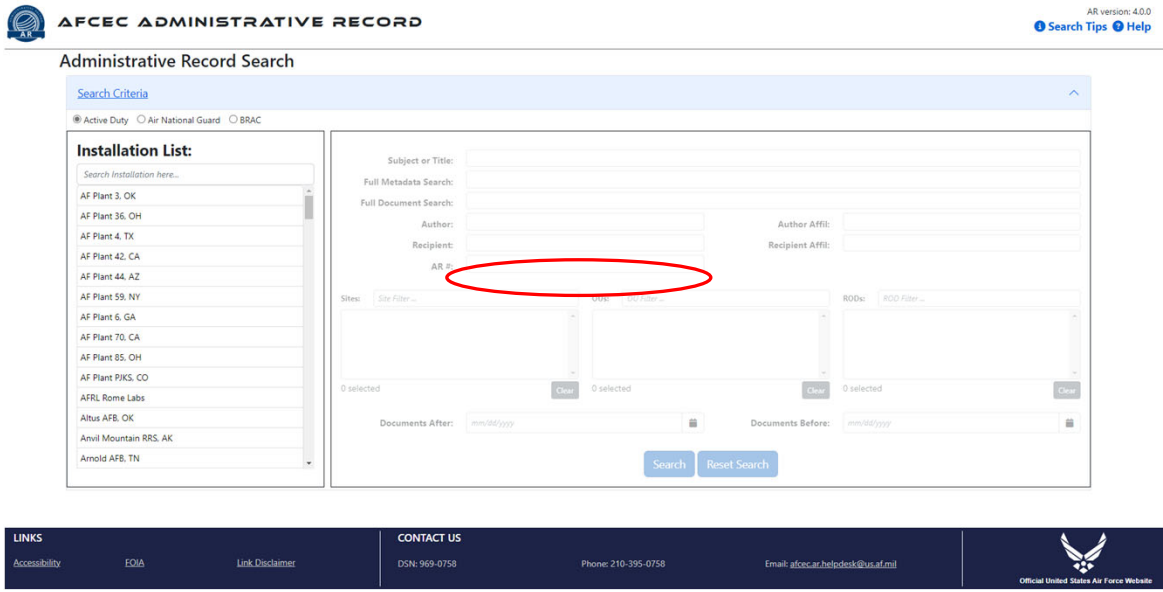
- Expenditures to date $67,580,921
  - Preliminary Assessment: $38,754
  - Site Inspection: $2,024,231
  - Off Base Site Inspection: $505,000
  - Remedial Investigation: $10,377,619
  - United States Geological Survey (USGS) work to understand groundwater flow: $735,000 in FY20, $1,065,000 in FY21, $987,000 in FY22, $582,000 in FY23
  - South-East Corner Engineering Evaluation/Cost Analysis – Pilot System: $20,840,491
  - North Playa Engineering Evaluation/Cost Analysis – Pilot System: $30,292,016
  - Due Diligence for Supplemental PFAS Sources: $133,810

Going Forward

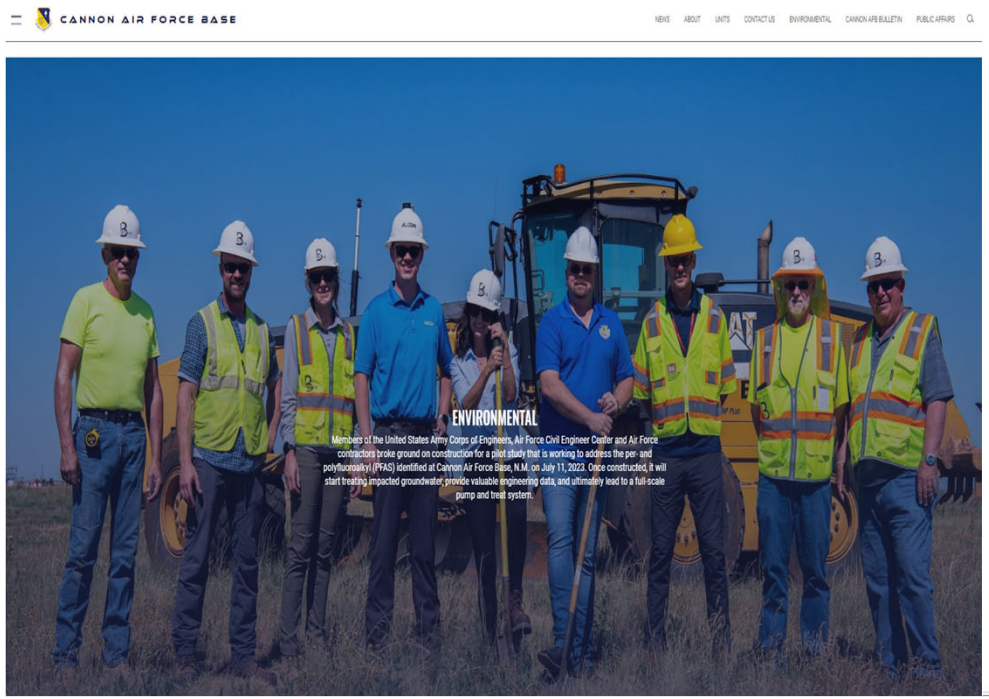
- South-East EE/CA - Pilot Study
  - Continue construction
- North Playa EE/CA - Pilot Study
  - Prepare work plans, then conduct bench scale test
- AFFF Remedial Investigation
  - Field work; continue monitoring well installation both on and off base while collecting additional soil and groundwater samples
- Due Diligence for Supplemental PFAS Sources
  - Commence field work consisting of data analysis
- Next Public Update
  - Tentatively planned 14 May 2024

Additional Information

- **Admin Record (AR) Links to Cannon Air Force Base reports: https://ar.afcec-cloud.af.mil/**
  - **PA: AR# 1941**
  - **SI: AR# 1938**
  - **Off base SI: AR# 1940**
  - **RRSE: AR# 2063, 2790, 2806**
  - **Treatability Work Plan: AR# 2072**
  - **RI Work Plan: AR# 2074**
  - **Aquifer Test Work Plan: AR# 2075**
  - **Treatability Report: AR# 2800**
  - **Aquifer Report: AR# 2801**
  - **South-East Pilot Study Design: AR# 2805**



Additional Information



https://www.cannon.af.mil/Environmental/

Common Acronyms

- Administrative Record (AR)
- Aqueous Film Forming Foam (AFFF)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Department of the Air Force (DAF)
- Department of Defense (DoD)
- Engineering Evaluation/Cost Analysis(EE/CA)
- Environmental Protection Agency (EPA)
- Food and Drug Administration (FDA)

Common Acronyms

- New Mexico Environmental Department (NMED)
- Parts Per Trillion (ppt)
- Per- and polyfluoroalkyl substances (PFAS)
- Perfluorooctanesulfonic acid (PFOS)
- Perfluorobutanesulfonic acid (PFBS)
- Perfluorooctanoic acid (PFOA)
- Preliminary Assessment (PA)
- Remedial Investigation (RI)
- Relative Risk Site Evaluation (RRSE)
- Site Inspection (SI)

Your Success is Our Mission!

Any question please contact 27SOCES.cannon.rpm@us.af.mil