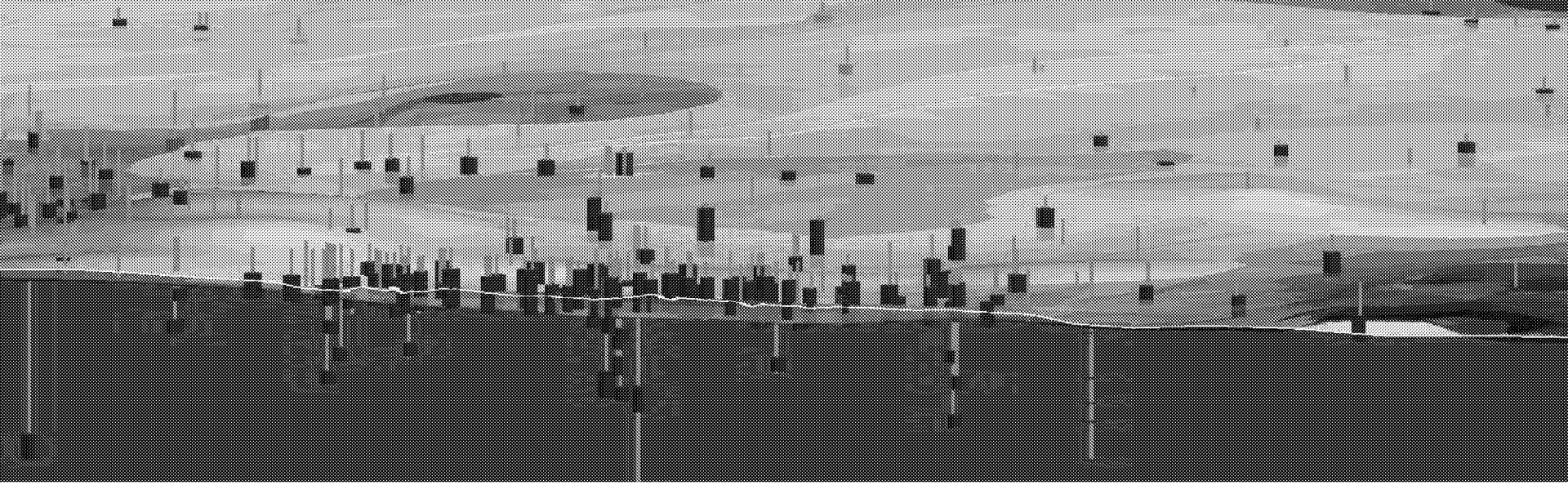
NEVADA ENVIRONMENTAL RESPONSE TRUST

LE PETOMANE XXVII, INC., NOT INDIVIDUALLY BUT SOLELY AS ENVIRONMENTAL RESPONSE TRUST TRUSTEE

Q1 2017 TECHNICAL STAKEHOLDER MEETING

LE PETOMANE INCORPORATED | NERT



PHASE 5 GROUNDWATER MODEL

NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

Presented by
Christopher M. Stubbs, PhD, PE

RAMBOLL ENVIRON

GROUNDWATER MODELING HISTORY

- Steady-state model developed by Northgate for site conditions in 2008/2009
  - Approved by NDEP on April 4, 2013
- Model Updates by Ramboll Environ:
  - Phase 1: (Reported in 2013 Semi Annual Report)
    - ✓ Developed conceptual water balance
  - Phase 2: (Reported in 2014 Annual Report)
    - ✓ Boundary flux refinement (Las Vegas Wash interaction)
    - ✓ Incorporation of aquifer testing results from 2013 GWETS Optimization
  - Phase 3: (Reported in 2015 Annual Report)
    - ✓ Extended Model Domain
    - ✓ Revised Geology/Layering, Conceptual Water balance
  - Phase 4: (Reported in 2015 Semi Annual Report)
    - ✓ Extended Model Domain to Three Kids Weir
    - ✓ Implementation of Weirs
  - **Phase 5: Transient flow model (November 2016)**

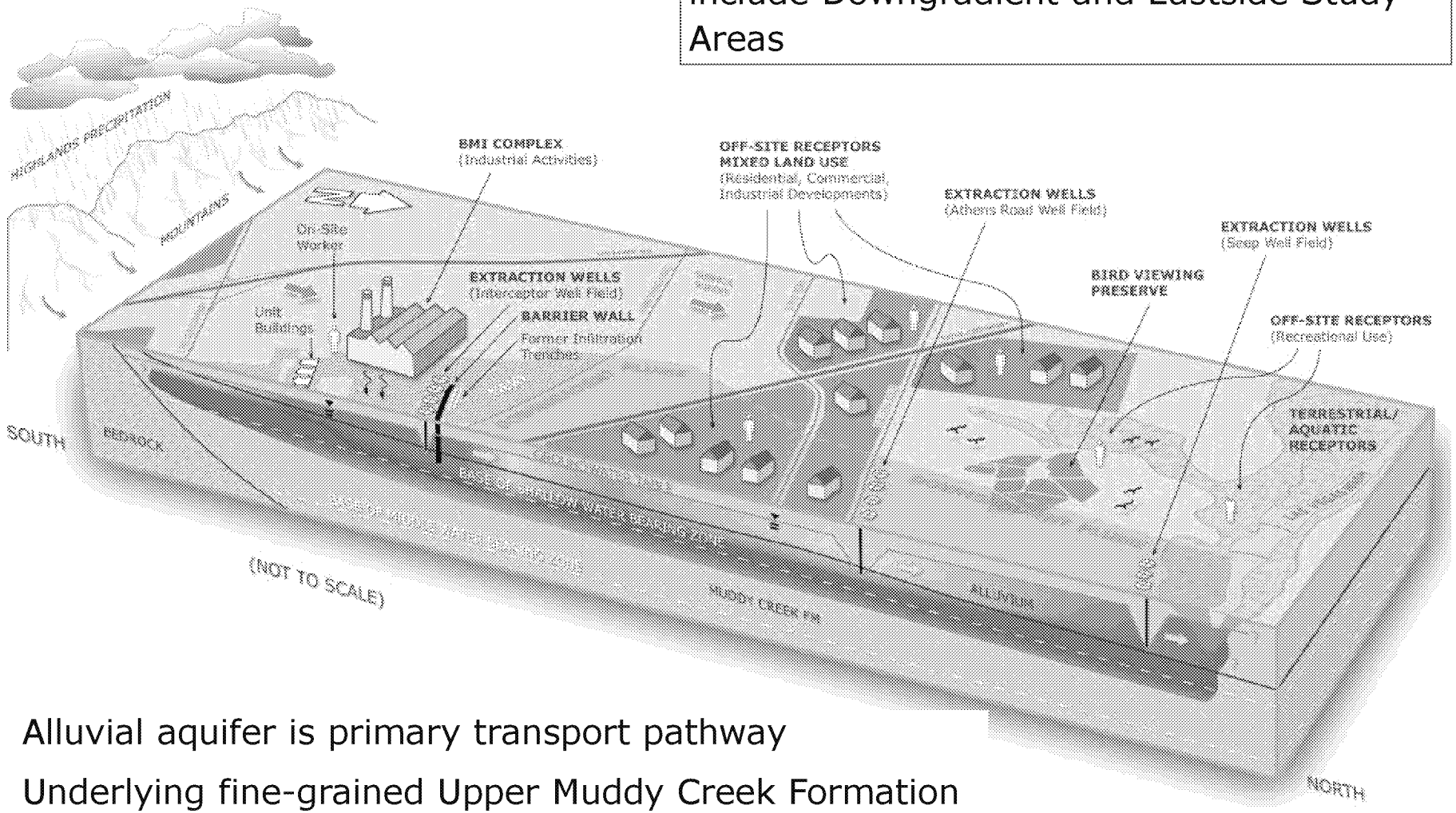
OBJECTIVES OF GROUNDWATER MODELING

- Steady-state flow model
  - To evaluate GWETS performance metrics semi-annually
  - To support 2013 GWETS Optimization Project and Continuous Optimization Program

- Transient flow model and contaminant transport model are being developed as part of Remedial Investigation (RI)
  - To develop a more detailed understanding of perchlorate mass loading to Las Vegas Wash
  - To synthesize the information collected in the RI into a conceptual model of groundwater flow and transport
  - To evaluate the relative performance of remedial alternatives to be considered in the Feasibility Study
  - To support the soil flushing and groundwater bioremediation treatability studies and other RI analyses
  - To evaluate performance of the Continuous Optimization Program

CONCEPTUAL SITE MODEL

As RI progresses, CSM will be updated to include Downgradient and Eastside Study Areas



- Alluvial aquifer is primary transport pathway
- Underlying fine-grained Upper Muddy Creek Formation (UMCf) is generally low conductivity

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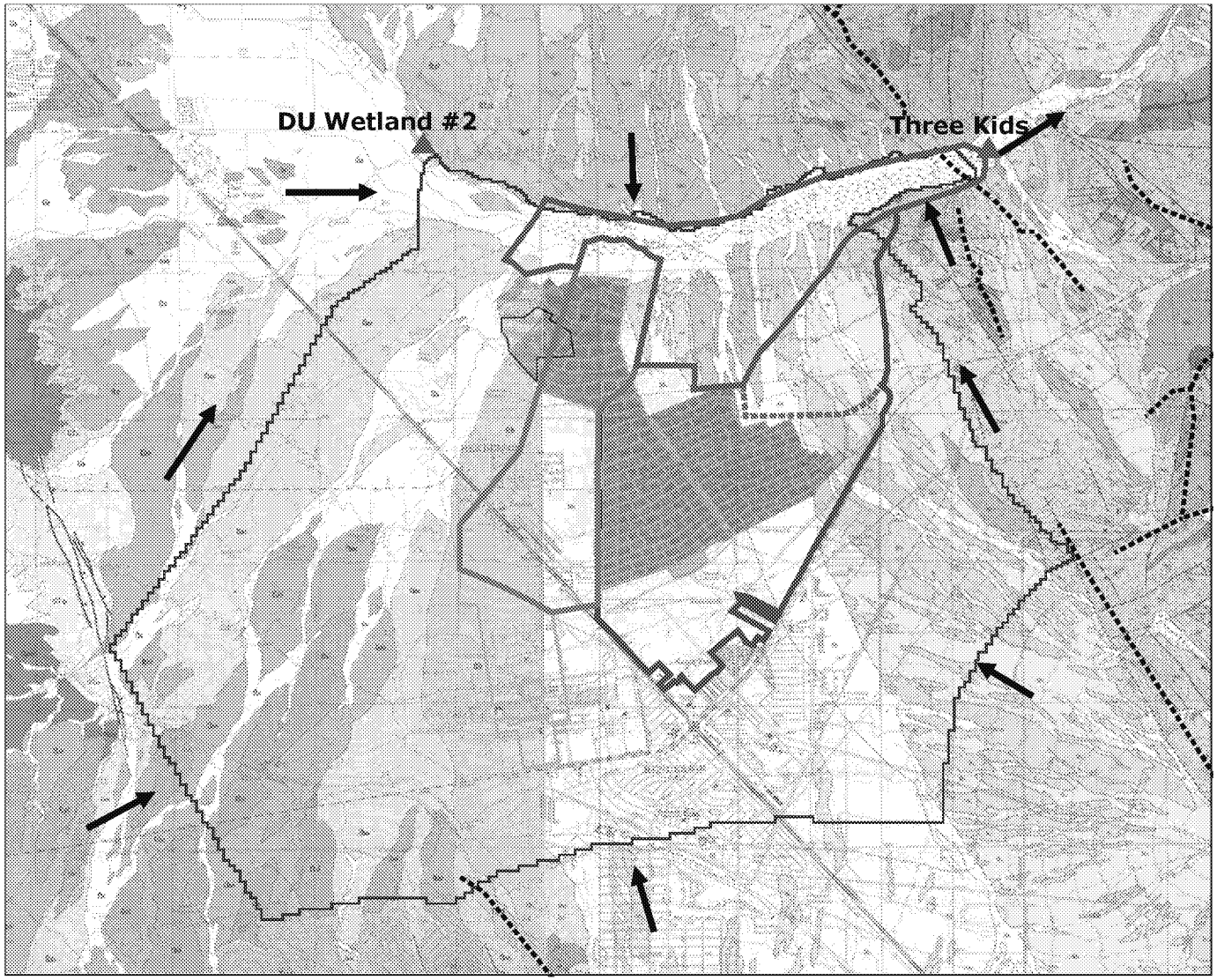
PHASE 5 TRANSIENT MODEL DEVELOPMENT

- Model domain is same as Phase 4 model
- Detailed conceptual water balance for the simulation period (2000 – 2015)
- Implementation of transient boundary conditions
- 3D geologic model development
- Preliminary evaluation of fate and transport of perchlorate in groundwater

PHASE 6 MODEL ENHANCEMENTS

- Incorporate new investigation results:
  - Phase II RI
  - Downgradient Study Area Investigation
  - Eastside Study Area Investigation
  - Soil flushing and groundwater bioremediation treatability study
- Development of contaminant transport capabilities

PHASE 5 MODEL DOMAIN



Groundwater Flow Direction

USGS Stream Gauge

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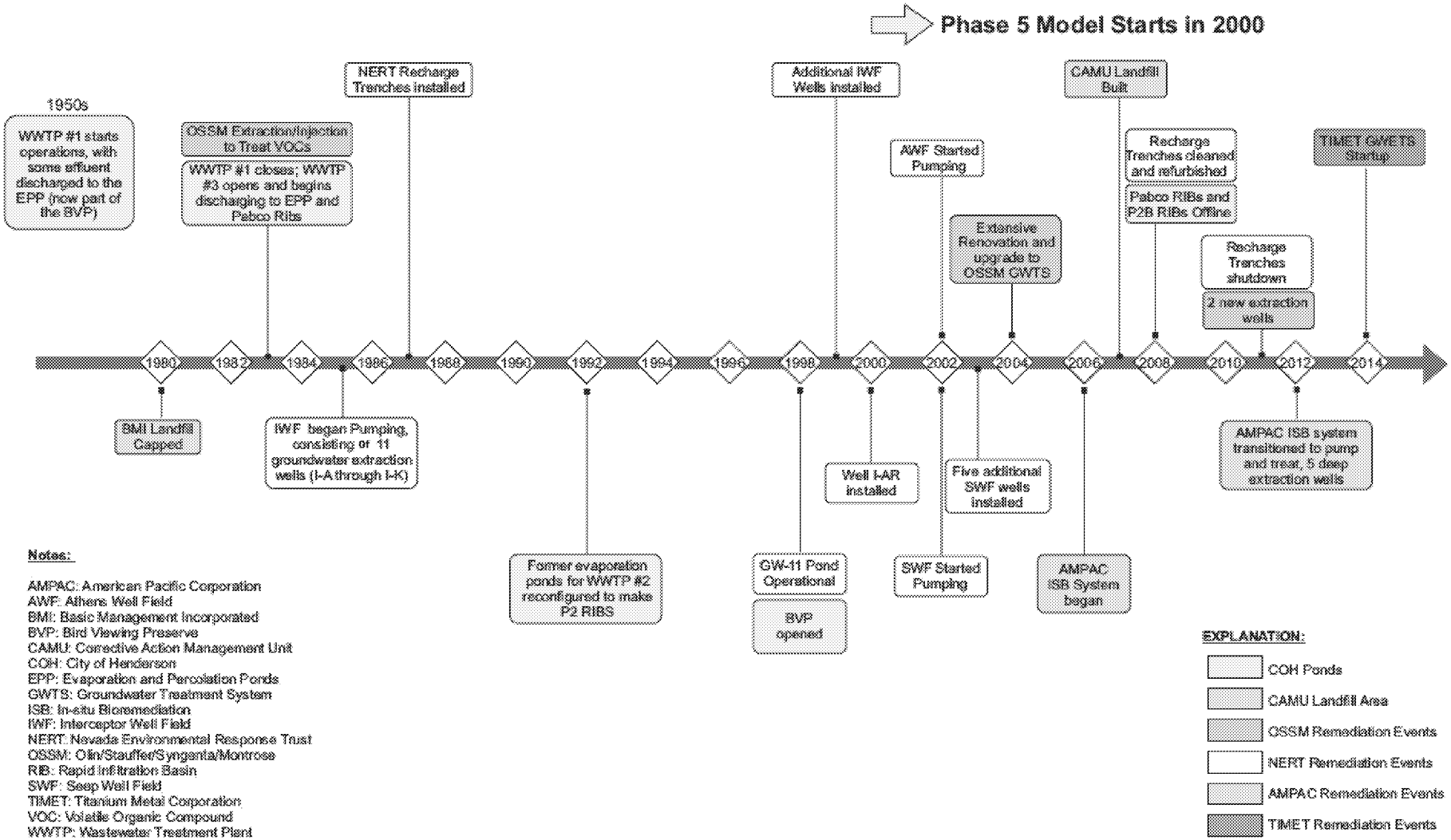
MODEL SIMULATION PERIOD



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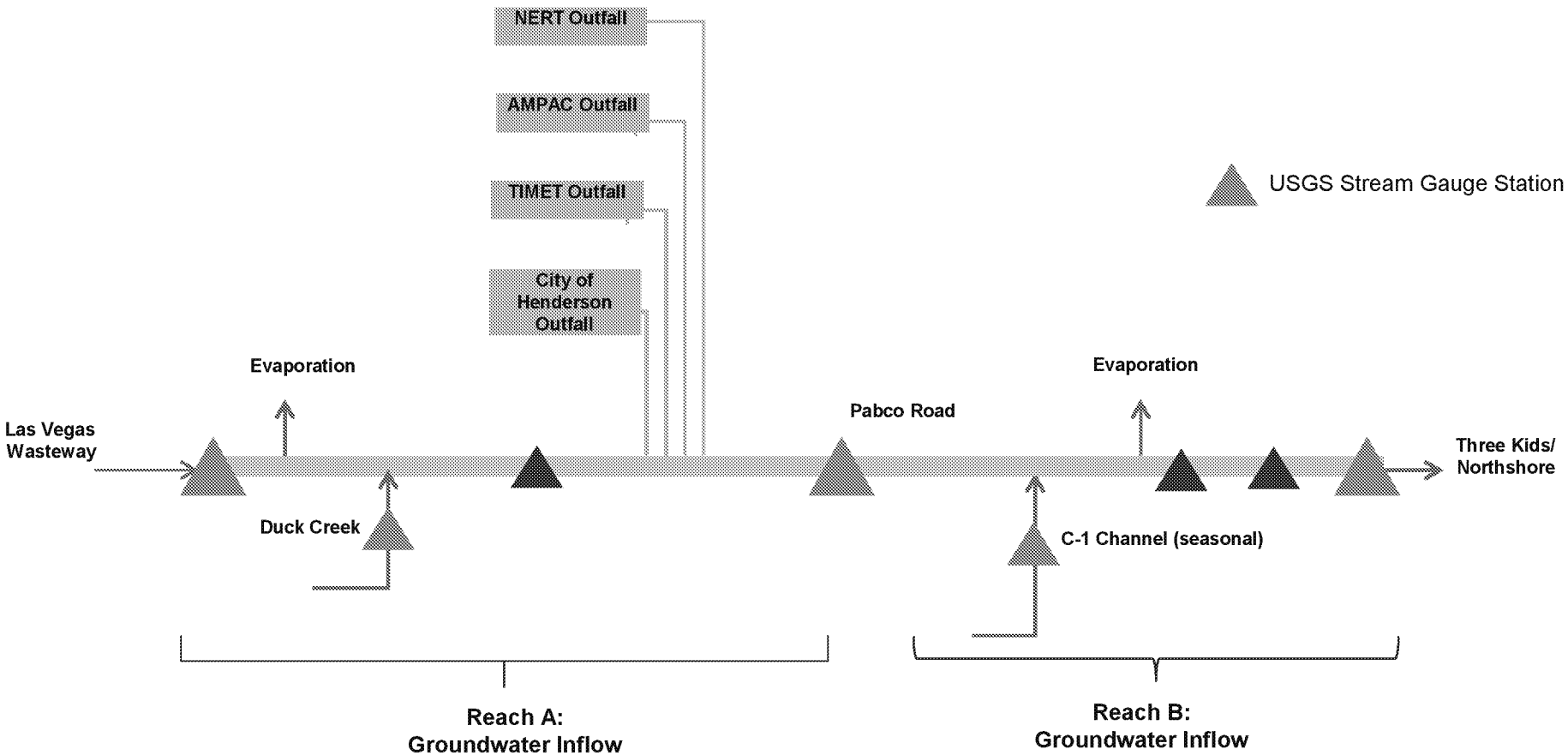
CONCEPTUAL WATER BALANCE COMPONENTS

- Groundwater Inflows
  - Boundary Inflows (south/north/west)
  - Areal Recharge
    - COH Birding Pond and other industrial ponds
    - Residential/Industrial Recharge
    - Golf Course recharge
    - Retention/Detention Basins
    - Injection/Recharge Trenches
- Groundwater Outflows
  - Remediation Pumping
  - Discharge to the Wash
  - Storm Drains
  - Eastern Boundary outflows
  - Evapotranspiration

LAS VEGAS WASH WATER BALANCE COMPONENTS



New Stream Gauge*

**will be evaluated for Phase 6 Model*

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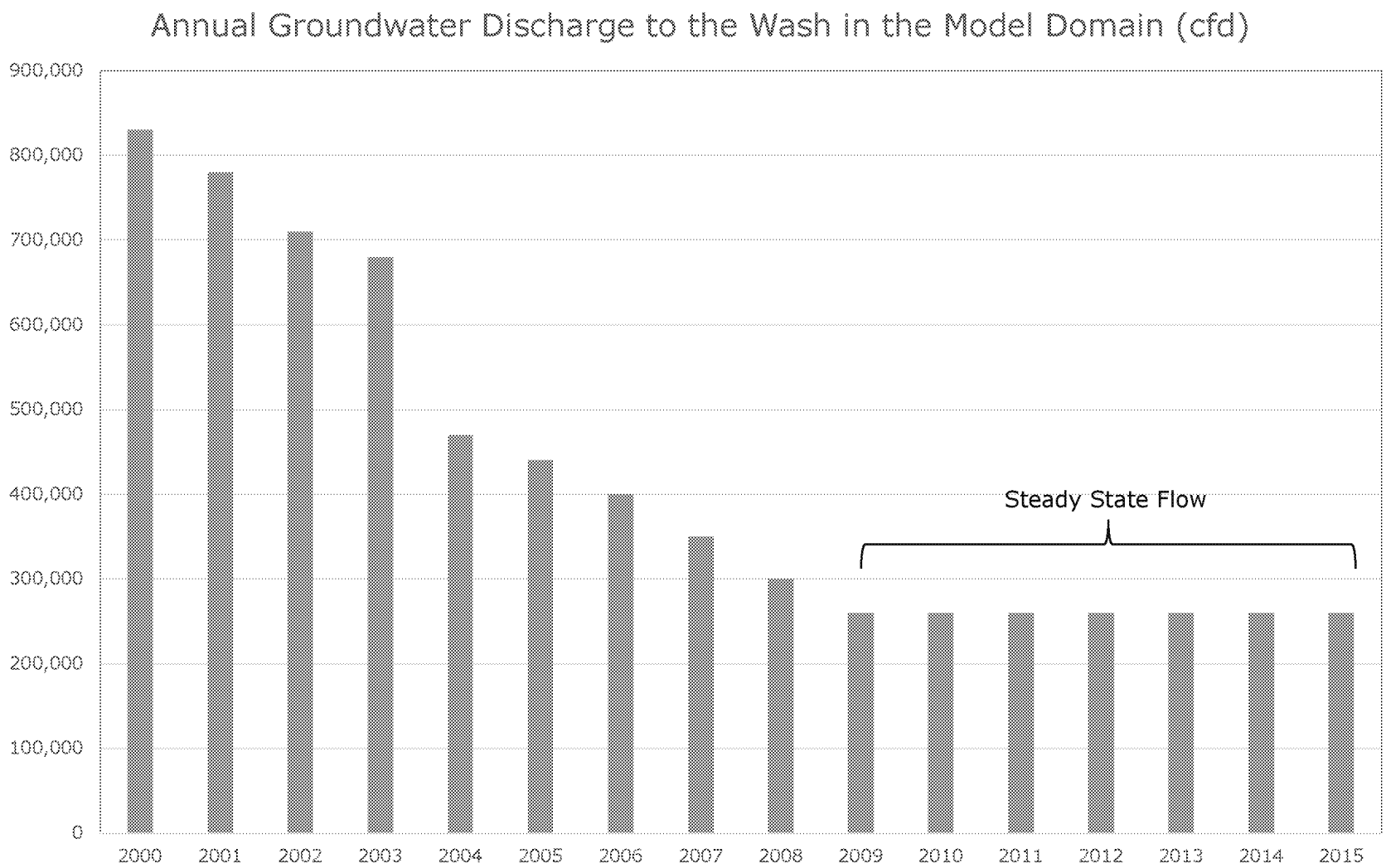
CONCEPTUAL WASH WATER BALANCE



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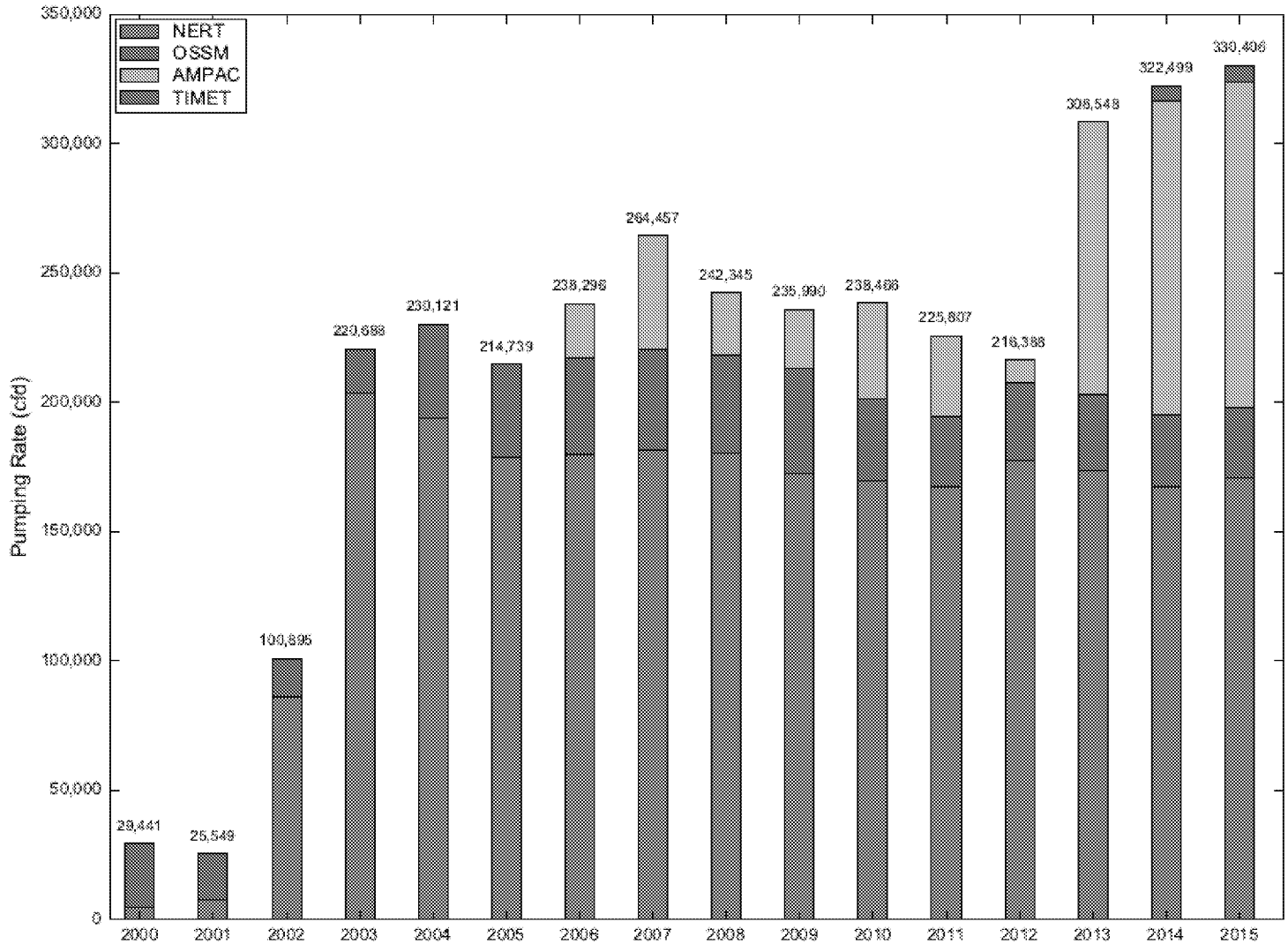
GROUNDWATER EXTRACTION (2000 - 2015)



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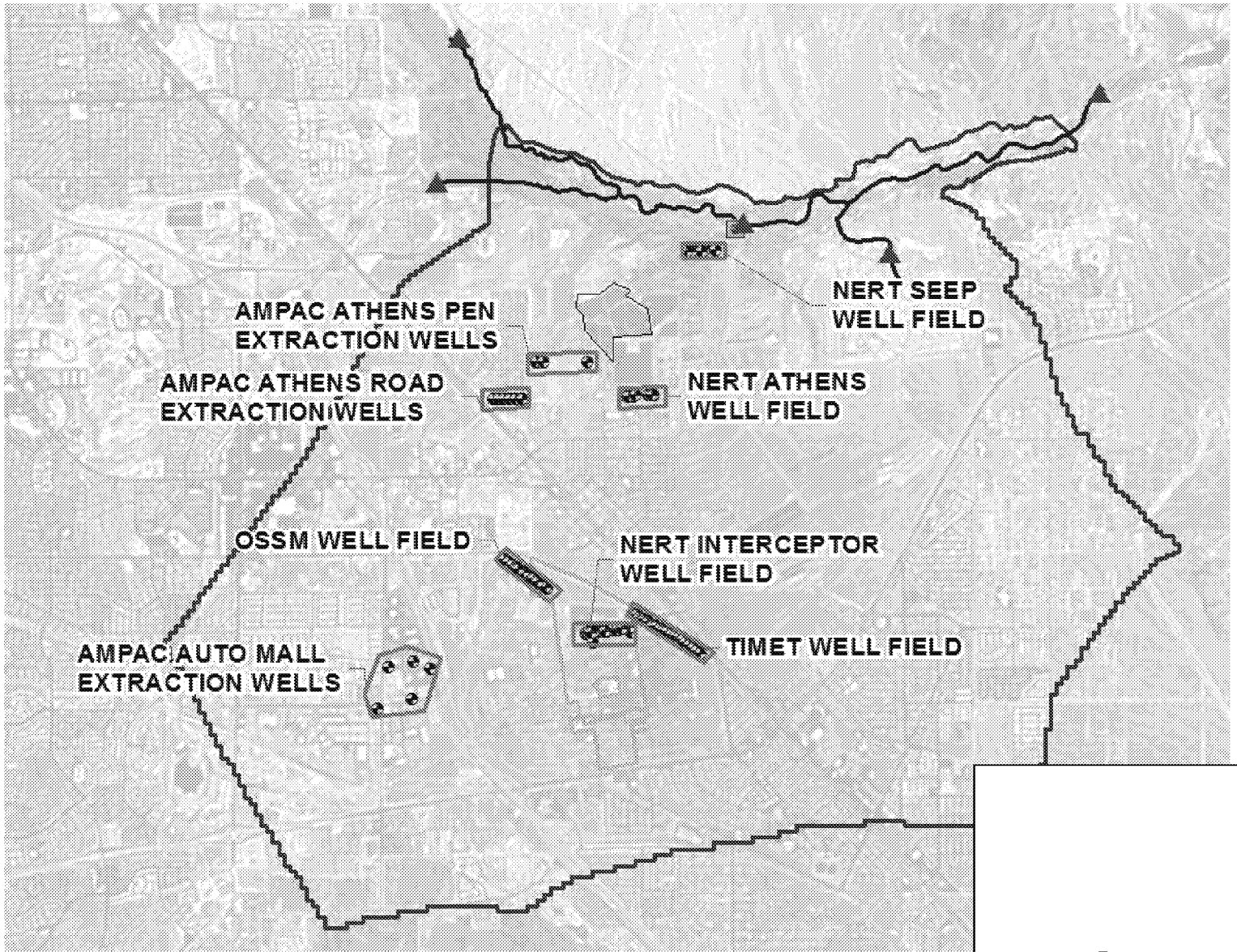
WELL FIELDS



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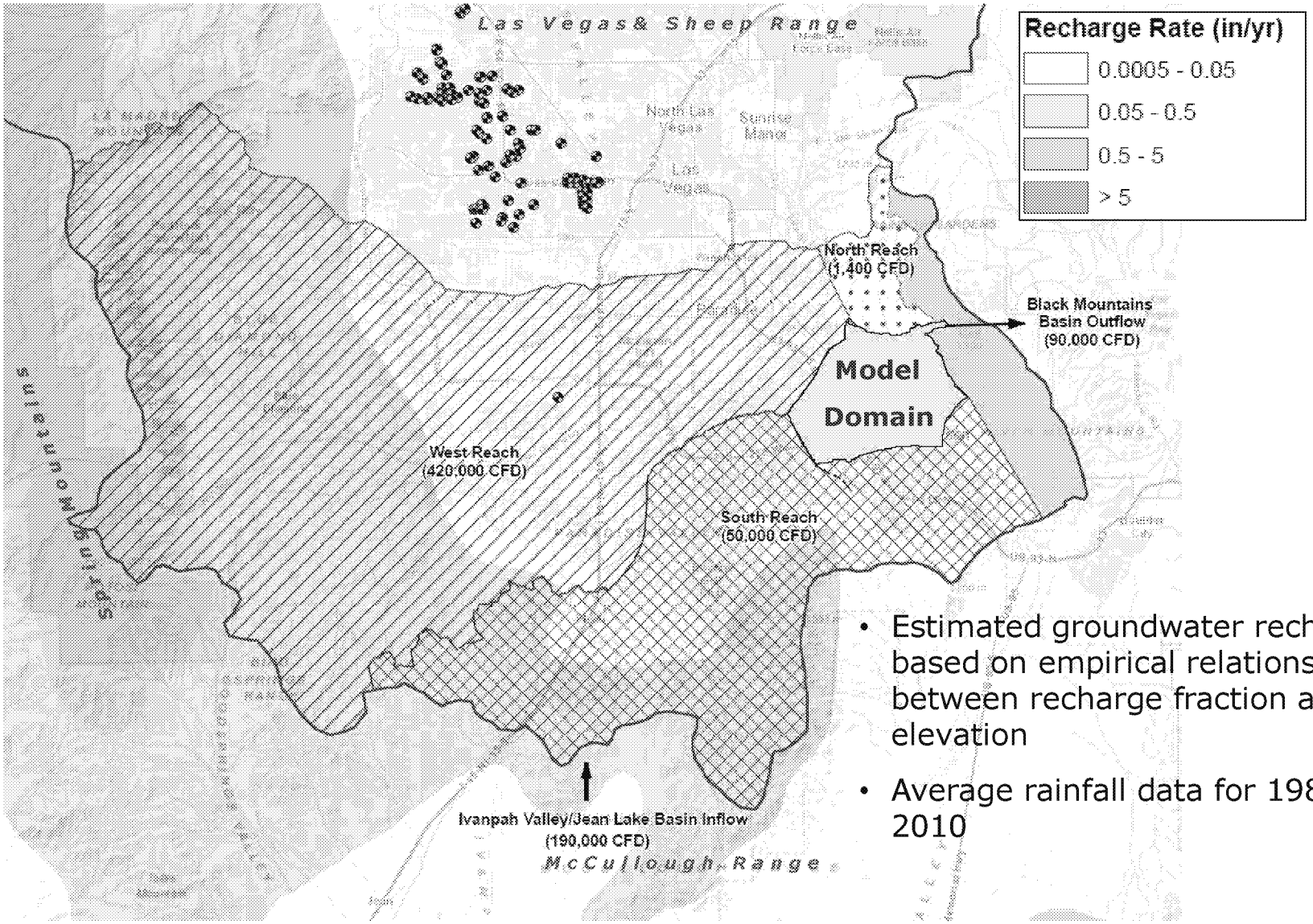
CONCEPTUAL BOUNDARY INFLOWS



- Estimated groundwater recharge based on empirical relationship between recharge fraction and elevation
- Average rainfall data for 1981-2010

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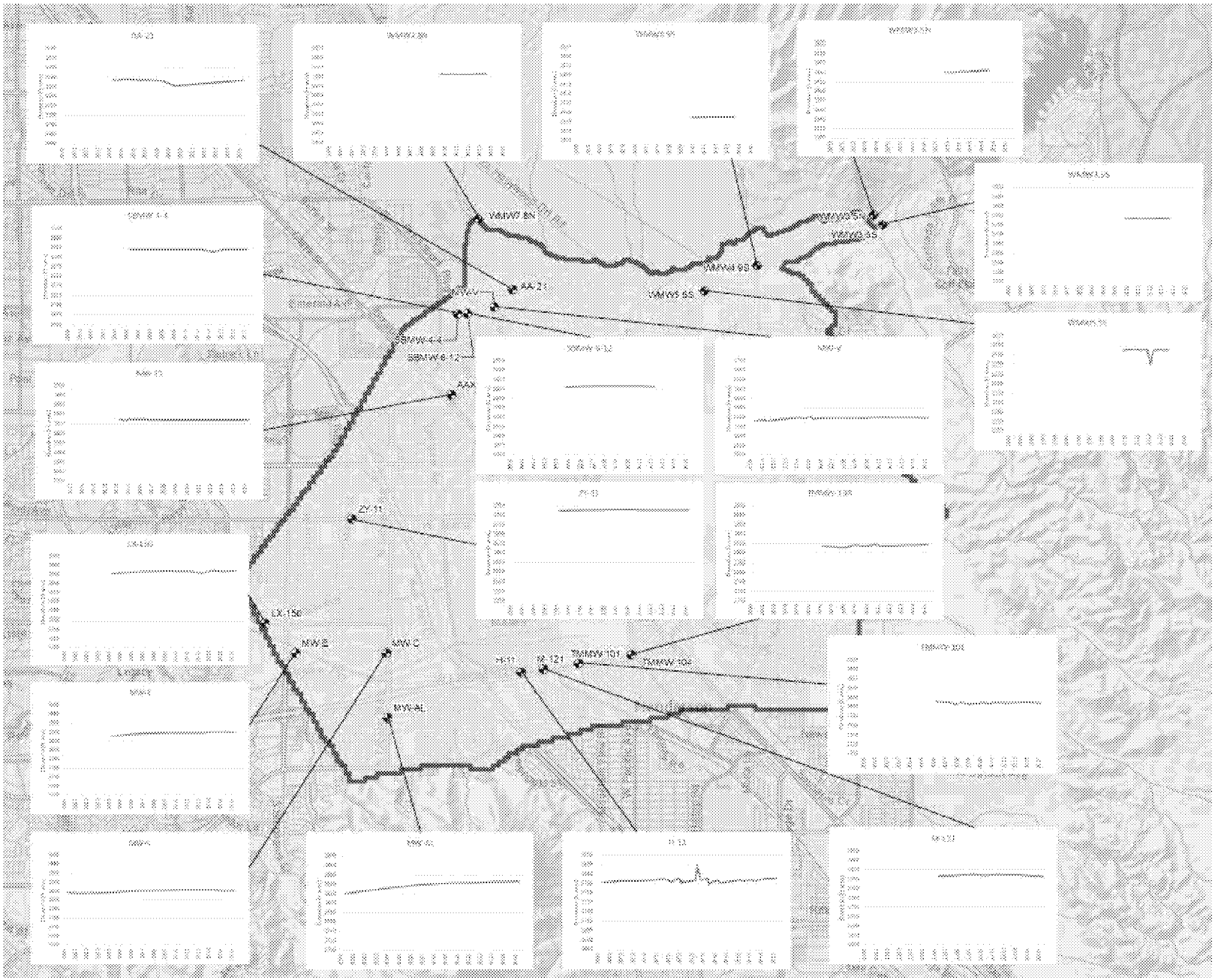
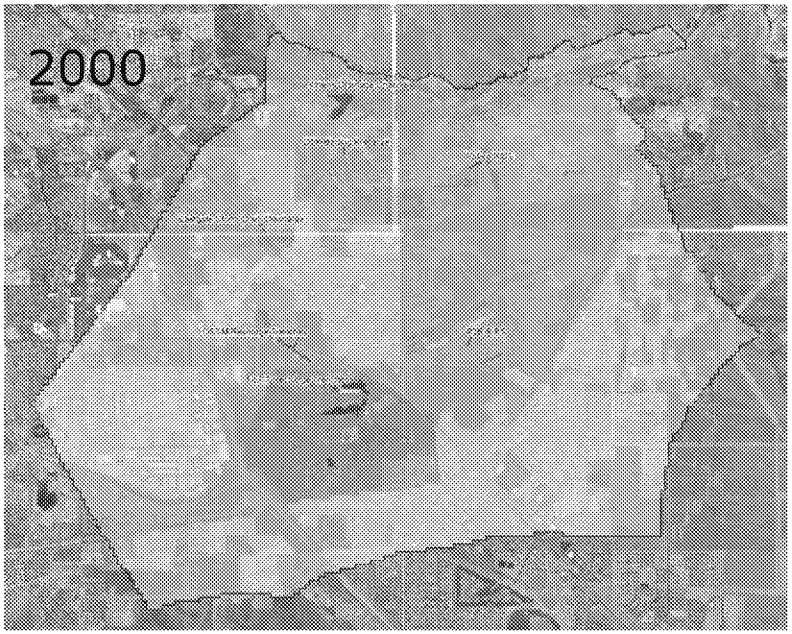
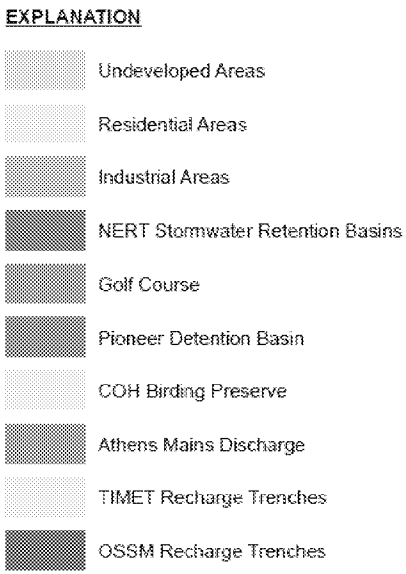
BOUNDARY INFLOWS ARE STEADY-STATE

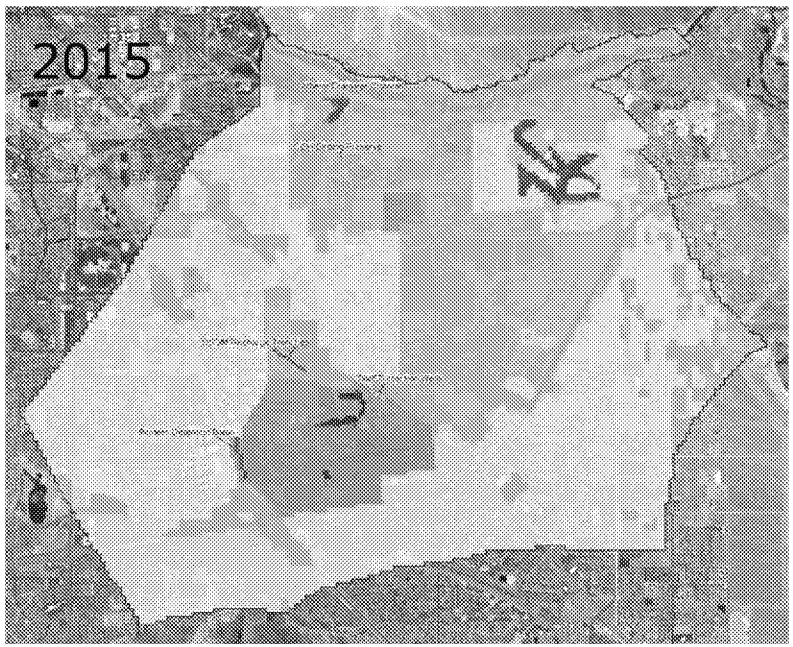


AREAL RECHARGE/ LAND USE CHANGE

- Land use areas mapped from aerial photos (2000 to 2015)
- Recharge rates based on land use







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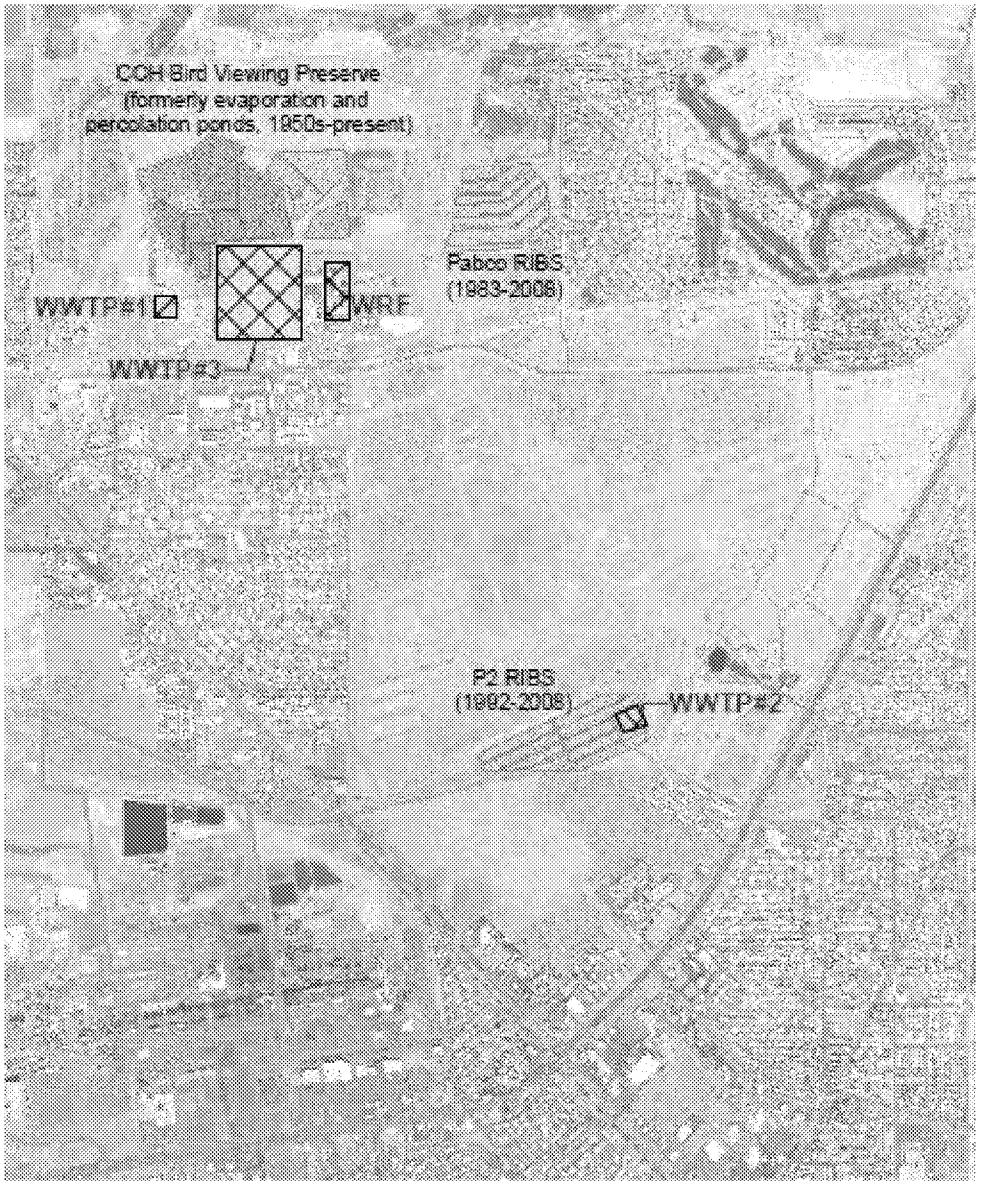
AREAL RECHARGE/ PONDS

- City of Henderson wastewater discharge rates to ponds and rapid infiltration basins (RIBs) changed during model period



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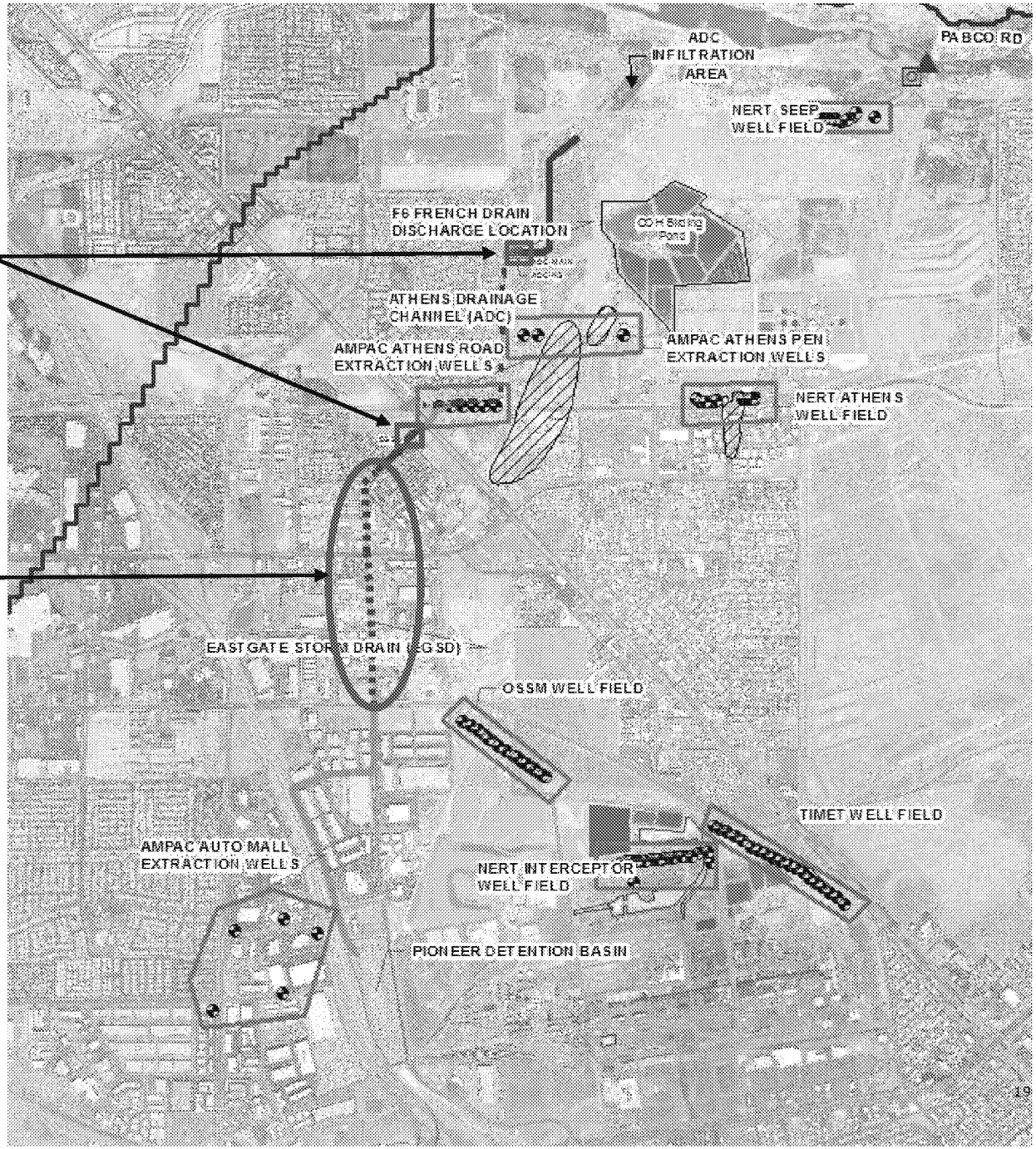
STORM DRAINS

Surface Water Sampling Location

Suspected Portion of Storm Drain with Groundwater Infiltration



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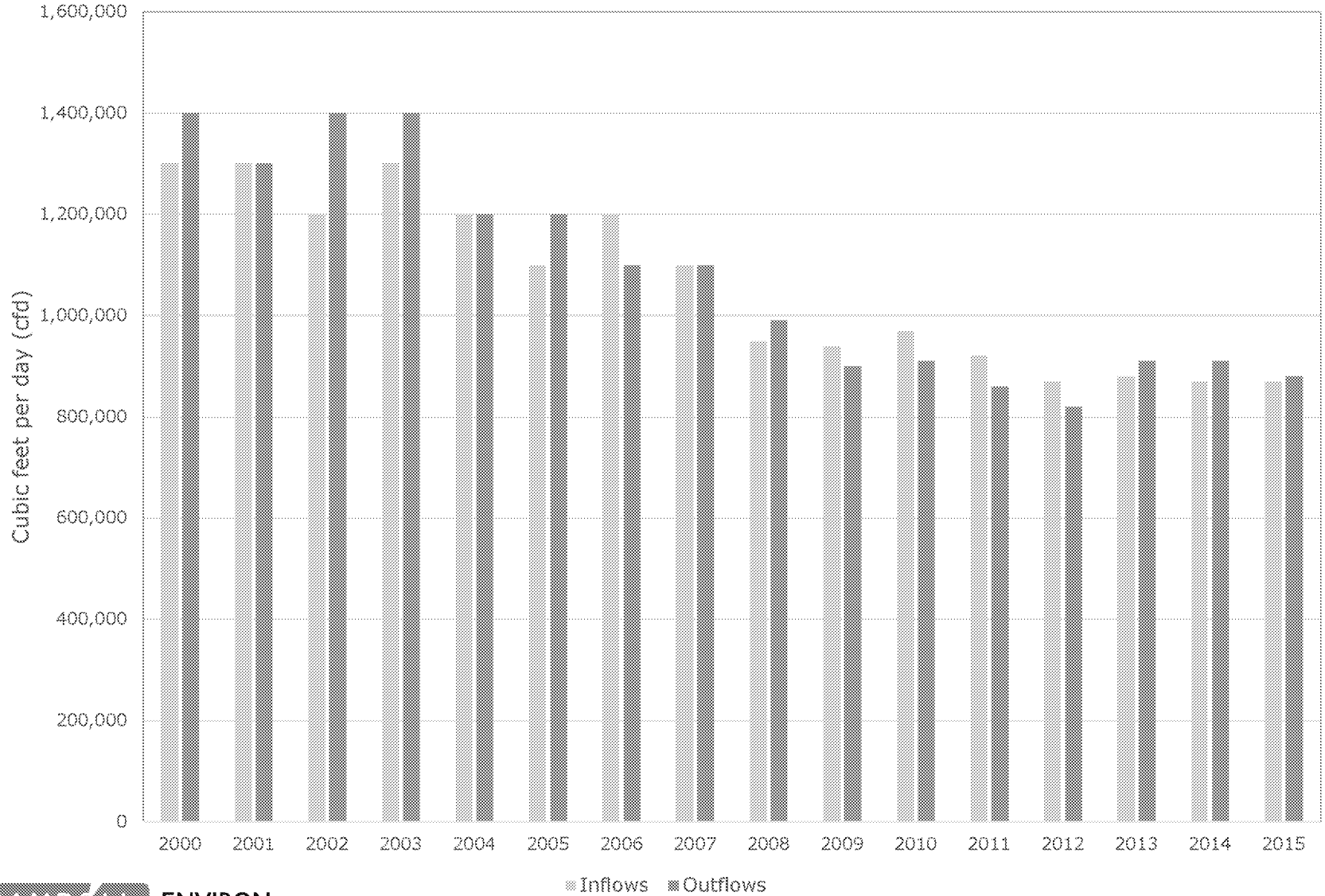
CONCEPTUAL WATER BALANCE



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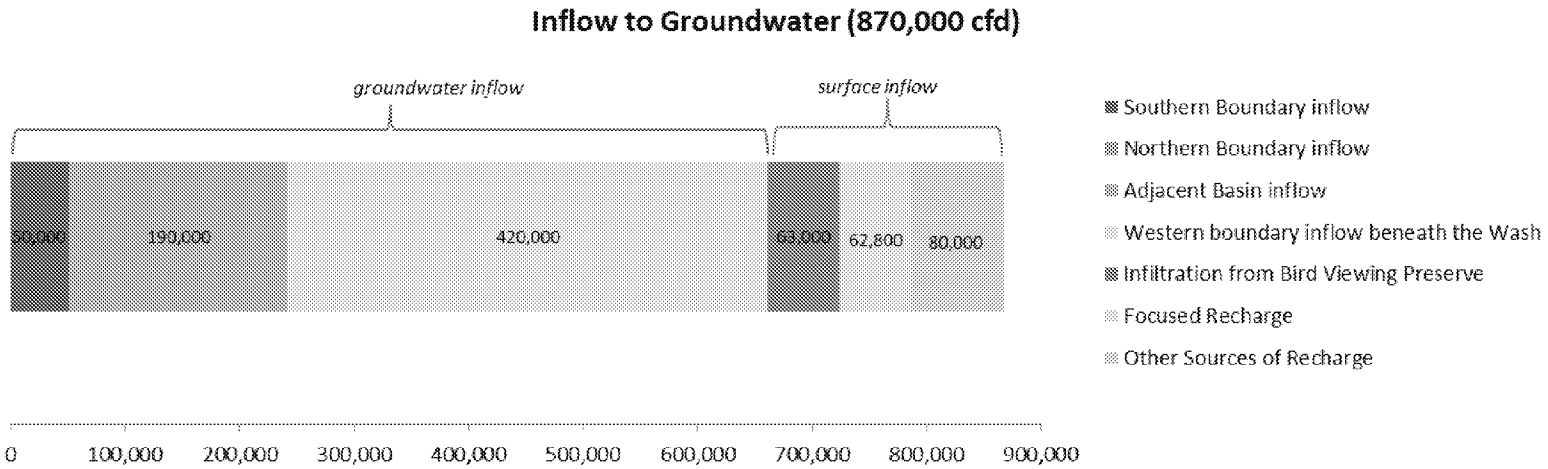
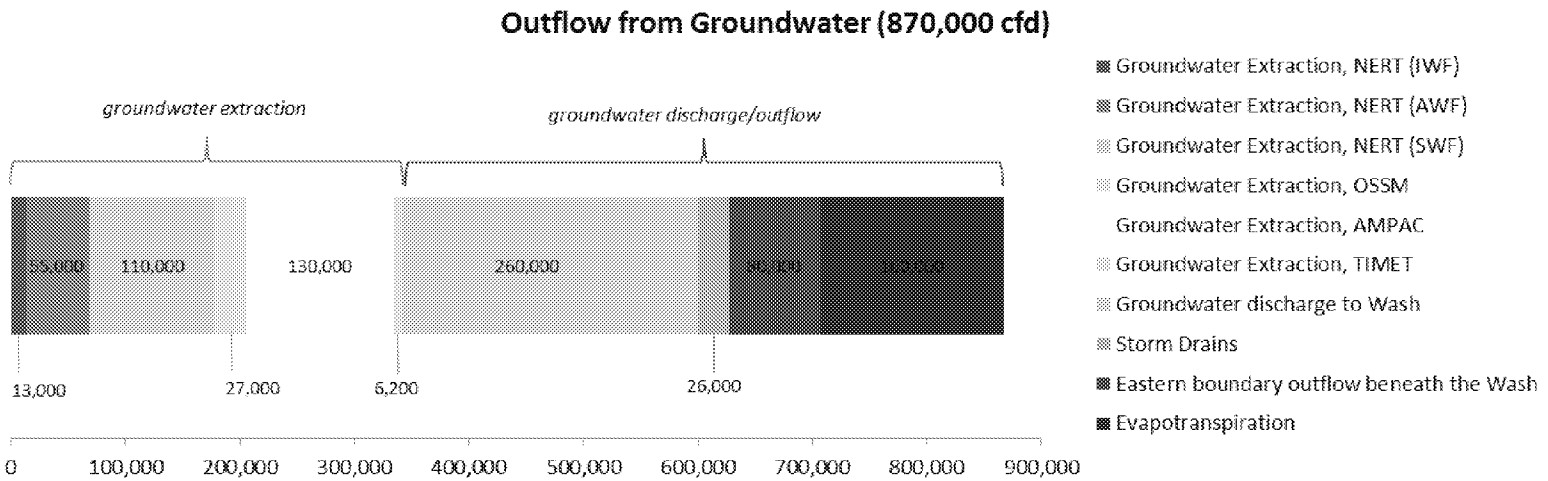
CONCEPTUAL WATER BALANCE COMPONENTS (2015)



The water balance will be refined in Phase 6 based on new RI data.



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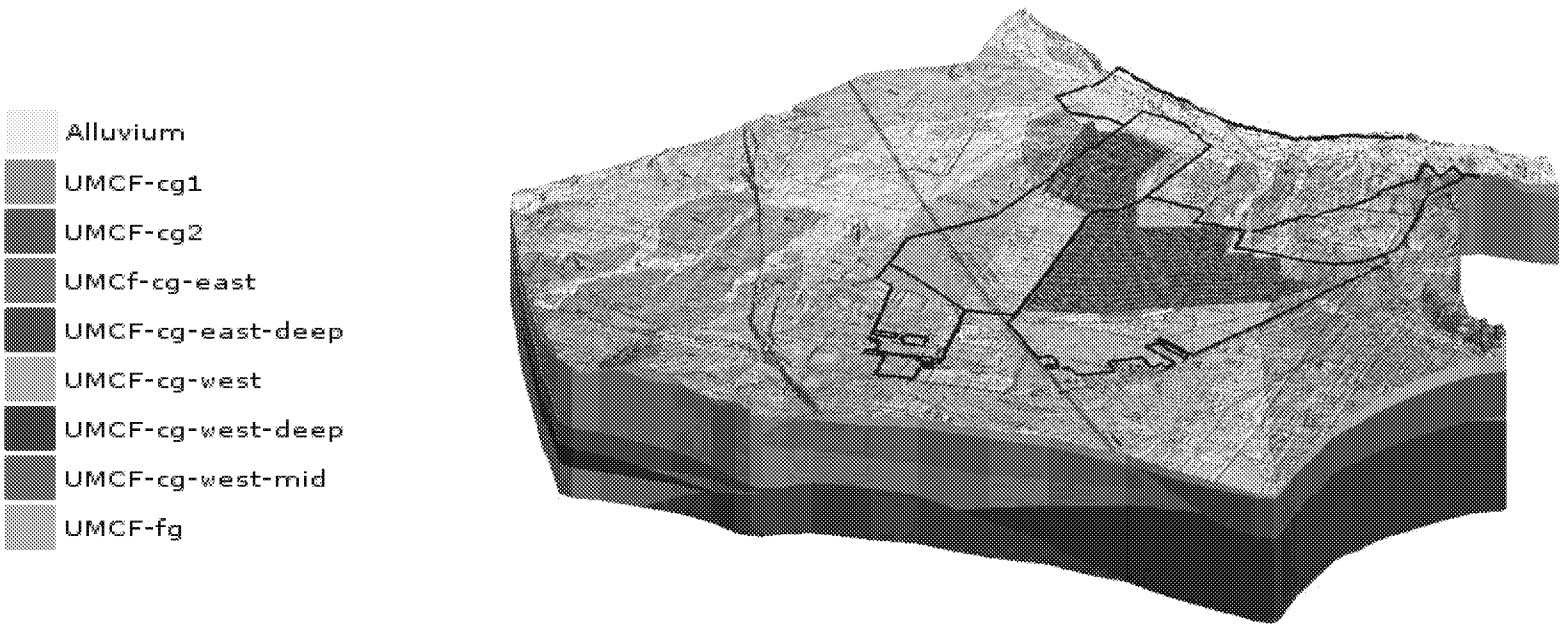
3D GEOLOGIC MODEL

- Revised stratigraphy in Leapfrog Hydro
  - Added new data sets
  - Refined representation of the UMCf coarse-grained facies
- Applied Leapfrog Hydro model to preliminary MODFLOW grid and hydraulic zone setup



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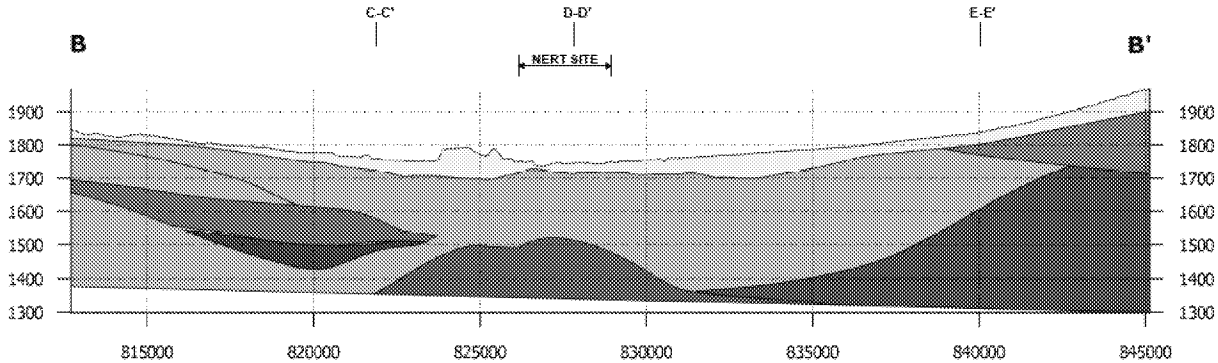
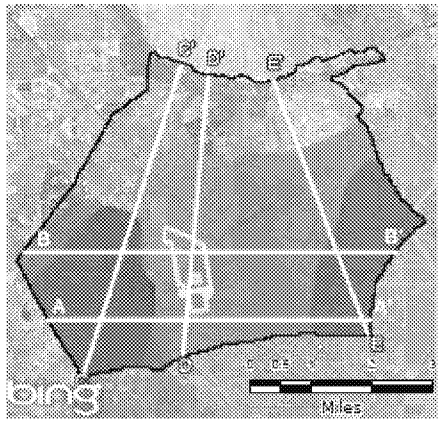
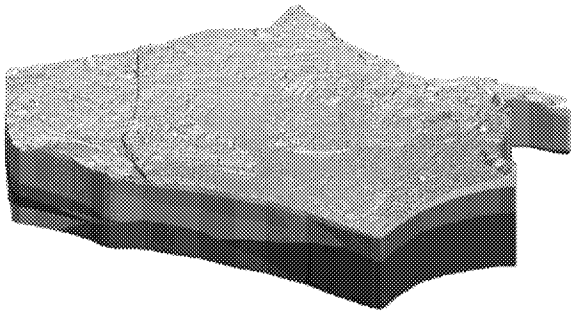
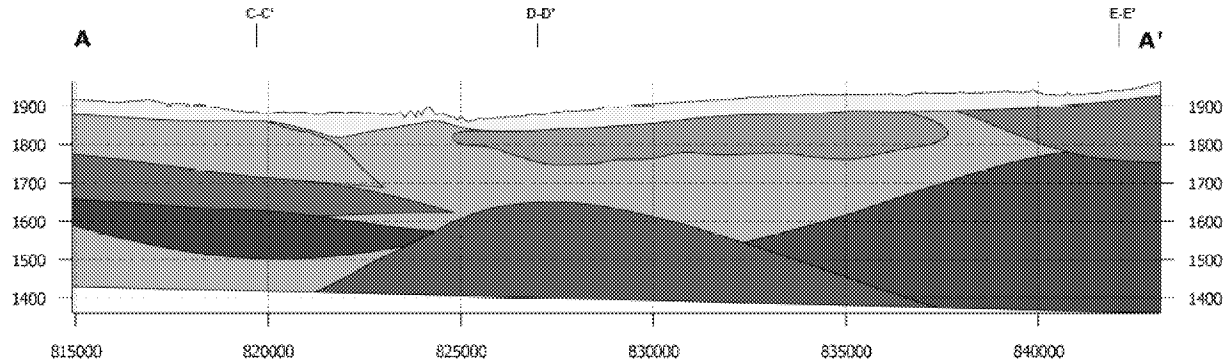
GEOLOGIC MODEL









EXPLANATION

- Alluvium
- UMCF-cg1
- UMCF-cg2
- UMCF-cg-west
- UMCF-cg-west-mid
- UMCF-cg-west-deep
- UMCF-cg-east
- UMCF-cg-east-deep
- UMCF-fg

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LEAPFROG HYDRO 3D GEOLOGICAL MODEL

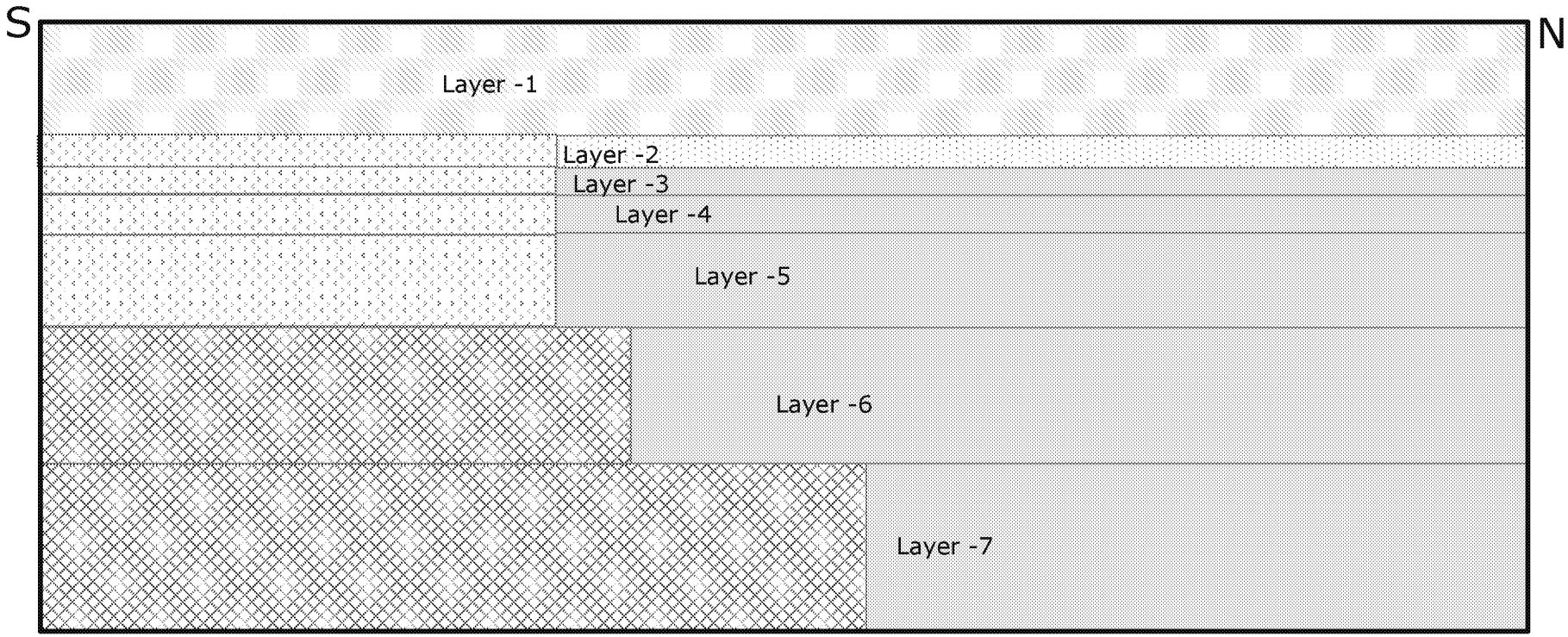
2016 MODEL UPDATES

NEVADA ENVIRONMENTAL RESPONSE TRUST SITE
HENDERSON, NEVADA

RAMBOLL ENVIRON

2200 Powell St, Ste 700; Emeryville, California 94608
August 10, 2016

MODEL LAYERS



Model Layer	Lithology
1	Alluvium
2	xMCf, UMCf-fg, UMCf-cg (SW, S, SE)
3	UMCf-fg, UMCf-cg (SW, SE)
4	UMCf-fg, UMCf-cg (SW, SE)
5	UMCf-fg, UMCf-cg (SW, SE)
6	UMCf-fg, UMCf-cg (SW,S,SE)
7	UMCf-fg, UMCf-cg (S, SE)

Alluvium

xMCf

UMCf-fg

UMCf-cg1

UMCf-cg2

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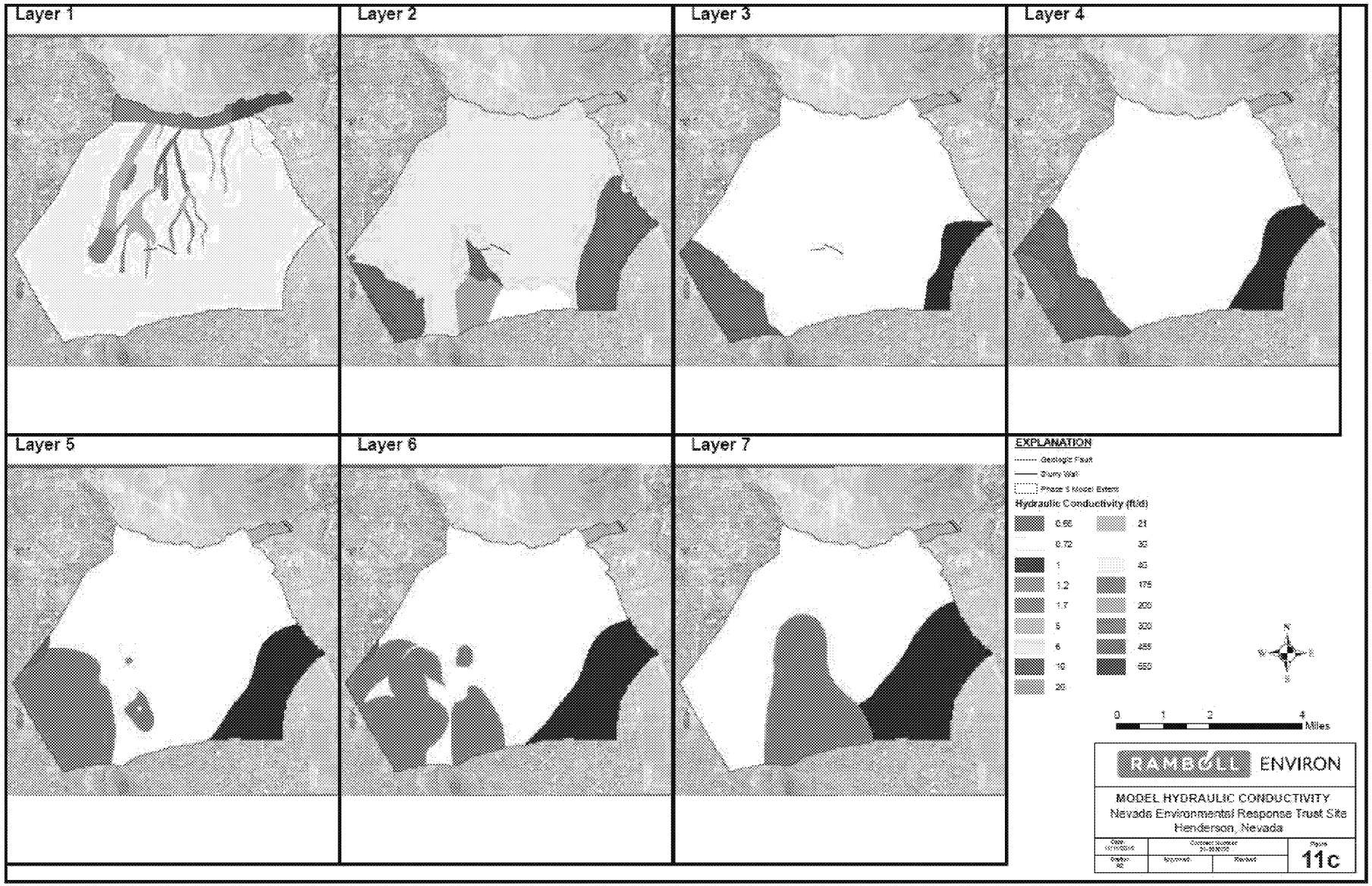
HYDRAULIC CONDUCTIVITY DISTRIBUTION



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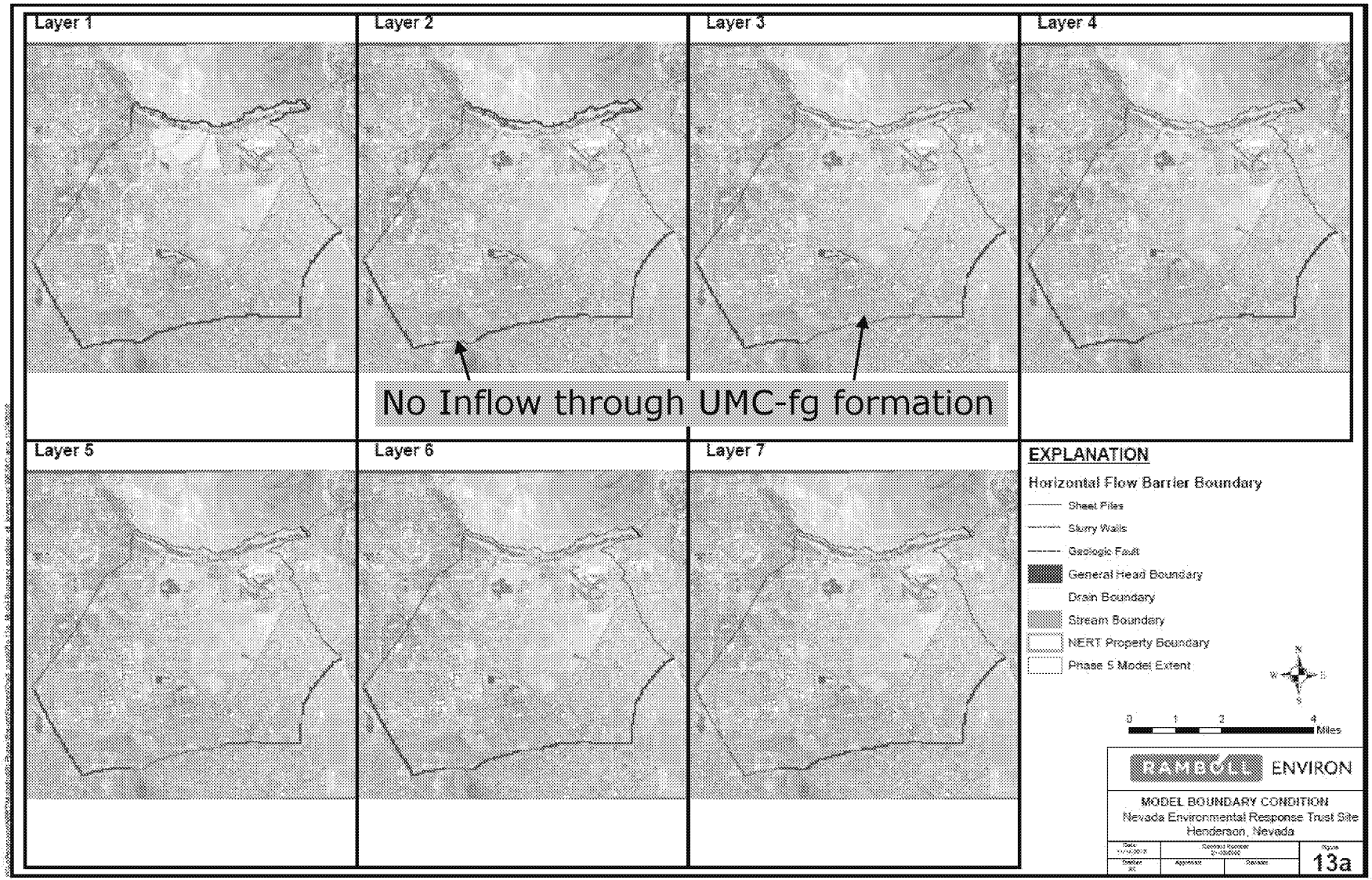
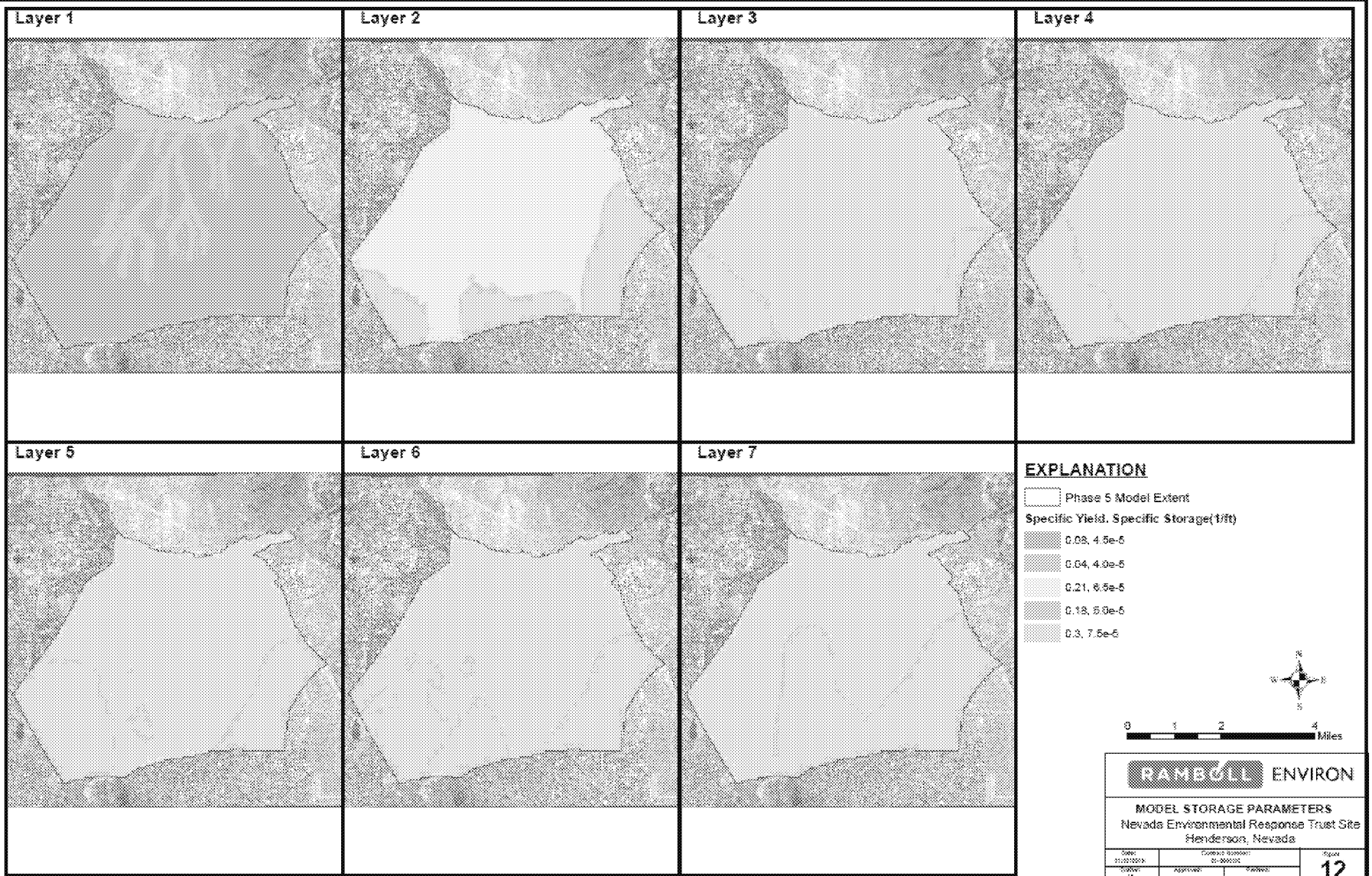
BOUNDARY INFLOWS AND OUTFLOWS



STORAGE PARAMETERS DISTRIBUTION



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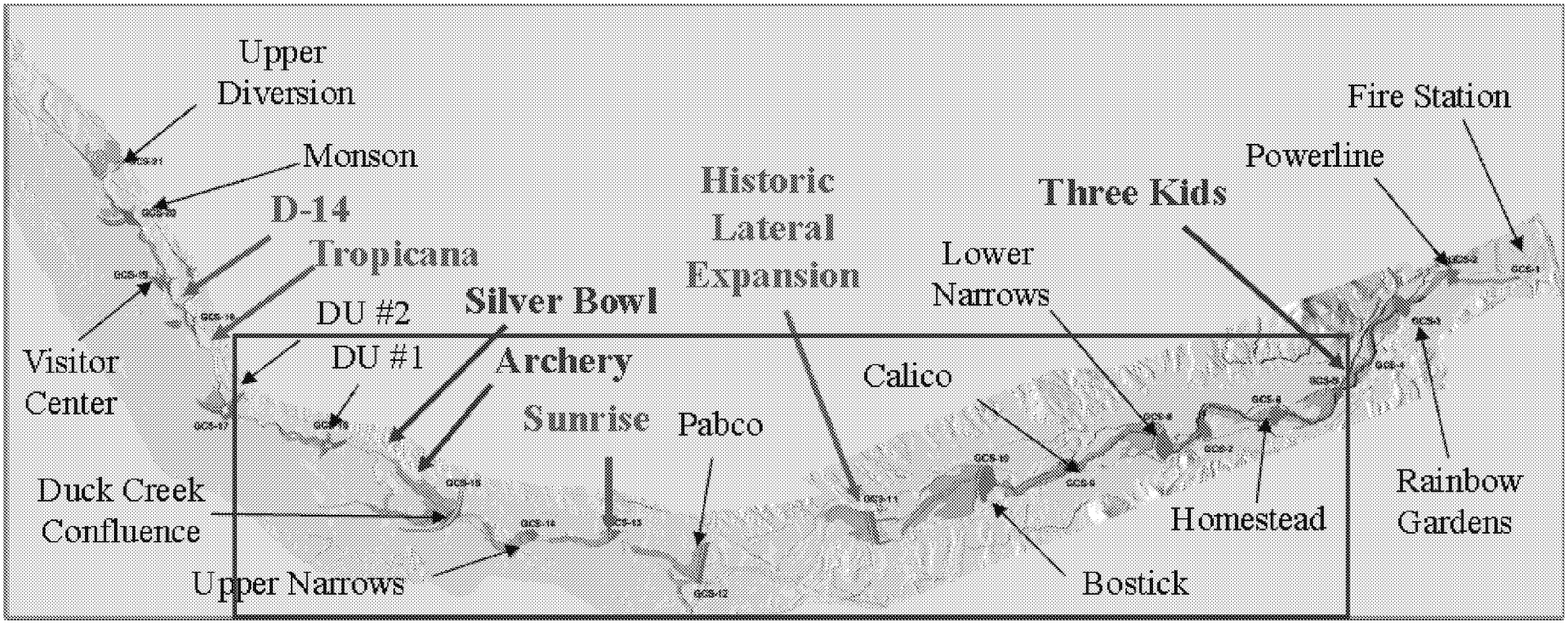
WEIRS IN MODEL DOMAIN



Completed 1999-2013

Completed in 2015

Future Design and Construction

Weirs within the Model Domain

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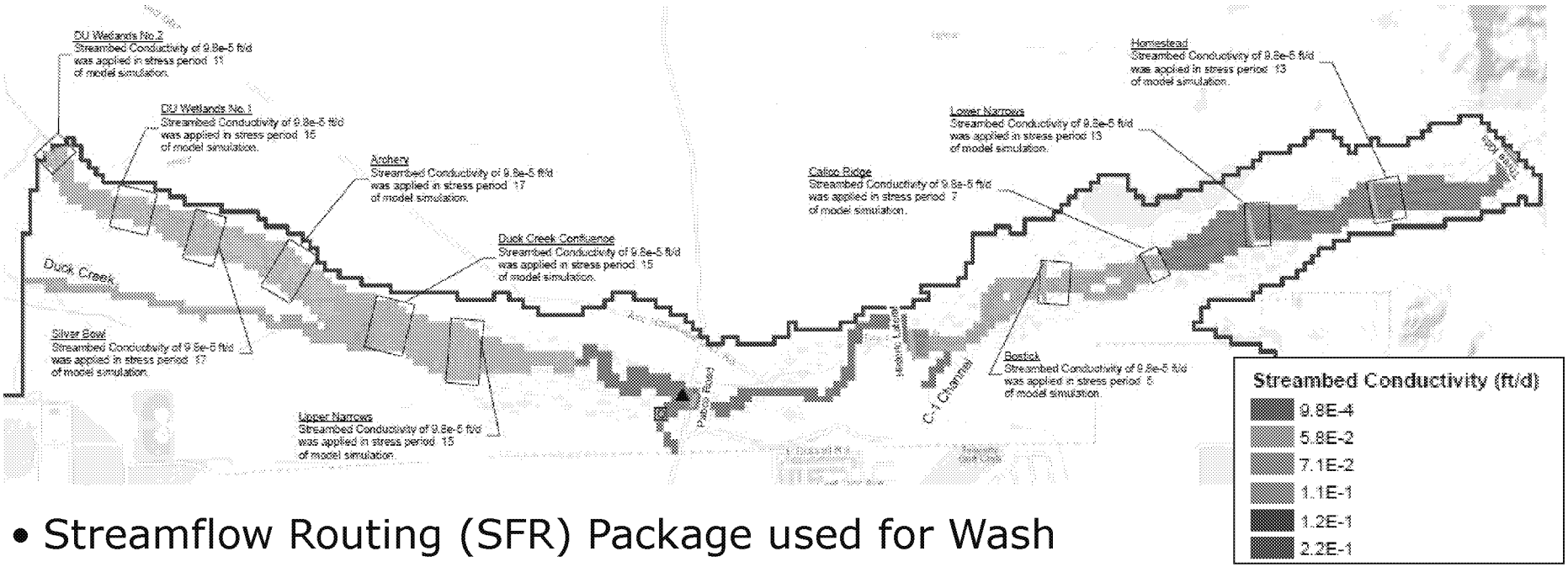
MODELING OF LAS VEGAS WASH



- Streamflow Routing (SFR) Package used for Wash
- Configuration of stream segments is constant, but ET rates vary to account for the change in water surface area
- Conductivity of streambed is reduced at weirs
- Weir sheet piles represented as transient horizontal flow barriers (HFBs) using One Water Hydrologic Flow Model

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PRE-2000 GROUNDWATER CONDITIONS/INITIAL CONDITIONS

- Pre-2000 GWE data compiled from
  - NDWR
  - USGS
  - On-site and nearby wells
  - SNWA wells
- Steady State Simulation of pre-2000 conditions

MODEL CALIBRATION TARGETS

- Water levels at monitoring wells (2000-2015)
- Conceptual water balance
- Streamflow at Pabco Road gaging station

CALIBRATION TARGETS IN 2000

EXPLANATION

Screened Stratigraphic Unit

- Quaternary Alluvium (Qal)
- Cross-screened (Qal/UMCf, Qal/xMCf, Qal/xMCf/UMCf)
- Upper Muddy Creek Formation (UMCf) or Transitional Muddy Creek Formation (xMCf)
- Off-site NERT RI Study Area
- NERT Property Boundary
- Phase 5 Model Extent
- Off-Site NERT RI Study Area
- Eastside Study Area
- Downgradient Study Area

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CALIBRATION TARGETS IN 2008

EXPLANATION

Screened Stratigraphic Unit

- Quaternary Alluvium (Qal)
- Cross-screened (Qal/UMCf, Qal/xMCf, Qal/xMCf/UMCf)
- Upper Muddy Creek Formation (UMCf) or Transitional Muddy Creek Formation (xMCf)
- Off-site NERT RI Study Area
- NERT Property Boundary
- Phase 5 Model Extent
- Off-Site NERT RI Study Area
- Eastside Study Area
- Downgradient Study Area

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CALIBRATION TARGETS IN 2015

EXPLANATION

Screened Stratigraphic Unit

- Quaternary Alluvium (Qal)
- Cross-screened (Qal/UMCf, Qal/xMCf, Qal/xMCf/UMCf)
- Upper Muddy Creek Formation (UMCf) or Transitional Muddy Creek Formation (xMCf)
- Off-site NERT RI Study Area
- NERT Property Boundary
- Phase 5 Model Extent
- Off-Site NERT RI Study Area
- Eastside Study Area
- Downgradient Study Area

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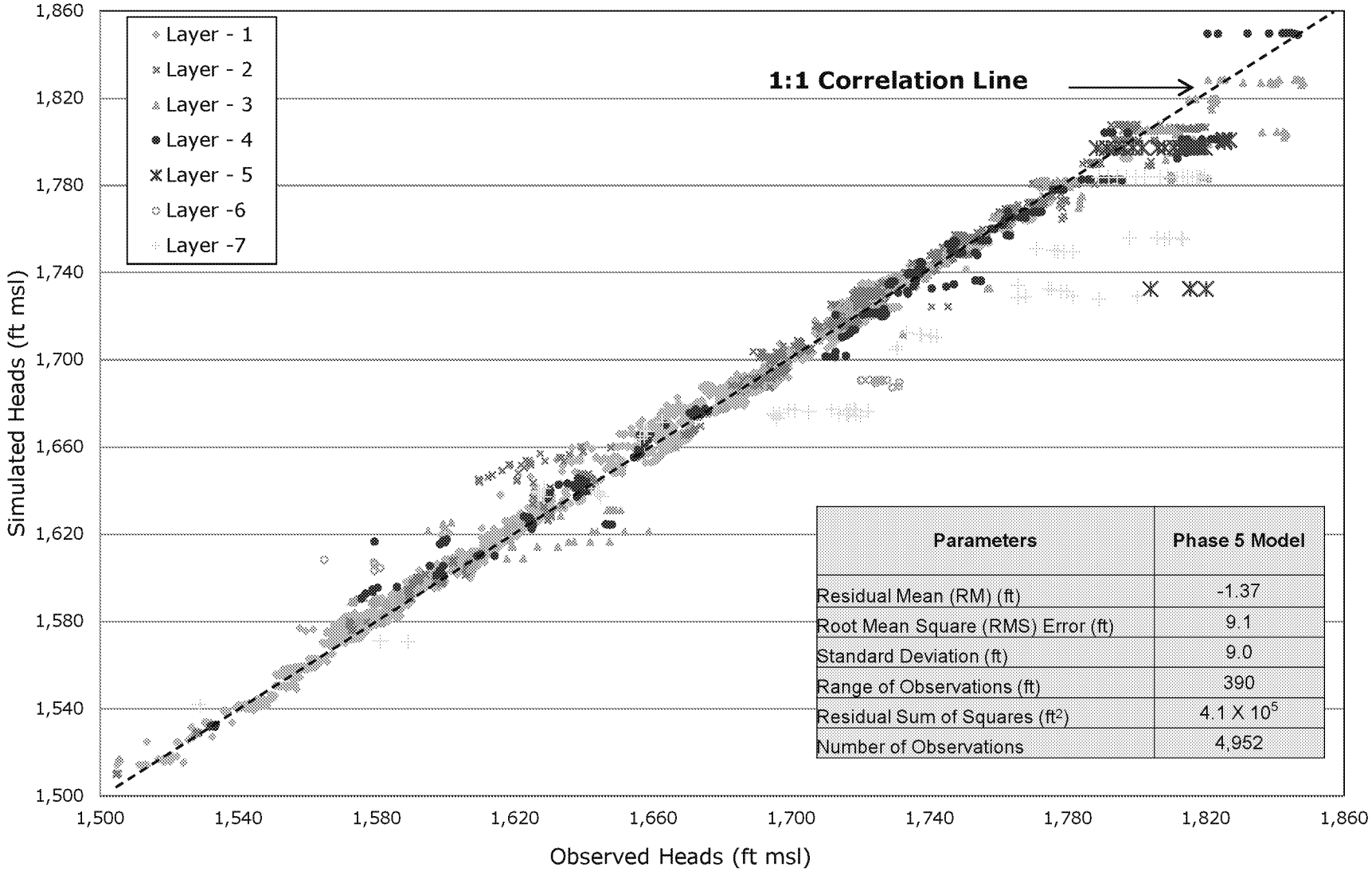
MODEL CALIBRATION – SHALLOW ZONE WELLS

MODEL CALIBRATION



Parameters	Phase 5 Model
Residual Mean (RM) (ft)	-1.37
Root Mean Square (RMS) Error (ft)	9.1
Standard Deviation (ft)	9.0
Range of Observations (ft)	390
Residual Sum of Squares (ft^2)	4.1×10^5
Number of Observations	4,952

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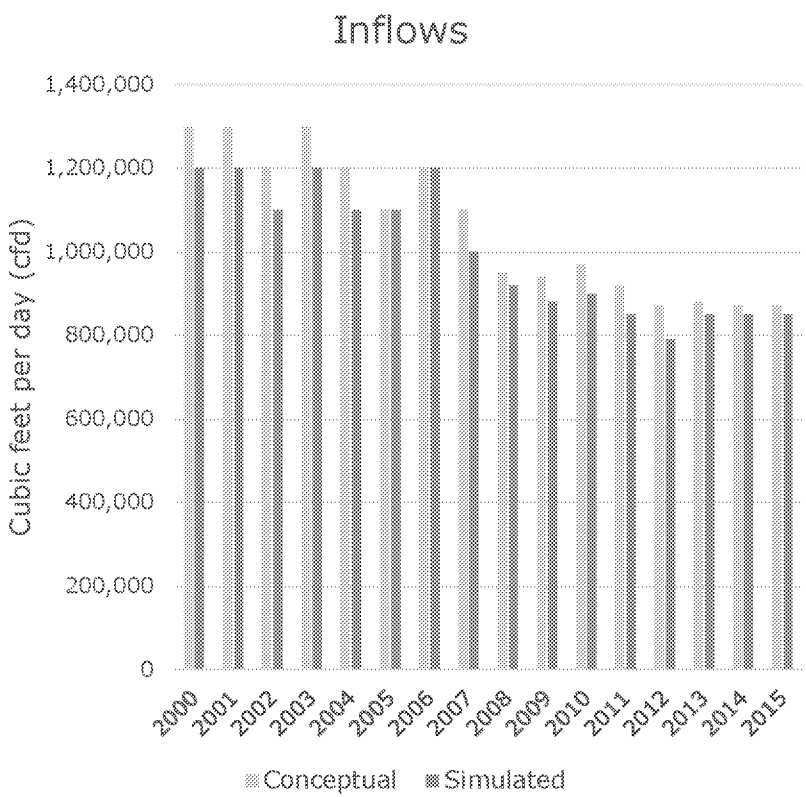
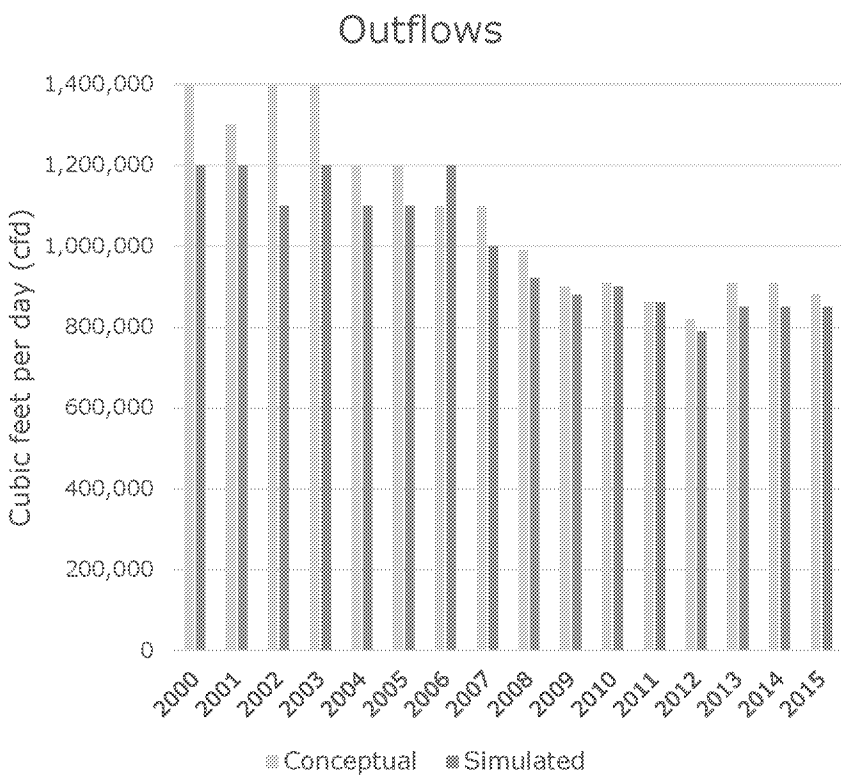
CONCEPTUAL VS. SIMULATED WATER BALANCE





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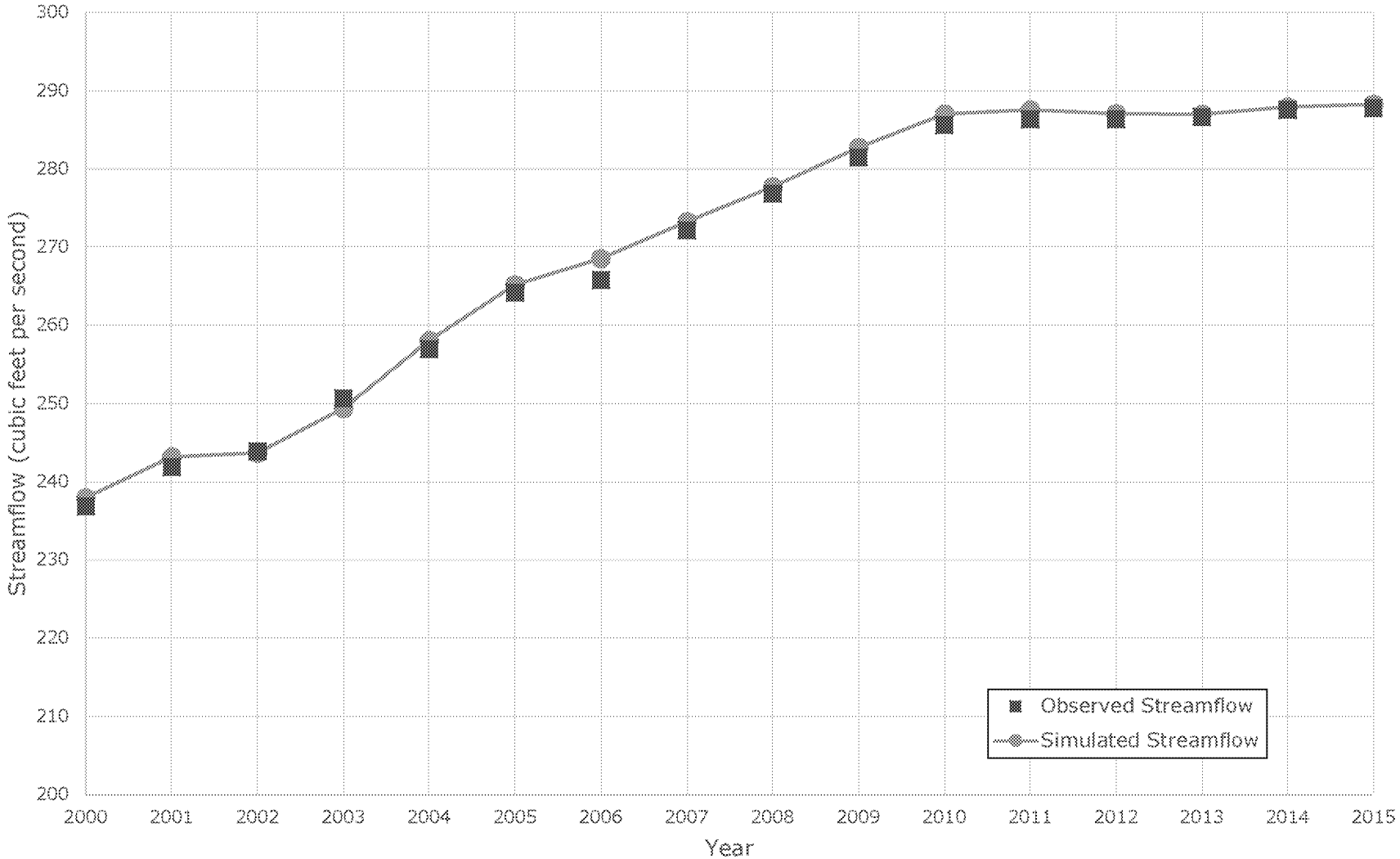
STREAMFLOW CALIBRATION AT PABCO STREAM GAUGE



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SENSITIVITY OF CALIBRATION TO KEY PARAMETERS

1. Horizontal Hydraulic Conductivity : Increasing values improves calibration, but not consistent with aquifer tests
2. Vertical Hydraulic Conductivity : Insensitive to vertical conductivity in alluvium
3. Areal Recharge : Very sensitive
4. Stream Conductance: Insensitive
5. Boundary Inflows: Changes to southern boundary conductance decrease calibration and reducing conductance makes it impossible to simulate observed pumping rates

CAPTURE ZONE EVALUATION: SHALLOW WBZ

NERT Site

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UNCERTAINTY ANALYSIS

Impact of changing model parameters on capture zones evaluated in uncertainty analysis.

Input Parameter	Value Used in Calibrated Model	Multiplier	% Change in Capture Zone Area
Horizontal Hydraulic Conductivity of Alluvium Outside of Paleochannels	40 ft/day	0.75	7%
		1.25	25%
Vertical Hydraulic Conductivity of Alluvium Outside of Paleochannels	0.6 ft/day	0.75	6%
		1.25	1%
Horizontal Hydraulic Conductivity of Alluvium Within Paleochannels	175 - 650 ft/day	0.75	7%
		1.25	4%
Vertical Hydraulic Conductivity of Alluvium Within Paleochannels	17.5 - 68.5 ft/day	0.75	6%
		1.25	0%
Horizontal Hydraulic Conductivity of UMCf-fg	0.72, 6 ft/day	0.75	25%
		1.25	3%
Vertical Hydraulic Conductivity of UMCf-fg	0.07 ft/day	0.75	12%
		1.25	5%
Horizontal Hydraulic Conductivity of UMCf-cg	Various	0.75	32%
		1.25	14%
Vertical Hydraulic Conductivity of UMCf-cg	Various	0.75	4%
		1.25	5%
Surface Recharge Rates	Various	0.75	28%
		1.25	4%
Streambed Hydrualic Conductivity	Various	0.75	0%
		1.25	0%
Southern Boundary Inflow	310,000 cfd	0.75	17%
		1.25	31%
Western Boundary Inflow	250,000 cfd	0.75	0%
		1.25	0%
Evapotranspiration Rate	0.014 ft/day	0.75	0%
		1.25	0%

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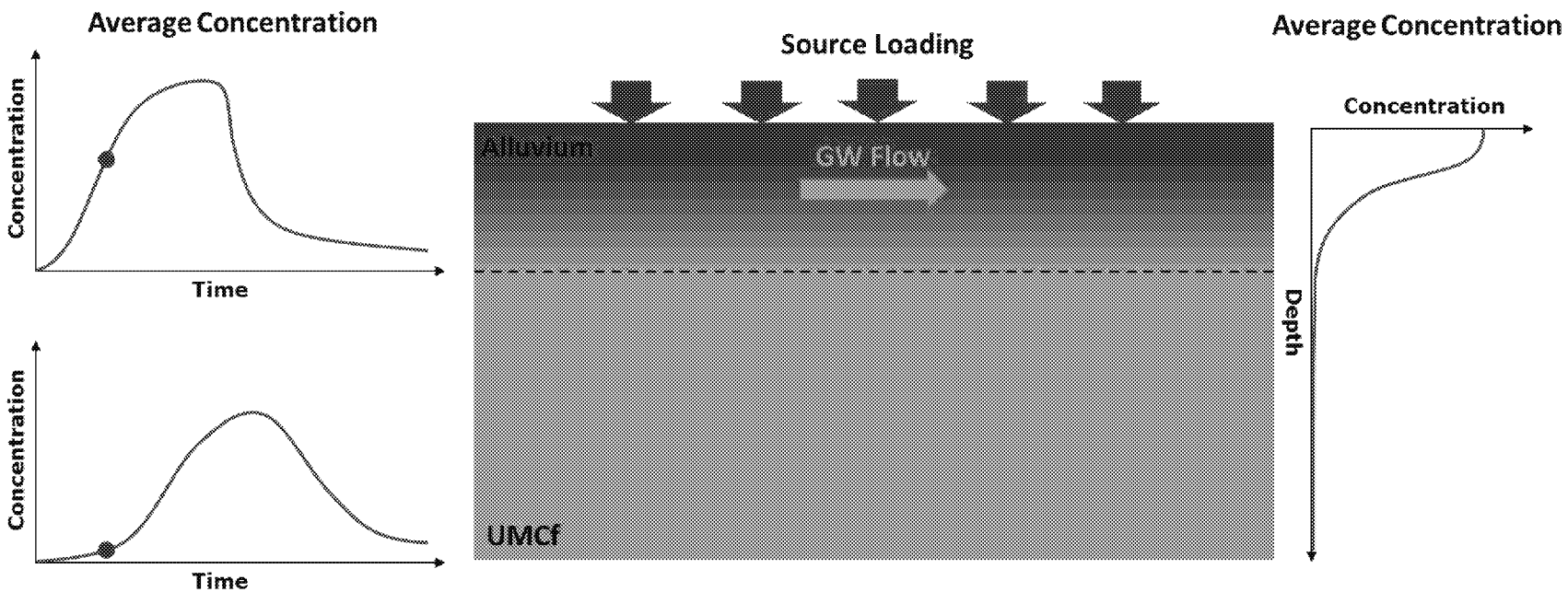
CONCEPTUAL FATE AND TRANSPORT OF PERCHLORATE

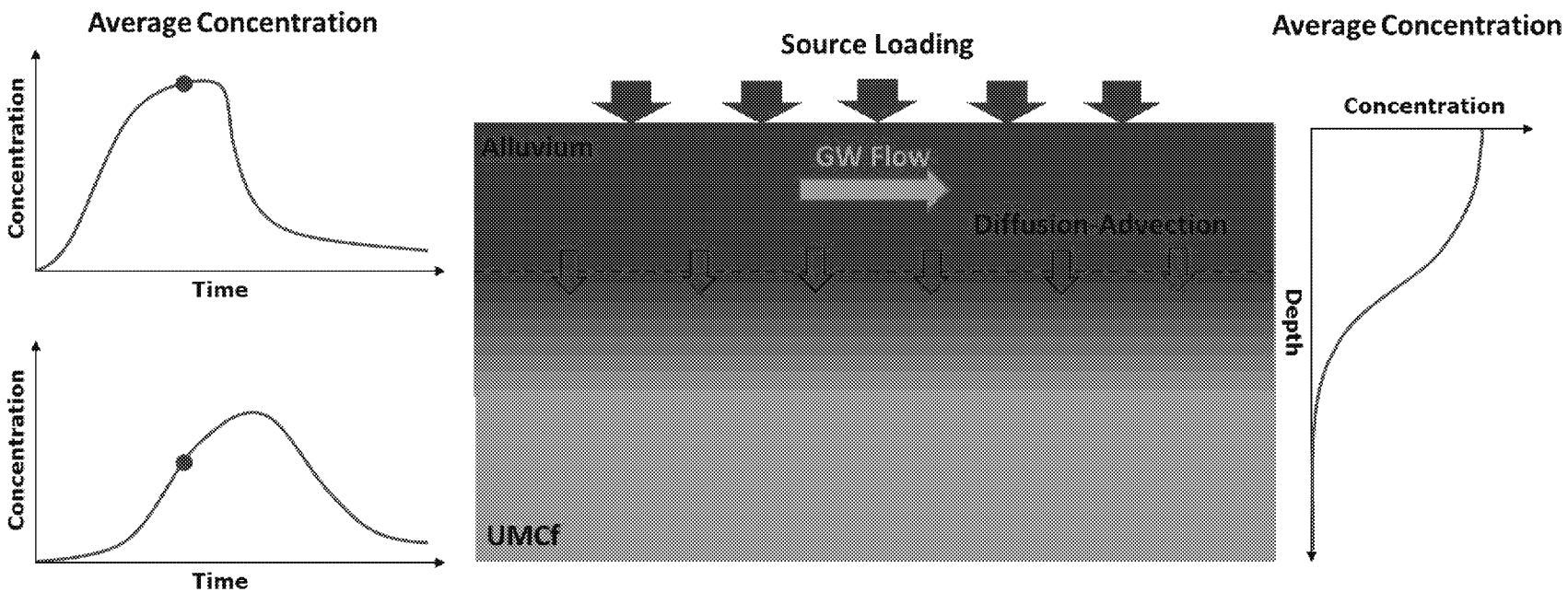


Concentration evolution in UMCf has similar behaviour as alluvium but with different rate and magnitude.

RAMBOLL ENVIRON

Conceptual Diagram. Not to Scale. Colors show relative concentration differences only.

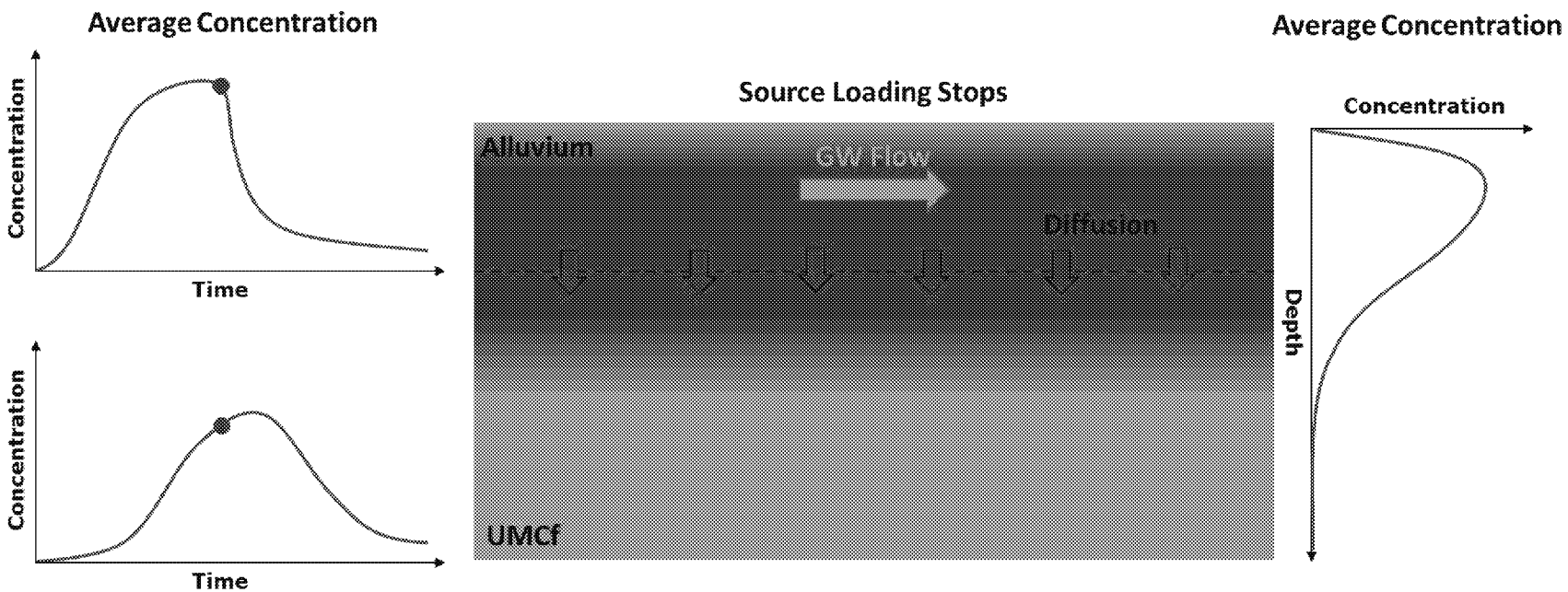
CONCEPTUAL FATE AND TRANSPORT OF PERCHLORATE



RAMBOLL ENVIRON

Conceptual Diagram. Not to Scale. Colors show relative concentration differences only.

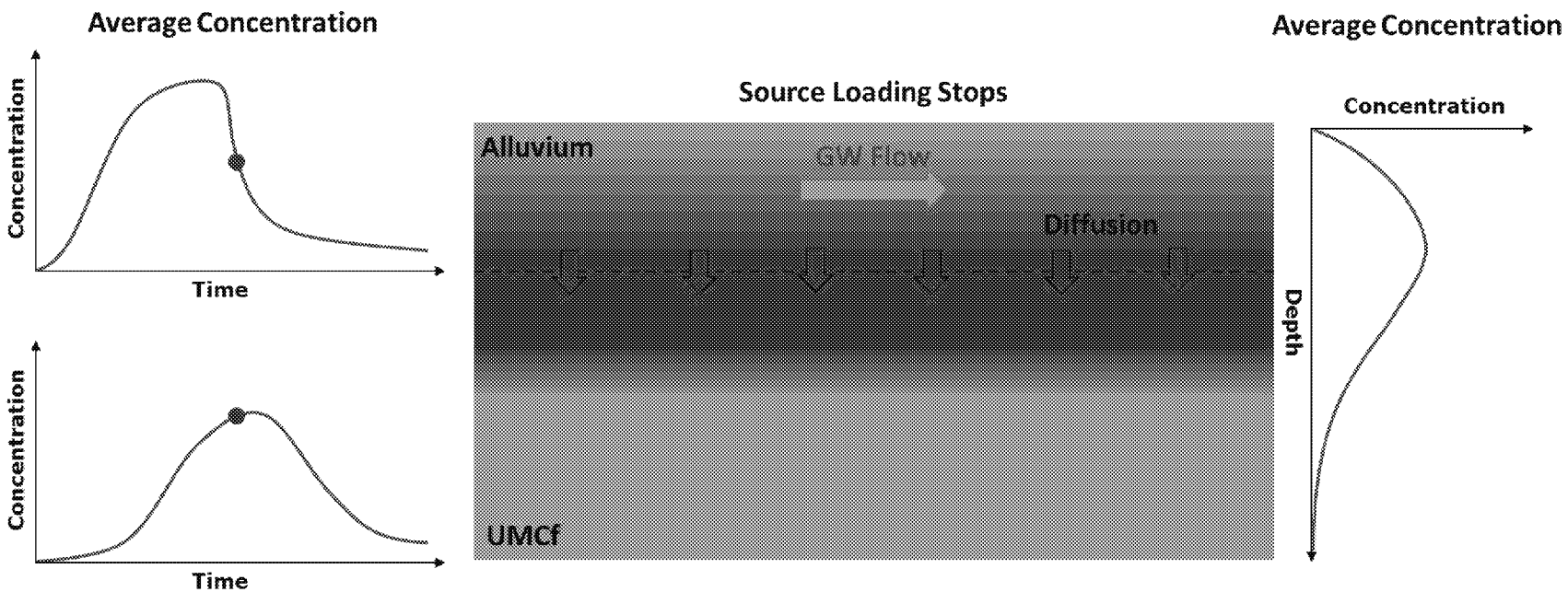
CONCEPTUAL FATE AND TRANSPORT OF PERCHLORATE



RAMBOLL ENVIRON

Conceptual Diagram. Not to Scale. Colors show relative concentration differences only.

CONCEPTUAL FATE AND TRANSPORT OF PERCHLORATE



RAMBOLL ENVIRON

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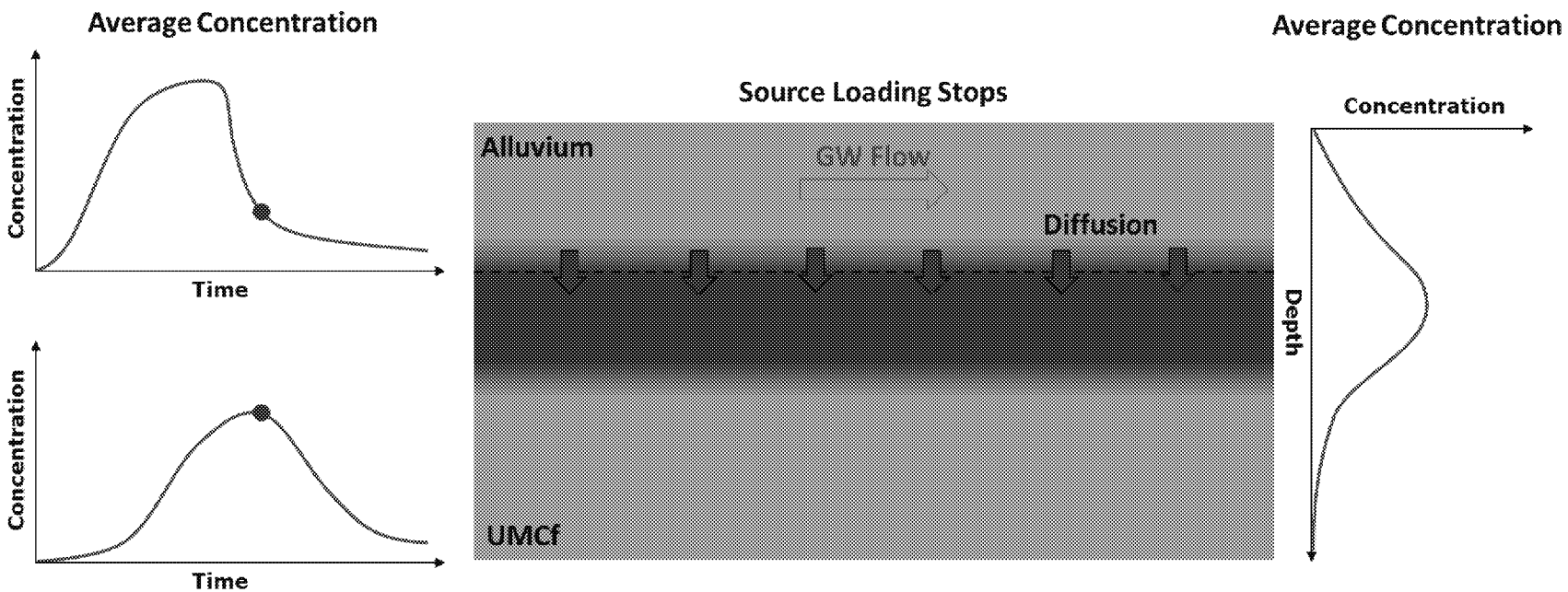

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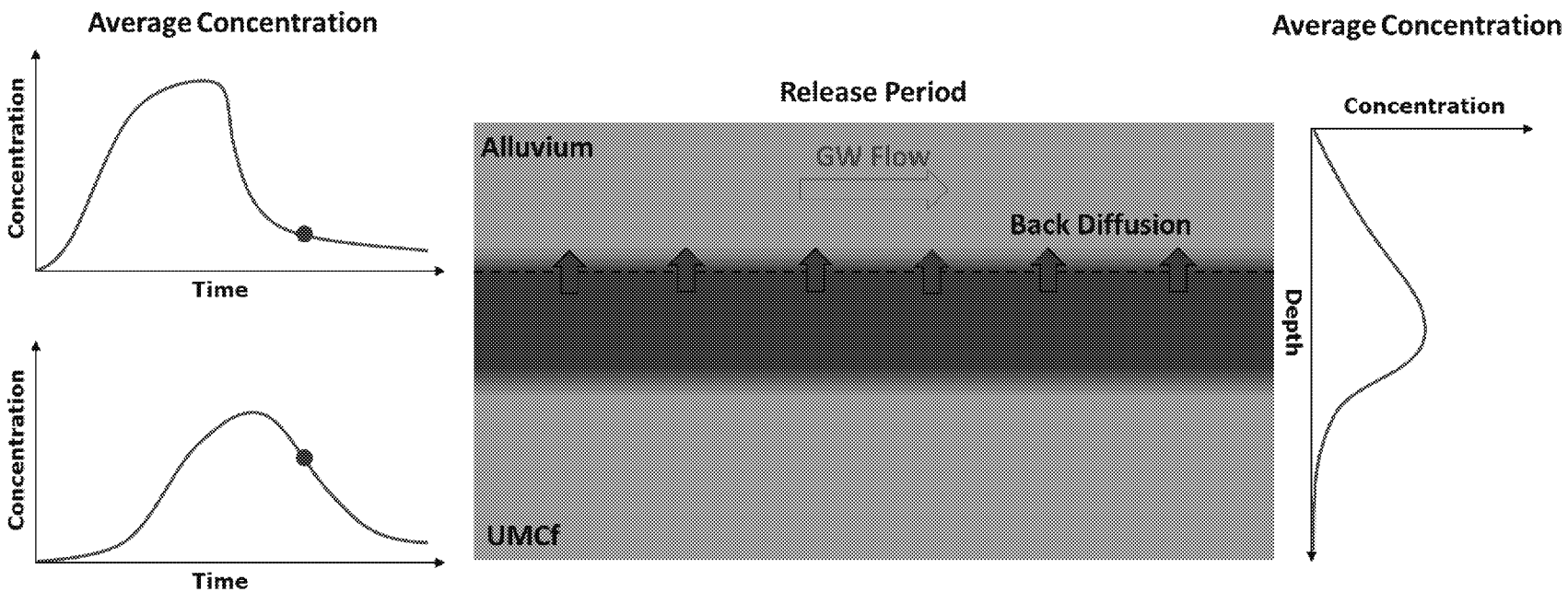

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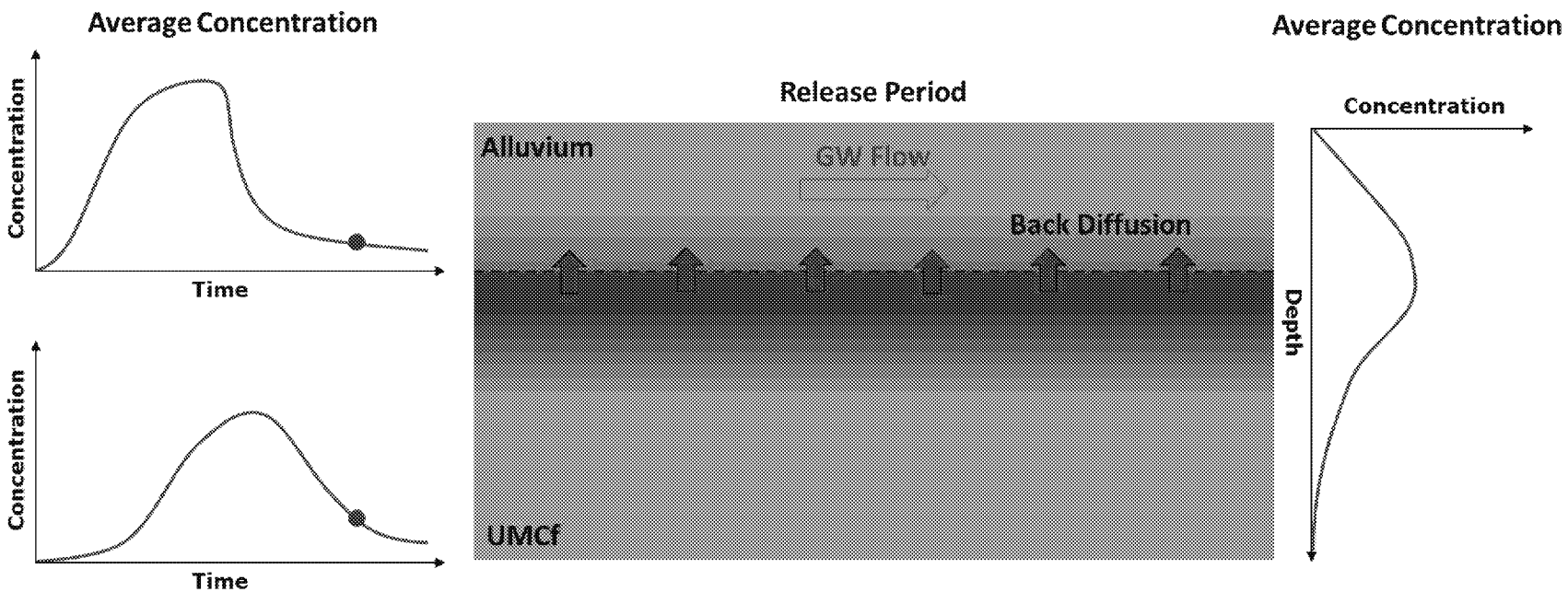

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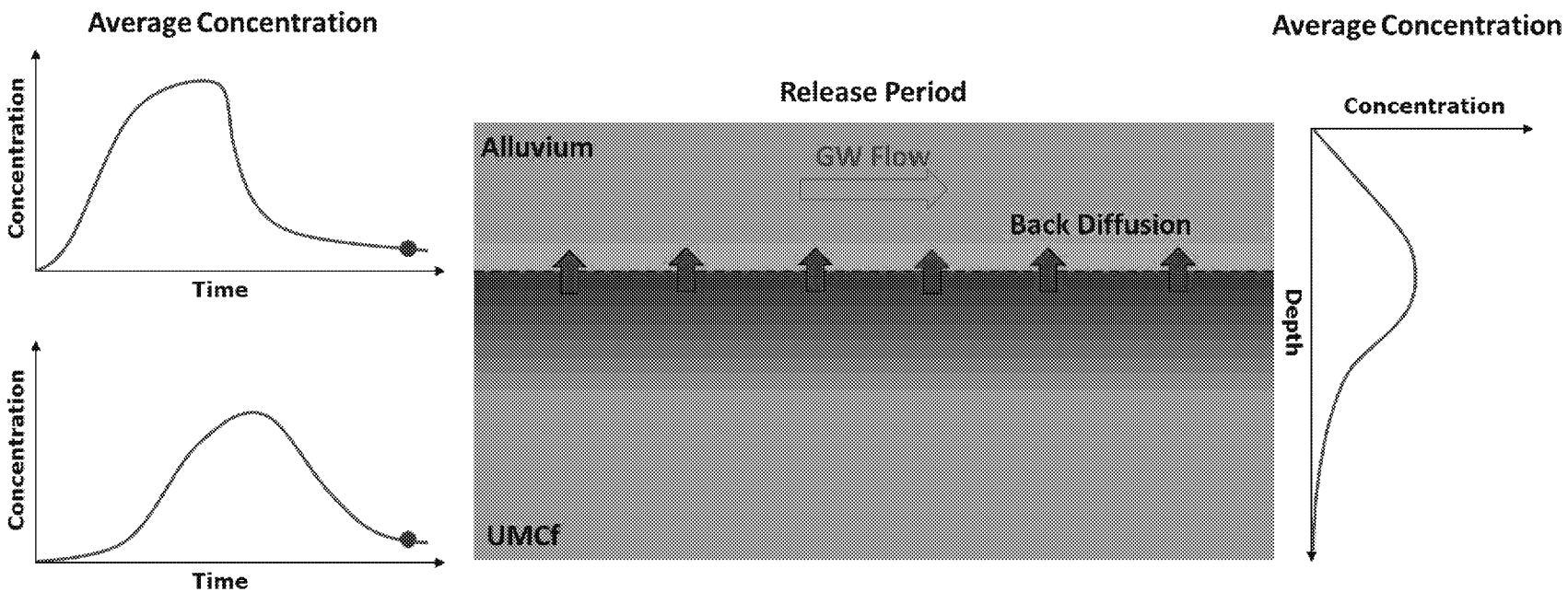
CONCEPTUAL FATE AND TRANSPORT OF PERCHLORATE

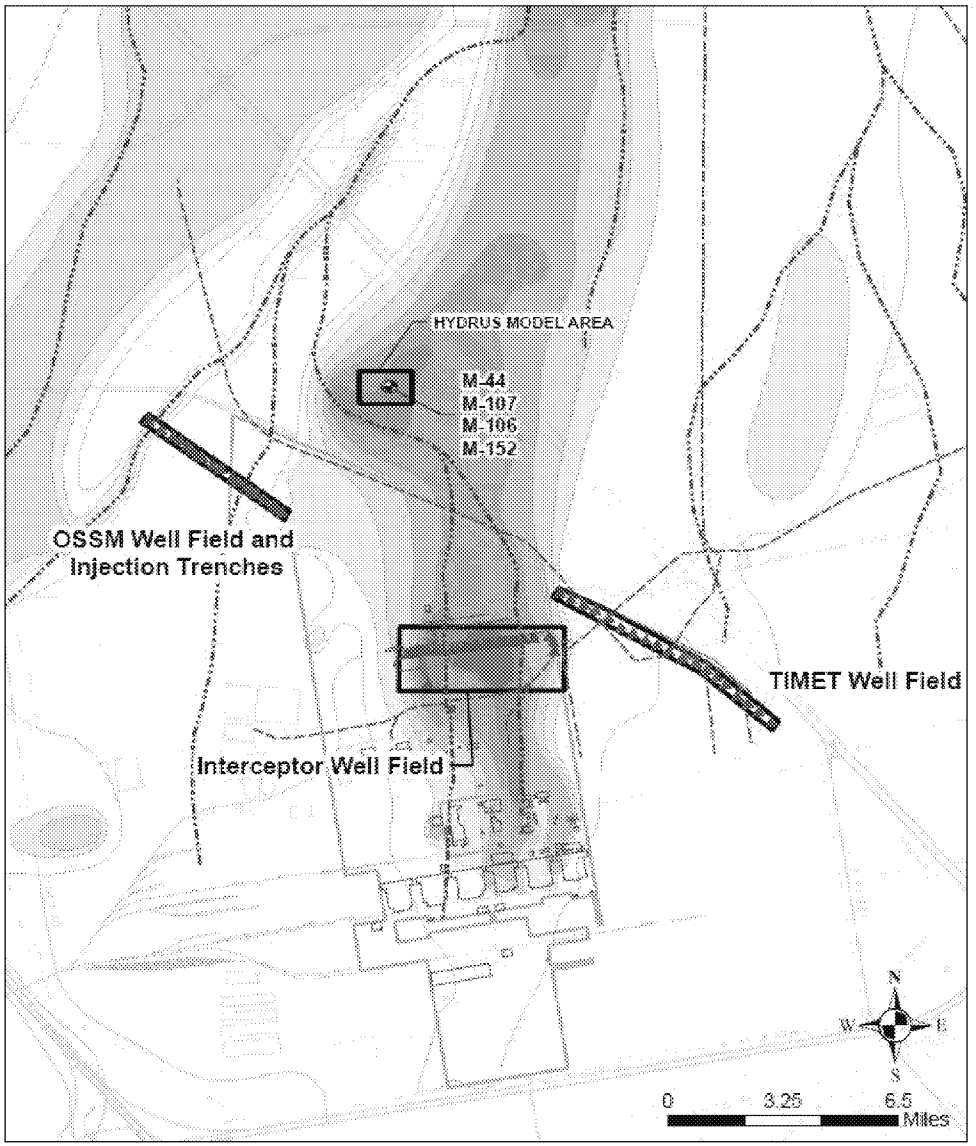


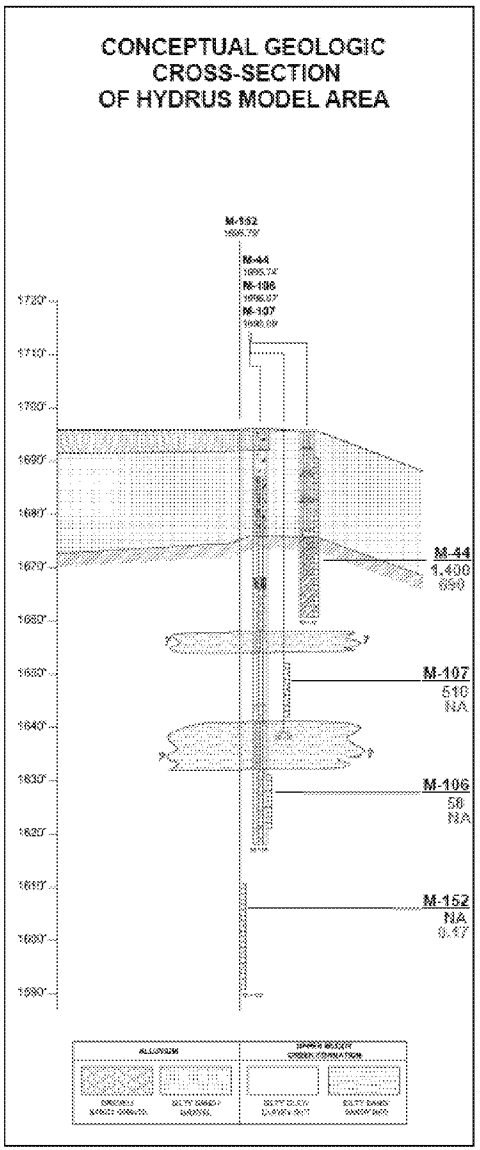
Upward gradient and recharge events will affect diffusion behavior of concentration in both formations.

RAMBOLL ENVIRON

Conceptual Diagram. Not to Scale. Colors show relative concentration differences only.

EVALUATION OF FATE AND TRANSPORT AT PILOT LOCATION





EXPLANATION

- Approx. Paleochannel Centerline
- Former Ditches
- Site Features (Buildings and Tanks)
- Slurry Wall
- NERT Recharge Tranches
- Monitoring Well
- Pumping Wells
- NERT Property Boundary
- Phase 5 Model Extent

Perchlorate Iso-concentration (2016)

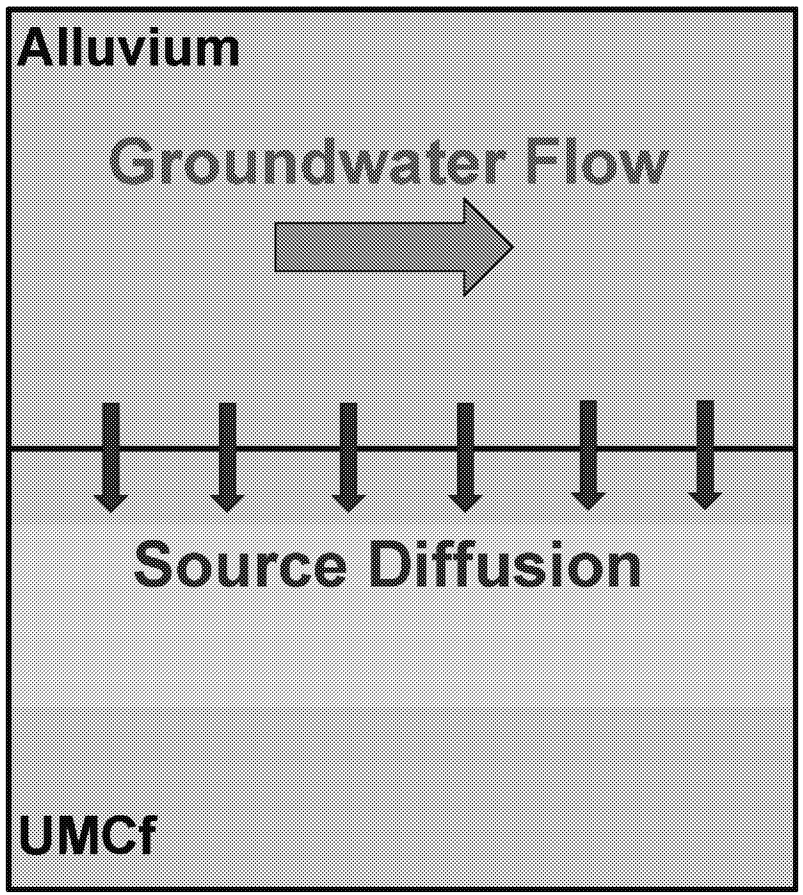
- <1 mg/L
- 1-10
- 10-25
- 25-100
- 100-250
- 250-500
- 500-1,000
- >1,000 mg/L

M-44 Well Name
1,400 Perchlorate Concentration in 2001 (in mg/L)
650 Perchlorate Concentration in 2016 (in mg/L)

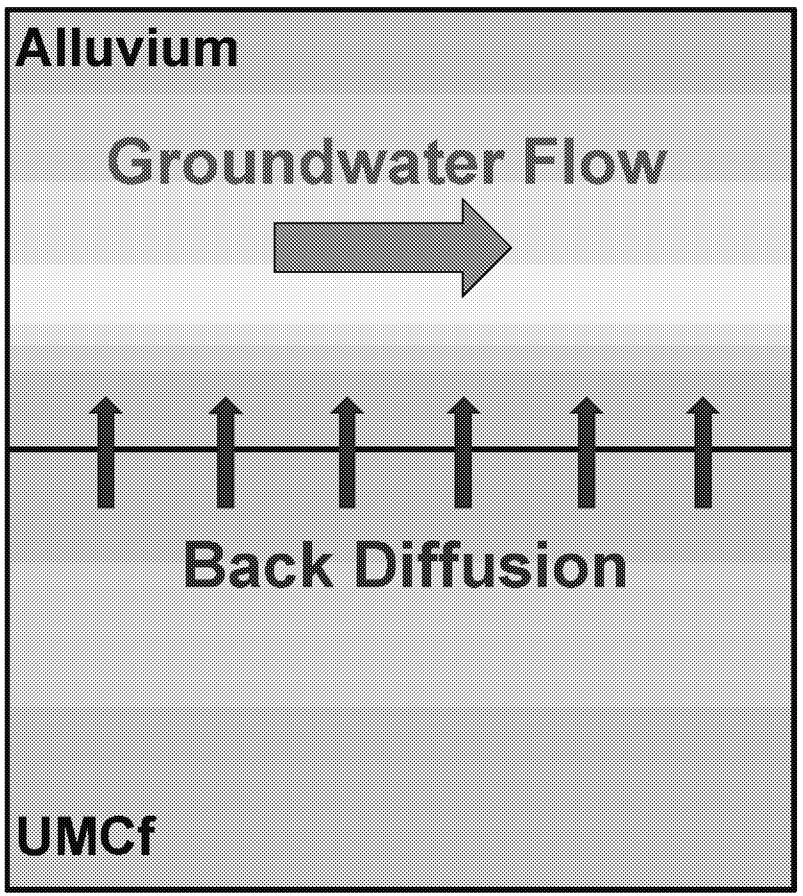
Notes:
NA = not available
mg/L= milligram per liter

HYDRUS SIMULATION PERIODS

(a) Source Diffusion



(b) Back Diffusion

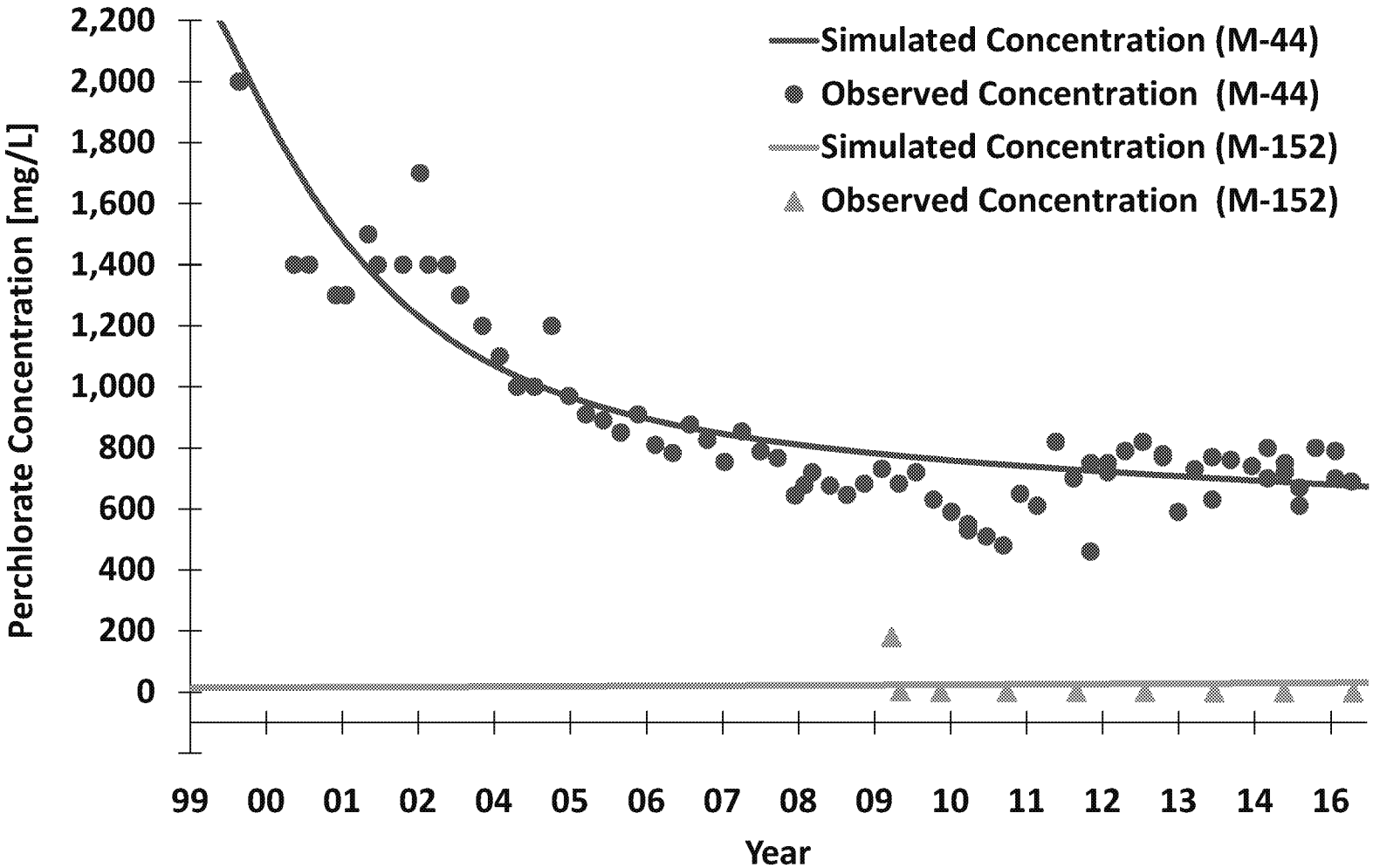


HYDRUS MODELING APPROACH

Dual-porosity concept:

- Pore space is divided into two regions (mobile and immobile)
- Water and solute move in the mobile region while mass transfer between mobile and immobile regions proceeds by diffusion
- During loading period the immobile region stores solute in the pore space
- Mass in the immobile region acts as a long term source during the release period by diffusing mass back to the mobile region
- HYDRUS-1D numerical model is used to simulate this process

HISTORICAL PERCHLORATE CONCENTRATIONS

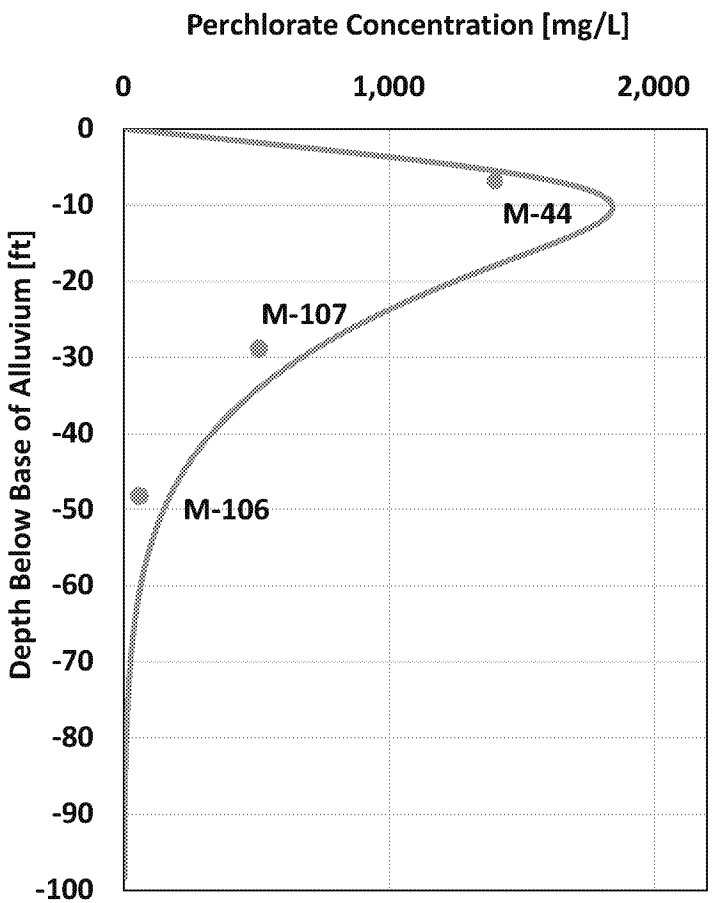


RAMBOLL ENVIRON

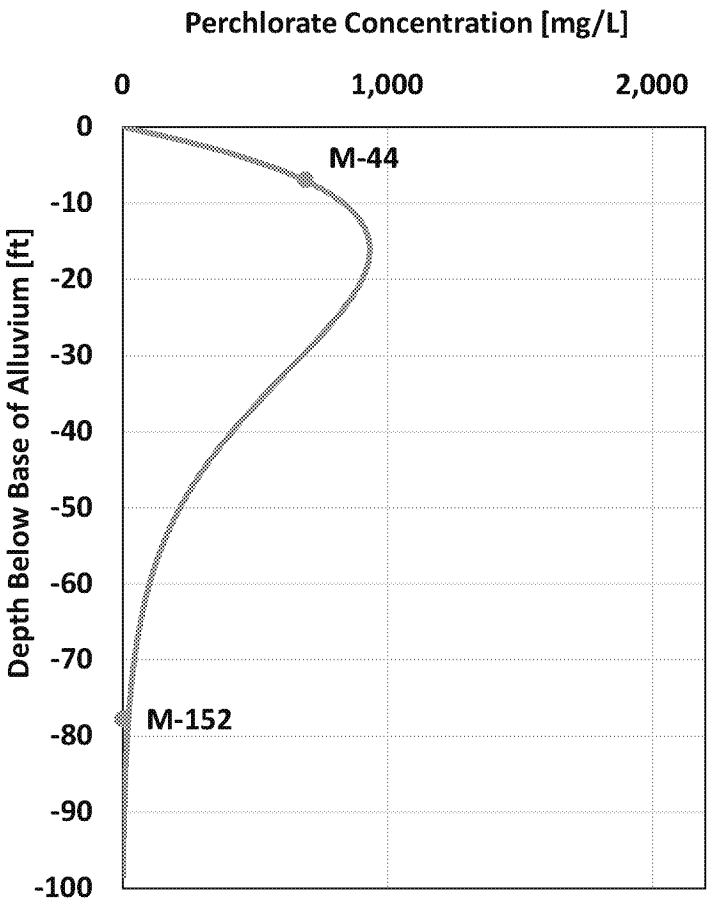
Simulated using Hydrus 1D Modeling code

VERTICAL PERCHLORATE CONCENTRATION PROFILE

2001



2016



RAMBOLL ENVIRON

TRANSPORT MODELING APPROACH

- Flow model will be extended to include fate and transport using MT3D-USGS transport
- Development of 3D transport model will be guided by Hydrus-1D models of locations with good vertical data coverage
- Initial results indicate that back diffusion from the UMCf is important
- Future work will evaluate dual porosity approach to simulate effects of back diffusion

PHASE 6 MODEL (2017-18)

- Incorporate new investigation results:
  - Phase II RI
  - Downgradient Study Area Investigation
  - Eastside Study Area Investigation
  - Soil flushing and groundwater bioremediation treatability study
- Development of contaminant transport capabilities

THANK YOU

QUESTIONS/DISCUSSIONS

NEVADA ENVIRONMENTAL RESPONSE TRUST

LE PETOMANE XXVII, INC., NOT INDIVIDUALLY BUT SOLELY AS ENVIRONMENTAL RESPONSE TRUST TRUSTEE

Q1 2017 TECHNICAL STAKEHOLDER MEETING
ION EXCHANGE TREATMENT SYSTEM STATUS

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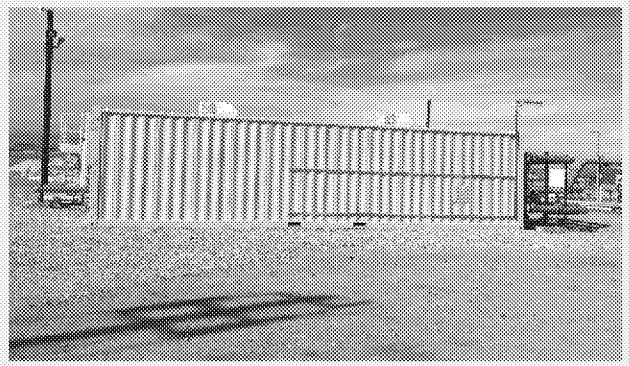
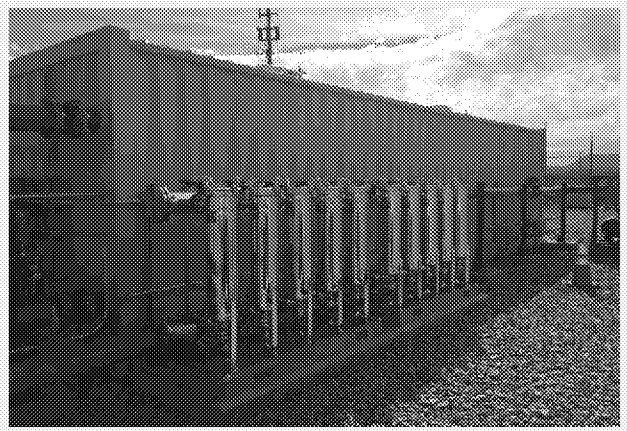
IX TREATMENT SYSTEM

System Status

Construction of the Ion Exchange (IX) Treatment System was completed in 2016

- IX can handle all SWF flow if needed (IX capacity is 1,000 gpm)
- Currently treating flows from PC-118, PC-119, PC-120, PC-121, and PC-133 (~250 gpm)



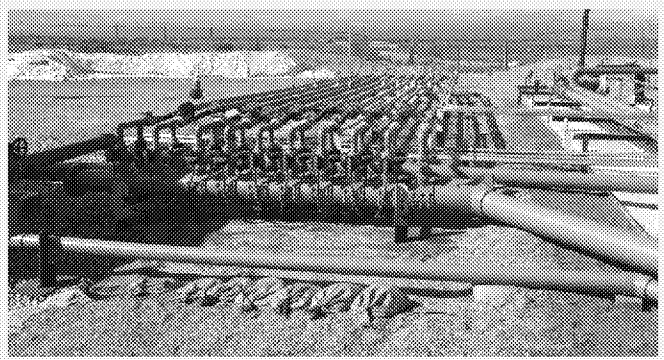


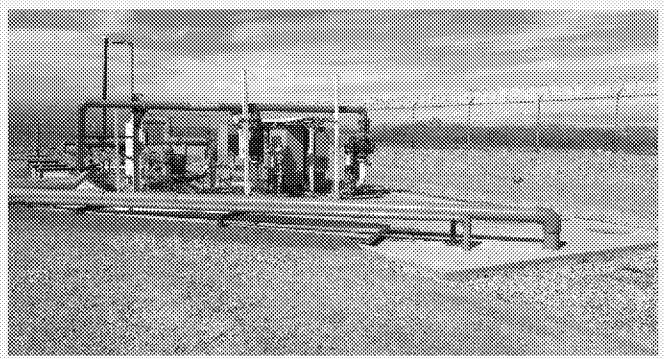
IX TREATMENT SYSTEM

Lift Station Improvements

Construction of the IX Treatment System was completed in 2016

- New manifold system – multiple treatment options
- Secondary containment structures were substantially improved





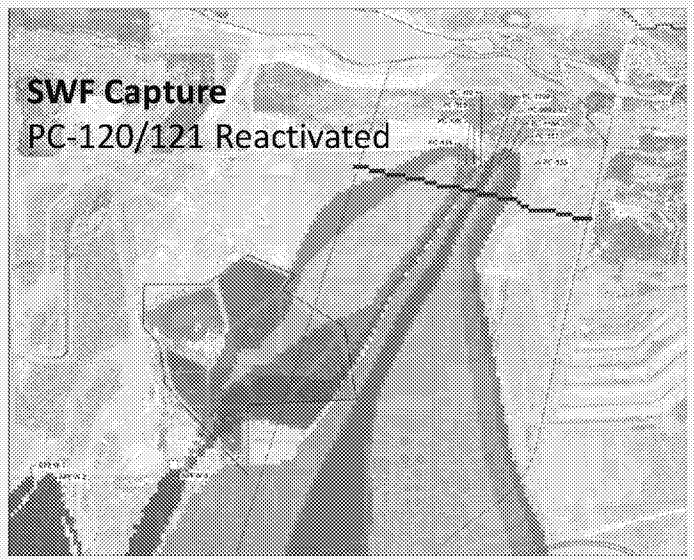
IX TREATMENT SYSTEM

SWF Optimization

Benefits

- Increases the capture zone and the amount of perchlorate removed from the environment, reduces flux to LVW

SWF Capture
Q2 2016 Pumping



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Q1 2017 TECHNICAL STAKEHOLDER MEETING
SNWA WEIR DEWATERING TREATMENT

LE PETOMANE INCORPORATED | NERT

PROJECT OVERVIEW

SCOPE OF THE PROJECT

- Southern Nevada Water Authority weir construction:
  - Sunrise Mountain Weir
  - Historic Lateral Weir

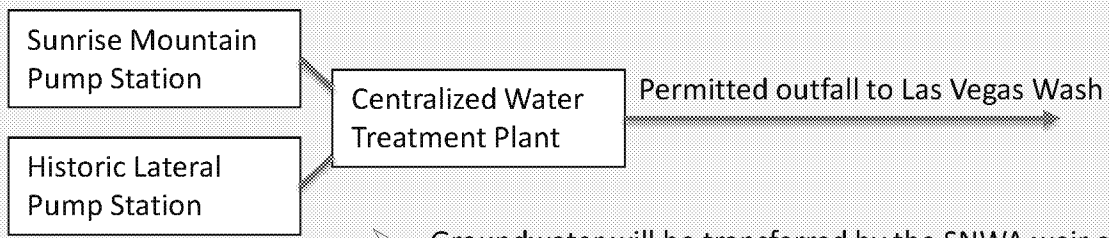
In the Las Vegas Wash adjacent to Clark County Wetlands Park

- Nevada Environmental Response Trust will be ordered to receive and treat the groundwater from construction dewatering.

PROJECT OVERVIEW

Scope of the Project

- The treatment system will consist of:



  - Groundwater will be transferred by the SNWA weir contractor to tanks at the pump stations.
  - Underground piping will connect the pump stations to the Centralized Water Treatment Plant.
  - Treatment will have hydrocyclones for large sediment, multi-media filters for residuals solids, and ion exchange to remove perchlorate.
  - The system will be completely disassembled and removed after weir construction is complete.

PROJECT LOCATION

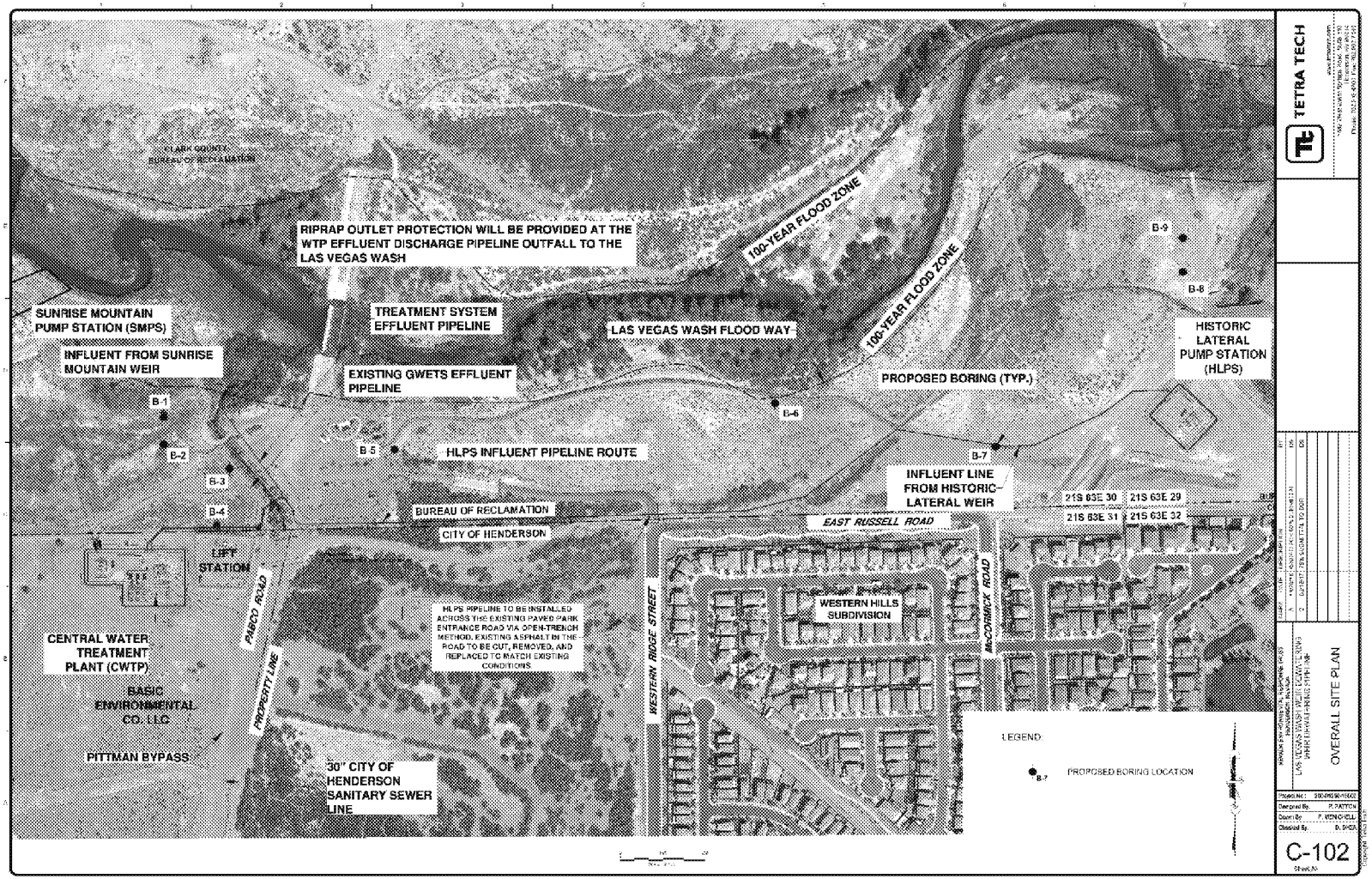
Private and Public Lands

Locations:

- Sunrise Mountain Pump Station and Centralized Water Treatment Plant
  - Private parcel west of NERT Lift Station 1, in City of Henderson jurisdiction
- Historic Lateral Pump Station
  - Bureau of Reclamation land, managed as Clark County Wetlands Park

PROJECT LAYOUT

75% Design



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PROJECT PERMITTING

Federal, State, Local

- Federal
  - Bureau of Reclamation Access Agreement
  - U.S. Fish and Wildlife Service Consultation
- State
  - NDEP National Pollutant Discharge Elimination System Permit
  - NDEP Construction Stormwater Permit
- City of Henderson
  - Design Review; Building; Grading; Electrical; Drainage; Stormwater
- Clark County
  - Building; Grading, Electrical; Air; Dust Control; Encroachment; Fuel Storage

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PROJECT SCHEDULE

75 % Design Schedule

Activity	2017
Design Complete	April
Mobilization	April
Construction Begins	June*
Construction Substantial Completion	August
Plant Commissioning	September
Plant Ready to Accept/Treat Water	October

**** This assumes land access approved by BOR by June 1, 2017***

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