Nevada Site Specific Advisory Board (NSSAB)

Full Board Meeting - Wednesday, April 17, 2024

Handouts…

Page 2 Attendance Spreadsheet

Page 3 Transfer Process of EM Sites on the Nevada National Security Sites to Long-Term Stewardship Briefing ~ Work Plan Item #5

Page 17 Educational Session: Pahute Mesa Groundwater Flow and Transport Model

NSSAB minutes, agendas, recommendations, meeting dates and locations, handouts, and member application is available on the NSSAB website at: www.nnss.gov/NSSAB/
NSSAB Phone: 702-523-0894; NSSAB Email: nssab@emcbc.doe.gov
NSSAB Address: 100 N. City Parkway, Suite 1750, Las Vegas, NV 89106
www.facebook.com/NNSANevada

The Nevada National Security Sites (NNSS) Environmental Report is available at
https://nnss.gov/publication-library/environmental-publications/

The Environmental Management (EM) Strategic Vision: 2024-2034 is available at
https://www.energy.gov/sites/default/files/2024-03/DOE EM Strategic Vision 2024 FINAL sm.pdf

NSSAB FULL BOARD MEETING ATTENDANCE

October 2023 through September 2024 (FY 2024)

Name	11/8/23	1/17/24	2/21/24	4/17/24	7/17/24	9/11/24	Max Term
MEMBERS							
Erik Anderson	√	√	√				2028
Joycelyn Austin-Mabe	√	√	√				2028
Lisa Blandi	E	√	√				2028
John Cole	√	√	√				2028
Bill Dolan	E	E	U				2026
Gary Elgort	√	√	√				2026
Anthony Graham	√	√	√				2024
Mark Hilton	√	√	√				2026
Bruce Jabbour	√	E	√				2026
Dan Peterson	√	U	√				2026
Janice Six	√	√	√				2024
Kevin Trainor	√	√	√				2028
Favil West	√	√	U				2026
Eddie Williams	√	√	√				2028
LIAISONS							
Clark County	√	√	√	E			
Consolidated Group of Tribes & Organizations	E	√	√				
Elko County Commission (limited)							
Esmeralda County Commission (limited)	√						
Lincoln County Commission	U	√	U				
Nye County Commission	√	E	√				
Nye County Emergency Management	√	√	√				
Nye Co. Natural Resources and Federal Facility	E	√	√				
State of NV Division of Env Protection	√	√	√				
U.S. Natl Park Service (limited)							
White Pine County Commission	U	U	√				

KEY: √ - Present E - Excused V - Vacant U - Unexcused

Transfer Process of EM Sites on the NNSS to Long-Term Stewardship – Work Plan Item #5

Tiffany Gamero, Regulatory/Federal Facility Agreement and Consent Order (FFACO) Lead
U.S. Department of Energy (DOE)
Environmental Management (EM) Nevada Program
April 17, 2024

ID 3357 – 4/17/2024
Log No: EMRP-2024-020

NSSAB - Work Plan Item #5

- From a community perspective, the Nevada Site Specific Advisory Board (NSSAB) will provide a recommendation on specific topics to be included in the final Site Transition Plan and how and to whom it should be communicated
- NSSAB recommendation is due in July 2024


NSSAB meeting

EM Nevada Environmental Restoration Mission Nears Completion

- EM Nevada Program’s FFACO commitments are almost complete:
  - Offsites: complete, stewardship transferred to DOE Office of Legacy Management (LM) in 2006
  - Soils: environmental restoration and closure completed in 2019
  - Underground Test Area (UGTA): three corrective action units (CAUs) closed, only Pahute Mesa remaining
  - Industrial Sites: only eight sites remain at Test Cell C (TCC) and Engine Maintenance, Assembly and Disassembly (EMAD) facilities

EM Nevada Environmental Restoration Mission Nears Completion

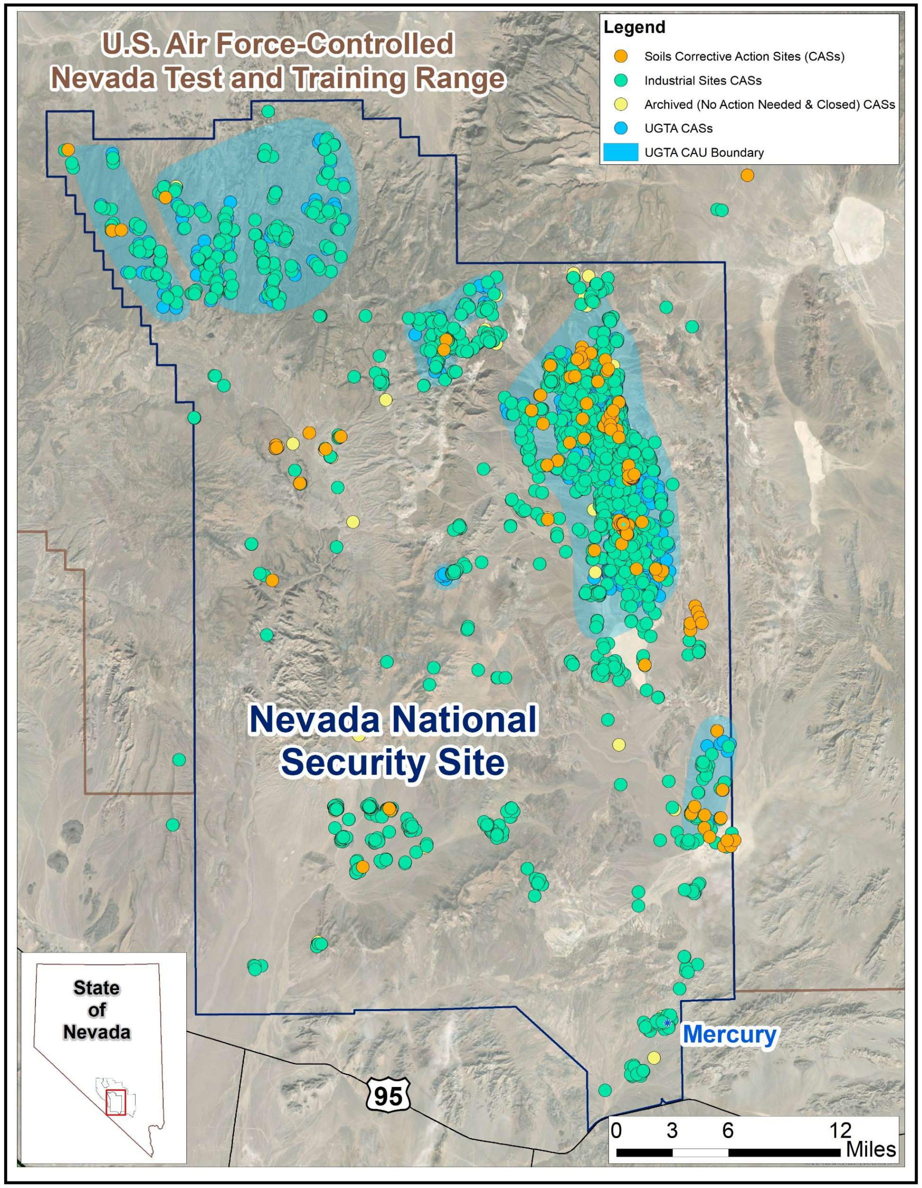
(continued)

- Remaining FFACO commitments at the Nevada National Security Sites (NNSS) will be completed within the next decade (approximately 2031*):
  - CAUs 101/102 Pahute Mesa (UGTA)
  - EMAD (Industrial Sites)

*Please note that date is subject to fluctuation based on project changes

Long-term Stewardship

- Some Soils and Industrial Sites (approximately 150) are closed in place and require post-closure monitoring and maintenance
- Closed UGTA (groundwater) sites require post-closure monitoring and sampling
- Even sites that are clean closed will need to have records maintained



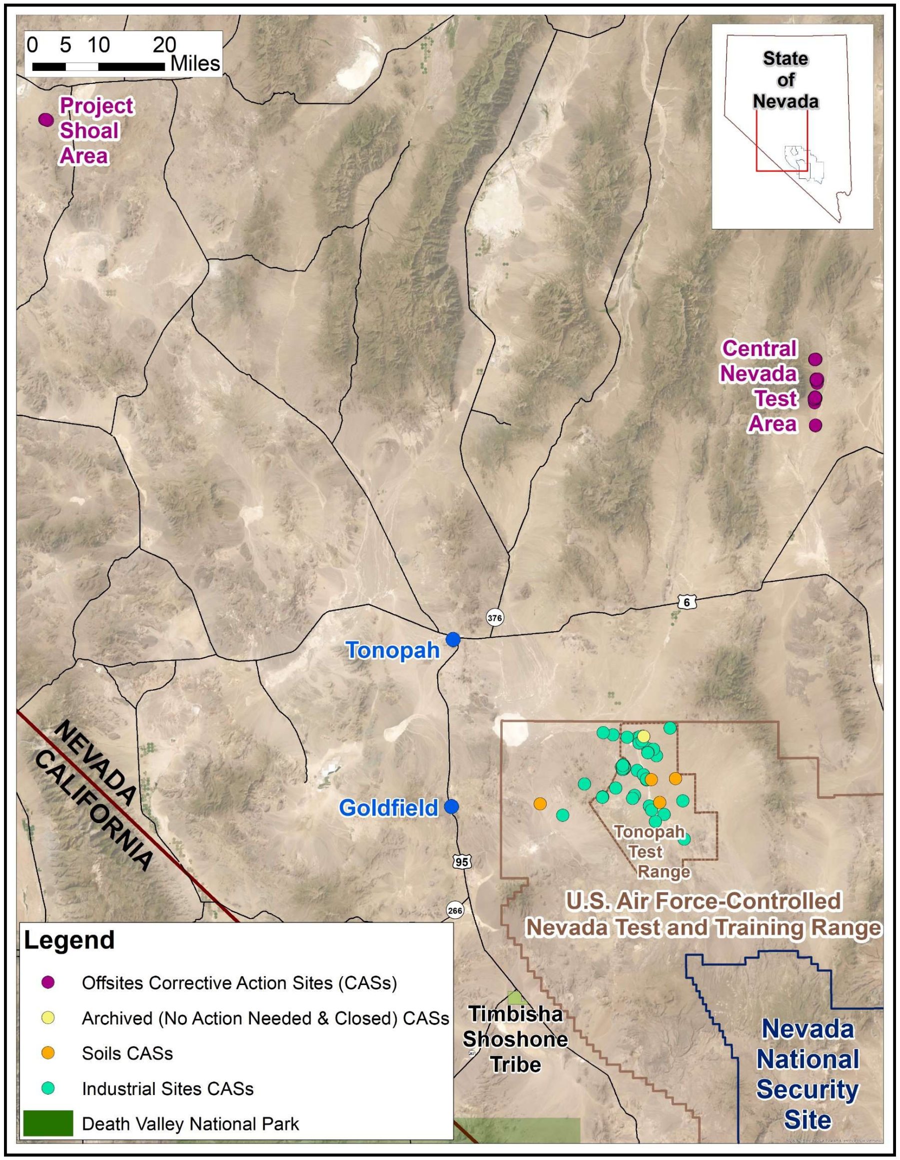
Long-term Stewardship

(continued)

- Normal process when EM is done with environmental restoration and closure is to transfer responsibility to another DOE entity for long-term stewardship
- EM must transfer responsibility; possibilities include:
  - Existing DOE lead program at site
  - If no DOE entity remains at site, LM will assume responsibility
    - LM is responsible for ensuring that DOE's post-closure responsibilities are met for sites that no longer have a continuing DOE mission

Past Examples

- FFACO Offsites:
  - Project Shoal, Central Nevada Test Area
  - No DOE lead program
  - Transferred to LM in 2006
- FFACO sites on the Tonopah Testing Range/Nevada Test and Training Range:
  - 70 Soils and Industrial Sites
  - U.S. Air Force is owner
  - Transferred to LM in 2020



FFACO Transition Planning

- EM Nevada Program is beginning to plan for eventual transition to another DOE long-term steward for sites on the NNSS
  - Long-term steward is not yet identified by DOE
  - Site Transition Plan development has begun
    - Bilateral document identifying the actions required to transfer long-term stewardship responsibilities between DOE entities
  - Project Closeout and Transition Plan Checklist development begun
    - Intended to help guide transition planning
  - FFACO Transition Working Group meets monthly including:
    - National Nuclear Security Administration Nevada Field Office
    - LM
    - EM Nevada Program
    - EM Headquarters

Next Steps/Timeline

- A Site Transition Plan is typically developed two years in advance of transfer
  - With over 3,000 FFACO sites, beginning the process earlier seems prudent
  - Draft Site Transition Plan has been slowly developed over the last two years
- Project Closeout and Transition Plan Checklist
  - Draft in development
- Decision to be made on a long-term steward
  - TBD

Site Transition Plan

- Planned format mirrors the Site Transition Plan for the transition of the Tonopah Test Range Sites from EM to LM
- Draft outline developed
- Living document to capture information as identified
- Sections will be completed as appropriate while subject matter expertise is available

Site Transition Plan Table of Contents

- Lists of Figures, Tables, Acronyms
- 1.0 Introduction
  - 1.1 Site Location and History
  - 1.2 Scope
  - 1.3 Objectives
- 2.0 Site Transition Framework
  - 2.1 Authorities and Accountabilities
  - 2.2 Site Conditions
  - 2.3 Milestones, Key Assumptions, and Potential Risks
  - 2.4 Engineered Controls, Operation and Maintenance Requirements, and Emergency/Contingency Planning
  - 2.5 Institutional Controls, Real and Personal Property, and Enforcement Authorities
  - 2.6 Regulatory Requirements and Authorities
  - 2.7 Long-term Surveillance and Maintenance Budget, Funding, and Personnel
  - 2.8 Information and Records Management
  - 2.9 Public Education, Outreach, Information, and Notice
  - 2.10 Natural, Cultural, and Historical Resource Management
  - 2.11 Closure Functions, Pension and Benefits, Contract Closeout or Transfer,
- 3.0 Transfer of Sites
  - 3.1 Readiness
- 4.0 References

Key Messages

- Planning for EM Nevada Program environmental restoration mission completion is underway
- FFACO sites on the NNSS with post-closure requirements will need a DOE entity to continue monitoring, maintenance, sampling, and reporting; all FFACO sites will need recordkeeping
- Long-term steward not yet identified
- Site Transition Plan, in development over next several years, will guide the transfer
- Plan will include:
  - Regulatory agreements
  - Authorities
  - Milestones
  - Records management

Questions

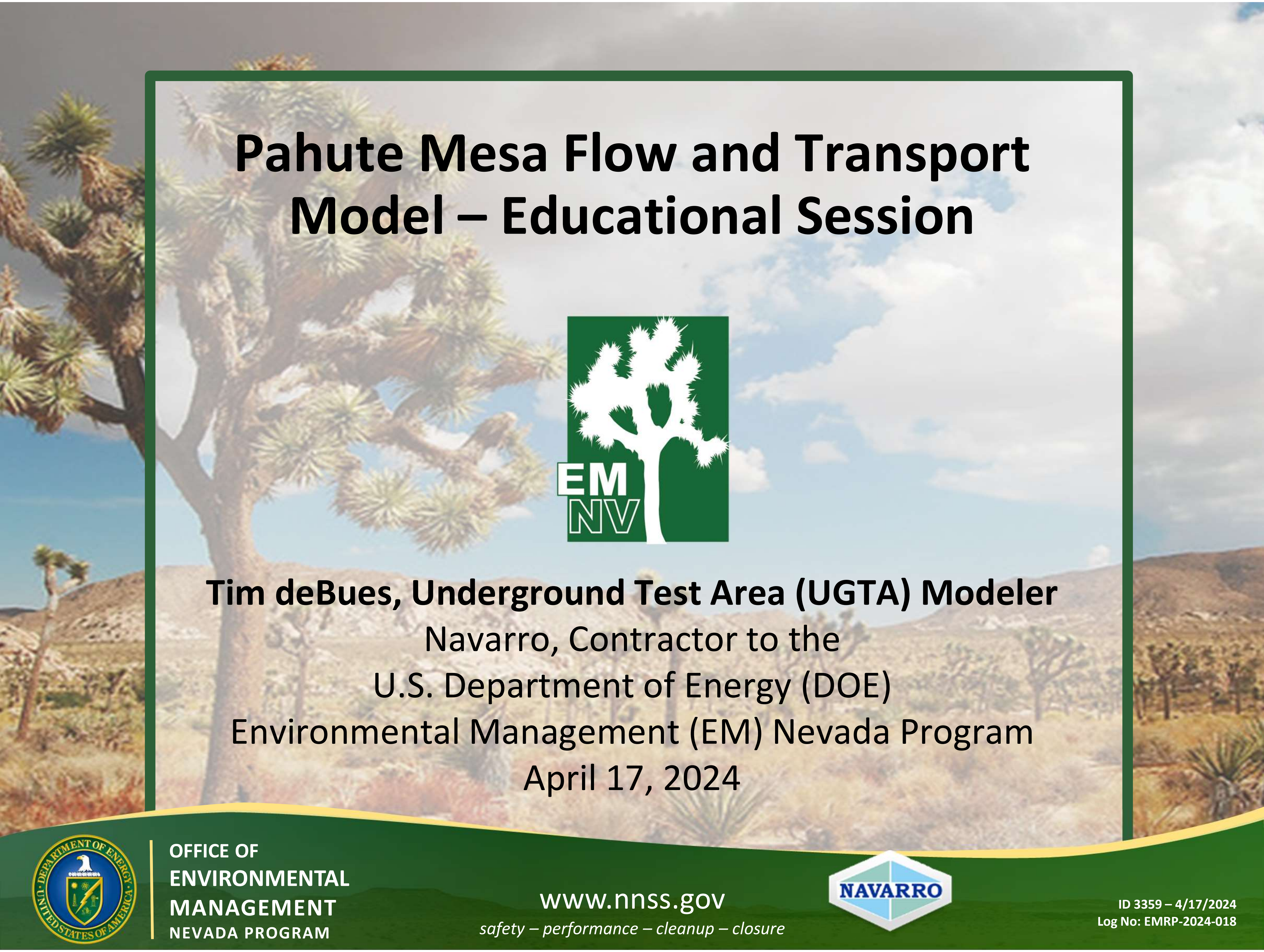
EM Nevada Program Subject Matter Expert (SME):
Tiffany Gamero

Navarro SME:
Irene Farnham

NSSAB Path Forward – Work Plan Item #5

- From a community perspective, the NSSAB will provide a recommendation on specific topics to be included in the final Site Transition Plan and how and to whom it should be communicated
- NSSAB recommendation is due in July 2024

NSSAB Meeting



Pahute Mesa Flow and Transport Model – Educational Session

Tim deBues, Underground Test Area (UGTA) Modeler

Navarro, Contractor to the
U.S. Department of Energy (DOE)
Environmental Management (EM) Nevada Program
April 17, 2024

ID 3359 – 4/17/2024
Log No: EMRP-2024-018

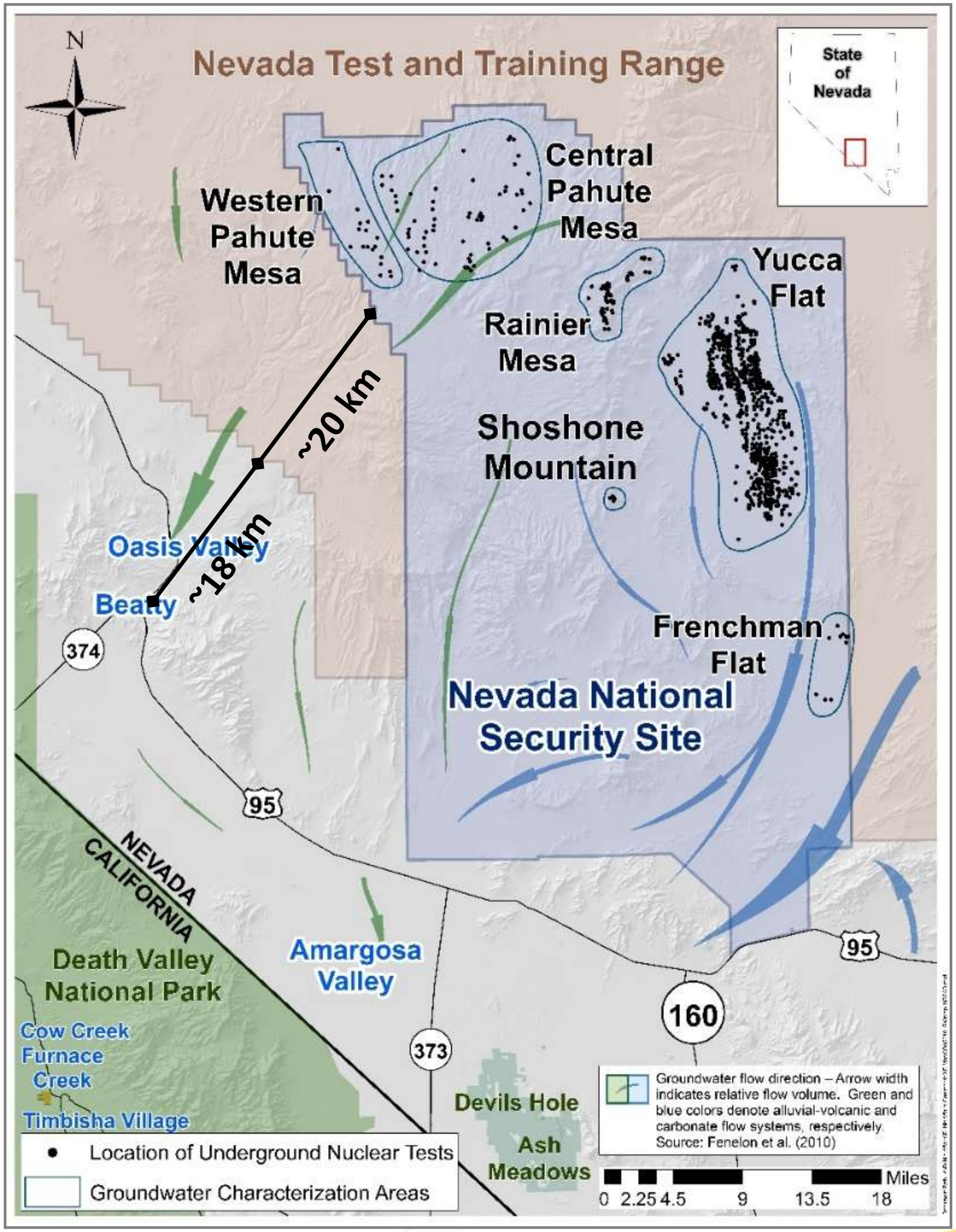
Discussion Topics

- Pahute Mesa (PM) site description
- Hydrologic conceptual model
- Hydrostratigraphic framework model
- Groundwater flow model
- Radiologic source term for transport model
- Radionuclide transport model
- Forecasts of radionuclide migration over the next 1,000 years

PM Site Description

PM Site Description

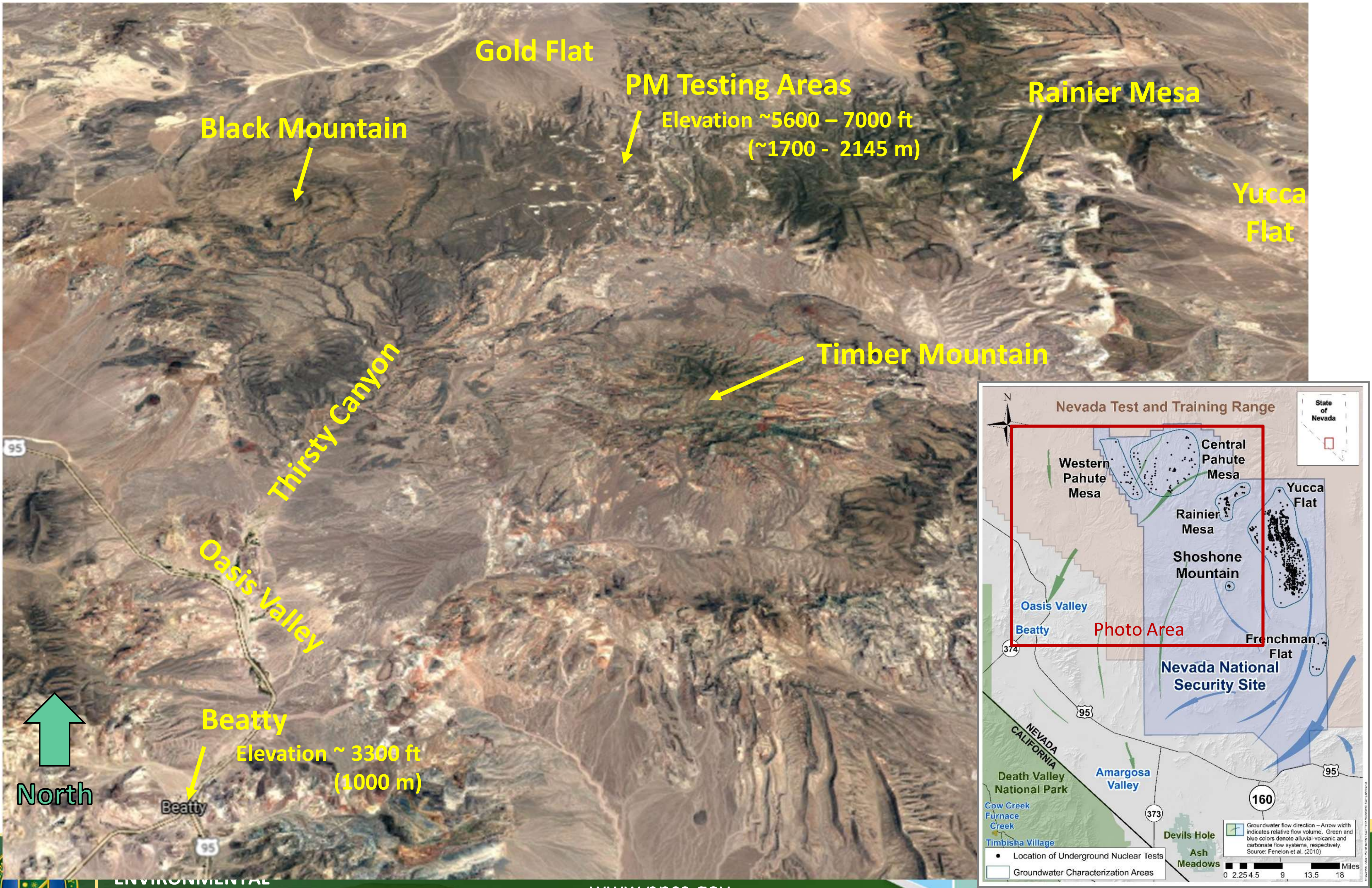
- PM located ~160 km (100 mi) northwest of Las Vegas, NV
- 85 underground nuclear tests, 1965-1992
- 43 long-lived radionuclides deposited in subsurface
- Geologically complex area
- Groundwater flow direction is southwest
- Nearest town is Beatty, NV
  - ~18 km (11 mi) southwest of Nevada Test and Training Range (NTTR) boundary



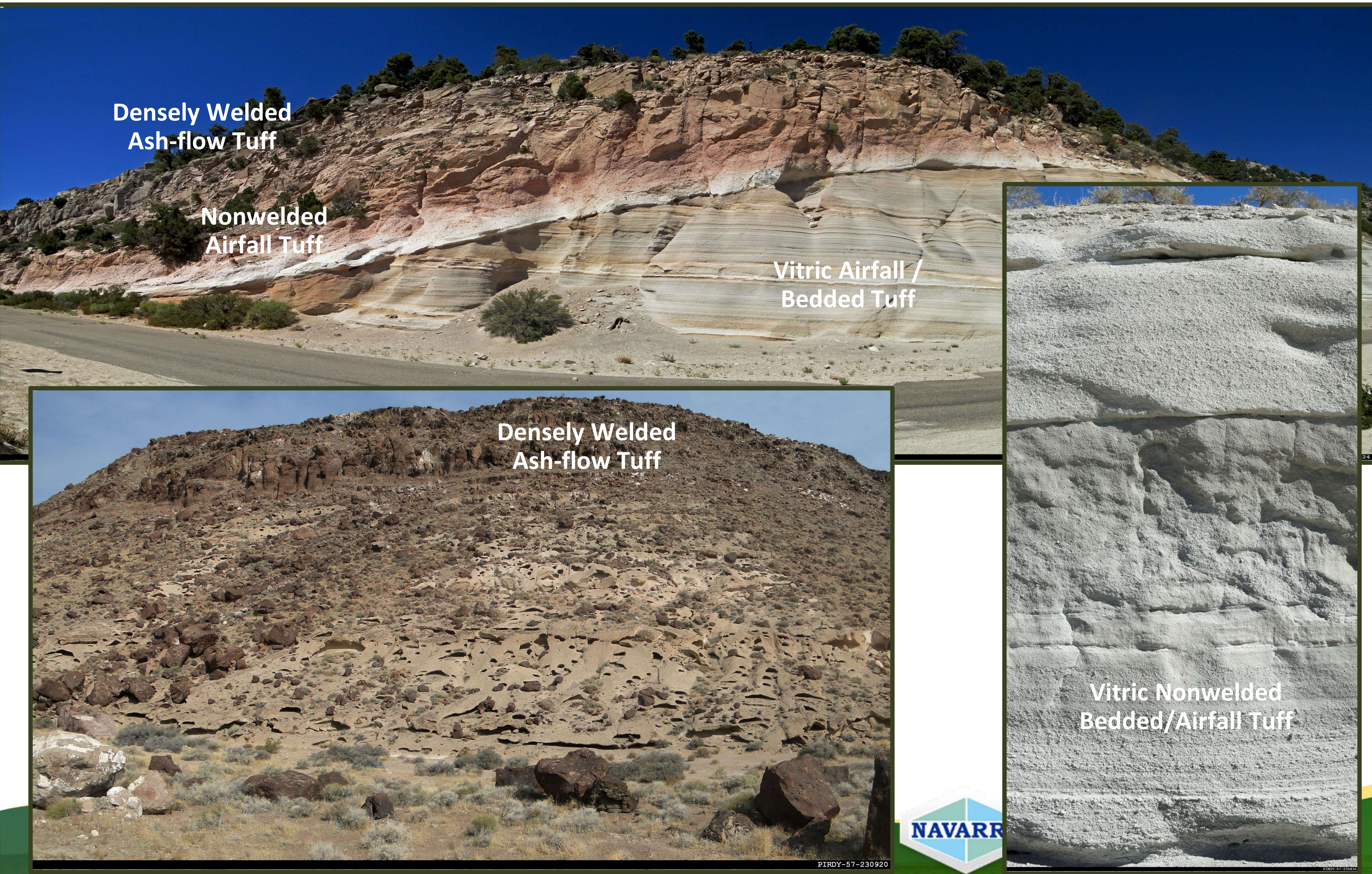
Number of Tests at PM is Small – Total Radiologic Inventory is Large

	PM	Nevada National Security Sites (NNSS)
Underground tests (DOE/NV--209-Rev. 16 [NNSA/NFO, 2015])	85 (~10%)	828 (100%)
Inventory as in 2012 (Finnegan et al., 2016)	2.68E+07 Curie (Ci) (~9.92 x 10^{+17} Becquerel [Bq]) (~60%)	4.46E+07 Ci (~1.65 x 10^{+18} Bq) (100%)

Physiographic Features Basin and Range, Modified by Volcanic Calderas



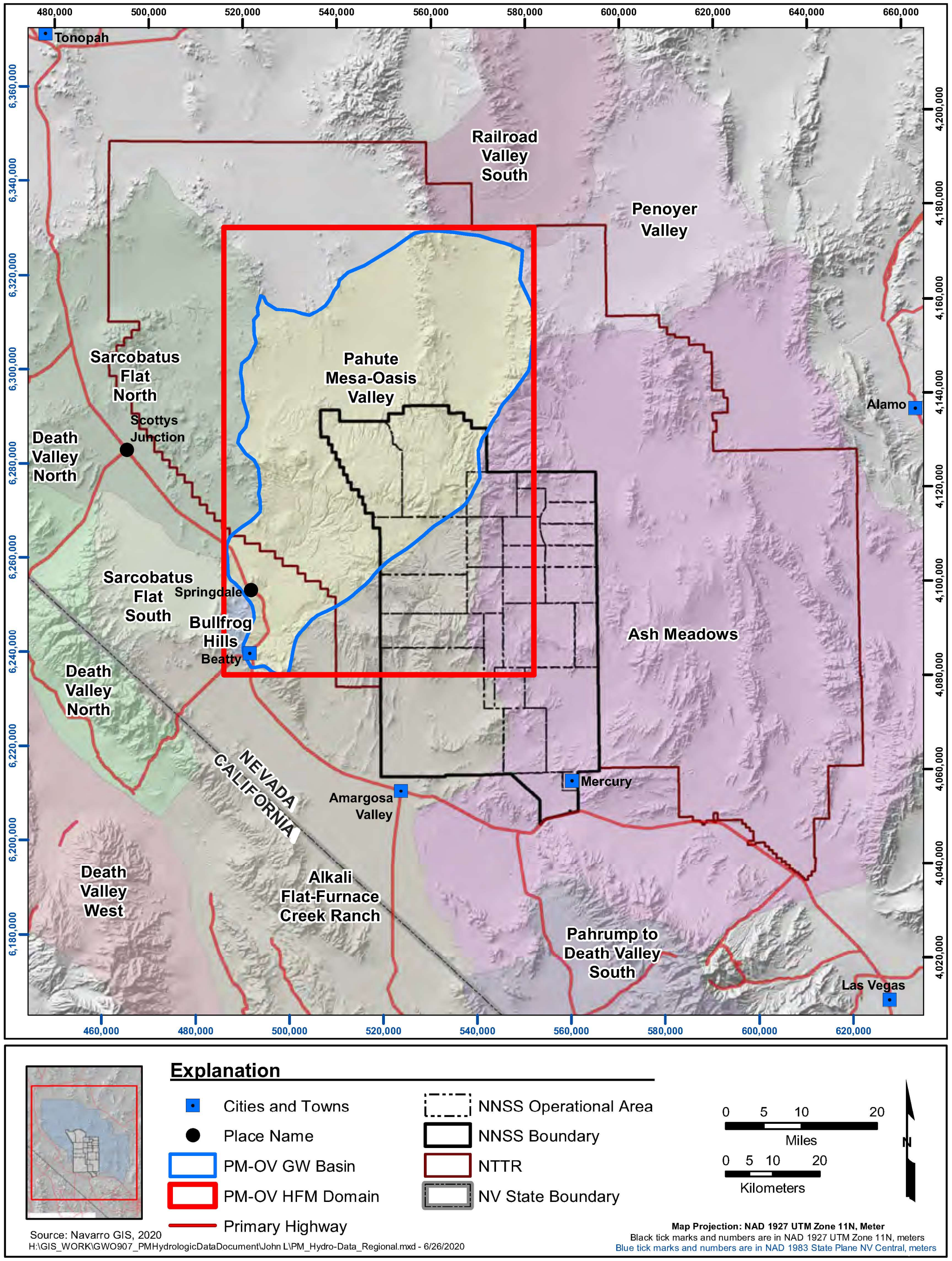
Geology Dominated by Rock Units from Volcanic Eruptions



Hydrologic Conceptual Model

(Fenelon et al., 2016; Jackson et al., 2020)

PMOV Groundwater Basin



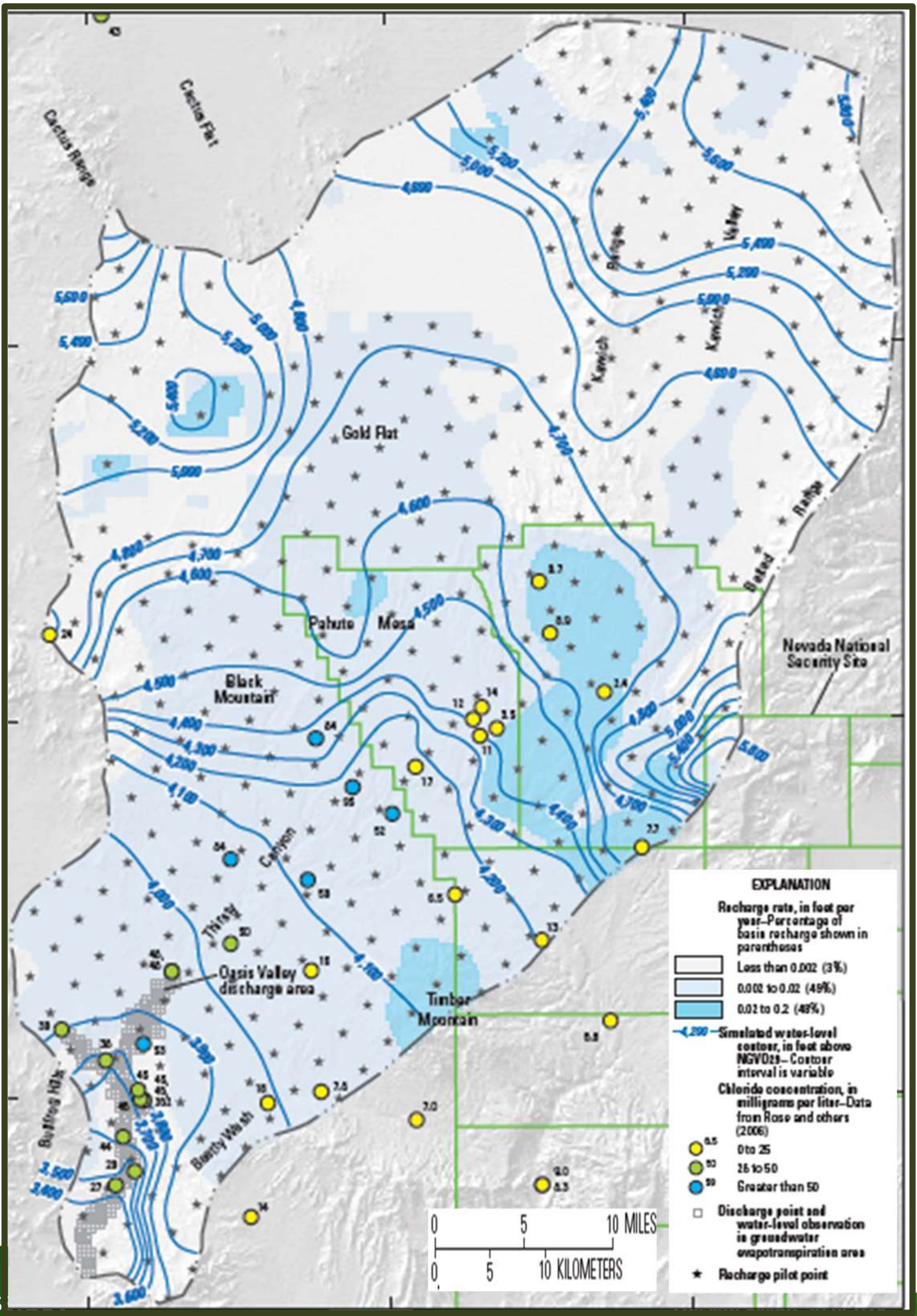
Source: Navarro GIS, 2020
H:\GIS_WORK\GWO907_PMHydrologicDataDocument\John L\PM_Hydro-Data_Regional.mxd - 6/26/2020

Map Projection: NAD 1927 UTM Zone 11N, Meter
Black tick marks and numbers are in NAD 1927 UTM Zone 11N, meters
Blue tick marks and numbers are in NAD 1983 State Plane NV Central, meters

- Shaded areas represent Pahute Mesa-Oasis Valley (PMOV) groundwater basin and the major groundwater basins surrounding the NNSS
- Testing area resides in central portion of the PMOV groundwater basin
- PMOV basin is hydrologically nearly closed (Fenelon et al., 2016):
  - Recharge infiltration via precipitation (~6,300 acre-ft/yr)
  - Discharge at springs in southwest area of basin (~5,900 acre-ft/yr)
  - Subsurface alluvium discharge in southern Oasis Valley (~100 acre-ft/yr)
  - Amargosa River surface outflow near Beatty (~300 acre-ft/yr)

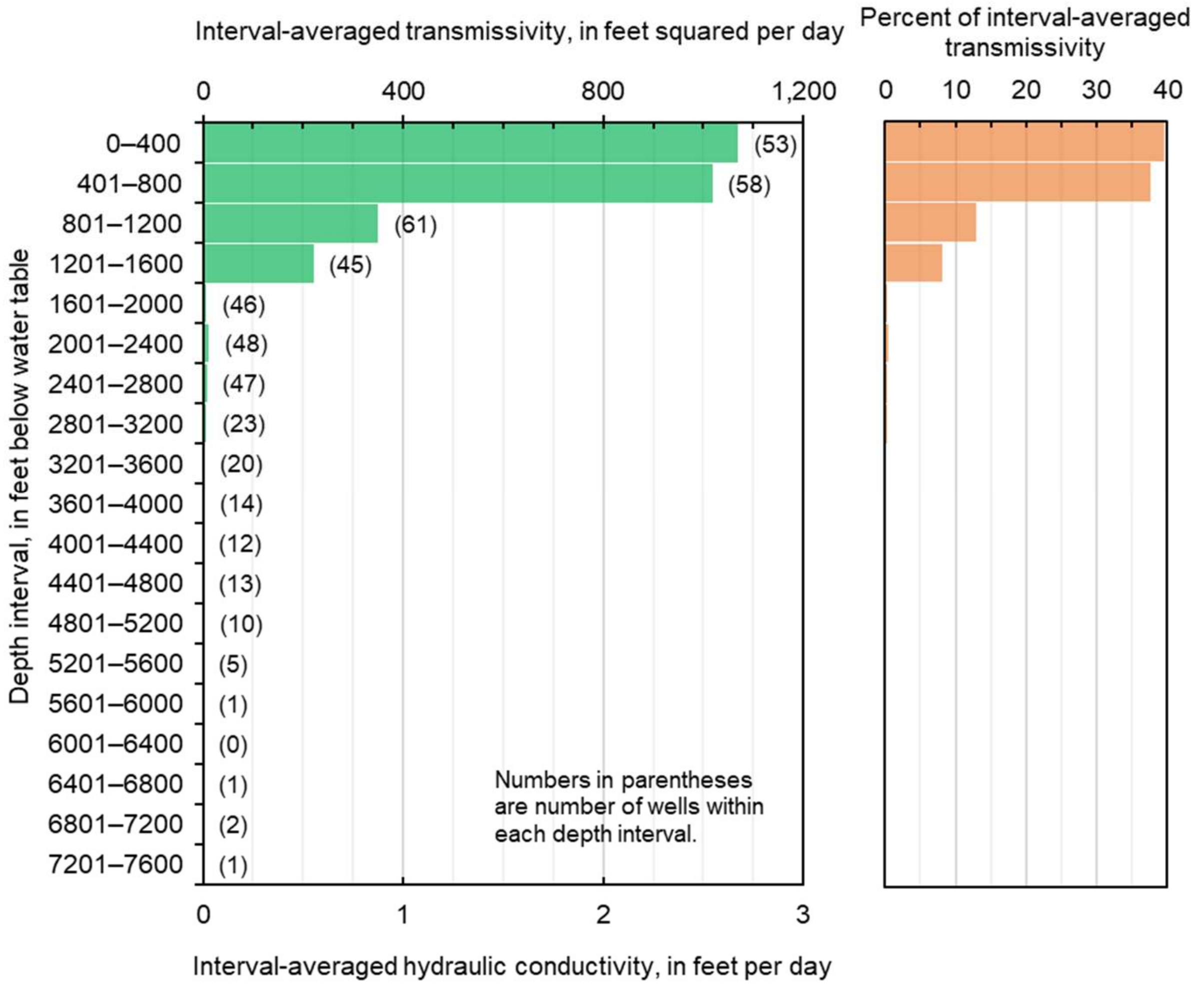
Recharge/Discharge

- Recharge to the water table is combination of slow, steady diffuse percolation (very old) and rapid infiltration following wet winters in the uplands
- Infiltration occurs over highlands via fractures and faults
- Runoff via short-lived washes
- Semi-perched zones occur locally diverting water laterally
- Natural discharge occurs only in Oasis Valley



Lower Boundary of Flow System

- From groundwater flow perspective, a lower boundary at 1,600 ft below the water table encompasses greater than 90 percent of transmissivity, and therefore, nearly all flow
- Depth of 4,000 ft below water table is sufficiently deep for lower boundary to encompass all nuclear tests, tritium plumes, and nearly all flow



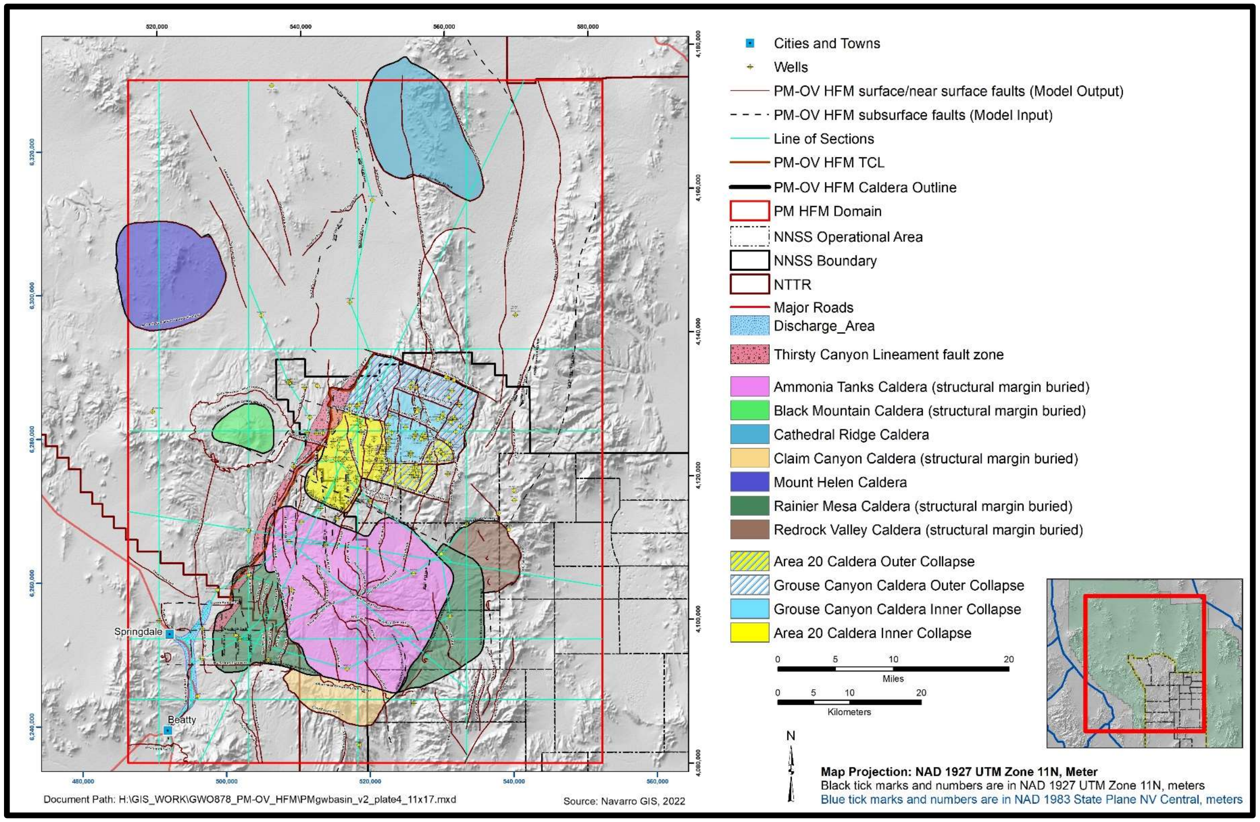
(Frus and Halford, 2018)

Hydrostratigraphic Framework Model (HFM)

(DOE/EMNV, 2020)

PMOV Structures

- HFM is a 3D geologic model that forms the basis of the flow and transport models
- Structures are informed by decades of geophysical studies in the PMOV region
- Recognition of geologic structures is biased by:
  - Surficial expression of structures
  - Structures observed in over 200 boreholes
  - Inference of structures from surface geophysical surveys



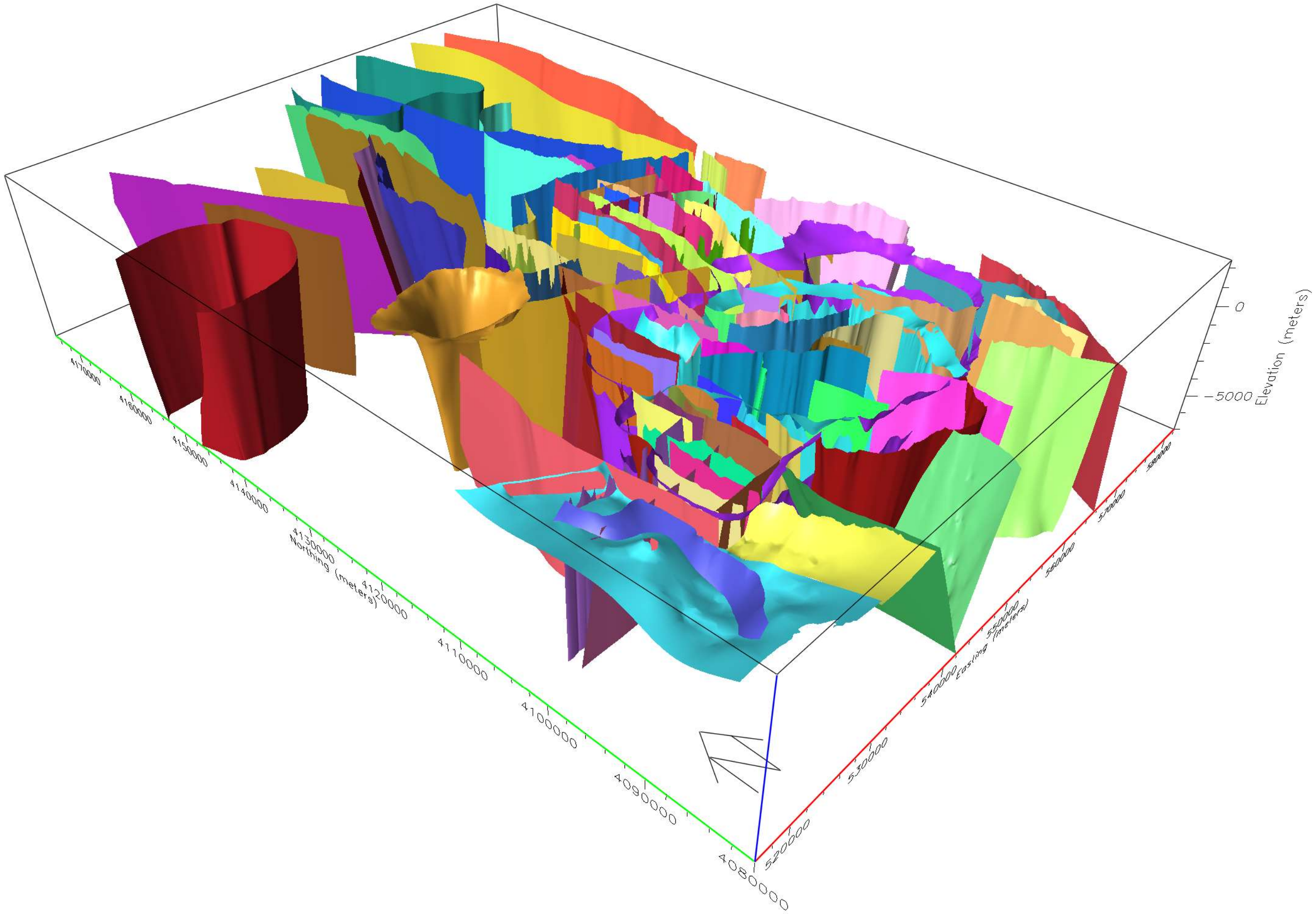
Document Path: H:\GIS_WORK\GWO878_PM-OV_HFM\PMgwbasin_v2_plate4_11x17.mxd

Source: Navarro GIS, 2022

Map Projection: NAD 1927 UTM Zone 11N, Meter
Black tick marks and numbers are in NAD 1927 UTM Zone 11N, meters
Blue tick marks and numbers are in NAD 1983 State Plane NV Central, meters

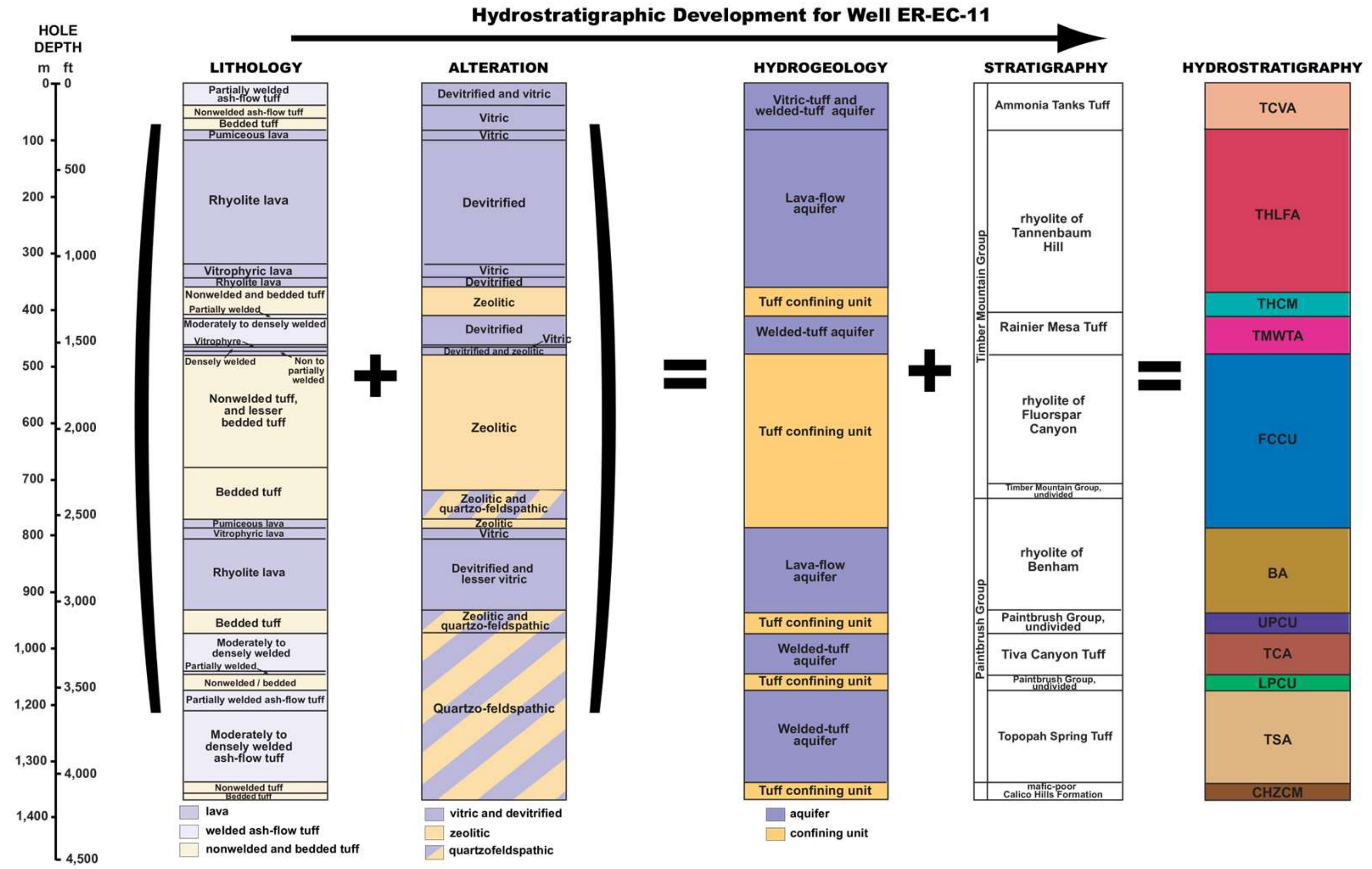
HFM Construction: Structural Surfaces

- Structural surface model is the foundation of an EarthVision framework model
- Major faults and calderas included in the HFM are shown



HFM Construction: Hydrostratigraphic Units

- Hydrostratigraphic Units (HSUs) are the “layers” in the HFM
- HSUs are groupings of contiguous stratigraphic units that have a particular hydrogeologic character, such as aquifer or confining unit



Rock type (may repeat down column)

Alteration due to time, pressure, temperature, etc.

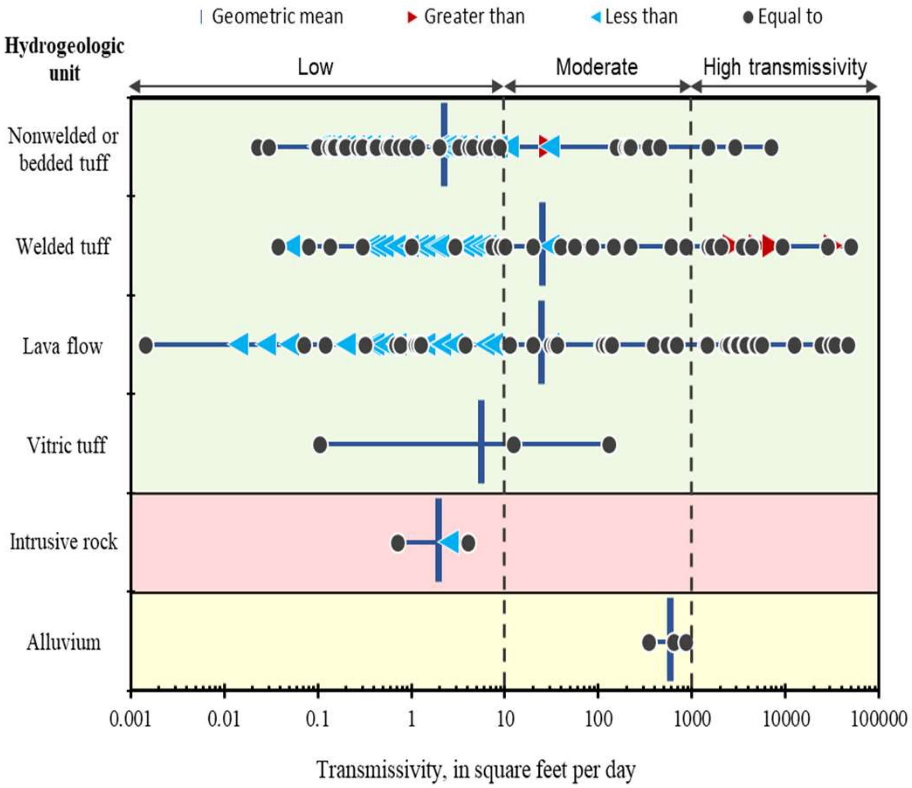
Hydrogeologic Unit (HGU) indicates influence on groundwater movement

Interpreted formations (groups of lithologies)

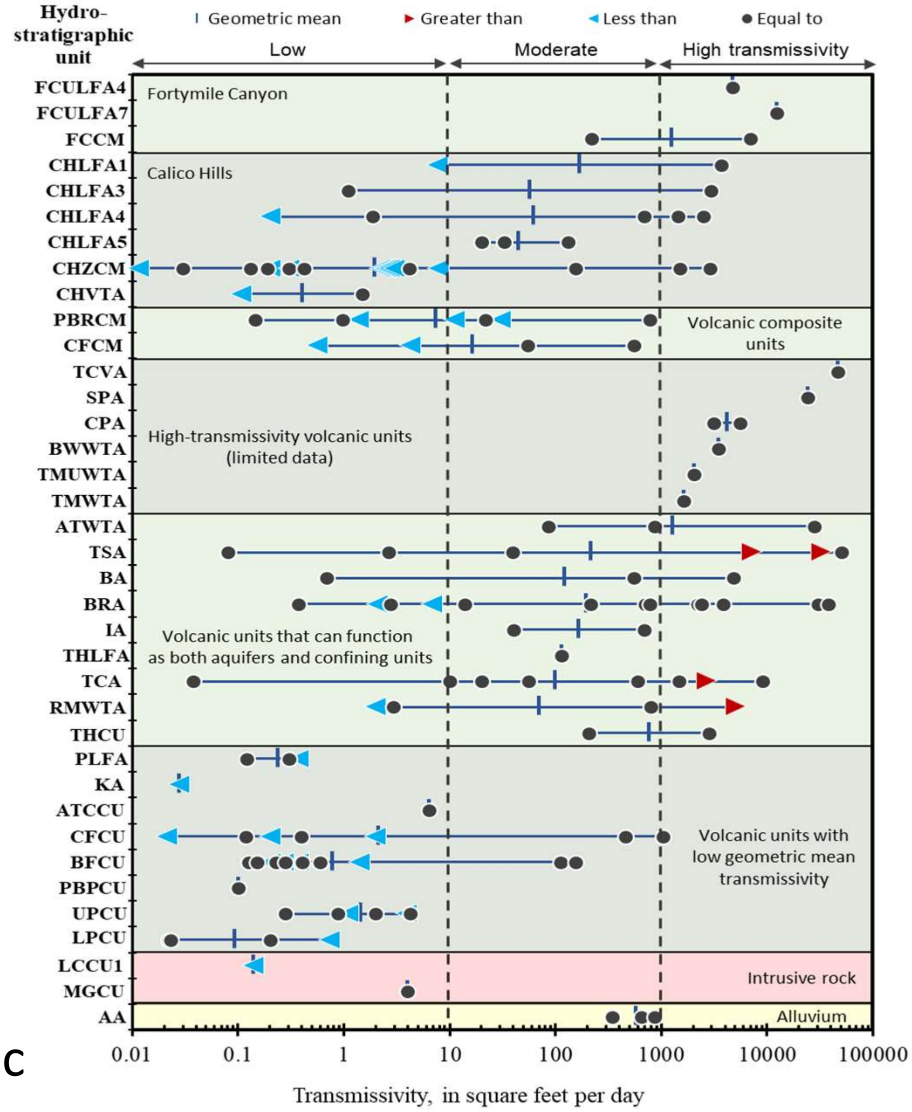
HSU from HGU and stratigraphy

Transmissivity*

By HGU



By HSU

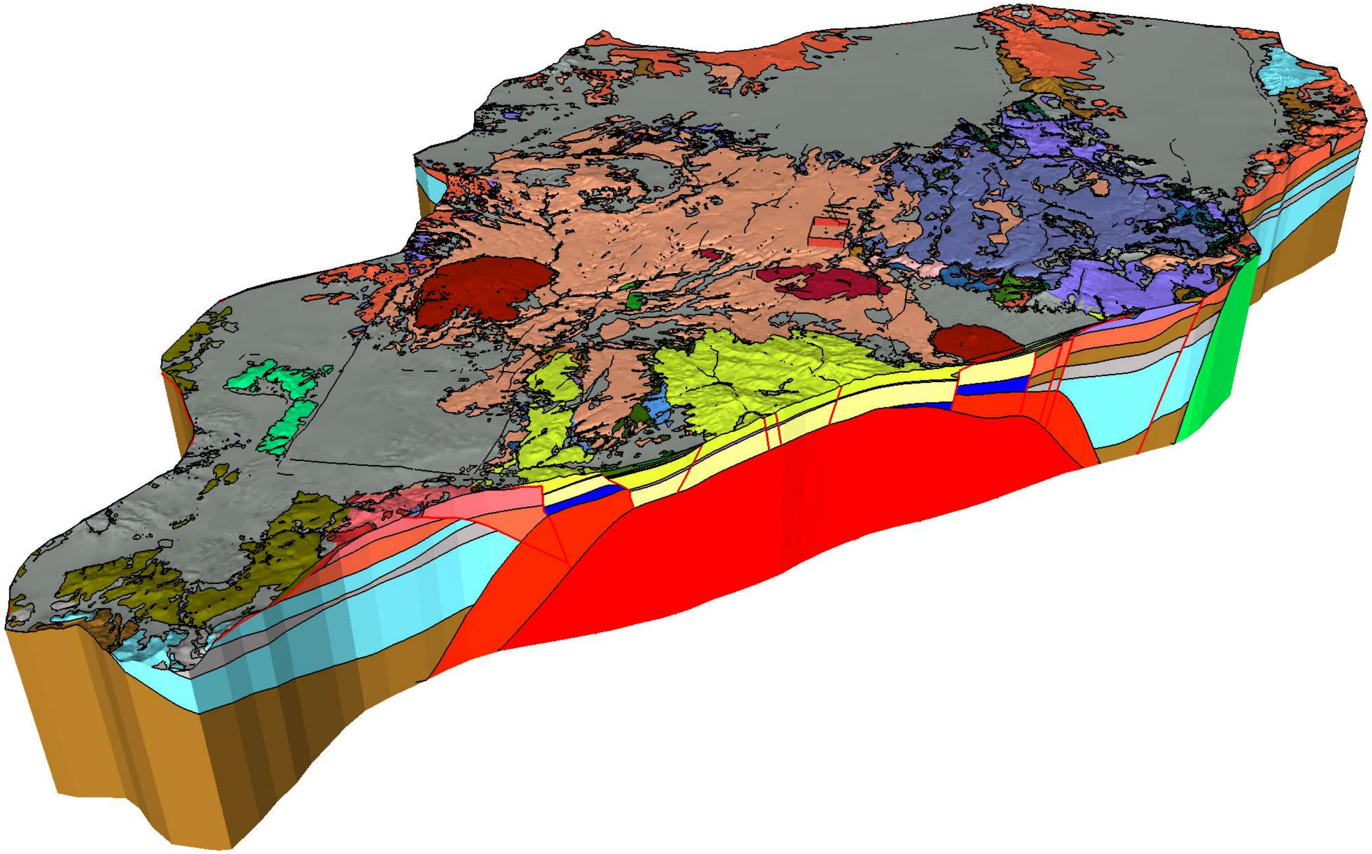


- HSUs can be very diverse and behave locally either as aquifers or confining units
- Aquifer HSUs have moderately higher hydraulic conductivity than confining unit HSUs
- Aquifers tend to be more fractured and less altered

***Transmissivity** – the rate groundwater can flow through a rock formation

PMOV HFM

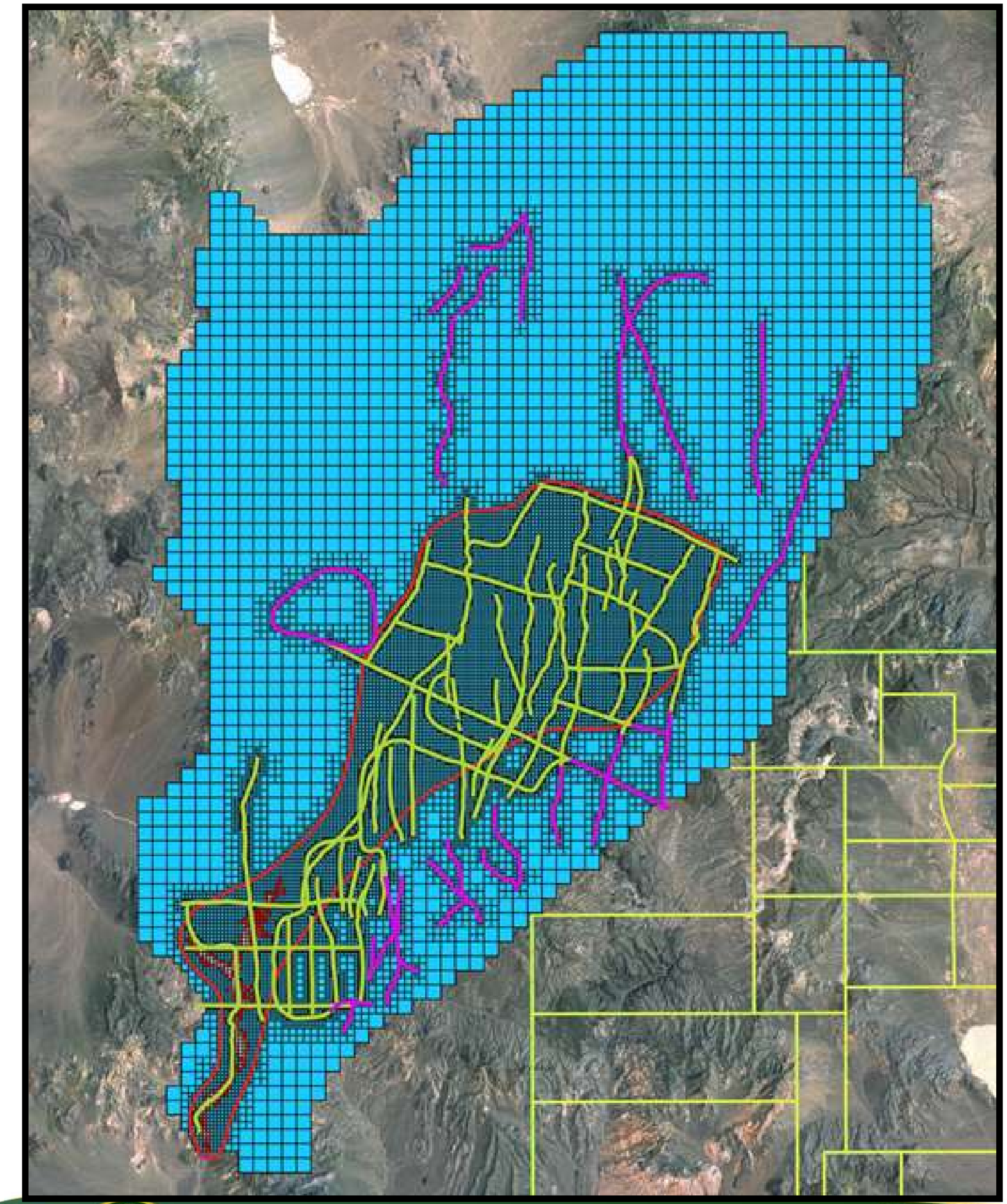
- Combination of structural surfaces and HSU layers results in PMOV HFM
- HFM cut by groundwater basin boundary defines the HSUs in the flow and transport model domain



Groundwater Flow Model

(DOE/EMNV, 2022)

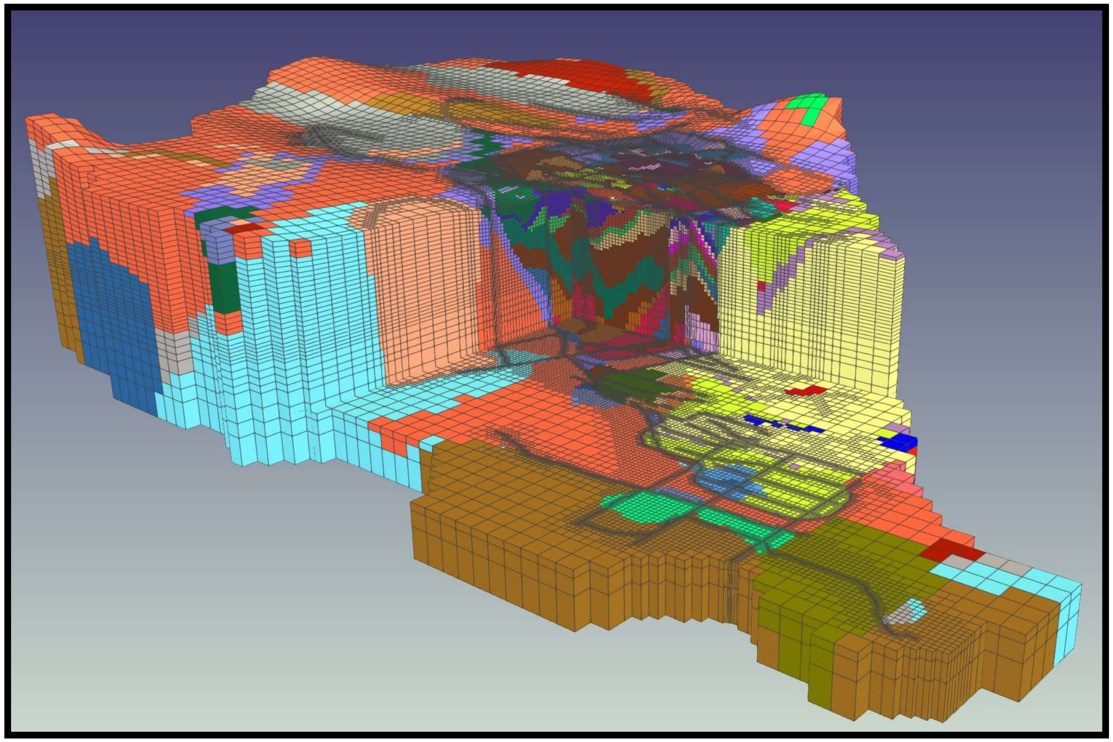
Model Domain and Grid



- Model domain encompasses the entire PMOV groundwater basin
- Cells dimensions range from 1,200 meters on a side to 75 meters on a side in the horizontal direction
- Model is refined to 300 meters within the main flow corridor from the testing areas to Oasis Valley (dense mesh area outlined by red)
- Coarse 600 meters fault refinement is used outside of main flow corridor (pink features)
- Fine 75 meters mesh refinement along faults is used along main flow corridor (yellow features)
- 1,328,019 total model cells

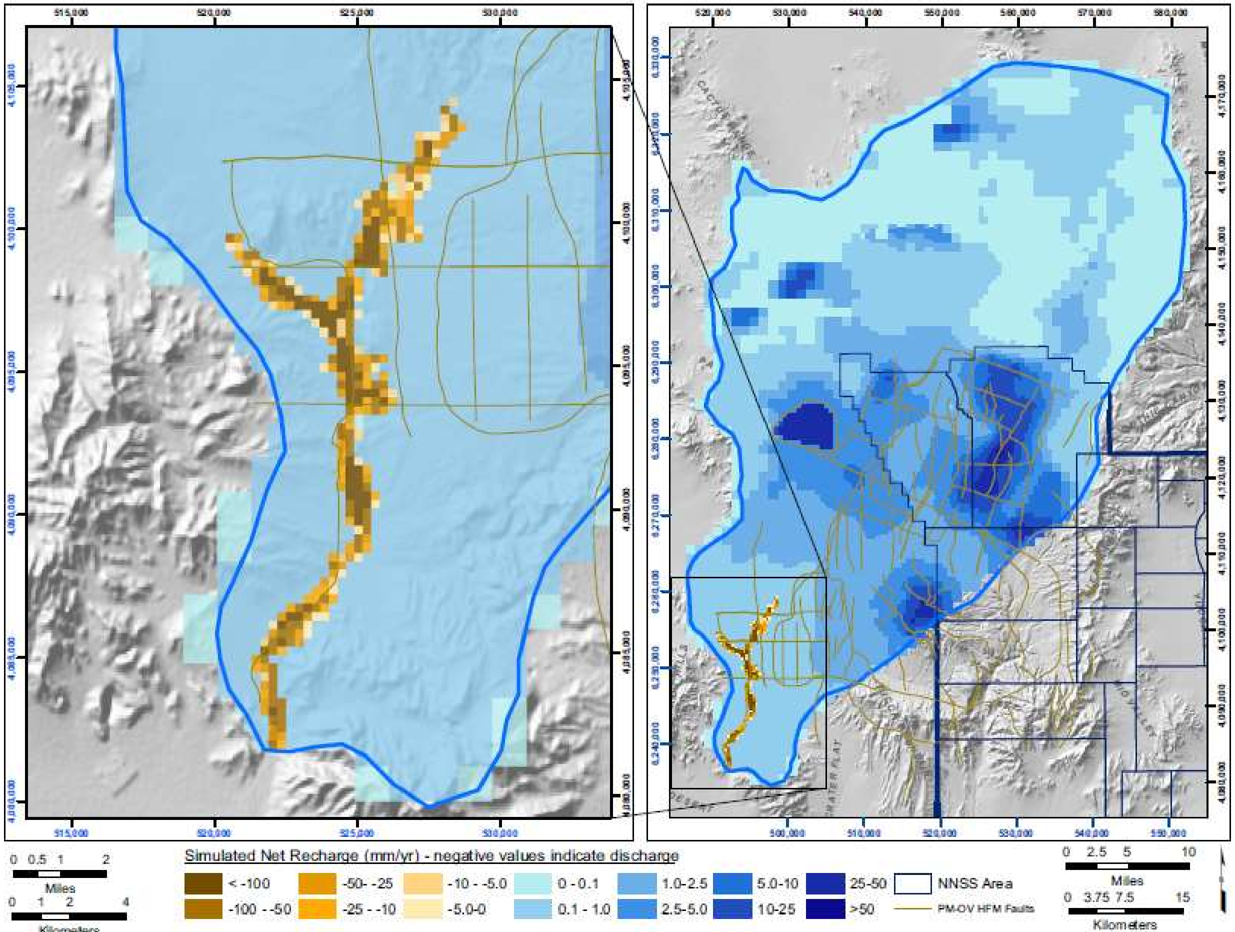
Model Vertical Extent and Grid Resolution

- Model grid shown (looking northeast) with cutaway from Oasis Valley to southwest Area 20 (10x vertical exaggeration)
- Colors represent different HSUs assigned from HFM
- 33 model layers with vertical refinement in upper half (layer thicknesses vary from 25 to 200 meters)
- Top boundary = water table as estimated by the U.S. Geological Survey (USGS) PMOV Basin Delineation Model (Fenelon et al. 2016)
- Bottom boundary = 0 meters elevation
- Model thickness varies from ~1,700 meters in the northeast to ~1,000 meters in Oasis Valley



Boundary Conditions

- Recharge and discharge applied at the top boundary (pictured)
  - Recharge occurs primarily in the highlands of PM
  - Discharge occurs in springs and seeps in Oasis Valley
  - Recharge/discharge distributions are from Fenelon et al. (2016)
- Small lateral outflow near Beatty:
  - Amargosa River surface flow and alluvium under-flow
  - Simulated with a constant head boundary
- No-flow on other boundaries

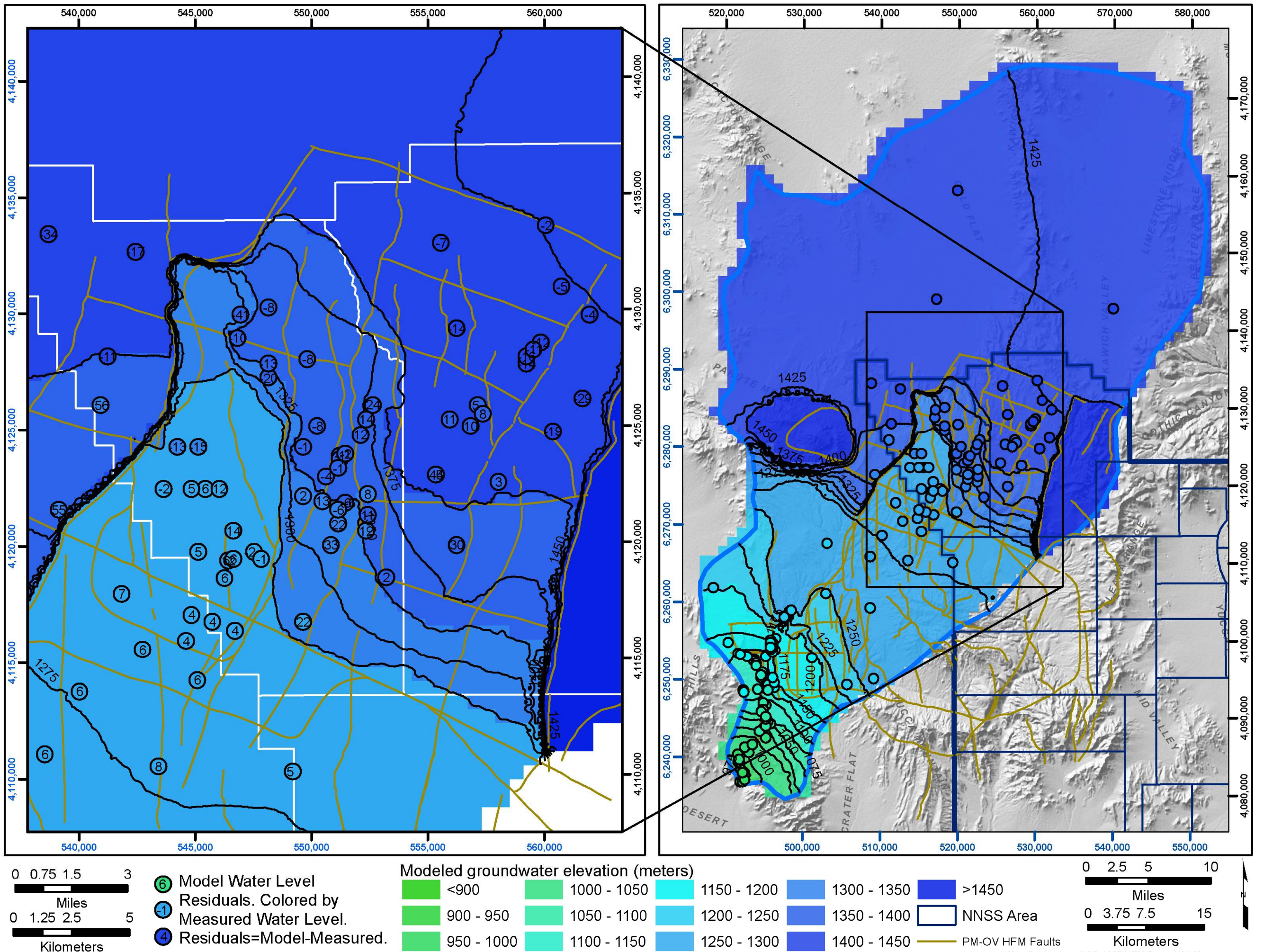


Source: Navarro GIS, 2022
H:\GIS_WORK\GWO42_PM_F-T_Model_Report\Chap_4_Figs\Sim_Recharge_detail.mxd - 3/4/2022

Map Projection: NAD 1927 UTM Zone 11N, Meter
Black tick marks and numbers are in NAD 1927 UTM Zone 11N, meters
Blue tick marks and numbers are in NAD 1983 State Plane NV Central, meters

Flow Model Calibration

- Flow model was calibrated to steady-state water levels and horizontal water level gradients
- Map shows modeled groundwater elevation (meters) from calibrated flow model
- Circles represent well locations
- Lines represent water level contours



Source: Navarro GIS, 2022
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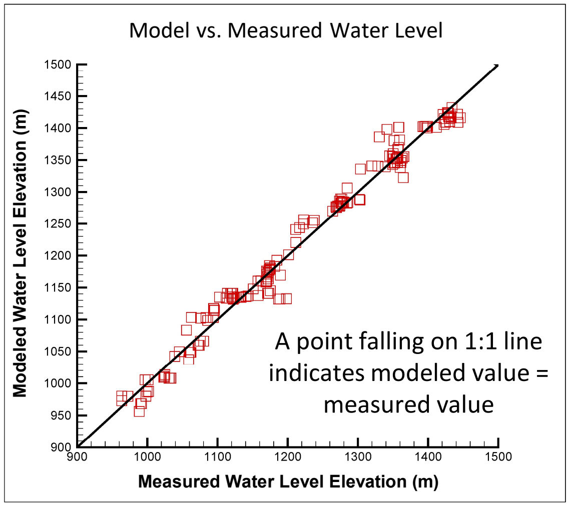
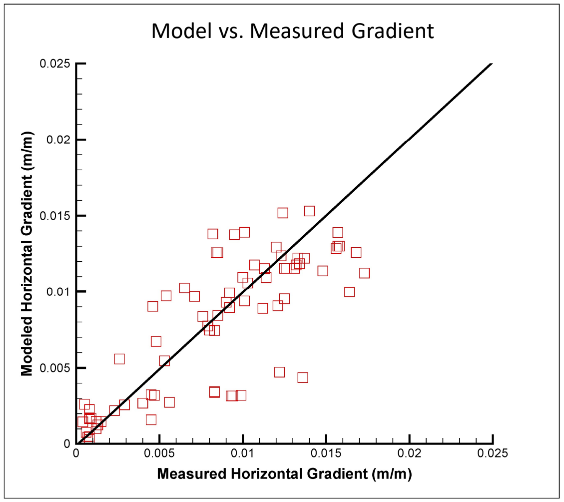
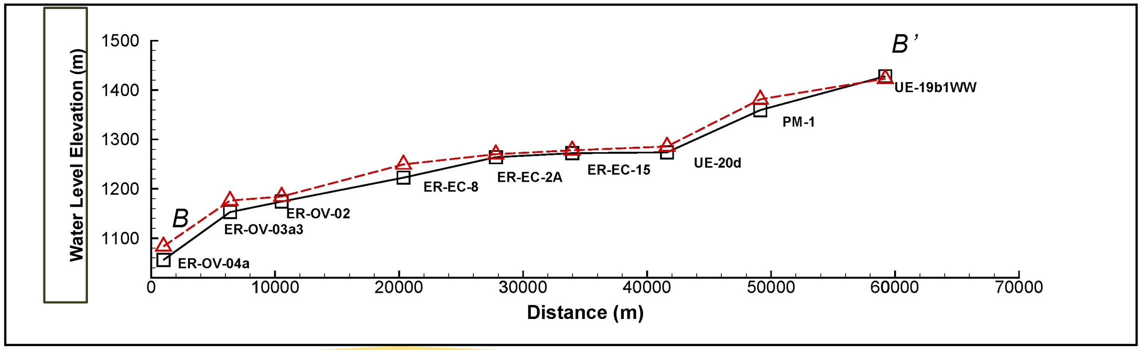
Flow Model Calibration

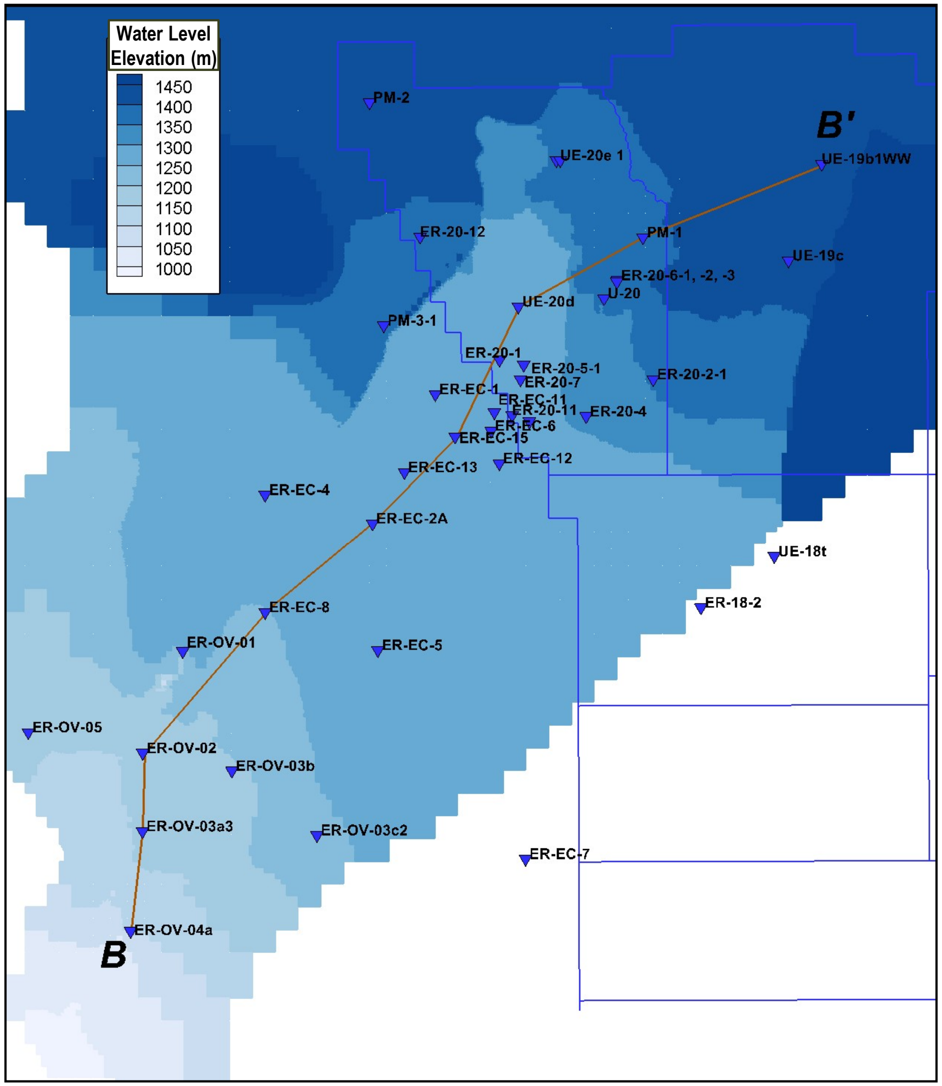
- Good agreement with steady-state water levels
- Fair agreement with horizontal gradients


Model vs. Measured Water Level

A point falling on 1:1 line indicates modeled value = measured value

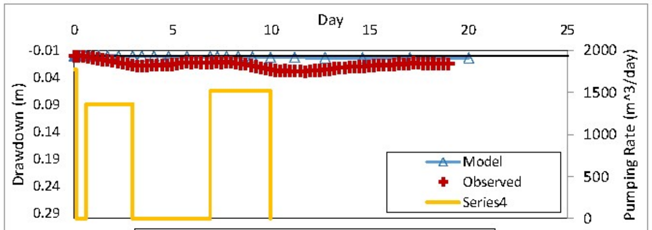

Model vs. Measured Gradient



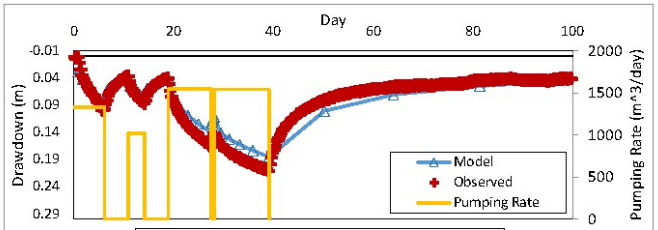


Flow Model Calibration

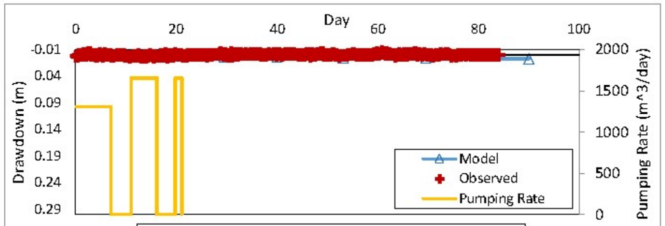
- Flow model also calibrated to 16 multi-well aquifer tests (MWATs)
- Figures show example of observed and modeled water level responses in wells during MWAT (red = observed , blue = modeled)
- Good agreement to most MWAT observations



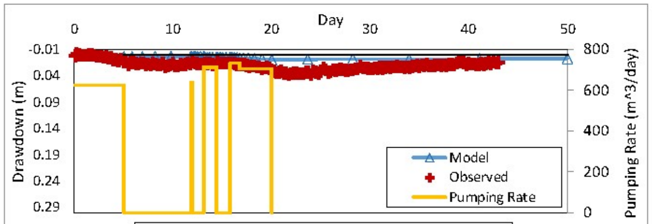
Pumping Well ER-20-7, Observation Well ER-EC-11I



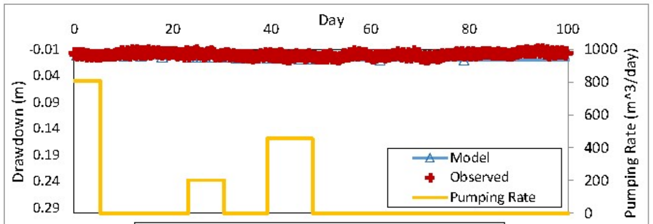
Pumping Well ER-20-11, Observation Well ER-EC-11I



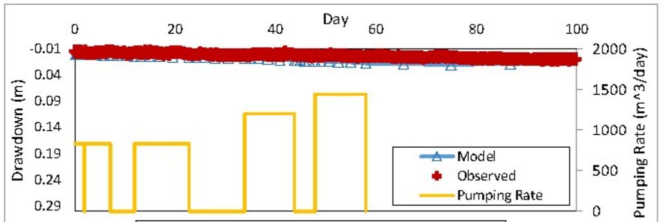
Pumping Well ER-EC-13UZ, Observation Well ER-EC-11I



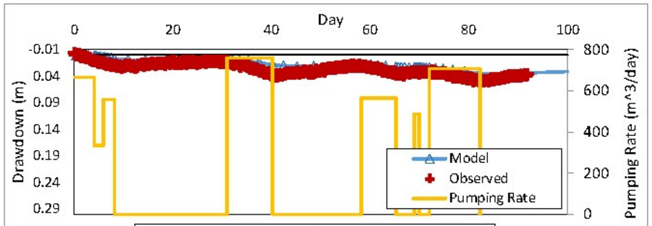
Pumping Well ER-20-8#2, Observation Well ER-EC-11I



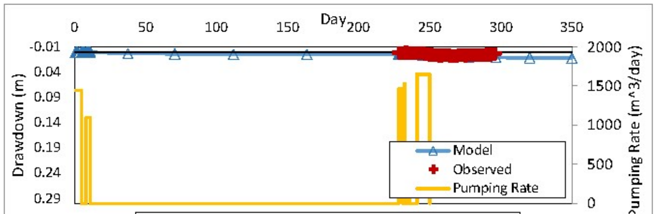
Pumping Well ER-EC-12, Observation Well ER-EC-11I



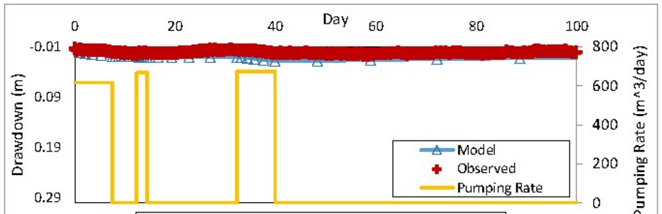
Pumping Well ER-EC-14, Observation Well ER-EC-11I



Pumping Well ER-20-8, Observation Well ER-EC-11I

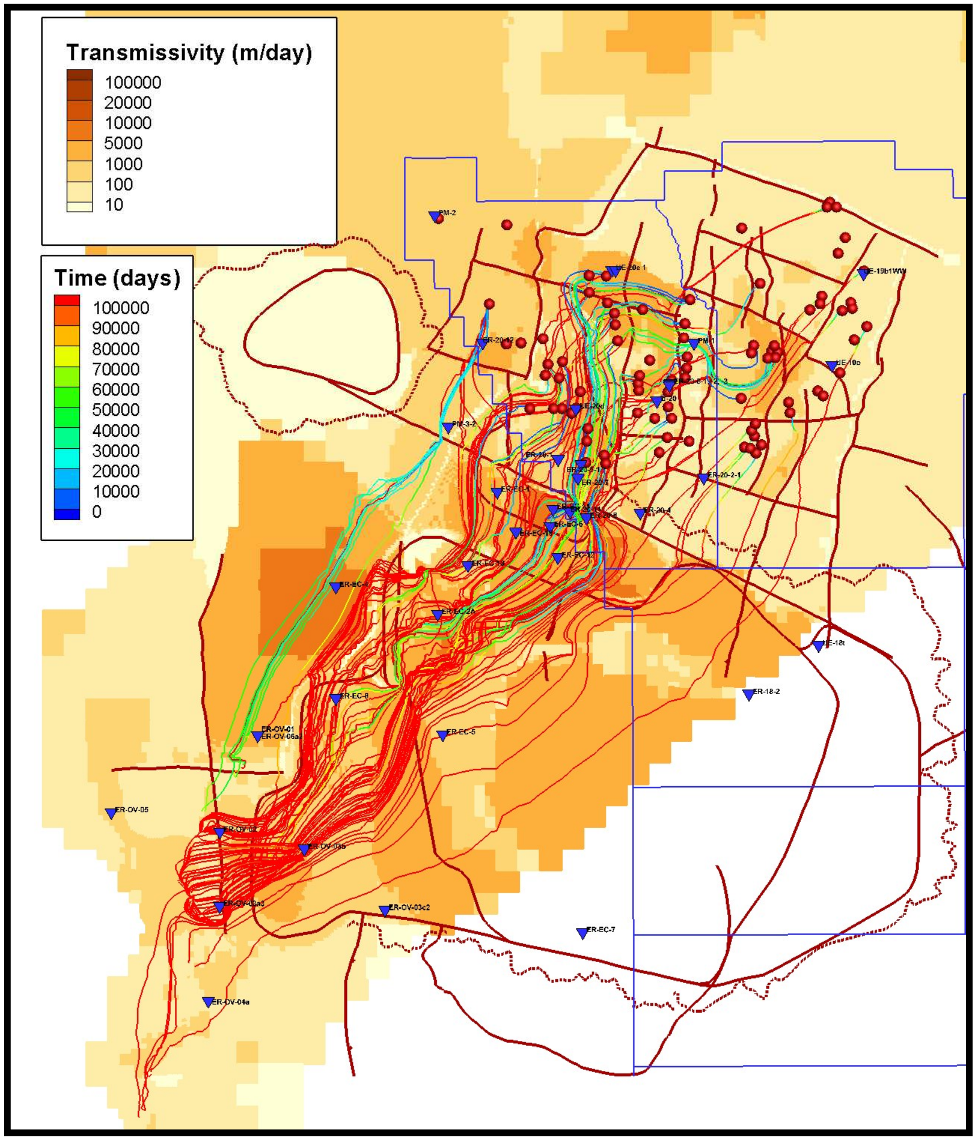


Pumping Well ER-EC-13LZ, Observation Well ER-EC-11I



Pumping Well ER-EC-15, Observation Well ER-EC-11I

Flow Paths from Test Locations



- Figure shows calculated flow paths from underground test locations for calibrated flow model (red = slower, blue = faster)
- Flow paths do not indicate radionuclide transport times
- Calculated transmissivity map from calibrated flow model is also shown
- Most fast flow paths pass through the central area
- All flow paths terminate in the discharge areas in Oasis Valley

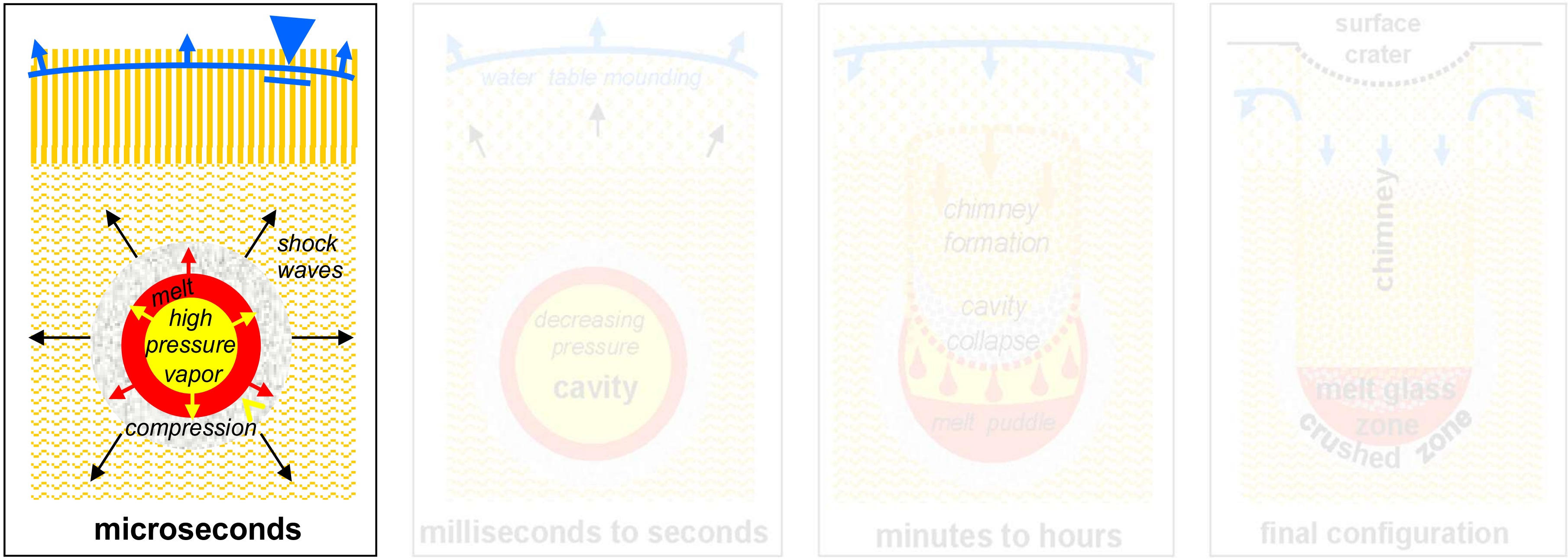
Alternative Models

- Four alternative models were constructed and calibrated to assess different interpretations:
  - A model with all faults defined with the HFM
  - Two models using alternative recharge distributions
  - A model using a water table upper boundary condition

Radiologic Source Term for Transport Model

(Carle et al., 2020; Navarro, 2021)

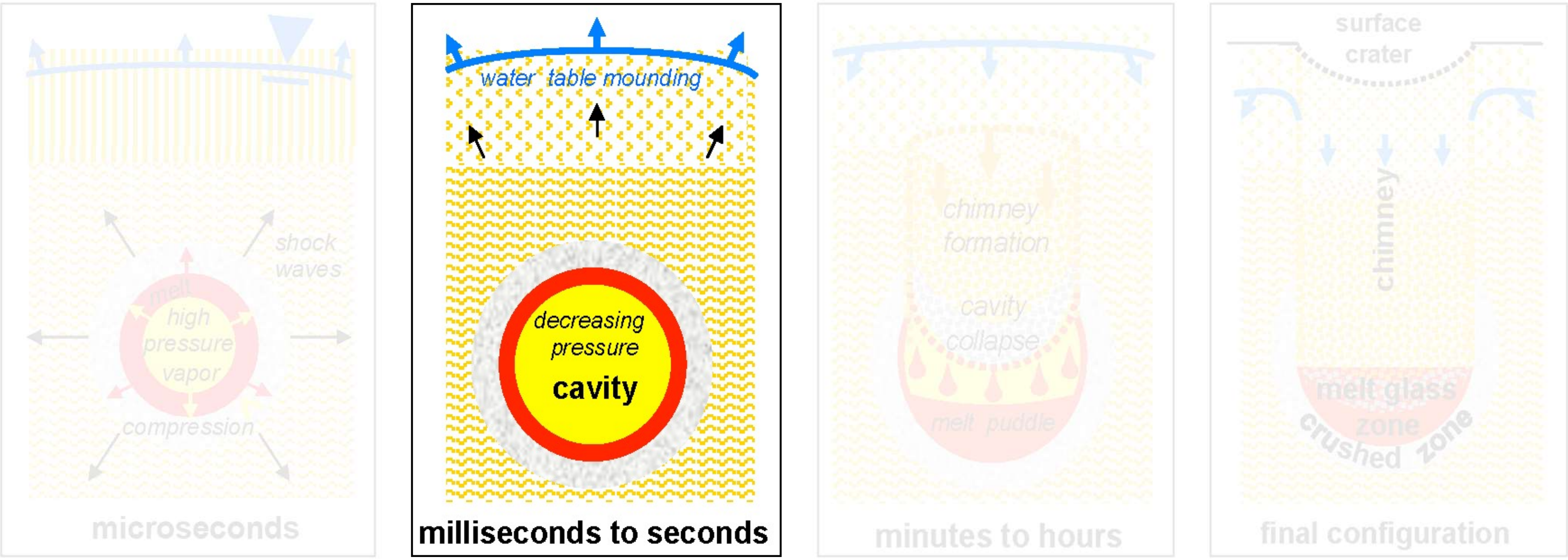
Underground Testing – Subsidence Crater Formation



1. Detonation
   - Instantaneous vaporization of rock and water
   - Extremely high temperatures and pressures
   - Pressure force generates a shock wave
     - Melts, heats, and alters surrounding rock

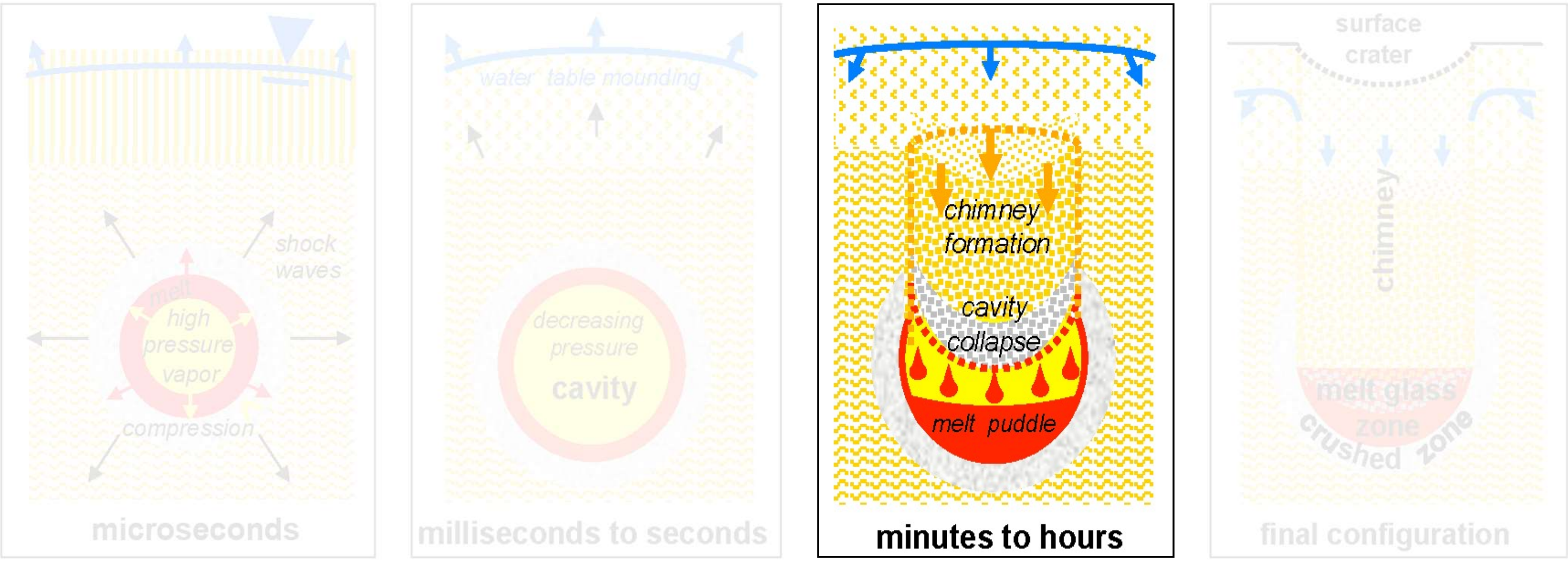
Underground Testing – Subsidence Crater Formation

(continued)



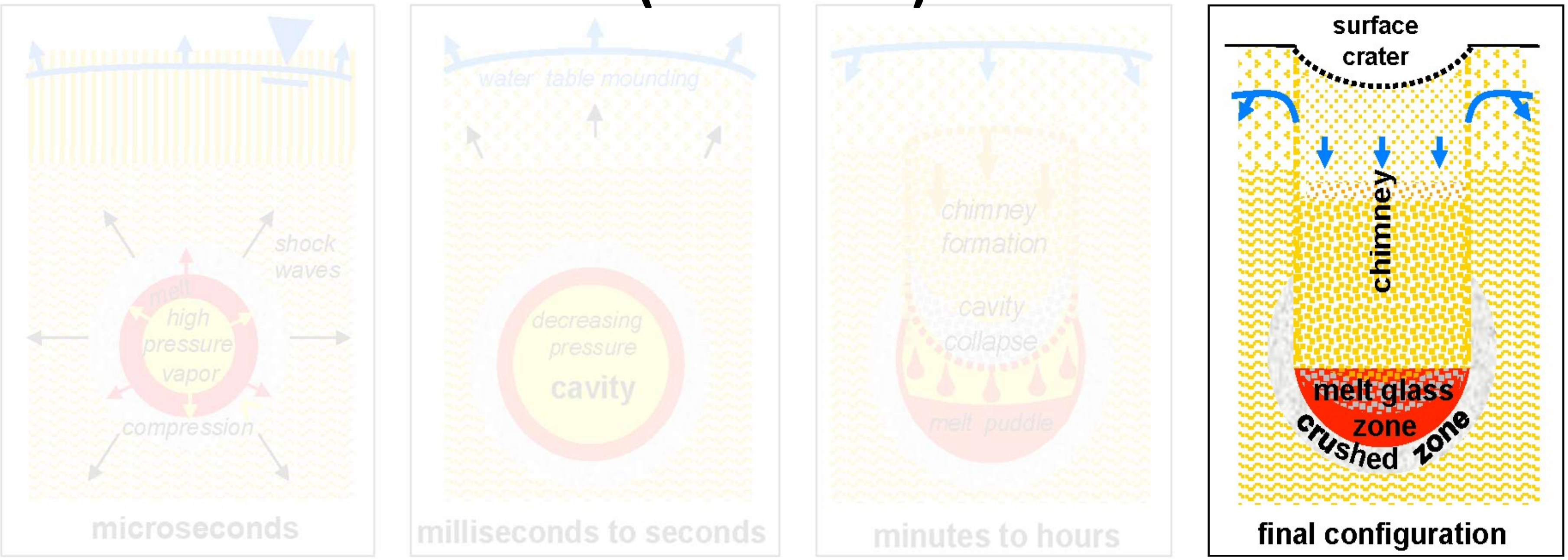
2. Cavity Formation
   - Cavity expansion
   - Cavity gases usually contained because of shock rebound stress (some exceptions)
   - Groundwater mounding possible

Underground Testing – Subsidence Crater Formation
(continued)



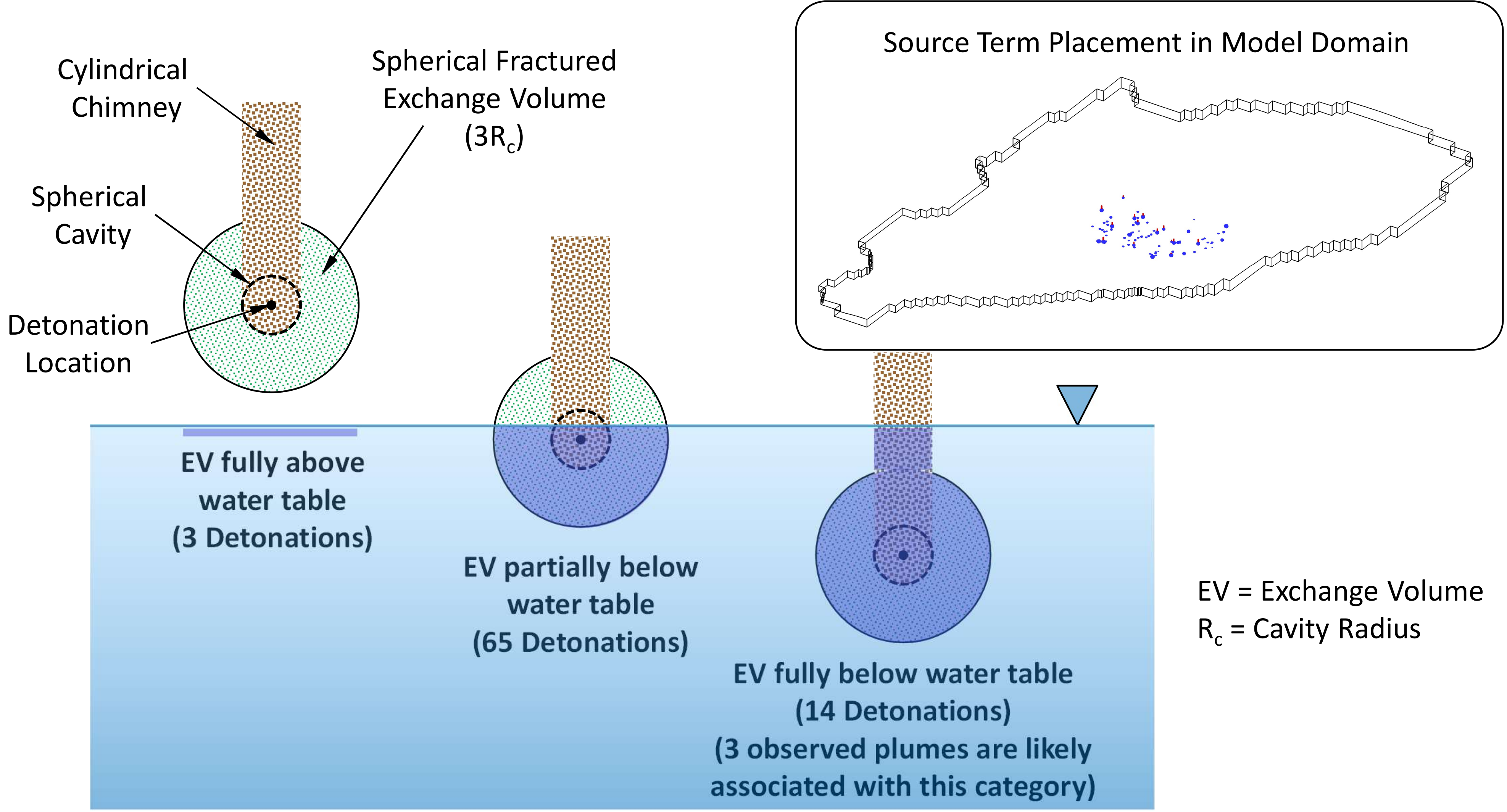
3. Cavity Collapse and Chimney Formation
   - Cavity gas condenses
   - Melt glass puddle forms within cavity
   - Collapse forms chimney and possible crater

Underground Testing – Subsidence Crater Formation (continued)



4. Final Configuration
   - Groundwater returns with temperature decrease
   - High temperature in melt glass and surrounding rock dissipates over years to decades
   - Possible chimney conduit (higher permeability)
   - A damaged zone surrounds the cavity

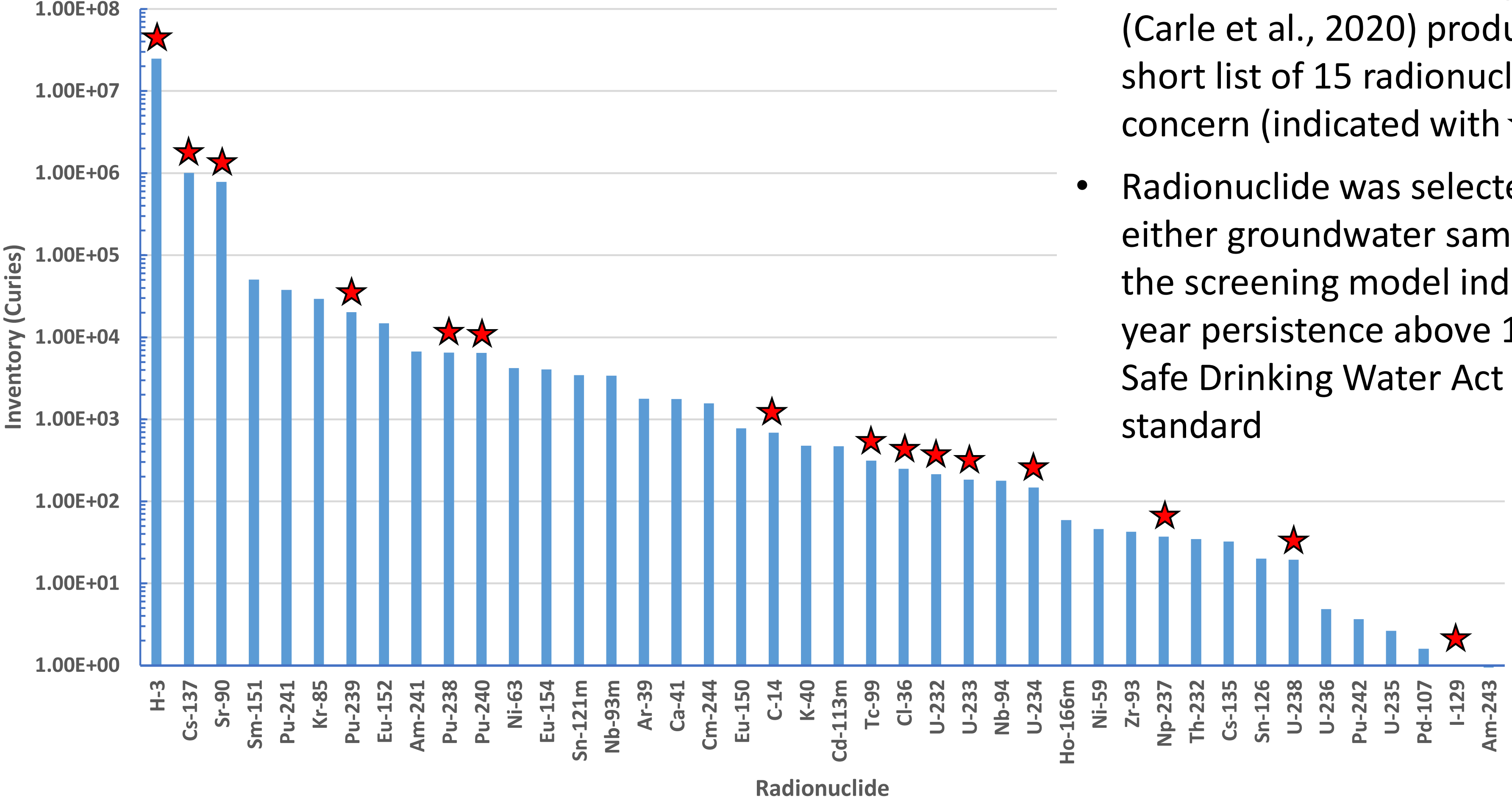
Source Term Representation in the PM Radionuclide Transport Model



EV = Exchange Volume
R_c = Cavity Radius

Cavity dimension based on maximum announced yield identified in DOE/NV--209 Rev. 16 (NNSA/NFO, 2015) and Equation 1 in UCRL-ID-136003 (Pawloski, 1999), except for HANDLEY for which minimum announced yield is used.

Underground Radiologic Inventory at PM Includes 43 Long-lived Isotopes



- A radionuclide screening analysis (Carle et al., 2020) produced a short list of 15 radionuclides of concern (indicated with ★)
- Radionuclide was selected if either groundwater sampling or the screening model indicate 100-year persistence above 10% of the Safe Drinking Water Act (SDWA) standard

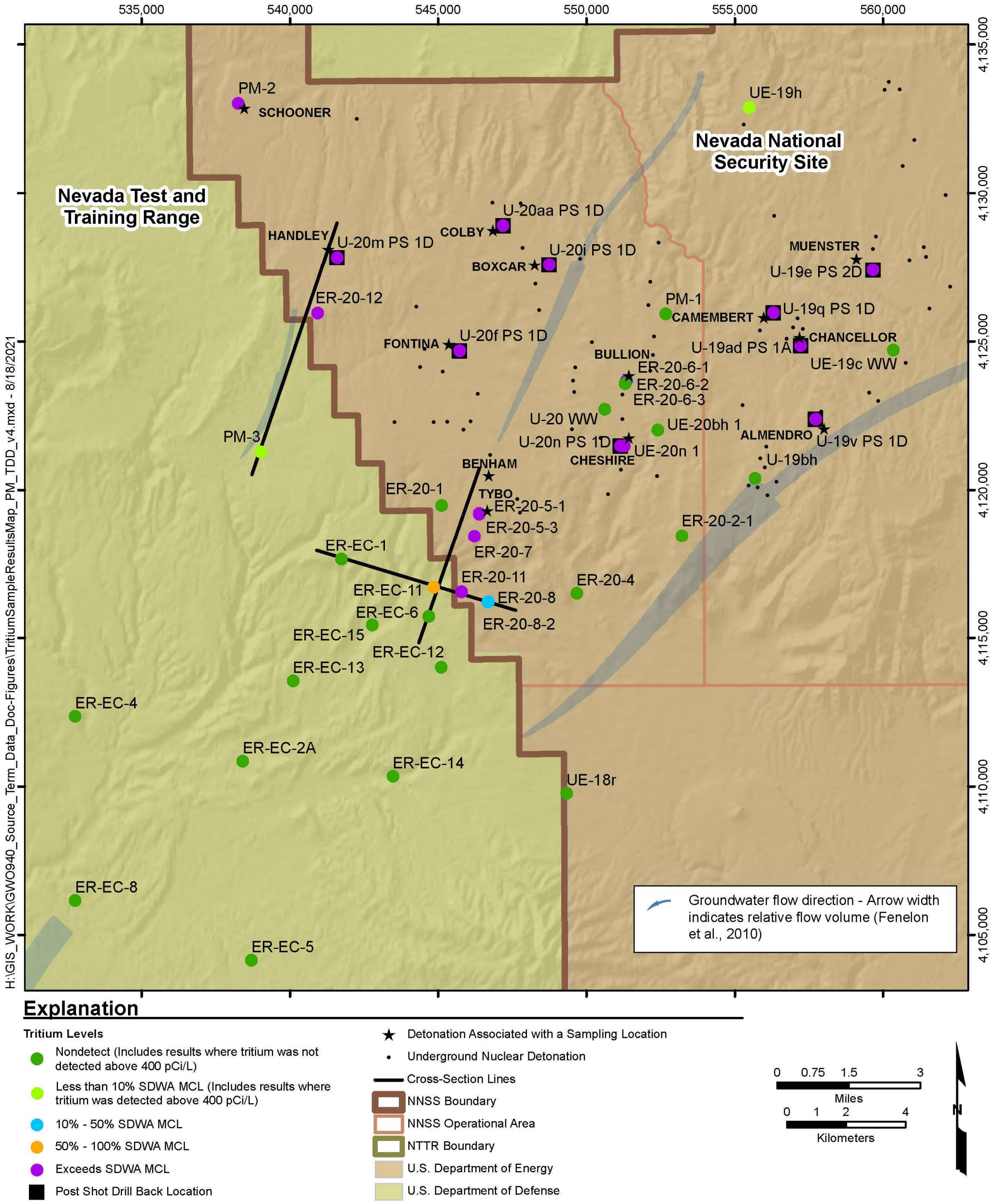
(Modified from Finnegan et al. 2016, Table 7)

Radionuclide Transport Model

(DOE/EMNV, 2022)

Tritium Observations

- Tritium is the only radionuclide observed away from the testing areas at concentrations exceeding the SDWA maximum contaminant level (MCL)
- Two tritium plumes are observed crossing the NNSS boundary onto the NTTR



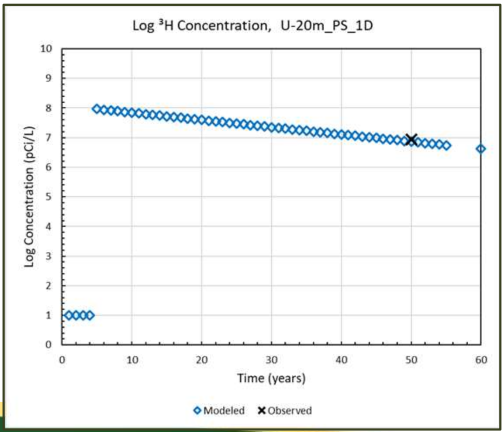
Source: Navarro GIS, 2021

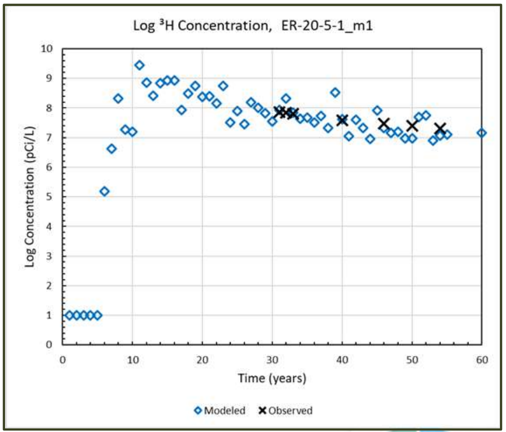
Coordinate System: NAD 1927 UTM Zone 11N, Meter

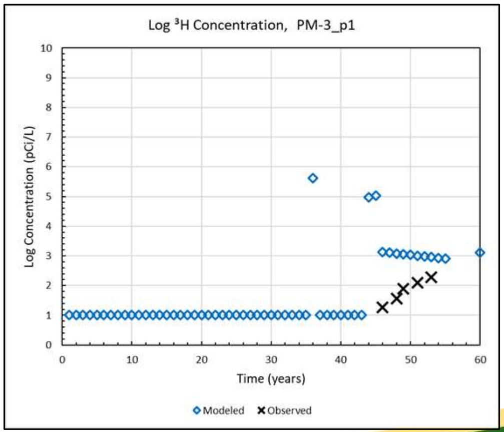
Transport Model Calibration

- Transport model was calibrated to observed tritium at wells
  - Guiding philosophy: better to conservatively overpredict tritium concentrations rather than underpredict, especially in areas of concern
- Calibration performed to build confidence in the probabilistic transport model to follow
  - Calibrated parameter values fall within probabilistic ranges
  - Calibration does not directly inform probabilistic analysis
- Good agreement with most of the 221 observations
- Model conservatively overpredicts at some locations
- Poor agreement (underprediction) at a few locations due to model resolution

Sample breakthrough plots:
These compare modeled tritium concentration (blue) and observed tritium concentration (black) over time, up to 60 years from start of model (transport model starts on date of first underground detonation in 1965)







Forecasts of Radionuclide Migration Over the Next 1,000 Years

Probabilistic Transport Model

- Results define 1,000-year contaminant boundary (probability of exceeding SDWA standards ≥ 5% over 1,000 years)
- Monte Carlo approach with 400 realizations
  - Each realization randomly sampled the following uncertain transport parameter distributions for each HSU/fault zone:
    - Effective (fracture) porosity
    - Fracture aperture (opening)
    - Matrix porosity
    - Matrix diffusion coefficient
    - Bulk rock density
    - Matrix sorption coefficients

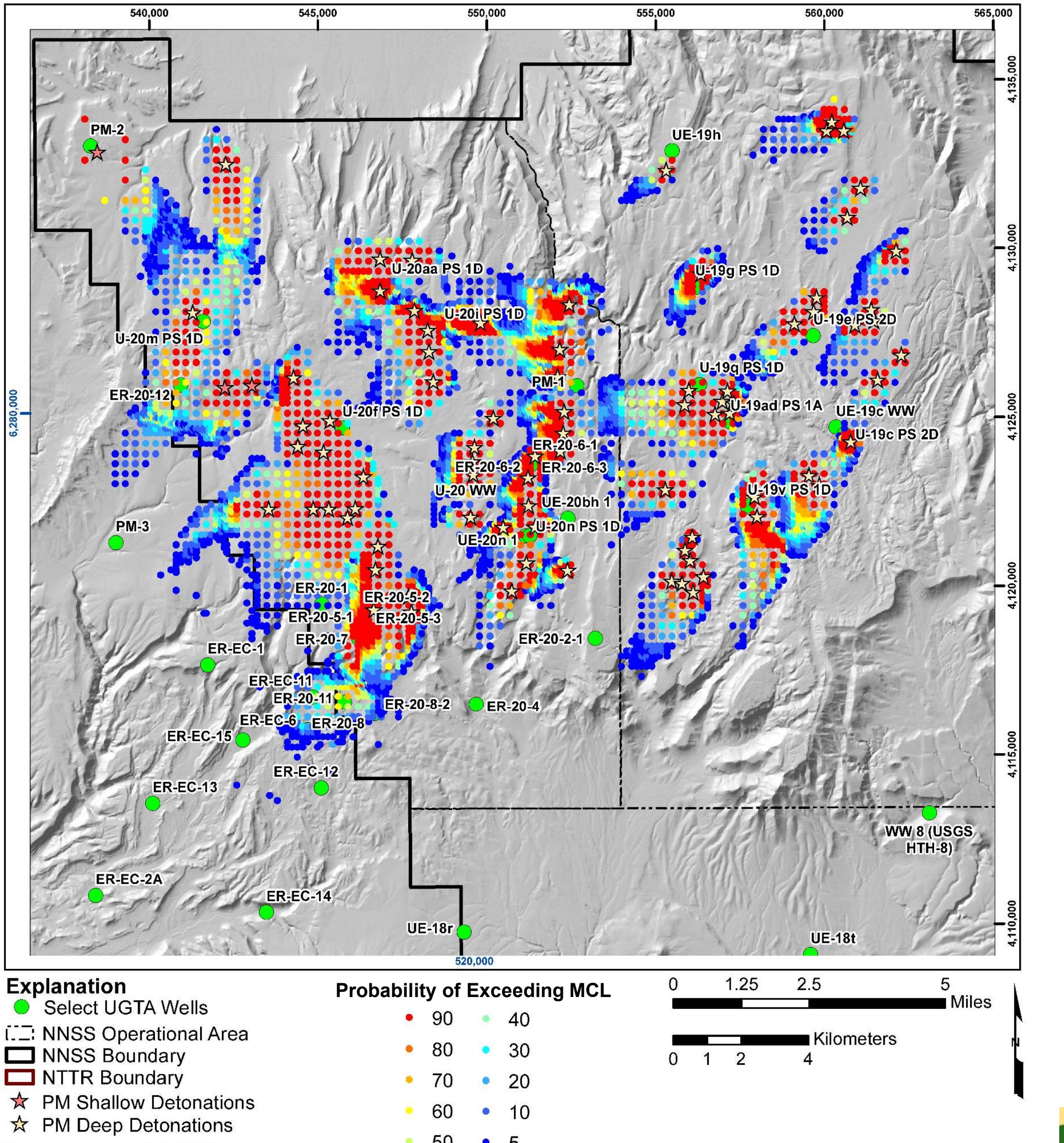
Probabilistic Transport Model

(continued)

- Four flow models considered
  - Base case
  - Two alternative recharge flow models
  - Alternative flow model including all faults

Forecast Contaminant Boundary (CB) Base Case

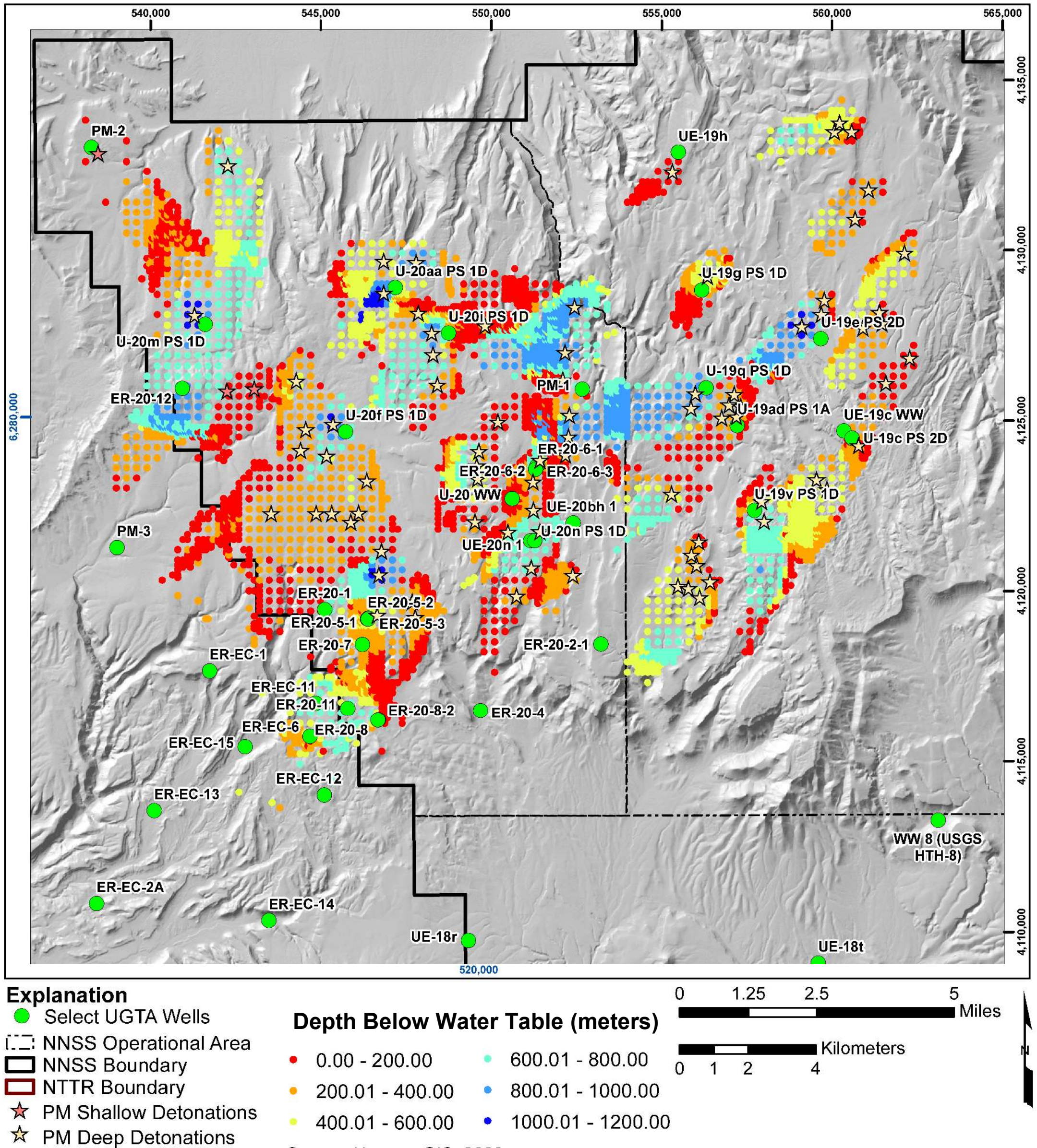
- Colored dots indicate where probability of exceeding SDWA standards ≥ 5% over 1,000 years
- CB perimeter is defined by the ground surface area that is obscured by the collection of colored dots
- CB extends ~3 km past the western NNSS boundary onto the NTTR at four locations
- Represents contributions from all 15 radionuclides modeled
- CB dominated by tritium



Source: Navarro GIS, 2022

CB Colored by Saturated Depth of Contamination Base Case

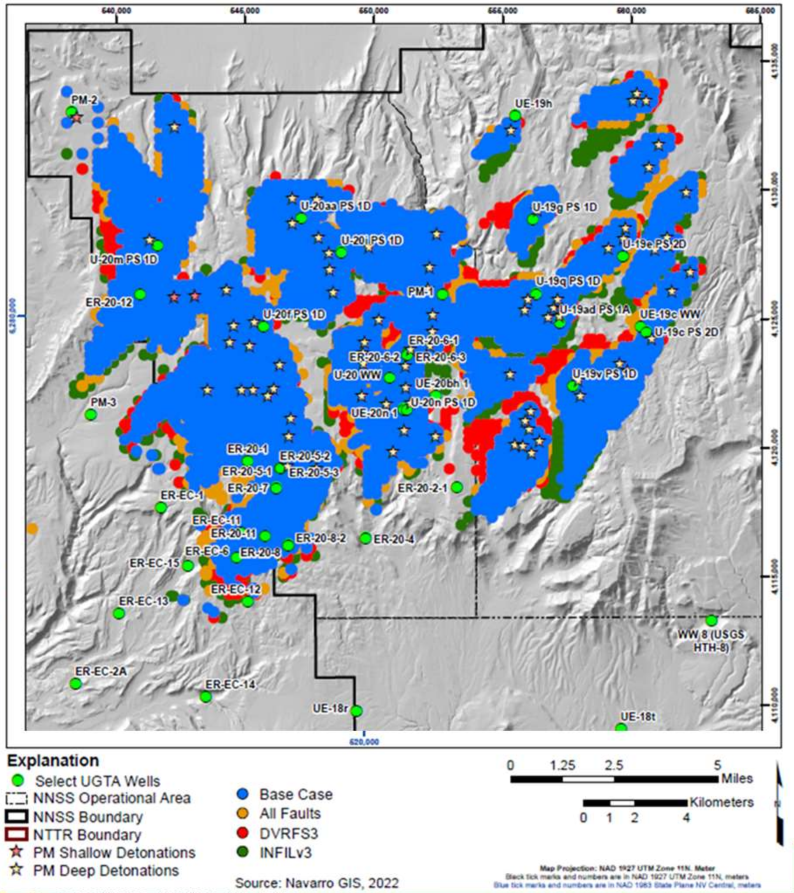
- Colored dots indicate saturated depth
- Both lateral extent and depth define CB



Source: Navarro GIS, 2022

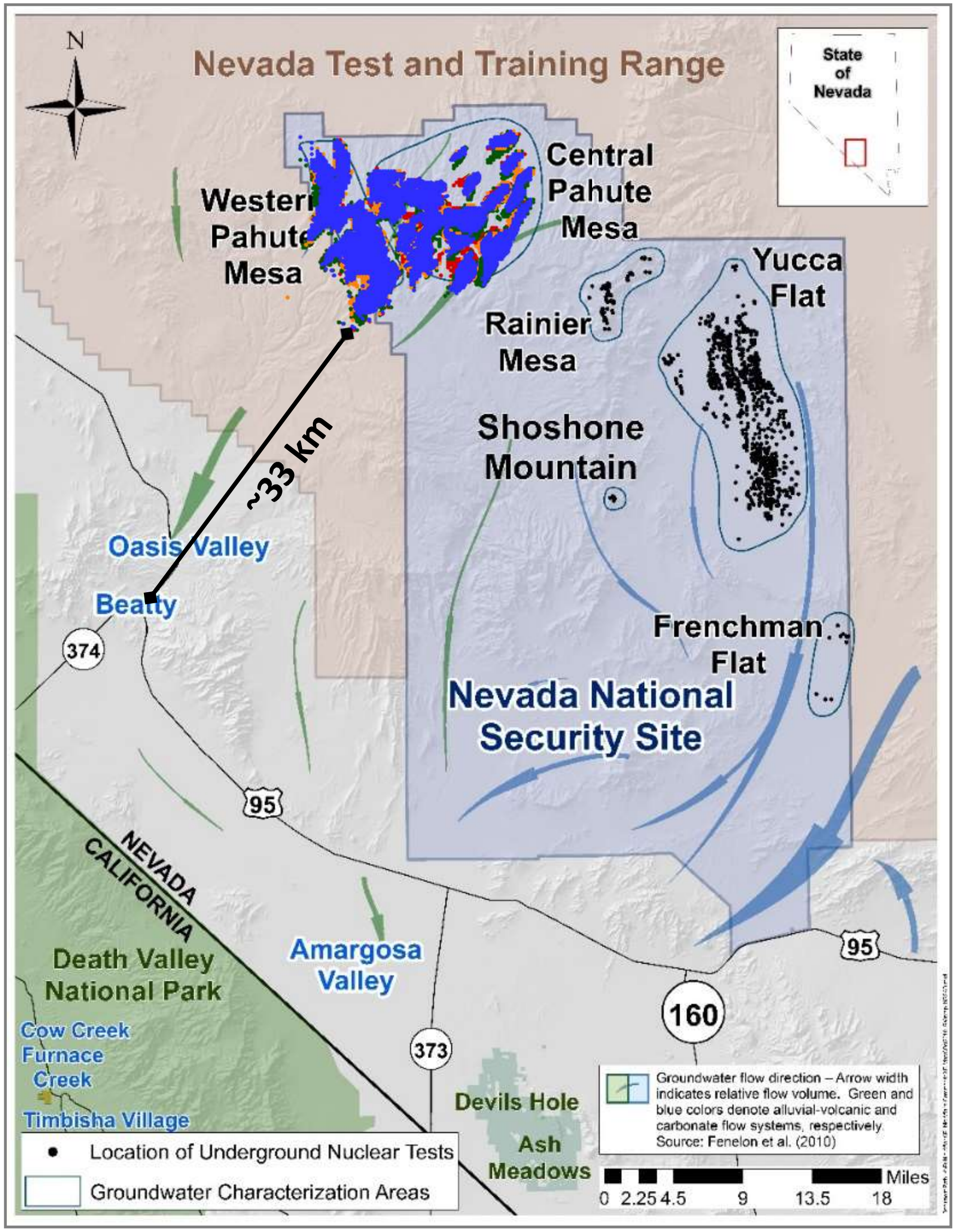
CB Ensemble

- CBs from four models are shown (unique color for each)
- Forecast extent is a few kilometers beyond the boundary of the NNSS
- Forecast extent remains ~15 km upgradient of the NTTR boundary and ~33 km from Beatty



Source: Navarro GIS, 2022

Map Projection: NAD 1927 UTM Zone 11N, Meter
Black tick marks and numbers are in NAD 1927 UTM Zone 11N, meters
Blue tick marks and numbers are in NAD 1983 State Plane NV Central, meters



Groundwater flow direction – Arrow width indicates relative flow volume. Green and blue colors denote alluvial-volcanic and carbonate flow systems, respectively. Source: Fenelon et al. (2010)

Key Messages

- The model forecasts show that:
  - The extent of contamination is dominated by tritium that is expected to decay below SDWA standards in less than 200 years
  - Other radionuclides are not likely to be present in downgradient groundwater at concentrations above SDWA standards
  - Nuclear test-related contamination will remain within federally controlled lands surrounding the NNSS over the next 1,000 years
  - Nuclear test-related contamination will not exceed SDWA standards at the accessible environment (i.e., outside the NTTR)
- Effective monitoring to track the migration of radionuclides will be necessary to ensure the long-term safety of downgradient groundwater users

Questions

Sampling activities

EM Nevada Program Subject Matter Expert (SME):
John Myers

Navarro SME:
Tim deBues, Ken Rehfeldt

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