ROCKY MOUNTAIN ARSENAL

Fiscal Year 2021 Annual Summary Report for Groundwater and Surface Water

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U.S. Department of the Army
Shell Oil Company

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LIST OF FILES ON THE ENCLOSED CD

Folder	Files
Report Text and Tables	FY21 Annual Summary Report for Groundwater and Surface Water Text-Tables Rev 0.pdf
Appendices	Individual folders presenting contents of Appendices A through J
Data and Quality Control Review	See list in Appendix H
FY21 BANS-BRES-CADT-Lime Basins	BANS Contaminant Removal Report_FY21.pdf
	BANS Water Management Report_FY21.pdf
	FY21 ASR BANS Mass Removal Rev0 07-20-22.xlsx
	Lime Basins Water Management Report_FY21.pdf
FY21 North Boundary Containment System	NBCS Contaminant Removal Report_FY21.pdf
	NBCS System Water Management Report_FY21.pdf
	NBCS Vertical Gradient Data FY21.xlsx
FY21 Northwest Boundary Containment System	NWBCS Contaminant Removal Report_FY21.pdf
	NWBCS Water Management Report_FY21.pdf
FY21 Off-Post Treatment Systems	FCTS Q4 Contaminant Removal Report_FY21.pdf
	OGITS Contaminant Removal Report_FY21.pdf
	OGITS System Water Management Report_FY21.pdf
	Note: Mass removal was not evaluated for the off-post systems in FY21
FY21 Quarterly Treatment Plant Effluent Water Quality Reports	Effluent Report_FY21_QTR1_Rev 0.pdf
	Effluent Report_FY21_QTR2_Rev 0.pdf
	Effluent Report_FY21_QTR3_Rev 0.pdf
	Effluent Report_FY21_QTR4_Rev 0.pdf

ACRONYMS

amsl	Above mean sea level
Army	U.S. Department of the Army
ARAR	Applicable or Relevant and Appropriate Requirements
ASR	Annual Summary Report for Groundwater and Surface Water
BANS	Basin A Neck System
BRES	Bedrock Ridge Extraction System
CADT	Complex Army Disposal Trenches
CBSG	Colorado Basic Standard for Groundwater
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFS	Confined Flow System
CSRG	Containment System Remediation Goal
DAR	Design Analysis Report
DNAPL	Dense Non-aqueous Phase Liquid
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
FCS	First Creek System
FCTS	First Creek Treatment System
FY	Fiscal Year (see note at end of list)
FY21	Fiscal Year 2021
FYRR	Five-Year Review Report
FYSR	Five-Year Summary Report
gpm	Gallons per Minute
ICS	Irondale Containment System
IQR	Interquartile range
IRA	Interim Response Actions
LCS	Laboratory control spikes
LNAPL	Light Non-Aqueous Phase Liquid
LT	Less Than (boolean for nondetect values from chemical analysis)
LTMP	*Long-Term Monitoring Plan for Groundwater and Surface Water*

ACRONYMS

MPS	Motor Pool System
MRL	Method Reporting Limit
MS	Matrix spike
Navarro	Navarro Research and Engineering, Inc.
NBCS	North Boundary Containment System
NDMA or NNDMEA	n-Nitrosodimethylamine
NDPA or NNDNPA	n-Nitroso-di-n-propylamine
NEE	Northeast Extension
NPS	Northern Pathway System
NPTS	Northern Pathway Treatment System
NWBCS	Northwest Boundary Containment System
OCN	Operational Change Notice
OCP	Organochlorine pesticides
OGITS	Off-Post Groundwater Intercept and Treatment System
OMC	Operations and Maintenance Contractor
O&M	Operations and Maintenance
OU	Operable Unit
PE	Performance Evaluation
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PQL	Practical Quantitation Limit
PRAS	Percent of relative aqueous solubility
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal

ACRONYMS

RMAED	Rocky Mountain Arsenal Environmental Database
ROD	Record of Decision
RPD	Relative Percent Difference
RVO	Remediation Venture Office
RYCS	Railyard Containment System
SAP	Sampling and Analysis Plan
Shell	Shell Oil Company
Shut-off SAP	*Railyard Containment System Shut-Off Sampling and Analysis Plan*
SQAPP	*Sampling Quality Assurance Project Plan*
SWE	Southwest Extension
TCHD	Tri-County Health Department
UFS	Unconfined Flow System
µg/L or UGL	Micrograms per Liter
UV	Ultraviolet
VOC	Volatile Organic Compound

Notes:

1. All chemical codes are listed in Appendix H2.
2. Numeric fiscal years are identified by the prefix "FY" followed by the last two digits of the four-digit year (e.g., Fiscal Year 2021 is indicated as FY21).

EXECUTIVE SUMMARY

This Fiscal Year 2021 (FY21) Annual Summary Report for Groundwater and Surface Water (ASR) includes an evaluation of the data collected and an evaluation of the compliance and performance criteria required for the operating systems; system-specific and site-wide groundwater and surface water hydrology; other monitoring conducted during FY21; as well as any Consultative Process notifications. The regulatory agencies are required to be notified of performance issues in accordance with the consultation triggers presented in Sections 3 through 9 in this report—Consultative Process Tables—in the *Long-Term Monitoring Plan for Groundwater and Surface Water* (LTMP) (Navarro 2021b). The ASR has been prepared to document and evaluate monitoring data collected at Rocky Mountain Arsenal (RMA) for the period October 2020 through September 2021 for the following systems and programs:

- Northwest Boundary Containment System (NWBCS)
- North Boundary Containment System (NBCS)
- Basin A Neck System (BANS)
- Bedrock Ridge Extraction System (BRES)
- Complex Army Disposal Trenches (CADT)
- Shell Oil Company (Shell) Disposal Trenches
- Lime Basins Slurry Wall Dewatering System and Dense Non-Aqueous Phase Liquid (DNAPL) Remediation Project
- North Plants Light Non-Aqueous Phase Liquid (LNAPL) Pilot Removal Action
- Off-Post Groundwater Intercept and Treatment System (OGITS) – System shut-down in May 2021
- First Creek Treatment System (FCTS) – System started operating in May 2021
- LTMP Off-Post Surface Water Monitoring
- Railyard Containment System (RYCS)
- Motor Pool System (MPS)/Irondale Containment System (ICS)

The current system-related and site-wide monitoring categories, as shown in the LTMP and reported in the FY21 ASR, include the following:

System-Related Monitoring	Site-Wide Monitoring
Effluent Compliance Monitoring	Water Level Tracking
Groundwater Performance Monitoring	Water Quality Tracking
Pre-Shut-Off Monitoring	Confined Flow System (CFS) Monitoring
Shut-Off Monitoring	Exceedance Monitoring
Post-Shut-Off Monitoring	Off-Post Water Level Monitoring
Operational Monitoring	Surface Water Monitoring

All of the groundwater containment and mass removal systems met the compliance monitoring criteria presented in the LTMP (Navarro 2021b) in FY21. In addition, the groundwater containment and mass removal systems generally met the performance criteria presented in the LTMP (Navarro 2021b), and the objectives identified in the On-Post Record of Decision (ROD) (Foster Wheeler 1996) and Off-Post ROD (HLA 1995). Performance criteria were not met in some portions of the following systems: NWBCS, BRES, and Lime Basins. Table ES-1 presents a summary of the compliance criteria and the system- and project-specific performance criteria and whether these criteria were met in FY21. In instances where performance criteria were not met or data suggest that performance criteria are at risk of not being met, proposed or current actions are identified and will be followed up in the FY22 ASR.

The data used for this ASR were collected pursuant to the 2021 revision of LTMP (Navarro 2021b), the Sampling and Analysis Plans (SAP) issued as part of the Operations and Maintenance Plans for the respective extraction and treatment systems, SAPs issued as part of the Post-Closure Plans, and the *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan* (Navarro 2019c).

The long-term groundwater monitoring program described in the LTMP satisfies the requirements of the On-Post and Off-Post RODs (Foster Wheeler 1996; HLA 1995). The main objectives, as stated in the RODs, are to evaluate the effectiveness of the remedies, to verify the effectiveness of existing on-post and off-post groundwater treatment systems, to satisfy Comprehensive Environmental Response, Compensation, and Liability Act of 1980 requirements for waste left in place, and to provide data for five-year reviews. The main component of the remedy related to groundwater is continued operation of the groundwater extraction and treatment systems.

Summarized below are the results and conclusions for system-specific operational compliance monitoring and performance monitoring relative to the criteria presented in Table ES-1.

ES.1 ON-POST EXTRACTION AND TREATMENT SYSTEMS

NWBCS

- In FY21, the NWBCS operated at an average flow rate of 820 gpm, pumping a total volume of 436,765,692 gallons and removing a total of 5.81 pounds of contaminant mass.
- The NWBCS met the compliance and the primary performance criteria for the Original System and objectives established in the LTMP. The NWBCS had no Containment System Remediation Goals (CSRGs)/Practical Quantitation Limit (PQL) analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY21. A reverse hydraulic gradient was maintained within the system and plume capture was evident within the original system as well as within the Northeast Extension (NEE) and the Southwest Extension. Thus, the NWBCS was functioning as intended.
- Dieldrin was detected above the PQL in Original System and NEE downgradient performance wells during the reporting period:

  - Original System downgradient well 37333 contained dieldrin above the PQL in FY21. However, the secondary performance criterion was met during the five-year reporting period because the long-term trend was not increasing in downgradient performance wells.
  - NEE downgradient wells 22512 and 22015 contained dieldrin above the PQL in FY21. However, the primary performance criterion was met because the long-term trend was not increasing in downgradient performance wells.

- Dieldrin above the PQL in downgradient performance wells may be attributed to a variety of factors including contamination due to mobilization of residual dieldrin or possible system bypass around the north end of the NEE slurry wall. An investigation of potential by-pass of the NEE slurry wall was conducted in FY21. While monitoring is ongoing within the NEE, preliminary data demonstrates that the water table is very low in the area north of the slurry wall, indicating limited groundwater flow in this area.

NBCS

- In FY21, the NBCS operated at an average flow rate of 240 gpm and pumped a total volume of 126,561,900 gallons and removed a total of 12.1 pounds of contaminant mass.
- The NBCS met the compliance and performance criteria and objectives established in the LTMP. The NBCS had no CSRG analyte exceedances. A reverse hydraulic gradient was maintained within the system throughout the year and plume capture was evident. Thus, the NBCS was functioning as intended.
- Dieldrin concentrations are above the PQL in downgradient performance wells but show stable or decreasing trends in a majority of wells. Concentrations of anions chloride, fluoride, and sulfate exceeded CSRGs. Chloride and sulfate are expected to naturally attenuate to background levels. Based on the FY21 information, the contaminant plumes continue to be captured by the NBCS system.
- Based on evaluation of data from select downgradient performance water quality wells and alternate wells over the past three years, there was no correlation identified in the concentrations of contaminants in each well. During the monitoring period, well 24207—as a replacement for well 37362—did not yield sufficient water for samples.

BANS

- In FY21, the BANS operated at an average flow rate of 20.5 gpm and pumped a total volume of 10,765,030 gallons, removing a total of 62.5 pounds of contaminant mass. The BANS had no CSRG analyte exceedances in effluent samples.
- The BANS met both of the performance criteria and objectives established in the LTMP. The 75 percent mass removal criterion was met in FY21, with mass removal estimated at 98.5 percent. Concentrations of analytes that remain above CSRGs/PQLs indicate stable or decreasing trends. Thus, the BANS was functioning as intended.

BRES

- In FY21, the BRES did not meet the plume capture performance criteria and objectives established in the LTMP. Analytes 12DCLE and trichloroethylene in well 36566 show increasing concentration trends. Although the plume appears captured at both edges of the system, bypass may be occurring within the west-central portion of the extraction system. Further evaluation of the system will be completed in FY22 to determine the need for system optimization to improve plume capture.

ES.2 OTHER ON-POST SYSTEMS

CADT

- In FY21, the CADT system met the performance criteria and objectives established in the LTMP. The inward gradient was maintained across the slurry wall and hydraulic control was maintained in the vicinity of performance wells 36216 and 36217.

Shell Disposal Trenches

- In FY21, the Shell Disposal Trenches met the performance criteria and objectives established in the LTMP. All groundwater elevations were below the bottom of the trenches at all of the borehole performance goal locations.

Lime Basins Slurry Wall Dewatering System

- The first performance criterion requires that positive inward hydraulic gradient be maintained across the slurry wall. In FY21, an inward gradient was present in all well pairs on the southern side while an outward gradient was still present for all the well pairs on the northern side, consistent with results obtained since FY14. Groundwater elevations inside of the slurry wall have been steadily decreasing; however, progress toward meeting the goal is dependent on water level fluctuations outside the slurry wall.
- The second performance criterion requires that water levels inside the slurry wall are below the elevation of the bottom of the waste (5,242 feet amsl). During all four quarters of FY21, the water elevation in each well inside the slurry wall was below the bottom of waste elevation. Therefore, this dewatering performance criterion was met during FY21.

Lime Basins DNAPL Remediation Monitoring

- The water level data and DNAPL measurements for FY21 indicated that DNAPL was detected in well 36235 outside and/or adjacent to the slurry wall. DNAPL was detected within the slurry wall in extraction wells 36319 and 36320 and monitoring well 36248. The data indicate that the slurry wall has not been adversely impacted by historical DNAPL contamination. Consistent head differentials across the slurry wall have been maintained for all the well pairs showing that the DNAPL remediation system is functioning as intended.
- The observed presence of DNAPL has been consistent since FY13. No additional areas of DNAPL were identified in the vicinity of the Lime Basins slurry wall in FY21. Current data indicate that no additional DNAPL sources zones appear to exist within the Lime Basins slurry wall and that the extent of DNAPL is decreasing.

North Plants LNAPL Pilot Removal Action

- No measurable LNAPL within the former North Plants area was present in the wells during FY21. These results are consistent with data collected since FY13.

ES.3 OFF-POST EXTRACTION AND TREATMENT SYSTEMS

- The OGITS plant was shut down on May 3, 2021 to support start-up of the new First Creek Treatment System (FCTS) plant and construction of the Northern Pathway Treatment System (NPTS) plant along with upgrades to the well field. The FCTS plant went online on May 24, 2021.
- While operational in FY21 (October 1, 2020 through May 3, 2021), the OGITS operated at an average flow rate of 160 gpm, pumping a volume of 49,158,772 gallons, and removing a total of 0.80 pounds of contaminant mass.
- From system startup on May 24, 2021 through October 1, 2021, the new FCTS operated at an average flow rate of 46.0 gpm, pumping a volume of 8,615,759 gallons, and removing a total of 0.91 pounds of contaminant mass.
- The OGITS and new FCTS plant met the compliance and the primary performance criteria and objectives established in the LTMP. The OGITS and FCTS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY21. Thus, the OGITS and FCTS were functioning as intended.
- The Northern Pathway System (NPS), included with the OGITS, was shut down on May 3, 2021. It was replaced by the Northern Pathway Treatment System (NPTS), which was under construction and was not started during the FY21 evaluation period.
- Dieldrin was detected in downgradient performance wells consistent with historic data. Detections of dieldrin above the PQL in downgradient performance wells within the First Creek System (FCS) and NPS are most likely related to the mobilization of residual dieldrin from the aquifer sediments and are not likely indicative of system performance. The concentrations of most CSRG analytes have decreased to below CSRGs/PQLs in upgradient wells in both the FCS and NPS.
- Mass removal was not calculated for the FCS and NPS for FY21 because both systems were not operational for much of the year.

ES.4 SITE-WIDE ON-POST MONITORING

Water Level Tracking

- Overall, groundwater flow directions and associated migration of contaminant plumes have not changed significantly during the FY21 reporting period.

Water Quality Tracking

- In FY21, as scheduled, the Water Quality Tracking network was not sampled. Site-wide water quality sampling was last conducted in FY19 as part of the twice-in-five-years monitoring program. The next sampling event for water quality tracking is scheduled for FY22.

CFS Monitoring

- In FY21, as scheduled, the CFS network was not sampled. CFS water quality sampling was last conducted in FY19 as part of the twice-in-five-years monitoring program. The next CFS sampling event is scheduled for FY22.
- Based on the FY19 data noting the first-time presence of dieldrin in groundwater within CFS wells 23187, 23193, 26147, and 26153 associated with Basin F, monitoring data and well integrity will be evaluated under a future program to investigate the CFS contamination.
- Based on the known presence of elevated levels of chloride in well 35083, a future evaluation is planned to evaluate whether the chloride is the result of anthropogenic sources, or can be attributed to natural background.

ES.5 SITE-WIDE OFF-POST MONITORING

Off-Post Surface Water

- In FY21 only arsenic, chloride and sulfate were detected in off-post surface water samples and at concentrations less than off-post CSRGs. The concentration of arsenic has been generally higher in First Creek at SW37001, furthest downstream of RMA and is consistent with the historical trends detected within First Creek. Based on statistical trend analyses, arsenic concentrations demonstrate a stable trend since August 2013, while chloride and sulfate concentrations show decreasing trends during the same time period. Therefore, it is likely that the presence of these constituents in surface water at SW37001 is naturally occurring and not attributable to RMA activities.

TCHD Off-Post Groundwater Monitoring

- Seventeen off-post private wells were sampled for DIMP, dieldrin, and 1,4-dioxane by Tri-County Health Department in FY21. In FY21, well 359D had a DIMP detection of 12.1 µg/L, which exceeds the CSRG. No other analyte concentrations exceeded CSRGs/PQLs in off-post private wells in FY21.
- Well 359D was installed in November of 2016, which is screened in two separate zones in the Lower Arapahoe aquifer, similar to the well it replaced, 359A. In FY21, a field investigation took place to evaluate the integrity of the well and whether DIMP in groundwater could be isolated to a specific zone within the Arapahoe aquifer. The result of the field investigation was a recommendation that a small-scale "point of entry" carbon filtration system be installed at the wellhead in order to provide uncontaminated water to the residents on the property. Bottled water is currently being provided to the residents, and installation of the treatment system will take place in 2022.

ES.6 POST-SHUT-OFF AND SHUT-OFF MONITORING

Shut-off and post-shut-off monitoring took place for two systems, and a summary of the results of those programs is presented below.

RYCS Shut-Off Monitoring

- During FY21, quarterly monitoring took place in accordance with the *Railyard Containment System Shut-Off Sampling and Analysis Plan* (RYCS Shut-Off SAP)

(Navarro 2016), and the results indicate that there were no contaminants that exceeded CSRGs. The two primary contaminants of concern (DBCP and trichloroethylene) were not detected in any wells. Based on the monitoring to date, the first quarter of FY22 most likely will represent the last sampling event under the RYCS Shut-Off SAP. If the sample results for early FY22 remain consistent the shut-off monitoring conducted to date, post-shut-off monitoring should begin in 2022.

Motor Pool/ICS Post-Shut-Off Monitoring

- Review of water level data presented in the FY21 regional water level map and similar maps over the previous five years indicates that the groundwater flow direction in the area appears unchanged. Since the SAP criteria were met in FY21, post-shut-off monitoring will continue in accordance with the MPS/ICS SAP (URS 2011).

ES.7 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

- RMA does not appear to be a significant source of perfluoroalkyl and polyfluoroalkyl substances (PFAS) contamination in groundwater. PFAS sample analysis in annual treatment plant influent and effluent samples and for select wells in the LTMP once-in-five-years sitewide water quality tracking network has been implemented to continue to evaluate site conditions.

- In accordance with the LTMP, annual influent and effluent samples were collected in July 2021 and analyzed for PFAS, including both perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). PFOA and PFOS were detected in the influent samples collected at the BANS, with only PFOS being detected in the NWBCS influent. All detected concentrations were less than the health advisory level of 0.070 µg/L by an order of magnitude. PFAS were not detected in any treatment plant effluent samples during FY21. Monitoring under the water quality tracking program will next take place in FY22 in accordance with the LTMP sampling schedule.

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Table ES-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Northwest Boundary Containment System – Treatment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Primary Performance Criteria [2] – Original System	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Secondary Performance Criterion [2] – Original System	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate performance wells where CSRG/PQL exceedances occurred.
Northwest Boundary Containment System – Northeast Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	No. Dieldrin was detected above the PQL in downgradient performance wells 22015 and 22512, however, the long-term trend is not increasing in downgradient performance wells. The potential for contaminated flow toward the downgradient performance wells will be further evaluated based on semiannual monitoring continuing through FY23.

Table ES-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs/PQLs in downgradient performance wells.	Yes. Stable and decreasing trends for CSRG analytes are currently present in downgradient performance wells.
Northwest Boundary Containment System – Southwest Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate decreasing concentration trends or that concentrations are at or below the CSRGs/PQLs in downgradient performance wells.	Yes
North Boundary Containment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Primary Performance Criteria [2]	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps, and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes

Table ES-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Secondary Performance Criterion [2]	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate performance wells where CSRG/PQL exceedances occurred.
Basin A Neck System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods (OCN-LTMP-2012-002).	Yes
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes
Bedrock Ridge Extraction System Performance Criteria	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	Yes
Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.	No. Concentrations of 12DCLE and trichloroethylene are above CSRGs in well 36566 and exhibit increasing trends. Supplemental monitoring data are being evaluated to determine whether system optimization is required.

Table ES-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Complex Army Disposal Trenches Performance Criteria	
Demonstrate groundwater elevations in performance monitoring wells 36216 and 36217 are below the target elevations of 5226 and 5227 ft, respectively, or Demonstrate hydraulic gradient from the performance monitoring wells locations is toward the extraction trench.	Yes. The CADT system met the performance criteria and objectives established in the LTMP. Although the water levels remained above the trench-bottom elevation in well 36217, hydraulic control was maintained at both performance well locations.
Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).	Yes
Shell Disposal Trenches Performance Criterion	
Demonstrate groundwater elevations are below the disposal trench bottom elevations within the slurry wall enclosure listed in the 2021 LTMP, Table 5.2-2.	Yes. Groundwater elevation is below the bottom of trenches at all borehole locations.
Lime Basins Slurry Wall Dewatering System Performance Criteria	
Maintain a positive gradient from the outside to the inside of the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	No. Outward gradient is present in wells on the north side of the slurry wall.
Maintain a groundwater level below the elevation of the Lime Basins waste (5242 feet) inside the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	Yes
Lime Basins DNAPL Remediation Monitoring Performance Criteria	
Primary Goals [3]	
To determine if additional DNAPL source zones exist in the Lime Basins area in addition to those previously identified.	Yes. No additional DNAPL source zones based on measured DNAPL in wells.
To determine if the extent and nature of any discovered DNAPL source zones have the potential to adversely impact the slurry wall.	Yes. No adverse impacts to the slurry wall due to the presence of DNAPL have been observed.
To characterize DNAPL, if present, for the purpose of correlation with groundwater characterization data as a tool in the identification of DNAPL source zones and for the purpose of waste disposal.	Yes. DNAPL continues to be characterized.

Table ES-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Off-Post Groundwater Intercept and Treatment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the FCS and the transect method for the NPS (OCN-LTMP-2012-002).	Not Applicable. Mass removal was not evaluated due to shut down and construction on both the FCS and NPS during the FY21 evaluation period.
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes.
Railyard Containment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Not Applicable. System has been shut off and annual shut-off monitoring is continuing. Five-year monitoring period ends in FY22.
Performance Criteria	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	Not Applicable. System has been shut off and annual shut-off monitoring is continuing. Five-year monitoring period ends in FY22.
Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.	

Notes:

[1] Criteria and goals are listed as presented in the LTMP and reflect any changes in accordance with OCNs as indicated. Primary criteria are provided unless otherwise noted. For systems without primary/secondary criteria, all criteria must be met.

[2] Only the NWBCS and NBCS are bound to secondary performance criteria, and only if primary performance criteria are not met.

[3] There are no performance criteria for the Lime Basins DNAPL Remediation Monitoring program, but goals are specified in the LTMP.

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1.0 INTRODUCTION

1.1 REPORT PURPOSE

This Fiscal Year 2021 (FY21) Annual Summary Report for Groundwater and Surface Water (ASR) includes an evaluation of the data collected and an evaluation of the compliance and performance criteria required for the operating systems; system-specific and site-wide groundwater and surface water hydrology; and any other supplemental monitoring conducted during FY21. In addition, the ASR includes data reporting for any site-wide monitoring conducted within FY21, project-specific monitoring, and any Consultative Process notifications (Table 1.1-1). The regulatory agencies are required to be notified of performance issues in accordance with the consultation triggers presented in the Consultative Process tables presented in Sections 4, 5 and 6 of the *Long-Term Monitoring Plan for Groundwater and Surface Water* (LTMP) (Navarro 2021b).

This report has been prepared to document and evaluate annual monitoring data collected at the Rocky Mountain Arsenal (RMA) for the period October 2020 through September 2021 for the following systems and programs:

- Northwest Boundary Containment System (NWBCS)
- North Boundary Containment System (NBCS)
- Basin A Neck System (BANS)
- Bedrock Ridge Extraction System (BRES)
- Complex Army Disposal Trenches (CADT)
- Shell Oil Company (Shell) Disposal Trenches
- Lime Basins Slurry Wall Dewatering System and Dense Non-Aqueous Phase Liquid (DNAPL) Remediation Project
- North Plants Light Non-Aqueous Phase Liquid (LNAPL) Pilot Removal Action
- Off-Post Groundwater Intercept and Treatment System (OGITS)
- First Creek Treatment System (FCTS)
- LTMP Off-Post Surface Water Monitoring
- Railyard Containment System (RYCS)
- Motor Pool System (MPS)/Irondale Containment System (ICS)

The current system-related monitoring categories, as presented in the LTMP, include the following:

- Compliance Monitoring
- Performance Monitoring
- Pre-Shut-Off Monitoring

- Shut-Off Monitoring
- Post-Shut-Off Monitoring
- Operational Monitoring

- The site-wide monitoring programs included in the ASR, as identified in the LTMP, include the following programs:, Water Level Tracking
- Water Quality Tracking
- Confined Flow System (CFS) Monitoring
- Exceedance Monitoring
- Off-Post Water Level Monitoring
- Surface Water Monitoring

Also included in this ASR are data summaries for all site-wide Long-Term Monitoring Programs during years when monitoring is conducted. In FY21, the site-wide programs where monitoring was conducted and included water level tracking and Tri-County Health Department (TCHD) off-post private well sampling. Long-term off-post surface water monitoring of three locations along First Creek was also conducted. Shut-off monitoring was conducted at the RYCS in the first quarter of FY21, and will continue annually for another year. Annual post-shut-off monitoring of the MPS/ICS was also conducted in FY21. All water level measurements and water quality analyses for FY21 are on the attached data CD.

1.2 MONITORING PROGRAMS OVERVIEW

The purpose of this report is to provide an integrated summary of monitoring for on-post and off-post treatment systems, post-closure sites, and the site-wide programs in FY21. This section presents an overview of each monitoring program with Sections 3 through 9 covering the results for FY21.

1.2.1 Treatment Systems Operations and Monitoring Overview

The selected groundwater remedies from the On-Post and Off-Post Record of Decision (ROD) include the continued operation of all groundwater intercept and treatment systems and on-post groundwater Interim Response Action (IRA) systems until shut-off criteria are met, and an extended monitoring program.

During the FY21 reporting period, the treatment systems were operated to maintain the concentrations of the CSRG analytes in the effluent below their respective regulatory requirements. Quarterly effluent samples were collected from the treatment plants and analyzed for CSRG analytes and other analytes using U.S. Department of the Army (Army) methods specified in the RMA *Sampling Quality Assurance Project Plan* (SQAPP) (Navarro 2019c). Treatment system compliance is based on moving averages for the last four quarters instead of single samples. Treatment system statistics and operational information are reported in the quarterly RMA *Treatment Plant Effluent Water Quality Data Reports* for the NWBCS, NBCS, BANS, and off-post treatment systems.

The CSRGs presented in the FY21 ASR are those identified in the On-Post ROD (Foster Wheeler 1996), the Off-Post ROD (HLA 1995), the Remediation Scope and Schedule (HLA 1996), and subsequent modifications. Results of sampling for CSRG analytes retained for quarterly monitoring, as described in the LTMP, are presented in this report along with results for those analytes required by the ROD that are monitored annually (Navarro 2021b).

The Practical Quantitation Limits (PQL) for data collected in FY21 for most of the CSRG analytes are those readily attainable from a certified commercial laboratory. The PQLs for aldrin, dieldrin, and n-nitrosodimethylamine (NDMA) were developed during a site-specific PQL study, which became effective in April 2012. The interim PQL for NDMA was updated during the first quarter FY17 (TtEC 2012; Navarro 2019c).

The system-specific "overview" tables list the CSRG analytes for each system with an indication of CSRG or PQL exceedances in wells designated for performance monitoring. Blank cells indicate that reported concentrations for the performance well samples were lower than the CSRG or PQL for the respective analyte. A shaded cell indicates that the water from that well was not sampled, not analyzed for that specific analyte in FY21, or the data were not usable.

Maps presented in Appendices A, B, C, and E include graphs depicting concentrations versus time for "select" analytes in wells in the vicinity of the NWBCS, NBCS, BANS, First Creek System (FCS) and Northern Pathway System (NPS). The analytes selected for these maps were detected at levels exceeding their respective CSRGs/PQLs in upgradient and/or downgradient performance wells during FY21, and were depicted over a 20-year time period to demonstrate visual concentration trends. In a few instances, analytes detected at levels less than CSRGs/PQLs have been presented on these maps as follow-up to recent years where performance goals were not met relative to ROD-based standards.

Selected CSRG-analyte concentrations in the treatment plants and in upgradient and downgradient performance monitoring wells are plotted on graphs for all systems in Appendices A, B, C and E. The graphs for the treatment plants are arranged so that the influent concentrations are plotted above the effluent concentrations, showing the amount of reduction in contaminant concentrations resulting from the treatment system. The graphs for the performance wells are arranged so that the upgradient well concentrations are plotted above the downgradient well concentrations and show the distribution of analyte concentrations along the line of upgradient and downgradient performance wells for each system. The four-quarter moving averages of all treatment plant effluent compliance samples collected during FY21 met the CSRGs or PQLs designated for each treatment plant.

System downtime, downtime attributable to equipment failures and maintenance, downtime attributable to power failure, the average annual flow rate, total treated volume, total mass of contaminants removed, major contaminants removed, carbon usage for all systems, and annual cost of operation for FY21 are presented for NWBCS, NBCS, BANS, and the off-post treatment systems in Sections 3 and 5.

In FY21, there were no modifications made to any of the on-post treatment systems other than normal operations and maintenance (O&M). As described in Section 5, modifications were

made to the First Creek and Northern Pathway systems, which included well field upgrades, the construction of two small-scale system-specific treatment plants, and shutdown of the OGITS plant.

1.2.2 On-Post Monitoring Overview

The data used to complete the FY21 ASR were collected under the LTMP (Navarro 2021b) and Sampling and Analysis Plans (SAP) issued as part of the O&M Plans for the respective extraction and treatment systems. The chemical analytes discussed in this report all have analyte-specific method reporting limits (MRL) established through a laboratory certification process described in the SQAPP (Navarro 2019c). The discussion of the monitoring results includes terms such as "not detected" or "non-detect," which means that the analyte in question was not detected at or above its MRL. Similarly, "detection" or "detected" refer to analyte concentrations at or above the MRL.

The long-term groundwater monitoring program described in the LTMP satisfies the requirements of the On-Post and Off-Post RODs (Foster Wheeler 1996; HLA 1995). The main objectives, as stated in the RODs, are to evaluate the effectiveness of the remedies, to satisfy Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requirements for waste left in place, and to provide data for the ASRs. The main component of the remedy that relates to groundwater is continued operation of the groundwater containment and treatment systems.

1.2.2.1 LTMP On-Post Monitoring

The LTMP defined six system-related monitoring categories that were developed to meet the On-Post ROD requirements for long-term groundwater monitoring and to support data evaluation. These categories were applied and are evaluated in this report:

- Compliance Monitoring – Quarterly monitoring of treatment system effluent water to confirm that CSRGs are met by on-post (and off-post) treatment systems. Compliance is based on running averages for the last four quarters.
- Performance Monitoring – Quarterly and annual water level and water quality monitoring performed to measure performance against specific criteria.
- Pre-Shut-Off Monitoring – Project- and system-specific monitoring or operational activities to confirm that shut-off should proceed and that the shut-off monitoring program should be initiated.
- Shut-Off Monitoring – Project- and system-specific water quality monitoring at containment systems that have met shut-off criteria defined by the RODs. Such monitoring is conducted for specified analytes for a period of five years to ensure that Applicable or Relevant and Appropriate Requirements (ARARs) continue to be met. This monitoring is to be conducted in accordance with a revised shut-off approach, with sampling frequencies reduced from the current quarterly sampling for five years to quarterly for the first and last years and annual in intervening years.

- Post-Shut-Off Monitoring – Project- and system-specific monitoring to track groundwater levels, flow directions, and water quality in the area after successful completion of the shut-off monitoring program and termination of system operation.
- Operational Monitoring – Annual monitoring of mass removal system and containment system extraction wells and monitoring wells located near the systems to optimize system performance and ensure that RAOs are met.

The site-wide monitoring program categories are as follows:

- Water Level Tracking – Annual on-post water level monitoring used to track the effects of the soil remedy to groundwater migrating within RMA.
- Water Quality Tracking – On-post water quality monitoring of indicator analytes to track contaminant migration in and downgradient of the source areas within the identified plumes. Sampling is conducted once or twice in five years.
- CFS Monitoring – Monitoring in response to the On-Post ROD requirement to monitor water quality in the confined aquifer in three areas— Basin A, South Plants, and Basin F. Sampling is conducted twice in five years.

1.2.2.2 On-Post Groundwater Treatment Systems Operational Monitoring

Groundwater Treatment System operational monitoring includes monitoring of system extraction wells, recharge wells, recharge trench piezometers, and/or monitoring wells associated with the system. Data are collected from wells upgradient of, and within the systems, to optimize system performance and ensure that RAOs are met. Most of the wells are used for water level monitoring to ensure proper extraction system operation; selected wells are also used for water quality monitoring of indicator compounds. These monitoring data are used to evaluate and adjust the system to ensure optimal operation for containment, capture, and treatment. Effective system operation depends on water level and water quality data and monitoring frequencies are determined based on operational data needs. Depending on the type of data and operational need, monitoring frequencies may be weekly, monthly, quarterly, semiannually, or annually. As operating conditions change, the operational monitoring program may also change. Accordingly, the operational monitoring program is flexible with respect to monitoring locations, frequencies, and chemical analyses. O&M Plans that address operations and monitoring are in place for each system and are updated as necessary. Operational monitoring data will continue to be evaluated and presented in the ASRs.

The operational monitoring program for existing groundwater containment and treatment systems at RMA is well established. This operational monitoring is conducted to provide the data necessary to ensure optimal performance for the extraction, treatment, and reinjection systems. The operational monitoring program includes water level data collection to determine the hydraulic gradients produced by the extraction system to achieve contaminant plume capture. In addition, influent and effluent samples are collected at various points in the treatment process to monitor treatment system performance. Water quality is also monitored in extraction wells and monitoring wells associated with the systems to optimize treatment system operation.

1.2.3 Off-Post Monitoring Overview

1.2.3.1 LTMP Off-Post Monitoring

The LTMP (Navarro 2021b) identified the following eight monitoring categories that meet the monitoring requirements identified in the Off-Post ROD:

- Compliance Monitoring – Quarterly monitoring of treatment system effluent water to confirm that CSRGs are met by off-post (and on-post) treatment systems. Compliance is based on running averages for the last four quarters.
- Pre-Shut-Off Monitoring – Project- and system-specific monitoring or operational activities to confirm that shut-off should proceed and that the shut-off monitoring program should be initiated.
- Shut-Off Monitoring – Project- and system-specific water quality monitoring at containment systems that have met shut-off criteria defined by the RODs. Such monitoring is conducted for specified analytes for a period of five years to ensure that ARARs continue to be met. This monitoring is to be conducted in accordance with a revised shut-off approach, with sampling frequencies reduced from the current quarterly sampling for five years to quarterly for the first and last years and annual in intervening years.
- Post-Shut-Off Monitoring – Project- and system-specific monitoring to track groundwater levels, flow directions, and water quality in the area after successful completion of the shut-off monitoring program and termination of system operation.
- Operational Monitoring – System-specific monitoring of containment system extraction wells, recharge wells, recharge trench piezometers, and monitoring wells located near the systems to optimize system performance and ensure that RAOs are met.
- Off-Post Water Level Monitoring – Annual water level monitoring conducted in support of the exceedance monitoring to assess flow paths and contaminant migration in the exceedance areas. (Separated from "Water Level Tracking" because it serves a different purpose.)
- Exceedance Monitoring – Long-term water quality monitoring conducted in compliance with the Off-Post ROD, to assess contaminant concentration reduction and remedy performance. These water quality data are also used to create groundwater CSRG exceedance area maps to support well permit institutional controls. The exceedance area maps are provided to the Office of the State Engineer, and to City of Commerce City, city of Brighton, and Adams County officials for their use in issuing notifications to well permit applicants and for controlling inappropriate use of off-post water with contaminant concentrations exceeding CSRGs. Sampling is conducted twice in five years.
- Surface Water Monitoring – Annual off-post surface water monitoring to assess changes in surface water quality related to the RMA remedy.

1.2.3.2 Off-Post Groundwater Treatment System Operational Monitoring

Similar to the on-post systems, operational monitoring conducted for the off-post treatment systems in FY21 consisted of monitoring system extraction wells, recharge wells, recharge trench piezometers, and monitoring wells associated with the OGITS (until shut-down in May 2021) and FCTS (after start-up in May 2021). Data are collected from monitoring wells upgradient of, and at the systems, to optimize system performance and ensure that RAOs are met. Most of the wells are used for water level monitoring to ensure proper extraction system operation; selected wells are also used for water quality monitoring of indicator compounds. These monitoring data are used to evaluate and adjust the system to ensure optimal operation for containment, capture, and treatment. . Depending on the type of data and operational need, monitoring frequencies may be weekly, monthly, quarterly, semiannually, or annually. As operating conditions change, the operational monitoring program may also change. The operational monitoring program, therefore, is flexible with respect to monitoring locations, frequencies, and chemical analyses. O&M Plans that address operation and monitoring are in place for each system and are updated as necessary.

1.2.3.3 Private Well Monitoring

In accordance with the 1997 Memorandum of Agreement between TCHD and the Army (PMRMA 1997), TCHD conducts sampling of private wells in the Off-Post operable unit (OU). Private well sampling is conducted to meet the following objectives:

- Provide data to assess contaminant concentration reduction and remedy performance
- Sample new wells installed in the off-post area as required by the Off-Post ROD (HLA 1995)
- Sample existing wells in response to citizen requests
- Sample a selected group of Arapahoe Formation CFS wells to assess well integrity and potential cross contamination from the overlying unconfined aquifer

The private well monitoring program is modified as new wells are installed and citizen requests are received. In accordance with the Off-Post ROD, owners of domestic wells with groundwater contaminants derived from RMA at concentrations at or above Colorado Basic Standard for Groundwater (CBSG) will be provided with an alternate water supply by the Army. In addition, wells that create a pathway for vertical migration of contaminants from the unconfined flow system (UFS) to the CFS will be closed if RMA-related contaminant concentrations in these wells exceed remediation goals. To verify the suitability of their water supplies for use, owners of wells within the DIMP plume footprint, as defined in the On-Post ROD (Foster Wheeler 1996), can request that their wells be included in the private well monitoring program that is conducted by TCHD with oversight from the Army. In addition, new wells installed in this area may be sampled to determine their water quality.

1.2.3.4 Off-Post Surface Water Monitoring

In accordance with the Off-Post ROD, off-post surface water monitoring is conducted to evaluate the effect of groundwater treatment on surface water quality. Generally, sampling is conducted

under low-flow conditions to provide more representative results. Conducting storm event monitoring at SW37001 was specifically identified in the *Off-Post Remediation Scope and Schedule for the Off-Post Operable Unit* (HLA 1996) to evaluate the effects of runoff and higher flows in First Creek. Since the on-post soil remedy was completed and all soil contamination was placed in landfills or is under soil covers, surface water contamination from runoff is no longer likely.

In order to continue to evaluate the effect of groundwater treatment on surface water quality in the Off-post OU, surface water quality monitoring continues at SW24004 (First Creek at the north fence line) and off-post site SW37001 (First Creek at Highway 2). An upstream sampling location (SW08003), where First Creek flows onto RMA, was added in FY13 to provide data to compare to the two downstream sites. Annual surface water quality samples are collected at these sites when there is low flow in First Creek, typically during the spring or summer. The target analyte list was expanded from arsenic and DIMP in FY13 to also include aldrin, chloride, dieldrin, NDMA, and sulfate. The requirements for sampling can be found in the LTMP, Section 6.3.

1.2.4 Site-Wide Monitoring Programs Overview

As presented in Sections 1.2.2 and 1.2.3, the following on-post and off-post site-wide monitoring programs are in place:

- Water Level Tracking
- Water Quality Tracking
- Confined Flow System Monitoring
- Exceedance Monitoring
- Off-Post Water Level Monitoring

Of these site-wide monitoring programs, only site-wide water level tracking took place in FY21, in accordance with the LTMP. Water levels were measured in the on-post water level tracking network and the off-post water level monitoring network in order to draw the FY21 site-wide potentiometric [water level] contour map (Figure F-1, Appendix F). Results of the water level tracking program are presented in Section 6.1.

The Annual Well Networks Update Summary is included in the ASR as required by the LTMP (Appendix J). The FY21 Annual Well Networks Update Summary includes information on newly installed wells, closed wells, damaged/repaired network wells, and updates to the Rocky Mountain Arsenal Environmental Database (RMAED).

1.2.5 Emerging Contaminants Monitoring Overview

Perfluoroalkyl and polyfluoroalkyl substances (PFAS), n-nitroso-di-n-propylamine (NDPA), and 1,4-dioxane have been classified as emerging contaminants by the U.S. Environmental Protection Agency (EPA). The Emerging Contaminants Monitoring Program included the collection of samples from the treatment plant influent/effluent locations, monitoring wells, and surface water locations (Navarro 2019d). Sampling was conducted in 21 wells from February

2017 through March 2018 for PFAS and NDPA analyses to characterize within and downgradient of potential source areas. Locations sampled for 1,4-dioxane included up to 228 wells and one surface water site as part of the emerging contaminants sampling network and their respective locations within the LTMP network (Navarro 2021b). The results of the Emerging Contaminants Monitoring Program were finalized and presented in the *Emerging Contaminants Data Summary Report* in January 2019 (Navarro 2019d).

Since the completion of the monitoring program in early 2019, the LTMP was revised under three operational change notices (OCN)—OCN-LTMP-2019-001, OCN-LTMP-2019-002, and OCN-LTMP-2020-002—to add 1,4-dioxane and NDPA to select on-post water quality tracking wells and off-post CSRG exceedance network wells to monitor plume concentrations and extent. In addition, the CBSGs for these emerging contaminants were added as CSRGs for the NBCS and NWBCS treatment plant influent and effluent, and water quality performance wells, to ensure that the boundary systems protect groundwater quality off post. The CBSG for NDPA was also added as CSRGs for the OGITS consistent with the system goal to provide beneficial impact on groundwater quality. Monitoring results for 1,4-dioxane and NDPA are provided in the fiscal year ASRs and quarterly treatment plant effluent water quality data reports. In this report, 1,4-dioxane and NDPA results are presented in Sections 3 through 7 for the relevant systems and monitoring programs. Monitoring for PFAS continues once every five years for groundwater and annually for treatment plant influent and effluent. PFAS monitoring results are provided in the fiscal year ASRs and quarterly treatment plant effluent water quality data reports. Section 9 of this report provides a summary of the results for PFAS monitoring conducted during FY21.

1.3 REPORT ORGANIZATION

This report serves as an annual assessment for FY21 that summarizes annual site-wide and treatment systems groundwater monitoring, project-specific monitoring, and surface-water monitoring and is organized as summarized below:

- **Introduction.** Section 1 presents the overall purpose of the ASR evaluations, a description of the sources of contamination and overviews of the treatment systems operations and the site-wide monitoring programs, as well as the organization of this report.

- **Data Quality Assurance.** Section 2 includes a summary of data quality assurance review process conducted for data collected during the fiscal year supporting the annual assessment of groundwater and surface water.

- **On-Post Extraction and Treatment Systems.** Section 3 provides an assessment of system performance for the major on-post extraction/treatment systems including the NWBCS, NBCS, BANS, and BRES.

- **Other On-Post Systems.** Section 4 presents an assessment of system performance for other on-post systems including the CADT, Shell Disposal Trenches, Lime Basins Slurry Wall Dewatering System and DNAPL Remediation Project, and the North Plants LNAPL Removal Action.

- **Off-Post Extraction and Treatment Systems.** Section 5 provides an assessment of off-post system performance for the OGITS, including the First Creek and Northern Pathway Systems.

- **Site Wide On-Post Monitoring.** Section 6 presents the results of on-post monitoring programs including water level and water quality tracking, and CFS monitoring.

- **Site Wide Off-Post Monitoring.** Section 7 presents the results for off-post monitoring programs including water level tracking, off-post surface water quality, and off-post private well monitoring administered by TCHD.

- **Post-Shut-Off and Shut-Off Monitoring.** Section 8 presents the results of post-shut-off monitoring for the MPS/ICS and shut-off monitoring for the RYCS.

- **Perfluorinated Compounds.** Section 9 provides an overview of the PFAS monitoring program conducted during FY21.

- **Summary and Conclusions.** Section 10 summarizes the results, conclusions, and recommendations relative to meeting the performance criteria and goals identified in the LTMP and other relevant monitoring plans.

- **References.** Section 11 lists the references used in the preparation of this report.

This report was prepared by Ms. Carol Rieger, Mr. Wade Thornburg, and Ms. Nicole Luke from Navarro Research and Engineering, Inc. (Navarro). Project management was provided by Mr. Tony LaChance and Mr. Scott Ache of Navarro. Navarro acknowledges the support and assistance of Ms. Shannon Gilbert, Mr. Michael Guthrie, and Ms. Kelli Schneider of the Rocky Mountain Arsenal Records Management and Information Technology Support contractor.

2.0 DATA QUALITY ASSURANCE

The data evaluated in this report were collected in accordance with the LTMP (Navarro 2021b), the RMA SQAPP (Navarro 2019c), and the following SAPs:

- MPS/ICS Post-Shut-Off Monitoring SAP
- LTMP Surface Water Monitoring SAP
- RYCS Shut-Off Monitoring SAP

Data review was limited to the respective CSRGs or LTMP analytes for each system or monitoring category. Monitoring program- and treatment system-specific data summary reports were not prepared as separate deliverables in FY21 but are included as narratives in this ASR.

The purpose of the data review is to evaluate data quality with respect to the established Data Quality Objectives (DQO). Components of the data review process include evaluating the data against the data quality indicators of precision, accuracy/bias, representativeness, sensitivity, completeness, and comparability; review of field and laboratory quality control (QC) results; and evaluating the data for suitability based on the intended use. Data were reviewed according to the procedures specified in the SQAPP. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. The data review parameters and results are discussed below.

2.1 PRECISION

Results of laboratory and field duplicates were used to calculate precision. Note that laboratory duplicates are prepared by the laboratory and analyzed for inorganics only. Relative Percent Difference (RPD) values will be calculated for LTMP analytes. If one or both results are rejected or not analyzed, the RPD will not be calculated. The formula for calculating the RPD is:

$$RPD(\%) = \left(\frac{Difference\ between\ concentrations}{Average\ of\ concentrations}\right) \times 100$$

Where:

$$Difference\ between\ concentrations = Investigative\ value - Duplicate\ value$$

$$Average\ of\ concentrations = \frac{Investigative\ value + Duplicate\ value}{2}$$

The default RPD evaluation limit for analytes without detections above the MRL will be less than or equal to 30 percent. The performance criteria for analytes with detections above the MRL will be calculated from historical RPD values for each program-specific LTMP analyte. The data utilized for the historical RPD value calculations will be limited to data values from historical analytical methods with similar MRLs. The analytical data utilized to calculate limits for individual analytes is included on the attached data CD.

For each site ID/LTMP analyte, the 25th and 75th percentile RPD values are calculated. The interquartile range (IQR) for each analyte is calculated by subtracting the 25th percentile value from the 75th percentile value. The acceptance, or upper, RPD limit is determined by adding 1.5 times the IQR to the 75th percentile value. The RPD evaluation limits are included on the attached data CD.

The investigative and duplicate results will be considered comparable if any of the following statements are true:

- If both sample results are less than the MRL
- If both sample results are greater than the MRL, but less than or equal to twice the MRL
- If both sample results are greater than twice the MRL and the RPD is less than or equal to the specified upper RPD limit
- If both sample results are greater than the MRL, one result is less than or equal to twice the MRL, one result is greater than twice the MRL, and the RPD is less than or equal to the specified upper limit
- If one sample result is less than the MRL, and one result is greater than the MRL and less than or equal to twice the MRL

The investigative and duplicate results will be considered not comparable if any of the following statements are true:

- If both sample results are greater than twice the MRL and the RPD is greater than the specified upper RPD limit
- If both sample results are greater than the MRL, one result is less than or equal to twice the MRL, one result is greater than twice the MRL, and the RPD is greater than the specified upper limit
- If one sample result is less than the MRL, and one result is greater than twice the MRL

Duplicate samples determined to be not comparable will be subject to data qualification. The non-comparable investigative and duplicate data will be assigned a "Z" data qualifier with the comment "Duplicate and investigative values are not comparable." The data are considered acceptable for their intended use and no additional action in addition to the data qualification is considered necessary.

A total of 648 field and laboratory duplicate analyses were performed. The data review identified 10 analyses as non-comparable. The non-comparable data were qualified with a "Z" data qualifier with the comment "Duplicate and investigative values are not comparable." Precision data are included on the attached data CD.

2.2 ACCURACY/BIAS

Accuracy is the degree of agreement between an observed value (sample result) and an accepted reference value. Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction (high or low). The terms accuracy and bias are used

interchangeably. Accuracy/bias is indicated by percent recovery calculated from laboratory spike data using the following formula:

$$Recovery\ Rate\ (\%) = (Measured\ value)/(True\ value) \times 100$$

Where:

Measured value = Value after the spike minus the value before the spike
True value = Value of the spike added

Accuracy/bias will be determined based on the percent recovery results of laboratory control spikes (LCS) and matrix spikes (MS). Laboratory control spikes utilize laboratory grade water with some additions of inorganic constituents to mimic water native to RMA. Matrix spikes utilize water native to RMA to account for matrix-related interferences.

The calculated recovery rates are compared to the lower and upper recovery rate limits specific to each analyte. Evaluation limits are calculated for each LTMP analyte by monitoring program to account for matrix interference differences. A single set of limits is calculated for LCS recoveries as matrix interferences will not be present in LCS samples. The recovery rate limits are determined by calculating the 25th and 75th percentiles for each analyte using historical recovery rates. The IQR is calculated by subtracting the 25th percentile value from the 75th percentile value. The lower and upper recovery limits are determined by subtracting and adding 1.5 times the IQR to the 25th and 75th percentile value, respectively. Data will not be qualified solely on an individual recovery rate outside the calculated recovery limits. If an analysis is outside both the MS and LCS recovery limits, the analysis will be assigned a "Z" data qualifier with the comment "MS and LCS recoveries were outside evaluation limits". The MS and LCS recovery data, calculations, and evaluation limits are listed on the attached data CD.

The data utilized for the historical recovery rate calculations were limited to the spike values for the analytical lots of the associated investigative data. Spike recoveries were calculated for all LTMP analytes. Specific monitoring programs were assigned to required site IDs and analytes. Recoveries for LTMP analytes not required for specific locations are also included with the sampling program unspecified. Matrix spike values exceeding four times the spiked amount are excluded from the calculation since the MS could possibly be diluted out due to the high original concentration. Analyses with an "@" flag code (value is estimated) or "B" flag code (analyte found in the method blank or QC blank as well as the sample) were also excluded from recovery rate calculations. The historical spike recoveries used in the calculations are included on the attached data CD.

For FY21, the average recovery rate for the 2,449 MS and LCS analyses was 91.4 and 95.2 percent, respectively. Upper and lower recovery rate limits are calculated for each analyte from historical recovery rates. Recovery rates outside the lower or upper limits were observed in 54 MS analyses and 22 LCS analyses. Recovery rates outside the limits for both MS and LCS were observed in two analyses and will be qualified with a "Z" data qualifier.

Analyst comments in the data packages note that Lot AJRQ had a high recovery for tetrachlorometaxylene (CL4XYL) and no re-analysis was necessary. No technical problems were reported for Lot AJOI.

All data are considered acceptable for their intended use and no additional action in addition to the data qualification is considered necessary. The MS and LCS results outside the evaluation limits are included on the attached data CD.

The Performance Evaluation (PE) program was conducted as specified in the SQAPP. The PE program is used to evaluate the ability of the laboratory to analyze environmental samples and provide required deliverables accurately and completely. The PE samples were submitted in June and September 2021. The PE program evaluated the following methods: volatile organic compounds (VOC), DIMP, organochlorine pesticides (OCP), NDMA, NDPA, nitrogen phosphorus pesticides, and 1,4-dioxane. The PE program reports and spreadsheets are included on the attached data CD in the Performance Evaluation folder. The PE program indicated the data are acceptable for their intended use.

2.3 REPRESENTATIVENESS

Representativeness is a qualitative term achieved by evaluating whether measurements were made, and samples were collected in a manner that the resulting data appropriately reflects the sampling unit. The performance criterion is a positive evaluation of representativeness. A review of field and laboratory documentation determined that samples were collected and analyzed as specified for each system or category. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the RMA treatment systems. The representativeness criterion was met for FY21.

2.4 COMPLETENESS

Completeness is the measure of the amount of valid data obtained from a measurement system; it is expressed as a percentage of the number of valid measurements compared to the total number of measurements planned in the DQOs. Completeness is calculated using the following formula:

$$Completeness\ (\%) = \frac{Amount\ of\ valid\ data}{Amount\ of\ valid\ data\ expected} \times 100$$

Completeness calculations of greater than or equal to 90 percent are acceptable. Completeness was calculated at 100 percent for FY21, so the completeness criterion was met.

2.5 COMPARABILITY

Comparability is a qualitative term achieved by using standard techniques to collect and analyze representative samples and reporting data in appropriate units. Standard techniques as identified in the SQAPP (Navarro 2019c) were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

2.6 SENSITIVITY

Sensitivity is the ability of the method or instrument to detect the target analytes at the level of interest. The performance criterion for sensitivity is no analyte detections above the MRL in the laboratory method blank. Analytical lots with method blank detections of target analytes exceeding the MRL may be qualified.

Method blank samples are analyzed for each analytical lot. A total of 2,692 method blanks consisting of laboratory water were analyzed for LTMP analytes. There were two method blank detections above the MRL for NDMA. There are seven investigative analyses in the lots with method blank detections. The NDMA investigative data above the MRL are qualified with a "B" flag code. Data qualification is not required for the investigative values that are below the MRL. Sensitivity is considered acceptable. Method blank data are included on the attached data CD.

2.7 FIELD AND QUALITY CONTROL SAMPLES

Field QC samples collected include field blanks, rinse blanks, and duplicate samples. Duplicate sample results are discussed in Section H1, Appendix H. Laboratory QC samples include lab duplicates and method blanks in addition to the MS and LCS samples previously discussed. The FY21 field blank, rinse blank, and method blank data are included on the attached data CD.

QC samples with values exceeding the MRL are evaluated according to the following criteria:

- If the associated investigative sample value is less than the MRL, then no action is required
- If the associated investigative sample value is greater than the blank value, then no action is required
- If the associated investigative sample value is less than the blank value, then validation of the analytical lot is requested

Field blanks are collected to determine if cross-contamination exists from ambient sources, such as engine exhaust or dust. In certain instances, field blanks may also be used as an indicator of contamination in the sample containers, or the deionized water used to decontaminate sample equipment and collect field QC samples. A total of 247 field blank analyses were performed with no analyses above the MRL.

Rinse blanks were collected to determine if the sampling equipment decontamination procedures are effective, thus preventing cross-contamination of samples and/or wells. A total of 378 rinse blank analyses were performed with 7 results above the MRL. No qualification of the data is required for the analysis as the rinse blank values are less than the investigative sample values in all seven cases.

2.8 DATA USABILITY EVALUATION

The data usability determination evaluates data quality with respect to the established data quality objectives. Components of the data review process include 1) evaluating the data against the data quality indicators of precision, accuracy/bias, representativeness, completeness,

comparability, and sensitivity; 2) review of field and laboratory QC results; 3) data verification and validation results; and 4) evaluating the data for suitability based on the intended use. Data were evaluated as specified in the RMA SQAPP (Navarro 2019c).

Data verification was performed by the RMA Data Management Contractor as described in the SQAPP. Data verification was performed on all data prior to final submittal to the RMAED. Issues identified by the data verification process are addressed prior to the final submittal of the data into the RMAED. The data verification results are included on the attached data CD in the Verification Validation Summary subfolder.

Data validation was performed on selected lots by the Operations and Maintenance Contractor (OMC) Chemist. Validation was performed as specified in the SQAPP. Issues identified during the data validation process are noted on the attached data CD in the Data and Quality Assurance folder within the Data Verification subfolder.

The suitability evaluation was conducted for only the CSRG or LTMP analytes specific to the sample location. In addition to the components specified above, the data were evaluated for potential outliers and trends. Data were evaluated using the U.S. Environmental Protection Agency software ProUCL, Version 5.1.001, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations (May 2016). The specifications for the data review include:

- Preparation of a box plot of the current data in addition to historical data with the same or similar MRLs
- Conduct an outlier test to evaluate the data for potential outliers using the Dixon (fewer than 25 values) or the Rosner (greater than or equal to 25 values) tests. The use of either outlier test assumes that the data are normally or lognormally distributed.
- Conduct the Mann-Kendall test to evaluate the data for trends
- Identify compliance samples exceeding the CSRG

A data usability evaluation was conducted on 3,128 records. An evaluation was not performed on treatment plant process control samples because these data are closely tracked throughout the fiscal year. The individual data usability spreadsheets by monitoring program are included on the attached data CD in the Data Usability subfolder.

The data usability evaluation identified nine analyses as statistical outliers. A listing of the results identified as outliers is included on the attached data CD in the Data Usability subfolder.

The Mann-Kendall test for trends identified 297 decreasing trends and 111 increasing trends for analytes at specific well locations. No data quality issues were found with the identified trends. A listing of the identified trends is included on the attached data CD in the Data Usability folder.

The data usability evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established DQOs. The data are of the correct type, quality, and quantity to support the intended use.

3.0 ON-POST GROUNDWATER EXTRACTION AND TREATMENT SYSTEMS

Performance monitoring is conducted in wells upgradient and downgradient of the containment and mass removal systems to evaluate system performance against established performance criteria and objectives. The performance criteria are specific to each system and depend on the location of the system and whether it is a containment or mass removal system. Depending on the criteria, performance monitoring includes water quality monitoring for all systems and in most cases water level monitoring. In some cases, operational wells are included in the performance monitoring networks as well, thereby serving a dual purpose.

Operational water level and/or water quality monitoring is conducted in extraction, recharge, and monitoring wells located near the containment or mass removal systems. Operational water quality monitoring is also conducted for the system influent and at sampling points within the system. Operational monitoring is conducted to:

- Evaluate and optimize system performance, and
- Ensure that RAOs are achieved.

Most of the operational wells are used for water level monitoring to ensure optimal extraction and recharge system operation; and selected wells are also used for water quality monitoring of indicator analytes. These monitoring data are used to evaluate and adjust the system to optimize operations for containment, capture, and treatment. As operating conditions change, the operational monitoring program may also change. Therefore, the operational monitoring program is flexible with respect to monitoring locations, frequencies, and chemical analyses, and is modified independently from the LTMP.

3.1 NORTHWEST BOUNDARY CONTAINMENT SYSTEM

The NWBCS treatment facility consists of a groundwater extraction system, monitoring wells, pre-treatment filtration, carbon adsorption, post-treatment filtration and a groundwater recharge system. A soil-bentonite barrier was installed as part of the system to help contain contaminant migration. The NWBCS is designed to intercept contaminated groundwater from the upgradient side of the soil-bentonite barrier, treat it to remove the organic contaminants, and inject the treated water back into the alluvial aquifer on the downgradient side of the barrier. The Original System, installed in 1984, consists of 15 extraction wells, 21 recharge wells, and a slurry wall that is 1,425 feet long, which extends across a portion of the system. The recharge wells are located northwest (downgradient) of the extraction wells and slurry wall. The objective of the system is to create hydraulic control to contain the contaminant plumes. Dieldrin and NDPA were the only contaminants above the CSRG in influent samples for the NWBCS system.

Modifications to the NWBCS include the addition of the Northeast Extension (NEE) constructed in 1990 to intercept flow through a small alluvial channel north of the Original System, and the Southwest Extension (SWE) extraction and recharge system in 1991 to extract groundwater from the dieldrin plume originating in Section 2 on the RMA.

The NEE consists of a 660-ft extension of the Original System slurry wall and two additional extraction wells that were installed to intercept a small northwest-trending alluvial channel. The flow downgradient of the slurry wall is ultimately towards the Original System recharge wells. Maintaining a reverse hydraulic gradient, therefore, is not required for this portion of the NWBCS. Dieldrin is the primary contaminant at the NEE.

The SWE was installed in 1991 and consists of four additional extraction wells and four additional recharge wells located southwest of the Original System. No slurry wall was installed in this area. The recharge wells were installed in an uncontaminated zone between the SWE and Original System, cross-gradient of the extraction wells, to prevent the SWE and Original System plumes from shifting away from their respective extraction systems. Consequently, the SWE has a hydraulic capture system design. Historically, dieldrin has been the primary contaminant at the SWE. Between 2004 and 2012, dieldrin concentrations were below the PQL of 0.05 micrograms per liter (µg/L) in all four extraction wells and the associated upgradient and downgradient monitoring wells. The PQL was lowered to 0.013 µg/L in 2012, and the dieldrin concentrations have exceeded the PQL in some of the upgradient wells, as recently as FY19, although dieldrin concentrations in SWE wells did not exceed the PQL in FY21.

FY21 treatment system performance data for the NWBCS are provided in Table 3.1-1. The results of CSRG-analyte sampling in NWBCS performance wells in FY21 are presented in Table 3.1-2. Appendix A provides figures to illustrate the performance of the NWBCS during FY21. Groundwater monitoring and water level data are provided on the attached data CD.

3.1.1 NWBCS Operations and Compliance

The NWBCS operated at an average flow rate of 821 gallons per minute (gpm), pumping a total volume of 436,765,692 gallons during FY21 and removing a total of 5.82 pounds of contaminant mass. The major contaminants removed via treatment included chloroform, dieldrin, endrin ketone, methoxychlor, and NDPA. Carbon usage has decreased over the past six years due to the reduction in contaminant mass treated by the system (Navarro 2020b). The total cost to operate the treatment plant in FY21 was $640,161 (Table 3.1-1).

Figure A-1 in Appendix A shows the NWBCS extraction and recharge wells, slurry walls, and associated monitoring wells.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The system effluent for the NWBCS was analyzed quarterly in FY21 using the LTMP routine CSRG-analyte list for the NWBCS and annually using the complete ROD CSRG list.

As presented in Table 3 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY21,* the NWBCS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY21 (Navarro 2022b, 2021a, 2021c, 2021d).

The treatment plant influent and effluent concentrations for analytes with concentrations that exceeded CSRGs in treatment plant influent, including dieldrin and NDPA, are shown in Figures

A-2 and A-3 (Appendix A). Historically, dieldrin has occasionally exceeded its PQL in plant effluent. The graphs indicate that treatment plant influent concentrations of dieldrin and NDPA exceeded CSRG/PQL, while concentrations of both analytes in plant effluent did not exceed CSRGs/PQLs in FY21.

In FY21, the NWBCS demonstrated system effectiveness for analytes addressed by treatment technologies, showing a decrease in concentrations exceeding CSRGs/PQLs in treatment plant influent compared to concentrations less than CSRGs/PQLs in the treatment plant effluent(Figures A-4 through A-9).

3.1.2 NWBCS Performance Evaluation

The performance criteria for the NWBCS are designed to address future monitoring needs and facilitate the system performance evaluation. Criteria presented in the LTMP address the Original System of the NWBCS. The primary performance criteria for the NWBCS are presented below:

- Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.
- Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

A secondary performance criterion was established to address system performance in the event that a reverse hydraulic gradient could not be maintained, which provides assurance that downgradient water quality is not being adversely impacted:

- If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least five years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

The SWE and NEE were designed to capture groundwater that was not being captured by the Original System. Performance criteria established for each of these two system extensions are presented below and both criteria must be met:

- Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.
- Demonstrate decreasing concentration trends, or that concentrations are at or below CSRGs/PQLs, in downgradient performance wells.

Figures A-10 and A-11 in Appendix A show that the reverse hydraulic gradient was maintained across the system for all quarters in FY21. Plume-edge capture at the NWBCS Original System can be verified in the overview of sample results for cross-gradient well 27010 in Table 3.1-2. The concentrations of CSRG analytes in plume-edge monitoring well 27010 were below the CSRGs/PQLs for all of FY21.

Flow rates in the NWBCS dewatering and recharge wells were adjusted and have successfully improved the plume-edge capture for the Original System. The potentiometric surface map for FY21 in Figure A-12 shows groundwater flow upgradient of south end of the Original System is captured by the system.

Plume capture at the NEE is demonstrated by the southwesterly gradients shown on Figure A-12. To support system optimization, downgradient performance well water quality is monitored regularly. Dieldrin was detected above the PQL in downgradient performance wells 22015 and 22512 (Table 3.1-2). These data are consistent with data from previous years. Since FY12, the dieldrin concentrations in wells 22015 and 22512 have not shown increasing trends. Although the trends are not increasing, the prolonged detection of dieldrin contamination in these wells has prompted additional evaluation to determine probable causes.

Historically, a small amount of contaminated flow from the NEE area migrates on the downgradient side of and parallel to the slurry wall where it is extracted by well 22309. Flow in the recharge wells creates a hydraulic barrier to off-post migration of this contaminated flow. However, in FY15, several analytes in addition to dieldrin were detected in well 37333 that are similar to those detected in NEE well 22508, located downgradient of the slurry wall. This suggests that a migration pathway from well 22508 to downgradient performance well 37333 may exist. In FY21, except for well 37333, the dieldrin concentrations in the Original NWBCS downgradient performance wells were below the PQL. Mann-Kendall trend analyses were completed for downgradient well 37333 as part of the data quality assurance review. The Mann-Kendall trend analyses indicate that dieldrin concentrations are probably decreasing in this well. Concentrations above the PQL in well 37333 might be related to the NEE plume capture issue described above.

As presented in FY21, the presence of groundwater in well 22085 indicates that bypass may be occurring north of the slurry wall during periods where the water table rises enough to produce uninterrupted flow. The low volume of water within the apparent dip in the bedrock surface in the vicinity of well 22085 may not support extraction wells in this area to capture flow. In addition, the lack of groundwater at the north end of the slurry wall, predicated on continued decreasing water levels since FY21, indicates that persistent bypass at this location is unlikely. As recommended, water quality sampling was addressed in an OCN to the LTMP (OCN-LTMP-2021-001) requiring semiannual sampling of well 22085 if sufficient water is present in the well 22085. In March and July 2021, sampling for OCPs was conducted with results indicating that dieldrin and isodrin concentrations exceeded CSRGs/PQLs. Semiannual sampling will continue through FY23, with an evaluation report to follow.

Plume capture at the SWE is demonstrated by the water elevation contours and flow directions indicated on Figure A-12. No analytes exceeded CSRGs/PQLs in performance wells at the SWE in FY21. Dieldrin concentrations have decreased in the upgradient performance well 27517 (Table 3.1-2 and Figure A-7). While the dieldrin concentration exceeded the PQL in downgradient well 27522 in FY18, concentrations have been decreasing and dieldrin was not detected in this well in FY21. Dieldrin concentrations in SWE cross-gradient wells 27516 and 28521 were also below the PQL in FY21.

Although primary performance criteria were met in FY21 for the NWBCS, evaluation of the system is ongoing relative to the secondary performance criterion. In the event that downgradient performance wells show analytes that are above CSRGs/PQLs, concentration trends are evaluated. Concentrations trends are determined by visual inspection of time versus concentration plots and supported by the use of Mann-Kendall statistical analysis as part of the data quality assurance review as options presented in the LTMP.

For the Original System, the concentration trend is determined over the previous period of at least five years. For dieldrin, Figure A-7 indicates that Original System downgradient performance well 37333 and NEE downgradient performance wells 22015 and 27522 were above the PQL. As demonstrated in Figure A-13, which shows concentration trends versus time in NWBCS wells, dieldrin is present at levels exceeding the PQL in upgradient and downgradient wells, but it is not increasing downgradient of the system.

Isodrin exceeded the PQL in NEE well 22508, but concentrations indicate a stable trend since 2009. For chloroform, Table 3.1-2 shows all downgradient performance wells either below detection limits or below the CSRG. Arsenic, isodrin and NDPA were also detected at levels exceeding CSRGs/PQLs in upgradient wells in FY21, but were not detected or detected at concentrations less than CSRGs/PQLs in downgradient wells (Figures A-5, A-8, and A-9, respectively).

3.1.3 NWBCS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the NWBCS in FY21 is provided in Appendix H1.1.

3.1.4 NWBCS Conclusions and Recommendations

In FY21, the NWBCS met the compliance and performance criteria and objectives established in the LTMP. There were no CSRG-analyte exceedances in either the four-quarter moving averages or in annual ROD water quality samples in the NWBCS treatment system effluent in FY21. The reverse gradient was maintained throughout the year, which is consistent with results in previous reporting periods.

During FY21, the average flow rate was 821 gpm and the total mass removed was 5.82 pounds. The contaminants that were above the CSRG in influent samples were dieldrin and NDPA, both of which were successfully treated by the treatment system. Dieldrin was detected above the PQL in Original System downgradient performance well 37333 and NEE downgradient performance wells 22015 and 22512, however, the long-term trend is not increasing in downgradient performance wells. The dieldrin concentrations were likely above the PQL in these NWBCS downgradient performance wells during the past few years because: 1) mobilization of residual dieldrin in the aquifer sediments downgradient of the slurry wall; 2) dieldrin concentrations previously have been near or above the current PQL in the NWBCS effluent; or 3) possible bypass from the NEE area. The potential for contaminated flow toward the downgradient performance wells will be further evaluated as a result of semiannual monitoring through FY23.

3.2 NORTH BOUNDARY CONTAINMENT SYSTEM

The NBCS treatment facility consists of a groundwater extraction system, monitoring wells, pre-filtration, carbon adsorption, post-filtration, ultraviolet (UV) oxidation, soil-bentonite slurry wall, and a groundwater recharge system. The NBCS was designed to intercept contaminated groundwater from the upgradient side of the soil-bentonite barrier, treat it to remove the organic contaminants, and inject the treated water back into the alluvial aquifer on the downgradient side of the barrier. The treatment facility was originally designed as a pulse bed granular activated carbon adsorption system; however, modifications to the treatment plant in May 1995 converted the plant to a down flow carbon adsorption system.

Additional modifications to the NBCS include the addition of UV oxidation treatment in the fall of 1997 to treat NDMA, and the addition of the South Channel well system in the fall of 2002 to extract groundwater upgradient of the NBCS to optimize NBCS operations.

The treatment system is designed to remove organic contaminants known to be present in the extracted groundwater to levels at or below the CSRGs established in the final ROD for the NBCS.

Treatment system information for the NBCS is provided for FY21 in Table 3.2-1. The results of CSRG-analyte sampling in FY21 are presented in Table 3.2-2, and in maps within Appendix B. Groundwater monitoring and water level data are provided in Excel files on the attached data CD.

3.2.1 NBCS Operations and Compliance

The NBCS operated at an average flow rate of 240 gpm and pumped a total volume of 126,561,900 gallons during FY21 and removed a total of 12.11 pounds of contaminant mass. The major contaminants removed via treatment included DCPD, DIMP, CPMSO2, carbon tetrachloride, trichloroethylene, tetrachloroethylene, chloroform, dieldrin, methoxychlor, 1,4-dioxane, and NDPA (Table 3.2-1). Carbon usage has decreased over the past six years due to the reduction in contaminant mass treated by the system (Navarro 2020b). The total cost to operate the treatment plant in FY21 was $476,568 (Table 3.2-1).

Figure B-1 in Appendix B shows the locations of NBCS monitoring wells, extraction and recharge wells, the slurry wall, and the South Channel extraction wells.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The system effluent for the NBCS was analyzed quarterly in FY21 using the LTMP CSRG-analyte list for the NBCS and annually using the complete ROD CSRG list.

As presented in Table 2 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY21*, the NBCS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY21, with the exception of 1,4-dioxane(Navarro 2022b, 2021a, 2021c, 2021d).

The treatment plant influent and effluent concentrations for 1,4-dioxane, carbon tetrachloride, chloride, dieldrin, NDMA, and NDPA, are shown in Figures B-2 through B-7, respectively (Appendix B). Only 1,4-dioxane exceeded CSRGs in the plant effluent (during the second and third quarters of FY21), although the moving average did not exceed the standard. The NBCS does not treat for 1,4-dioxane. The graphs indicate that carbon tetrachloride, chloride, dieldrin, NDMA, and NDPA exceeded CSRGs/PQLs in treatment plant influent concentrations, while concentrations in plant effluent did not exceed CSRGs/PQLs in FY21

In FY21, the NBCS demonstrated system effectiveness for analytes addressed by treatment technologies, showing a decrease in concentrations exceeding CSRGs/PQLs in treatment plant influent compared to concentrations less than CSRGs/PQLs in the treatment plant effluent (Figures B-2 through B-7).

3.2.2 NBCS Performance Evaluation

The performance criteria for the NBCS are designed to address future monitoring needs and facilitate the system performance evaluation. The primary performance criteria for the NBCS are presented below:

- Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.
- Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

A secondary performance criterion was established to address system performance in the event that a reverse hydraulic gradient could not be maintained, which provides assurance that downgradient water quality is not being adversely impacted:

- If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show

decreasing concentration trends, based on annual evaluations, over the previous period of at least five years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

The primary performance requirement for the NBCS is to maintain a reverse hydraulic gradient across the system in the alluvium and to ensure plume-edge capture. Figures B-22 and B-23 in Appendix B show that the reverse hydraulic gradient was maintained across the system during all four quarters of FY21. Plume-edge capture at the NBCS can be verified by inspection of the water-table map in Figure B-26. Water-table contours indicate that groundwater flow is being captured at the edges of the system. Since both primary performance criteria were met, the NBCS functioned as intended during FY21.

Although primary performance criteria were met in FY21 for the NBCS, evaluation supporting system optimization is ongoing relative to the secondary performance criterion. In the event that downgradient performance wells show analytes that are above CSRGs/PQLs, concentration trends are evaluated. Concentration trends are determined by visual inspection of time versus concentration plots and supported by the use of Mann-Kendall statistical analysis of the data completed as part of the data quality assurance review.

The distribution of contaminants in performance wells upgradient and downgradient of the NBCS is shown for 12DCLE, 1,4-dioxane, arsenic, carbon tetrachloride, chloride, DCPD, dieldrin, DIMP, fluoride, NDMA, NDPA, sulfate, and trichloroethylene in Figures B-8 through B-21 in Appendix B. Table 3.2-2 shows downgradient performance wells are either below detection limits or below the CSRG/PQL for most of the CSRG analytes. The only organic analytes detected above CSRGs/PQLs were dieldrin in 11 wells, 1,4-dioxane in 5 wells, and DIMP in 1 well; while arsenic (in 1 well) and anions chloride, fluoride, and sulfate were also detected above CSRGs/PQLs.

As presented in Table 3.2-2, dieldrin concentrations were above the PQL in 8 of the 11 downgradient performance wells (wells 23405, 23434, 23438, 24004, 24415, 24418, 24421, and 24424). Five alternate wells being considered for future monitoring in place of existing wells were also sampled for dieldrin. Three of those wells had levels of dieldrin greater than the PQL (wells 24163, 24164, and 24429). Trends in alternate wells could not be established since they were not sampled between 1999 and 2019. Alternate well 24429 was sampled for the first time in 2019, as it was originally installed as a recharge well for the system—and along with all other NBCS recharge wells was replaced by recharge trenches. Due to its affinity for soil, the presence of dieldrin in groundwater is attributed to the mobilization of residual soil contamination as the water table fluctuates.

Dieldrin concentrations in 8 of the 11 downgradient performance wells show stable to decreasing trends using visual inspection and statistical trend analyses. Because no visual trend could be determined for well 23434, 23436, and 24421, Mann-Kendall tests for trends were performed. Mann-Kendall test results indicate no trends are discernible for wells 23434, 23436, and 24421 through FY21. The dieldrin concentrations present above the PQL in the downgradient wells are likely due to its lower solubility and more sorptive nature. Fluctuations in groundwater levels downgradient of the NBCS slurry wall caused by variations in the recharge trench flow rates and

variable recharge from First Creek likely causes desorption of dieldrin from the aquifer sediments.

Regarding anions, wells 23434, 23436, 24415, 24418, and 24424—as well as alternate wells 24163, 24164, and 24429—had concentrations of chloride, fluoride, and/or sulfate greater than CSRGs. Although not treated at the NBCS, sulfate in plant effluent has been consistently below the CSRG and further evaluation will take place in FY22 related to meeting the attenuation goal set forth in the ROD. Concentrations of chloride in groundwater are also eventually expected to meet the CSRG via natural attenuation processes.

Concentration versus time trend in NBCS wells for analytes with concentrations that exceeded CSRGs/PQLs in downgradient performance wells are presented in Figures B-27 through B-34. In these figures, dieldrin, chloride, fluoride, and sulfate are present in groundwater at levels greater than CSRGs/PQLs, but are generally not increasing in concentration downgradient of the system. As discussed in previous ASRs, the downgradient detections of organic contaminants are most likely caused by residual contamination and are not representative of system effectiveness. The anion concentrations seem consistent with typical natural conditions; however, additional evaluation is necessary to assess chloride and sulfate attenuation in groundwater towards meeting remediation goals.

3.2.3 NBCS Alternate Well Evaluation

Downgradient monitoring at the NBCS has shown concentrations of some contaminants exceeding CSRGs. Evaluations in the 2005 and 2010 Five-Year Reviews concluded that these concentrations may not have been representative of system effectiveness, but were indicative of residual contamination present before construction of the system and slow migration of contaminants through fine-grained sediments.

As part of the 2015 Five-Year Review Report (FYRR), an evaluation of the hydrogeology in the area north of the NBCS slurry wall was completed to further evaluate water quality downgradient of the system and the mechanisms causing contaminant concentrations to exceed CSRGs. Recommended changes to the downgradient performance well monitoring network included replacing five wells with alternate wells that were expected to be more representative of evaluating system performance based on the lithology of the saturated zone in which the wells were screened. During subsequent discussions with the regulatory agencies, it was decided that the original performance wells and the alternate wells, as presented below, should be sampled in order to compare data in making a final decision about the downgradient performance monitoring network.

Performance Well	Alternate Well
23405	23253
24006	24412
24418	24163
24421	24164
37362	24429

Annual sampling of the performance monitoring wells and the alternate wells was conducted in FY19, FY20, and FY21. Based on evaluation of the data, there was no indication that the alternate wells would provide more useful information in evaluating system performance. There was no correlation identified in the concentrations of contaminants that have an affinity for fine-grained sediment and the levels of contaminants in each well. A summary of the water quality data for performance wells and corresponding alternate wells sampled FY19 through FY21 is provided in Appendix B (Exhibit B-1).

Well 24429 served as an alternate to well 37362, which was replaced in 2019 by new well 24207 due to safety concerns in accessing this location along 96th Avenue. No samples were collected from 37362 during the three-year monitoring period, and well 24207 did not yield sufficient water to collect samples. To support continued and consistent performance water quality monitoring at the eastern end of the NBCS, it is recommended to add well 24429 to the performance monitoring network. In addition, the Army recommends no changes to the current downgradient performance well network for wells 23405, 24006, 24418, and 24421, and to discontinue monitoring the remaining four alternate wells.

3.2.4 NBCS Denver Formation Monitoring

3.2.4.1 Denver Formation Hydraulic Gradients

Reverse Gradients

Reverse lateral hydraulic gradients across the slurry wall and upward vertical hydraulic gradients on the upgradient (south) side of the slurry wall are desirable in the Denver unconfined wells but are not required to maintain hydraulic control. Water levels were measured quarterly at seven well pairs screened in the Denver Formation sandstone that extends under the slurry wall in the western half of the NBCS and are adjacent to the NBCS slurry wall. Reverse gradient graphs are shown in Figures B-24 and B-25 in Appendix B. The reverse gradient graphs have been consistent for the last several years.

To evaluate reverse gradients across the slurry wall, water levels for well pairs (listed from west to east) were reviewed: 23536/23537, 23538/23539, 23138/23126, 23540/23541, 23194/23195, 23542/23543, and 23242/23243. Water levels in these well pairs show that a flat to reverse hydraulic gradient was not present in well pairs 23536/23537, 23538/23539, 23540/23541, and 23542/23543. A reverse gradient was present in well pairs 23138/23126, 23194/23195 and 23542/23543 during at least one quarter of FY21. The inability to maintain a constant reverse gradient is due to the semi-confined sands in the Denver Formation, which have become a significant factor in this area as water levels have decreased in the region over the past few years.

Vertical Gradients

Vertical gradients were evaluated on the upgradient (south) and downgradient (north) sides of the slurry wall to determine whether the potential exists for downward migration within the UFS of contaminants from the alluvium into the Denver Formation indicative of underflow across the slurry wall. Vertical gradients were calculated utilizing the data presented in the FY21 North Boundary Containment System folder on the attached CD.

Vertical gradients on the upgradient/south side of the slurry wall were evaluated for well pairs (listed from west to east): 23208/23537, 23207/23539, 23214/23126, 23533/23541, 23534/23195, 23535/23543, and 23212/23243. An upward vertical hydraulic gradient from the Denver Formation unconfined zone to the overlying alluvium on the upgradient side of the slurry wall indicates hydraulic containment with depth. Upward gradients were present from the unconfined Denver wells to the adjacent alluvial wells during all measured quarters in five of the seven well clusters on the extraction-well side of the slurry wall.

Upward vertical gradients were not observed in well pair 23533/23541 located west of the "bend" in the slurry wall at western end of the system. The vertical gradient in well pair 23208/23537, located at the far west end of the system, could not be determined because the alluvial well (23208) was dry each quarter. Well pair 23533/23541 is located at the bend in the slurry wall and had downward gradients during the first, second, and fourth quarters. The lack of upward gradients in this area is not uncommon in that area of the system, and becomes more pronounced as water levels decrease in the UFS. There is no indication of underflow in this area considering a reverse gradient was maintained across the slurry wall in this portion of the NBCS during FY21.

On the downgradient/north side of the slurry wall, vertical gradients were evaluated for the following well pairs (listed from west to east): 23519/23538, 23215/23138, 23510/23194, 23528/23542, and 23217/23242. All of the vertical hydraulic gradients in these well pairs were downward in FY21 indicating hydraulic control was maintained, which is further substantiated by the presence of a reverse gradient across the slurry wall in this portion of the NBCS.

Summary

The FY21 hydraulic gradients in the Denver unconfined wells are consistent with historical gradients. The lateral hydraulic gradients indicate that underflow of contaminants likely is not occurring as upward vertical gradients in well pairs located on the upgradient side of the slurry indicate hydraulic containment are being maintained.

3.2.4.2 Denver Formation Water Quality

As presented in Section 4.4.4 of the LTMP, Denver Formation select UFS and CFS wells are sampled once every five years, with the next sampling event taking place in FY22. Therefore, no water quality data are reported for these wells in FY21.

3.2.5 NBCS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the NBCS in FY21 is provided in Appendix H1.2.

3.2.6 NBCS Conclusions and Recommendations

In FY21, the NBCS met the performance criteria and objectives established in the LTMP. Only emerging contaminant 1,4-dioxane exceeded the CSRG in the NBCS treatment system effluent during the second and third quarters of FY21, but the moving average was less than the CSRG during all four quarters. As an emerging contaminant, 1,4-dioxane was not part of the design for the NBCS treatment system and therefore not treated by the system. The reverse gradient was maintained throughout the year in the alluvial aquifer. The concentrations in the downgradient performance wells were less than the CSRGs/PQLs, or show decreasing trends in most of the wells. Dieldrin concentrations were above the PQL in eight downgradient performance wells, but show stable or decreasing trends in these wells. The downgradient dieldrin concentrations above the PQL likely are caused by residual contamination that is not representative of system performance.

Based on the FY21 information, the contaminant plumes were captured at NBCS. There was no indication of underflow within the Denver Formation as vertical gradients were generally upward upgradient of the slurry wall, and contaminant levels were significantly higher upgradient of the slurry wall. Although a few analytes are above CSRGs/PQLs in downgradient wells because of residual downgradient contamination, the NBCS is functioning as intended. Continued monitoring will be conducted in downgradient performance wells where PQL exceedances occurred in FY21.

The evaluation of alternate downgradient performance wells over the past three years did not indicate any appreciable difference between the original wells and the alternate wells in regard to water quality. During the monitoring period, well 24207—as a replacement for well 37362—did not yield sufficient water for samples. The Army recommends no changes to the current downgradient performance well network for wells 23405, 24006, 24418, and 24421, and that the evaluation be discontinued for the remaining four alternate wells. It is recommended that well 24429 be added to the performance monitoring network in order to support continued and consistent performance water quality monitoring at the eastern end of the NBCS.

3.3 BASIN A NECK SYSTEM

The BANS was designed and constructed in 1989 to intercept contaminated alluvial groundwater originating from Basin A. Contaminated groundwater is removed from the upgradient side of a soil-bentonite barrier, treated by means of air stripping and granular activated carbon adsorption to remove the organic contaminants, and injected back into the alluvial aquifer through recharge trenches on the downgradient side of the barrier. Since the original plant was constructed, two additional extraction systems were added in 2000, and one additional system was added in 2011. These systems include the BRES, which extracts contaminated groundwater from an area in the north-central part of Section 36, the CADT dewatering system, which pumps contaminated groundwater from the CADT area in the southeast portion of Section 36, and the Lime Basins, which pumps contaminated groundwater from the southwest corner of Section 36. All three of these extraction systems convey contaminated groundwater to the BANS for treatment.

The contaminated groundwater from the BRES and CADT systems requires pre-treatment by air stripping for removal of VOCs. In order to accommodate the increased flows from the additional

extraction systems, a new shallow tray air stripping system was installed in 2002 to replace the original packed bed air stripping system. In 2004, the air stripper was relocated to the headworks of the plant in order to process the entire plant flow. The Lime Basins Treatment Relocation Project, which directed groundwater from the Lime Basins extraction wells into the BANS treatment plant, was started in FY10 and was completed in FY11. A full description of the project is presented in Section 1.2.6 of the FY11 ASR report (RVO 2013).

The treatment system is designed to remove organic contaminants and arsenic to levels at or below the CSRGs established in the final On-Post ROD for the BANS.

Treatment system information for the BANS is provided for FY21 in Table 3.3-1. The results of CSRG-analyte sampling and water level monitoring in BANS performance wells in FY21 are presented in Table 3.3-3, and in maps within Appendix C. Groundwater monitoring and water level data are included on the attached CD.

3.3.1 BANS Operations and Compliance

The BANS operated at an average flow rate of 20.5 gpm and pumped a total volume of 10,765,030 gallons during FY21, removing a total of 62.49 pounds of contaminant mass. The major contaminants removed via treatment included the following:

12DCE	DIMP	PPDDT
12DCLE	DITH	TCLEA
Arsenic	DLDRN	TCLEE
CHCL3	NDPA	TRCLE
CPMSO2	OXAT	

Carbon usage has remained steady over the past few years (Navarro 2020b). The total cost to operate the treatment plant in FY21 was $453,542 (Table 3.3-1).

Figure C-1 in Appendix C shows the BANS monitoring wells, extraction wells, recharge trenches, and slurry wall.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The system effluent for BANS was analyzed quarterly in FY21 using the complete ROD CSRG list.

As presented in Table 4 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY21*, the BANS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY21 (Navarro 2022b, 2021a, 2021c, 2021d).

The treatment plant influent concentrations for the following 12 analytes exceeded CSRGs/PQLs as shown in Figures C-2 through C-13 (Appendix C).

12DCLE	DIMP	PPDDT
14DIOX	DITH	TCLEA

CHCL3	DLDRN	TCLEE
CPMSO2	NDPA	TRCLE

The graphs indicate that while treatment plant influent concentrations exceeded CSRGs/PQLs, concentrations in plant effluent did not exceed CSRGs/PQLs in FY21.

Although not a compliance requirement, reverse hydraulic gradient is monitored at the BANS as an operational consideration. As presented in the quarterly *Treatment Plant Effluent Water Quality Data Reports FY21*, the reverse hydraulic gradient at BANS was similar to its historical trend in previous years. Although a reverse hydraulic gradient was not present on the far western and eastern ends of the system, it was maintained in the central part of the system containing the highest concentrations of contaminants.

In FY21, the BANS demonstrated treatment system effectiveness that showed concentrations exceeding CSRGs/PQLs in treatment plant influent were less than CSRGs/PQLs in treatment plant effluent (Figures C-2 through C-13).

3.3.2 BANS Performance Evaluation

The performance criteria for the BANS were designed to address future monitoring needs and facilitate the system performance evaluation and are presented below:

- Demonstrate effective mass removal through comparison of calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods.
- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

Performance of the BANS in FY21 relative to these two criteria is presented below.

3.3.2.1 BANS Mass Removal

A revised approach to evaluate contaminant mass removal at the BANS, as well as the off-post systems, was proposed in 2019 consisting of a comparison of the calculated mass removed by the system to contaminant plume mass flux approaching the system. The revised technical approach serves as a prospective revision to the LTMP by focusing on measuring the effectiveness of mass removal at the point of capture (extraction) within each system, and not the mass treated at the treatment plant. The mass removal evaluation presented in this report provides a quantitative measure of extraction system performance and better quantifies contaminated groundwater not captured as an indication of potential system bypass. The potentiometric surface map of the BANS area for FY21 is consistent with previous data indicate flow towards the system, and water levels in FY21 show the apparent gaps between either end of the slurry wall and unsaturated alluvium has decreased since FY21 (Figure C-24).

Consistent with the methodology incorporated into the LTMP in 2012 (OCN-LTMP-2012-002), two methods are used in combination to estimate contaminant mass removal:

- Transect method – Used to estimate the mass flux approaching the BANS.

- Well capture method – Used to estimate the mass removal extracted within the BANS capture zone by extraction wells.

The revised mass removal performance criterion specifies removal of at least 75 percent of the contaminant plume mass migrating toward the system. As the revised approach has been implemented for only two years, an evaluation of the appropriateness of the 75 percent criterion will be conducted in the FY22 ASR. Additional details on the technical approach and methodology for the evaluation of contaminant mass removal is presented in LTMP, OCN-LTMP-2012-002. The calculations for contaminant mass removal for the BANS are provided in the FY21 BANS-BRES-CADT-Lime Basins folder on the attached CD.

The approximate total contaminant flow rate approaching the BANS was 15.42 gpm as shown in Table 3.3-2. The total flow rate is based on the averaged measured extraction flow rate within the capture zone of 14.67 gpm and the estimated contaminated flow outside the capture zone was approximately 0.75 gpm. Based on these flow rates, approximately 95 percent of the estimated contaminated flow was extracted and treated.

In FY21, the mass flux outside the capture zone was estimated to be 0.19 pounds/year for all organic and inorganic CSRG analytes, while the mass flux within the capture zone was 12.23 pounds per year (pounds/year) for the dewatering wells. Based on these data, the total BANS mass removal is 98.5 percent, which exceeds the LTMP performance criterion of 75 percent (Table 3.3-2). Any apparent discrepancies in the quantities for mass removal can be accounted for in mathematical rounding as shown in the calculations presented in the Excel file on the attached CD.

From FY12 through FY21, mass removal has ranged from 88.5 to 99.7 percent, with an average of 97.6 percent. The lowest percentage of mass removal occurred during periods of high precipitation and an increase in the water table where flow around the northern and southern end of the slurry wall likely occurred, thus decreasing capture. Based on the trend over the past 10 years, the Army will evaluate the mass removal goal for BANS in FY22 in consideration of a higher percentage goal.

3.3.2.2 Downgradient Performance Wells

The second performance requirement is to demonstrate that concentrations in downgradient performance wells are below CSRGs/PQLs, or stable or decreasing if they are above the CSRGs/PQLs.

Table 3.3-3 presents an overview of the FY21 water quality results for the BANS performance wells. Figures C-14 through C-23 in Appendix C show the upgradient and downgradient performance well concentrations. Time versus concentration graphs in the maps on Figures C-25 through C-27 show the concentrations for analytes with concentrations that exceeded CSRGs/PQLs in downgradient wells over the past few years, including CPMSO2, dieldrin, and DIMP.

Dieldrin concentrations were above the PQL in two of the four downgradient performance wells (35505 and 35525), but appear to be decreasing in these wells when evaluating the long-term

trends. The concentrations of CSRG analyte CPMSO2 are now less than the CSRG in downgradient performance wells indicating a decrease in CSRG analyte levels downgradient of the system (Table 3.3-3). Although not a CSRG analyte, DIMP was detected at concentrations greater than the CBSG upgradient of the BANS in FY21, but levels of DIMP did not exceed the CBSG downgradient of the system in FY21. The data do not indicate an increasing trend for any of the contaminants as verified by Mann-Kendall trend analyses completed as part of the data quality assurance review.

3.3.3 BANS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review for BANS includes BRES, CADT, and Lime Basins data. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the BANS in FY21 is provided in Appendix H1.3.

3.3.4 BANS Conclusions and Recommendations

In FY21, the BANS met the treatment plant compliance requirements established in the LTMP. During the FY21 reporting period, BANS average pumping rate was 20.5 gpm. As presented in Table 4 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY21*, the BANS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY21. The BANS demonstrated treatment system effectiveness, specifically related to CPMSO2, dieldrin, and DIMP. Each contaminant showed concentrations exceeding CSRGs/PQLs in upgradient wells and treatment plant influent, and concentrations less than CSRGs/PQLs in treatment plant effluent.

In FY21, the BANS met the performance criteria and objectives established in the LTMP. Utilizing the revised approach to evaluate mass removal, BANS met the 75 percent goal for FY21, with mass removal estimated at 98.5 percent. Based on the trend in mass removal over the past 10 years, the Army recommends revising the goal from 75 percent to 90 percent.

3.4 BEDROCK RIDGE EXTRACTION SYSTEM

The BRES intercepts groundwater flowing northeast out of Basin A from the CADT area. The monitoring network for the BRES is presented in C-28. The potentiometric surface map (Figure C-38) indicates that the groundwater was flowing north-northwest in the vicinity of the extraction wells.

3.4.1 BRES System Operations

Extraction water from BRES is piped to and treated at BANS. The distribution of analytes exceeding CSRGs/PQLs in upgradient and/or downgradient performance wells in FY21—including 11DCE, 12DCLE, carbon tetrachloride, chloroform, dieldrin, DIMP, dieldrin, tetrachloroethylene, and trichloroethylene—are shown in Figures C-29 through C-37 (Appendix

C). Concentrations of these analytes are greater than CSRGs in upgradient wells flowing towards the extraction system (Table 3.3-3).

3.4.2 BRES Performance Evaluation

The performance criteria for the BRES are designed to evaluate the effectiveness of the extraction system in controlling downgradient contaminant migration. The system performance evaluation criteria are presented below:

- Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.
- Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.

The map contours illustrated in Figure C-38 in Appendix C indicate that the plume appeared to be generally captured at the western and eastern edges of the extraction system based on the potentiometric surface. There were no significant changes in the groundwater flow directions in the BRES during FY21 compared to previous years.

An overview of downgradient water quality for the BRES performance wells in FY21 is provided in Table 3.3-3. No CSRG analytes were detected at concentrations exceeding CSRGs in downgradient performance wells 36555, 36571, and 36572 in FY21. Concentrations of 12DCLE, carbon tetrachloride, chloroform, DIMP, tetrachloroethylene, and trichloroethylene were above the CSRGs in well 36566. Of these contaminants, concentrations of 12DCLE and trichloroethylene show increasing trends; while carbon tetrachloride, chloroform, DIMP, and tetrachloroethylene do not indicate increasing trends in downgradient water quality. Well 36566 is located downgradient of extraction well 36302, where the hydraulic gradient is much flatter than at the other downgradient performance wells. Therefore, the contamination in well 36566 would be expected to migrate much slower than in other areas of the plume.

Figures C-39 through C-43 include concentration trends versus time plots in BRES performance wells where concentrations exceeded CSRGs/PQL including 12DCLE, chloroform, DIMP, tetrachloroethylene, and trichloroethylene. These contaminants are present in groundwater at levels greater than CSRGs/PQLs in some wells, primarily upgradient of the extraction wells, but generally do not indicate increasing concentrations downgradient of the system.

Based on water quality data for well 36566, system bypass may be occurring in the vicinity of extraction wells 36302 and 36306. The investigation to evaluate the potential for system bypass within the BRES concluded in August 2021. As part of that investigation, two new monitoring wells—36256 and 36257—were installed in July 2019 and monitoring of these wells indicates that the highest levels of CSRG analytes are present in well 36256, which is located between extraction wells 36302 and 36306. Concentrations of CSRG analytes in well 36257, located approximately 45 feet west of well 36302, are lower than those detected in 36256—indicating that plume capture is not occurring in the central part of the system. An evaluation of data

collected from new and existing wells will be completed in FY22 to determine the need for system optimization for plume capture within the BRES.

3.4.3 BRES Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Because water extracted at BRES is treated at the BANS, data review for BRES is included with the data for BANS as summarized in Section 3.3.3. Detailed information on the quality assurance evaluation for samples collected to support the BRES in FY21 is provided in Appendix H1.3.

3.4.4 BRES Conclusions and Recommendations

In FY21, the BRES did not meet the plume capture performance criteria and objectives established in the LTMP as indicated by increasing trends in one downgradient well for some contaminants. The potentiometric surface map indicates that the plume is captured at the edges of the system. In well 36566, 12DCLE and trichloroethylene indicated increasing concentration trends through FY21. Well 36566 is located downgradient of the extraction system where the hydraulic gradient is relatively flat compared to the other downgradient performance wells. Therefore, the contamination in well 36566 is expected to decrease at a slower rate compared to other wells. Further evaluation of the system will be completed in FY22 to determine the need for system optimization to improve plume capture. There were no trigger events for BRES during FY21.

4.0 OTHER ON-POST SYSTEMS

4.1 COMPLEX ARMY DISPOSAL TRENCHES DEWATERING SYSTEM

The performance criteria for the CADT dewatering system are based on achieving water elevation goals (i.e., below the bottoms of the disposal trenches), rather than water quality or contaminant mass removal goals. Quarterly water level monitoring is conducted in 11 wells to monitor the hydraulic gradient across the slurry wall, and water levels inside the slurry-wall enclosure, to assess progress toward meeting the dewatering goals (see Figure D-1 for well locations). The groundwater pumped by the CADT dewatering system is treated at the BANS to meet CSRGs and reinjected in the BANS recharge trenches. Consultation trigger events for the CADT were established based on system performance criteria and non-routine operational events that might lead to performance issues. These triggers, along with notification requirements, type of consultation, and follow-up criteria, are presented in Table 5.1-1 of the LTMP. The table also includes a list of operational trigger events that could potentially result in a performance issue.

4.1.1 CADT System Operations

Groundwater extracted from the CADT dewatering trench is piped to and treated at BANS. Extracted groundwater is also sampled and monitored to support BANS operations and treatment.

4.1.2 CADT Performance Evaluation

Evaluation of existing conditions at the CADT indicated that there is hydraulic control due to flow directed towards the extraction trench through active dewatering. Because the hydraulic gradient toward the extraction trench represents containment, the LTMP was revised (OCN-LTMP-2019-009) to incorporate demonstration of hydraulic control as an alternate performance goal under the first performance criterion for the CADT as follows:

- Demonstrate groundwater elevations in performance monitoring wells 36216 and 36217 are below the target elevations of 5226 and 5227 feet, respectively, or demonstrate hydraulic gradient from the performance monitoring well locations is toward the extraction trench.
- Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).

Relative to the first criterion, quarterly water levels in well 36216 were below the target elevation of 5226 feet above mean sea level (amsl) for all quarters. The water level in well 36217 remained above the target elevation for all four quarters, consistent with previous results. Water levels in wells 36216 and 36217 have been generally decreasing since October 2016, such that the water elevation in well 36217 is now less than 0.5 feet above the target elevation. The hydraulic gradient from both performance monitoring wells was toward the extraction well as indicated in Figure D-1 (Appendix D), which presents the water levels March through April 2021 and the potentiometric surface showing that hydraulic control was achieved at the CADT as groundwater flows toward the extraction trench at both wells 36216 and 36217.

Relative to the second criterion, as shown in Figure D-2, the inward gradient across the CADT slurry wall was maintained where quarterly water levels were measured in well pairs 36218/36219 and 36220/36221.

In FY21, the CADT system met the performance criteria and objectives established in the LTMP. The inward gradient was maintained across the slurry wall and, although the water levels remained above the trench-bottom elevation in well 36217, hydraulic control was maintained at both performance well locations.

4.2 SHELL DISPOSAL TRENCHES

The performance criteria for the Shell Trenches are based on achieving water elevations below the bottom of the disposal trenches (RVO 1997). In accordance with the LTMP, quarterly water level monitoring was conducted in 14 wells to monitor the hydraulic gradient across the slurry wall and water levels inside the slurry-wall enclosure to assess progress toward meeting the performance criteria through passive dewatering.

The performance requirement for Shell Disposal Trenches is to demonstrate that groundwater elevations are below the disposal trench-bottom elevations within the slurry-wall enclosure shown in Figure D-3 in Appendix D and Table 4.2-1. Table 4.2-1 also lists the borings drilled through the disposal trenches where the trench-bottom elevations were determined, including the most recent boring location SDT-02. The elevation of the water table at each bore location was interpolated using the quarterly groundwater elevations from monitoring wells. As shown in Table 4.2-1, the water elevations were below the bottom of the trenches at all of the borehole performance goal locations each quarter of FY21.

4.3 LIME BASINS

Baseline operational data collection and system startup of the Lime Basins Slurry Wall Dewatering System began in March 2009. Initially, groundwater was extracted and treated in a periodic “batch” mode, but it was determined that the system needed to run more continuously in order to meet dewatering goals. After notification to the regulatory agencies in September 2014, continuous operation of the system commenced.

4.3.1 Slurry Wall Dewatering System

Dewatering system performance for the Lime Basins must meet the standards established in the Amendment to the ROD (TtEC 2005) and cited in the LTMP. The performance criteria for the Lime Basins dewatering include the following:

- Maintain a positive gradient from the outside to the inside of the slurry wall (for as long as the surrounding local groundwater table is in the alluvium).
- Maintain a groundwater level below the elevation of the Lime Basins waste (5,242 feet amsl) inside the slurry wall (for as long as the surrounding local groundwater table is in the alluvium).

Figure D-4 presents the monitoring well network for the Lime Basins.

The first performance criterion requires that positive inward hydraulic gradient be maintained across the slurry wall. Groundwater elevations inside and outside of the slurry wall have been steadily decreasing since remedy was completed, with a greater change observed in wells located within the southern slurry wall. Figure D-5 (Appendix D) shows the reverse gradient plots for the northern and southern wells measured during FY21.

During the first quarter of FY21, an inward gradient was present in the well pairs along the southern slurry wall segment, in contrast to an outward gradient present in the northern well pairs. Progress toward meeting the inward gradient goal is dependent on successful dewatering within the slurry wall and the groundwater trend outside the wall. Although the groundwater elevation continues to decrease inside the wall, regional drought conditions and falling water table outside the wall have resulted in slower progress toward meeting the goal and difficulty in projecting a date for achievement. In accordance with OCN-LTMP-2021-004, September 2024 is the current projected target date to re-evaluate whether the inward gradient goal has been achieved. Monitoring of the Lime Basins water levels will continue, and progress toward meeting the inward gradient goal will be reported in the ASRs.

The second performance criterion requires water levels inside the slurry wall to be below the elevation of the bottom of the waste. Figure D-5 also presents quarterly water levels for wells inside the slurry wall relative to the bottom-of-waste elevation of 5,242 feet amsl. Based on observed water levels, groundwater inside the slurry wall was below the bottom of waste during all four quarters of FY21.

4.3.2 DNAPL Remediation

In August 2009, monitoring of the Lime Basins dewatering wells indicated the potential presence of DNAPL. A Remedial Investigation/Feasibility Study (RI/FS) was conducted and three suspected DNAPL source zones were identified in the Lime Basins area as shown in Figure D-6 in Appendix D. According to the RI/FS, DNAPL at the Lime Basins primarily consists of the following five compounds: 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, chlorobenzene, and DCPD. The selected remedy consists of DNAPL source containment, removal of DNAPL to the extent practicable, and DNAPL and groundwater monitoring (TtEC and URS 2011). Extracted groundwater is treated at the BANS to meet CSRGs. In FY12, four well pairs were installed adjacent to the slurry wall, and data collection specified in the Design Analysis Report (DAR) (TtEC and URS 2012) began in FY13.

The monitoring goals for Lime Basins DNAPL Remediation include the following:

- Determine if additional DNAPL source zones exist in the Lime Basins area in addition to those previously identified.
- Determine if the extent and nature of any discovered DNAPL source zones have the potential to adversely impact the slurry wall.
- Characterize DNAPL, if present, for the purpose of correlation with groundwater characterization data as a tool in the identification of DNAPL source zones and for the purpose of waste disposal.

Lime Basins DNAPL Remediation Project monitoring consists of measuring DNAPL thickness and water levels, and sampling monitoring and dewatering wells. Figure D-4 in Appendix D presents a map of the well locations in the Lime Basins area.

4.3.2.1 DNAPL Thickness and Water Levels

Figure D-7 in Appendix D is the Lime Basins potentiometric surface map for third quarter FY21. Based on interpolated data, groundwater flows to the north-northwest inside the slurry wall area. The hydraulic gradient is relatively flat inside the slurry wall, ranging from 0.002 to 0.003 feet per foot, which is comparable to previous results. The highest water level inside the slurry wall was measured at 5239.55 feet amsl in well 36248 on the eastern side of the slurry wall enclosure, with the lowest water elevation, at 5237.74 feet amsl, measured in the northwest corner in well 36232. Water levels inside the slurry wall continue to decrease as dewatering continues. There are no depressions in the water table other than those created by the dewatering wells. Additionally, there is no apparent deviation of water levels in the wells adjacent to the slurry wall that would indicate degradation of the slurry wall..

The water level data and DNAPL measurements for FY21 indicate that the slurry wall has not been adversely impacted by DNAPL according to criteria in the DAR (TtEC and URS 2012). Consistent head differentials across the slurry wall have been maintained for all the well pairs showing that the DNAPL remediation system is functioning as intended. During FY21, DNAPL was removed from well 36248 and extraction wells 36319 and 36320 as summarized in Table 4.3-1. No DNAPL was detected outside of and/or adjacent to the slurry wall.

4.3.2.2 Monitoring Well and Dewatering Well Sampling

In the Lime Basins DNAPL RI Summary Report (TtEC 2010), the percent of relative aqueous solubility (PRAS) of the DNAPL compounds was used as a screening tool to assess the potential presence of DNAPL source zones using water quality data. The PRAS is calculated by dividing the dissolved concentration of an analyte by the aqueous solubility of the analyte, with a PRAS greater than or equal to 75 percent indicating the potential presence of a DNAPL source zone.

Prior to FY21, the performance criteria for the Lime Basins DNAPL monitoring included, as a decision rule, the calculation of PRAS for DNAPL constituents to identify potential DNAPL source zones. Monitoring since 2012 has shown that the PRAS calculations have not been a reliable indicator of DNAPL presence. The LTMP was revised in accordance with OCN-LTMP-2021-005 to remove the decision rule requiring the calculation of PRAS as an indicator of a DNAPL source zone, and utilizing the single rule that a DNAPL source zone exists if DNAPL has been detected in the monitoring well. As demonstrated since 2012, continued quarterly and semiannual monitoring is more reliable to evaluate the presence of DNAPL.

The results for FY21 DNAPL monitoring are provided in Table 4.3-1. DNAPL was measured in monitoring wells 36235 and 36248, and extraction wells 36319 and 36320. During the fourth quarter of FY21, OMC personnel removed DNAPL from wells 36248, 36391, and 36320 where the thickness was greater than 1 foot (TtEC and URS 2012). The data for FY21 Lime Basins water level, DNAPL thickness, and water quality are provided in the attached data CD.

4.4 NORTH PLANTS LNAPL PILOT REMOVAL ACTION

An LNAPL pilot removal system was implemented in 2008 to evaluate and remove LNAPL due to a historical release of fuel oil in the North Plants and to gather operating data for the potential design of a full-scale LNAPL removal action. The design of the pilot removal action is presented in the North Plants LNAPL Removal System Action Plan (TtEC and URS 2009). A separate evaluation report was issued for the LNAPL Removal Action prior to FY12 (URS 2012). As discussed in the report, over two years of monitoring was conducted in the North Plants LNAPL recovery and monitoring wells without detection of sufficient quantities of LNAPL in these wells to support the removal of LNAPL. Data for the North Plants Pilot LNAPL Removal Program have been presented in ASRs and Five-Year Summary Reports (FYSR) since FY12 (URS 2012). The future of the LNAPL Removal Project was evaluated during the 2015 Five-Year Review and the monitoring frequency was reduced to annual in FY15 (Navarro 2016a).

Figure D-8 in Appendix D shows the well locations and March and April 2021 water elevations. The flow direction and hydraulic gradient in Figure D-8 are consistent with previous years. No measurable LNAPL was detected in FY21, consistent with data since FY14.

The thickness of LNAPL remaining in the formation, if present, is probably insufficient to overcome the capillary pressure of the wells. A falling water table may cause the apparent thickness of LNAPL in the wells to increase if sufficient potentially mobile LNAPL is still present in the formation; however, LNAPL has not been observed during the past six years of decreasing water elevations.

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5.0 OFF-POST EXTRACTION AND TREATMENT SYSTEMS

The OGITS included groundwater "pump and treat" systems consisting of extraction wells, recharge trenches, and recharge wells in the Northern Pathway and First Creek paleochannels. Groundwater was extracted within the FCS and the NPS, and a single plant treated the combined groundwater from both systems with carbon adsorption. The FCS began operating in January 1993, and the NPS began operating in May 1993.

The FCS originally consisted of five extraction wells and six recharge trenches. Two FCS extraction wells (wells 37803 and 37804) were turned off in September 2003 (Navarro 2021b). FCS recharge trenches 1 and 2 have not been in use since September 2015 and January 2009, respectively. Figure E-1 (Appendix E) presents the locations of FCS extraction wells and recharge trenches.

The NPS is on the west side of Highway 2, north of 104th Avenue, and is bisected by Peoria Street as shown in Figure E-2 (Appendix E). The NPS consists of the "original" system and an additional "modified" system that went online in September 2006. The NPS operated through May 3, 2021, with 13 extraction wells, 10 recharge wells, and 5 recharge trenches in operation within the original system.

In FY21, the FCS and NPS went through significant changes which resulted in the design and construction of a new smaller treatment plant at each site, and the shutdown of the OGITS plant in May 2021. Within the First Creek area, system modifications included an upgrade of the piping and electrical systems, and removal of extraction well concrete vaults. Recharge trenches RCT-1 and RCT-2 were permanently abandoned. Extraction wells 37803 and 37804 were converted to potential use as monitoring wells. Extraction well 37800 (FE-01) was found to be severely corroded and therefore replaced by a new extraction well 37830 (FE-01R) located in the same area.

Within the Northern Pathway, well field upgrades took place with the addition of seven extraction wells, three recharge trenches, one monitoring well, and nine piezometers. These additions to the Northern Pathway well field were designed and constructed to cover the "gap" area in the southern part of the system where contaminated groundwater was not being captured by the existing system. The net result of the Northern Pathway field upgrades is a more consolidated footprint of the extraction and recharge wellfield with no gaps in extraction. The construction of Northern Pathway Treatment System was not completed prior to the end of the FY21 reporting period.

During FY21, operation of the OGITS and construction of the FCTS and NPTS are summarized below to provide context for plant operations in FY21:

- October 8, 2020 – Quarter 1 influent and effluent sampling conducted at OGITS reflecting operations of the FCS and NPS.
- January 7, 2021 – FCS recharge trenches are shut off and all OGITS effluent is routed to NPS recharge trenches.

- January 11, 2021 – Quarter 2 influent and effluent sampling conducted at OGITS reflecting operations of the FCS and NPS.
- April 7, 2021 – Influent/effluent sampling conducted at OGITS for NPS operations covering FY21 Quarter 3.
- May 3, 2021 – OGITS is shut off to accommodate construction at the NPS. NPS remained offline through FY21 as construction continued.
- May 24, 2021 – New FCTS plant began operations.
- June 8, 2021 – Initial monthly influent sampling conducted for FCTS operations evaluation.
- July 8, 2021 – Influent/effluent sampling conducted for the FCTS operations covering FY21 Quarter 4.
- August 3, 2021 – Monthly influent sampling conducted for FCTS operations evaluation.
- September 7, 2021 – Monthly influent sampling conducted for FCTS operations evaluation.

For FY21, operations and compliance will be presented for OGITS and the FCTS for the time periods each were operating.

5.1 OGITS OPERATIONS AND COMPLIANCE

The OGITS operated at an average flow rate of 150 gpm, pumping a volume of 49,158,772 gallons during FY21, and removing a total of 0.8 pounds of contaminant mass from October 1, 2020 through May 3, 2021. The major contaminants removed via treatment included DIMP, chloroform, and tetrachloroethylene. The only contaminants that exceeded CSRGs in influent samples were dieldrin, DIMP, and NDPA. The total cost to operate the off-post treatment plants (includes both OGITS and FCTS) in FY21 was $519,081 (Table 5.1-1).

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. OGITS effluent was sampled during the first three quarters of FY21, while the fourth quarter included only sampling FCTS effluent. OGITS effluent samples were analyzed using the LTMP CSRG-analyte list for OGITS. Since OGITS was not operational during the fourth quarter of FY21, the FCTS effluent was sampled for the fourth quarter annual event which was analyzed for the complete ROD CSRG list.

Presented in Table 1 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY21,* the OGITS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY21 (Navarro 2022b, 2021a, 2021c, 2021d). The treatment plant influent and effluent concentrations for dieldrin, DIMP, and NDPA—the only organic analytes that exceeded CSRGS/PQLs in treatment plant influent—are shown in Figures E-3 through E-5. The graphs demonstrate that the treatment plant effluent concentrations were below the CSRGs/PQLs for these analytes in FY21.

In FY21, the OGITS demonstrated treatment system effectiveness, specifically related to dieldrin and NDPA. For both of these contaminants, concentrations exceeded CSRGs/PQLs in upgradient well and treatment plant influent, while concentrations were less than CSRGs/PQLs in treatment plant effluent and downgradient performance wells.

5.2 FCTS OPERATIONS AND COMPLIANCE

From system startup on May 24 through October 1, 2021, the new FCTS operated at an average flow rate of 47.5 gpm, pumping a volume of 8,075,759 gallons, and removing a total of 0.91 pounds of contaminant mass. The major contaminants removed via treatment included DIMP and DCPD. The only contaminants that exceeded CSRGs in influent samples were dieldrin, DIMP, and NDPA. The total cost to operate the off-post treatment plants (both OGITS and FCTS) in FY21 was $519,081 (Table 5.1-1).

As previously stated, OGITS effluent was sampled during the first three quarters of FY21, while the fourth quarter included only sampling of FCTS effluent. The fourth quarter annual event included sampling FCTS effluent, which was analyzed for the complete ROD CSRG list.

As presented in Table 1 in each of the quarterly *Treatment Plant Effluent Water Quality Data Report FY21,* the OGITS four-quarter moving averages showed no exceedances during FY21 (Navarro 2022b, 2021a, 2021c, 2021d). There was no four-quarter moving average for FCTS as only one quarter of data were collected. The First Creek Treatment Plant influent and effluent concentrations for dieldrin, DIMP and NDPA—the only organic analytes that exceeded CSRGS/PQLs in treatment plant influent—are shown in Figures E-6 through E-8. The graphs demonstrate that the treatment plant effluent concentrations were below the CSRGs/PQLs for these analytes in FY21.

In FY21, the FCTS demonstrated treatment system effectiveness, specifically related to dieldrin and NDPA. For both of these contaminants, concentrations exceeded CSRGs/PQLs in upgradient well and treatment plant influent while concentrations were less than CSRGs/PQLs in treatment plant effluent.

5.3 OFF-POST SYSTEMS PERFORMANCE EVALUATION

The performance criteria for the OGITS were designed to address future monitoring needs and facilitate the system performance evaluation and are presented below:

- Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated combined well capture and transect methods for the FCS and the transect method for the NPS.
- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

For FY21, contaminant mass removal was not evaluated due to construction activities taking place within each off-post system. The lack of consistent treatment system data over the course of the fiscal year would not provide for a meaningful evaluation of system effectiveness relative

to capture within extraction wells. For First Creek, system extraction wells 37801 and 37802 were operational for the full year. Extraction well 37800 (FE-01) was found to be severely corroded during construction, thus requiring replacement. Well 37800 was not operational from May through October 2021 when it was replaced by extraction well 37830 (FE-01R). For the Northern Pathway, system extraction wells operated while OGITS was in operation (October 1, 2020 through May 3, 2021). Construction of the new NPTS was not completed prior to the end of the FY21 reporting period.

5.3.1 FIRST CREEK SYSTEM DOWNGRADIENT PERFORMANCE EVALUATION

The second performance criterion for OGITS is to demonstrate that concentrations of CSRG analytes are below the CSRGs/PQLs, or are stable or decreasing, in downgradient performance wells. The following sections present the results of performance water quality monitoring for both of the off-post systems operating during FY21.

Table 5.2-1 presents an overview of the FY21 water quality results for the FCTS performance wells. Figures E-9 through E-15 in Appendix E show the upgradient and downgradient performance well concentrations for 12DCLE, chloride, dieldrin, DIMP, fluoride, isodrin, NDPA, and sulfate in FY21. Time versus concentration graphs in the maps on Figures E-24 through E-28 show the concentrations for chloride, dieldrin, DIMP, fluoride, and sulfate.

Chloride, dieldrin, DIMP, fluoride, and sulfate exceeded CSRGs/PQLs in both upgradient and downgradient wells in FY21. Regarding downgradient performance wells, well 37343 was replaced by well 37163 in FY21 because its location was deemed unsafe to access due to high traffic volume along Highway 2 (OCN-LTMP-2020-003). Historically, dieldrin exceeded the CSRG/PQL in downgradient well 37343, although concentrations decreased from FY16 through FY20. In FY21, the dieldrin concentration in well 37163 was 0.0278 µg/L, exceeding the CSRG/PQL in the sample collected in FY21; and this concentration was comparable to the last measured concentration of dieldrin in well 37343 of 0.0227 µg/L. The dieldrin concentration in downgradient well 37084 also continued to decrease, while dieldrin has never been detected in well 37110. It is expected that the dieldrin levels within the FCTS will generally continue to decrease over time.

It is unlikely that the dieldrin, and other OCPs, detected downgradient in well 37163 is caused by bypass of the system, but rather dieldrin in soil that was remobilized in groundwater due to fluctuating water levels in the vicinity of First Creek (Figure E-23). Supporting this theory, DIMP occurs more frequently than dieldrin in wells located upgradient of the dewatering wells, however, DIMP levels in downgradient wells are below the CSRG and are decreasing or stable (Figure E-25). Therefore, the dieldrin detections above the PQL in some downgradient wells are not believed to be indicative of system performance.

Samples from the downgradient performance wells also exceeded the CSRGs for chloride, fluoride, and sulfate, but the inorganic standards for chloride and sulfate at OGITS are expected to be met by attenuation consistent with the On-Post ROD (Foster Wheeler 1996).

5.3.2 NORTHERN PATHWAY SYSTEM DOWNGRADIENT PERFORMANCE EVALUATION

Table 5.2-1 presents an overview of the FY21 water quality results for the NPS performance wells. Figures E-16 through E-22 in Appendix E show the upgradient and downgradient performance well concentrations for carbon tetrachloride, chloride, dieldrin, DIMP, NDMA, NDPA, and sulfate in FY21.

Chloride was the only contaminant detected above the CSRGs in FY21 in downgradient performance wells (well 37012). Sulfate was detected above the CSRG in FY21 in cross-gradient performance well 37027. Time versus concentration graphs in the maps on Figures E-30 through E-35 show the concentrations for chloride, dieldrin, DIMP, NDMA, fluoride, and sulfate.

Although elevated concentrations of chloride and sulfate are present in groundwater within the NPS, the standards are expected to be met by attenuation consistent with the On-Post ROD (Foster Wheeler 1996). Future evaluation will take place in order to assess chloride and sulfate attenuation in groundwater towards meeting remediation goals.

5.4 OFF-POST SYSTEMS QUALITY ASSURANCE SUMMARY

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review for OGITS includes FCS and NPS data. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the OGITS in FY21 is provided in Appendix H1.4.

5.5 OFF-POST SYSTEMS CONCLUSIONS AND RECOMMENDATIONS

In FY21, the OGITS and FCTS met the treatment plant compliance requirements established in the LTMP. The OGITS operated at an average flow rate of 150 gpm, pumping a volume of 49,158,772 gallons during FY21. On May 3, 2021 the OGITS was shut down and the new FCTS plant went into operation on May 24, 2021. During its initial fiscal year of operation, the FCTS met treatment plant compliance requirements, operating at a flow rate of 47.5 gpm and pumping a volume of 8,075,759 gallons.

There were no CSRG-analyte exceedances of the four-quarter moving averages in the OGITS or the FCTS systems effluent in FY21. The OGITS and FCTS systems met the performance criteria and objectives established in the LTMP. Thus, both systems were functioning as intended.

Detections of dieldrin above the PQL, as well as other OCPs detected below CSRGs/PQLs, in FCS downgradient performance well 37163 is most likely related to the remobilization of residual OCPs from the aquifer sediments, and is not indicative of system performance.

Due to construction activities in the First Creek and Northern Pathway system areas, and shutdown of the treatment systems during FY21, contaminant mass removal was not evaluated. Mass removal for both the FCTS and NPTS will be evaluated in FY22. Therefore, the Army recommends maintaining the current performance goal of 75 percent for the off-post systems until mass removal can be evaluated aligning with system-specific goals to be recommended in the FY22 ASR.

6.0 SITE-WIDE ON-POST MONITORING

The site-wide on-post monitoring evaluation includes data from water level tracking, water quality tracking, and CFS monitoring. Water level monitoring for water level tracking is performed annually and a water level contour map is used to present the potentiometric surface. The twice-in-five-years groundwater quality sampling of both UFS and CFS wells was last conducted in FY19. The once-in-five-years water quality tracking was last conducted in FY17. The next effort for both sampling frequencies is planned for FY22.

Water level and water quality monitoring are conducted in areas upgradient of the containment systems to track changes in groundwater flow and contaminant migration within the UFS. Delineation and characterization of groundwater contaminant plumes were completed during the RI/FS and used to describe baseline conditions at the time of remedy selection. Remedies implemented within designated source areas were assumed to have short-term and long-term effects on water levels and water quality. Through implementation of long-term monitoring, the effects of these remedies will be substantiated by tracking water levels and the resulting groundwater flow paths and associated water quality over time. The objective of long-term monitoring is to detect any changes in groundwater conditions that are indicative of remedy performance after implementation. To meet the primary objective of long-term monitoring, a limited number of wells located proximal and downgradient to source areas, and upgradient of the boundary containment systems, are sampled for indicator analytes that represent constituents of the major plumes on post.

6.1 WATER LEVEL TRACKING

Water level tracking, which includes measuring on-post and off-post water levels and determining groundwater flow directions, is the primary means of tracking the effects of remedy activities. Water levels were measured in both on-post and off-post water-level wells in FY21. Each year, Army and Shell collect water level data to construct a site-wide water level map of the RMA, which is used to determine groundwater flow paths and identify changes in groundwater flow directions within the UFS that could affect contaminant plume migration. The site-wide water-table contour map is provided in Figure F-1 in Appendix F.

As expected, remediation activities—such as the installation of groundwater extraction and recharge systems, engineered caps and covers, and slurry walls—have had an effect on water levels in localized areas across the RMA. Precipitation events also affect water levels and are an important source of recharge to the shallow UFS at RMA. Army and Shell collect precipitation data on-post from two locations in Section 36, one at the Shell Disposal Trenches and one at the Lime Basins.

The average annual precipitation at RMA, measured at the rain gauge station at the Lime Basins, was 10.44 inches in FY21, which is 2.05 inches more than what was measured in FY20. Annual precipitation data over the past five years, FY17 through FY21, showed a variable trend ranging from a low of approximately 8.35 inches in FY18 to a high of approximately 10.94 inches in FY17.

6.2 WATER QUALITY TRACKING

The Water Quality Tracking network (Figure F-2) was not sampled in FY21 in accordance with the LTMP sampling schedule. Site-wide water quality sampling was last conducted in FY19 as part of the twice-in-five-years monitoring program. The next sampling event for water quality tracking is scheduled for FY22.

6.3 CONFINED FLOW SYSTEM MONITORING

The CFS network was not sampled in FY21 in accordance with the LTMP sampling schedule. CFS water quality sampling was last conducted in FY19 as part of the twice-in-five-years monitoring program. The next CFS sampling event is scheduled for FY22. Figure F-3 presents a map of the CFS monitoring network.

On May 13, 2020, the regulatory agencies were notified about the increased concentration of dieldrin in the CFS north of Basin F. Dieldrin was also detected in three wells at concentrations triggering notification—23187, 23193 and 26147 (Table 1.1-1). Based on the first-time presence of dieldrin in groundwater within CFS wells 23187, 23193, 26147, and 26153 associated with Basin F, monitoring data and well integrity will be evaluated under a future program to better assess the nature of CFS contamination (Navarro 2020b).

In addition to the investigation of the presence of dieldrin in CFS wells, a future evaluation of chloride in the CFS is planned to determine the source of elevated chloride levels in well 35083. A recommendation was made in the FY19 ASR/FYSR to consider the collection of data that will support the characterization of water quality in the CFS to determine whether the elevated levels of chloride can be attributed to natural background or degradation due to RMA contamination.

7.0 SITE-WIDE OFF-POST MONITORING

The following sections describe the RMA and TCHD off-post monitoring programs.

7.1 OFF-POST EXCEEDANCE MONITORING

No off-post exceedance monitoring was conducted in FY21 in accordance with the LTMP sampling schedule. Off-post exceedance monitoring was last conducted in FY19. The results were published in the FY19 Off-Post CSRG Exceedance Map (Army 2021). Off-post exceedance monitoring will next take place in FY22.

7.2 OFF-POST SURFACE WATER MONITORING

In order to continue to evaluate the effect of groundwater treatment on surface water quality off-post of RMA, sampling is conducted during low-flow or base-flow conditions when groundwater is most likely to be discharging into First Creek. Surface water quality monitoring will continue at SW24004 (First Creek at the north fence line) and off-post site SW37001 (First Creek at Highway 2). An upstream sampling location (SW08003), where First Creek flows onto RMA, was added in FY13 to provide data to compare to the two downstream sites. Figure F-4 (Appendix F) presents the locations of LTMP off-post surface water sample locations.

Annual surface water quality samples will be collected at these sites when there is low flow in First Creek. Typically, this sampling occurs during the spring or summer. The target analyte list includes aldrin, arsenic, chloride, dieldrin, DIMP, NDMA, and sulfate. The requirements for sampling are provided in the LTMP, Section 6.3.

7.2.1 Results of FY21 Off-Post Surface Water Monitoring

Sites SW08003, SW24004, and SW37001 were sampled once in FY21, on June 16, 2021. Only arsenic, chloride and sulfate were detected in surface water samples, and none of the concentrations were greater than the off-post CSRGs (Table 7.2-1).

In FY21, the concentrations of arsenic, chloride, and sulfate were higher in First Creek at SW37001 than at SW24004. Historically, arsenic in the First Creek sample collected at Hwy. 2 (SW37001) has occurred at higher concentrations compared to samples collected at the RMA boundary at 96th Avenue (SW24004), which is consistent with the historical trends in arsenic detected within First Creek. Therefore, it is likely that the presence of arsenic in surface water at SW37001 is naturally occurring and not attributable to RMA activities. Similar to arsenic, the highest concentrations of chloride and sulfate were detected in the First Creek sample in FY21. Based on Mann-Kendall analyses, arsenic concentrations demonstrate a stable trend since August 2013, while chloride and sulfate concentrations show decreasing trends during the same time period.

7.2.2 Quality Assurance Review for Off-Post Surface Water Monitoring

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the

intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the off-post surface water sampling program in FY21 is provided in Appendix H1.5.

7.3 TRI-COUNTY HEALTH DEPARTMENT OFF-POST GROUNDWATER MONITORING

The Private Well Monitoring Program is administered by TCHD via a 1997 Memorandum of Agreement with the Army and summarized in the 2005 FYRR (Army 2007). Under this program, TCHD samples private wells and surface water sources in the off-post study area. The program is separate and independent from the off-post monitoring program administered and conducted by the Army. Private well monitoring provides water quality data to address community health concerns and communicate the effectiveness of the remedy to the public related to off-post groundwater contamination. Data from the TCHD private well monitoring program is used to help delineate the CSRG exceedance area. In addition, TCHD collects samples from newly installed private wells within the CSRG exceedance area and from off-post CFS wells that may act as conduits for contaminants to migrate from the shallower UFS to the CFS.

Seventeen off-post private wells were sampled for DIMP, dieldrin, and 1,4-dioxane by TCHD in FY21 (TCHD 2021; Appendix I). In FY21, well 359D had a DIMP detection of 12.1 µg/L, which exceeding the CSRG. No other analyte concentrations exceeded CSRGs/PQLs in off-post private wells in FY21.

Well 359D was installed by the Army in November of 2016 to replace well 359A. The well is screened in two separate zones in the Lower Arapahoe aquifer, similar to well 359A (Navarro 2017a). In FY21, well 359D was sampled on July 6, 2021 by TCHD. From July 12-14, 2021, a field investigation took place to evaluate the integrity of the well and whether DIMP in groundwater could be isolated to a specific zone within the Arapahoe aquifer. The two screened zones were sampled utilizing a pneumatic packer system and discrete samples were collected representing each zone. The DIMP concentration within the upper and lower screened zones were 8.97 µg/L and 12.8 µg/L, respectively (Navarro 2022a). The well was also sampled from the spigot, and DIMP was detected at concentrations of 6.25 µg/L and 6.85 µg/L prior to and after purging, respectively. The result of the field investigation was a recommendation that a small-scale “point of entry” carbon filtration system be installed at the wellhead in order to provide uncontaminated water to the residents on the property. Bottled water is currently being provided to the property owner and installation of the treatment system will take place in 2022 (Navarro 2022a). Table 7.3-1 presents the analytical results for private well sampling during FY21.

The results of the FY21 off-post private well sampling are presented in Appendix I.

8.0 POST-SHUT-OFF AND SHUT-OFF MONITORING

8.1.1 RYCS Shut-Off Monitoring

The RYCS was designed to capture the Railyard DBCP plume. When the MPS/ICS extraction systems were shut down, treatment of the remaining Railyard plume was moved from the ICS to the new RYCS in July 2001. Recharge of the treated water was also transferred from the ICS to the RYCS. DBCP was the major contaminant removed via treatment.

The RYCS was shut down on May 25, 2016 because the system met ROD and LTMP shut-off requirements, and pre-shut-off monitoring was successfully completed. ROD- and LTMP-required shut-off monitoring commenced thereafter. Concentrations of the CSRG analytes DBCP and trichloroethylene were below the CSRGs in the shut-off wells sampled in June and August 2016.

The *Railyard Containment System Shut-Off Sampling and Analysis Plan* (Shut-off SAP), and associated Decision Document DD-34, were prepared for review and approval by the regulatory agencies in 2016 (Navarro 2016b). The shut-off water quality monitoring network consists of eight wells, which are shown on Figure G-1 in Appendix G:

03501	03529
03502	03530
03503	03534
03528	03538

The wells are sampled for the ICS CSRG analytes DBCP and trichloroethylene. The RYCS met shut-off criteria and was shut down in the third quarter of FY16, at which time quarterly shut-off monitoring was required for one year. During the first quarter of FY17, the DBCP concentration in one well exceeded the CSRG, and quarterly sampling took place beginning in the second quarter of FY17 through the first quarter of FY18, with detections at or below the CSRGs for DBCP (0.2 µg/L) and trichloroethylene (5 µg/L) (Navarro 2020b). Because the results for quarterly monitoring indicated that there were no CSRG exceedances, the regulatory agencies were notified. Annual shut-off monitoring began again in FY18 and continued through FY20. There were no DBCP or trichloroethylene detections above the CSRG.

During FY21, quarterly monitoring took place in accordance with the RYCS Shut-off SAP (Navarro 2016b). Table 8.1-1 presents the results for sampling that indicate DBCP and trichloroethylene were not detected in any wells.

Based on the results of monitoring, the first quarter of FY22 most likely will represent the last sampling event under the RYCS Shut-off SAP. If the sample results for early FY22 remain consistent the shut-off monitoring conducted to date, post-shut-off monitoring should begin in 2022.

8.1.2 RYCS Quality Assurance Review

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality

indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the RYCS shut-off monitoring program in FY21 is provided in Appendix H1.6.

8.2 MOTOR POOL SYSTEM/IRONDALE CONTAINMENT SYSTEM POST-SHUT-OFF MONITORING

8.2.1 MPS/ICS Post-Shut-Off Monitoring

In FY21, wells 04535 and 33081 were sampled under *Motor Pool System/Irondale Containment System Post-Shut-Off Monitoring Sampling and Analysis Plan* (URS 2011). Figure G-2 in Appendix G shows the well locations within the MPS/ICS area. Well 04535 is downgradient of the MPS and was sampled for trichloroethylene. Well 33081 is located between the RYCS and former ICS and was sampled for DBCP.

The goals of the MPS/ICS Post Shut-Off Monitoring SAP (URS 2011) were to monitor groundwater to evaluate concentrations relative to CSRGs in order to substantiate shutdown of the system. On August 25, 2021 wells 04535 and 33081 were sampled. DBCP was not detected in well 33081 and trichloroethylene was detected in well 04535 at a concentration of 0.822 µg/L, which is below the CSRG of 5 µg/L (Table 8.2-1).

Review of water level data presented in the FY21 regional water level map (Figure F-1) and similar maps over the previous five years indicates that the groundwater flow direction in the area appears unchanged.

The water level and water quality data for the MPS/ICS are included in the attached data CD. Since the SAP criteria were met in FY21, post-shut-off monitoring will continue in accordance with the MPS/ICS SAP (URS 2011).

8.2.2 MPS/ICS Quality Assurance Review

The purpose of the data review is to evaluate data quality with respect to the DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the MPS/ICS shut-off monitoring program in FY21 is provided in Appendix H1.6.

9.0 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

PFAS have been classified as emerging contaminants by the EPA. Although there is no current standard, EPA has developed a health advisory level for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in drinking water of 0.070 µg/L, either individually or combined when both are present.

Prior to 2016, when the Army issued guidance for evaluating restoration sites for potential PFAS contamination, PFAS had not been evaluated previously in RMA groundwater; therefore, no historical PFAS groundwater data exist. The Army conducted an investigation from July 2017 to August 2018 to assess the potential for PFAS groundwater contamination at the RMA (Navarro 2017b). The results of the investigation indicated detectable levels of PFAS in RMA groundwater, although only one location near the South Plants spill area was above the EPA health advisory level. The initial investigation concluded that further characterization of PFAS contamination was necessary (Navarro 2019d).

In FY19, PFAS were analyzed in samples from a select group of wells and the treatment plant influents/effluents to verify the PFAS results from 2017 and 2018 and determine the extent of potential releases at RMA. PFAS were detected above the health advisory level in one South Plants well, which is located in the area of the single documented use on site, and in four wells immediately downgradient. PFAS were not present at concentrations above the health advisory level in the remaining wells sampled or in the treatment plant influent/effluent (Navarro 2020h).

Groundwater data and historical information indicate that RMA is not a significant source of PFAS contamination in groundwater. However, the LTMP was revised to include PFAS for select water quality tracking wells, which are sampled once every five years, within and downgradient of the South Plants source area. PFAS were also added to annual treatment plant influent and effluent sampling to provide continuing monitoring of these emerging contaminants. Monitoring under the water quality tracking program will next take place in FY22 in accordance with the LTMP sampling schedule. In FY21, influent and effluent samples were collected in July 2021 and analyzed for PFAS. The results of PFAS monitoring are provided in Table 9.0-1 and are summarized below.

PFAS, including both PFOA and PFOS, were detected in the influent samples collected at the BANS. The only other detection was PFOS in the NWBCS influent (Table 9.0-1). PFAS were not detected in any treatment plant effluent samples during FY21. All detected concentrations were less than the health advisory level of 0.070 µg/L by an order of magnitude (Table 9.0-1).

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10.0 SUMMARY AND CONCLUSIONS

This FY21 ASR includes an evaluation of the data collected to evaluate the compliance and performance criteria related to the operating systems, groundwater and surface water quality and hydrology, as well as other supplemental monitoring in FY21. In addition, the ASR includes data reporting for the FY21 site-wide monitoring programs, project-specific monitoring, and Consultative Process notifications.

Sections 10.1 through 10.5 summarize the results supporting the FY21 ASR reporting period as presented in greater detail within Sections 3 through 9 of this report.

10.1 ON-POST AND OFF-POST TREATMENT SYSTEMS

All of the groundwater containment and mass removal systems met the compliance monitoring criteria presented in the LTMP (Navarro 2021b) in FY21. In addition, the groundwater containment and mass removal systems generally met the performance criteria presented in the LTMP (Navarro 2021b), and the objectives identified in the On-Post ROD (Foster Wheeler 1996) and Off-Post ROD (HLA 1995).

In FY21, performance criteria were not met in some portions of the NWBCS, BRES, and Lime Basins systems. Table 10.0-1 presents a summary of the compliance criteria and the system- and project-specific performance criteria and whether these criteria were met in FY21. In instances where performance criteria were not met, or data suggest that performance criteria are at risk of not being met, proposed or current actions are indicated and will be followed up in the FY22 ASR. Recommendations presented in previous sections of the report are also presented below, which will result in OCNs to the LTMP.

Summarized below are the results and conclusions for system-specific operational compliance monitoring and performance monitoring relative to the performance criteria and goals as stated in the LTMP.

10.1.1 On-Post Extraction and Treatment Systems

NWBCS

- In FY21, the NWBCS operated at an average flow rate of 820 gpm, pumping a total volume of 436,765,692 gallons and removing a total of 5.81 pounds of contaminant mass.
- The NWBCS met the compliance and the primary performance criteria for the Original System and objectives established in the LTMP. The NWBCS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY21. A reverse hydraulic gradient was maintained within the system and plume capture was evident within the original system as well as within the NEE and SWE. Thus, the NWBCS was functioning as intended.
- Dieldrin was detected above the PQL in Original System and NEE downgradient performance wells during the reporting period:

  - Original System downgradient well 37333 contained dieldrin above the PQL in FY21. However, the secondary performance criterion was met during the five-year reporting period because the long-term trend was not increasing in downgradient performance wells.
  - NEE downgradient well 22512 and 22015 contained dieldrin above the PQL in FY21. However, the secondary performance criterion was met because the long-term trend was not increasing in downgradient performance wells.

- Dieldrin above the PQL in downgradient performance wells may be attributed to a variety of factors including contamination due to mobilization of residual dieldrin or possible system bypass around the north end of the NEE slurry wall. An investigation of potential by-pass of the NEE slurry wall was conducted in FY21. While monitoring is ongoing within the NEE, preliminary data demonstrates that water table is very low in the area north of the slurry wall, indicating limited groundwater flow in this area.

NBCS

- In FY21, the NBCS operated at an average flow rate of 240 gpm and pumped a total volume of 126,561,900 gallons and removed a total of 12.1 pounds of contaminant mass.
- The NBCS met the compliance and performance criteria and objectives established in the LTMP. The NBCS had no CSRG/PQL analyte exceedances for the four-quarter moving average in the treatment system effluent in FY21. A reverse hydraulic gradient was maintained within the system throughout the year and plume capture was evident. Thus, the NBCS was functioning as intended.
- Dieldrin concentrations are above the PQL in downgradient performance wells but show stable or decreasing trends in a majority of wells. Concentrations of anions chloride, fluoride, and sulfate exceeded CSRGs. Chloride and sulfate are expected to naturally attenuate to background levels. Based on the FY21 information, the contaminant plumes continue to be captured by the NBCS system.
- Based on evaluation of data from select downgradient performance water quality wells and alternate wells over the past three years, there was no correlation identified in the concentrations of contaminants in each well. During the monitoring period, well 24207—as a replacement for well 37362—did not yield sufficient water for samples.

Recommended Additional Action: Add alternate well 24429 to the performance monitoring network in order to support continued and consistent performance water quality monitoring at the eastern end of the NBCS, and discontinue monitoring the remaining alternate wells 23405, 24006, 24418, and 24421.

BANS

- In FY21, the BANS operated at an average flow rate of 20.5 gpm and pumped a total volume of 10,765,030 gallons, removing a total of 62.5 pounds of contaminant mass. The BANS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY21.

- The BANS met both performance criteria and objectives established in the LTMP. The 75 percent mass removal criterion was met in FY21, with mass removal estimated at 98.5 percent. Concentrations of analytes that remain above CSRGs/PQLs indicate stable or decreasing trends. Thus, the BANS was functioning as intended.

Recommended Additional Action: Maintain the current performance goal of 75 percent for the BANS until mass removal can be evaluated aligning with system-specific goals to be recommended in the FY22 ASR.

BRES

- In FY21, the BRES did not meet the plume capture performance criteria and objectives established in the LTMP. Analytes 12DCLE and trichloroethylene in well 36566 show increasing concentration trends. Although the plume appears captured at both edges of the system, bypass may be occurring within the west-central portion of the extraction system. Further evaluation of the system will continue with the evaluation to be completed in FY22 to determine the need for system optimization to improve plume capture.

10.1.2 Other On-Post Systems

CADT

- In FY21, the CADT system met the performance criteria and objectives established in the LTMP. The inward gradient was maintained across the slurry wall and hydraulic control was maintained in the vicinity of performance wells 36216 and 36217.

Shell Disposal Trenches

- In FY21, the Shell Disposal Trenches met the performance criteria and objectives established in the LTMP. All groundwater elevations were below the bottom of the trenches at all of the borehole performance goal locations.

Lime Basins Slurry Wall Dewatering System

- The first performance criterion requires that positive inward hydraulic gradient be maintained across the slurry wall. In FY21 an inward gradient was present in all well pairs on the southern side while an outward gradient was still present for all the well pairs on the northern side, consistent with results obtained since FY14. Groundwater elevations inside of the slurry wall have been steadily decreasing; however, progress toward meeting the goal is dependent on water level fluctuations outside the slurry wall.
- The second performance criterion requires that water levels inside the slurry wall are below the elevation of the bottom of the waste (5,242 feet amsl). During all four quarters of FY21, the water elevation in each well inside the slurry wall was below the bottom of waste elevation. Therefore, this dewatering performance criterion was met during FY21.

Lime Basins DNAPL Remediation Monitoring

- The water level data and DNAPL measurements for FY21 indicated that DNAPL was detected in well 36235 outside and/or adjacent to the slurry wall. DNAPL was detected within the slurry wall in extraction wells 36319 and 36320 and monitoring well 36248. The data indicate that the slurry wall has not been adversely impacted by historical DNAPL contamination. Consistent head differentials across the slurry wall have been

maintained for all the well pairs showing that the DNAPL remediation system is functioning as intended.

- The observed presence of DNAPL has been consistent since FY13. No additional areas of DNAPL were identified in the vicinity of the Lime Basins slurry wall in FY21. Current data indicate that no additional DNAPL sources zones appear to exist within the Lime Basins slurry wall and that the extent of DNAPL is decreasing.

North Plants LNAPL Pilot Removal Action

- No measurable LNAPL within the former North Plants area was present in the wells during FY21. These results are consistent with data collected since FY13.

10.1.3 Off-Post Extraction and Treatment Systems

- The OGITS plant was shut down on May 3, 2021 to support start-up of the new FCTS plant and construction of the NPTS plant along with upgrades to the well field. The FCTS plant went online on May 24, 2021.
- While operational in FY21 (October 1, 2021 –May 3, 2021), the OGITS operated at an average flow rate of 160 gpm, pumping a volume of 49,158,772 gallons and removing a total of 0.80 pounds of contaminant mass.
- From system startup (May 24, 2021) through October 1, 2021, the new FCTS operated at an average flow rate of 46.0 gpm, pumping a volume of 8,615,759 gallons, and removing a total of 0.91 pounds of contaminant mass.
- The OGITS and new FCTS plant met the compliance and the primary performance criteria and objectives established in the LTMP. The OGITS and FCTS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY21. Thus, the OGITS and FCTS were functioning as intended.
- The Northern Pathway System, as part of OGITS, was shut down on May 3, 2021. It was replaced by the NPTS, which was under construction and not started during the FY21 evaluation period.
- Dieldrin was detected in downgradient performance wells consistent with historic data. Detections of dieldrin above the PQL in downgradient performance wells within the FCS and NPS are most likely related to the mobilization of residual dieldrin from the aquifer sediments and are not likely indicative of system performance. The concentrations of most CSRG analytes have decreased to below CSRGs/PQLs in upgradient wells in both the FCS and NPS.
- Mass removal was not calculated for the First Creek and Northern Pathway systems for FY21 because both systems were not operational for much of the year.

Recommended Additional Action: Maintain the current performance goal of 75 percent for the off-post systems until mass removal can be evaluated aligning with system-specific goals to be recommended in the FY22 ASR.

10.2 SITE-WIDE MONITORING

A summary of the results of site-wide monitoring for the on-post and off-post programs is presented below for the five-year reporting period. Based on the evaluation of data collected during the reporting period, additional actions have been recommended for some monitoring programs as indicated.

10.2.1 Site-Wide On-Post Monitoring

Water Level Tracking

- Overall, groundwater flow directions and associated migration of contaminant plumes have not changed significantly during the FY21 reporting period.

Water Quality Tracking

- In FY21, as scheduled, the Water Quality Tracking network was not sampled. Site-wide water quality sampling was last conducted in FY19 as part of the twice-in-five-years monitoring program. The next sampling event for water quality tracking is scheduled for FY22.

CFS Monitoring

- In FY21, as scheduled, the CFS network was not sampled. CFS water quality sampling was last conducted in FY19 as part of the twice-in-five-years monitoring program. The next CFS sampling event is scheduled for FY22.
- Based on the FY19 data noting the first-time presence of dieldrin in groundwater within CFS wells 23187, 23193, 26147, and 26153 associated with Basin F, monitoring data and well integrity will be evaluated under a future program to investigate the CFS contamination.
- Based on the known presence of elevated levels of chloride in well 35083, a future evaluation is planned to evaluate whether the chloride is the result of anthropogenic sources or can be attributed to natural background.

10.2.2 Site-Wide Off-Post Monitoring

Off-Post Surface Water

- In FY21, only arsenic, chloride and sulfate were detected in off-post surface water samples at concentrations less than off-post CSRGs. The concentration of arsenic has been generally higher in First Creek at SW37001, furthest downstream of RMA and is consistent with the historical trends detected within First Creek. Based on statistical trend analyses, arsenic concentrations demonstrate a stable trend since August 2013, while chloride and sulfate concentrations show decreasing trends during the same time period. Therefore, it is likely that the presence of these constituents in surface water at SW37001 is naturally occurring and not attributable to RMA activities.

TCHD Off-Post Groundwater Monitoring

- Seventeen off-post private wells were sampled for DIMP, dieldrin, and 1,4-dioxane by TCHD in FY21. In FY21, well 359D had a DIMP detection of 12.1 µg/L, which exceeded the CSRG. No other analyte concentrations exceeded CSRGs/PQLs in off-post private wells in FY21.

- Well 359D was installed in November of 2016, which is screened in two separate zones in the Lower Arapahoe aquifer, similar to the well it replaced, 359A. In FY21, a field investigation took place to evaluate the integrity of the well and whether DIMP in groundwater could be isolated to a specific zone within the Arapahoe aquifer. The result of the field investigation was a recommendation that a small-scale "point of entry" carbon filtration system be installed at the wellhead in order to provide uncontaminated water to the residents on the property. Bottled water is currently being provided to the residents and installation of the treatment system will take place in 2022.

10.3 POST-SHUT-OFF AND SHUT-OFF MONITORING

Shut-off and post-shut-off monitoring took place for two systems, and a summary of the results of those programs is presented below.

RYCS Shut-Off Monitoring

- During FY21, quarterly monitoring took place in accordance with the RYCS Shut-Off SAP, and the results indicate that there were no contaminants that exceeded CSRGs. The two primary contaminants of concern, DBCP and trichloroethylene, were not detected in any wells. Based on the monitoring to date, the first quarter of FY22 most likely will represent the last sampling event under the RYCS Shut-Off SAP. If the sample results for early FY22 remain consistent the shut-off monitoring conducted to date, post-shut-off monitoring should begin in 2022.

Motor Pool/ICS Post-Shut-Off Monitoring

- Review of water level data presented in the FY21 regional water level map and similar maps over the previous five years indicates that the groundwater flow direction in the area appears unchanged. Since the SAP criteria were met in FY21, post-shut-off monitoring will continue in accordance with the MPS/ICS SAP.

10.4 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

- RMA does not appear to be a significant source of PFAS contamination in groundwater. PFAS sample analysis in annual treatment plant influent and effluent samples and for select wells in the LTMP once-in-five-years sitewide water quality tracking network has been implemented to continue to evaluate site conditions.

- In accordance with the LTMP, annual influent and effluent samples were collected in July 2021 and analyzed for PFAS, including both PFOA and PFOS. PFOA and PFOS were detected in the influent samples collected at the BANS, with only PFOS being detected in the NWBCS influent. All detected concentrations were less than the health advisory level of 0.070 µg/L by an order of magnitude. PFAS were not detected in any treatment plant effluent samples during FY21. Monitoring under the water quality tracking program will next take place in FY22 in accordance with the LTMP sampling schedule.

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Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
FY21 Tigger Events and Agency Notifications			
12/9/2020	BANS—Failure to collect performance monitoring data in FY20 well 35306	The annual performance water quality sample for well 35306 was collected on August 27, 2020 and was packaged for shipment with other samples collected that day. The shipper missed the delivery and the temperature in the cooler went out of range, so analysis was canceled. The samples were labelled as cancelled in the sample tracking database. Although the OMC performs data queries to check for missing samples, cancelled samples were not identified as missing.	The well was resampled on December 1, 2020 after discovering that no sample had been collected. Although the sample was not collected in FY20, results were included with other FY20 performance monitoring data for the FY20 ASR system evaluation. Another sample will be collected later in FY21 when BANS performance monitoring wells are scheduled. The database queries have been corrected to identify cancelled samples with no lot number as missing samples. Database maintenance will include deleting samples that were cancelled.
1/12/2021	NWBCS—Loss of primary performance criterion—reverse hydraulic gradient for one quarter	On December 17, 2020, as part of the preparation of the *Treatment Plant Effluent Water Quality Data Report for Fourth Quarter Fiscal Year 2020*, review of the reverse gradient data for designated well pairs indicated that a reverse gradient did not exist during the monitoring event for well pair 22061/22056 at the southern end of the NWBCS original system. On August 13, 2020, data for upgradient well 22061 appeared to be higher during the fourth quarter monitoring event compared to downgradient well 22056 by 1.01 feet, thus indicating an apparent forward gradient. The Army believes that the lack of reverse gradient was due to a water level measurement error in well 22061. The water level in well 22061 appears to have increased 0.52 feet from the third to fourth quarters of FY20, while water level data for all monitoring wells in the vicinity (22056, 22021, 22042, 22043, 22045, and 22501) indicate a consistent decreasing trend. Operational data indicate that extraction wells 22301 and 22302, located on either side of well 22061 were operating at normal flow rates. Recharge wells 22402 and 22403, located on either side of well 22056, were also operating at normal flow rates. A review of recent FY21 data indicate	Since a reverse gradient was present within the well pair—and across the NWBCS original system—during the subsequent quarter, no additional action is necessary. The water level data for well 22061 measured on August 13, 2020 has been flagged with a “Z” code in the RMA Environmental Database indicating that the data point is questionable based on evaluation of the situation as previously described.

Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
		that a reverse gradient was present within well pair 22061/22056 during the first quarter monitoring event on November 30, 2020, and the water level in 22061 is consistent with the other NWBCS wells evaluated.	
2/3/2021	NBCS—Individual effluent sample above the CSRG	Quarterly sampling was performed at the NBCS on January 5, 2021. The 1,4-dioxane concentration in the plant effluent sample was 0.359 ug/L, which exceeds the CSRG of 0.35 ug/L. The 4-quarter moving average remains below the CBSG at 0.34 ug/L.	1,4-Dioxane is not currently treated at the NBCS and is present in the groundwater approaching the system above the CSRG. This is the second notification for NBCS effluent exceedance since the 1,4-dioxane CSRG was adopted in May 2020. The Army will continue to provide influent and effluent monitoring results at Water Team meetings and in quarterly effluent reports but will not provide separate LTMP notifications for occurrences above the CSRG until construction of the Consolidated Water Treatment Plant. Significant changes in effluent water quality, such as increasing trend, will be discussed at Water Team as needed.
5/4/2021	OGITS/FCS—Extraction or recharge system problems that could potentially affect system performance	Maintenance of the FCS well field is being performed in accordance with DCN-FCS-001. While in the process of installing a pitless adapter on well 37800 (FE-01) in the FCS, it was determined that the carbon steel casing was severely impacted by corrosion. This area is frequently inundated with surface water and the steel casing was corroded due to contact with the surface water. Several attempts were made to reinforce and ultimately to replace the carbon steel casing. Eventually the casing completely collapsed allowing surface water that was in the excavation to flood the well. The well was determined to be irreparable.	A new extraction well 37830 (FE-01R) was installed on October 2, 2021 in the same general location as 37800 to maintain system performance.
6/22/2021	BANS—Treatment system issues that could potentially affect compliance	On June 14 and June 15, while replacing the pump in the extraction trench for the CADT, maintenance staff identified an electrical short in the power supply to the extraction well. The short was located between the well and the electrical	Repair could not be accomplished without cover soil excavation to inspect the electrical line. The system was off-line for six days. Temporary aboveground wiring was installed on June 21 to provide power to the CADT extraction well.

Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
		control panel located about 250 feet away. Repair was necessary to prevent the possible loss of hydraulic control.	An NRAP was approved on August 4, 2021 for ICS cover disturbance to coordinate cover excavation with system repair. The line was repaired on August 17, 2021.
FY21 Operational Change Notices			
Approved 1/27/2021	Concentrations of dieldrin in downgradient performance wells for the NWBCS Northeast Extension are above the PQL (0.013 ug/l).	Wells 22085 and 22086 were installed as part of the NWBCS Northeast Extension investigation to evaluate potential flow around the northeast end of the slurry wall. The wells are being added to the LTMP networks to provide water level data for continued system evaluation.	OCN-LTMP-2021-001 – The LTMP was revised to add 22085 to the NWBCS performance water level network and well 22086 to the site-wide water level tracking network. In addition, semi-annual water quality sampling is also planned for well 22085 through second quarter FY23 (Navarro 2021b).
Approved 2/22/2021	Wells 37045 and 37139 were removed during FCS construction activities associated with DCN-FCS-001.	The wells were piezometers located within recharge trenches 1 and 2 and are not needed since these trenches are no longer being used.	OCN-LTMP-2021-002 – The LTMP was revised to remove wells 37045 and 37139 from the OGITS performance water level network for FCS.
Approved 2/18/2021	Concentrations of dieldrin in downgradient performance wells for the NWBCS Northeast Extension are above the PQL (0.013 ug/l).	Well 22084 was installed as part of the NWBCS Northeast Extension investigation to evaluate potential flow around the northeast end of the slurry wall. The well is being added to the LTMP network to provide water level data for continued system evaluation.	OCN-LTMP-2021-003 – The LTMP was revised to add well 22084 to the NWBCS performance water level network. In addition, semi-annual water quality sampling is also planned for well 22084 through second quarter FY23 (Navarro 2021b).
Approved 5/3/2021	Lime Basins inward gradient goal along the north slurry wall was not met by the projected April 2021 date.	The performance criteria for the Lime Basins dewatering system includes maintaining a positive gradient from the outside to the inside of the barrier wall and maintaining a groundwater level below the elevation of the Lime Basins waste (5242 ft) inside the barrier wall. The latter goal has been met since 2016. However, an inward gradient is not yet present in well pairs along the north wall.	OCN-LTMP-2021-004 – The LTMP was revised to discuss progress toward meeting the inward gradient goal and set a new projected date for September 2024 for achievement of the goal. Monitoring of the Lime Basins water levels will continue and progress toward meeting the inward gradient goal and will be reported in ASRs and the FYSR. Determination of whether the inward gradient goal has been met will be determined using September 2024 as a

Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
		Although the groundwater elevation continues to decrease inside the wall, regional drought conditions and falling water table outside the wall result in slower progress toward meeting the goal and difficulty in projecting a date for achievement. However, establishing a revised projected date as a goal will help track progress in achieving compliance.	compliance date to correspond to the data cutoff date for the next Five-Year Review.

Table 3.1-1. NWBCS Treatment Systems Statistics for FY21

Total Downtime	117.5 hours
Downtime attributable to maintenance, equipment failure, or other events	35.5 hours
Downtime attributable to power failure	82 hours
Average flow rate and total volume treated [1]	820 gpm 436,765,692 gallons
Total mass of contaminants removed [2]	5.81 lbs
Contaminants contributing to the majority of the mass removed	Chloroform – 4.39 Dieldrin – 1.18 Endrin ketone – 0.13 NDPA – 0.07 Methoxychlor – 0.02
Carbon Usage	55,000 lbs
Cost of Operations	$640,161

Notes:

FY21 data covers the time period October 3, 2020 through October 1, 2021. Refer to Appendix H2 for listing of contaminant names.

[1] Average flow rate and total volume treated are based on metered readings for the three adsorbers within the NWBCS plant. See NWBCS Water Management Report_FY21.pdf included in data accompanying the report.

[2] See NWBCS Contaminant Removal Report_FY21.pdf included in data accompanying the report.

gpm – gallons per minute

lbs – pounds

Table 3.1-2. Overview of FY21 CSRG Analyte Sampling for NWBCS Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient							Cross-gradient			Downgradient							
		SWE	Original System					NEE	SWE		Original	SWE	Original System					NEE	
		27517	22008	22043	22053	22081	27500	22505	27516	28521	27010	27522	37330	37331	37332	37333	37600	22015	22512
Dieldrin[1a]	0.002/0.013		Q4	Q4	Q4	Q4	Q1-Q4	Q4								Q1-Q4		Q1 Q4	Q1-Q3
Endrin	2																		
Isodrin	0.06							Q4											
Chloroform	6		Q4	Q4															
Trichloroethylene	3																		
NDMA[1b]	0.00069/0.009																		
NDPA	0.005		Q4		Q4	Q4		Q4											
Arsenic	2.35							Q4											

Notes:

The reported concentration for a well sample was higher than the CSRG or PQL for the respective analyte during the quarters indicated.

Shading indicates that the respective well was not sampled for the indicated analyte or the data were not usable in FY21.

Blank cells indicate that reported concentrations for the well samples were lower than the CSRG or PQL for the respective analyte.

1. The ROD indicates PQLs for the following analytes:
   [a] Dieldrin – Effective April 2012
   [b] NDMA – Effective September 2016

Table 3.2-1. NBCS Treatment Systems Statistics for FY21

Total Downtime	26 hours
Downtime attributable to maintenance, equipment failure, or other events	3.25 hour
Downtime attributable to power failure	22.75 hours
Average flow rate and total volume treated [1]	240 gpm 126,561,900 gallons
Total mass of contaminants removed [2]	12.1 lbs
Contaminants contributing to the majority of the mass removed	DCPD – 6.00 DIMP – 2.05 Trichloroethylene – 0.75 Carbon tetrachloride – 0.66 Chloroform – 0.62 Tetrachloroethylene – 0.49 NDPA – 0.41 Dieldrin – 0.30 MEXCLR – 0.19 14DIOX – 0.10
Carbon Usage	60,000 lbs
Cost of Operations	$476,568

Notes:

FY21 data covers the time period October 3, 2020 through October 1, 2021. Refer to Appendix H2 for listing of contaminant names.

[1] Average flow rate and total volume treated are based on metered readings for the three adsorbers within the NBCS plant. See NBCS Water Management Report_FY21.pdf included in data accompanying the report.

[2] See NBCS Contaminant Removal Report_FY21.pdf included in data accompanying the report.

gpm – gallons per minute

lbs – pounds

Table 3.2-2. Overview of FY21 CSRG Analyte Sampling for NBCS Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells											Downgradient Wells															
		23119	23160	23211	24101	24105	24106	24114	24117	24185	24199	24201	23405	23253 [2]	23434	23436	23438	24004	24006	24412 [2]	24415	24418	24163 [2]	24421	24164 [2]	24424	37362	24429 [2]
1,2-Dichloroethane	0.4		Q3		Q3							Q3																
1,2-Dichloroethylene	70																											
1,4-Dioxane	0.35	Q3	Q3		Q3							Q4		Q3					Q3			Q3		Q3				Q3
1,4-Oxathiane	160																											
Aldrin [1a]	0.002/0.014																											
Arsenic	2.35			Q3																			Q3					
Atrazine	3																											
Benzene	3																											
Carbon tetrachloride	0.3									Q3																		
Chloride	250,000	Q3	Q3	Q3	Q3							Q3			Q3	Q3					Q3	Q3	Q3		Q3	Q3		Q3
Chloroform	6																											
CPMS	30																											
CPMSO	36																											
CPMSO2	36																											
DBCP	0.20																											
DCPD	46				Q3																							
Dieldrin [1a]	0.002/0.013	Q3	Q3	Q3	Q3		Q3		Q3	Q3		Q3	Q3		Q3		Q3	Q3			Q3	Q3	Q3	Q3	Q3	Q3		Q3
DIMP	8				Q3							Q3								Q3								
Dithiane	18																											
Endrin	2																											
Fluoride	2,000	Q3		Q3								Q3				Q3												
Isodrin	0.06	Q3	Q3		Q3							Q3																
Malathion	100																											
Methylene chloride	5																											

Table 3.2-2. Overview of FY21 CSRG Analyte Sampling for NBCS Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells											Downgradient Wells															
		23119	23160	23211	24101	24105	24106	24114	24117	24185	24199	24201	23405	23253 [2]	23434	23436	23438	24004	24006	24412 [2]	24415	24418	24163 [2]	24421	24164 [2]	24424	37362	24429 [2]
NDMA [1b]	0.00069/0.009	Q3	Q3		Q3							Q3																	
NDPA	0.005	Q3	Q3		Q3							Q3																	
Sulfate	540,000	Q3	Q3	Q3	Q3		Q3					Q3			Q3	Q3					Q3								
Tetrachloroethylene	5											Q3																	
Toluene	1000																												
Trichloroethylene	3		Q3		Q3							Q3																	
Xylenes	1000																												

Notes:

The reported concentration for a well sample was higher than the CSRG or PQL for the respective analyte during the quarters indicated.

Shading indicates that the respective well was not sampled for the indicated analyte or the data were not usable in FY21.

Blank cells indicate that reported concentrations for the well samples were lower than the CSRG or PQL for the respective analyte.

1. The ROD indicates PQLs for the following analytes:

   [a] Aldrin and Dieldrin – Effective April 2012

   [b] NDMA – Effective September 2016

2. Alternate NBCS well sampled in accordance with OCN-LTMP-2019-004.

Table 3.3-1. BANS Treatment Systems Statistics for FY21

Total Downtime	15 hours
Downtime attributable to maintenance, equipment failure, or other events	8.25 hours
Downtime attributable to power failure	9.75 hours
Average flow rate and total volume treated [1]	20.5 gpm 10,765,030 gallons
Total mass of contaminants removed [2]	62.5 lbs
Contaminants contributing to the majority of the mass removed	Trichloroethylene – 13.65 DIMP – 13.15 Chloroform – 12.97 Dithiane – 9.71 Tetrachloroethylene – 3.69 CPMSO2 – 2.82 12DCE – 1.028 TCLEA – 1.11 1,4-Oxathiane – 1.04 NDPA – 0.10 Arsenic – 0.88 12DCLE – 0.81 Dieldrin – 0.06
Carbon Usage	15,170 lbs
Cost of Operations	$453,542

Notes:

FY21 data covers the time period October 3, 2020 through October 1, 2021. Refer to Appendix H2 for listing of contaminant names. BANS treatment supports groundwater extracted at BANS, BRES, CADT, and Lime Basins.

[1] Average flow rate and total volume treated are based on metered readings for the effluent tank within the BANS plant. See BANS Water Management Report_FY21.pdf included in data accompanying the report.

[2] See BANS Contaminant Removal Report_FY21.pdf included in data accompanying the report.

gpm – gallons per minute

lbs – pounds

Table 3.3-2. FY21 BANS Estimated Contaminant Flow Rate and Mass Removal

Contaminant Flow Rate [1]	Total – 15.42 gpm Into Capture Zone – 14.67 gpm North of Capture Zone – 0.75 gpm South of Capture Zone – 0.00074 gpm
Plume Mass Flux [1]	Total – 12.42 lbs Into Capture Zone – 12.23 lbs North of Capture Zone – 0.19 lbs South of Capture Zone – 0.00018 lbs
Extracted Mass	12.23 lbs
Percent Mass Removed	**98.5%**

Notes:

1. Any apparent discrepancies in the quantities for mass removal can be accounted for in mathematical rounding as shown in the calculations presented in the FY21 BANS-BRES-CADT-Lime Basins folder on the attached CD.

Table 3.3-3. Overview of FY21 CSRG Analyte Sampling for BANS and BRES Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	BANS Wells															BRES Wells							
		Upgradient											Downgradient				Upgradient				Downgradient			
		26307	26507	35301	35302	35303	35304	35305	35306	35512	35514	35516	26501	26505	35505	35525	36565	36567	36575	36250	36555	36566	36571	36572
1,1,1-Trichloroethane	200																							
1,1-Dichloroethylene	7																	Q2 Q4						
1,2-Dichlorobenzene	600																							
1,2-Dichloroethane	0.4	Q4		Q4	Q4	Q4	Q4	Q4	Q1 Q4		Q4	Q4						Q2 Q4		Q4		Q2 Q4		
1,3-Dichlorobenzene	94																							
1,4-Dichlorobenzene	75																							
1,4-Oxathiane	160																							
Arsenic	50																							
Atrazine	3																							
Benzene	5							Q4																
Carbon tetrachloride	0.3																	Q2 Q4		Q4		Q4		
Chlorobenzene	100																							
Chloroform	6																	Q2 Q4		Q4		Q2 Q4		
CPMS	30																							
CPMSO	36																							
CPMSO2	36				Q4			Q4			Q4													
Dicyclopentadiene	46																							
Dieldrin [1a]	0.002/0.013	Q4	Q4	Q4	Q4	Q4	Q4	Q4	Q1 Q4	Q4	Q4	Q4			Q4	Q4		Q4						
DIMP [2]	8			Q4			Q4											Q4		Q4		Q4		
Dithiane	18				Q4	Q4	Q4	Q4			Q4													
Endrin	2																							
Hexachlorocyclopentadiene	50																							

Table 3.3-3. Overview of FY21 CSRG Analyte Sampling for BANS and BRES Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	BANS Wells															BRES Wells							
		Upgradient											Downgradient				Upgradient				Downgradient			
		26307	26507	35301	35302	35303	35304	35305	35306	35512	35514	35516	26501	26505	35505	35525	36565	36567	36575	36250	36555	36566	36571	36572
Mercury	2																							
PPDDT	0.10							Q4	Q1	Q4	Q4	Q4				Q4								
Tetrachloroethane	0.18							Q4																
Tetrachloroethylene	5							Q4										Q2 Q4		Q4		Q2 Q4		
Trichloroethylene	5							Q4										Q2 Q4		Q4		Q2 Q4		

Notes:

The reported concentration for a well sample was higher than the CSRG or PQL for the respective analyte during the quarters indicated.

Shading indicates that the respective well was not sampled for the indicated analyte or the data were not usable in FY21.

Blank cells indicate that reported concentrations for the well samples were lower than the CSRG or PQL for the respective analyte.

1. The ROD indicates PQLs for the following analytes:

   [a] Dieldrin – Effective April 2012

2. DIMP is not a BANS CSRG analyte, but the CBSG is provided for reference.

Table 4.2-1. Shell Disposal Trenches FY21 Performance Groundwater and Trench Bottom Elevations

Borehole ID	Trench Bottom Elevation (feet amsl)	Groundwater Elevation (feet amsl)			
		Quarter 1 12/3/2020	Quarter 2 2/25/2021	Quarter 3 5/27/2021	Quarter 4 7/28/2021
3178	5242.0	5236.4	5236.1	5238.1	5238.2
3444	5244.1	5236.8	5236.5	5236.9	5236.9
3445	5240.5	5236.0	5235.8	5237.2	5236.7
3446	5240.6	5235.7	5235.4	5236.7	5236.5
3457	5240.8	5236.5	5236.1	5237.7	5237.8
SDT-02	5238.4	5237.0	5236.8	5237.1	5237.2

Notes:

Groundwater elevations for each quarter at each bore location are presented quarterly in Treatment Plant Effluent Water Quality Data Reports FY21 (Navarro 2022b, 2021a, 2021c, 2021d). Trench bottom elevations were higher than groundwater elevations for all four quarters of FY21.

Table 4.3-1. FY21 Lime Basins DNAPL Removal

Well	FY21 Quarterly Monitoring		Removal Operations – 9/29/2021	
	Date	DNAPL Thickness (feet)	DNAPL Thickness (feet)	DNAPL Removed (gallons)
Monitoring Wells				
36235	8/11/2021	0.83	<1	—
36248	8/11/2021	2.67–2.83	2.75	0.5
Extraction Wells				
36319	8/11/2021	2.75–3.17	2.92	4.5
36320	8/11/2021	1.08–1.92	1.08	2.00

Table 5.1-1. Off-post Treatment Systems Statistics for FY21

Treatment System	OGITS [1]	FCTS [2]
Dates of Operation	10/1/2020–5/3/2021	5/24/2021–10/1/2021
Total Downtime	43.25 hours	13.25 hours
Downtime attributable to maintenance, equipment failure, or other events	22 hours	9.25 hours
Downtime attributable to power failure	21.25 hours	4 hours
Average flow rate and total volume treated [3]	160 gpm 49,158,772 gallons	46.0 gpm 8,615,759 gallons
Total mass of contaminants removed [4]	0.80 lbs	0.97 lbs
Contaminants contributing to the majority of the mass removed (lbs) [5]	DIMP – 0.57 Chloroform – 0.11 Tetrachloroethylene – 0.07	DIMP – 0.95 DCPD – 0.013
Carbon Usage	20,000 lbs	1,500 lbs
Cost of Operation	$519,081 total for OGITS and FCTS in FY21	

Notes:

[1] FY21 data for OGITS covers the time period October 3, 2020 through May 3, 2021 when the OGITS was operational and treating FCS groundwater during quarters 1 and 2, and NPS groundwater during quarter 3.

[2] FY21 data for FCTS covers the time period May 24 through October 1, 2021.

[3] Average flow rate and total volume treated are based on metered readings for the effluent tanks within the OGITS and FCTS plants. See OGITS and FCTS Water Management Report_FY21.pdf included in data accompanying the report.

[4] See OGITS Contaminant Removal Report_FY21.pdf and FCTS Contaminant Removal Report_FY21.pdf included in data accompanying the report.

[5] Refer to Appendix H2 for listing of contaminant names.

gpm – gallons per minute
lbs – pounds

Table 5.2-1. Overview of FY21 CSRG Analyte Sampling for First Creek System Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells						Extraction Wells			Downgradient Wells		
		37074	37075	37076	37083	37370	37373	37800	37801	37802	37084	37110	37163
1,2-Dichloroethane	0.4			Q4	Q4								
1,3-Dichlorobenzene	6.5												
1,4-Oxathiane [3]	160												
Aldrin [1a]	0.002/0.014												
Arsenic	2.35												
Atrazine [3]	3												
Benzene	3												
Carbon tetrachloride	0.3												
Chlordane [2]	0.03			Q4									
Chloride	250,000			Q4		Q4				Q4	Q4	Q4	Q4
Chlorobenzene	25												
Chloroform	6												
CPMS [3]	30												
CPMSO [3]	36												
CPMSO2 [3]	36												
DBCP	0.2												
DCPD	46												
Dieldrin [1a]	0.002/0.013	Q4	Q4	Q4		Q4	Q4			Q4			Q4
DIMP	8		Q4	Q4	Q4		Q4		Q4	Q4			Q4
Dithiane [3]	18												
Endrin	2												
Ethylbenzene	200												

Table 5.2-1. Overview of FY21 CSRG Analyte Sampling for First Creek System Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells						Extraction Wells			Downgradient Wells		
		37074	37075	37076	37083	37370	37373	37800	37801	37802	37084	37110	37163
Fluoride	2,000	Q4										Q4	
Hexachlorocyclopentadiene	0.23												
Isodrin	0.06												Q4
Malathion [3]	100												
NDMA [1b]	0.00069/ 0.009												
NDPA	0.005			Q4	Q4								
PPDDE	0.1												
PPDDT	0.1												
Sulfate	540,000			Q4		Q4					Q4	Q4	
Tetrachloroethylene	5												
Toluene	1000												
Trichloroethylene	3												
Xylenes	1000												

Notes:

The reported concentration for a well sample was higher than the CSRG or PQL for the respective analyte during the quarters indicated.

Shading indicates that the respective well was not sampled for the indicated analyte or the data were not usable in FY21.

Blank cells indicate that reported concentrations for the well samples were lower than the CSRG or PQL for the respective analyte.

1. The ROD indicates PQLs for the following analytes:
   - [a] Aldrin and Dieldrin – Effective April 2012
   - [b] NDMA – Effective September 2016
2. Chlordane value was obtained by adding the results of cis-chlordane (ACLDAN) and trans-chlordane (GCLDAN).
3. These analytes are monitored twice every five years and will next be analyzed in FY22.

Table 5.2-2. Overview of FY21 CSRG Analyte Sampling for Northern Pathway System Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells											Cross-Gradient Wells			Downgradient Wells [2]					
		37157	37160	37159	37158	37457	37458	37469	37471	37473	37474	EPA-4	37027	37039	37452	37008	37009	37010	37011	37012	37013
1,2-Dichloroethane	0.4																				
1,3-Dichlorobenzene	6.5																				
1,4-Oxathiane	160																				
Aldrin [1a]	0.002/0.014																				
Arsenic	2.35																				
Atrazine	3																				
Benzene	3																				
Carbon tetrachloride	0.3							Q4													
Chlordane	0.03																				
Chloride	250,000	Q4				Q4	Q4						Q4							Q4	
Chlorobenzene	25																				
Chloroform	6																				
CPMS	30																				
CPMSO	36																				
CPMSO2	36																				
DBCP	0.2																				
DCPD	46																				
Dieldrin [1a]	0.002/0.013			Q4					Q4	Q4	Q4										
DIMP	8																				
Dithiane	18																				
Endrin	2																				
Ethylbenzene	200																				

Table 5.2-2. Overview of FY21 CSRG Analyte Sampling for Northern Pathway System Performance Wells

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells											Cross-Gradient Wells			Downgradient Wells [2]					
		37157	37160	37159	37158	37457	37458	37469	37471	37473	37474	EPA-4	37027	37039	37452	37008	37009	37010	37011	37012	37013
Fluoride	2,000		Q4										Q4								
Hexachlorocyclopentadiene	0.23																				
Isodrin	0.06																				
Malathion	100																				
NDMA [1b]	0.00069/ 0.009																				
NDPA	0.005					Q4	Q4														
PPDDE	0.1																				
PPDDT	0.1																				
Sulfate	540,000						Q4						Q4								
Tetrachloroethylene	5																				
Toluene	1000																				
Trichloroethylene	3																				
Xylenes	1000																				

Notes:

The reported concentration for a well sample higher than the CSRG or PQL for the respective analyte during the quarters indicated.

Shading indicates that the respective well was not sampled for the indicated analyte or the data were not usable in FY21.

Blank cells indicate that reported concentrations for the well samples were lower than the CSRG or PQL for the respective analyte.

1. The ROD indicates PQLs for the following analytes:
   - [a] Aldrin and Dieldrin – Effective April 2012
   - [b] NDMA – Effective September 2016
2. In October 2020, Wells 37094, 37095, 37395 and 37404 were replaced by wells 37157, 37160, 37159 and 37158, respectively.

Table 7.2-1. Analytical Results of the FY21 Off-Post Surface Water Monitoring Program

Analyte	CSRG/PQL (µg/L)	SW08003 First Creek Near Buckley Road	SW24004 First Creek Near 96th Avenue	SW37001 First Creek Near Hwy 2
		Concentrations (µg/L) – Sampled 6/16/2021 [1]		
Aldrin	0.014	LT 0.00605	LT 0.00605	LT 0.00605
Arsenic [2]	2.35	LT 1	1.32	2.14
Chloride	250,000	137,000	169,000	179,000
Dieldrin	0.013	LT 0.00252	LT 0.00252	0.00252
DIMP	8	LT 0.5	LT 0.5	LT 0.5
NNDMEA	0.009	LT 0.003	LT 0.003	LT 0.003
Sulfate	540,000	193,000	223,000	236,000

Notes:

[1] No results exceeded CSRGs/PQLs as presented in the LTMP Surface Water Sampling and Analysis Plan (Navarro 2014).

[2] All arsenic concentrations represent filtered samples.

Table 7.3-1. FY21 Water Quality Data for the Off-Post Private Well Network

Private Well ID	Sample Date [1]	Analyte Concentrations (µg/L)		
		DIMP (CBSG – 8 µg/L)	1,4-Dioxane (CBSG – 0.35 µg/L)	Dieldrin (PQL – 0.013 µg/L)
Alluvial Aquifer				
359C	7/6/2021	0.712	NA	NA
541A	6/29/2021	LT 0.50	0.301	NA
986A	6/16/2021	0.79	0.257	0.00813
989A	8/4/2021	LT 0.50	LT 0.075	0.00861
1324B	7/29/2021	LT 0.50	LT 0.075	LT 0.00252
1402B	6/22/2021	LT 0.50	0.141	0.00369
Arapahoe Aquifer				
359D	7/6/2021	12.1	NA	NA
486A	9/1/2021	LT 0.50	LT 0.075	LT 0.00252
983A	8/11/2021	0.645	LT 0.075	LT 0.00252
984B	6/14/2021	0.701	NA	NA
986B	6/16/2021	LT 0.50	LT 0.0075	LT 0.00252
986B-R	7/22/2021	LT 0.50	LT 0.0075	LT 0.00252
1190A	6/8/2021	LT 0.50	NA	NA
1324A	7/29/2021	LT 0.50	0.176	LT 0.00252
1334H	7/6/2021	LT 0.50	NA	NA
1377C	6/9/2021	LT 0.50	NA	NA
1556A	9/1/2021	LT 0.50	LT 0.075	LT 0.00252

Notes:

[1] Results are provided for calendar year 2021 as presented in the Private Well Monitoring Program Annual Summary for Fiscal Year 2021 (TCHD 2021).

LT – Analyte not detected and reported as a value less than the reporting limit.

NA – Not analyzed

Table 8.1-1. Railyard Containment System Shut-Off Monitoring Results for FY21

Well	Sample Date	Analyte Concentration (µg/L)	
		DBCP (CSRG – 0.2 µg/L)	Trichloroethylene (CSRG – 5 µg/L)
Upgradient Wells			
03501	12/7/20	LT 0.0192	LT 0.2
	3/9/21	LT 0.0192	LT 0.2
	5/12/21	LT 0.0194	LT 0.2
	7/19/21	LT 0.0192	LT 0.2
03502	Not sampled in FY21	—	—
03503	12/7/20	LT 0.0188	LT 0.2
	3/9/21	LT 0.019	LT 0.2
	5/12/21	LT 0.0194	LT 0.2
	7/19/21	LT 0.0194	LT 0.2
03534	12/7/20	LT 0.019	LT 0.2
	3/9/21	LT 0.019	LT 0.2
	5/13/21	LT 0.0192	LT 0.2
	7/20/21	LT 0.0194	LT 0.2
03538	12/7/20	LT 0.019	LT 0.2
	3/9/21	LT 0.0192	LT 0.2
	5/12/21	LT 0.0194	LT 0.2
	7/19/21	LT 0.0194	LT 0.2
Downgradient Wells			
03528	12/8/20	LT 0.019	LT 0.2
	3/8/21	LT 0.0192	LT 0.2
	5/13/21	LT 0.0194	LT 0.2
	7/19/21	LT 0.0194	LT 0.2
03529	12/8/20	LT 0.019	LT 0.2
	3/8/21	LT 0.0192	LT 0.2
	5/13/21	LT 0.0192	LT 0.2
	7/20/21	LT 0.0194	LT 0.2
03530	12/8/20	LT 0.0194	LT 0.2
	3/8/21	LT 0.019	LT 0.2
	5/13/21	LT 0.0192	LT 0.2
	7/20/21	LT 0.0192	LT 0.2

Notes:
LT – Analyte not detected and reported as less than the reporting limit.

Table 8.2-1. Motor Pool System/Irondale Containment System Post-Shut-Off Monitoring Results for FY21

Well	Analyte Concentrations (µg/L) – Sampled 8/25/2021 [1]	
	DBCP (CSRG – 0.2 µg/L)	Trichloroethylene (CSRG – 5 µg/L)
Motor Pool System		
04021	Not sampled in FY21 [2]	
04535	NA	LT 0.2
Irondale Containment System		
33081	LT 0.0192	NA

Notes:

[1] No concentrations of detected analytes exceeded CSRGs in FY21. Annual sampling for wells 04535 and 33081 will next take place in the first quarter of FY22.

[2] Well 04021 is sampled twice every five years. This well will be sampled next in FY22.

NA – Not analyzed

Table 9.0-1. Perfluorinated Compounds Results for FY21 Treatment Plant Samples

Treatment Plant	Sample Date	Sample Location	Analyte Concentrations (µg/L) Health Advisory Level – 0.070 µg/L [1]	
			PFOA	PFOS
NWBCS	7/13/2021	Influent	LT 0.002	0.003
		Effluent	LT 0.002	LT 0.002
NBCS	7/6/2021	Influent	LT 0.002	LT 0.002
		Effluent	LT 0.002	LT 0.002
BANS	7/7/2021	Influent	0.006	0.0064
		Effluent	LT 0.002	LT 0.002
Off-Post – FCTS [2]	7/8/2021	Influent	LT 0.002	LT 0.002
		Effluent	LT 0.002	LT 0.002

Notes:

[1] None of the PFOA and PFOS results exceeded the health advisory level of 0.070 µg/L.

[2] Only First Creek treatment plant influent and effluent were sampled in FY21. The Northern Pathway treatment plant was under construction in FY21.

LT – Analyte was not detected and reported as less than the method reporting limit.

Table 10.0-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Northwest Boundary Containment System – Treatment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Primary Performance Criteria [2] – Original System	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Secondary Performance Criterion [2] – Original System	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate performance wells where CSRG/PQL exceedances occurred.
Northwest Boundary Containment System – Northeast Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	No. Dieldrin was detected above the PQL in downgradient performance wells 22015 and 22512, however, the long-term trend is not increasing in downgradient performance wells. The potential for contaminated flow toward the downgradient performance wells will be further evaluated based on semiannual monitoring continuing through FY23.

Table 10.0-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs/PQLs in downgradient performance wells.	Yes. Stable and decreasing trends for CSRG analytes are currently present in downgradient performance wells.
Northwest Boundary Containment System – Southwest Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate decreasing concentration trends or that concentrations are at or below the CSRGs/PQLs in downgradient performance wells.	Yes
North Boundary Containment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Primary Performance Criteria [2]	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps, and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes

Table 10.0-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Secondary Performance Criterion [2]	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate performance wells where CSRG/PQL exceedances occurred.
Basin A Neck System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods (OCN-LTMP-2012-002).	Yes
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes
Bedrock Ridge Extraction System Performance Criteria	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	Yes
Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.	No. Concentrations of 12DCLE and trichloroethylene are above CSRGs in well 36566 and exhibit increasing trends. Supplemental monitoring data are being evaluated to determine whether system optimization is required.

Table 10.0-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Complex Army Disposal Trenches Performance Criteria	
Demonstrate groundwater elevations in performance monitoring wells 36216 and 36217 are below the target elevations of 5226 and 5227 ft, respectively, or Demonstrate hydraulic gradient from the performance monitoring wells locations is toward the extraction trench.	Yes. The CADT system met the performance criteria and objectives established in the LTMP. Although the water levels remained above the trench-bottom elevation in well 36217, hydraulic control was maintained at both performance well locations.
Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).	Yes
Shell Disposal Trenches Performance Criterion	
Demonstrate groundwater elevations are below the disposal trench bottom elevations within the slurry wall enclosure listed in the 2021 LTMP, Table 5.2-2.	Yes. Groundwater elevation is below the bottom of trenches at all borehole locations.
Lime Basins Slurry Wall Dewatering System Performance Criteria	
Maintain a positive gradient from the outside to the inside of the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	No. Outward gradient is present in wells on the north side of the slurry wall.
Maintain a groundwater level below the elevation of the Lime Basins waste (5242 feet) inside the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	Yes
Lime Basins DNAPL Remediation Monitoring Performance Criteria	
Primary Goals [3]	
To determine if additional DNAPL source zones exist in the Lime Basins area in addition to those previously identified.	Yes. No additional DNAPL source zones based on measured DNAPL in wells.
To determine if the extent and nature of any discovered DNAPL source zones have the potential to adversely impact the slurry wall.	Yes. No adverse impacts to the slurry wall due to the presence of DNAPL have been observed.
To characterize DNAPL, if present, for the purpose of correlation with groundwater characterization data as a tool in the identification of DNAPL source zones and for the purpose of waste disposal.	Yes. DNAPL continues to be characterized.

Table 10.0-1. Summary of FY21 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Off-Post Groundwater Intercept and Treatment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the FCS and the transect method for the NPS (OCN-LTMP-2012-002).	Not Applicable. Mass removal was not evaluated due to shut down and construction on both the FCS and NPS during the FY21 evaluation period.
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes.
Railyard Containment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Not Applicable. System has been shut off and annual shut-off monitoring is continuing. Five-year monitoring period ends in FY22.
Performance Criteria	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	Not Applicable. System has been shut off and annual shut-off monitoring is continuing. Five-year monitoring period ends in FY22.
Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.	

Notes:

[1] Criteria and goals are listed as presented in the LTMP and reflect any changes in accordance with OCNs as indicated. Primary criteria are provided unless otherwise noted. For systems without primary/secondary criteria, all criteria must be met.

[2] Only the NWBCS and NBCS are bound to secondary performance criteria, and only if primary performance criteria are not met.

[3] There are no performance criteria for the Lime Basins DNAPL Remediation Monitoring program, but goals are specified in the LTMP.

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