Homestake Mining Company of California
Grants Reclamation Project
ACL Application
April 14, 2022

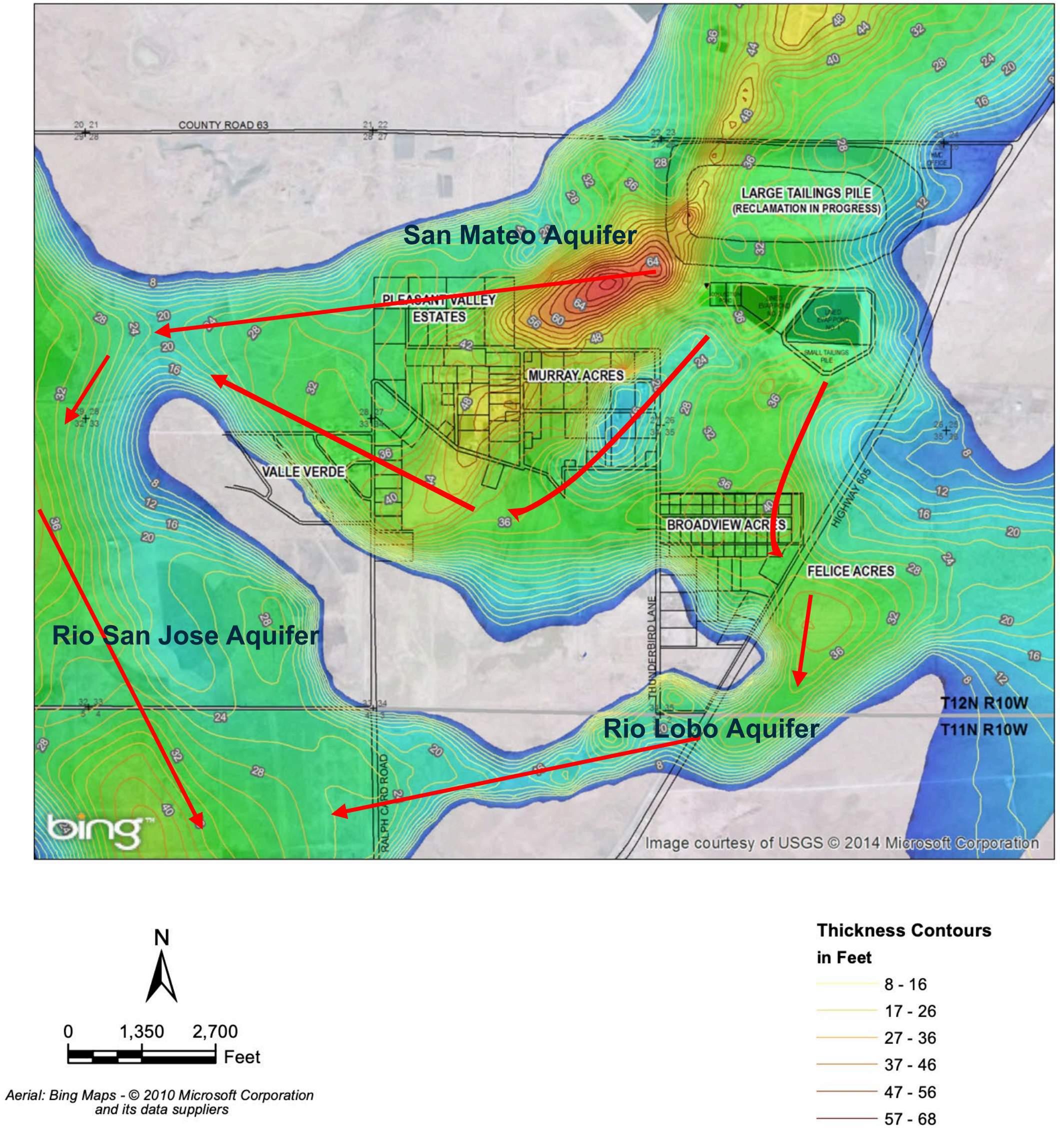
How Did We Get Here?

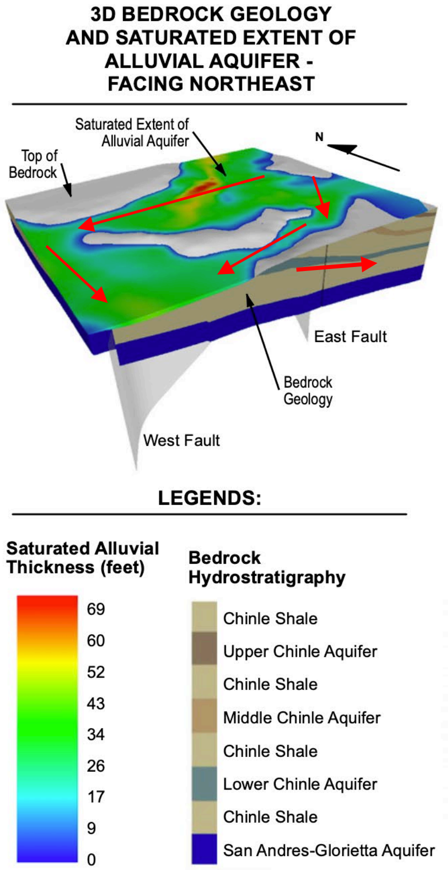
- Mill licensed in 1958 under AEC, operated in compliance with License, tailings were permitted as unlined impoundments.
- New environmental regulations passed by Congress in 1970s (Clean Air Act, Clean Water Act, Safe Drinking Water Act, Uranium Mill Tailings Radiation Control Act, Comprehensive Environmental Response Compensation and Liability Act)
- Groundwater corrective action initiated in 1977.
- Last groundwater CAP approved by NRC in 1989, amended for reverse osmosis water treatment in 1998, and amended for zeolite water treatment in 2019.
- Groundwater CAP infrastructure and scope evolved from 1977 through present day to address nature and extent of groundwater impacts.
- NRC reviewed and inspected groundwater CAP regularly between 1989 and 2021
- HMC submitted revised groundwater CAPs in 2006, 2012, 2019, and 2020

Summary of Groundwater Corrective Action

- Over 10 billion gallons of water collected
- Over 1 million pounds of uranium collected
- Over 3 billion gallons of water lost to evaporation as a result of groundwater remediation
- Approximately 87% of uranium mass that seeped out of the tailings pile has been collected.
- More than $230M spent on remediation and reclamation

ACL Application – Hydrogeology



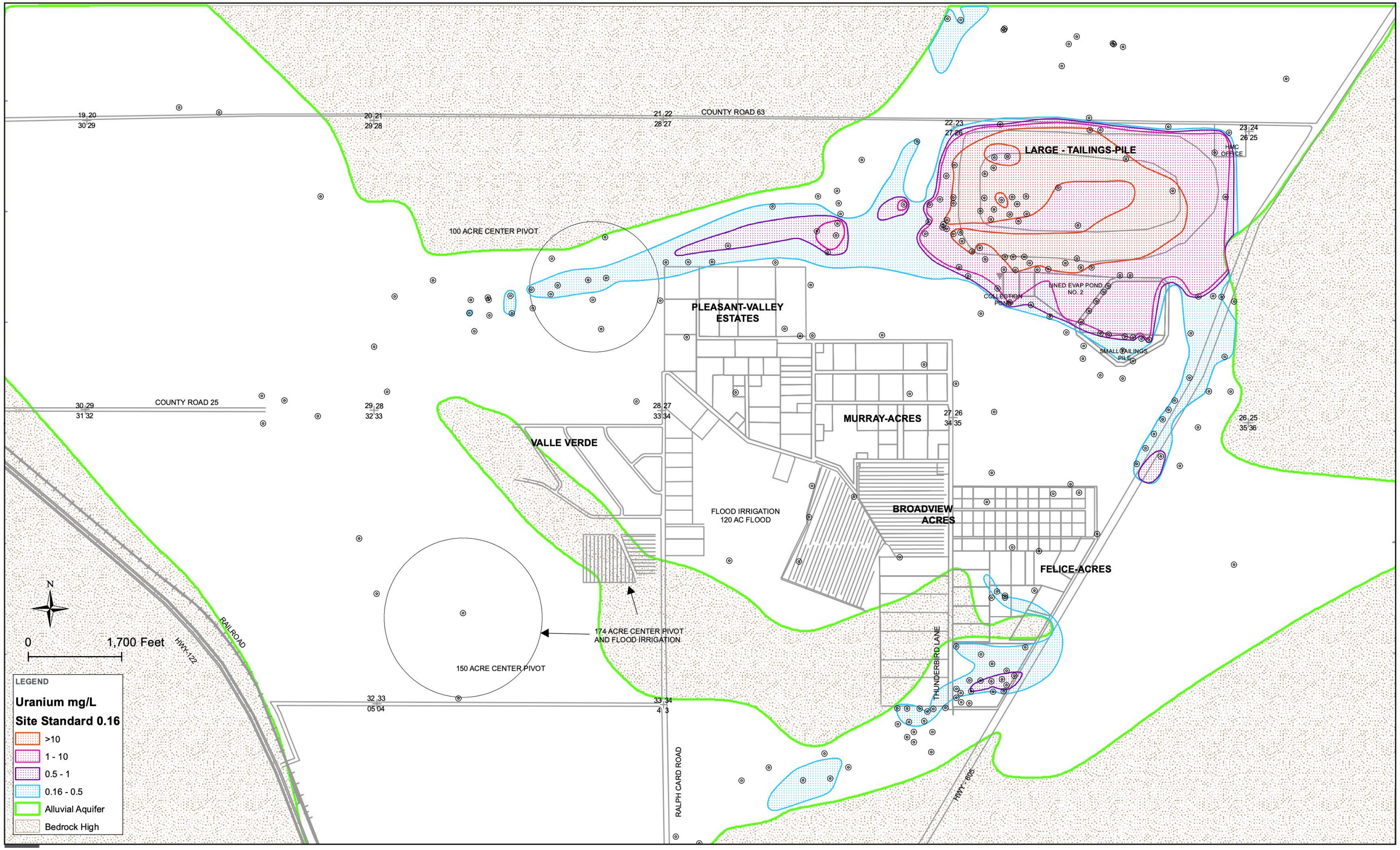


Source: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

Note northeast down-dip groundwater flow in Chinle sandstone units

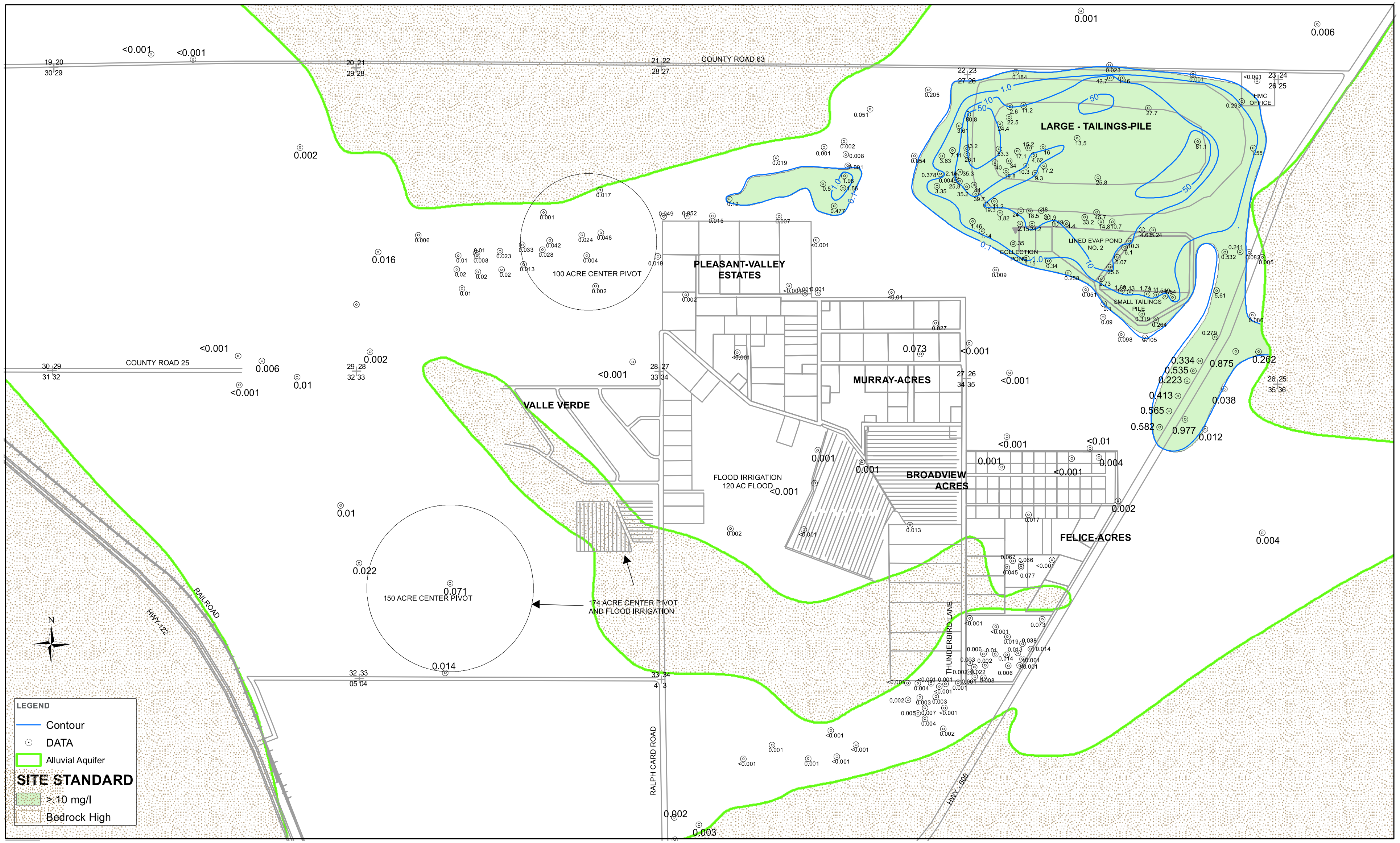
ACL Application - Constituents

- Current License Condition 35B
  - molybdenum, selenium, vanadium,
  - uranium, radium-226+228, thorium-230
  - chloride, nitrate, sulfate, total dissolved solids
- Reviewed data to verify identification of constituents to be addressed
  - 1987 NRC tailings sampling data
  - HMC tailings sampling data
  - HMC groundwater quality data
- Identified additional constituents (reasonably derived from milling, in uppermost aquifer)
- Total dissolved solids not considered a hazardous constituent for this application but retained as a monitoring parameter



Grants Reclamation Project
Corrective Action Program

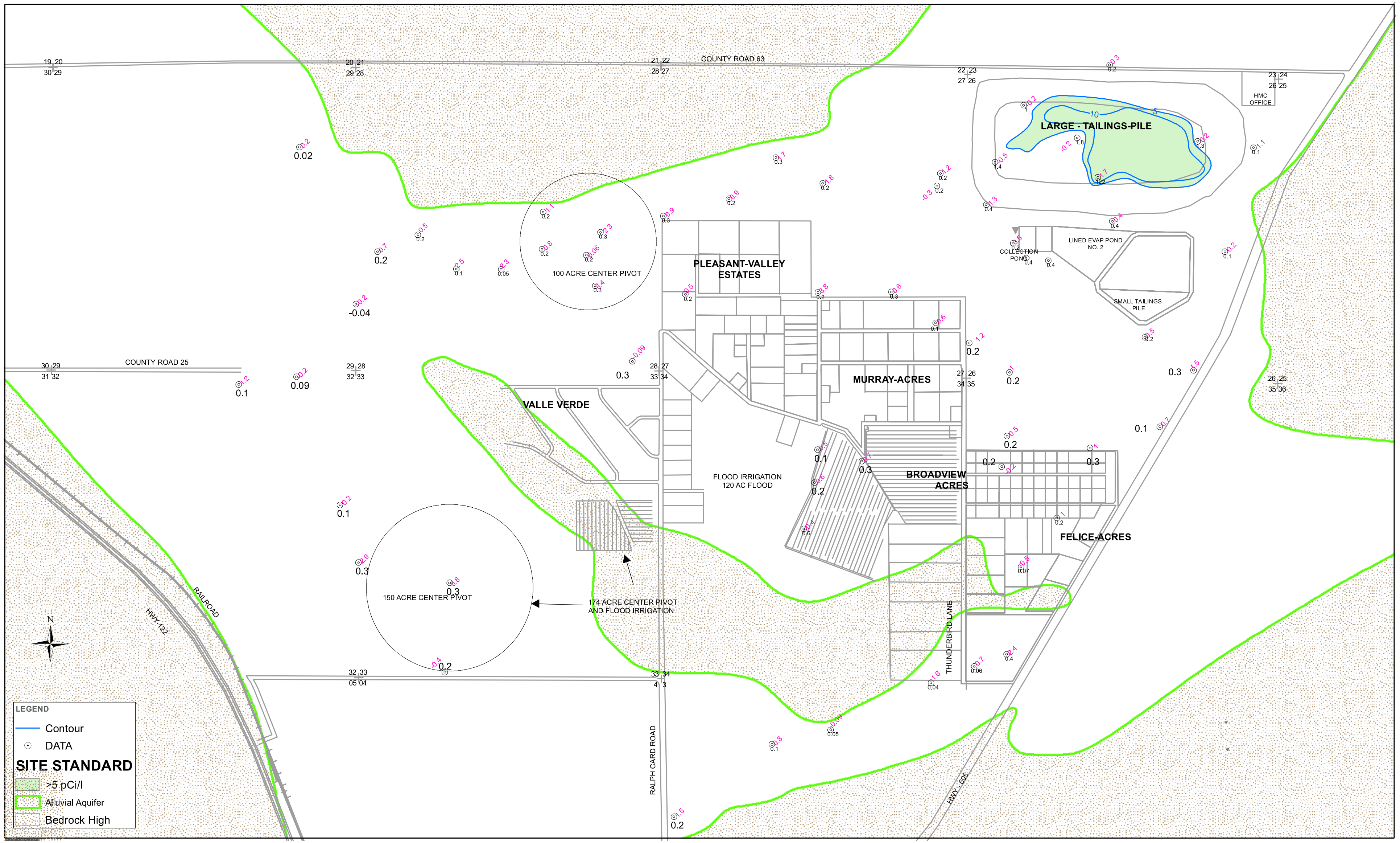
Alluvial Groundwater Uranium Concentrations, 2019



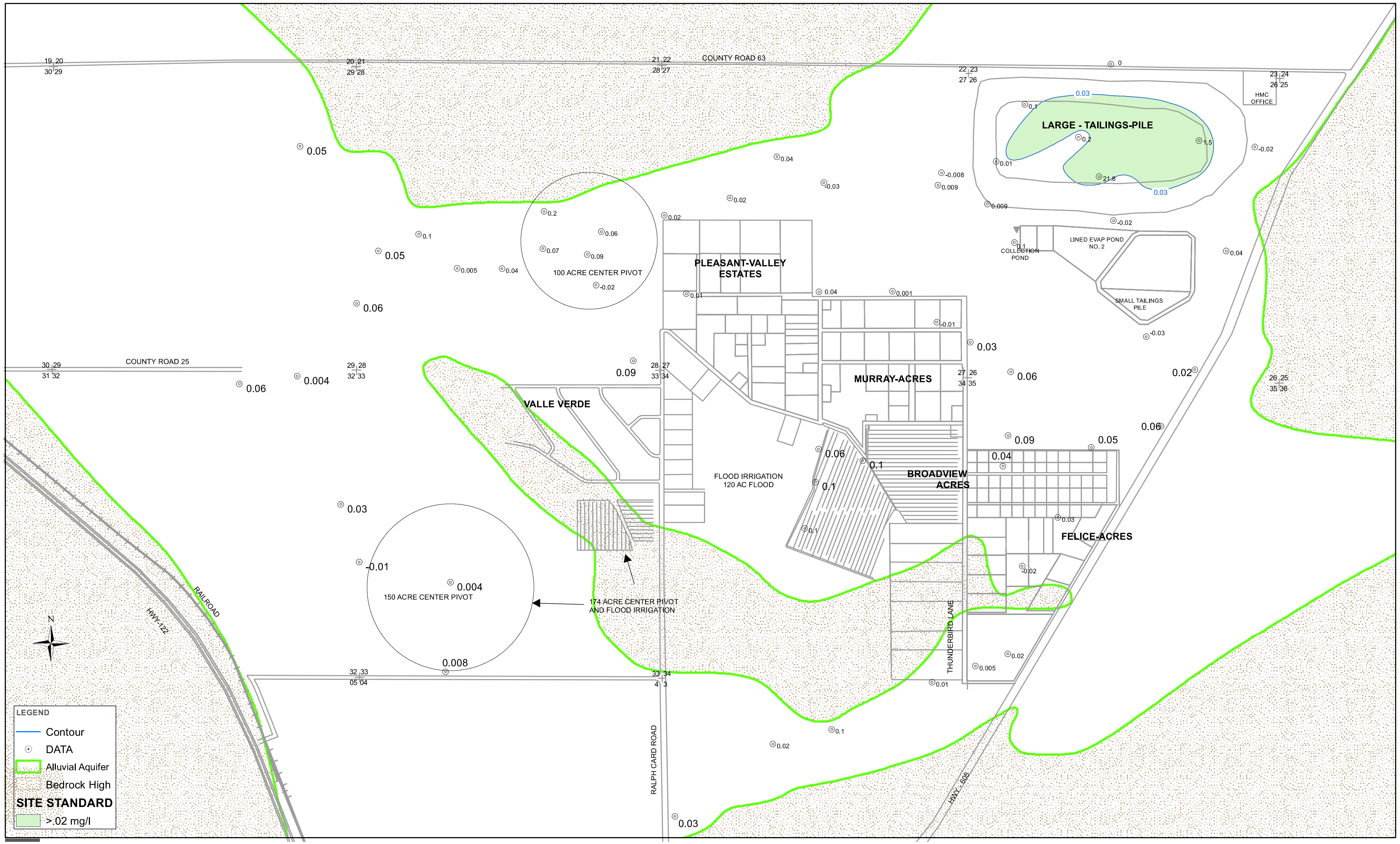
HOMESTAKE

Grants Reclamation Project
Corrective Action Program

Alluvial Groundwater Molybdenum Concentrations, 2019

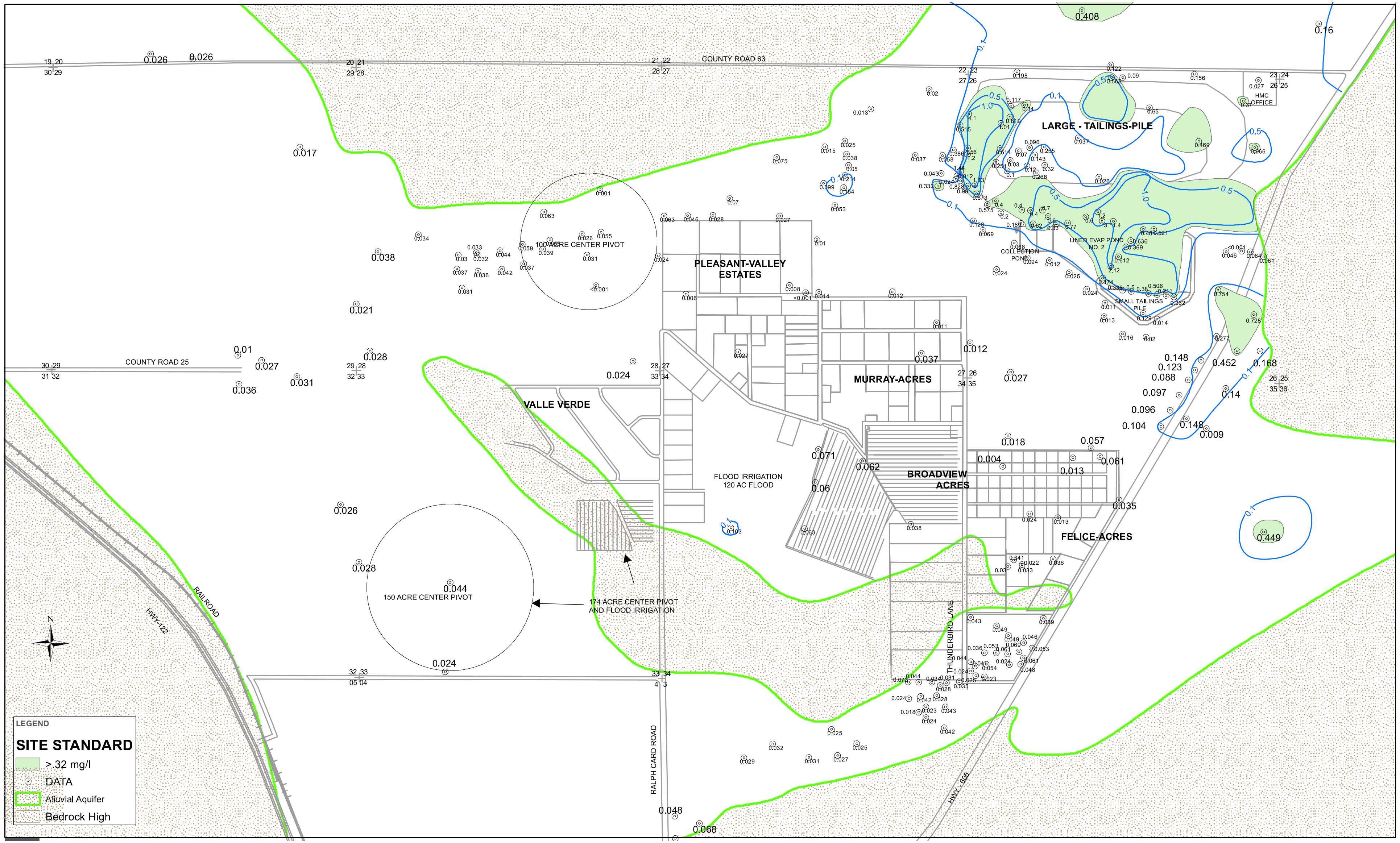


Alluvial Groundwater Radium-226+228 Concentrations, 2019

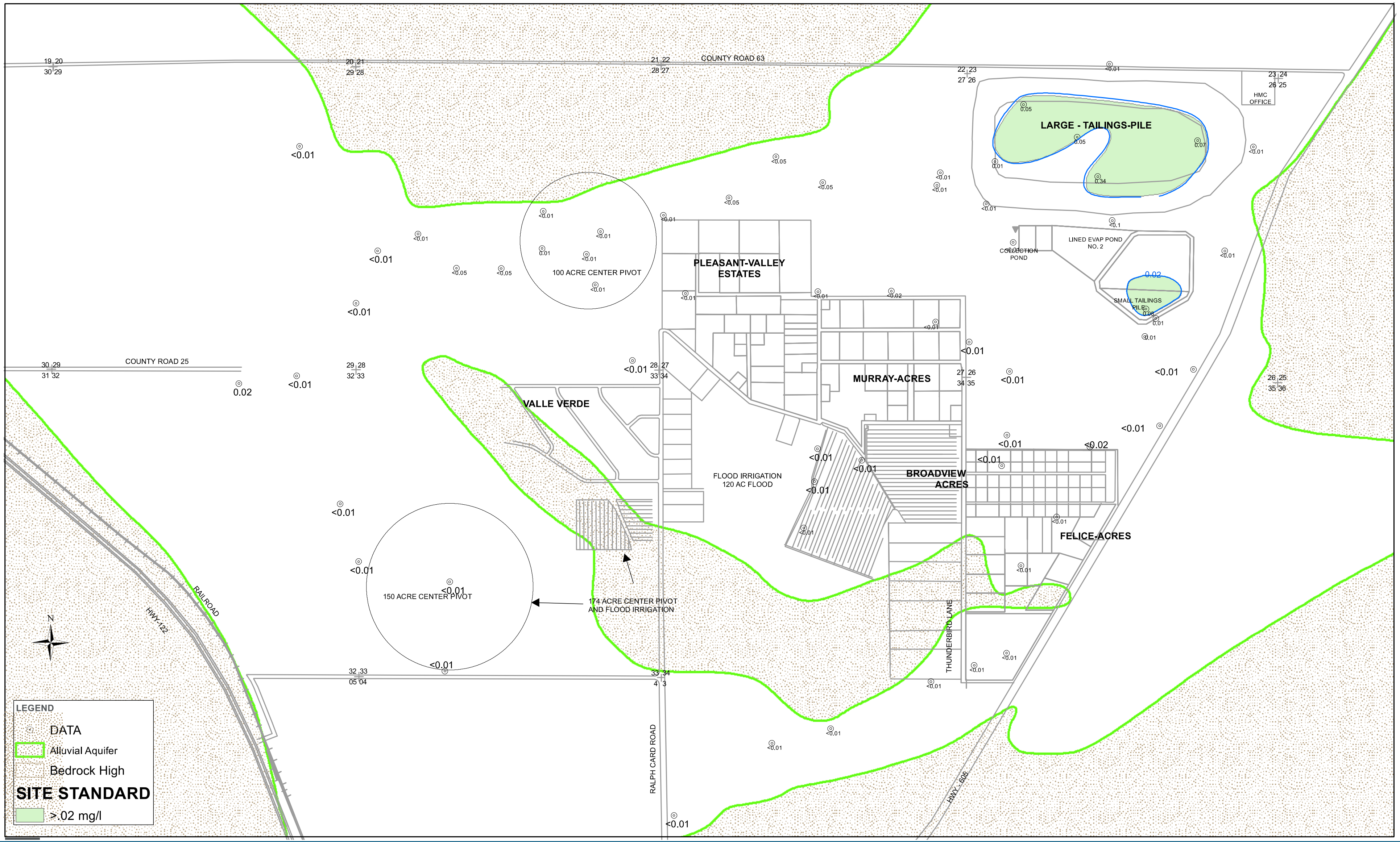


Grants Reclamation Project
Corrective Action Program

Alluvial Groundwater Thorium-230 Concentrations, 2019

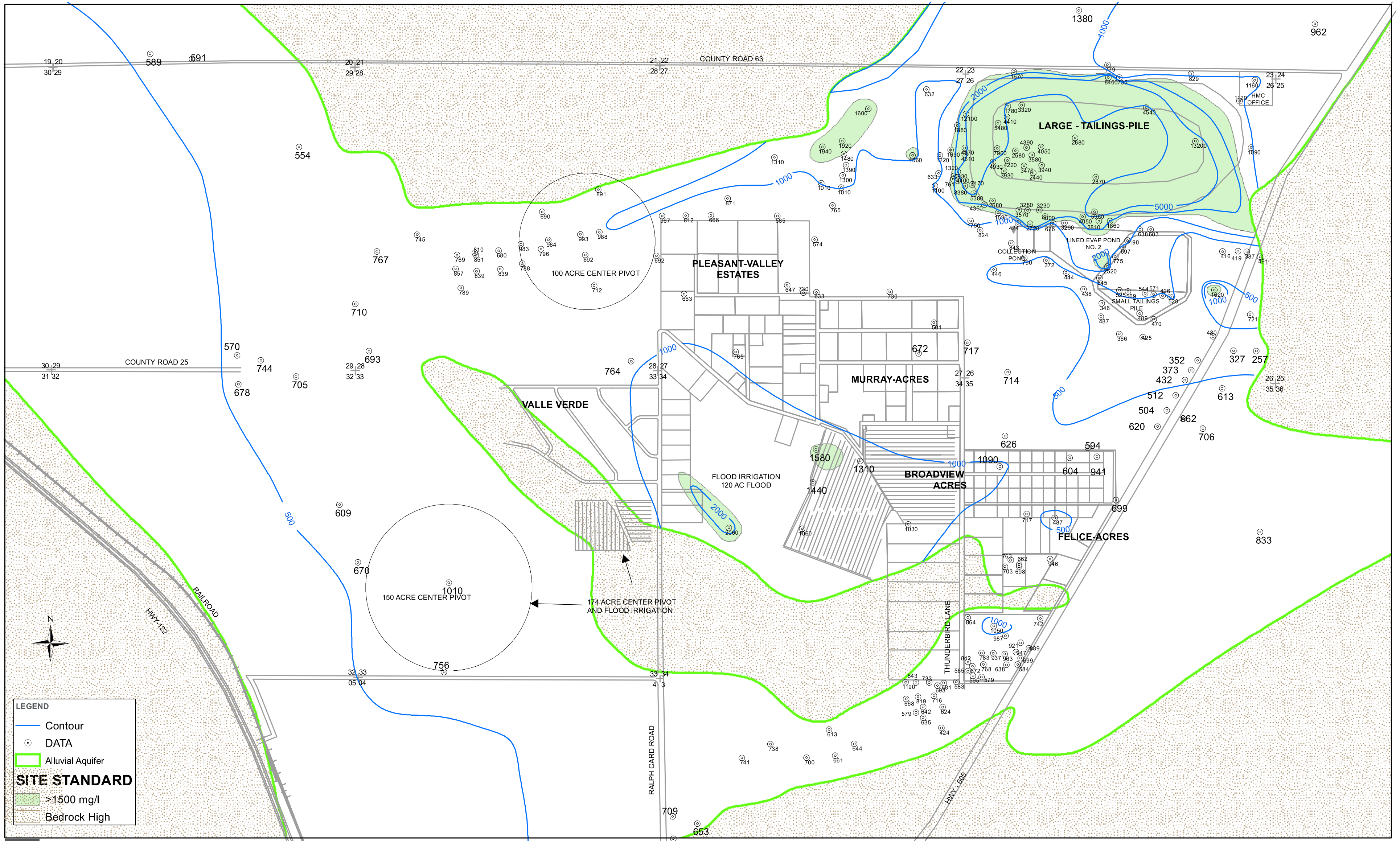


Alluvial Groundwater
Selenium Concentrations, 2019



HOMESTAKE
Grants Reclamation Project
Corrective Action Program

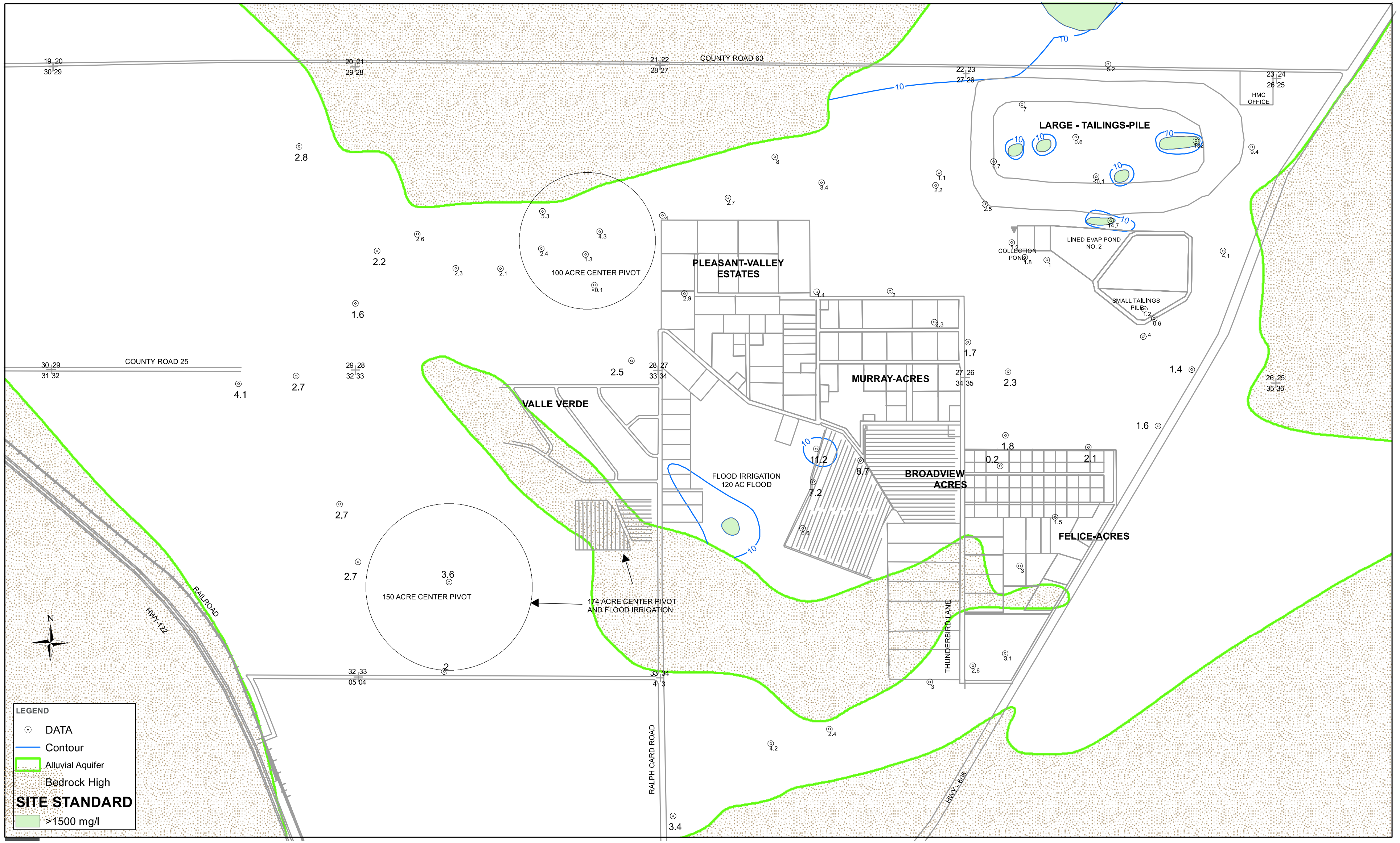
Alluvial Groundwater Vanadium Concentrations, 2019



HOMESTAKE

Grants Reclamation Project
Corrective Action Program

Alluvial Groundwater Sulfate Concentrations, 2019



Grants Reclamation Project
Corrective Action Program

Alluvial Groundwater Nitrate Concentrations, 2019

ACL Application-Development of Alternatives

- Used objectives and action types for development of range of alternatives
  - Objective: Prevent human ingestion of groundwater.
  - Objective: Restore groundwater quality.
  - Objective: Reduce seepage and migration from the tailing piles.
- Assessed a broad range of technology types and process options
- Alternatives address source control and plume mitigation
  - Active and passive technologies
  - *In situ* and *ex situ* technologies
  - Proven and innovative technologies
- Three alternatives developed and assessed

On-Site
- Groundwater has multiple constituents requiring treatment
- Groundwater concentrations higher than Off-Site areas
- Groundwater treated with reverse osmosis

Off-Site
- Only uranium requires treatment
- Groundwater concentrations lower than On-Site
- Groundwater treated with zeolites and reverse osmosis

ACL Application-Analysis of Alternatives

- **Alternative 1:** No Action
  - Continue existing groundwater collection, *ex situ* treatment, re-injection
    - Source Control
      - Tailings water collection in toe drains, Large Tailings Pile cover reduces infiltration
    - Plume Mitigation
      - Off-Site areas for 150 years
      - On-Site Areas for 1,000 years (containment)
    - Groundwater access controls via fee title ownership, monitoring and reporting

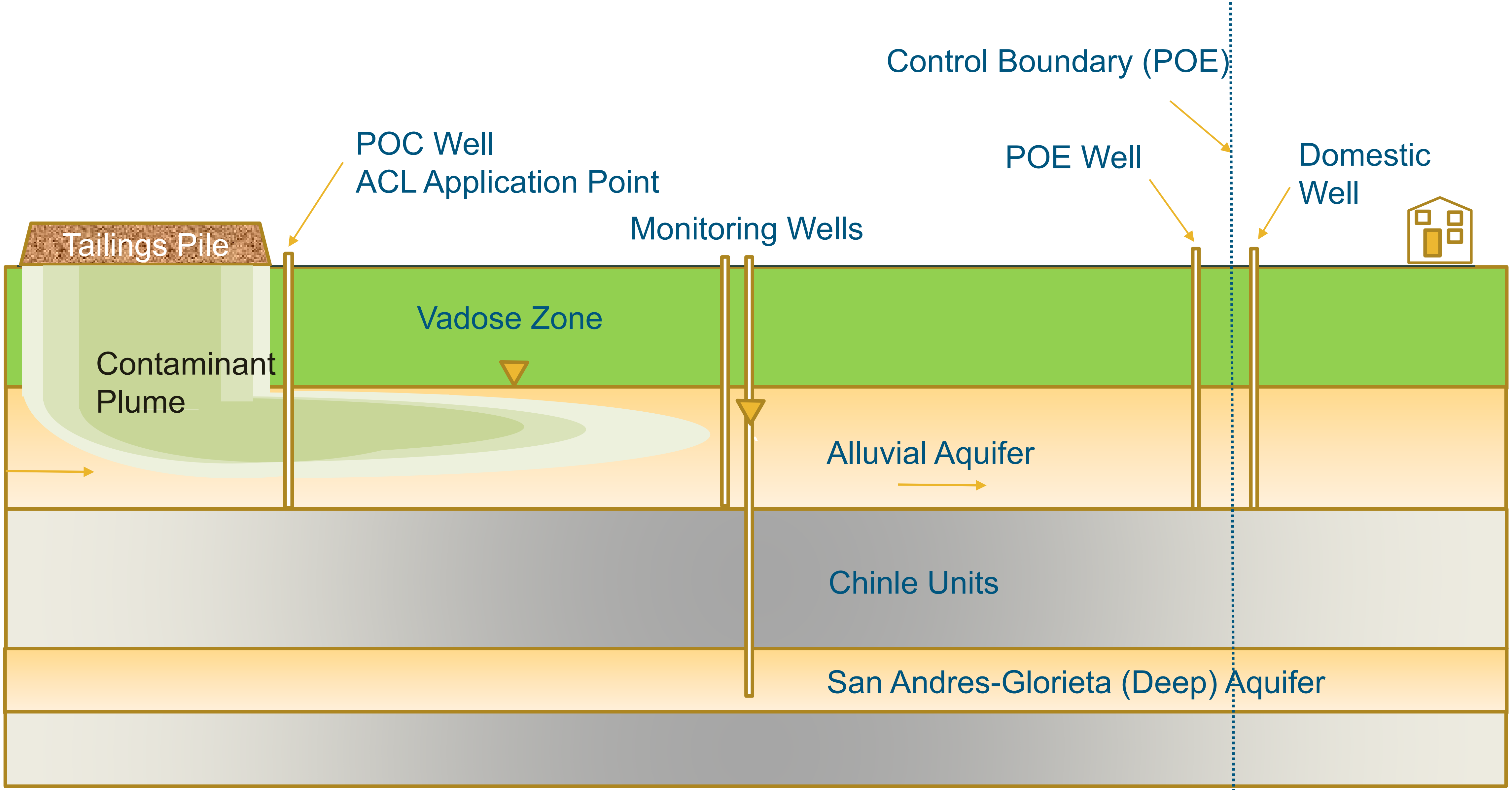
ACL Application-Analysis of Alternatives

- **Alternative 2:**
  - Continue existing groundwater collection, *ex situ* treatment, re-injection, add permeable reactive barrier On-Site
    - Source Control
      - Tailings water collection in toe drains, Large Tailings Pile cover reduces infiltration
    - Plume Mitigation
      - Off-Site areas for 150 years
        - On-Site area source control for 35 years, followed by hydroxyapatite permeable reactive barrier for 965 years, replaced every 50 years
    - Groundwater access controls via fee title ownership, monitoring and reporting

ACL Application-Analysis of Alternatives

- **Alternative 3:** ACLs
  - Source Control
    - Large Tailings Pile cover reduces infiltration
  - Plume Mitigation
    - Monitored Natural Attenuation
    - Groundwater access controls via fee title ownership, monitoring and reporting

Alternative Concentration Limits



ACL Application-Analysis of Alternatives

- Modeling of Alternatives
  - Used calibrated base-case groundwater model to simulate each Alternative's performance over 1,000-year period
    - Model well calibrated to transient data for period 2002-2019
      - Flow calibrated to 10,051 water level values in 442 locations over 4 water bearing units
      - Uranium transport calibrated to 5,896 concentration values in 337 locations over 4 water bearing units
      - High confidence in representation and prediction of flow and transport conditions
  - Modeled Constituent for purposes of Alternatives Assessment
    - Uranium: most extensive constituent above its respective standard

ACL Application-Analysis of Alternatives

- **Eight Criteria for assessing Alternatives**

1. Protection of Human Health - Occupational Health and Safety
2. Protection of Human Health - Public Health and Safety
3. Protection of the Environment - Risks to Wildlife
4. Protection of the Environment - Preservation of Groundwater Resource
5. Implementation - Ability to Construct and Operate
6. Implementation – Administrative Feasibility
7. Implementation – Restoration of Resource
8. Implementation - Source Reduction and Control

- **Cost for each alternative developed**
  - Not used to select Proposed Action

ACL Application-Cost/Benefit and ALARA

NUREG-1620:

- ALARA analysis considers:
  - (a) the direct and indirect benefits of implementing each corrective action to achieve the target concentration levels;
  - (b) the costs of performing the corrective action; and
  - (c) a determination whether any of the evaluated corrective action alternatives will reduce contaminant levels below the proposed alternate concentration limit, considering the benefits and costs of implementing the alternative

- *"A proposed alternate concentration limit is considered as low as Is reasonably achievable if the comparison of the costs to achieve the target concentrations lower than the alternate concentration limit are far in excess of the value of the resource and the benefits associated with performing the corrective action alternative."* (Section 4.3.3.3(4))

ACL Application-Cost/Benefit & ALARA

Benefits	Costs
Current and projected value of the pre-contaminated groundwater resource ($)	Remediation Costs ($) (Capital, O&M, Decommissioning)
[A]Collective Averted Dose ($)	Additional Occupational/Public Dose (qualitative)
Regulatory Costs Avoided ($)	Occupational Non-Radiological Risk (qualitative)
Changes in land Value (qualitative)	Transportation Direct Costs and Implied Risks (qualitative)
Timeliness of Remedy Completion (qualitative)	Environmental Impacts (qualitative)
Aesthetics (qualitative)	Present Value of Irretrievable Commitment of Groundwater ($)
	Loss of Economic Use of Site/Facility (qualitative)

$$^{A}B_{AD} = V_{AD} \times PW(AD_{Collective})$$

Where:

B_{AD} = benefit from averted dose for a remediation action, in current U.S. dollars

V_{AD} = value in dollars of a person-rem averted (NUREG-1530)

$PW(AD_{Collective})$ = present worth of a 1,000-year collective averted dose

Considered

- NUREG-1620
- NUREG-1757, Vol. 2 Rev.1 , Appendix N
- NUREG-1530
- NUREG/BR–0058

ACL Application-Alternatives Summary

- Based upon the eight evaluation criteria of how the alternatives met the objectives of protecting human health, protecting the environment, and considering the implementability of each alternative, Alternative 3 was identified as the alternative that best met the evaluation criteria
- Alternatives 1 and 2 rely upon perpetual treatment in order to maintain groundwater concentrations below the protective standard due to the persistent sources
- This perpetual treatment generates an irretrievable loss to evaporation of the water resource for the entire duration of active remediation

ACL Application-Alternative 3 Summary

- Proposed Action is Alternative 3 (ACLs)
- All properties with permitted access to groundwater in affected area are connected to municipal water supply
- Control over access to and use of groundwater via fee title land ownership (acquisition of remaining properties in process)
- Demonstrate with conservative modeling that maximum predicted POE concentrations are protective of public health, safety, and the environment for 1,000 years
- Demonstrate through assessment of costs and benefits, per NRC guidance[1] that 45 years of corrective action and the controls included in Alternative 3 have reduced groundwater concentrations to levels that are ALARA.

[1]NUREG-1620 (NRC,2003); NUREG-1757, Appendix N Vol (NRC, 2006) NUREG-1530 (NRC,2022)

ACL Calculation – Bounding-Case Modeling

- Assessment of alternatives and selection of Proposed Action supported by calibrated base-case models
- Calculation of ACLs supported by modified bounding-case models
  - Applies parameters at end-points of their reasonable ranges to promote transport
  - Addresses uncertainties with modeling inputs and provides additional assurance ACLs remain protective at POE for 1,000 years
- 8 Base-Case Model Parameters Combined to Form Bounding-Case Models
  1. Precipitation-Based Areal Groundwater Recharge (increased recharge)
  2. Large Tailings Pile Seepage (increased seepage rates)
  3. Large Tailings Pile Seepage Concentration (increased seepage concentrations)
  4. Freundlich Sorption-Based Retardation Factor (decreased retardation factors)
  5. Initial Concentrations Beneath the Tailings (increase mobile domain initial concentrations)
  6. San Andres – Glorieta Aquifer Municipal Groundwater Extraction (added wells for increases in future demand)
  7. Dual-Domain Mass Transfer Coefficients (increased coefficients)
  8. Dual-Domain Mobile/Immobile Alluvium Porosity Ratio (increased immobile domain porosity)

ACL Calculation – Bounding-Case Modeling

- Bounding-Case Models of Alternative 3
  - Conservative predictions of maximum POE concentrations
    - Uranium transport
    - Conservative solute transport
      - Surrogate for all constituents for which model was not calibrated
      - Assumes no retardation in transport, all other hydrologic conditions from uranium model retained
      - Uses a unit concentration approach (concentration of 1 [no units] applied to tailings seepage)
    - Predicted maximum POE concentrations are therefore percentages of the source concentration
    - Then, scale unit predicted concentrations to measured source conditions for each constituent to calculate maximum POE concentrations and ACLs

ACL Calculation

- Given
  - License groundwater protection standard for each unit ($C_{Protect}$)
  - Source area maximum ***modeled*** concentration (C_{POC})
  - Maximum predicted POE concentration (C_{POE}) for each aquifer from bounding-case model
- Attenuation Factor = $C_{POC} \div C_{POE}$
  - This is a metric of concentration decrease between POC and POE in transport
- Factor of Safety at the POE = $C_{Protect} \div C_{POE}$
  - Metric of how much the $C_{Protect}$ is above the maximum predicted POE concentration
  - Factor of safety can be used as a scaling factor, the amount by which C_{POC} can be increased and still have C_{POE} be at or below protective standard ($C_{Protect}$)

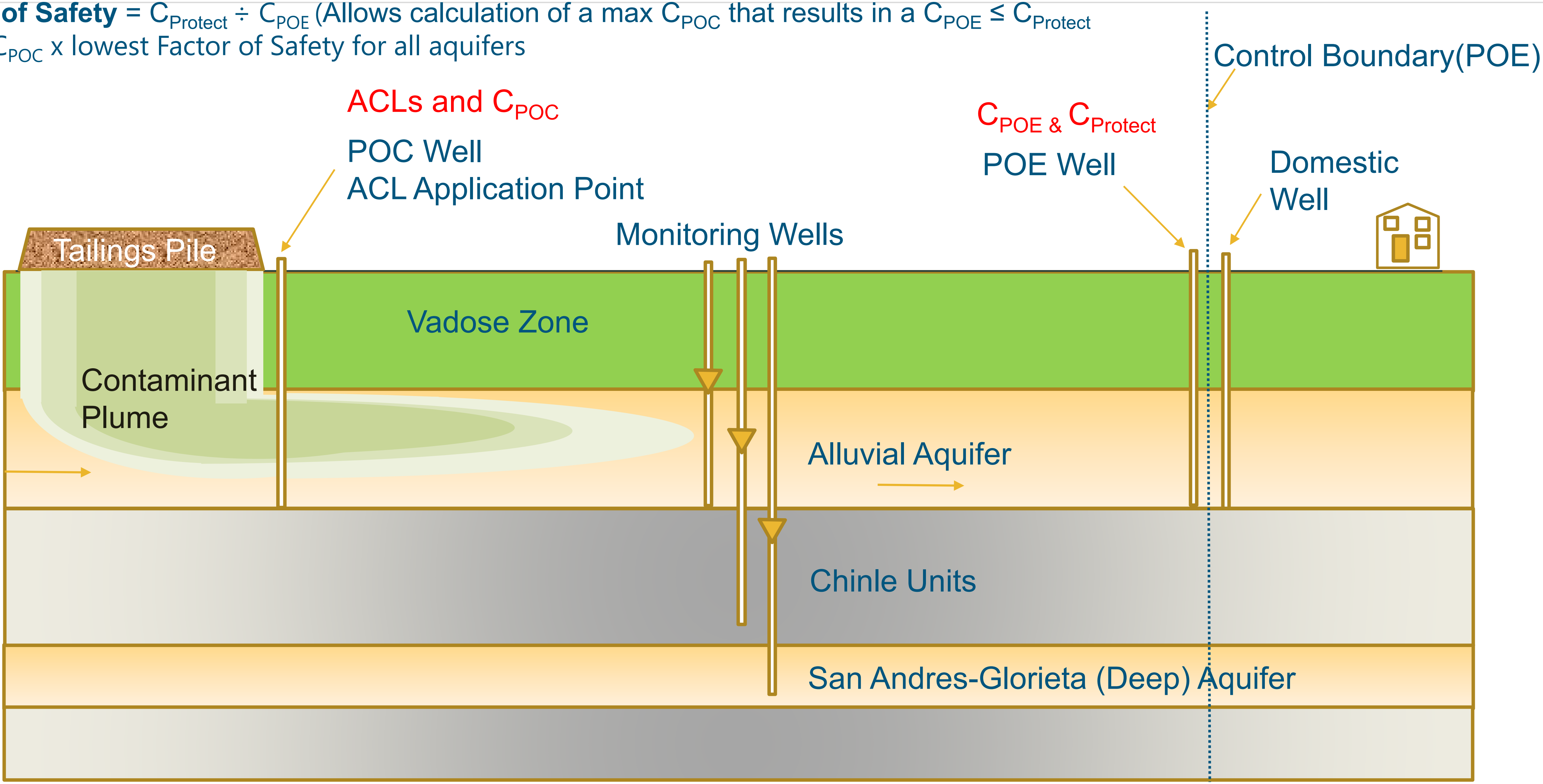
ACL Calculation

- Calculate ACLs using the ***lowest*** Factor of Safety for all water bearing units:
  - ACL = C_{POC} x Factor of Safety
- ACLs are only identified and proposed for the uppermost aquifer (alluvium)
  - By calculating the proposed ACLs using the ***lowest*** attenuation factor for ***each*** water bearing unit and the ***lowest*** factor of safety for ***all*** water bearing units, the proposed ACL, measured at the POC in the alluvial aquifer, will ensure protection at **all** POE for **all** water bearing units.

Attenuation Factor = $C_{POC} \div C_{POE}$ (Allows calculation of a C_{POE} for a measured C_{POC})

Factor of Safety = $C_{Protect} \div C_{POE}$ (Allows calculation of a max C_{POC} that results in a $C_{POE} \leq C_{Protect}$

ACL = C_{POC} x lowest Factor of Safety for all aquifers



ACL Application – Proposed Amendment

- Propose modifications to:
  - License Condition 15 (reporting frequency)
  - License Condition 35A (Groundwater Monitoring Plan)
    - Identify POC monitoring wells around tailings
    - Identify intermediate monitoring wells in all affected water bearing units
    - Identify a control boundary within which access to groundwater is to be controlled by fee title ownership
    - Identify monitoring analytes
    - Identify monitoring and reporting frequency
  - License Condition 35B (groundwater protection standards)
- Propose deletions of:
  - License Condition 35C (implement groundwater corrective action)
  - License Condition 35E (operate zeolite water treatment system)
  - License Condition 35F (corrective action performance report)

Questions?