U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Initial Five-Year Evaluation of the Interim Measures for Chromium Plume Control with An Assessment of Potential Modifications to Operations

ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

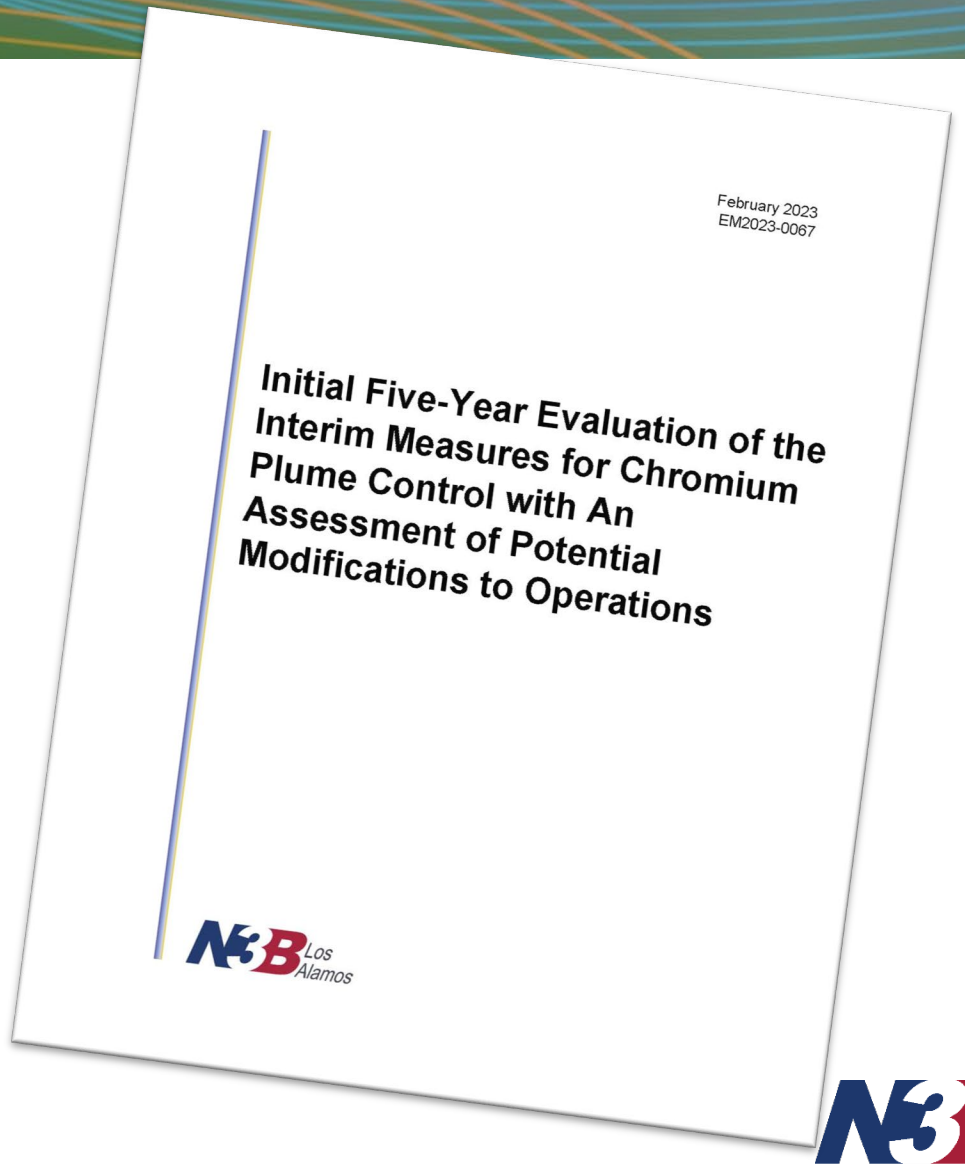
N3B

Clean Up The Environment - Protect Our Future

N3B Los Alamos

Overview

- Initial 5-yr analysis of IM influence on the regional aquifer
  - Background
  - Conceptual Site Model (CSM)
  - Changes in the potentiometric surface
  - Capture zone analysis
  - Chromium concentrations / plume behavior
  - Tracer analyses to date
  - Injection at plume edge
- Analyze impacts of potential modifications to the Interim Measures (IM)
  - Full IM operations (~285 gallons per minute [gpm])
  - Partial/reduced IM P&T operations (~140 gpm)
  - No injection - Land application only
  - No operations
- Recommendations



Water Rights and Permits

Joint Water Rights

Total water right to extract 5,541.3 acre feet per year (ac-ft/yr) for municipal, industrial, and related purposes jointly owned by the DOE and LAC, with a 30/70 split, respectively. LAC leased the DOE-owned water rights 2001 to 2011, when the lease expired.

2001-2011

Land Application Permit

Jul 2015

Discharge Permit 1793 (DP-1793) obtained from New Mexico Environment Department (NMED) Groundwater Quality Bureau (GWQB) to land apply up to 350,000 gallons per day of treated water. Several operational conditions exist (e.g., daylight operations only, no freezing conditions, no rainfall conditions, etc.) and water must be treated to 90% of numeric standards.

Water Right Application and Emergency Authorization Request

May 2016

DOE and Los Alamos County (LAC) submitted joint application to the New Mexico Office of State Engineer (OSE) to Change an Existing Water Right for 679 acre feet per annum (afa) along with a request for Emergency Authorization for approval to use the water rights immediately to operate the Chromium Plume Control IM addressing plume migration.

Underground Injection Control Well Permit

Aug 2016

Discharge Permit 1835 (DP-1835) granted from NMED GWQB, permitting injection into the regional aquifer through up to six Class V Underground Injection Control (UIC) wells, requiring all groundwater treated to achieve numeric standards equal to less than 90% of the numeric standards for seven analytes, including chromium.

Emergency Authorization

Sep 2016

Emergency Authorization to use the Ground Waters of the State of New Mexico approved "because operation of the additional groundwater Points of Diversion (PODs) are necessary to prevent detrimental delay in implementation of the interim measure to prevent plume migration and characterization of the chromium plume, which would result in serious economic loss.". Authorized no more than 679 afa.

Water Rights, Permits, and IM Operations

Jan 2017 — Southern IM Operations Initiated

Operations in the southern plume area were initiated in January 2017, with only CrEX-1, CrIN-4, and CrIN 5 in operation

May 2018 — Sustained Southern Operations

Sustained operations in the southern plume initiated 1.5 years after initial operations, and included CrEX-1, CrEX-2, CrEX 3, CrIN-3, CrIN-4, and CrIN-5.

Jan 2019 — Water Right Application and Emergency Authorization Request

Second joint application and request for Emergency Authorization submitted to the OSE to Change an Existing Water Right for 679 afa along with a request for Emergency Authorization for approval to use the water rights immediately to operate IM. 2019 Application and EA request added an extraction well and monitoring wells.

Sep 2019 — Emergency Authorization

Emergency Authorization to use the Ground Waters of the State of New Mexico approved "because operation of the additional groundwater PODs are necessary to prevent detrimental delay in implementation of the interim measure to prevent plume migration and characterization of the chromium plume, which would result in serious economic loss." Authorized no more than 679 afa. The 2019 EA supersedes the 2016 EA. IM operation continues under this EA.

Nov 2019 — Sustained Eastern Area Operations

Sustained eastern area operations began in November 2019, with all five extraction wells (CrEX-1, 2, 3, 4, & 5) and five injection wells (CrIN-1, 2, 3, 4 & 5) operational when available.

Dec 2020 — Joint Water Rights

Total water right to extract 5,541.3 afa for municipal, industrial, and related purposes jointly owned by the DOE and LAC, with a 30/70 split, respectively. LAC leased the 30% DOE-owned water rights December 2020.

NMED Direction

Notice of Violation under DP-1835

NMED GWQB issued a notice of violation (NOV) to U.S. Department of Energy Environmental Management Los Alamos Field Office (EM-LA). NOV was based on measured concentrations of total dissolved chromium in the regional aquifer at well R-45 screen 2 exceeding the 20.6.2.3103 New Mexico Administrative Code groundwater standard of 0.050 mg/L (50 ppb or 50 µg/L). NMED GWQB identified injection well CrIN-1 as the reason for the increased Cr concentration. Quality of injected water has never exceeded standards required by DP-1835

Direction to Continue Partial Operation

In an NMED Hazardous Waste Bureau (HWB) email dated November 21, 2022; NMED directed DOE to leave CrEX-1, CrEX-2, CrEX-3, CrIN-1, CrIN-2, and CrIN-3 offline until further notice.

Jun 6, 2022

Sep 22, 2022

Nov 21, 2022

Dec 12, 2022

Submittal of R-45 Action Plan

In response to NOV, EM-LA submitted the Regional Aquifer Monitoring Well R-45 Action Plan (N3B 2022, EM2022-0318). This plan included 4 Key Actions:

1. Qualitative and quantitative analyses examining the cause for concentration increases at regional
2. Simulation plan for identifying alternative extraction and injection rates to decrease chromium concentrations below the 0.050 mg/L standard at R-45 screen 2
3. New regional aquifer monitoring wells, one downgradient of R-45 (R-80) and one located in the northeastern region of the plume (R-79)
4. Continued monitoring to evaluate plume mass movement within the regional aquifer using the existing well network

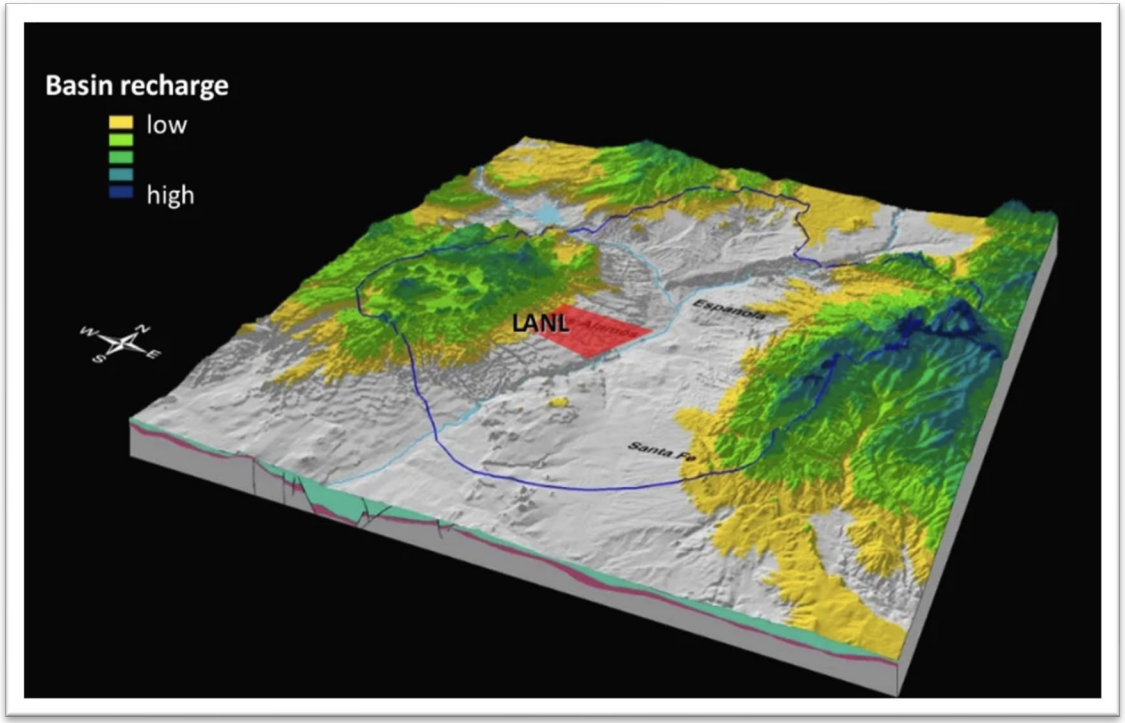
Direction to Cease All Injection

December 12, 2022, response to the R-45 Action Plan; NMED GWQB found Action Plan acceptable; however, requested additional actions "…to control the cause of the contamination migration and prevent further migration of the contamination plume." The letter also directed EM-LA to cease "…all injection activities until the Permittees complete the proposed corrective actions and can definitively prove through qualitative and quantitative analyses, simulations, monitoring well installation, and continued monitoring that further migration is not occurring." The date for cessation of all injection is April 1, 2023.

Conceptual Site Model (CSM)

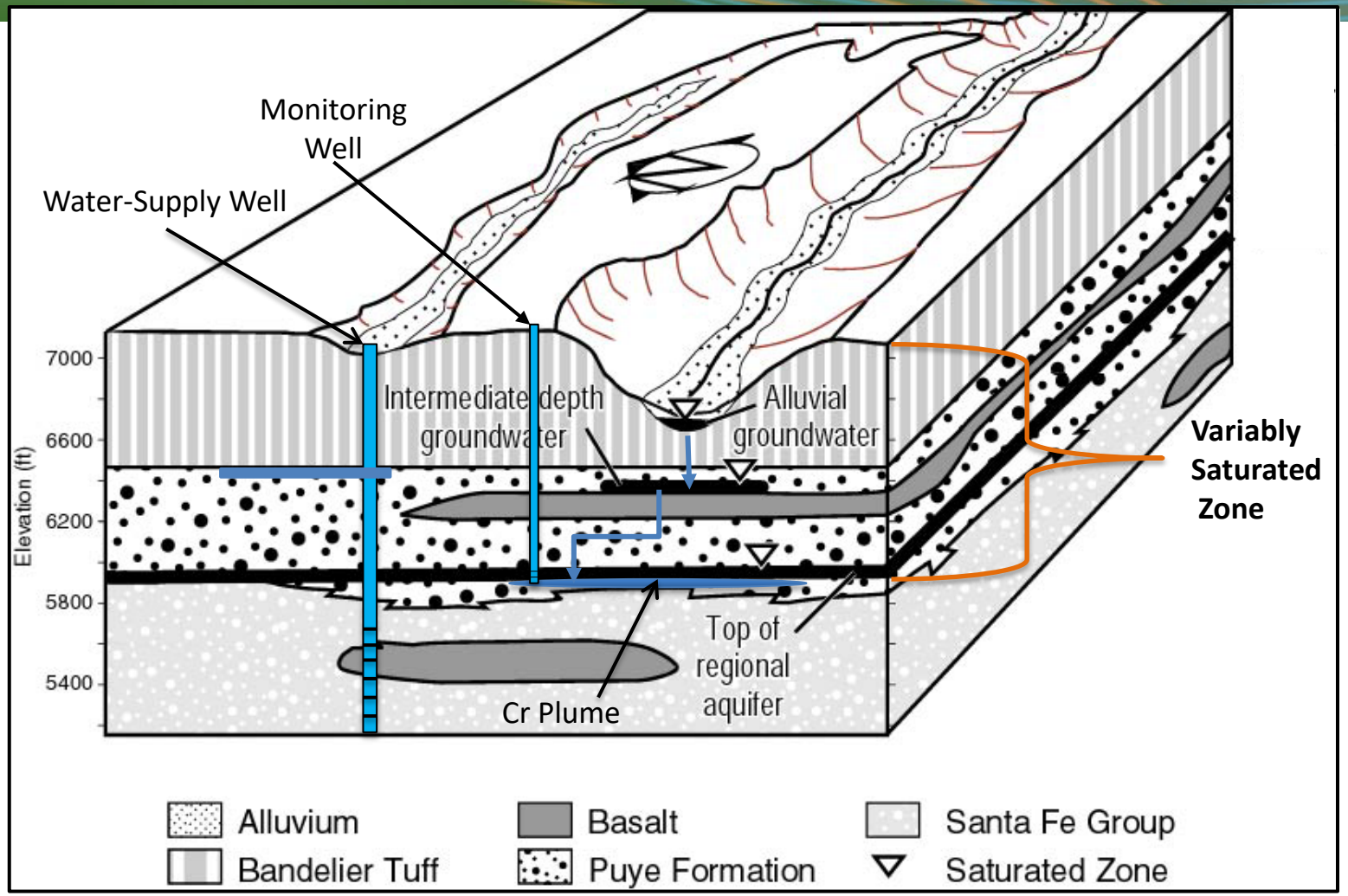
Hydrogeologic Setting

- Hexavalent Chromium (Cr) plume is located in the regional aquifer beneath The Laboratory property, with a small footprint relative to the Espanola basin
- Water infiltrating to the regional aquifer is higher in the mountain regions relative to the lowlands
- Canyons can create zones of focused recharge

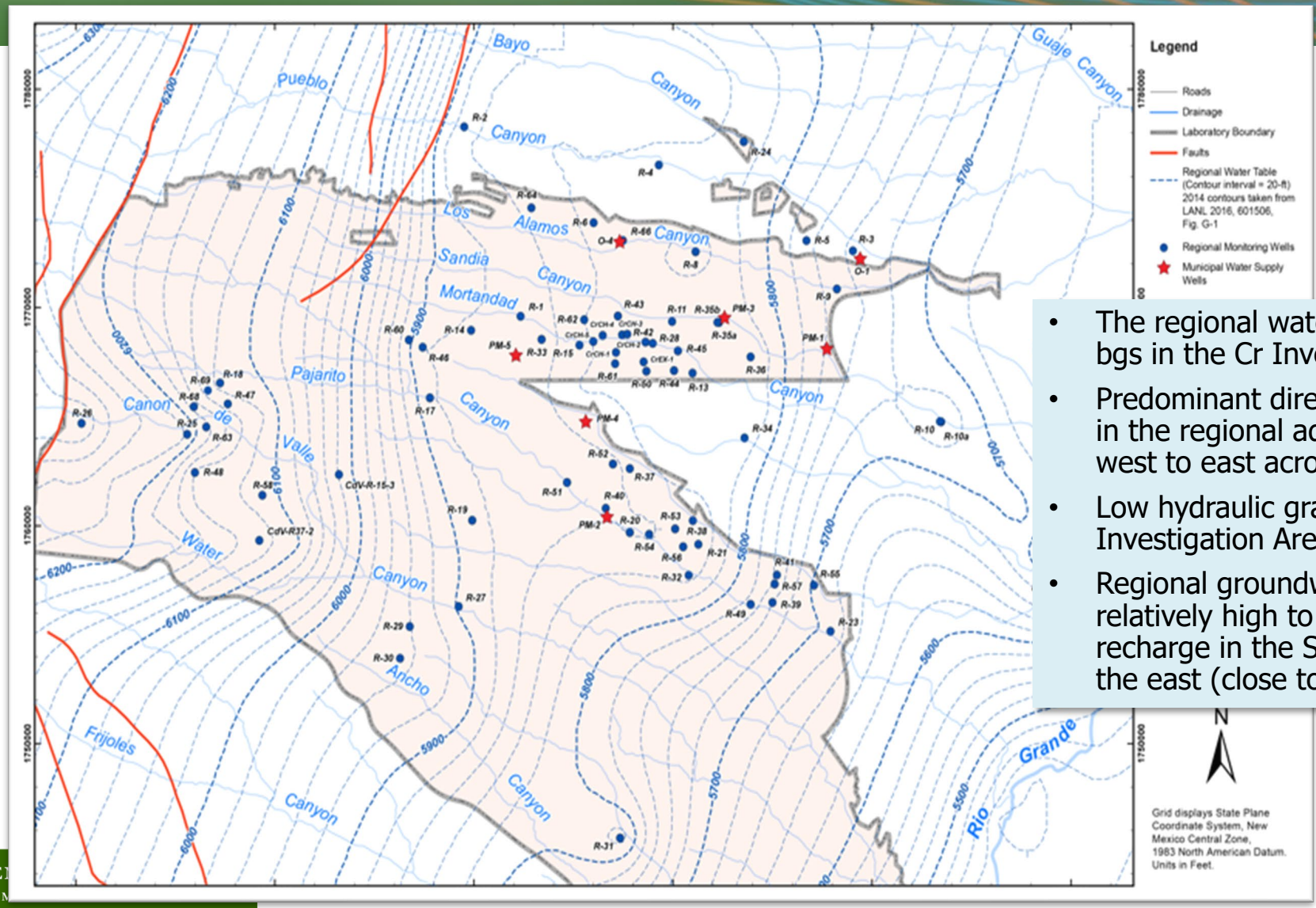


Current plume footprint estimated at ~1.0 mile x -.5 miles within the Espanola basin aquifer (18-40 miles wide and ~50 miles long. (Image from Vessilinov et. al 2010)

Major Geologic Units



Regional Aquifer



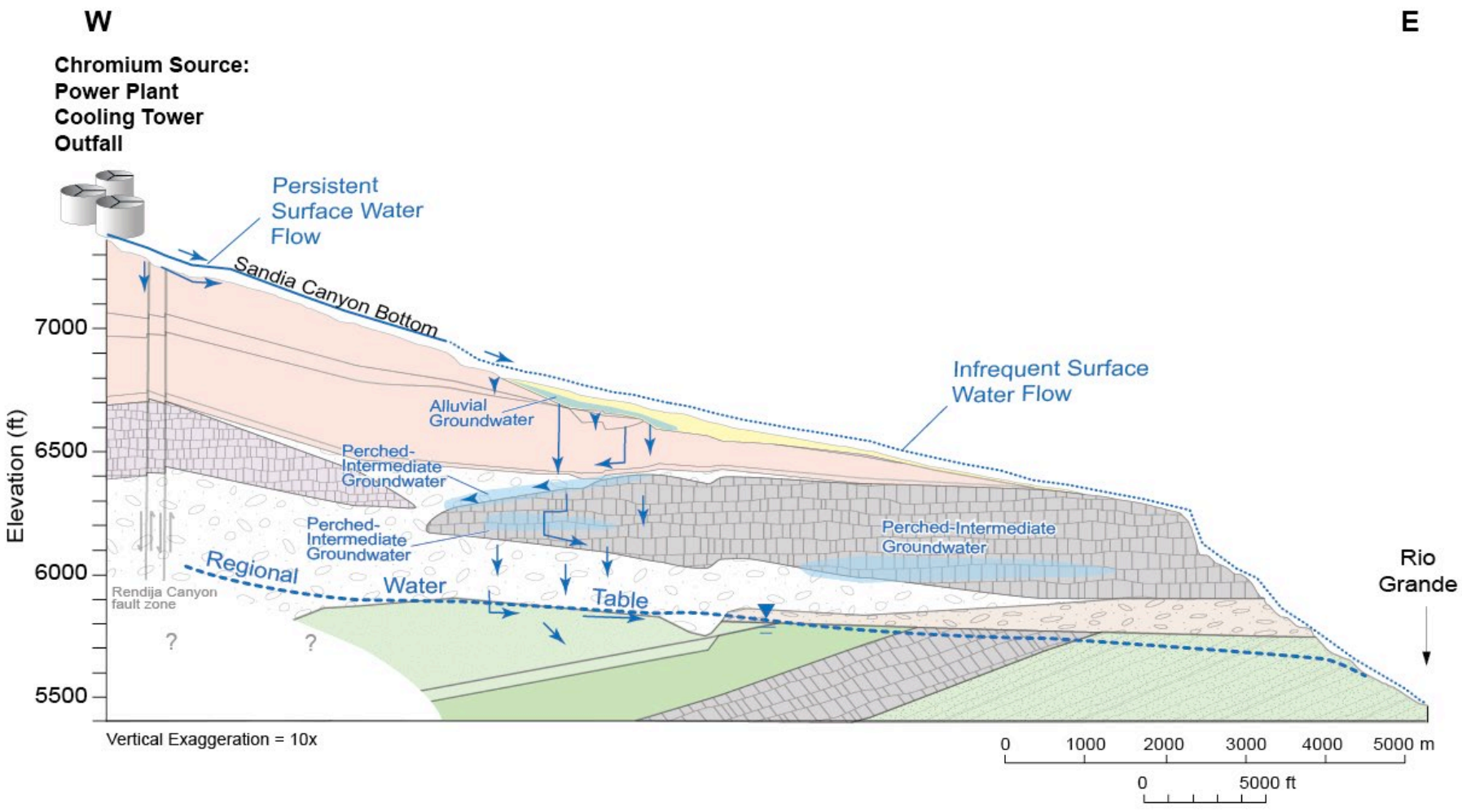
- The regional water table is ~900 – 1000 ft bgs in the Cr Investigation Area
- Predominant direction of groundwater flow in the regional aquifer is generally from west to east across the Pajarito Plateau
- Low hydraulic gradients in the Cr Investigation Area
- Regional groundwater flow gradients are relatively high to the west (close to recharge in the Sierra de los Valles) and to the east (close to the Rio Grande)

Hexavalent Chromium Fate and Transport

- Potassium dichromate used in cooling towers at a Laboratory power plant
- Up to 160,000 lb. released from 1956-72 in hexavalent (mobile) form [Cr(VI)]
- Water containing chromium travelled down Sandia Canyon until reaching an infiltration window, then migrating laterally and vertically until reaching Mortandad Canyon
- Not all of the chromium released is present in groundwater

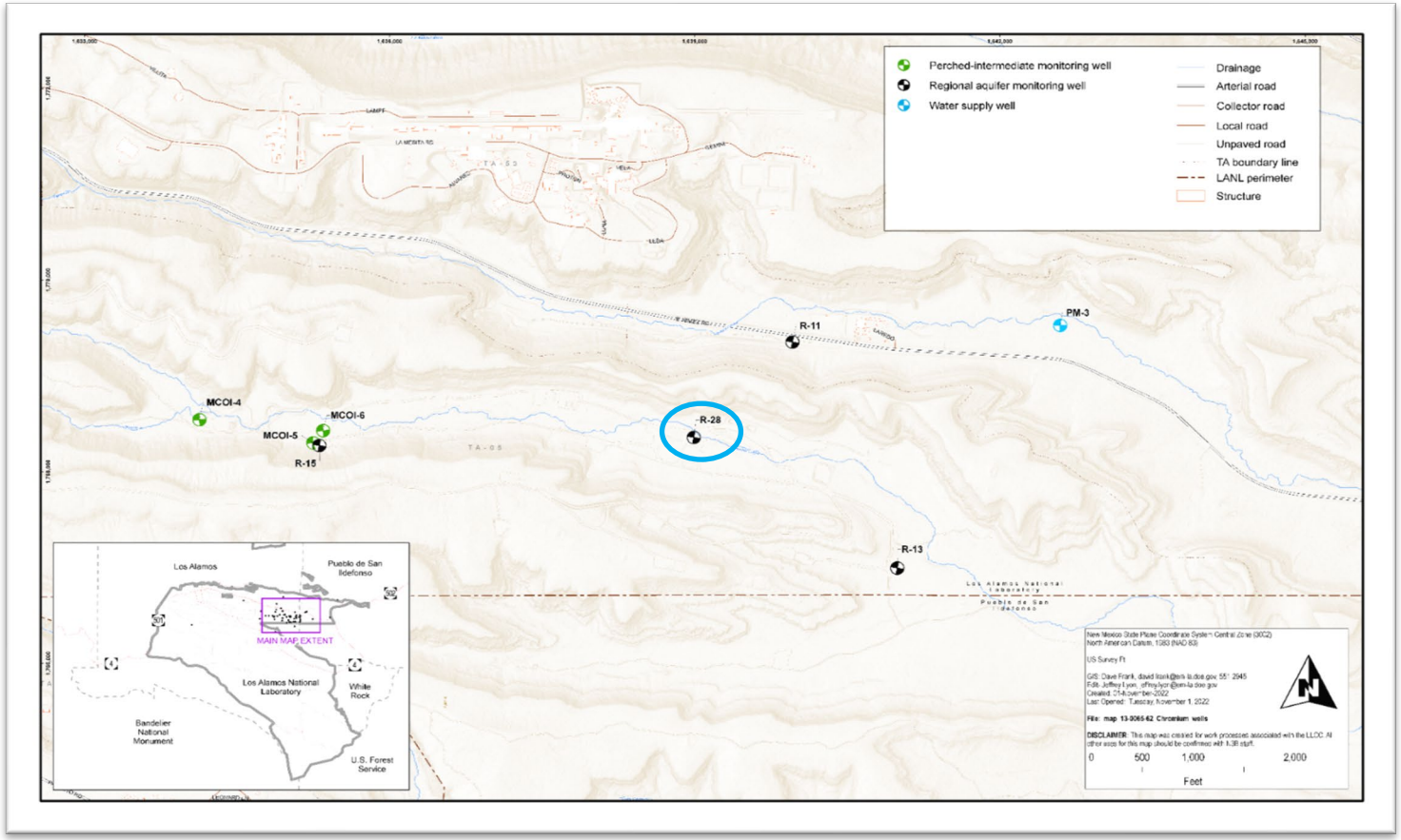
Pathway for Hexavalent Chromium

Conceptual model of chromium transport in the subsurface



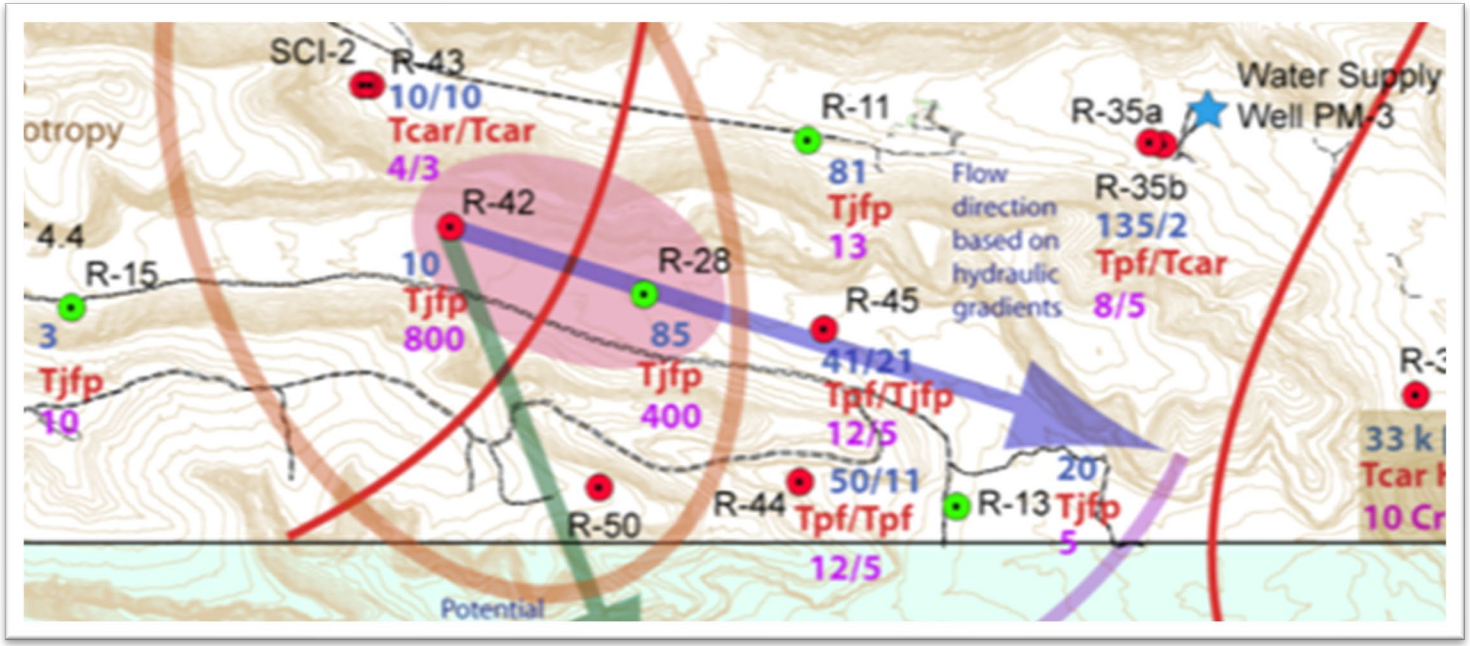
First Samples at R-28 (2005)

- Monitoring Well R-28 was installed in Mortandad Canyon in 2004 as part of an Investigation of the regional aquifer beneath Los Alamos National Laboratory (Hydrogeologic Work Plan 2004)
- First groundwater samples from R-28 contained Cr concentrations of 400 parts per billion (ppb); ~8 times the New Mexico drinking water standard (2005)
- R-11, R-13, and R-15: 10-15 ppb
- PM-3: 4-6 ppb



Conceptual Site Model (2009)

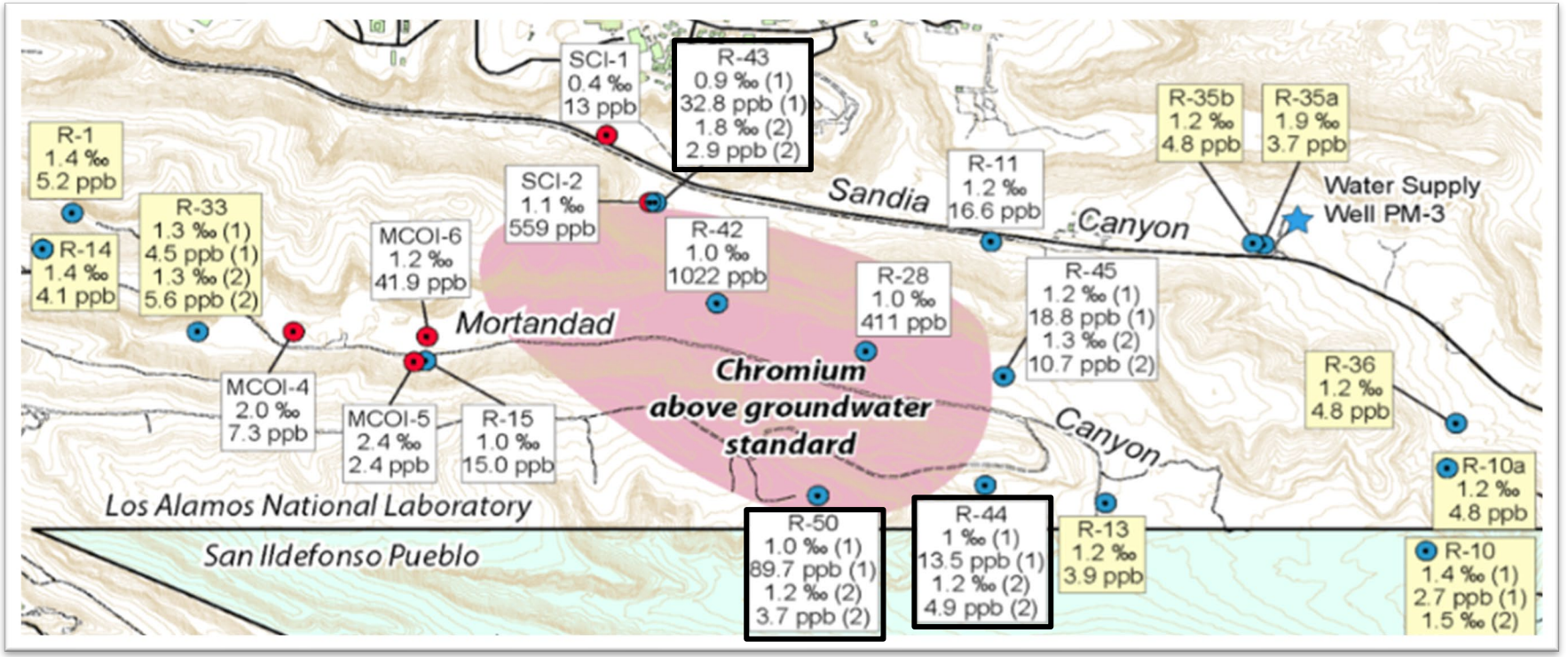
- Cr detected above 50 ppb at Wells R-42 and R-28
- Cr concentrations less than 50 ppb at Wells R-43, R-44, R-45
- No data at Well R-50
  - Data collection initiated in 2010
- Plume extends from Wells R-42 to R-28



Sandia Canyon Investigation Report, 2009

Conceptual Site Model (2012)

- Approximately 100 ppb at R-50
- Concentrations at R-43 screen (S) 1 and R-45 S1 and S2
- R-50 S1 Cr concentrations above standard



Sandia Canyon Phase II, 2012

Geologic Conceptual Model

- Detailed evaluation of stratigraphy to inform groundwater flow velocities and chromium transport behavior
- Three primary formation-scale units operate as a single hydrostratigraphic unit

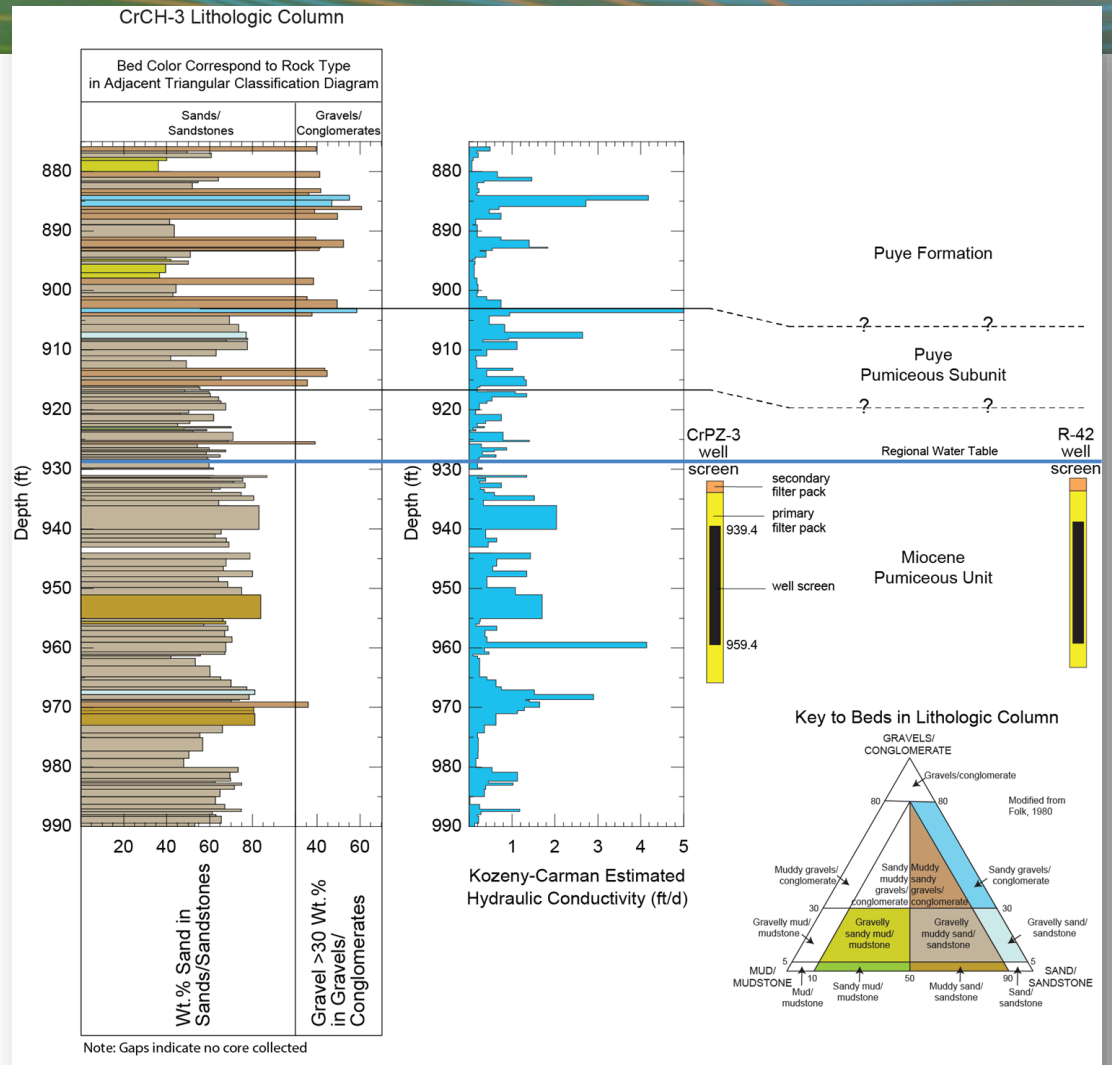
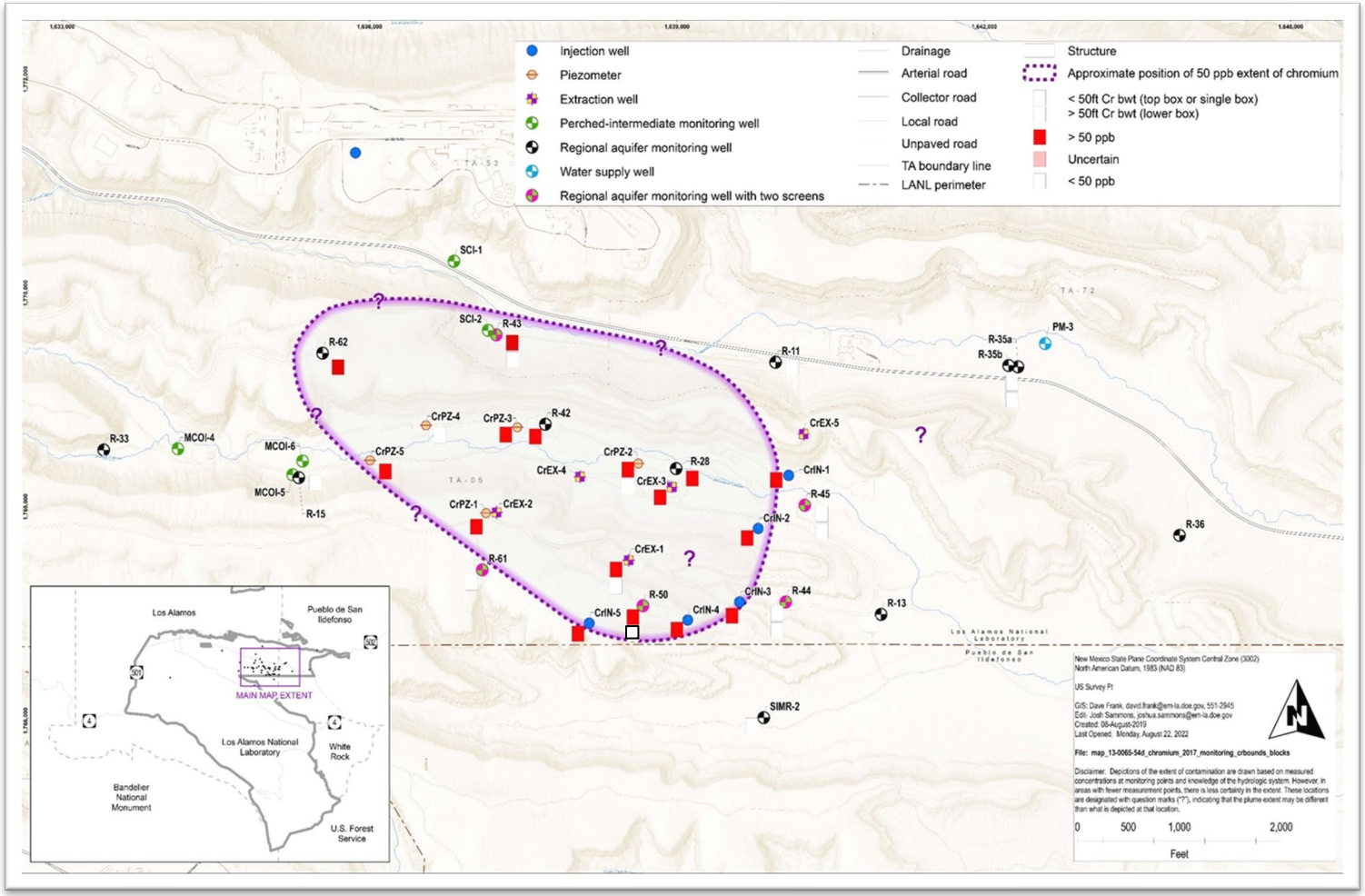


Figure 3.3.3-2 CrCH-3 lithologic column showing rock types for individual beds making up strata in the upper part of the regional aquifer. The CrPZ-3 (completed in the CrCH-3 bore hole) and R-42 well screens are shown for reference.

Chromium Conceptual Site Model (2015)

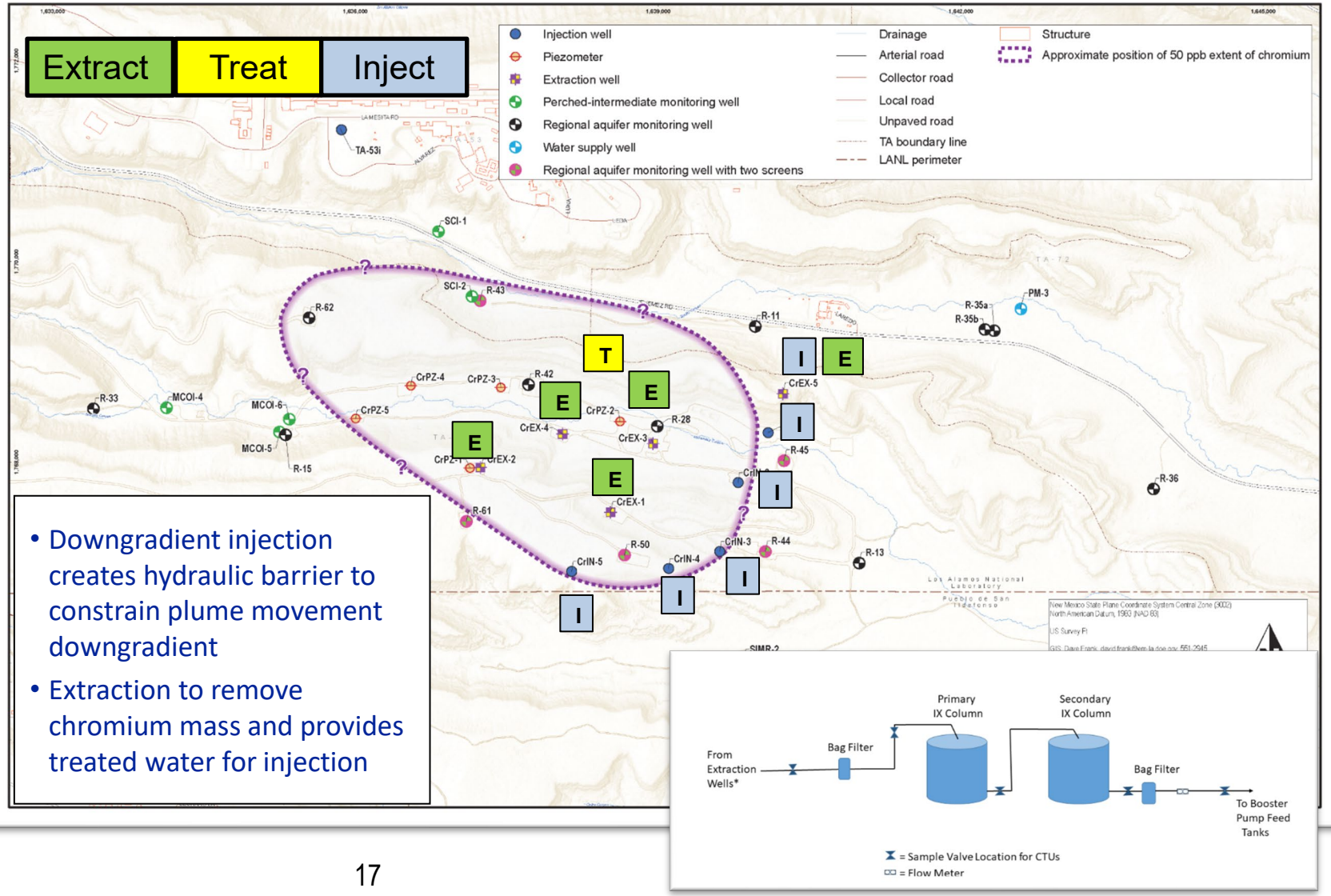
- Hexavalent Cr mobile under oxidizing conditions of regional aquifer
  - Sorption not significant
  - Assumed to be present in upper 50-60 ft of regional aquifer
- Groundwater flows west to east
  - Transport velocities highly variable due heterogeneity of basin fill sediments
  - Average groundwater velocity ~30 ft/yr



Plume depiction depicting the level of chromium concentrations (>50 or <50 ppb) at sampling locations.

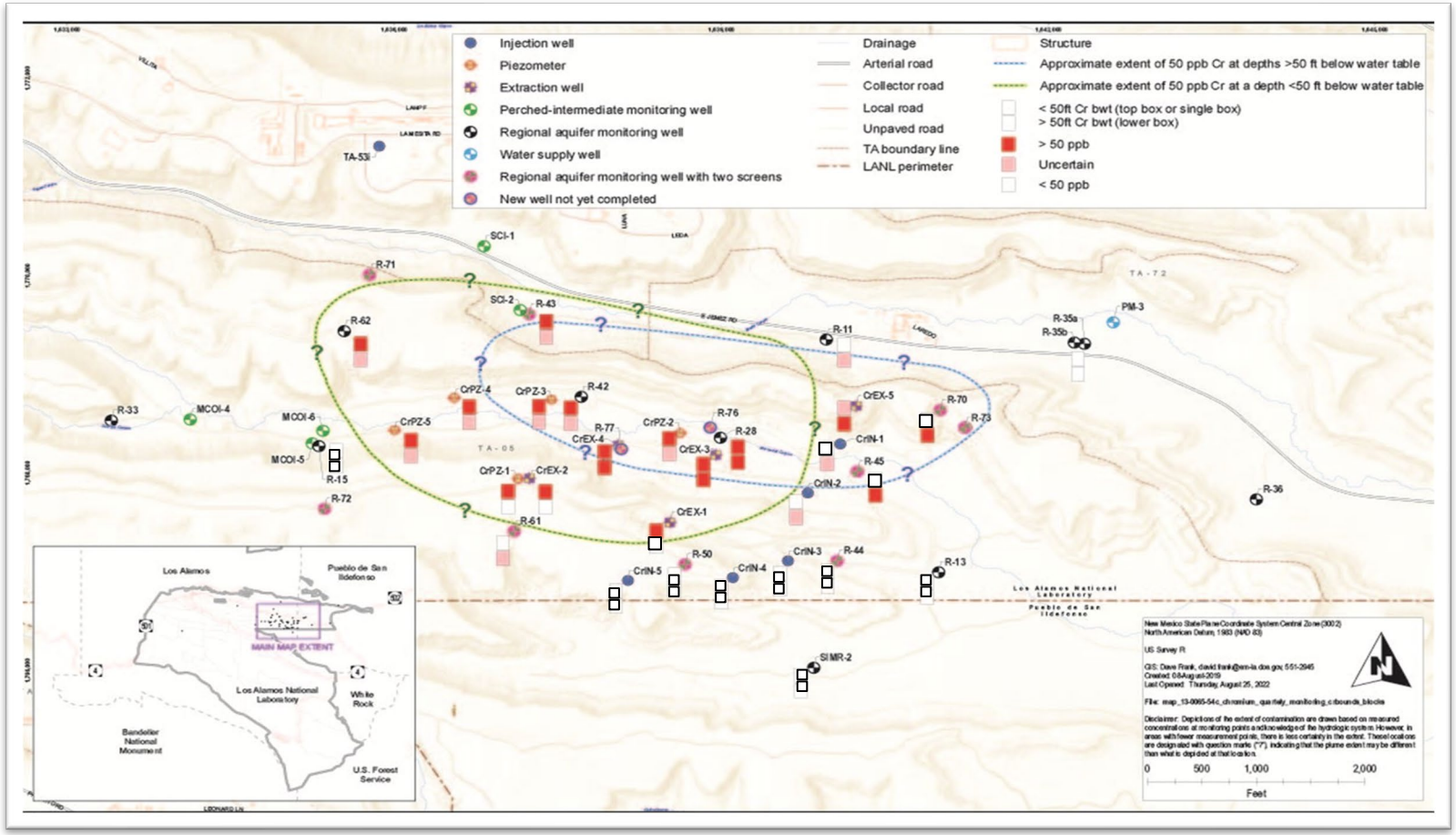
Interim Measures Design

- Designed for hydraulic plume control
  - Maintain 50 ppb plume edge within the Laboratory boundary
  - Combination of extraction and injection along the downgradient plume edge to lower concentrations at R-50 in less than 3 years of operation
- Five extraction and five injection wells
- Treatment trains (CTUs)
  - Primary ion exchange (IX) column (lead)
  - Secondary IX column (lag)
- Extracted water combined in the pipeline before reaching CTUs
- Distributed to injection wells



Chromium Conceptual Site Model (2023)

- CrEX-4 (2017) chromium located at depth near R-28 and R-42 in plume centroid (~75 ft below water table)
- CrEX-5 (2018) conversion of CrIN-6 to CrEX-5 to address high Cr concentrations and control plume
- R-70 S2 (2019) chromium located at depth (~90 ft below water table)
  - S1 concentrations near water table below standard
- Combination of extraction and injection resulted in a retreat of the 50 ppb plume line a significant distance north of the boundary with Pueblo de San Ildefonso



Present-day plume depiction, along with symbols depicting the level of chromium concentrations (>50 or <50 ppb) at sampling locations.

No Injection – Discharge Permit 1793, Land Application of Treated Water

Discharge Permit 1793 Terms and Conditions

1. Land application is prohibited at the following locations:
   - Watercourses; Water Bodies; Wetlands;
   - Areas of Concern (AOCs) (with the exception of the following canyon bottom AOCs : C-00-00 l; through C-00-019 and C-00-021);
   - Solid Waste Management Units (SWMUs);
   - Slopes greater than 2% if the site is poorly vegetated (<50% ground cover); and
   - Slopes greater than 5% if the site is well vegetated (>50% ground cover).
2. Land application cannot result in water flow from an approved land application site.
3. Land application cannot create ponds or pools or standing water.
4. Land application must be conducted in a manner that maximizes infiltration and evaporation.
5. Land application is restricted to daylight hours and for a maximum of 10 hrs/day.
6. Land application must be supervised.
7. Land application cannot extend off LANL property without written permission from the land owner.
8. Land Application will be terminated if leaks in the application system are detected.
9. Land application is prohibited while precipitation is occurring or when temperatures are below freezing.

Current Land Application of Treated Water

Transfer to Frac Tanks

Water destined for treatment at CTU-B transferred to frac tanks at nominal rate of 80pm (11 frac tanks; 220K total gal capacity)

CTU-B Treatment

Transfer water to CTU-B for treatment to 90% of numeric standards. Then transferred to lagoons (3 lagoons, each w/200K gal capacity)

Water Quality Sampling

Water quality samples taken to confirm treatment (ten-day turnaround on analytical results)

Land Application

Stationary spray area or water trucks have ~3,000-10,000 gal capacity. Approx. 60 truckloads to transfer water from three lagoons to approved locations

Land Application Cycle

All land application activities must be supervised and occur during daylight

Land Application Cycle:

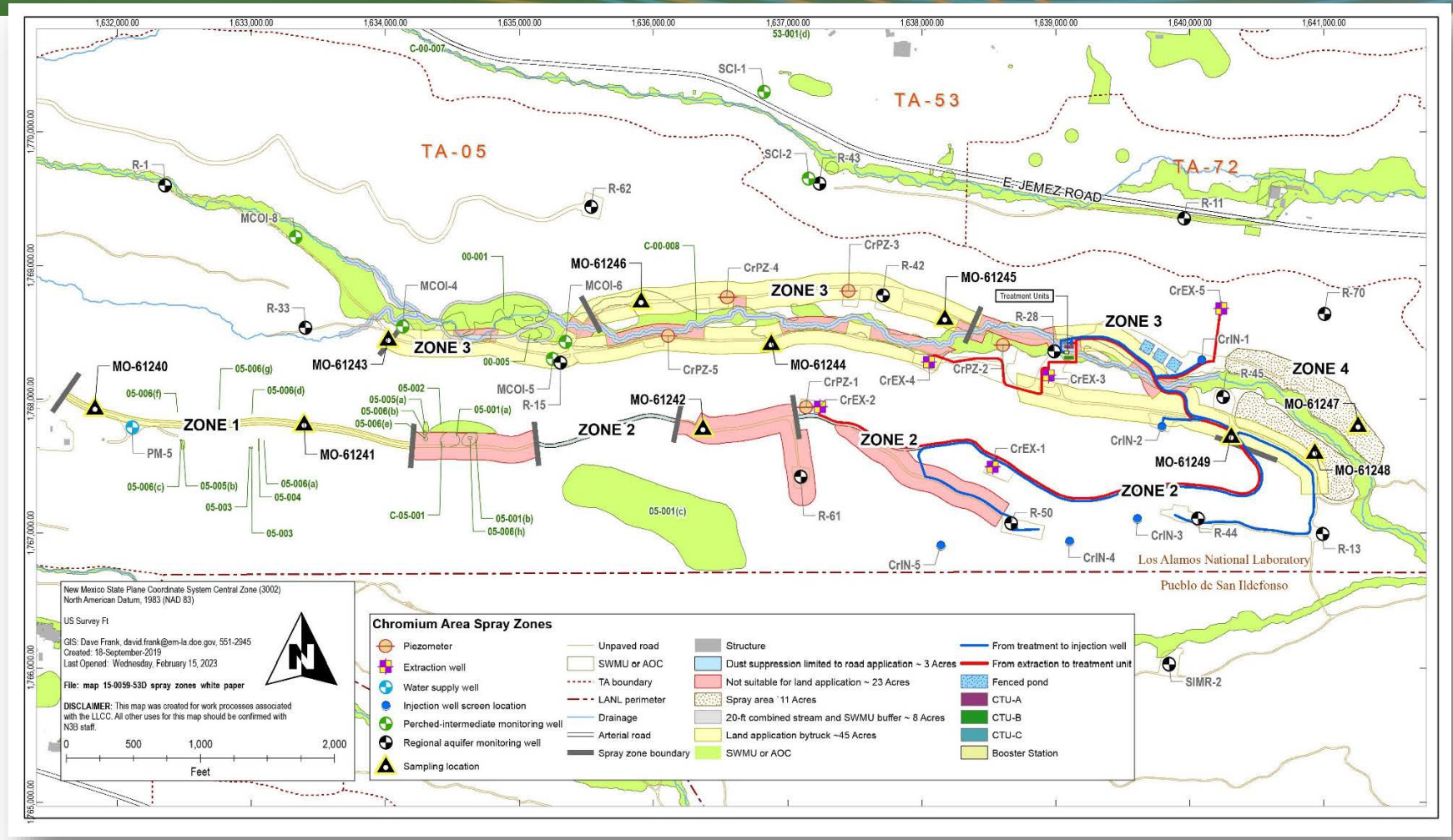
- Five days for LA of one lagoon (200,000 gal at ~100 gpm)
- ~2 weeks required for LA before repeating treatment cycle

Bottleneck

IM operates for 3 days at 140 gpm 8 hrs/day, followed by a 2-week period of no operations to disposition water for land application

Interim Measures – Land Application

- Without injection only treated water disposition is and application under DP-1793
- Modify system design (extraction well to CTUs)
- Work Plan approval
- Land Application Cycle:
  - All land application activities must be supervised and occur during daylight
  - Five days for LA of one lagoon (200,000 gal at ~100 gpm)
  - ~2 weeks required for LA before repeating treatment cycle



Treatment system infrastructure and the area approved for land application

Interim Measures Evaluation

- Potentiometric Surfaces
- Capture Zone Analysis
- Concentration Trends
- Tracer Analysis from Injection Wells
- Injection of Plume Periphery

Potentiometric Surfaces

Analysis Approach

Water Level Data

- Potentiometric surface maps that supported quarterly DP-1835 reporting
- Vertical hydraulic gradient information-based water level data to identify IM impacts at depth

Hydraulic Gradients

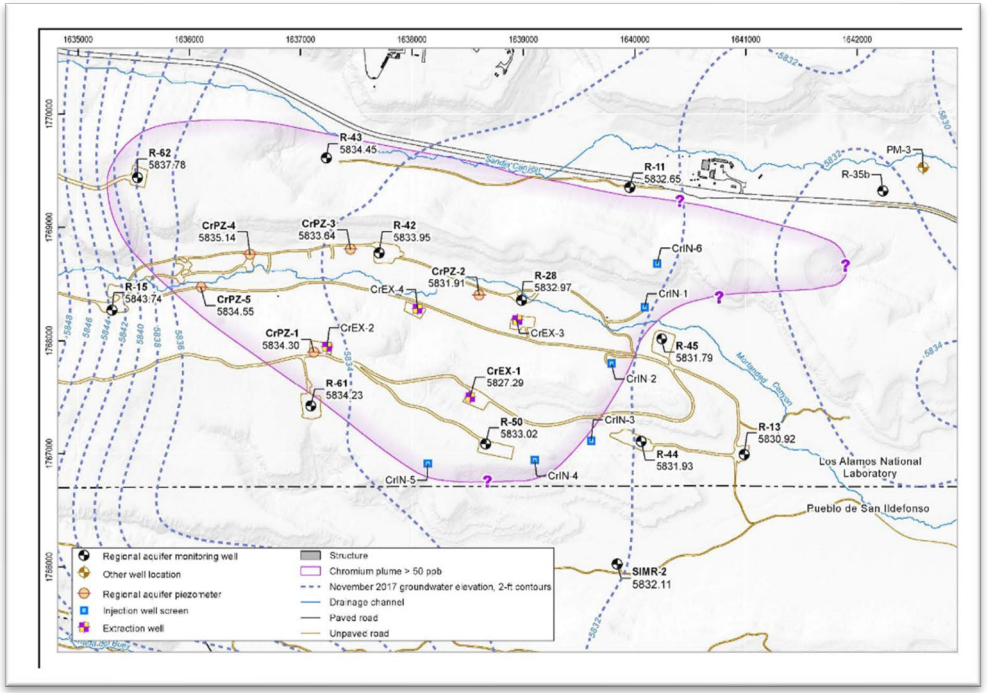
- Analyzed all data but restricted analysis to Q4 maps to minimize seasonal impacts of Los Alamos County water supply wells

Key Observation

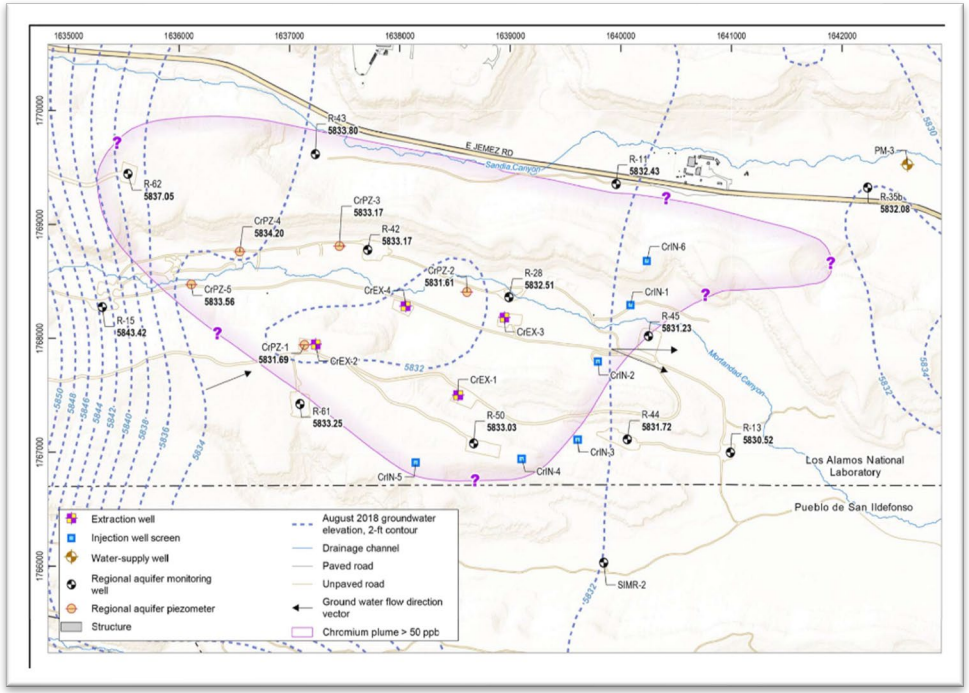
- Water table configuration changes required approximately one year to stabilize

Potentiometric Surface Analysis

- Pre-IM: Groundwater flow directions predominately from west to east/southeast
- Sustained Southern Operations: Cone of depression between extraction wells CrEX-2 and CrEX-4



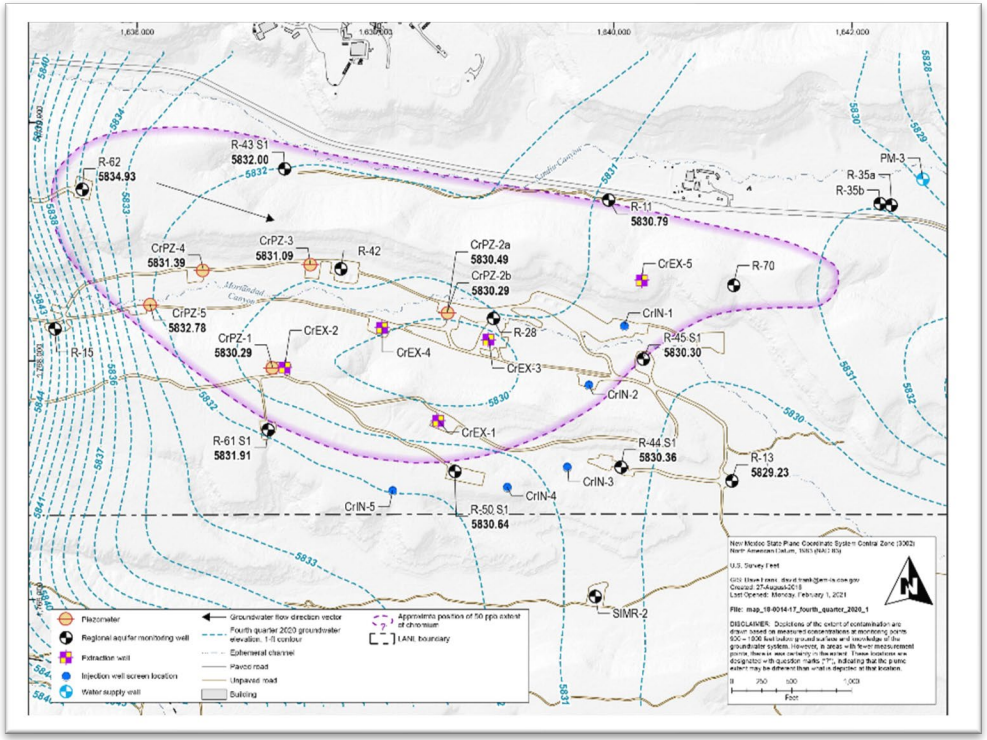
Groundwater elevation contour map, 2017, Quarter (Q) 4 Pre-IM



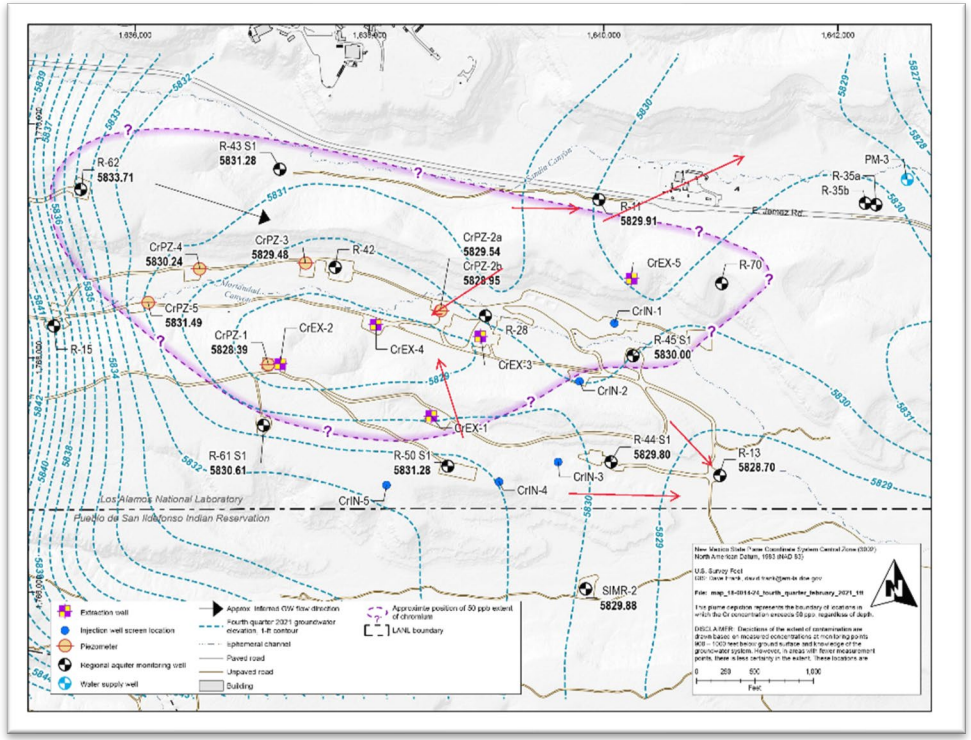
Groundwater elevation contour map, 2018, Q4 After Southern IM Operations

Potentiometric Surface Analysis

- Sustained Eastern Operations: CrIN-1 and CrIN-2 create a flow divide between cone of depression and eastern edge of plume (Mounding is not observable due to flat gradient)



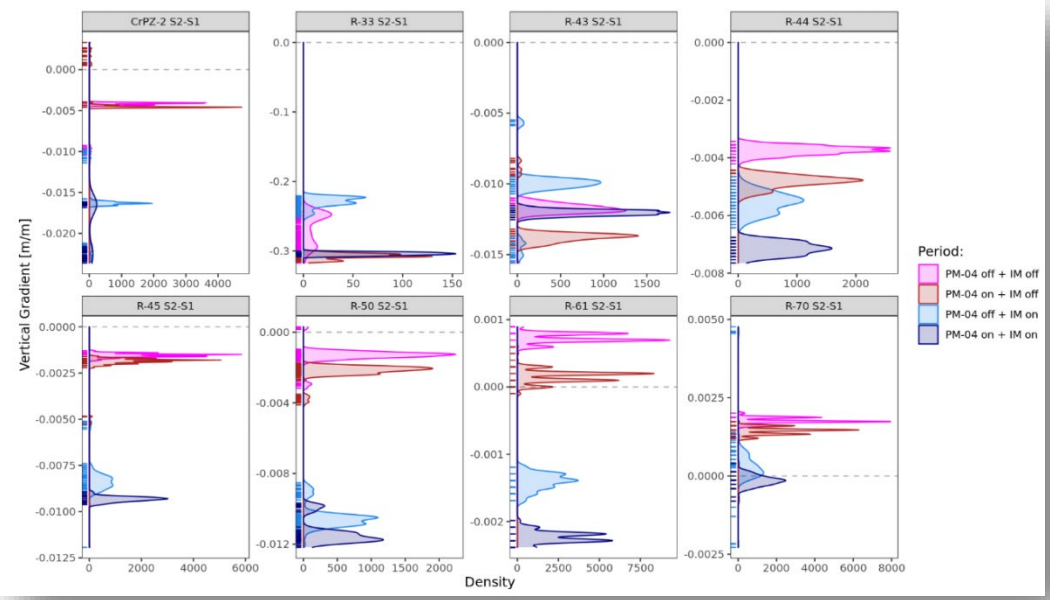
Groundwater elevation contour map, 2020, Q4
Post- Sustained Eastern IM Operations



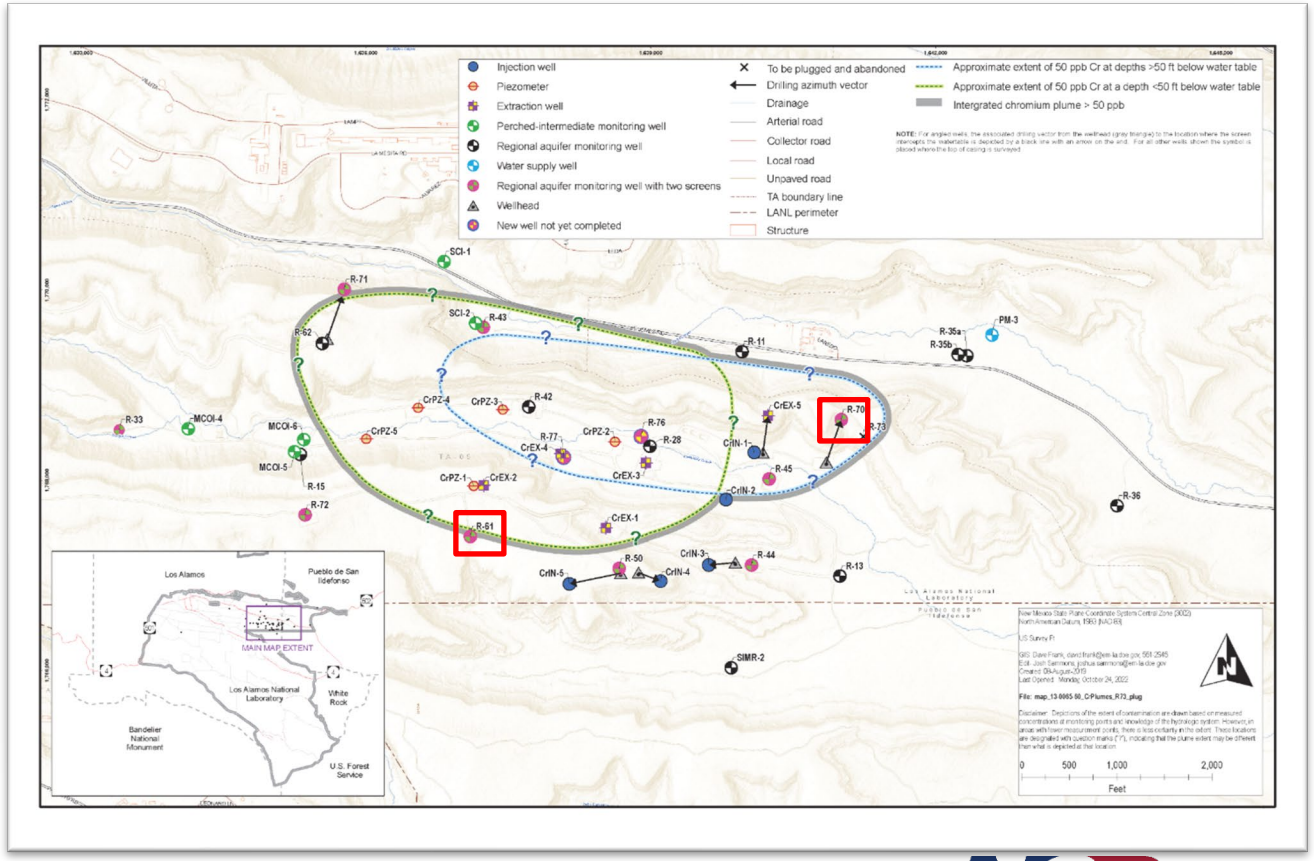
Groundwater elevation contour map, 2021, Q4
Arrows showing groundwater divide

Influences at Depth

- IM operations increase the magnitude of the downward vertical gradient
- Impact of IM injection is observed to a much lesser extent at wells R-61 (located to west of CrIN-5) and R-70 (located near CrEX-5)
- PM-4 pumping impacts hydraulic gradients



Temporal (hourly) hydraulic gradients at dual screened wells



Capture Zone Analysis (CZA)

Capture Zone Analysis

Analytical Methods

Assumptions
- Geologic homogeneity
- Steady-state flow-field

Methods
- ✓ Potentiometric surface maps
- ✓ Analytical approach (EPA 2008)

Output
- Estimates horizontal capture only

Numerical Methods

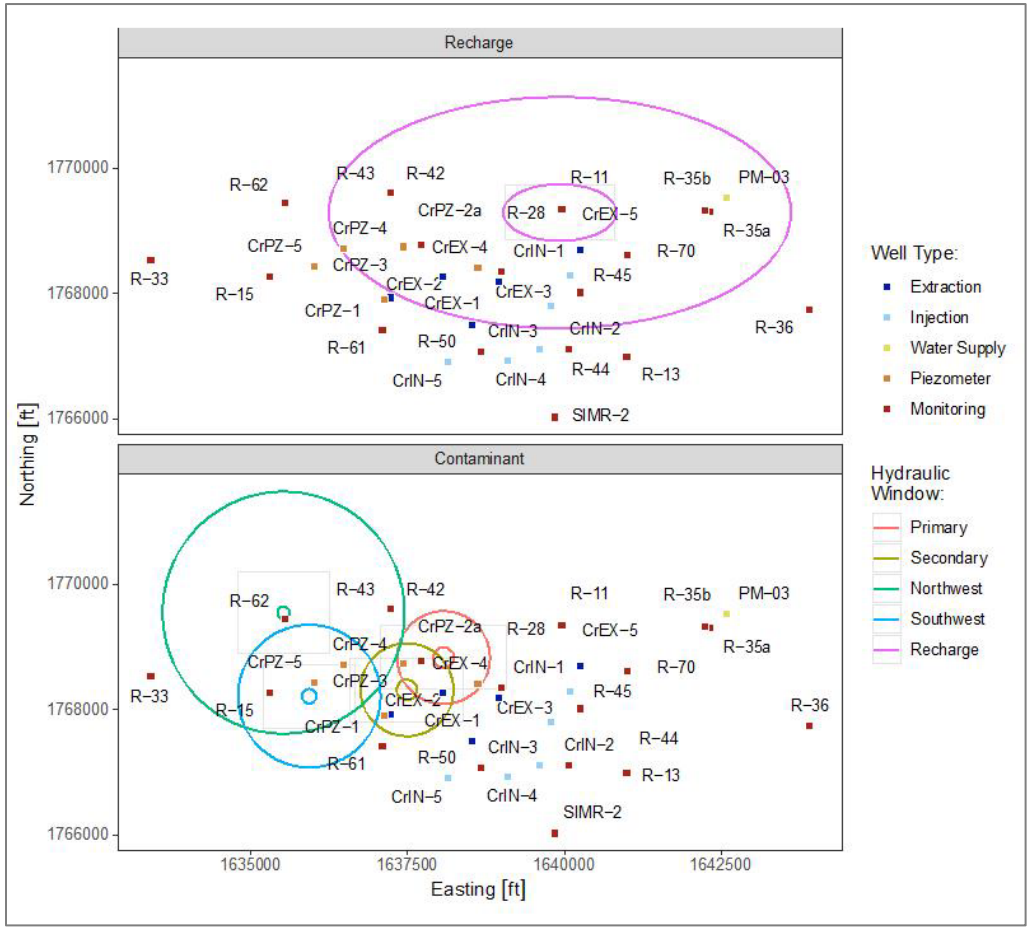
Assumptions
- Calibrated groundwater flow and transport model
- Steady-state flow field

Methods
- ✓ Streamlines
- ✓ Tracer transport
- ✓ Particle tracking

Output
- Horizontal and vertical capture that accounts for geologic heterogeneity

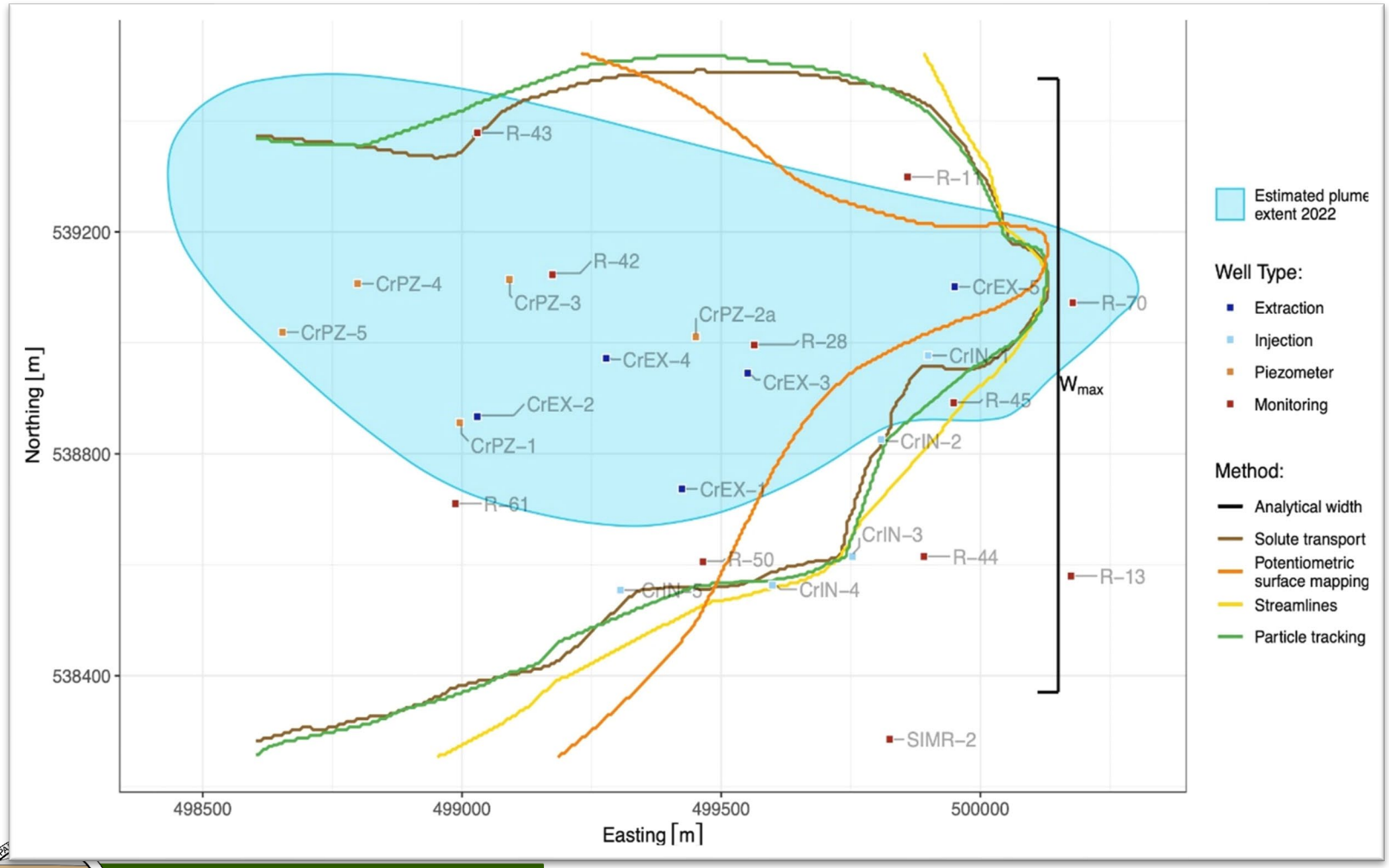
Chromium Model

- Chromium Model (CM): Numerical model built using Finite Element Heat and Mass Transfer (FEHM) (https://fehm.lanl.gov/)
- Model inputs
  - Parameters include porosity, dispersivity, hydraulic conductivity, and specific storage
  - Boundary conditions include natural recharge and infiltration from cooling towers
  - Considers **uncertainty** using ranges of input parameter values
- CM has been calibrated to available field data through October 22, 2022
  - Water level data, hydraulic gradients, and chromium concentrations



Plan view chromium and water sources in CM

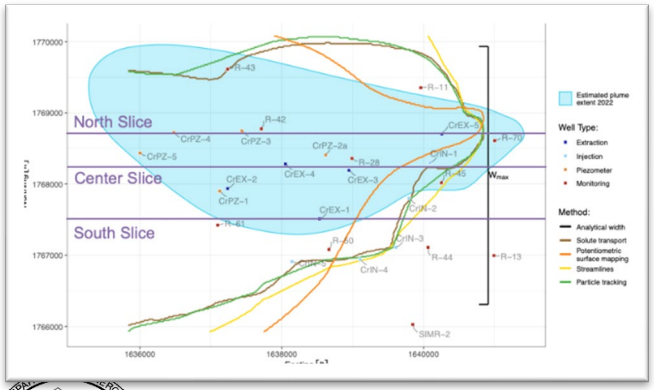
Horizontal Capture

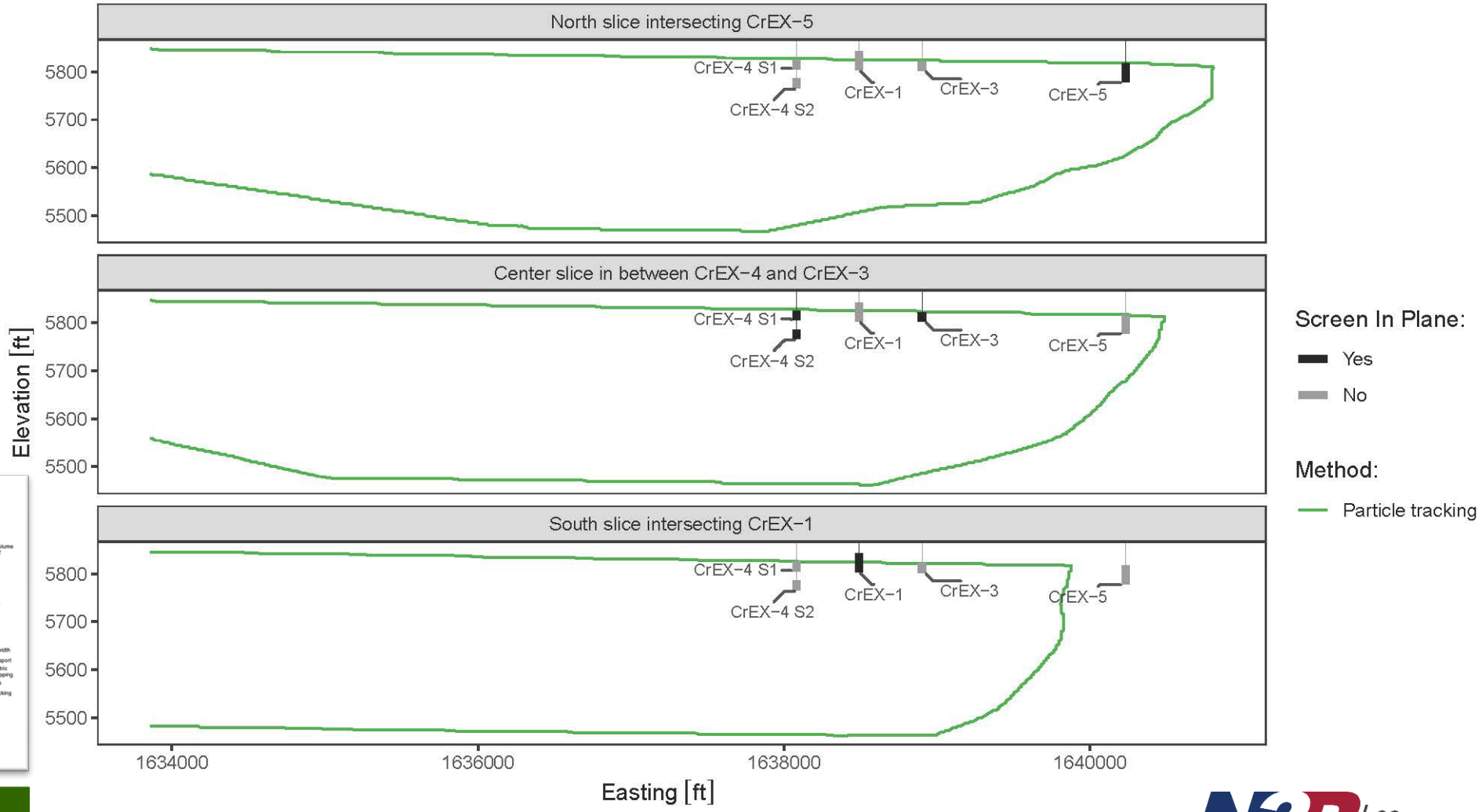


All five methods (analytical and numerical) show similar horizontal extent of capture

Vertical Capture

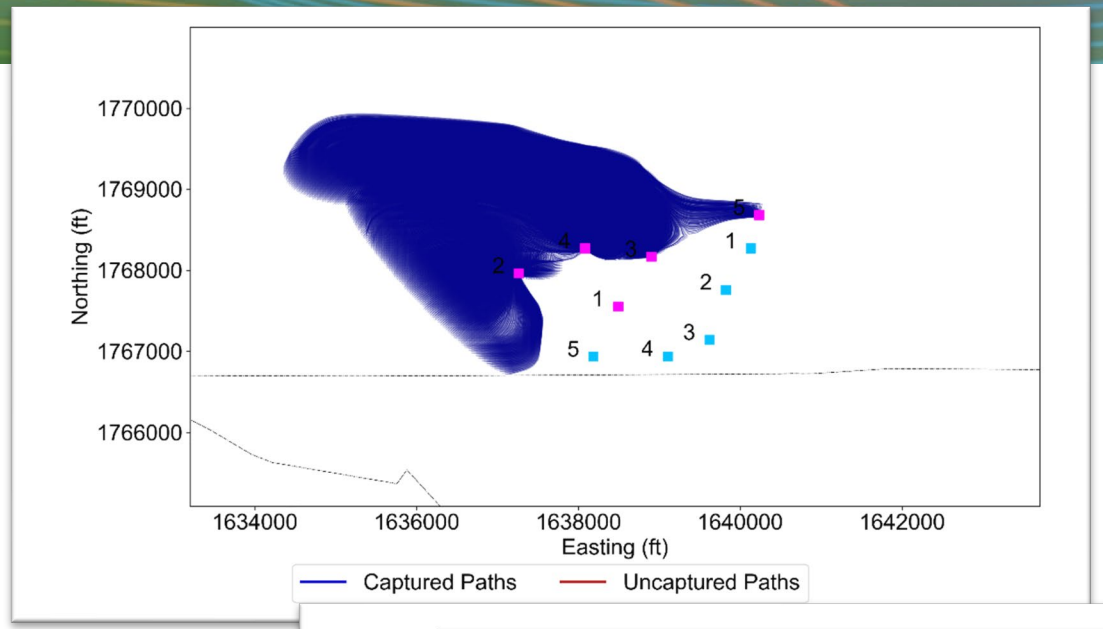
- Extraction well screens extend 50-60 ft below the water table
- Under steady-state conditions, depth of capture extends up to ~250 below the water table

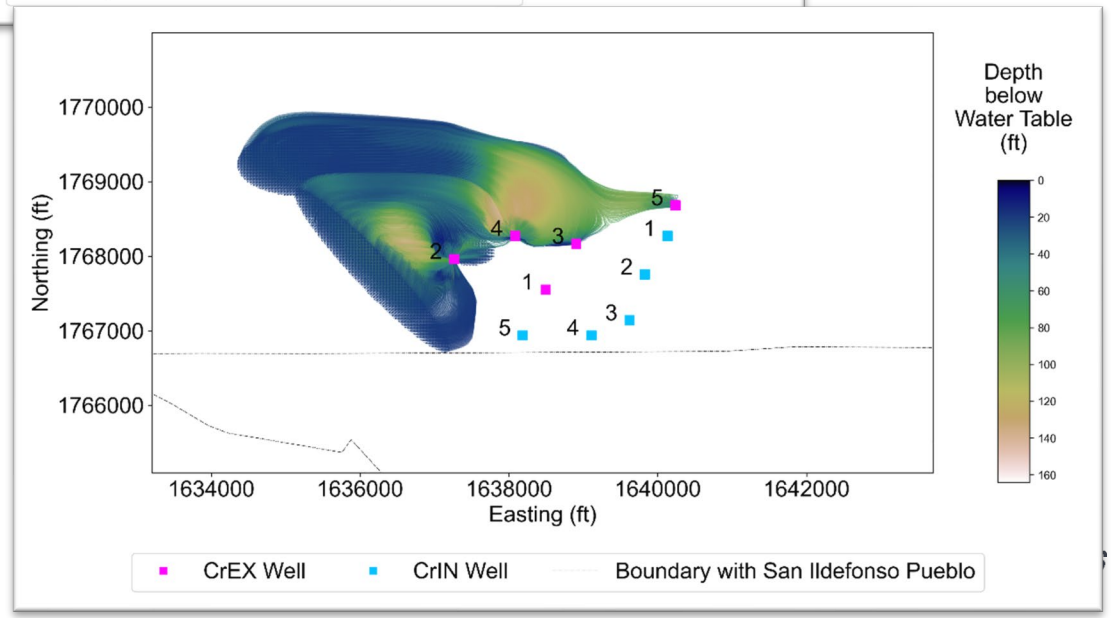




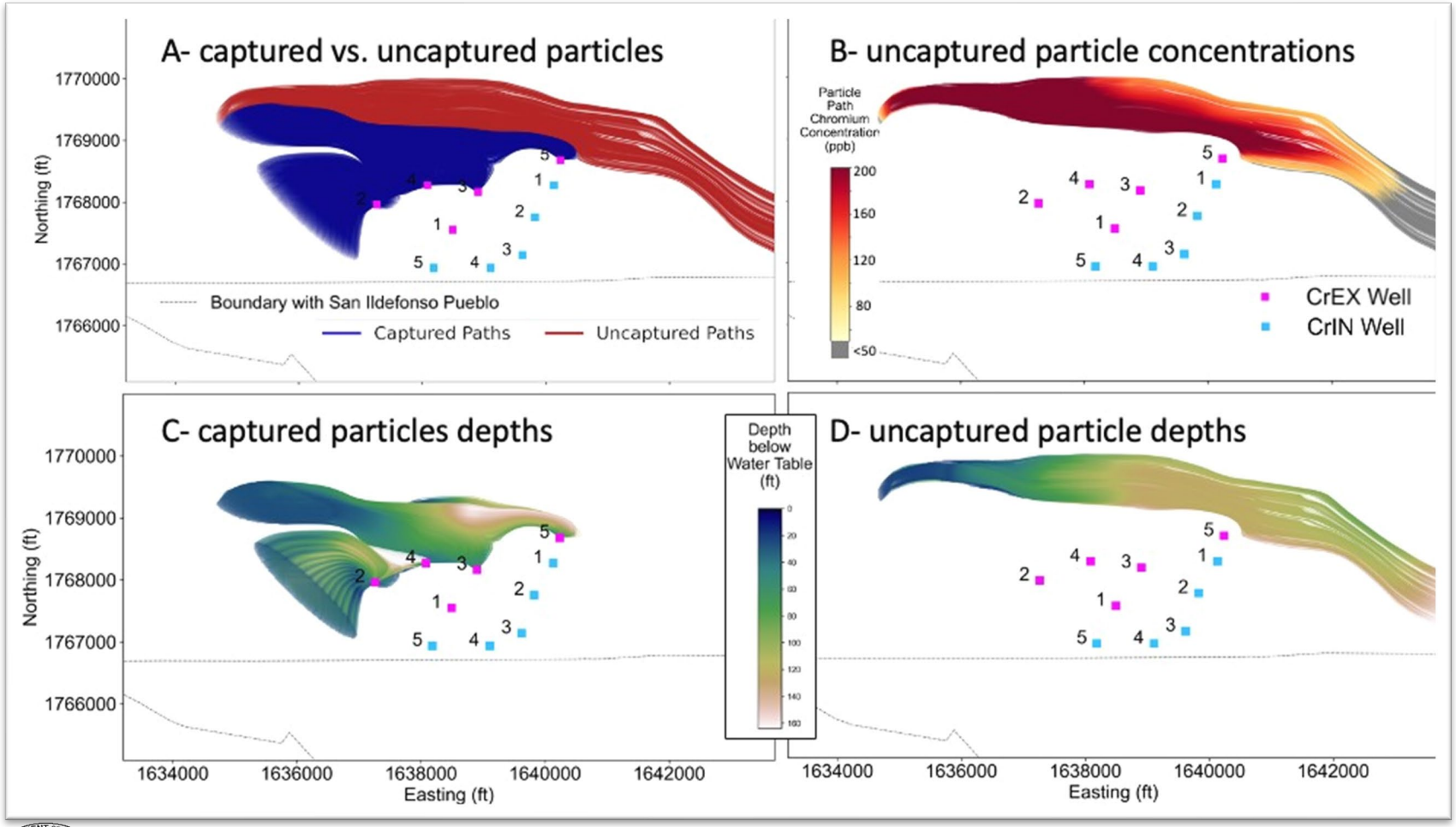
Particle Tracking Pathways

- Particle tracking releases particles in the model and different locations and they are “tracked” to final locations
- Uncertainty considerations means a range of outcomes is possible
- 75% of the simulations showed that all particles were captured by the IM extraction wells





Particle Tracking Pathways

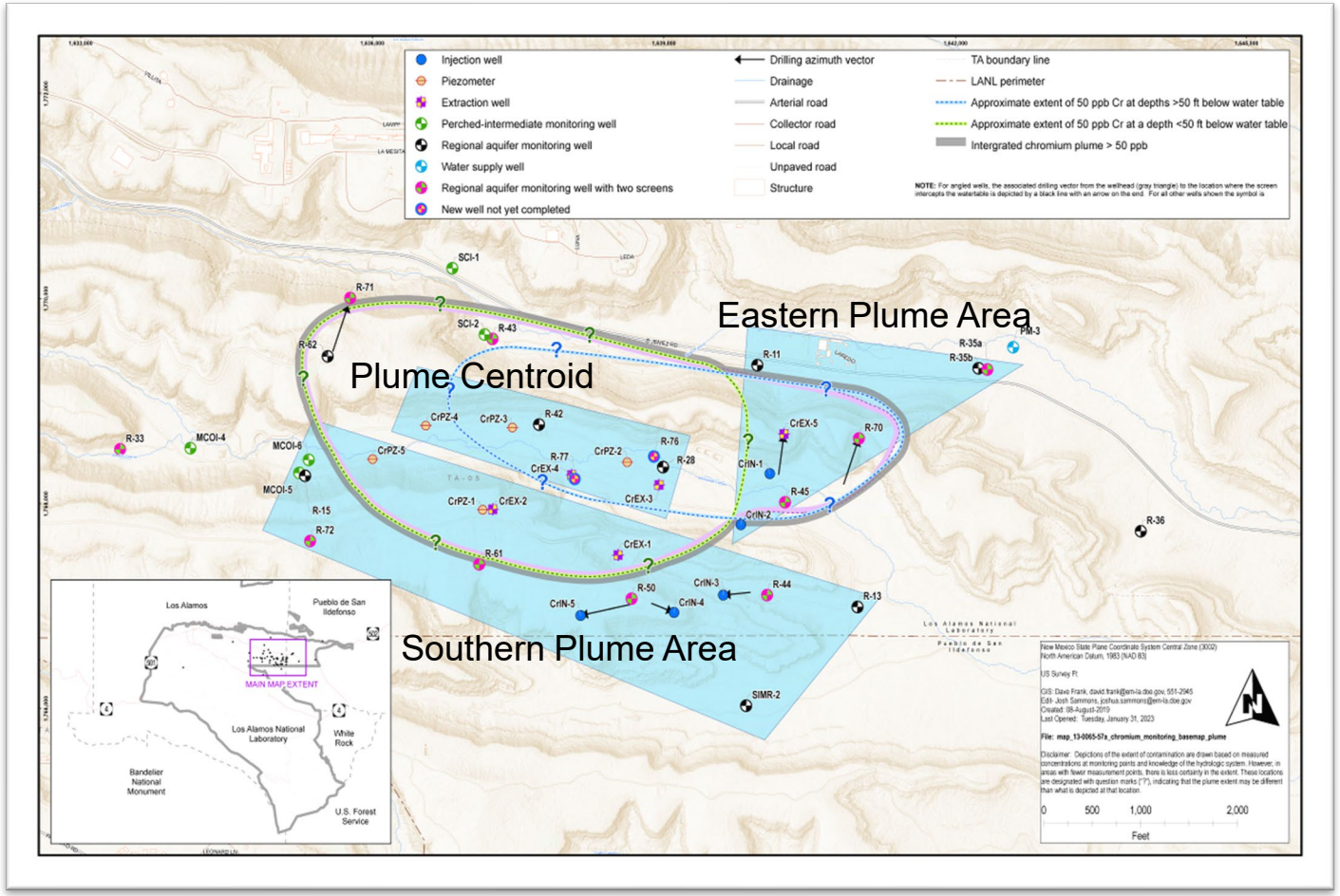


- 25% of the simulations resulted in the potential for incomplete capture north of R-70
- Complete capture in the southern plume area and plume centroid
- Concentrations decrease below standard downgradient of IM system

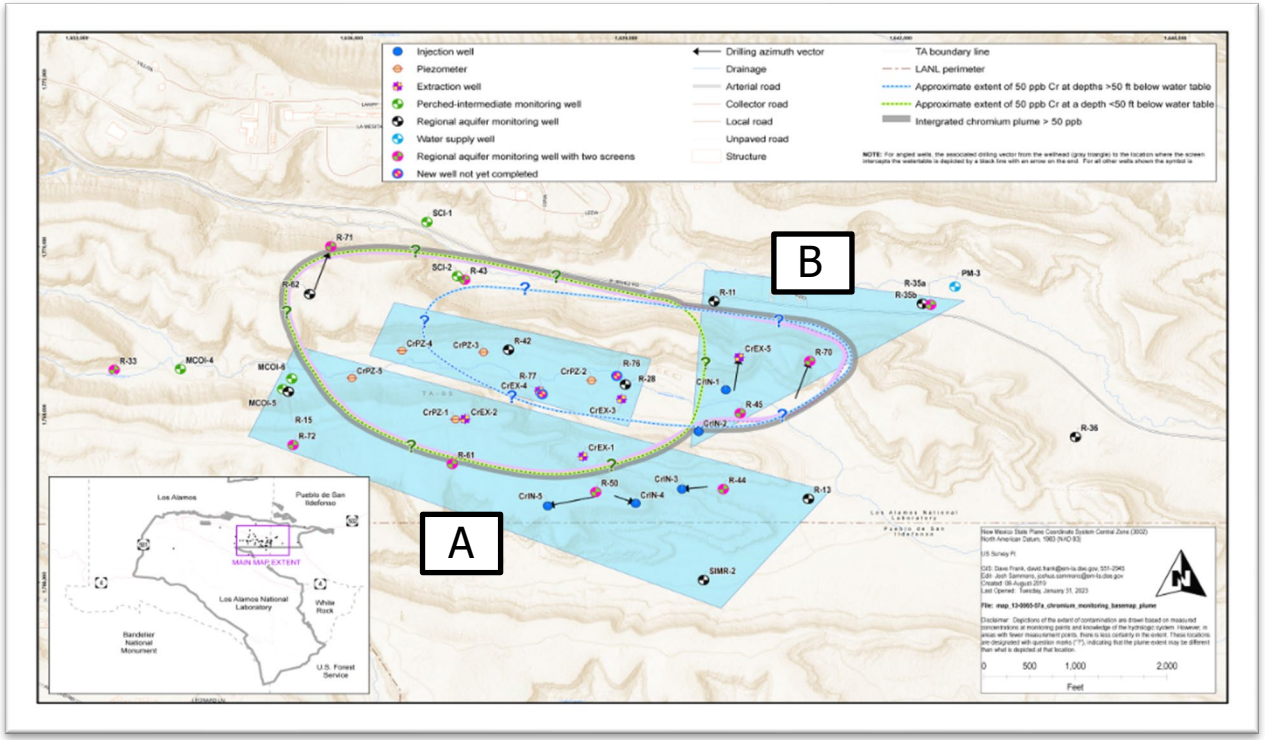
Concentration Analyses

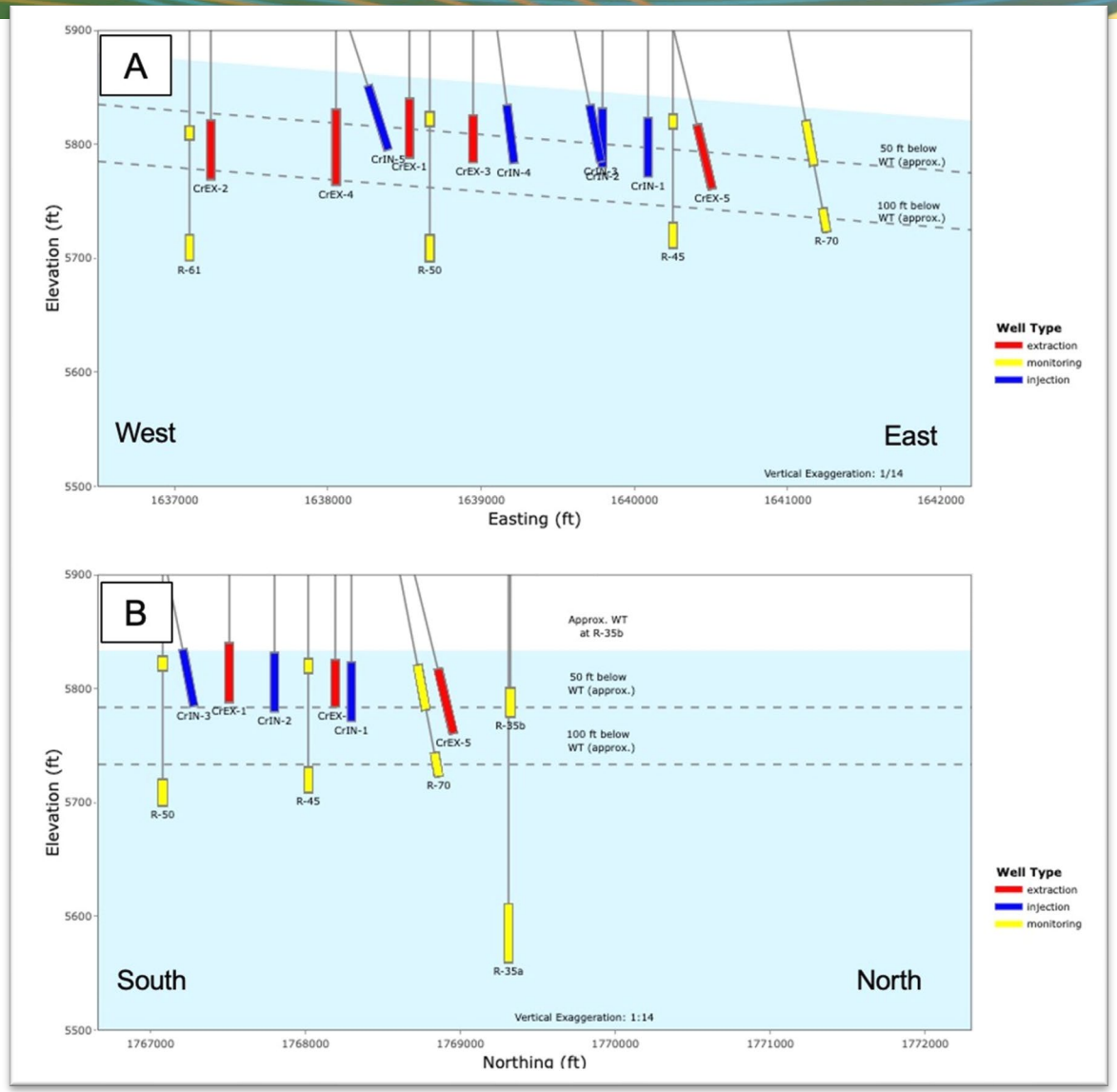
Chromium Concentration Analysis

- Grouped monitoring wells into three different regions
  - Wells R-43 and R-62 excluded based on distance from IM wells and Cr concentration trends predating IM operations
  - Piezometers CrPZ-1, -2a, -2b, -3, -4, and -5 omitted for simplicity
- Identified statistically significant trends based on different operational phases of the IM using Mann-Kendall (M-K) testing
- Geochemical signature of injection water
  - Low Cr concentrations
  - Co-located anions in plume pass thru treatment system and contained in injection water



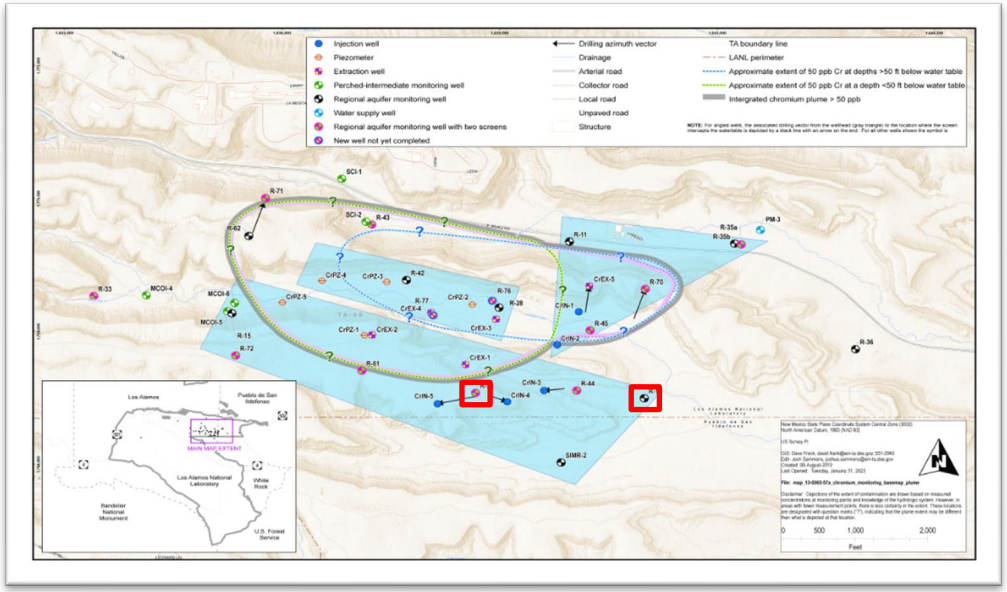
Well Screen Locations

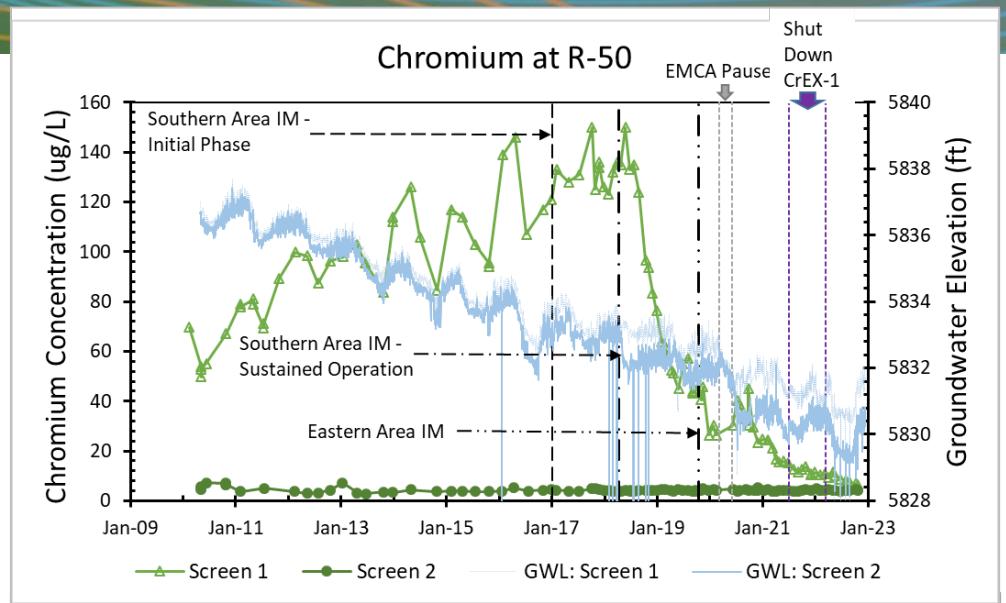


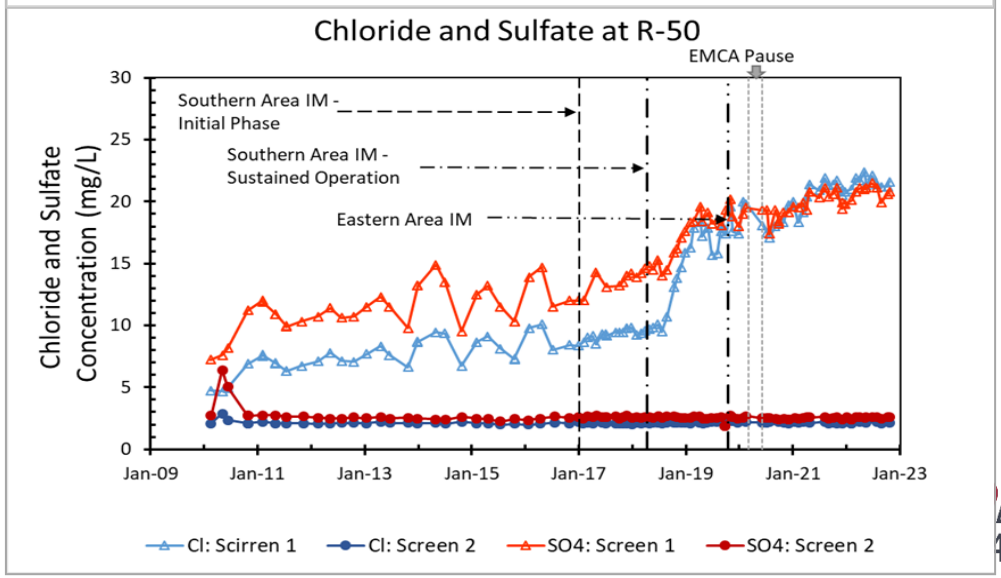


Southern Plume Area

- Cr concentrations decreasing in R-50 S1, reversing trend prior to IM operations
- Injection water signature present in shallow screens (R-50, R-44)

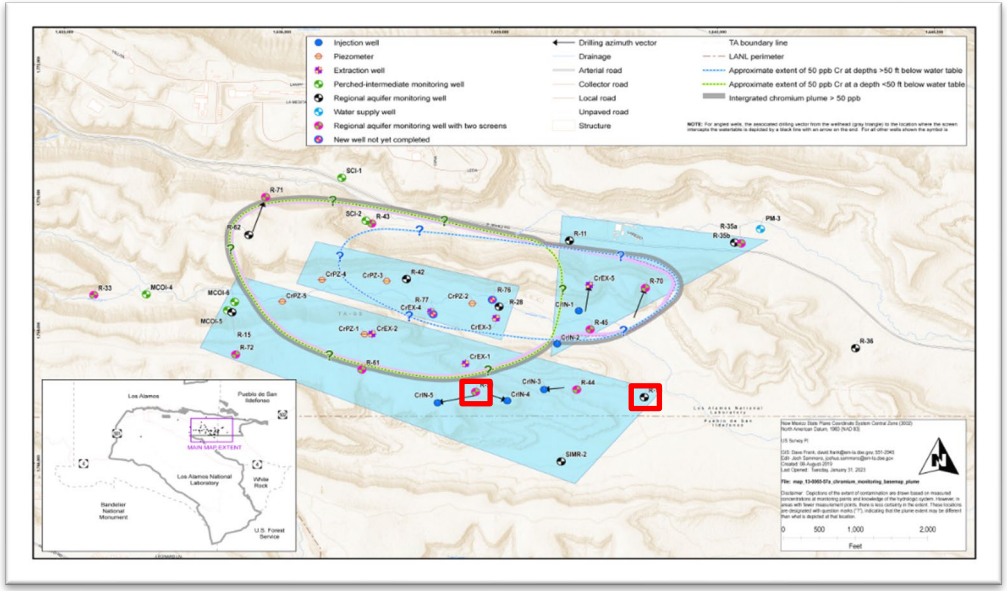


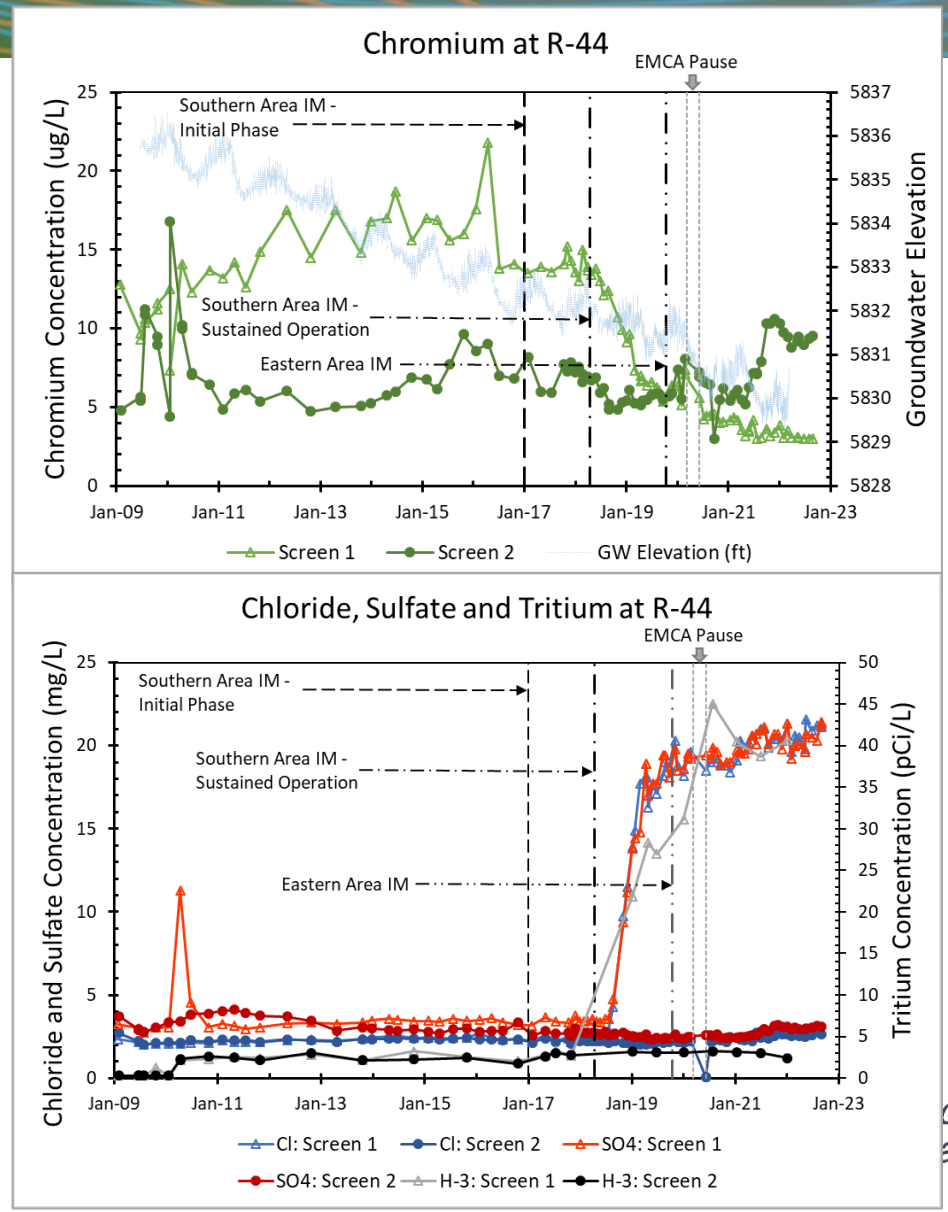




Southern Plume Area

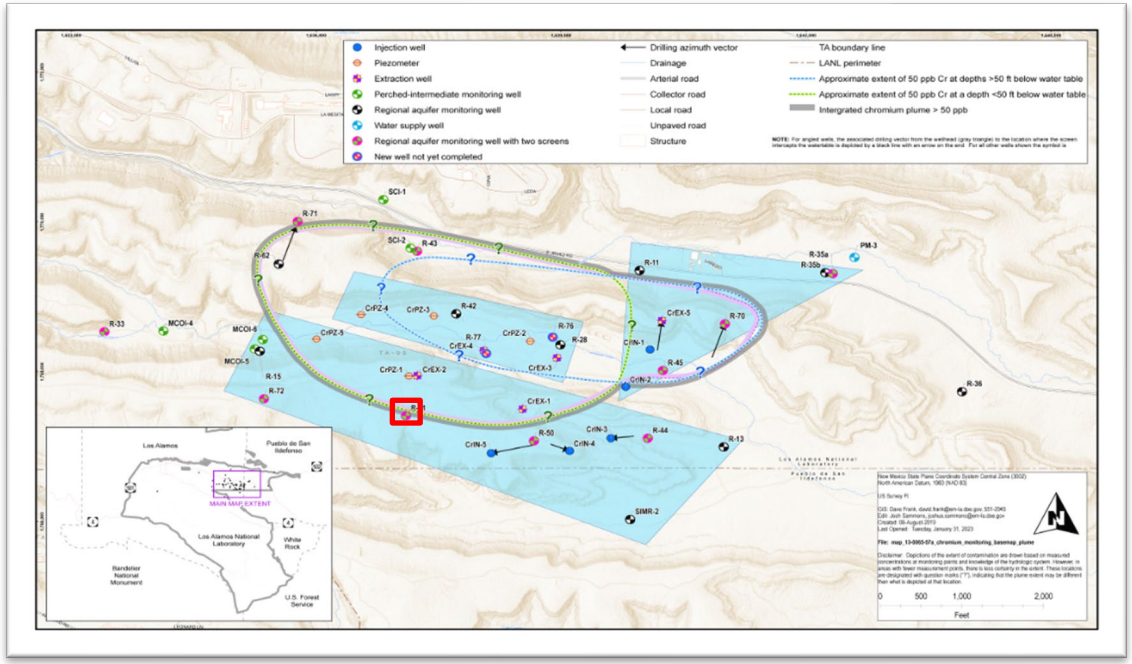
- Cr concentrations decreasing in R-50 S1, reversing trend prior to IM operations
- Injection water signature present in shallow screens (R-50, R-44)

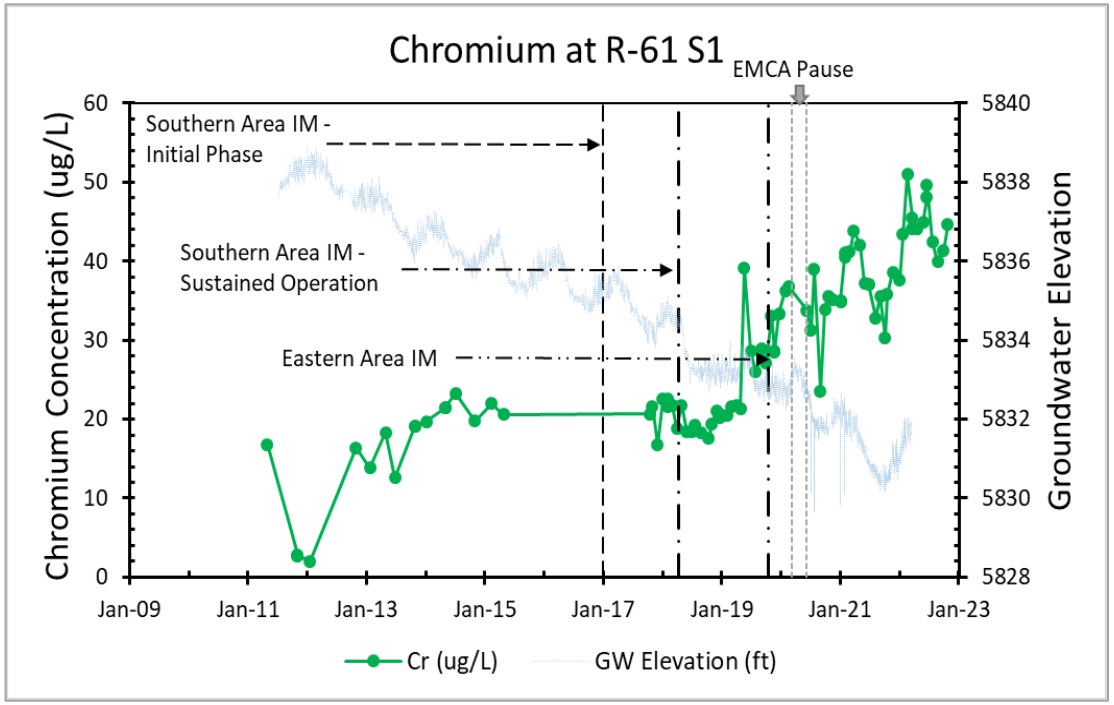




Southern Plume Area

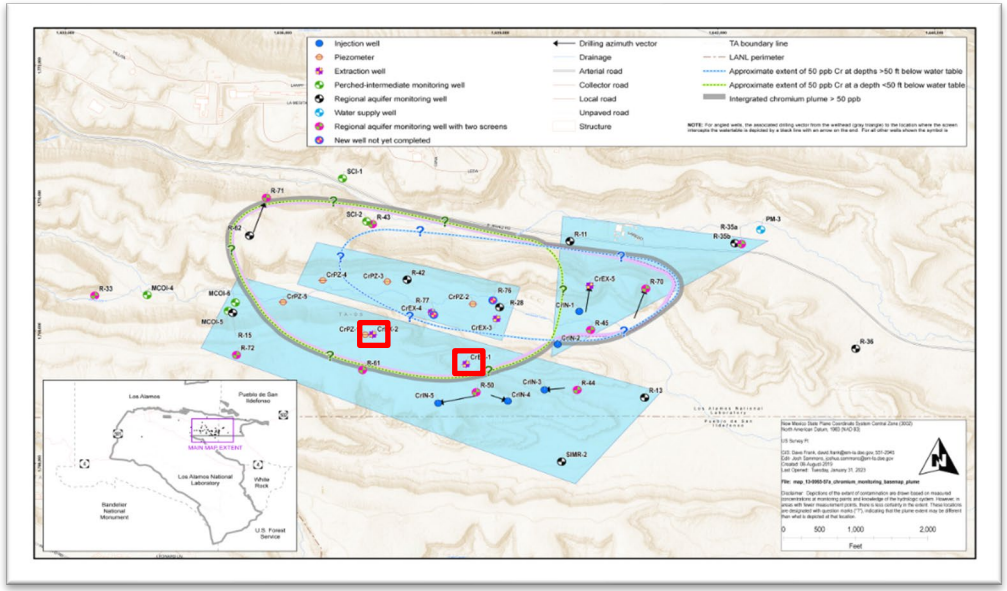
- R-61 concentrations increasing, continuing trend prior to IM operations (currently below standard)

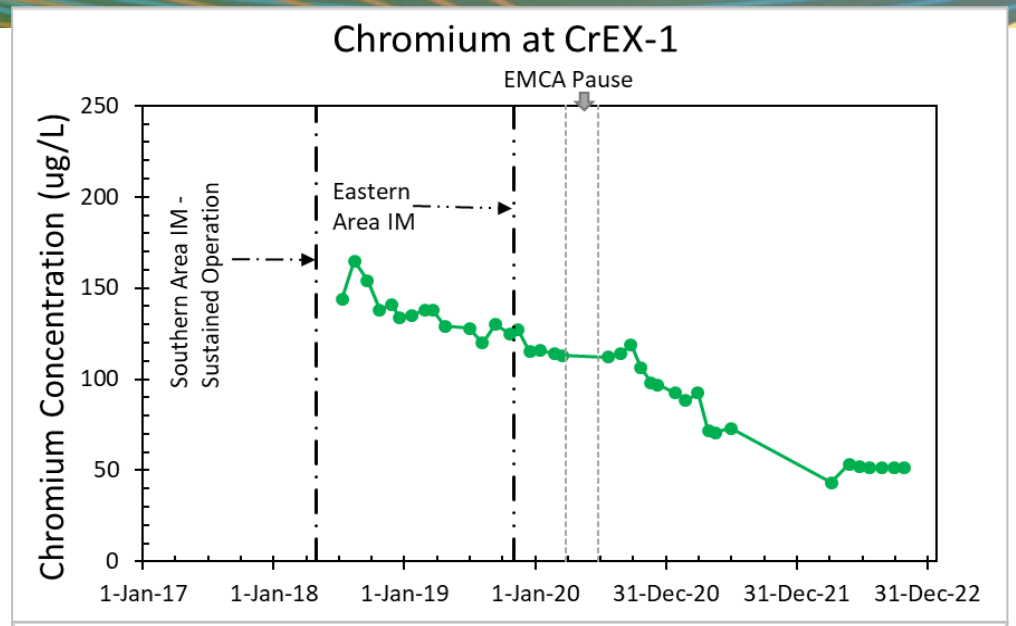


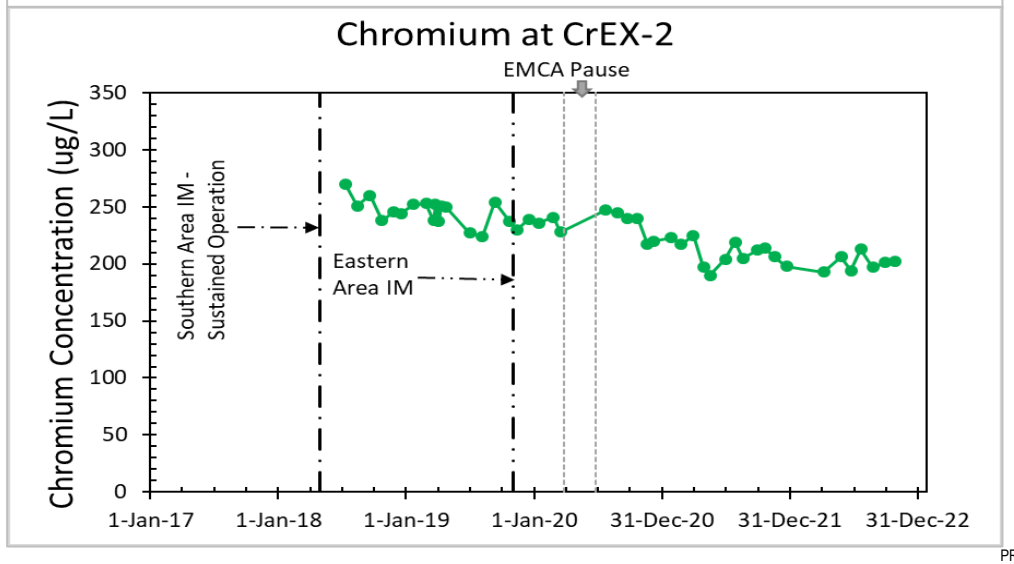


Southern Plume Area

- Cr concentrations decreased to ~50 ppb standard at CrEX-1
- Cr concentrations exhibit decreasing trend at CrEX-2
- CrEX-1 shows evidence of injection water signatures (from CrIN-4 and CrIN-5)

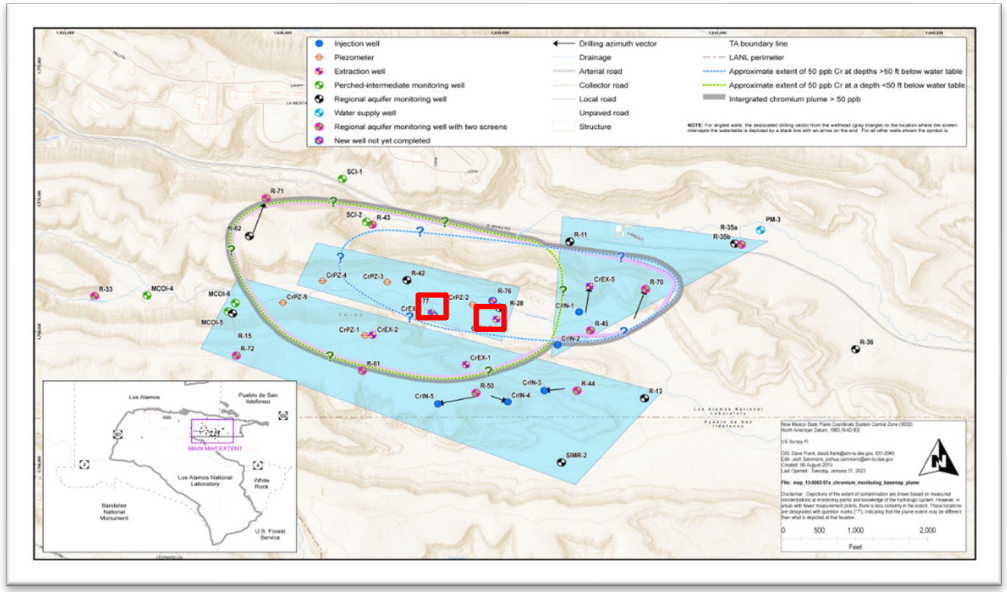


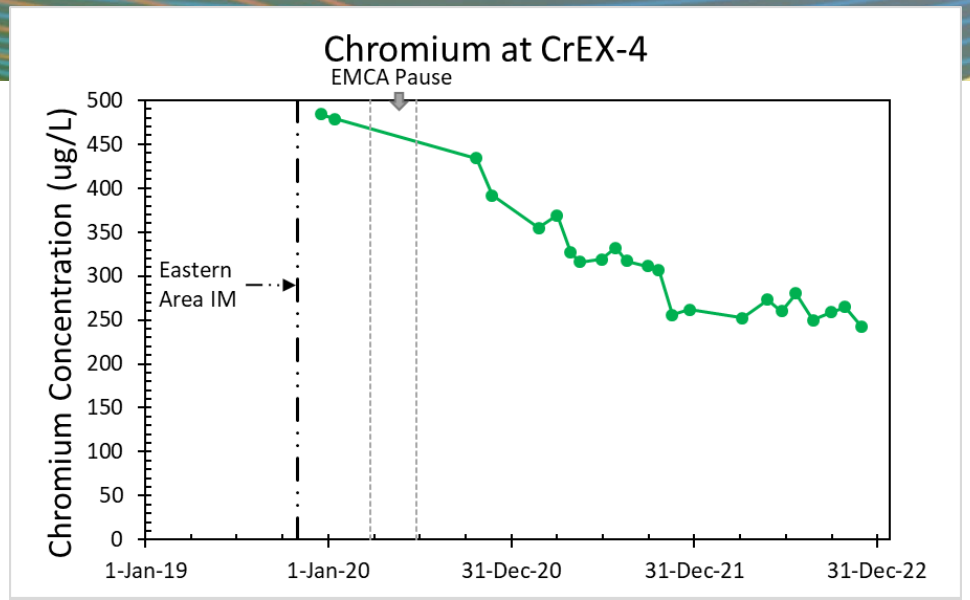


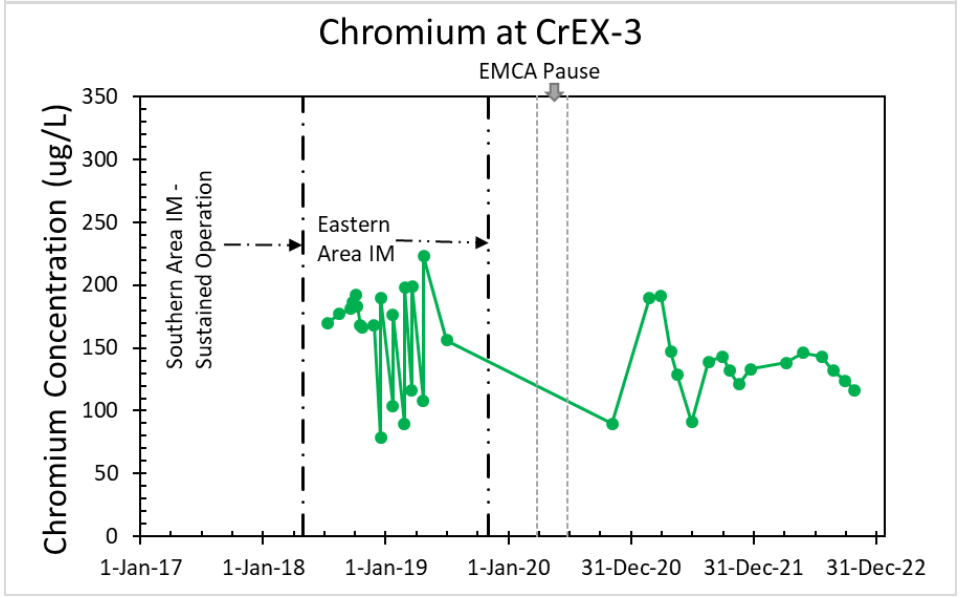


Plume Centroid

- Steady decline in Cr concentration from ~500 ppb to ~250 ppb at CrEX-4
- CrEX-3 Cr concentrations show more variability due to intermittent operations and lower extraction rates (nominally 30-35 gpm vs. 65-80 gpm)

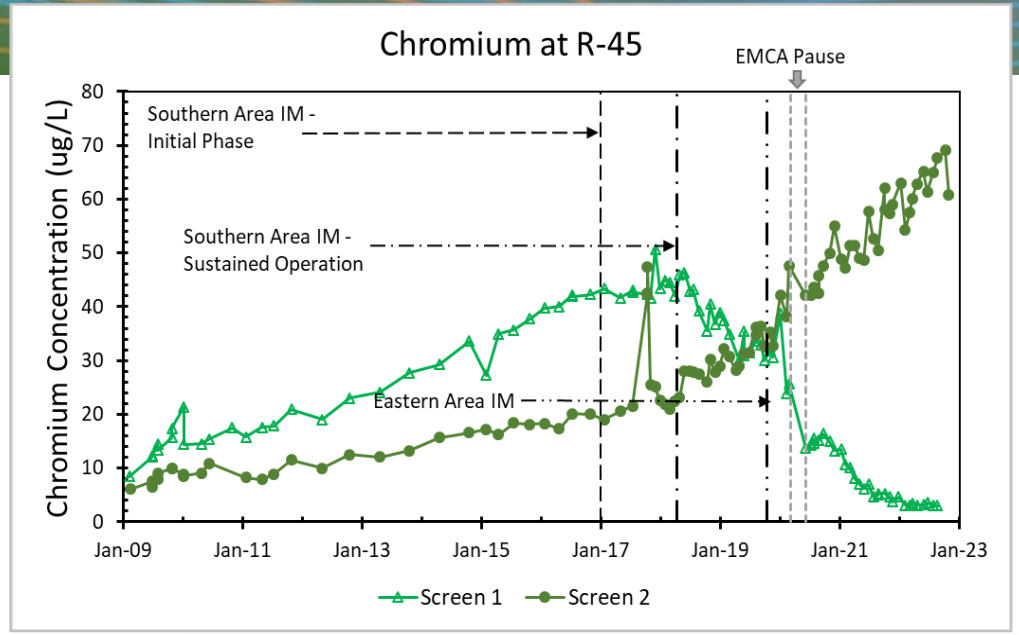


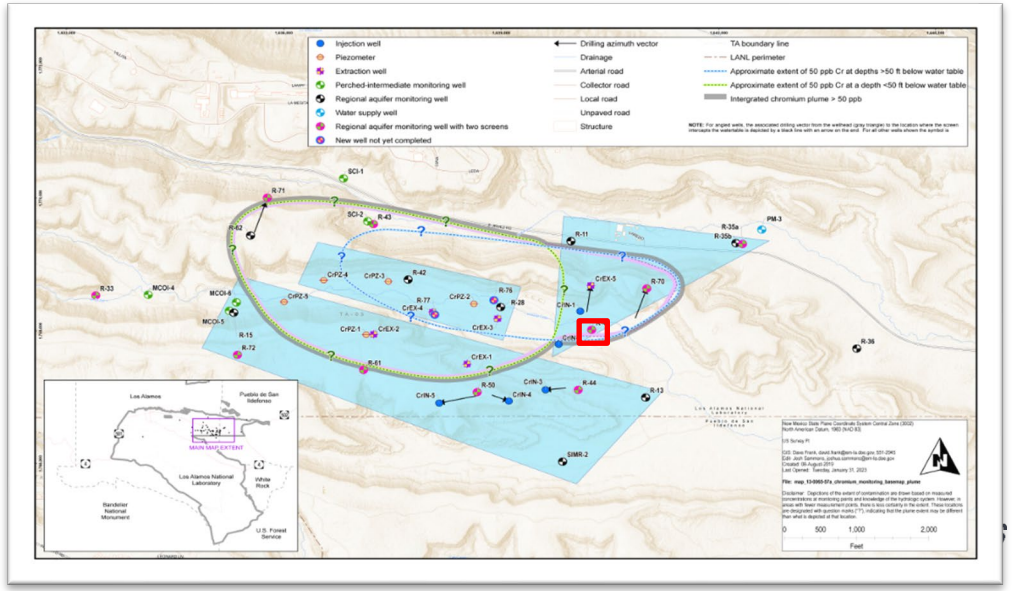




Eastern Plume Area: R-45

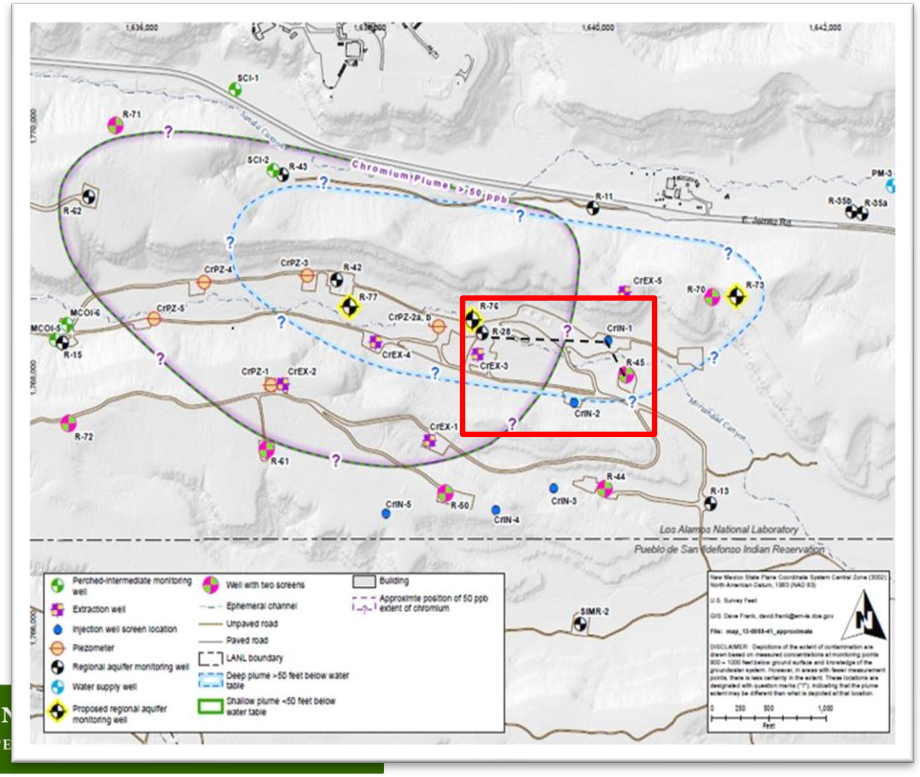
- Pre-IM Operations (2009 – 2016)
  - Concentrations increased at S1 and S2
  - Indicative of an upstream source at both screens
- Sustained Southern Area Operations
  - Cr concentrations decreased in S1
  - Injection water geochemical signature in S1
- Sustained Eastern Area Operations
  - Cr concentrations increased in S2
  - No Injection water geochemical signature in S2

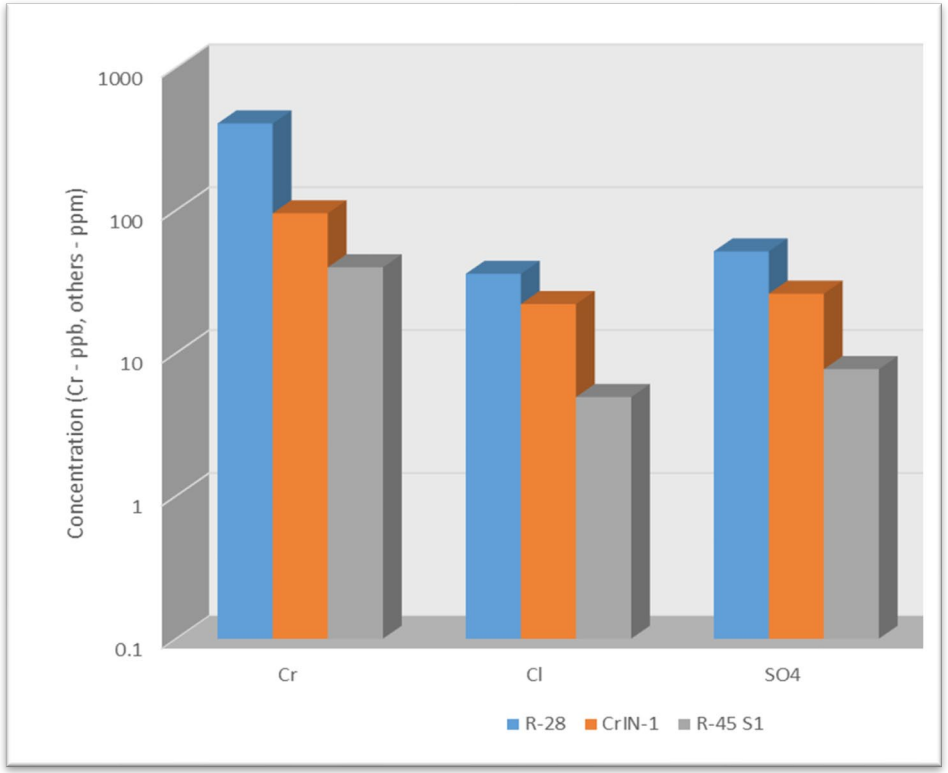




Pre-IM Concentration Trends at R-45

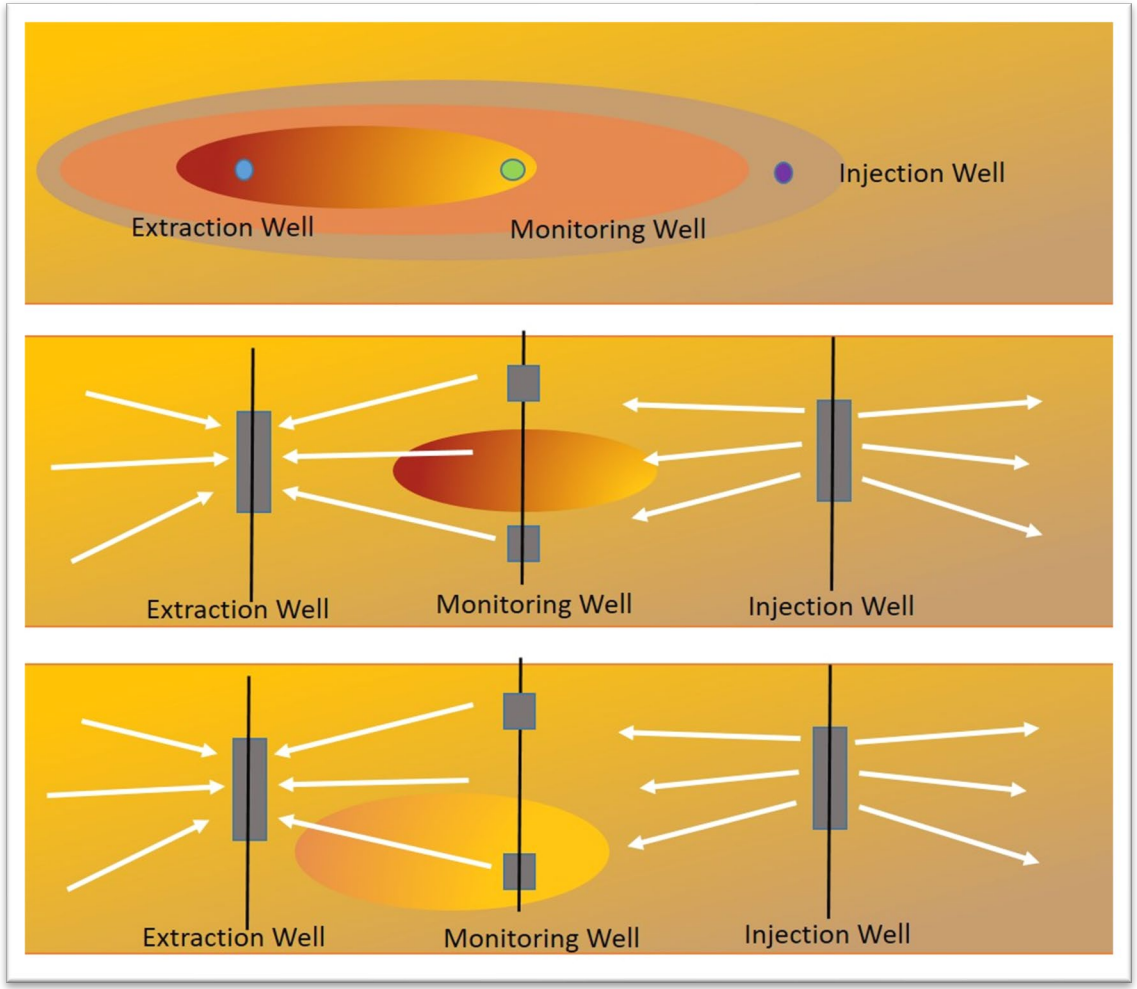
- Higher chromium, chloride, and sulfate concentrations existed prior to IM operations at R-28 CrIN-1 and CrIN-2
- Concentration increases anticipated downgradient, irrespective of IM operations





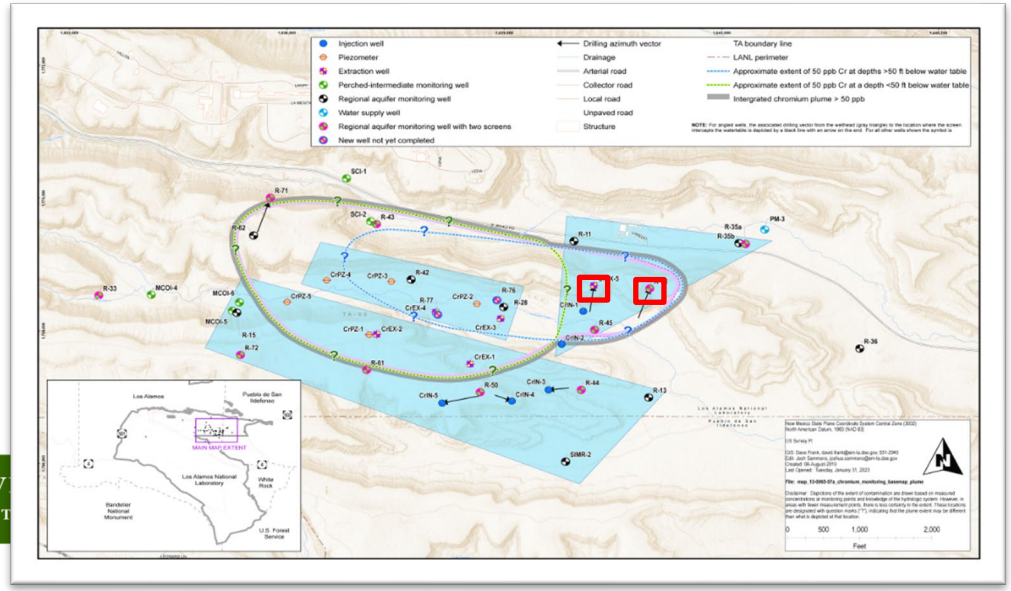
R-45 Concentration Trends

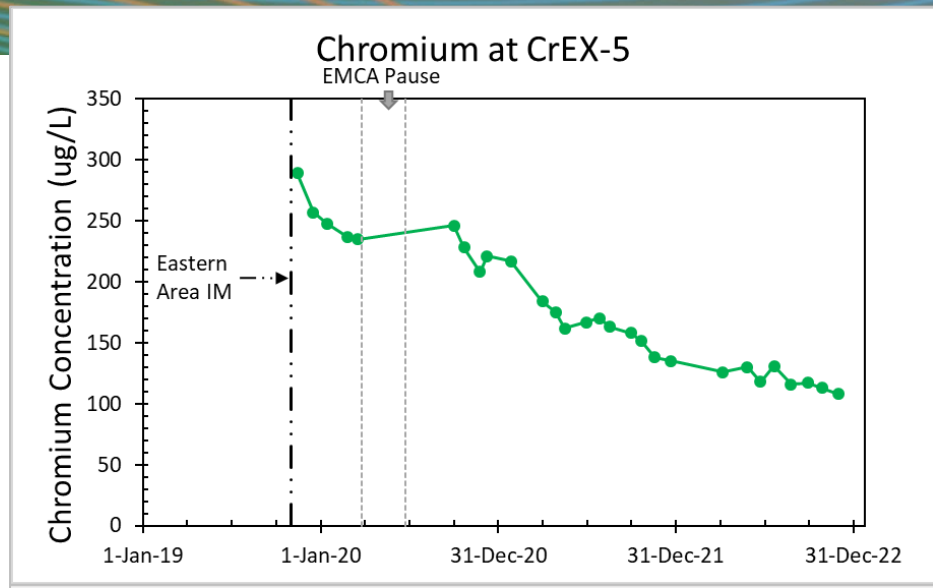
- Injection water impacts concentration zone located **between** R-45 S1 and S2
  - Displaced to a depth below the water table at the bottom depth of the CrIN-well screens
  - Concentrations are diluted at S1 and within the injection zone
  - Modest concentration increases at R-45 S2
- Peak Cr concentrations still remain between R-45 S1 and S2
  - Likely less than the 95 ppb observed at CrIN-2 pre-IM because dilution will have occurred (due to injection water)

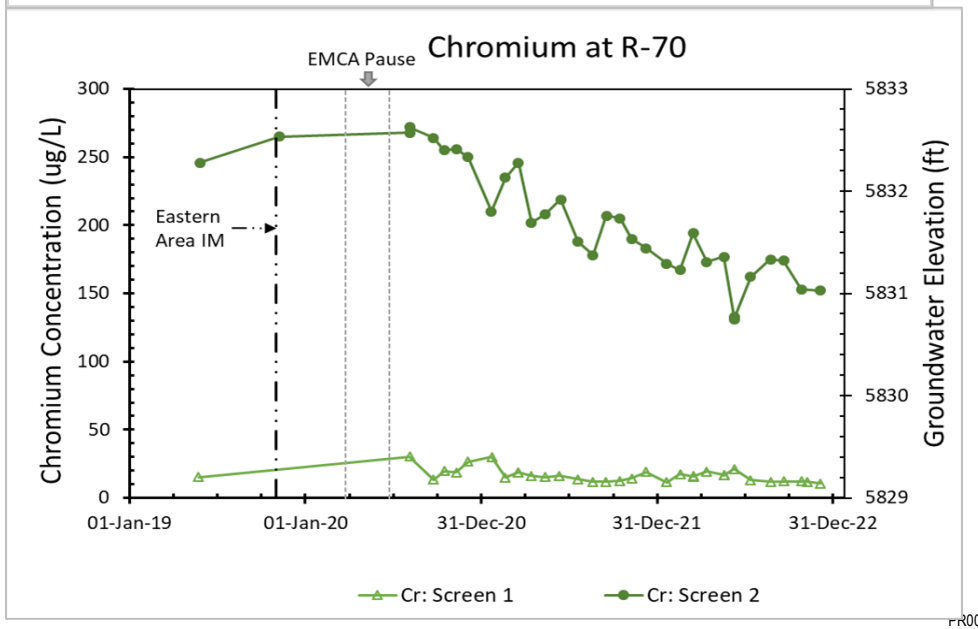


Eastern Plume Area

- CrEX-5
  - Planned injection well but converted to extraction well (Cr conc ~300 ppb)
- R-70: Vertical Cr concentration distribution inverted
  - Below standard at upper screen (near the water table)
  - ~250 ppb at lower screen located ~90 ft below the water table
- No evidence of injection water geochemical signature at either screen location
- Similar concentration trends indicate that CrEX-5 may be extracting water from downgradient area at R-70 S2



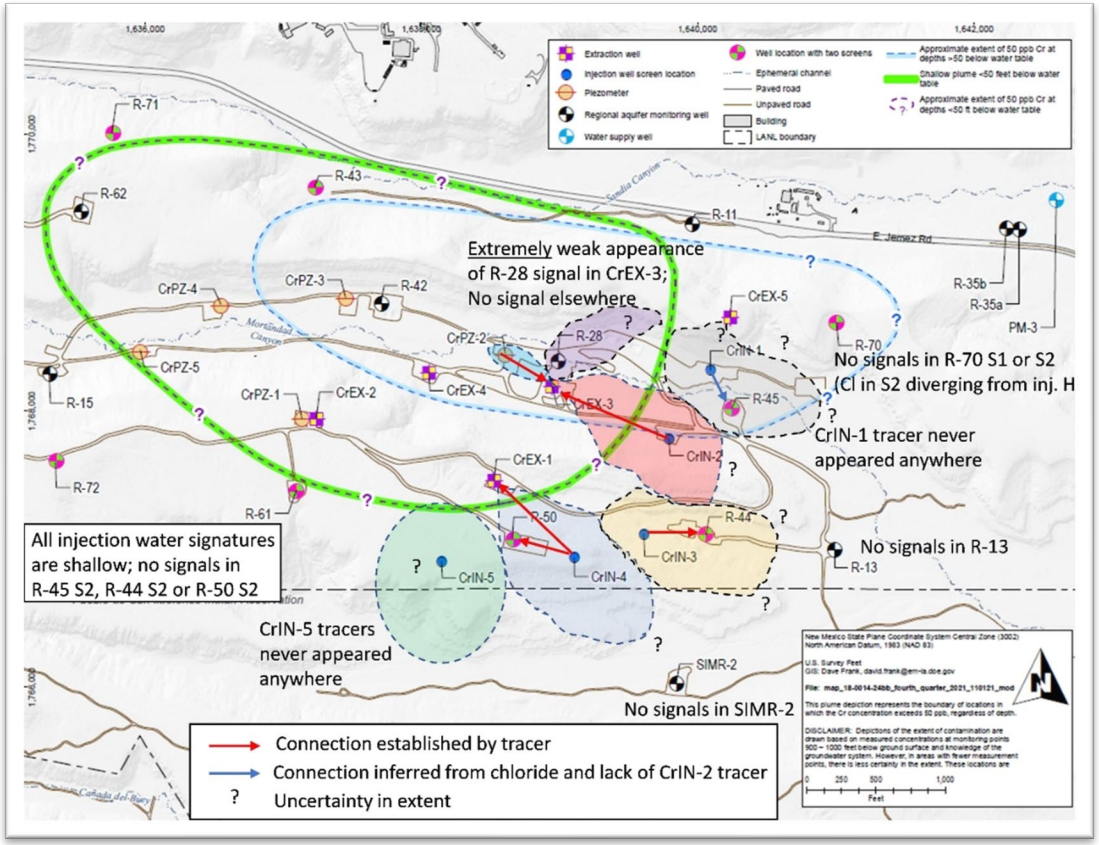




Tracers

Flow from Injection Wells

- CrIN-1
  - Tracer has not been definitively detected
  - Injection water chemistry has been observed in R-45 S1, presumably from CrIN-1
- CrIN-2
  - Tracer injection reached CrEX-3
  - Injection water geochemistry not definitively detected
- CrIN-3
  - Injected tracer reached R-44 S1
  - Injection water geochemistry observed at R-44-S1 but not S2
- CrIN-4
  - Injected tracer reached R-50 S1 and CrEX-1
  - Injection water geochemistry observed at R-50 S1 but not S2
- CrIN-5
  - Tracer has not been definitively detected



Summary of Concentration and Tracer Results

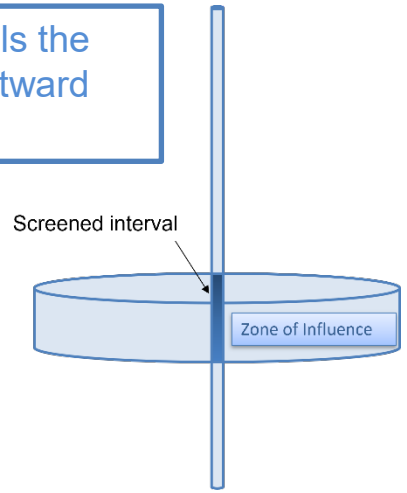
Monitoring Well	Screen	Pre-IM Operations	Sustained Southern IM Operations	Sustained Eastern IM Operations	Injection Water Signature (Cl^- and SO_4^{2-})	Tracer Injection
Southern Plume Area						
R-15		↑	↓	↓		
R-61	S1	↑	↑	↑		
	S2	–	–	–		
CrEX-2				↓		
CrEX-1				↓	✔	**CrIN-4**
R-50	S1	↑	↓	↓	✔	**CrIN-4**
	S2	–	–	–		
R-44	S1	↑	↓	↓	✔	**CrIN-3**
	S2	–	↓	↑		
SIMR-2		–	–	–		
R-13		–	–	–		
Eastern Plume Area						
R-11		↑	↓	–		
CrEX-5				↓		
R-45	S1	↑	↓	↓	✔	
	S2	↑	↑	↑		
R-70	S1			↓		
	S2			↓		
R-35a		–	–	–		
R-35b		–	–	–		
Plume Centroid						
CrEX-3				↓		**CrIN-2**
CrEx-4				↓		

Injection at Plume Periphery

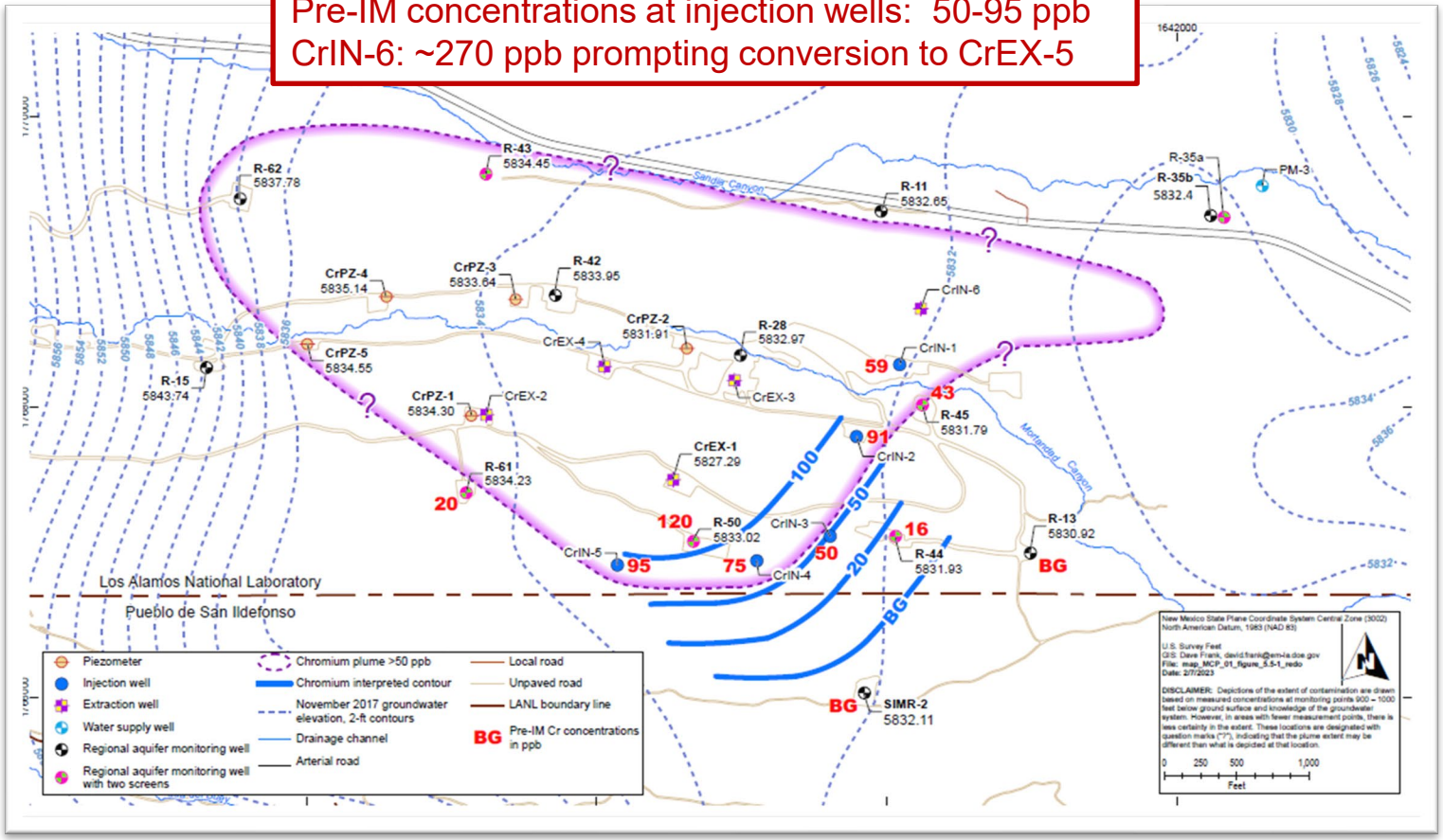
Injection at Plume Boundary

Determine extent of injection water and fate of the Cr in the vicinity of the injection zone

Injection water fills the pore space in outward radial flow



Pre-IM concentrations at injection wells: 50-95 ppb
CrIN-6: ~270 ppb prompting conversion to CrEX-5

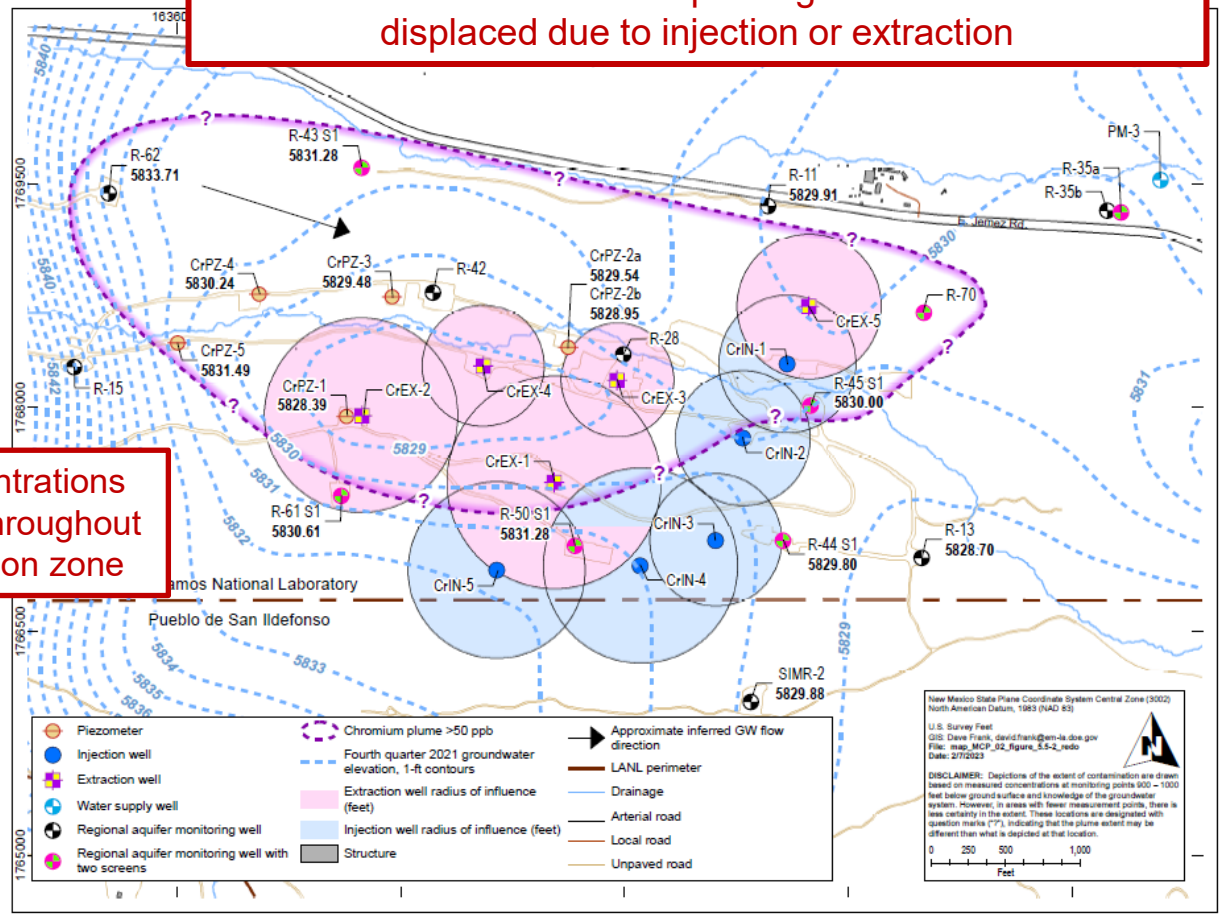


Pre-IM Water Table Contours and Cr Plume Depiction 2017

Injection at Plume Boundary

Zone of influence: disk-shaped region in which water is displaced due to injection or extraction

Cr concentrations are low throughout the injection zone



Q4 2021 Cr Plume Depiction and Zones of Influence

- A “clean zone” of low Cr concentration has been created
- 50 ppb plume boundary has been pushed well into the LANL property
- Cr concentrations greater than background are likely present south of the LANL boundary, but concentration levels are unknown
- Background Cr concentrations are still observed at R-13 and SIMR-2, as well as at depth in R-50 S2 and R-44 S2

Analysis of IM Operational Scenarios

Evaluation of IM Operations Modifications

Modeling simulations used to demonstrate change in concentrations at sentinel locations under four different operational scenarios

- Historical pumping records used to date
- Differences assumed beginning April 1, 2023
- Simulations executed until January 1, 2027

1

Full Operations

All five extraction and all five injection wells operating 24/7, ~285 gpm

2

Reduced Operations

Continuation of current system configuration, CrEX-4, CrEX-5, CrIN-4, and CrIN-5 operating 24/7 at 140 gpm

3

Land Application

Assumed CrEX-4 and CrEX-5 with no injection operating at 140 gpm, 8 hrs/day for 3 days, followed by 2-weeks of no operations during land application. No operations Nov – April.

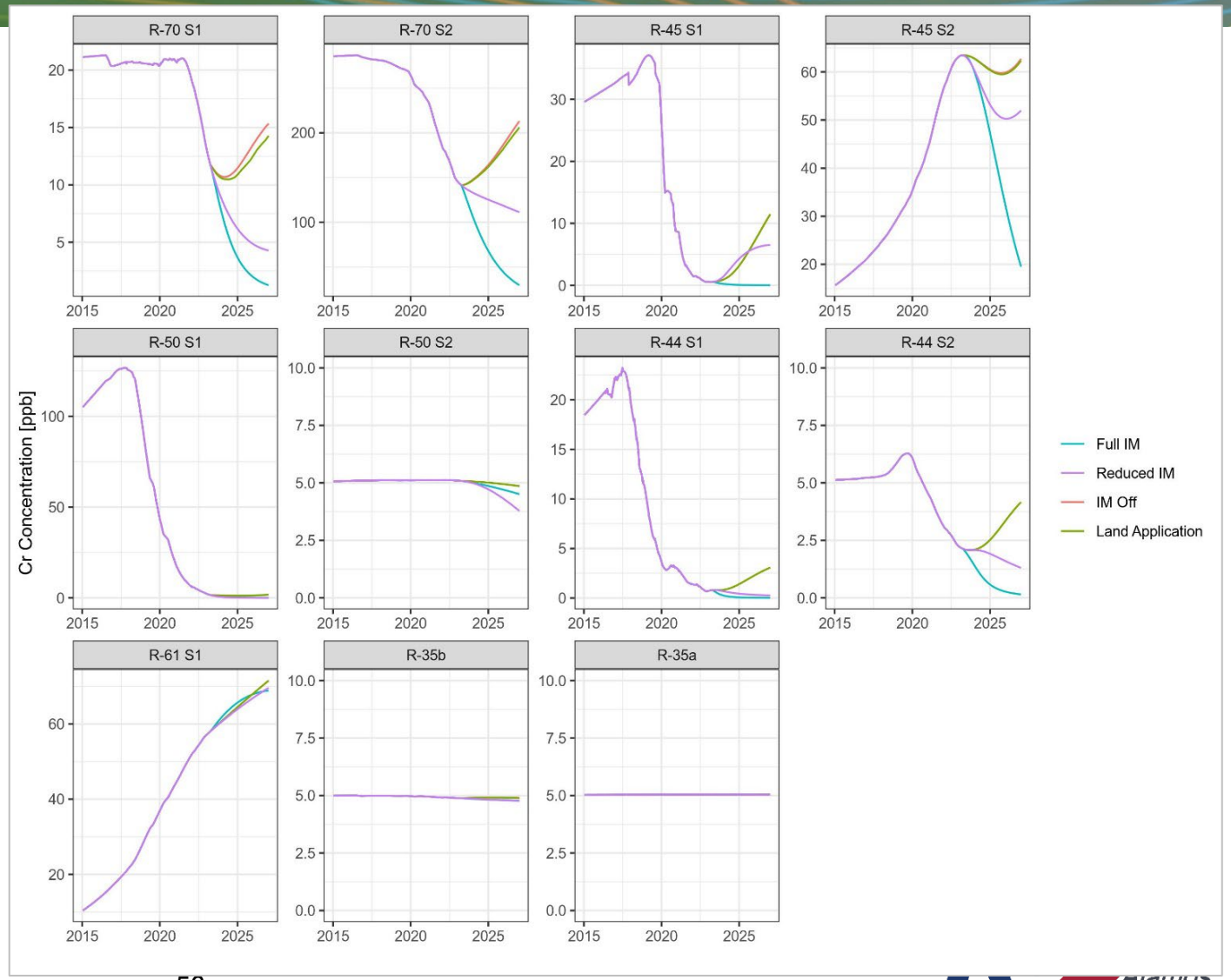
4

No Operations

Complete shutdown of system, 0 gpm for all wells.

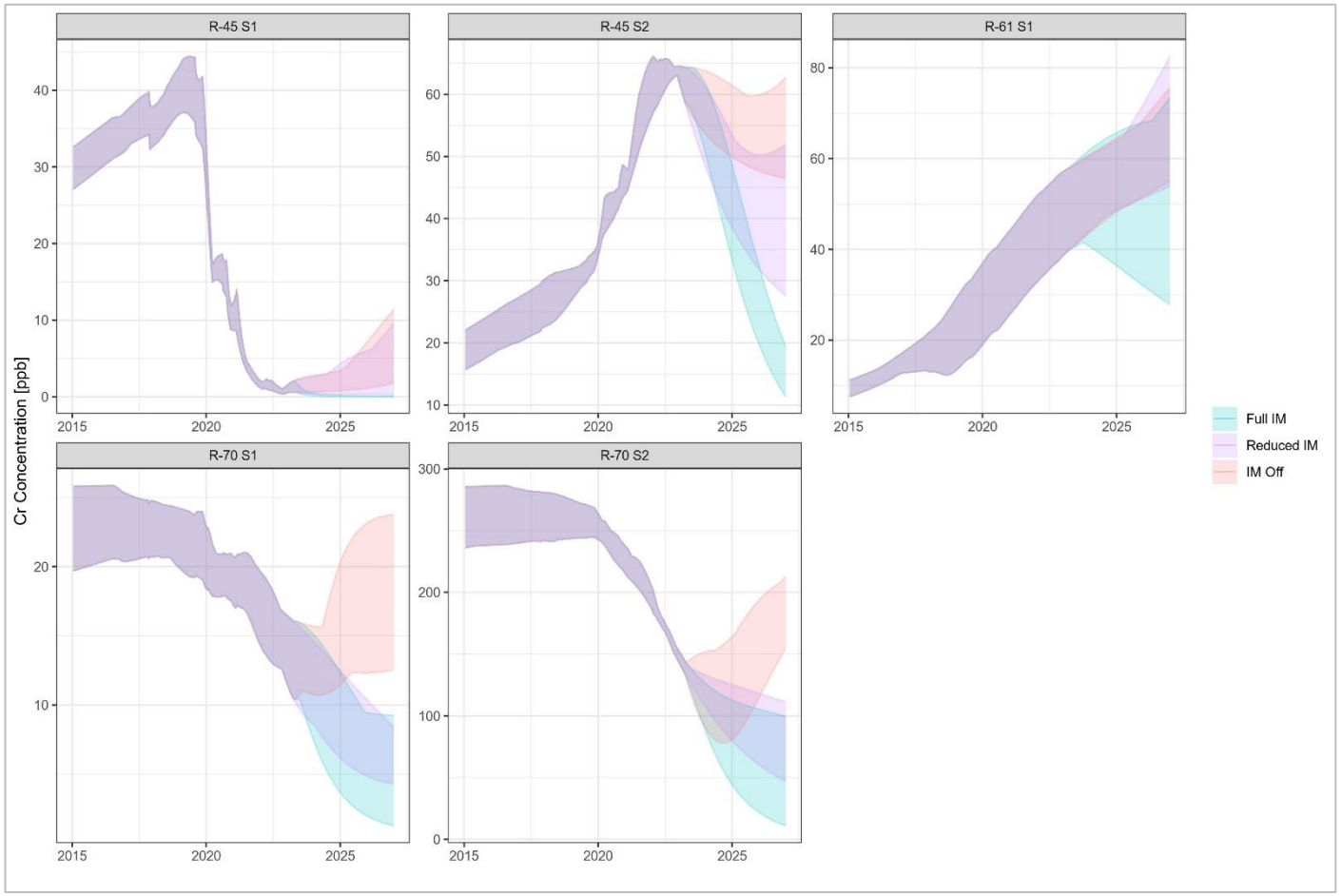
Concentration Predictions at Key Well Locations

- Land application equivalent to no operations (99% reduction relative to full operations)
- Chromium concentrations at R-50 remain below standard in all scenarios
- Full IM operations best scenario for reducing concentrations at R-45 and R-70



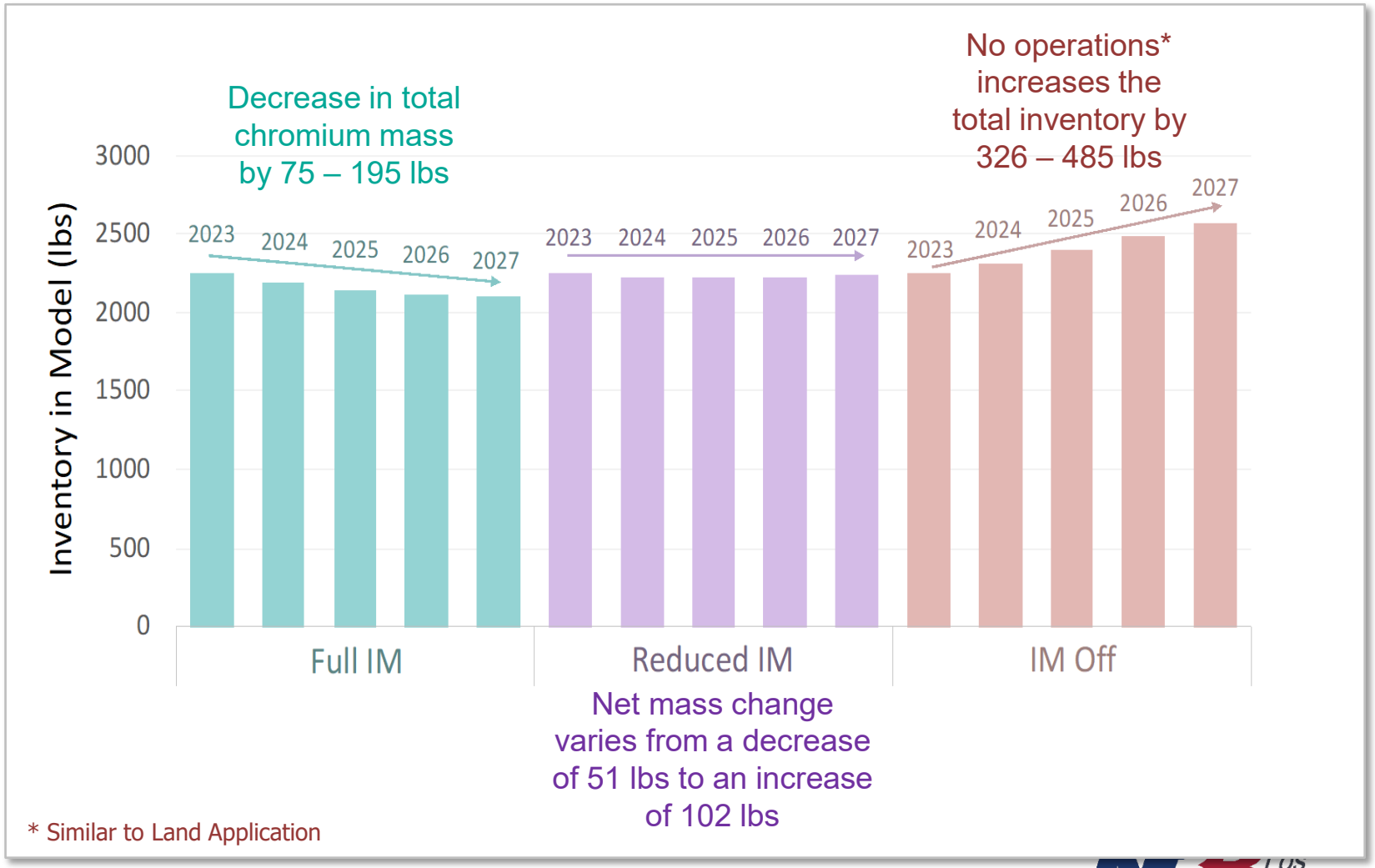
Uncertainty Considerations

- R-45
  - Full IM operations is the only scenario demonstrating definitive decrease in Cr concentrations at R-45 S2 to background chromium concentrations
    - Rebound likely to occur by 2026 under reduced IM scenario
- R-70
  - Cr concentrations increase under land app/no operations
  - S2 concentration reduction achieved under reduced and full operations due to CrEX-5
- R-61
  - Cr concentrations could increase, level off or decline
  - Outcome more dependent on source rather than IM operations



Total Inventory (Cr Mass)

- Simulations conservatively assume under all operational scenarios that Cr sources from the vadose and perched intermediate zones continue to enter groundwater (326 – 485 lbs)



Simulation Results Summary

1 Land-application results in a significant reduction in operations and is functionally equivalent to no operations

Land Application

2 If IM operations cease, chromium mass in the regional aquifer increases due to continuing sources of chromium entering the aquifer

Land Application and No Operations

3 Continued operation of CrEX-5 is critical for plume control and Cr concentration reduction in the northeast plume area

Full and Reduced IM

4 Full IM results in the lowest predicted concentrations in both screens at wells R-45 and R-70 and reduces the total mass in the aquifer

Full IM

5 Full IM is the only operational scenario that reduces Cr concentrations at R-42 screen 2 to below the 50 ppb without rebound occurring (through calendar year 2026)

Full IM

Summary and Conclusions

Conceptual Site Model (CSM) Updates and Changes in Concentration

1. CSM has been refined due to information obtained during IM operation to consider deeper contamination than was envisioned at the start of the IM
2. Changes in the potentiometric surface during the IM suggest that IM operations are successful in attaining hydraulic control of the plume
3. IM has been successful in reducing concentrations along the southern boundary of the plume, and creating a hydraulic barrier to flow in the southern plume area
4. Monitoring well R-45 S2 increases likely due to IM operation
5. Monitoring well R-61 S1 cause for increase is unknown and under investigation

- Plume Updates
- Potentiometric Surface Update
- Concentration Reduction
- Concentration Increase
- Concentration Increase

Hydraulic Plume Control

1. Modeling of capture zones suggests that IM extraction wells capture chromium mass in the south and southeastern areas of the plume
2. Modeling indicates that in 25% of the simulations, mass in the northeastern region may not be captured
3. Full IM is the most successful at maintaining hydraulic plume control and reducing concentrations
4. Land application without injection are of limited value, with performance essentially the same as shutdown of the system
5. Permit conditions would need to be changed for more streamlined and continuous operations but likely at least 1-2 yr timeframe required

- Plume Updates
- Potentiometric Surface Update
- Concentration Reduction
- Concentration Increase
- Concentration Increase

Recommendations

Full IM Operations

The IM system should continue to be operated at full capacity to maximize IM benefits

CrEX-5

Ensuring continued extraction at CrEX-5 should be a priority for the IM going forward

R-79 and R-80

Planned monitoring wells R-79 and R-80 are needed on a priority basis to reduce uncertainties and to provide additional performance monitoring

Depth of Cr

Deep extraction does not appear to be necessary at this time to continue to achieve IM objectives, but may emerge as a priority, pending installation of deeper monitoring wells (R-76 and R-77)

IM Evaluation

Returning the system to full operation will confirm or refute the conclusions presented in this evaluation and provide important new information on plume behavior that will aid in final remedy design

U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Questions

ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

Produced by Los Alamos Legacy Cleanup Contractor, N3B Los Alamos
on behalf of DOE's Environmental Management Los Alamos Field Office

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