Maximizing Recharge Capacity for Tulare Irrigation District in Support of Sustainable Groundwater Management

Montgomery & Associates

HydroMetrics Water Resources Inc.

HydroMetrics WRI

Tulare Irrigation District
Formed in 1889

Montgomery & Associates

Overview

1. Assessment of current recharge capacity
   – TID's entire water distribution system
2. Recharge feasibility study
   – Identify opportunities to ↑ recharge capacity

Overall goal: maximize recharge potential to offset groundwater storage deficit due to long-term pumping

Tulare Irrigation District

- Located in San Joaquin Valley, south part of the Central Valley
- Established in 1889
- 109 sq. miles (70,000 acres)
- Kaweah Sub-basin
- ~200 Irrigation Customers

Tulare Irrigation District

- Renewable water supplies

Source	Avg. Amount (acre-ft/yr)
Central Valley Project Water (Friant)	~70,000
Kaweah River / Local Water	~90,000
Other exchanges/diversions (pending)	~11,000

- Conjunctive use district
- Proactive recharge program

Planning for Sustainability

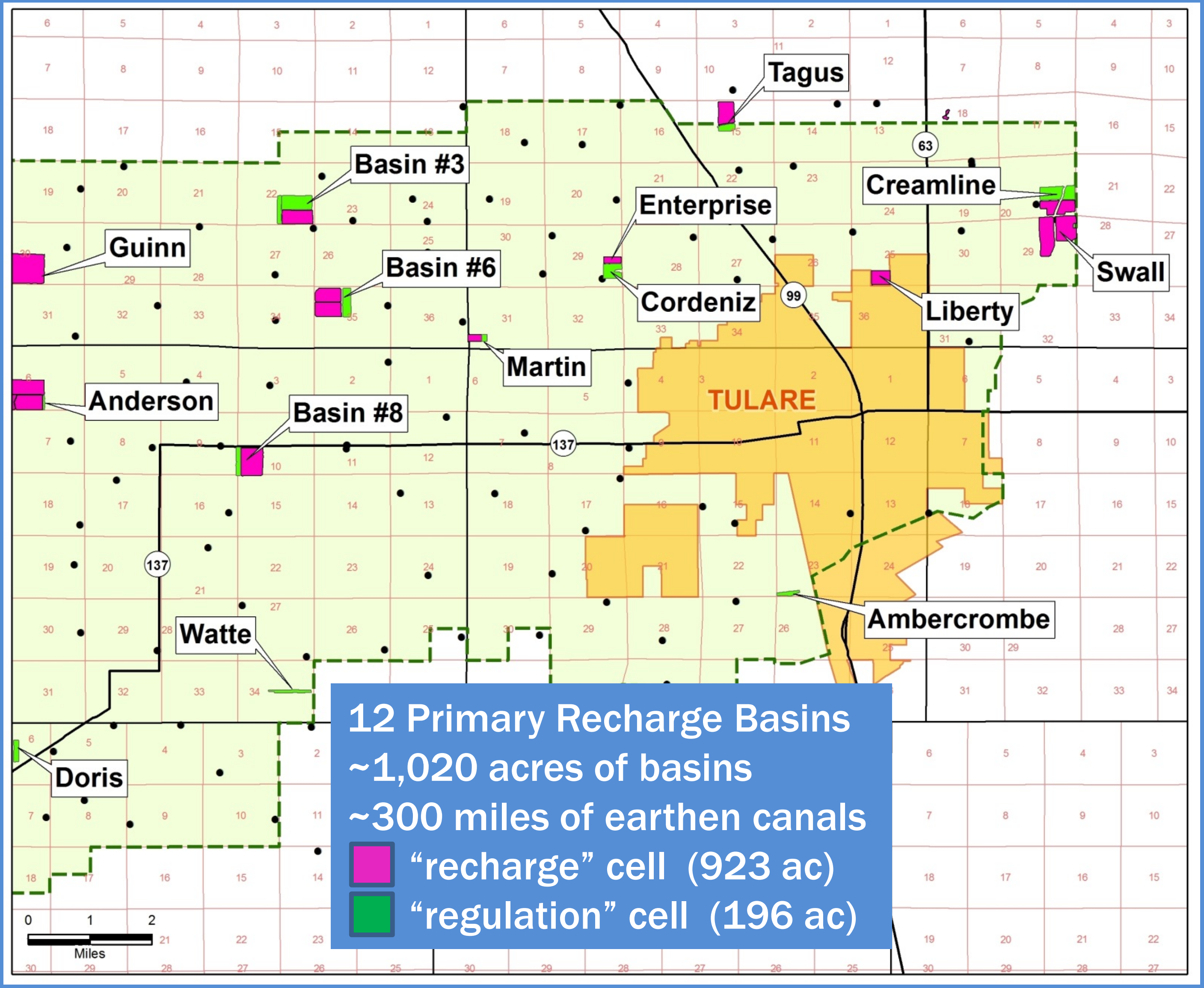
- High-priority critically overdrafted GW basin
- Mid-Kaweah GSA with City of Visalia and City of Tulare
- TID has been recharging for many decades
- Recharge study (USBR Grant)

Phase 1
- Water Balance

Phase 2
- BMPs for basin O&M

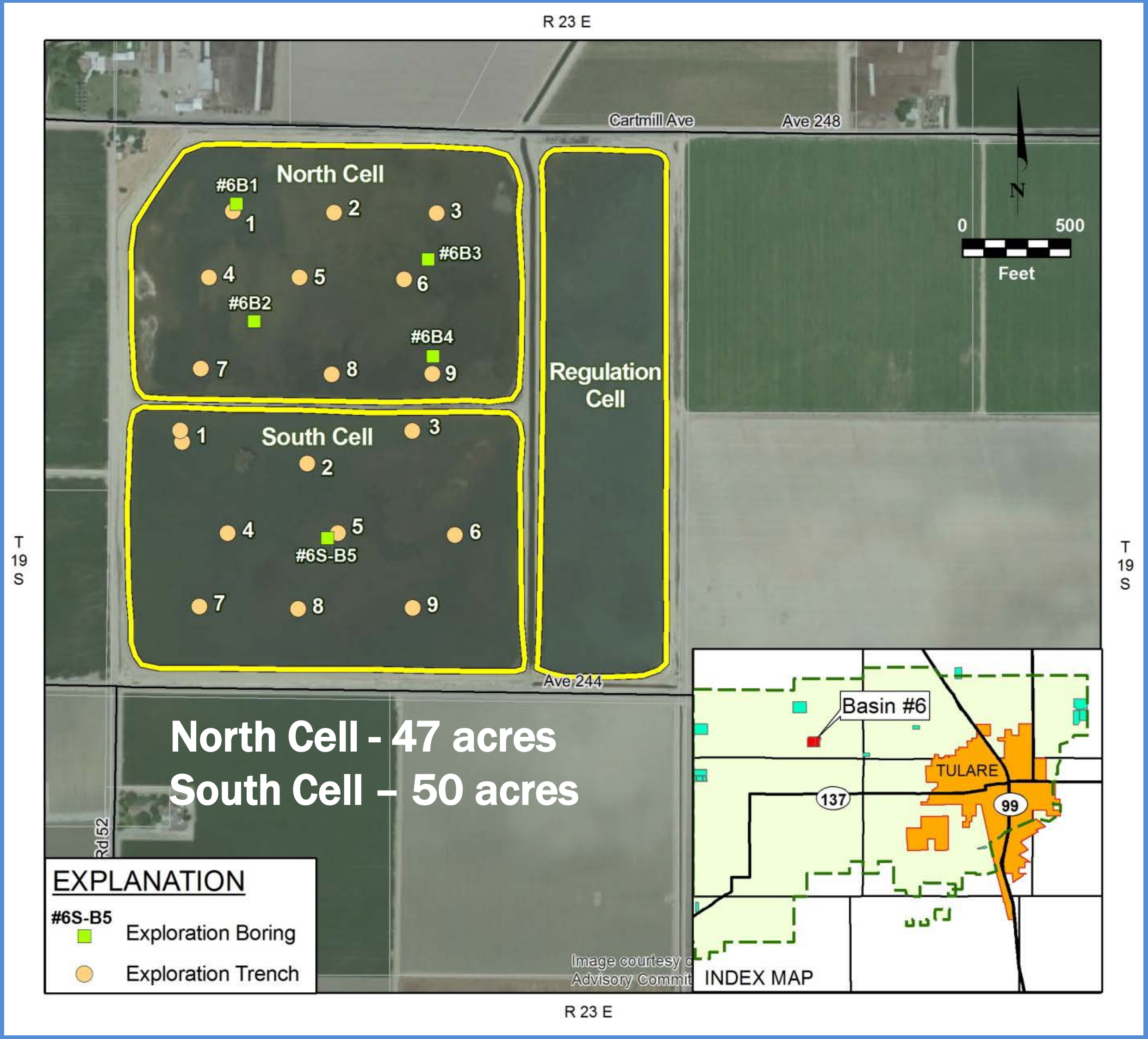
Phase 3
- Recharge Capacity Assessment

TID Map: Recharge Basins



12 Primary Recharge Basins
~1,020 acres of basins
~300 miles of earthen canals
"recharge" cell (923 ac)
"regulation" cell (196 ac)

Basin #6


R 23 E
Cartmill Ave
Ave 248
North Cell
#6B1
1
2
3
#6B3
4
5
6
#6B2
#6B4
7
8
9
Regulation Cell
South Cell
1
2
3
4
5
6
#6S-B5
7
8
9
Ave 244
N
0
500
Feet
T 19 S
T 19 S
Rd 52
North Cell - 47 acres
South Cell – 50 acres
EXPLANATION
#6S-B5
Exploration Boring
Exploration Trench
Basin #6
TULARE
137
99
INDEX MAP
R 23 E

Groundwater Storage Deficit

- Water balance results (HydroMetrics WRI)
  - Annual average deficit (1999 – 2012)
    - ~20,000 acre-feet/yr
  - Pumping > recharge
- Increase recharge to offset deficit
  - Surface water availability….chief limitation
  - Sufficient recharge capacity

Options to Increase Recharge

- Add recharge basins
- Improve existing basins**
- On-farm recharge
- Other methods: injection wells?

Critical Questions

What is current District recharge capacity?

How much additional capacity is needed to meet replenishment goals?

Can existing recharge capacity be feasibly increased to meet replenishment goals?

Investigation Methods

(in the basins)

TRENCHING

- Backhoe
- Up to 12 foot deep
- Lithologic descriptions
- Sample collection

BOREHOLE DRILLING

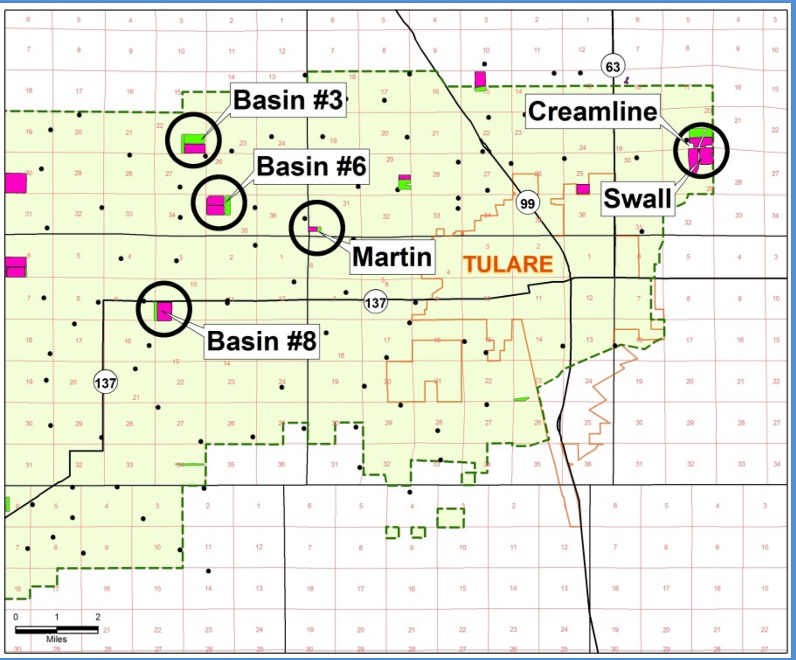
- Auger method
- Up to 50 feet deep
- Lithologic descriptions
- Sample collection

INFILTRATION TEST

- Entire basin
- Falling head tests
- Staff gage
- Transducer / datalogger

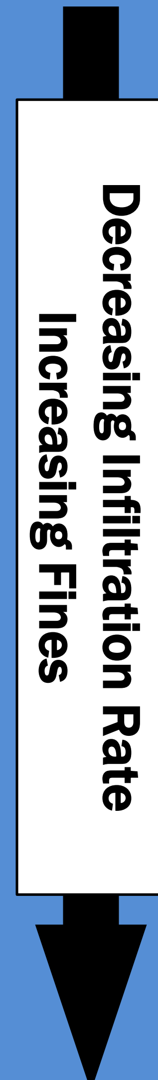
Field Study Approach

- Flexible and Adaptable
  - Limited funds
  - Decision-based investigation approach
  - Maximize amount of useful data
- Basins investigated
  - Creamline / Swall
  - Basins #3, #6, #8
  - Martin

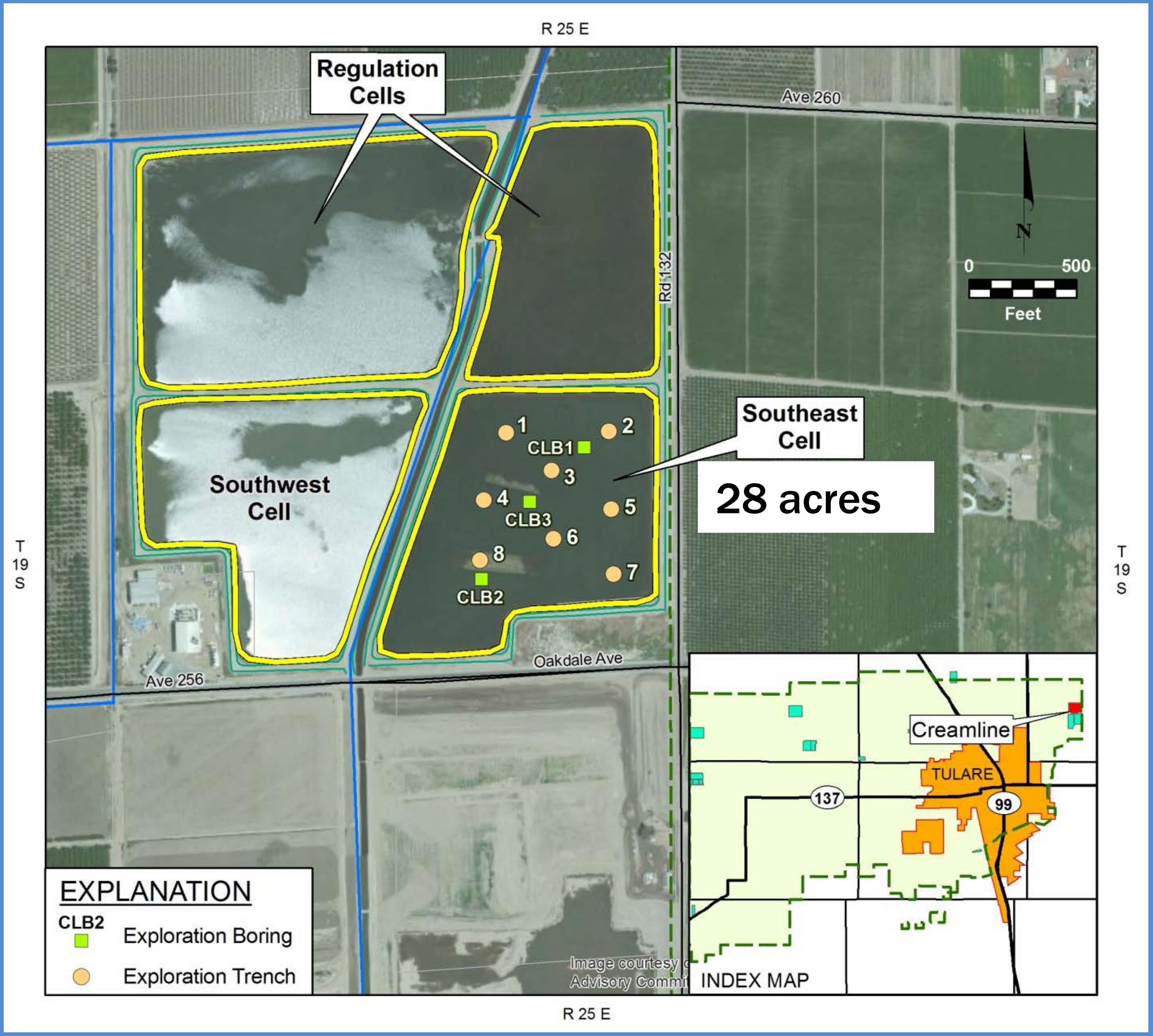


Lithologic / Infiltration Categories

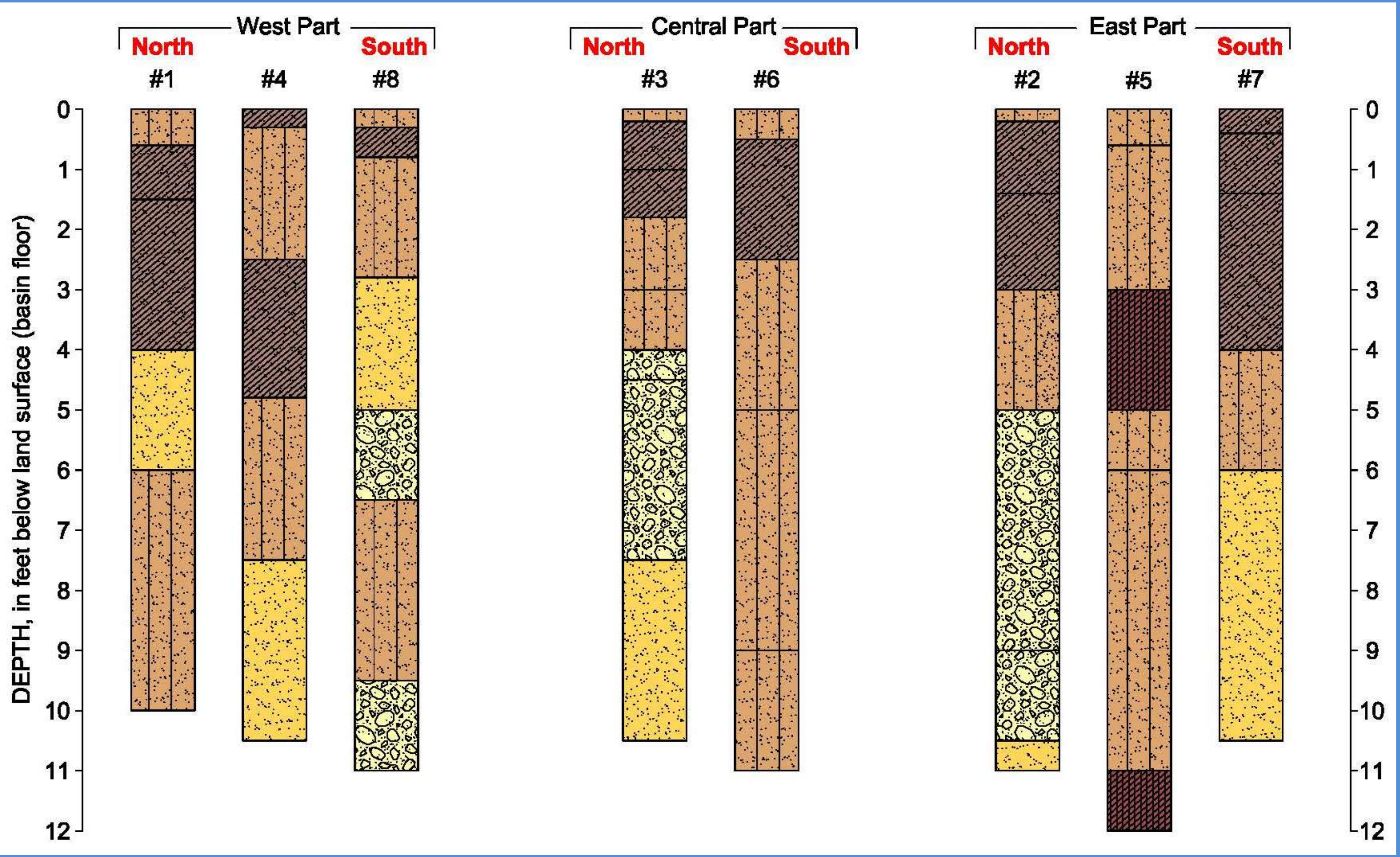
Description	Estimated Infiltration Rate (feet per day)
SAND; SILTY SAND (may have minor gravel content). Generally less than or equal to 20% silt; non-cohesive and non-lithified. VERY LARGE estimated permeability (>3 feet/day)	> 3
SILTY (FINE) SAND, (may have minor clay content). Generally 25% to 35% silt and clay; generally non to slightly cohesive and non-lithified. LARGE estimated permeability (1.5 to 3 feet/day)	1.5 - 3
SILTY (FINE) SAND, SANDY SILT, (CLAYEY) SANDY SILT. Generally 40% to 55% silt and clay; generally non to slightly cohesive and non-lithified, but includes some moderately cohesive sediments. MODERATE estimated permeability (0.8 to 1.5 feet/day)	0.8 - 1.5
SANDY SILT; (CLAYEY) SANDY SILT. Generally 55% to 70% silt and clay; generally very slightly to moderately cohesive and non-lithified. SMALL estimated permeability (0.4 to 0.8 feet/day)	0.4 - 0.8
(SANDY) CLAYEY SILT, (SANDY) SILT AND CLAY. Generally greater than or equal to 75% silt and clay; generally slightly to very cohesive. VERY SMALL estimated permeability (<0.4 feet/day)	< 0.4



Creamline Basin SE Cell Trenching & Drilling

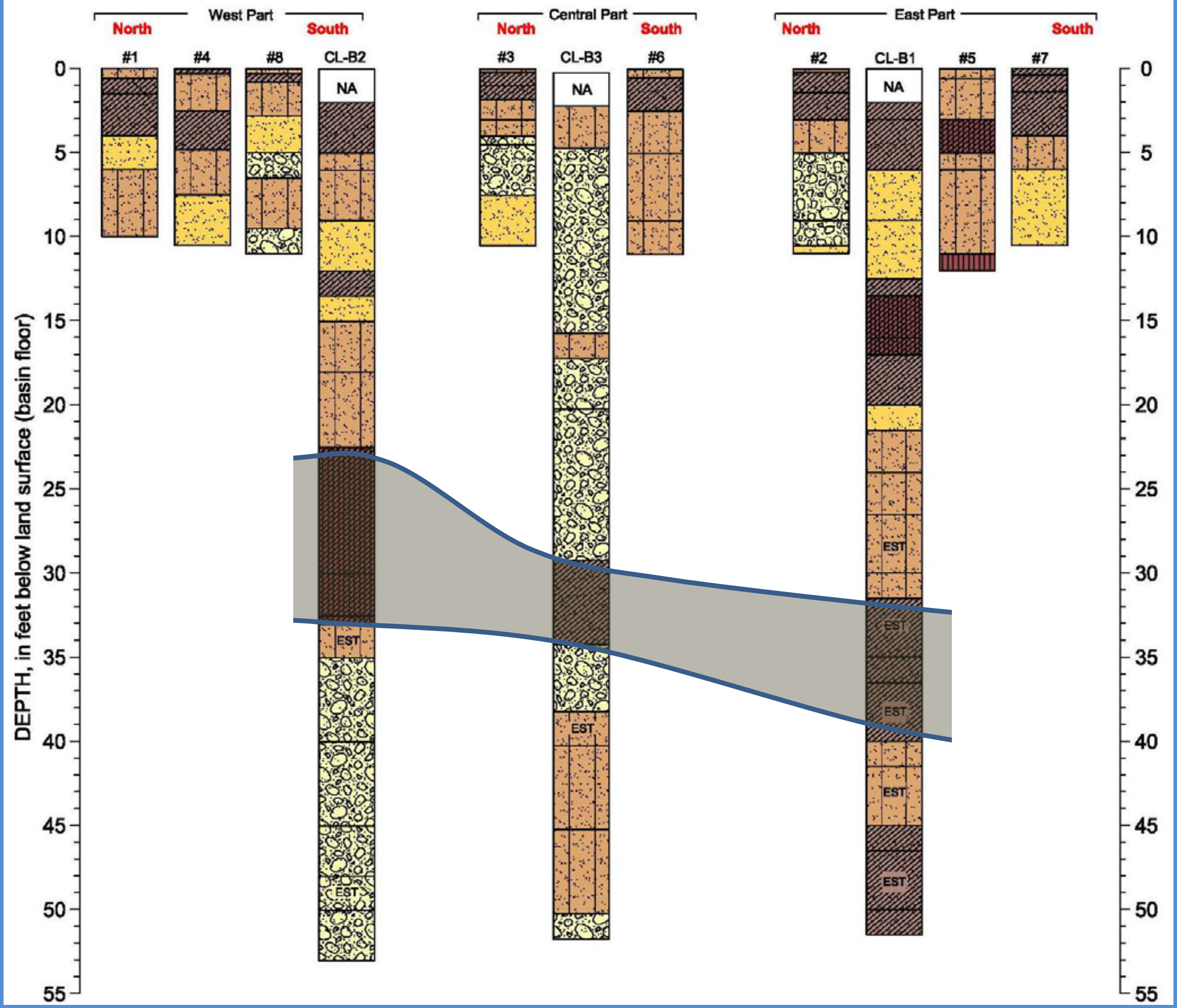


Creamline Basin SE Cell



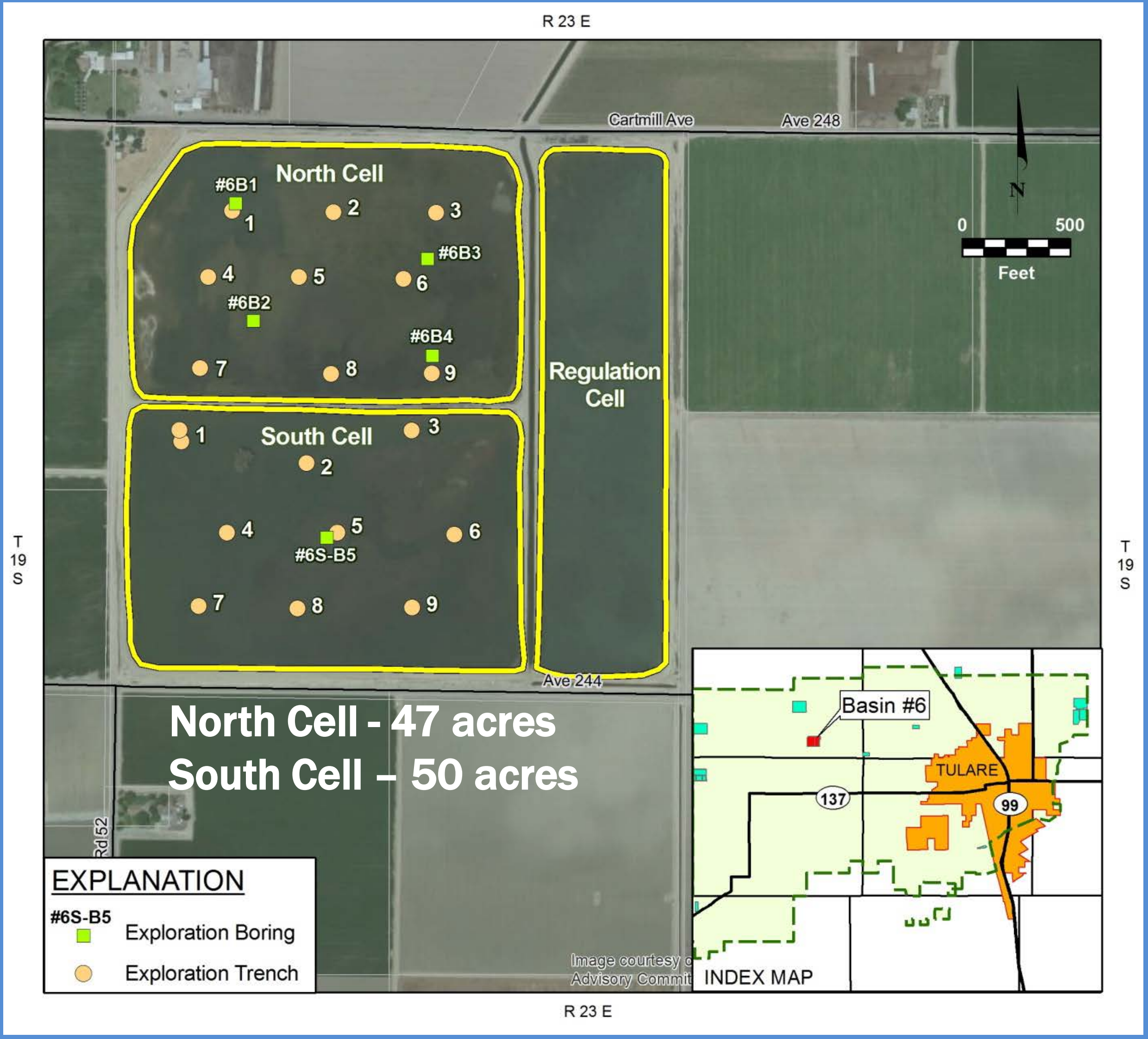
Infiltration rate would be increased by excavating upper 5 feet

Creamline Basin SE Cell

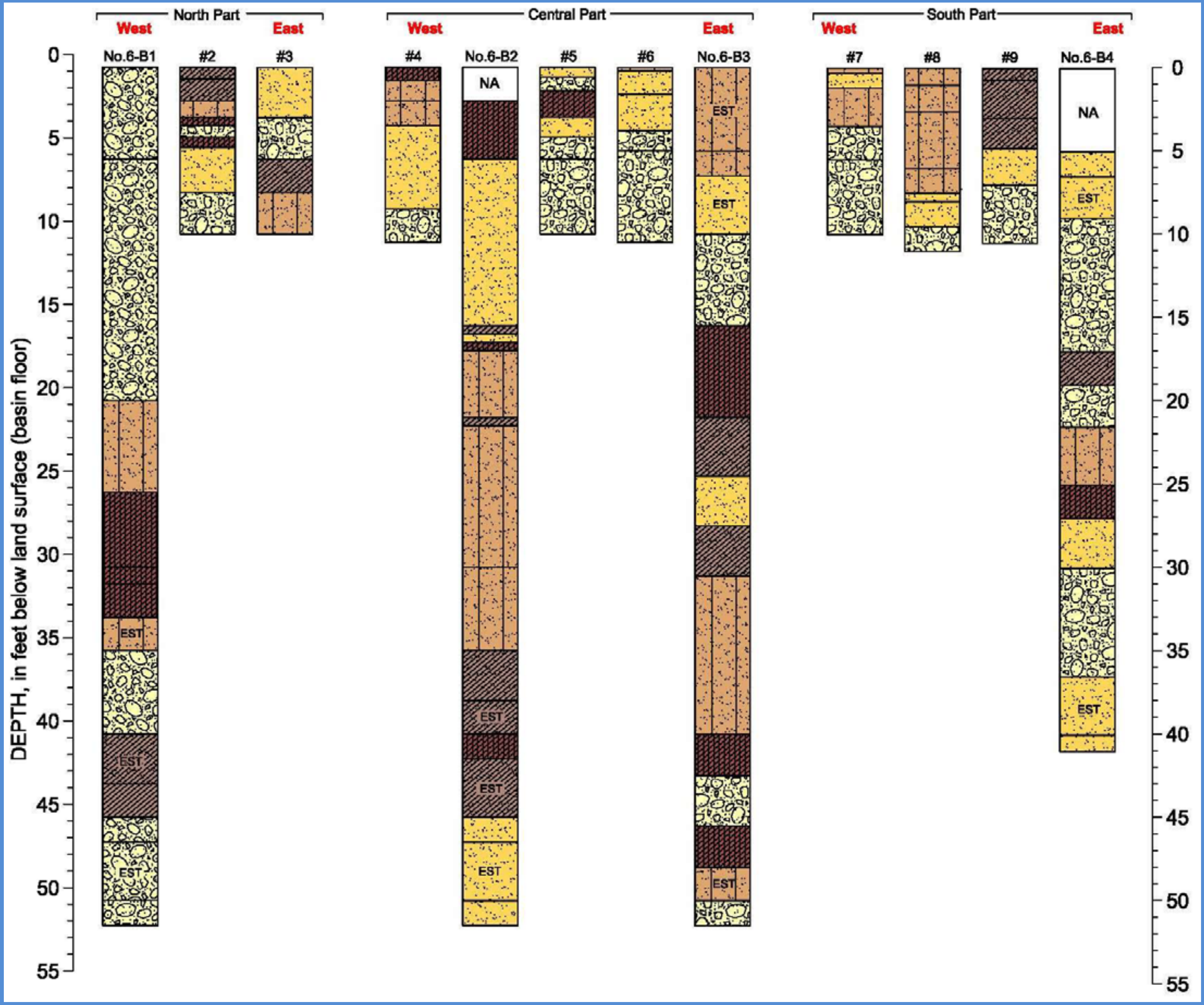


Continuous impeding layer between 20 and 40 feet
Mounding of perched water may limit infiltration

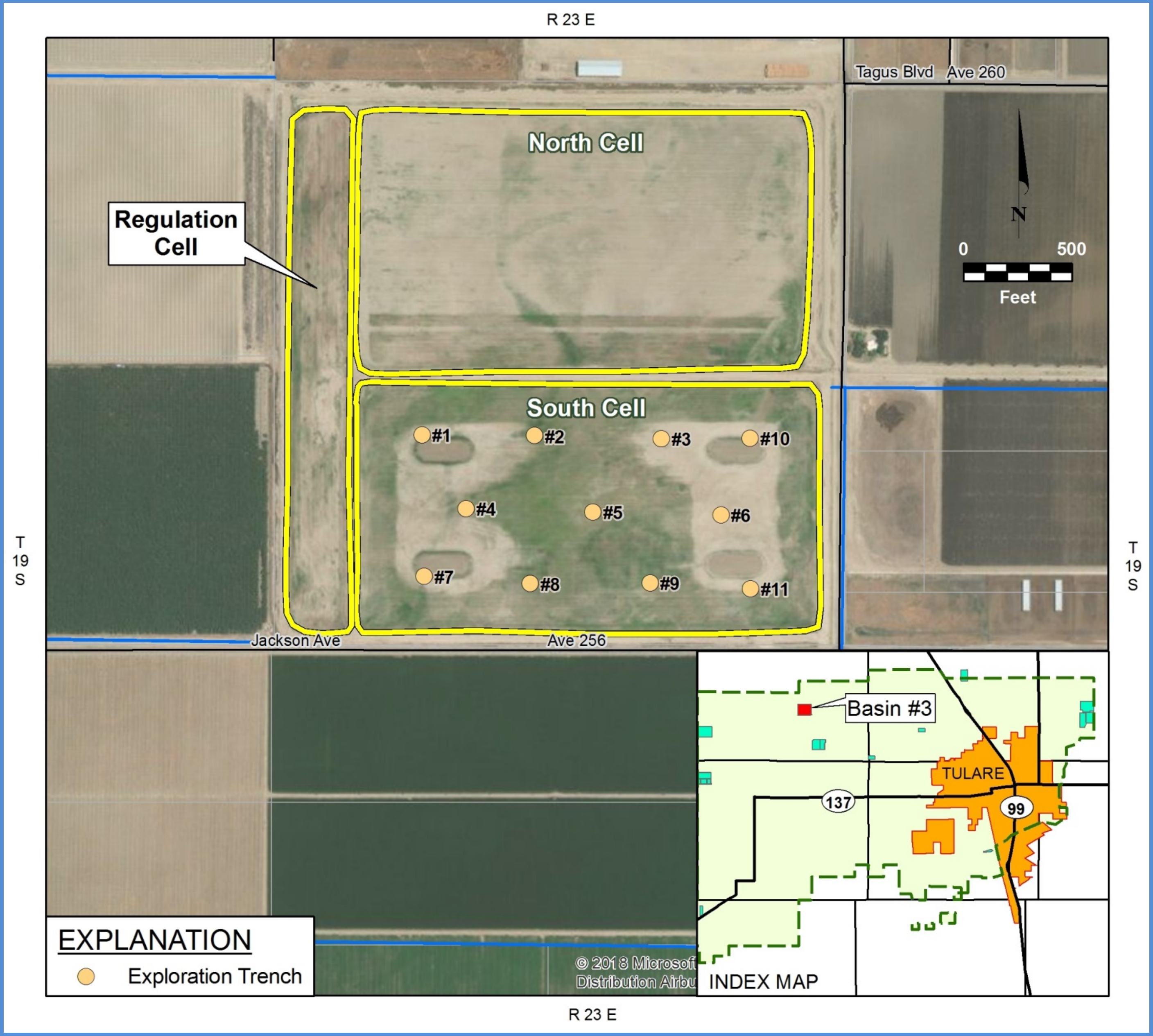
Basin #6 Trenching & Drilling



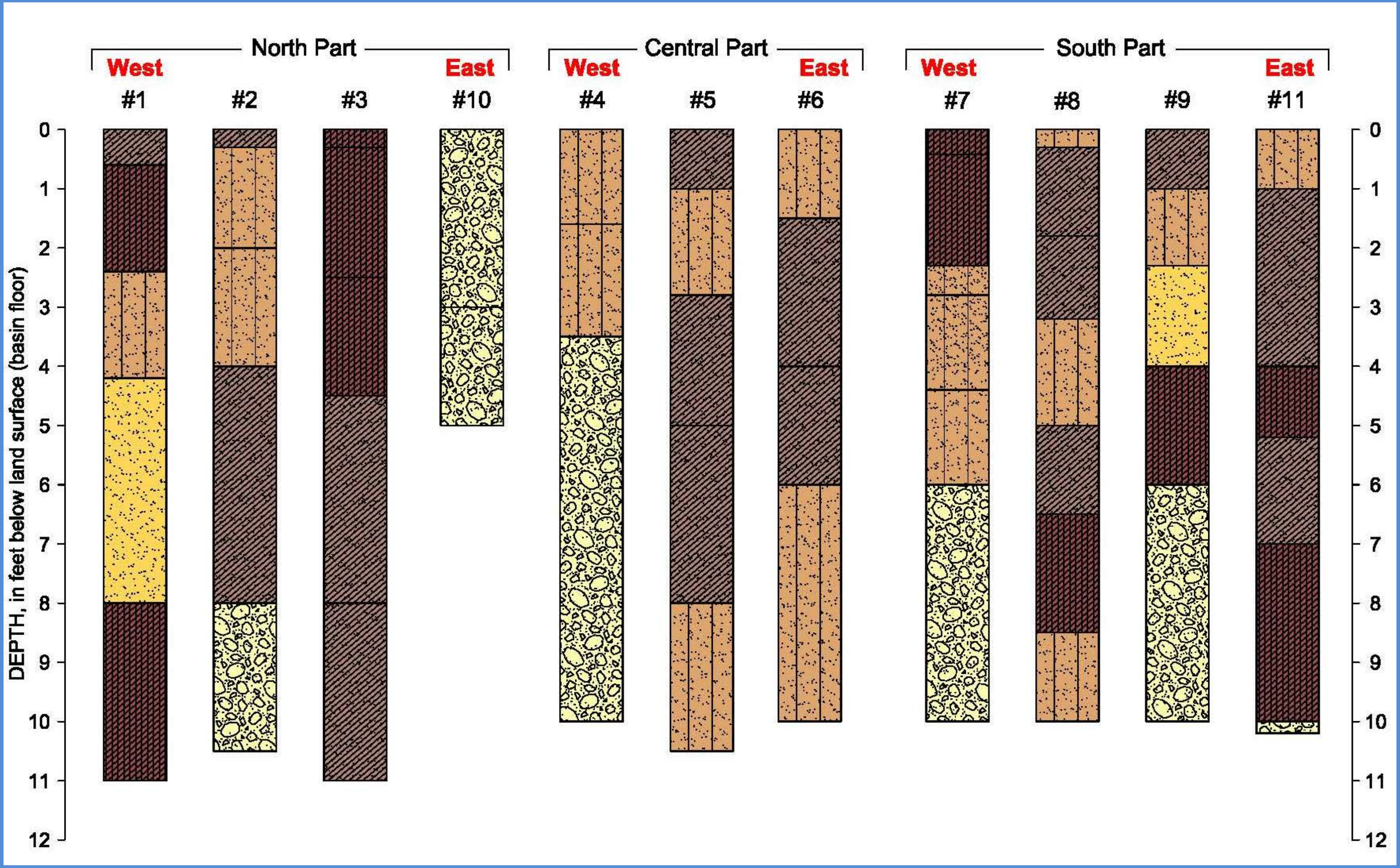
Basin #6 North Cell



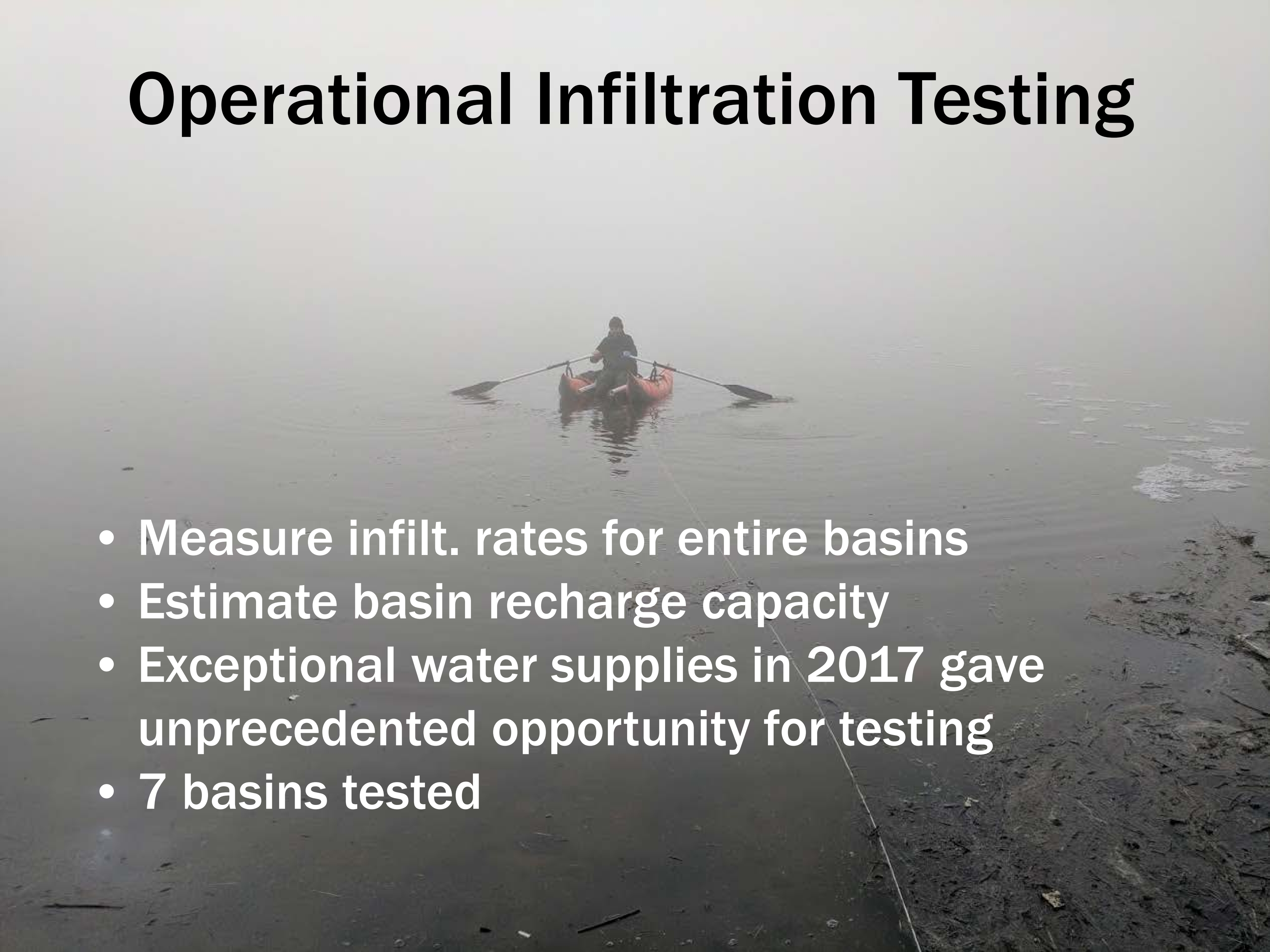
Basin #3 Trenching



Basin #3 South Cell



Operational Infiltration Testing



- Measure infilt. rates for entire basins
- Estimate basin recharge capacity
- Exceptional water supplies in 2017 gave unprecedented opportunity for testing
- 7 basins tested

Infiltration Test Considerations

- Simple falling-head tests….several F.H. cycles in each basin
  - Measure W.L. decline with pressure transducer
  - Tests were integrated into recharge ops….variable heads
  - Incremental infiltration rates measured for 6-hr. periods
- Large-scale (entire basin) tests….direct measurement of infiltration capacity under actual recharge conditions
  - Does not allow evaluation of specific layers

Infiltration Test Results

BASIN / CELL	INFILTRATION RATE (feet/day)	AVERAGE HEAD (feet)
Creamline Basin SE Cell	0.5	4 to 5
Creamline Basin SW Cell	0.5	3 to 4
Swall Basin East Cell	0.45	5 to 6
Swall Basin NW Cell	0.53	6.5
Basin No. 3 South Cell	0.45	1 to 2
Basin No. 6 North Cell	0.25	5
Martin Basin	0.6	4 to 6

Recharge Capacity of TID's Water Distribution System

- Two primary components of the system
  - Recharge and regulation basins and canals
  - 300 miles of earthen irrigation ditches
- TID maximized inflow and recharge of surface water….filled their system
  - 7 months of surplus water deliveries
  - Included on-farm recharge and use of borrow pits

Flow regulation/metering

TID Recharge Distribution

Addresses 1st key question

Recharge Component	Recharge Duration	Inflows (cfs)	Recharge Volume (acre-feet)
Recharge system (basins and canals)*	Jan - July	320	133,000
Irrigation ditches	Jan - July	100	42,000
On-farm recharge	Jan - Feb	25	3,000
Borrow pits	Jan - June	20	7,000
Total		465	185,000

* Recharge basins alone = 98,000 acre-feet

Basin Deepening Assessment

- 3 candidate basins (cells)
- Cost-Benefit analysis – remove 3 to 5 feet
- ↑ recharge: 1,500 - 7,000 AF (120 days)
  - (est. ↑ infilt. rate: 0.5 – 1.25 ft/day)
- Excavation costs: $231,000 - $1.2 M
- Cost-benefit: $172K – $330K per 1,000 AF ↑
- More cost effective than injection wells for conditions in the District (prelim. analysis)

Summary

- TID has a proactive & effective recharge program
  – Full utilization in 2017: 185,000 AF
  – Irrigation ditches contributed up to 42,000 AF
- Maximizing recharge capacity is critical for conjunctive water management
  – Water balance: ↑ recharge by 20,000 AF/yr (ave.)
  – Benefit of addt'l capacity only realized when there is surplus surface water.....but is the only opportunity!
  – Benefit will grow as new water supplies are identified

Summary (cont.)

- Increasing recharge capacity appears feasible
  - Utilization of irrigation ditches
  - On-farm recharge (pending water quality concerns)
  - Basin performance….deepening
- Cost-effectiveness may seem low in short term but could be high in long term

Summary (cont.)

- Study has provided meaningful new information
- Site-specific investigations are critical
  - Infiltration rates are generally low (0.25 – 0.6 ft/day)
  - Lithology: identify basins that would benefit from deepening (and those that would not)
- Results of study are a necessary step for evaluating feasibility of recharge capacity enhancement for sustainable GW management

Next Steps

- Pursue funding to continue recharge feasibility studies
  - Addt'l trenching, drilling, and infilt. testing (at depths) in the 3 candidate basins
  - Investigate selected remaining basins
  - Operational infiltration testing in remaining basins (when water supply allows)
- More comprehensive evaluation of cost-benefit of recharge program improvements