

A Comparison of Two Different Case Histories in Arizona: The Tucson Sweetwater Underground Storage and Recovery Facility and the Mesa Northwest Water Reclamation Plant

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Soil-Aquifer Treatment for Sustainable Water Reuse

- a tailored collaborative research study funded by

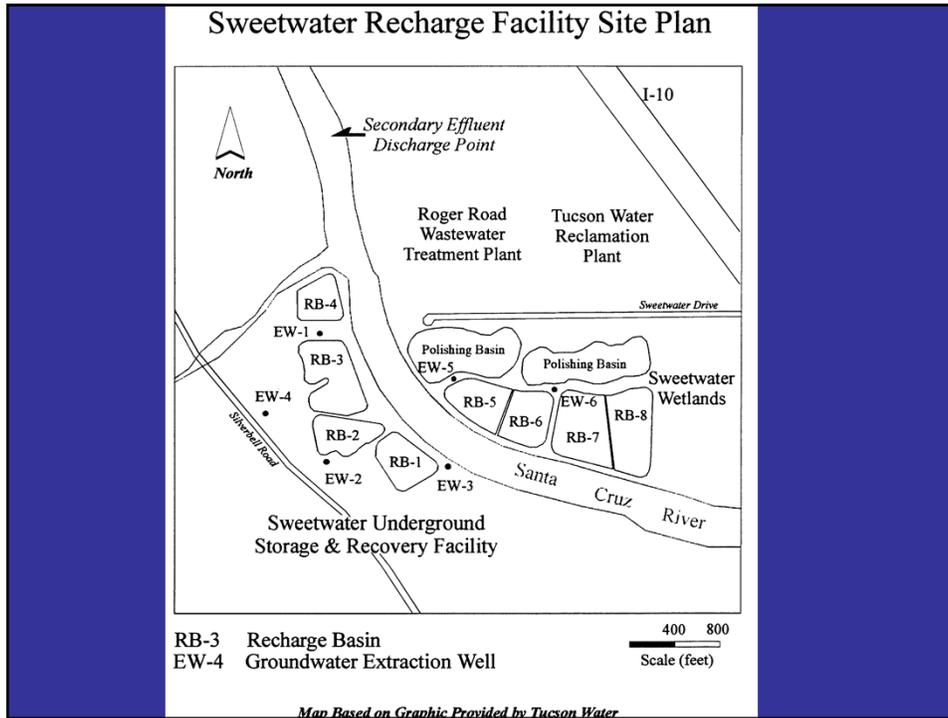


Tucson Sweetwater – Treatment Process

- Roger Road Wastewater Treatment Plant – Primary Clarifier, Trickling Filters, Secondary Clarifier, Chlorination and Dechlorination
- Tucson Water Reclamation Plant – Pressure Filtration and Wetlands
- Dissolved Organic Carbon – 12-15 mg/L
- Ammonia Nitrogen > 20 mg-N/L

Mesa Northwest – Treatment Process

- Primary Clarification, Deep Oxidation Ditch with Nitrification/Denitrification, Secondary Clarification, Traveling Bridge Filters
- UV disinfection only for NPDES – not for recharge
- Dissolved Organic Carbon – 5-7 mg/L
- Ammonia Nitrogen < 2 mg-N/L
- Nitrate Nitrogen 4-7 mg-N/L



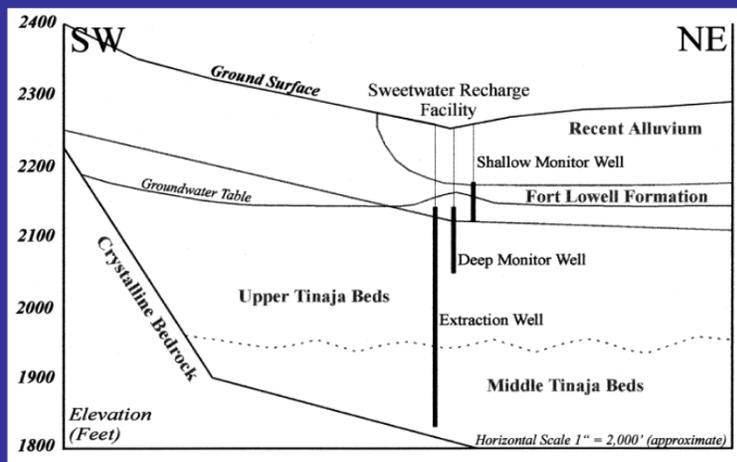
Tucson Sweetwater

- Permitted for 6,500 acre-ft/yr
- RB-1 to RB-4 operated since 1990 – 13.8 acres and 12 ft deep
- RB-5 to RB-8 added in 1997 – 14 acres
- 4 original extraction wells - 1990
- 2 additional extraction wells - 1997

Infiltration Rates

- Initial Infiltration rates averaged 2 ft/d
- Decreased to 1 ft/d by 1997
- Typical Operation changed from 5 days wet/4 days dry to 3 days wet/4 days dry to improve rates
- Pond Depth – 1.5 ft

Geological Profile - Tucson



Groundwater

- Depth to Groundwater – 120 ft
- Groundwater Flow to Northwest – parallel to Santa Cruz River at 2-3 ft/d
- Clay Lenses at 19 ft deep cause ponding
- Estimated travel time in vadose zone – 2 weeks

Lysimeter sampling depths below recharge basins below land surface of basin

Vadose Zone Monitoring – Suction Lysimeters RB-1, RB-7, RB-8

| Basin RB-1 (ft (m)) | Basin RB-7 (ft(m)) | Basin RB-8 (ft(m)) |
|------------------------|-----------------------|-----------------------|
| 1 (0.3) | 1 (0.3) | 1 (0.3) |
| 2.5 (0.76) | 2.5 (0.76) | 2.5 (0.76) |
| 5 (1.9) | 5 (1.9) | 5 (1.9) |
| 10 (3.0) | 10 (3.0) | 10 (3.0) |
| 17 (6) | | 25 (7.6) |
| 40 (12) | | 50 (15) |
| 60 (18) | | 75 (23) |
| 80 (24) | | 100 (30) |

Lysimeters in North/South Transects for RB-1

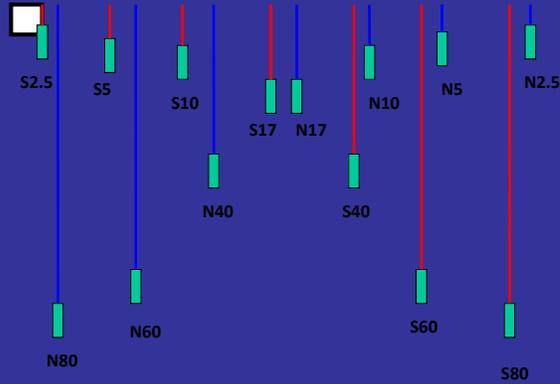
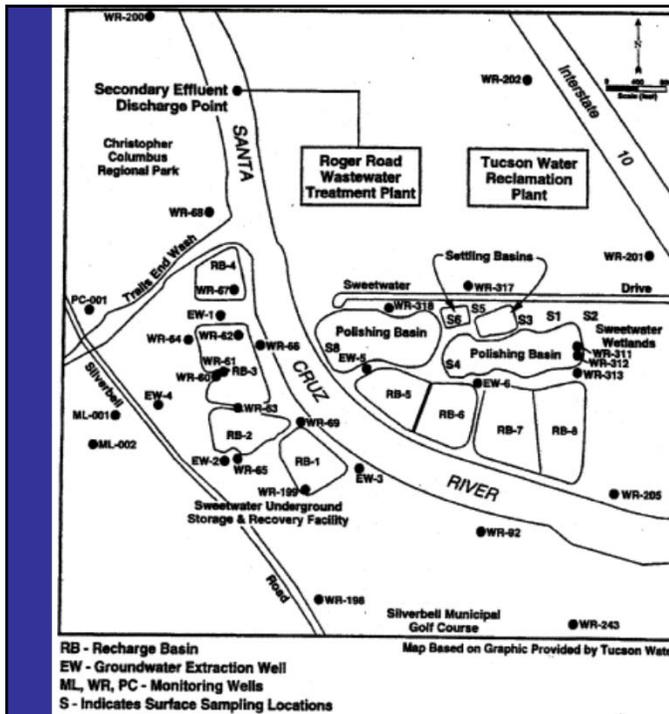


Figure 2.3 Lysimeter profile for recharge basin RB-1. Each pair of lysimeters at representative depths is separated by 10 to 12 ft (3.3 – 4 m) in a north/south transect. East/west separation is 8 ft (2.6m). Note N17 refers the lysimeter in north transect installed at a depth of 17 ft (5.2 m)

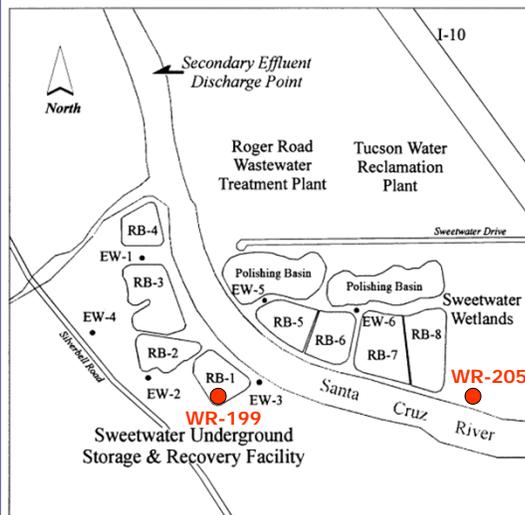


ML – Shallow Monitoring Wells

WR – Monitoring Wells

Compliance – quarterly sampling of several WR wells

Sweetwater Recharge Facility Site Plan



RB-3 Recharge Basin
EW-4 Groundwater Extraction Well

400 800
Scale (feet)

Map Based on Graphic Provided by Tucson Water

Tucson Sweetwater Recharge and Storage Facility



- vadose zone treatment (120 ft)

Mesa Northwest – In contrast

- 1990 – Original Design – 4 Basins – 30 acres total
- Preliminary Assessment of Infiltration Rates – Designed for Plant Capacity of 8 MGD
- Fine layers of clay not identified, actual recharge capacity was 4 MGD
- Plant only operated one 4 MGD treatment train until NPDES permit obtained in 2000



Infiltration/Operations

- Infiltration Rate = 0.5 ft/d
- Fine clay lenses result in horizontal flows
- Lack of clogging layer – saturated flow conditions
- 7 days wetting – 21 days drying
- Weed control necessary to prevent mosquitoes

High Tech Weed Control - Goats



Infiltration Through a Clogging Layer

The infiltration rate through a clogging layer is analogous to determining infiltration rate through an earth liner with a saturated hydraulic conductivity of K_c . The infiltration rate, v_i may be described as follows:

$$v_i = K_c \frac{H_w + L_c - h_b}{L_c} \quad 22.3$$

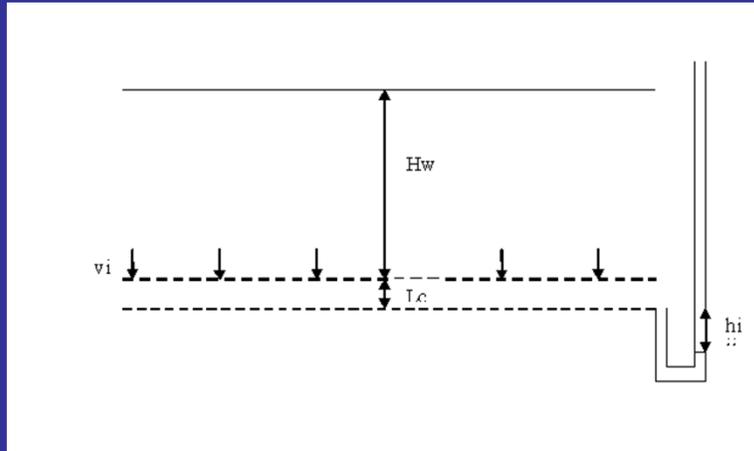
Where

H_w = water depth above the liner

L_c = thickness of the earth lining

h_b = pressure head of water at bottom of the liner.

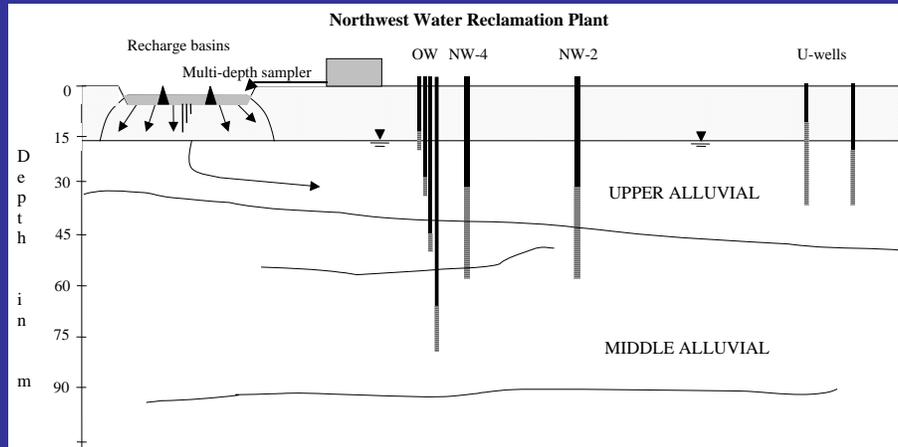
If $K_c < K_s$ unsaturated conditions below
At Mesa $K_c > K_s$ – Clogging Not a Factor



Monitoring

- Sampling points and piezometers inserted in ponds 2 and 4 at 5 foot intervals to depth of 30 feet
- No tensiometers required since saturated
- 4 NW wells – quarterly sampling for compliance
- Multiple depth piezometers – OW wells
- Reclaimed Water Plume moves Southwest to Superfund Site – over 20 monitoring wells

NWWRP Mesa, Cross section



not to scale

Tucson Water Reuse

- Demand for Irrigation in Summer months – recover stored groundwater and direct reuse of effluent
- Recharge in winter months when demand for irrigation is low
- Irrigation of city parks, schools and golf courses – dual distribution system

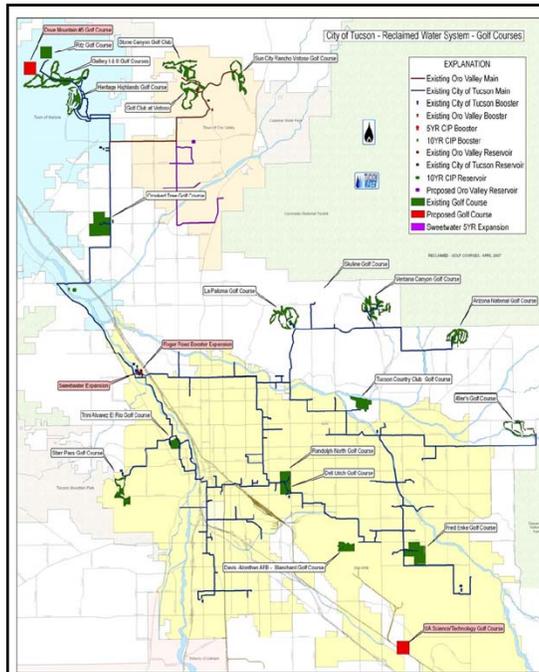
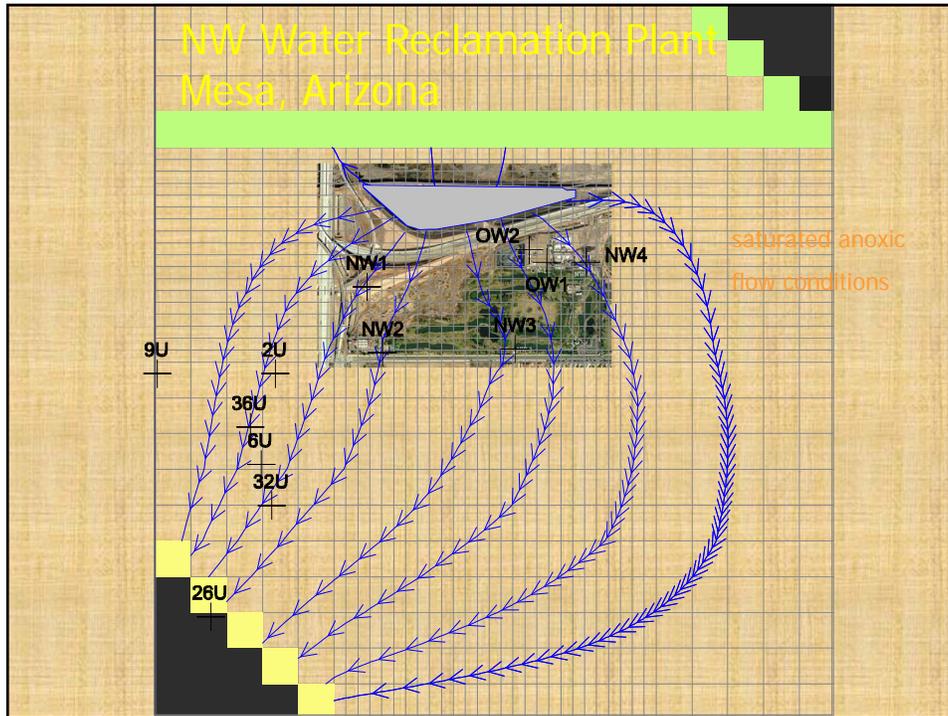


Figure 1 – The Tucson Water Regional Reclaimed Water System

Tucson Reclaimed Water System

Mesa

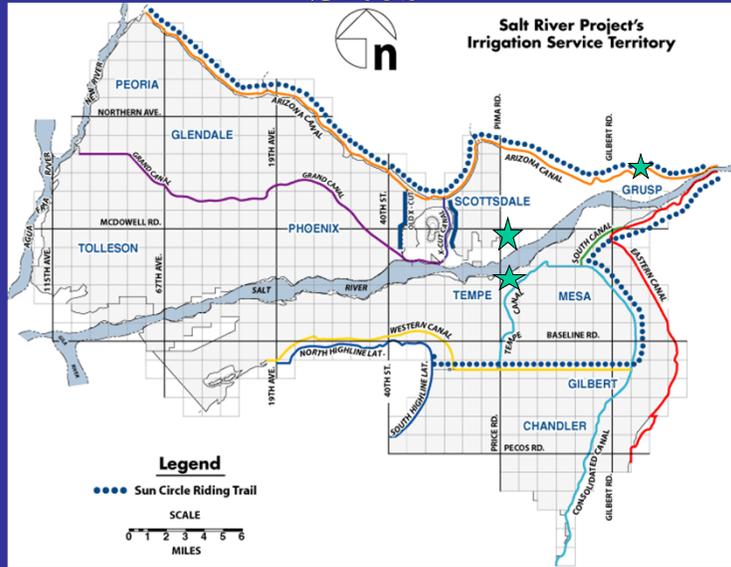
- Adjacent Riverview Golf Course
- Minimal Recovery for Reuse
- Salt River Flows for 7 Months in 1994 – raises groundwater table 50 ft (no change in GW elevation in Tucson)
- Plume of Reclaimed Water Extends 3-4 Miles into Tempe, AZ



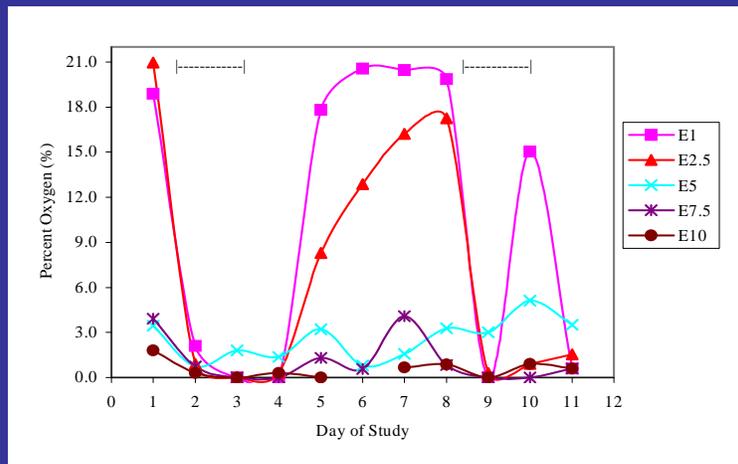
Mesa Expansion

- 1990 Built for 8 MGD, Limited to 4 MGD by infiltration
- 2000 – Expansion to 32 MGD
- NPDES Permit for Discharge – 50% credit for recharge
- Additional Recharge Basins in Salt/Pima Indian Reservation
- Pipeline 6 Miles to Granite Reef Underground Storage and Recovery Project

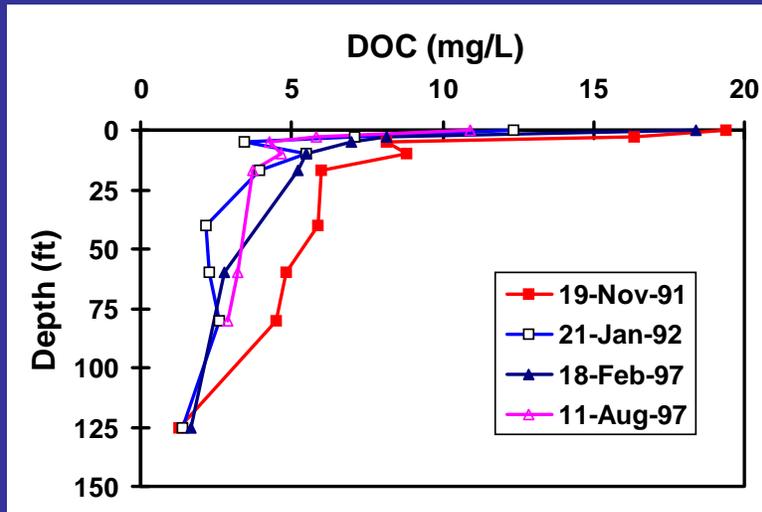
Mesa – Three Possible Recharge Sites



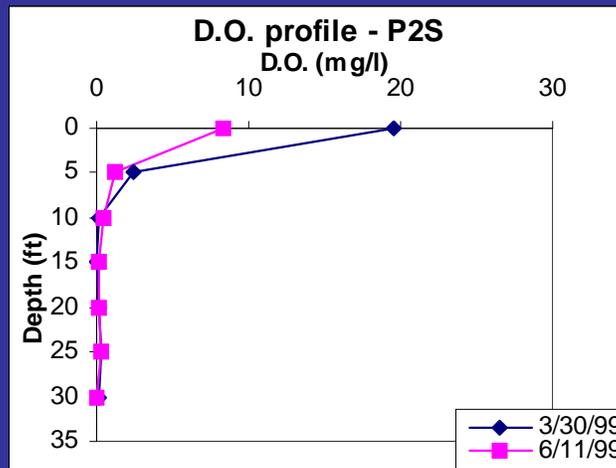
Tucson – Dissolved Oxygen



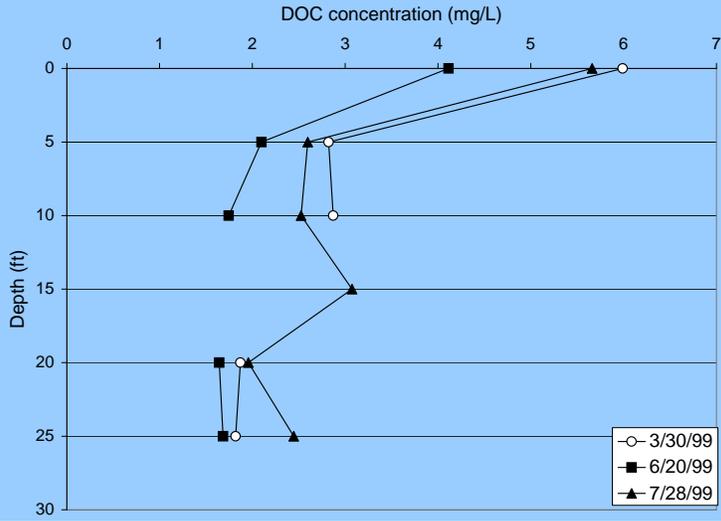
Tucson – DOC Removal Depth Profile



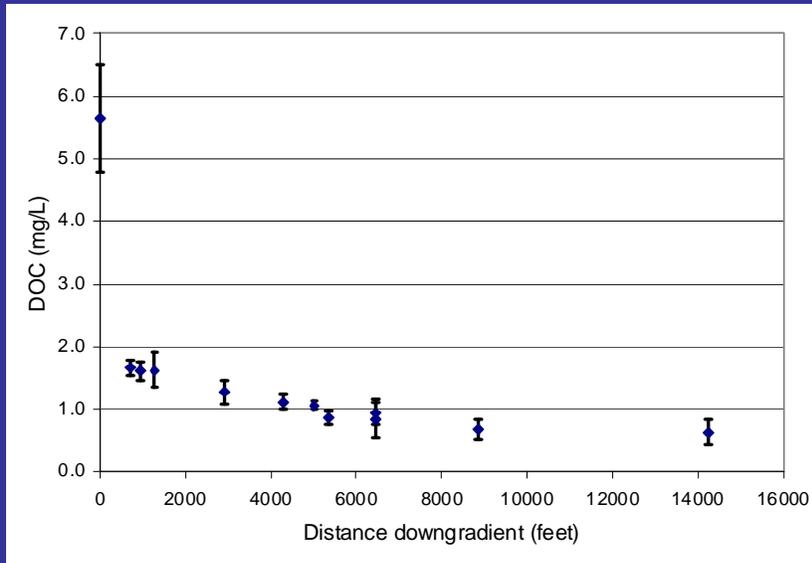
Mesa – Dissolved Oxygen Depth Profile



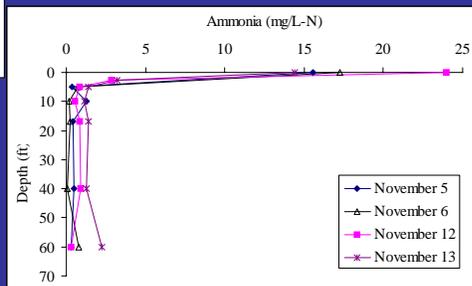
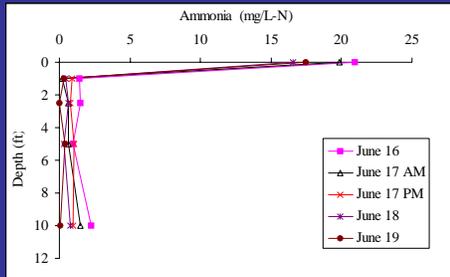
Mesa – DOC Depth Profile Below Pond



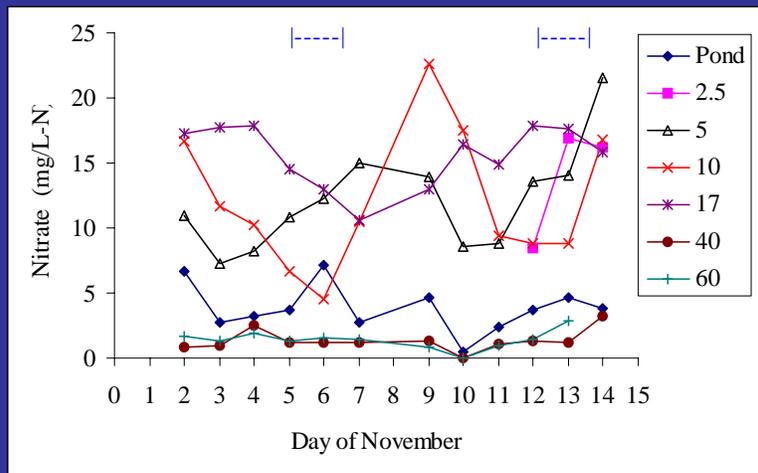
Mesa - Long Term DOC Removal



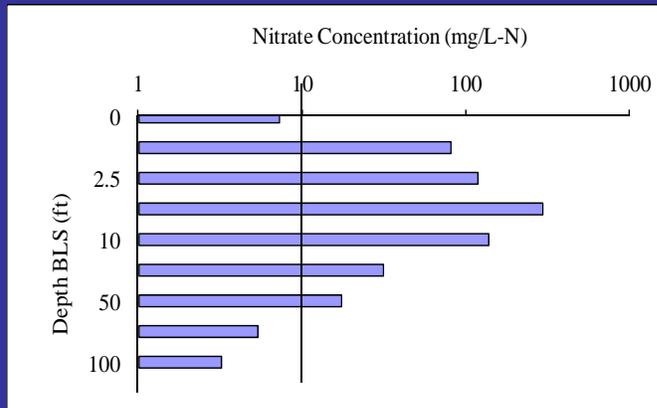
Tucson Nitrogen – Ammonia Depth Profiles



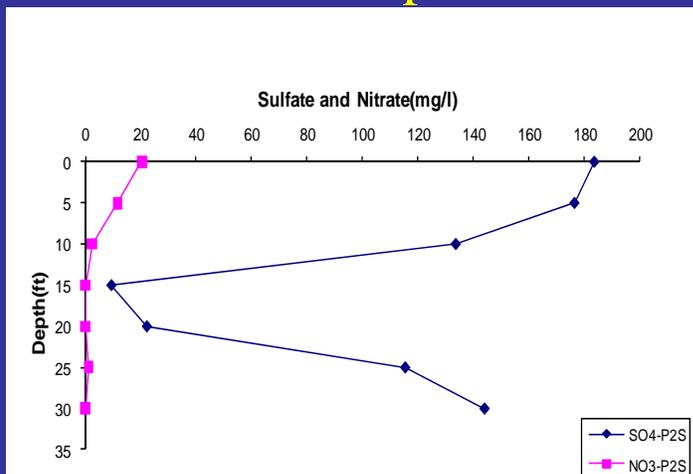
Tucson – Nitrate is Produced and Removed



Nitrate – Minimum to Maximum Depth Profile – Spikes are Possible in Vadose Zone



Mesa – Anoxic Conditions below 5 ft – Nitrate is Electron Acceptor

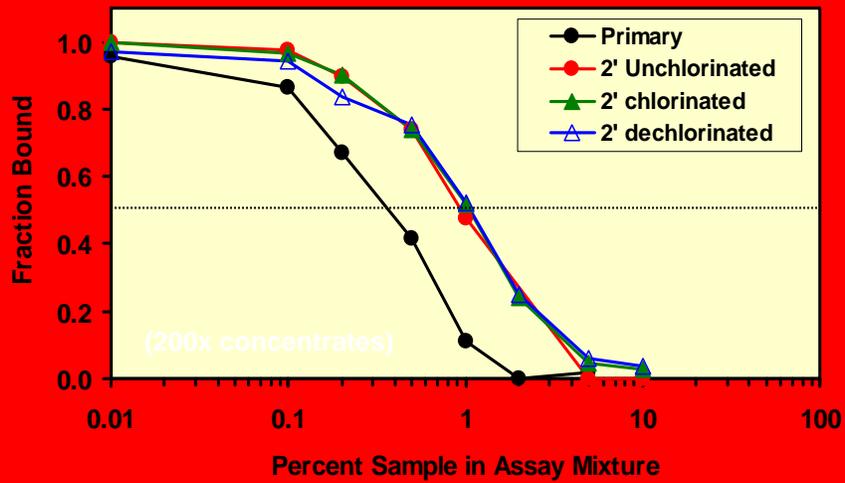


Nitrate nitrogen concentrations for Mesa U wells (average 1996 – 1999)

Mesa – Reclaimed Water Plume Cleaner than Background

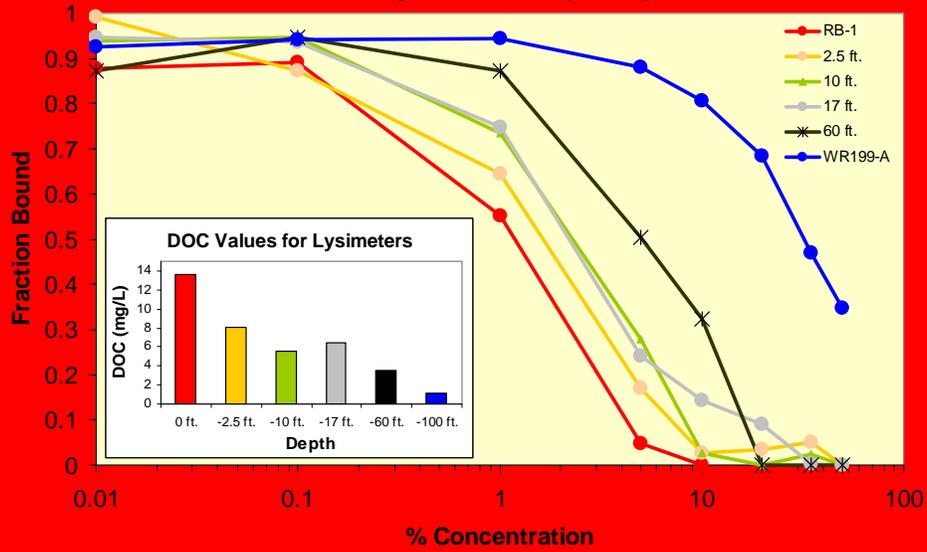
| Well ID | Distance from recharge basin (feet) ¹ | Percent reclaimed water ² | Nitrate-N (mg/L) |
|------------------|--|--------------------------------------|------------------|
| 2U | 3000 | 74 | 0.93 |
| 37U | 3600 | 85 | 2.02 |
| 36U | 3900 | 57 | 1.11 |
| 6U | 4200 | 80 | 2.52 |
| 9U | 4275 | 64 | 3.12 |
| 53U | 4350 | 79 | 2.45 |
| 32U | 4800 | 81 | 2.37 |
| 43U ⁴ | 5475 | 32 | 4 |
| WMW-4 | 5625 | 26 | 1.86 |
| 1U | 6075 | 39 | 3.62 |
| 10U | 6450 | 55 | 2.97 |
| 26U | 6450 | 55 | 4.25 |
| 44U | 7425 | 18 | 3.62 |
| 3U | 8700 | 14 | 4.06 |
| 39U | 8850 | ID ³ | 6.37 |
| 25U | 10875 | ID | 4.03 |
| 40U | 12750 | ID | 4.71 |

Tucson Evidence for Removal of Estrogenic Activity Secondary Treatment (binding assay)

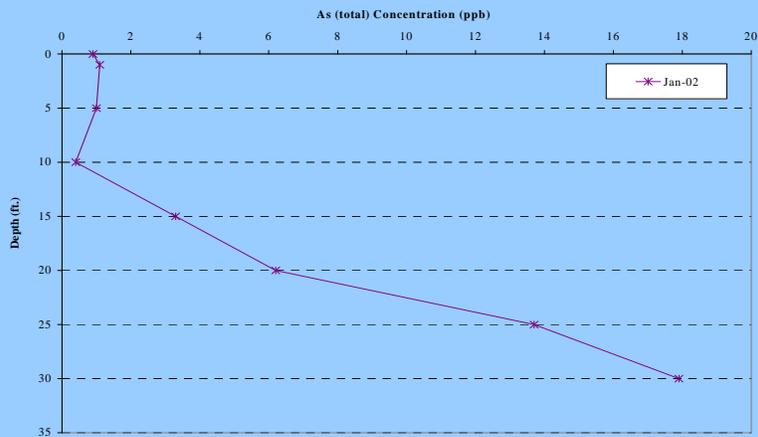


Soil Aquifer Treatment

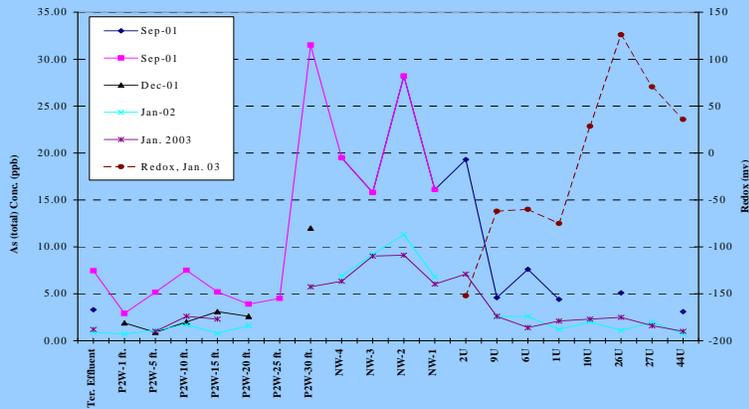
RB-1 Lysimeters (200x)



Mesa – Arsenic Depth Profile – Mostly As(III) released under low redox conditions



Mesa Reclaimed Water Plume – Contains Arsenic until Redox Potential Increases



Any
questions?

Des
question?

