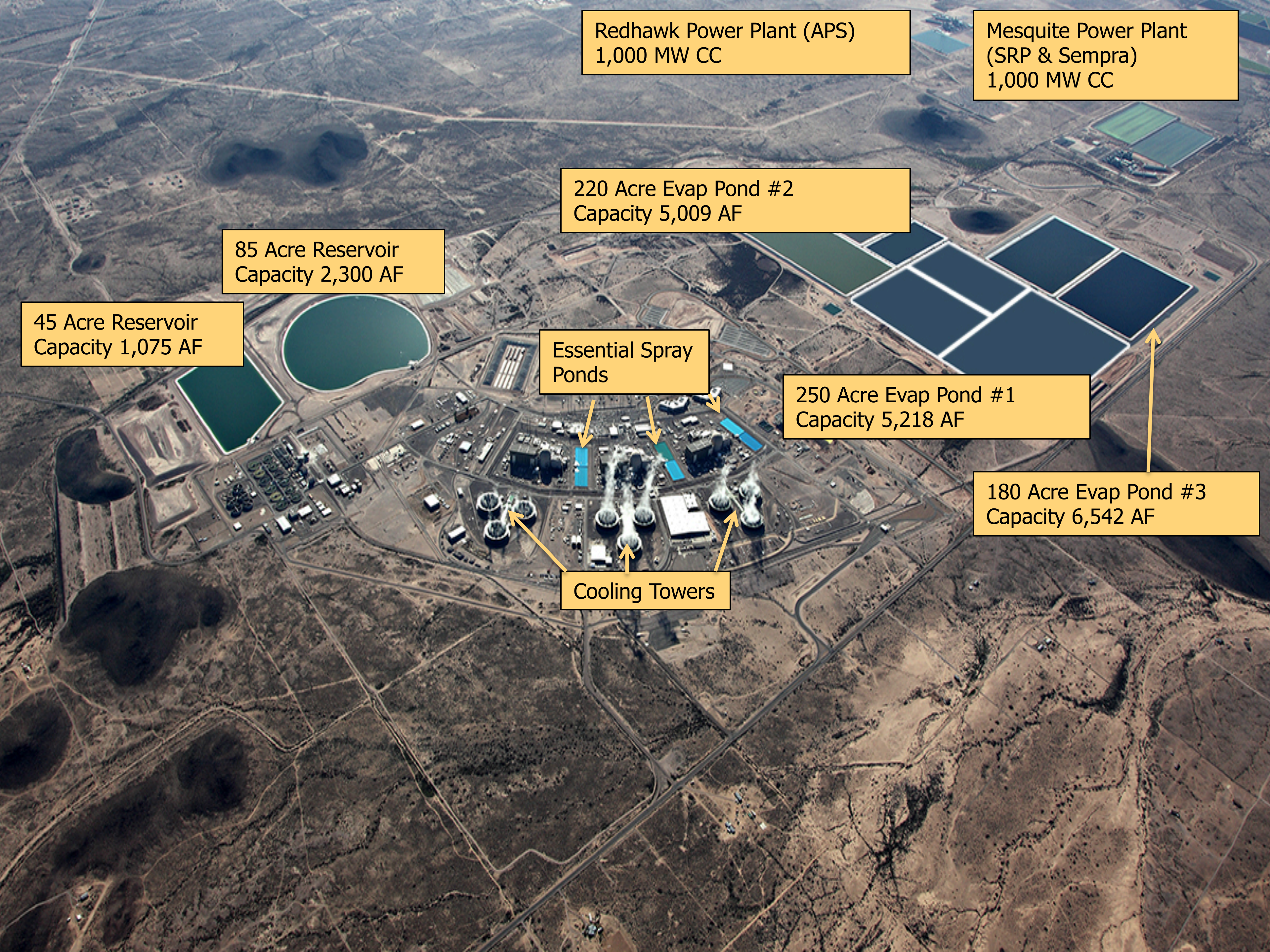
Water and Energy in Arizona

Bob Lotts

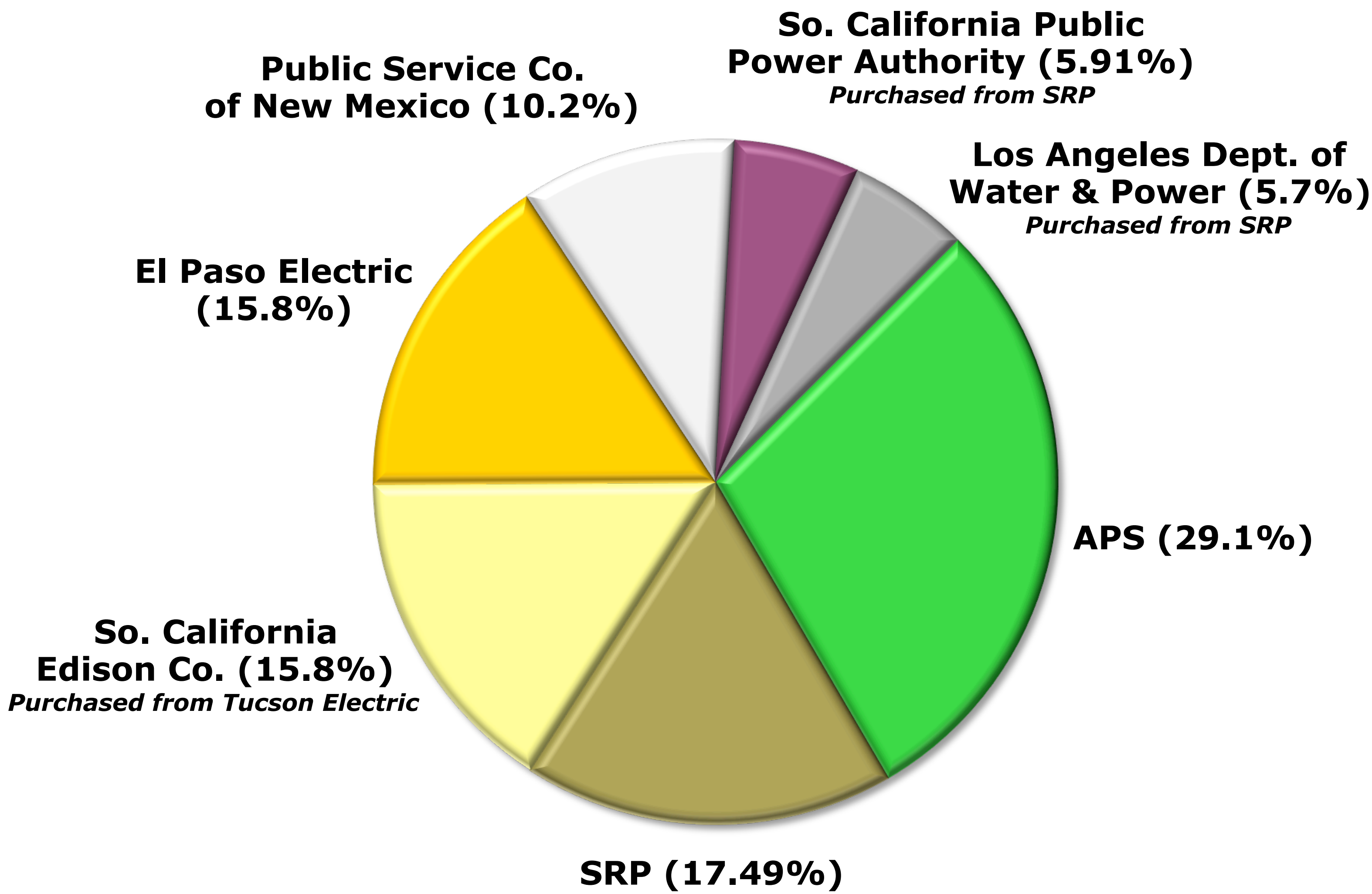
Arizona Public Service Company

Multi States Salinity Coalition Summit

3/2/2017


Redhawk Power Plant (APS)
1,000 MW CC
Mesquite Power Plant
(SRP & Sempra)
1,000 MW CC
220 Acre Evap Pond #2
Capacity 5,009 AF
85 Acre Reservoir
Capacity 2,300 AF
45 Acre Reservoir
Capacity 1,075 AF
Essential Spray
Ponds
250 Acre Evap Pond #1
Capacity 5,218 AF
180 Acre Evap Pond #3
Capacity 6,542 AF
Cooling Towers

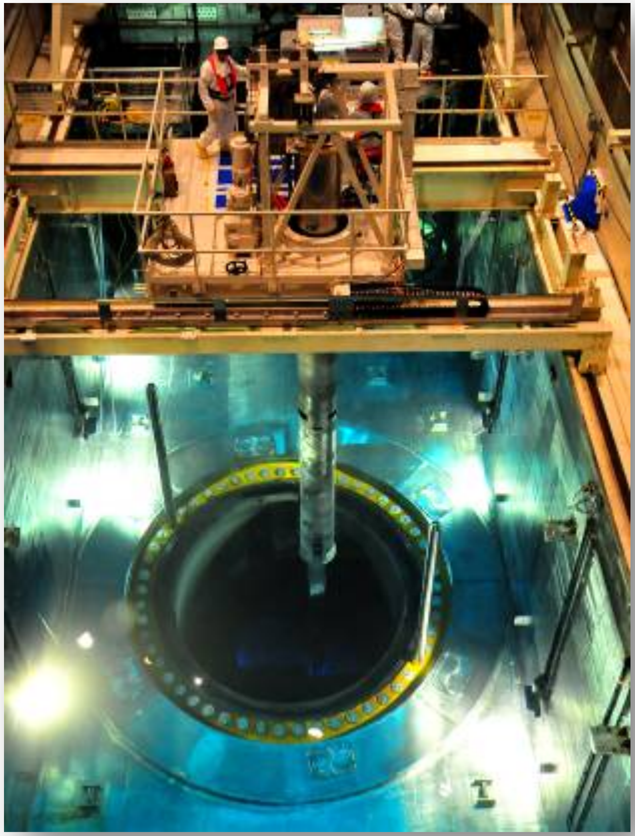
Palo Verde Participants



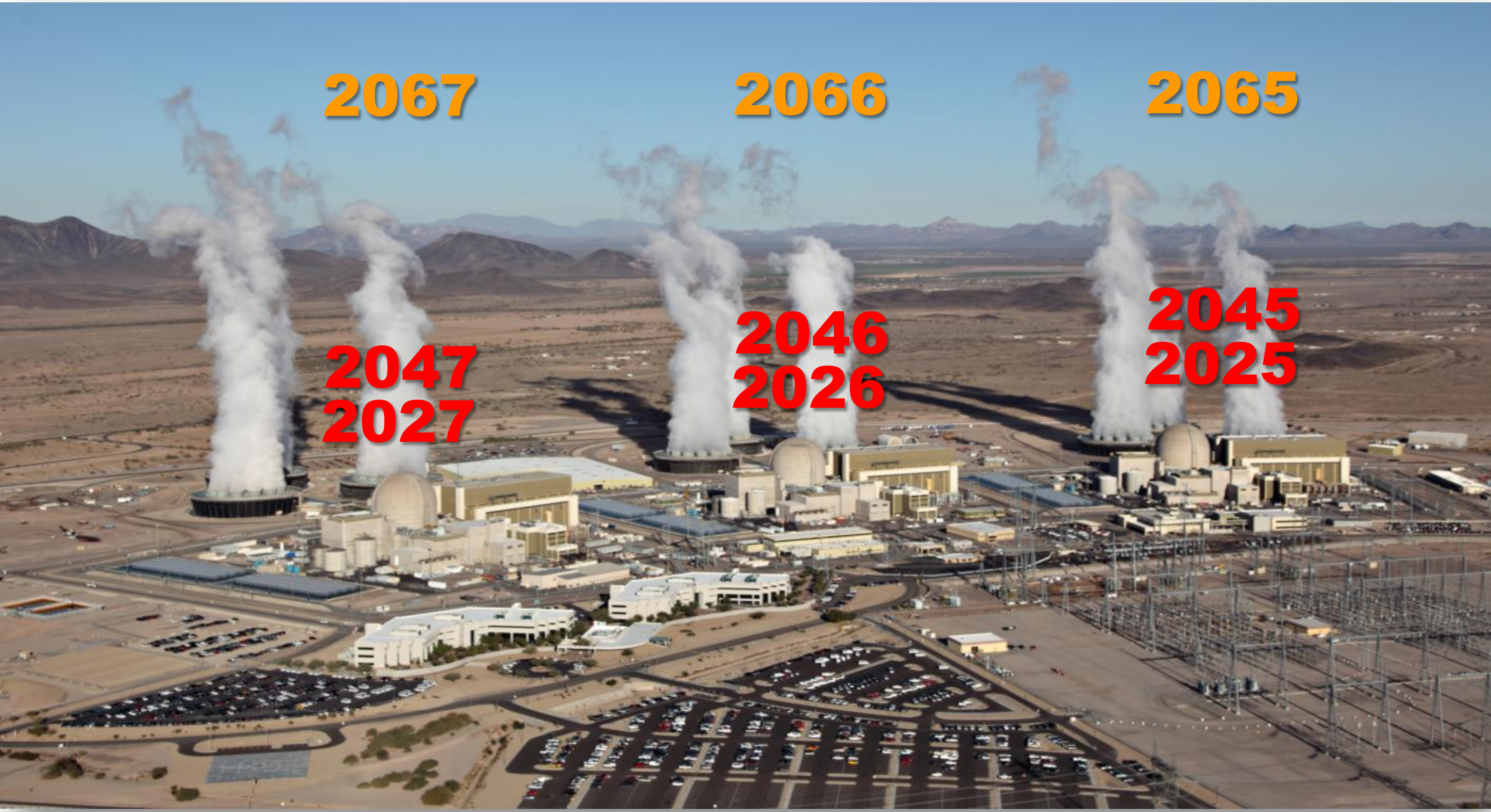
Palo Verde…

By the Numbers

- Largest power generator in the U.S.
- Total output 4,030 net megawatts
  - Meets the electrical needs of approximately 4 million people around the clock



License Renewal



Palo Verde Economic Impact

- Total estimated annual impact of $1.8 billion in Arizona
  - Largest single commercial taxpayer in Arizona, including nearly $50 million in property taxes annually
  - Local purchases of materials and services
  - Palo Verde employees donate approximately $1 million annually to local charities
  - Approximately 2,500 employees

SOURCE: Applied Economics, Palo Verde Economic Study, May 2010

Water to Support Palo Verde

- Industrial and population boom during the late 50' through the 60's in Arizona
- Concept of large nuclear generating station presented to APS Board of Directors in 1969
- Arizona Nuclear Resource Study Group completed study in 1971
  - Nuclear Power Plant was feasible
- Primary issue – water supply
  - Estimated need = 140,000 AFA
    - 46B gallons annually

Cooling Water Options Evaluated

- Groundwater
  - Sustainability
  - Subsidence issues
- Surface Water
  - Limited accessibility
  - Supply fully appropriated
- Colorado River Water
  - Accessibility issues (1973)
- Effluent
  - Adequate supply
  - Reliable and sustainable
  - Not being utilized in 1973

Photo Source-Land Subsidence near Phoenix AZ , courtesy ADWR

Major Concerns in Water Reuse

General

- **Water Use**
- **Water Quality**
- **Quality Variations**
- **Reliability**
- **Aesthetics**
- **Public Health**
- **Discharge Limitations**

Specific

- Scale
- Fouling
- Corrosion
- Temperature
- Biogrowth
- Foaming
- Blowdown

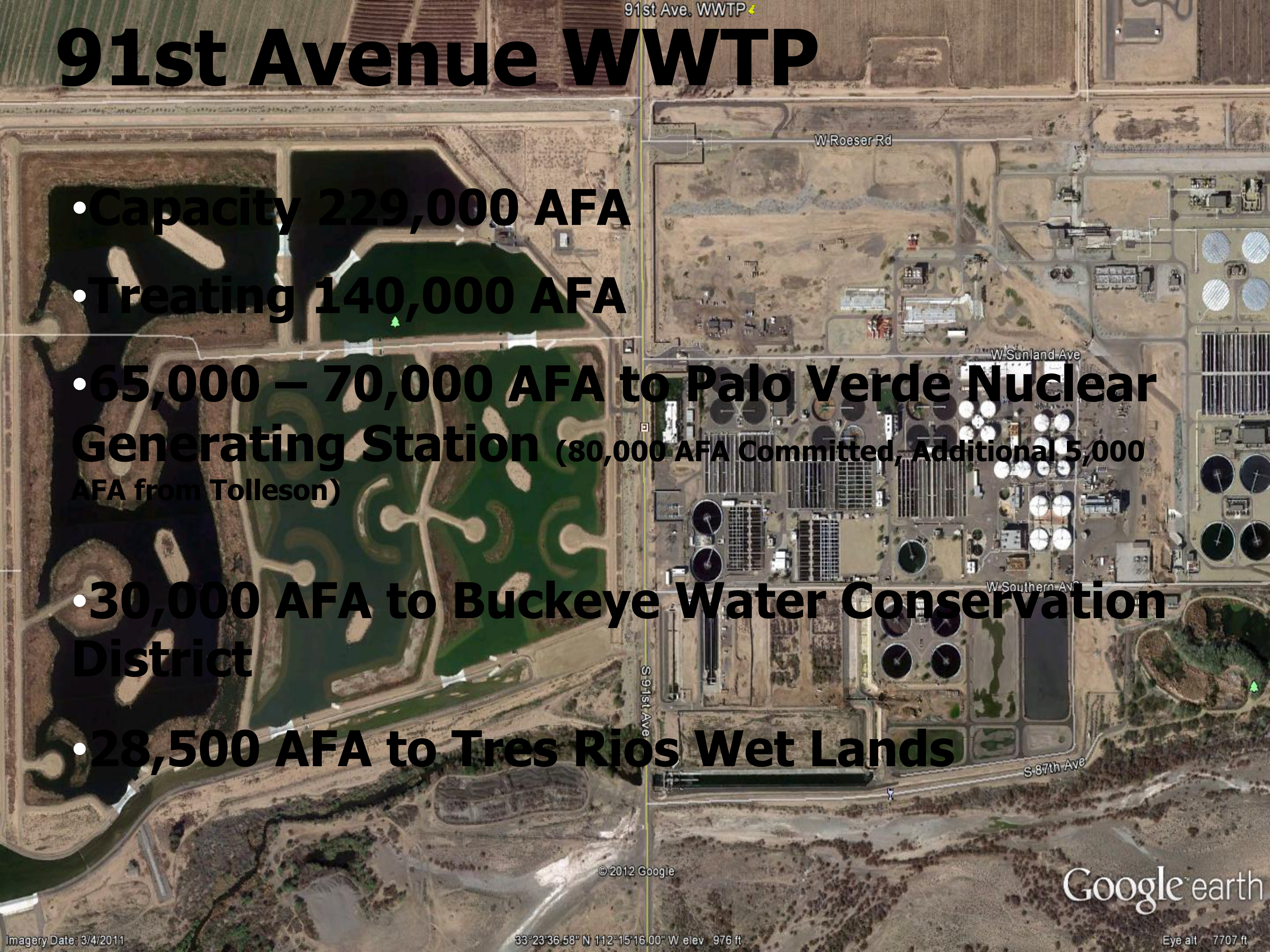
Each of these concerns were fully analyzed prior to construction
Other than foaming these same concerns would exist today

Palo Verde Nuclear Generating Station Water Reclamation Facility

Because of its desert location, Palo Verde is the only nuclear power facility that uses 100% reclaimed water for cooling. Unlike other nuclear plants, Palo Verde maintains "Zero Discharge," meaning no water is discharged to rivers, streams, or oceans.

91st Avenue WWTP

- Capacity 229,000 AFA
- Treating 140,000 AFA
- 65,000 – 70,000 AFA to Palo Verde Nuclear Generating Station (80,000 AFA Committed, Additional 5,000 AFA from Tolleson)
- 30,000 AFA to Buckeye Water Conservation District
- 28,500 AFA to Tres Rios Wet Lands



Conveyance System

28.5 miles of gravity flow with 100-foot elevation drop,
8 miles pumped flow with 150-foot elevation increase
Total volume ~67 Million Gallons

Phoenix-area Water Treatment Plants

6 miles of 114" gravity flow pipe

8 miles of 66" pressure flow pipe

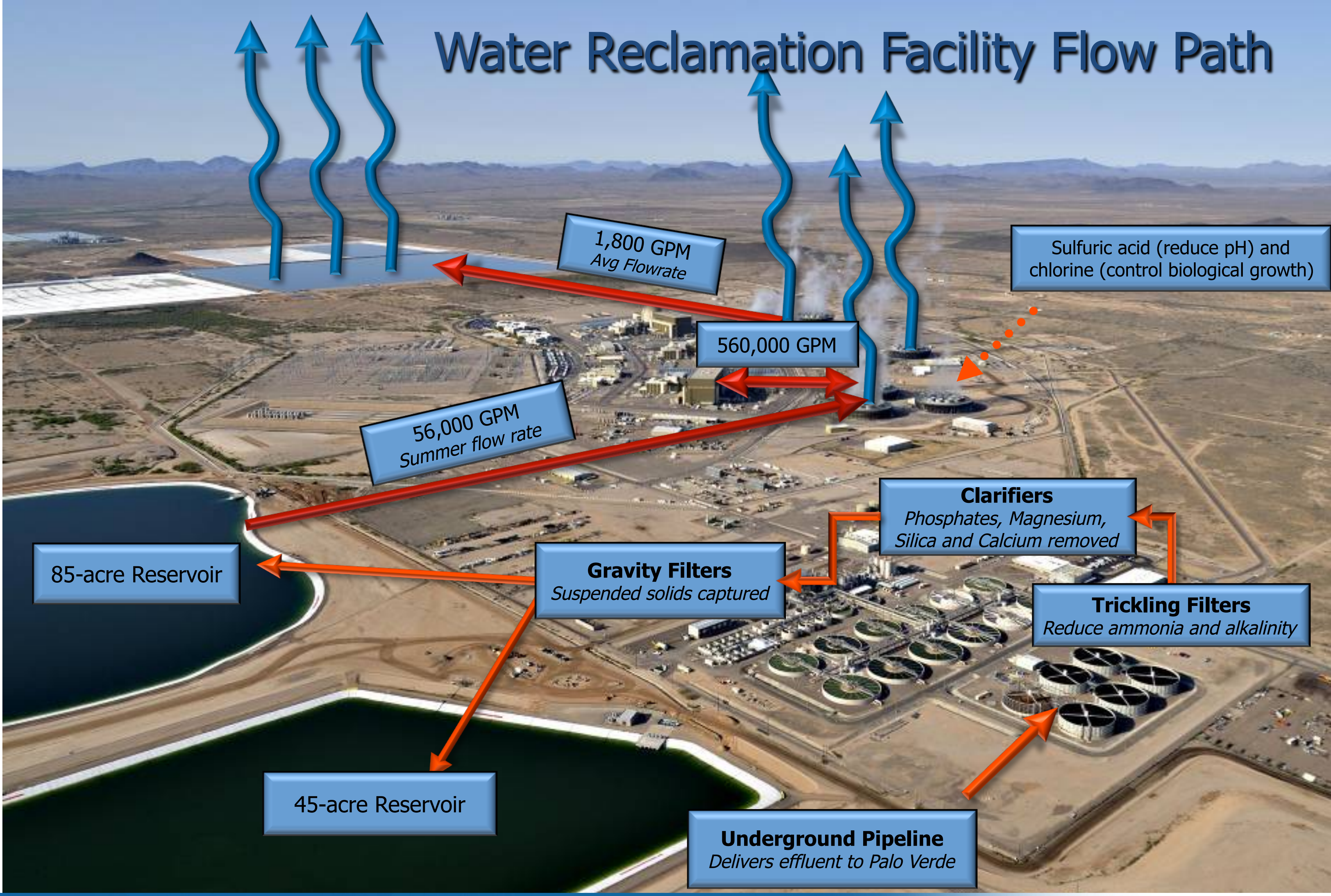
22.5 miles of 96" gravity flow pipe

Hassayampa Pump Station

Water Reclamation Facility

The Palo Verde Water Reclamation Facility (WRF), is a 90 MGD tertiary treatment plant that reclaims treated secondary effluent from local valley cities.

Water Reclamation Facility Flow Path

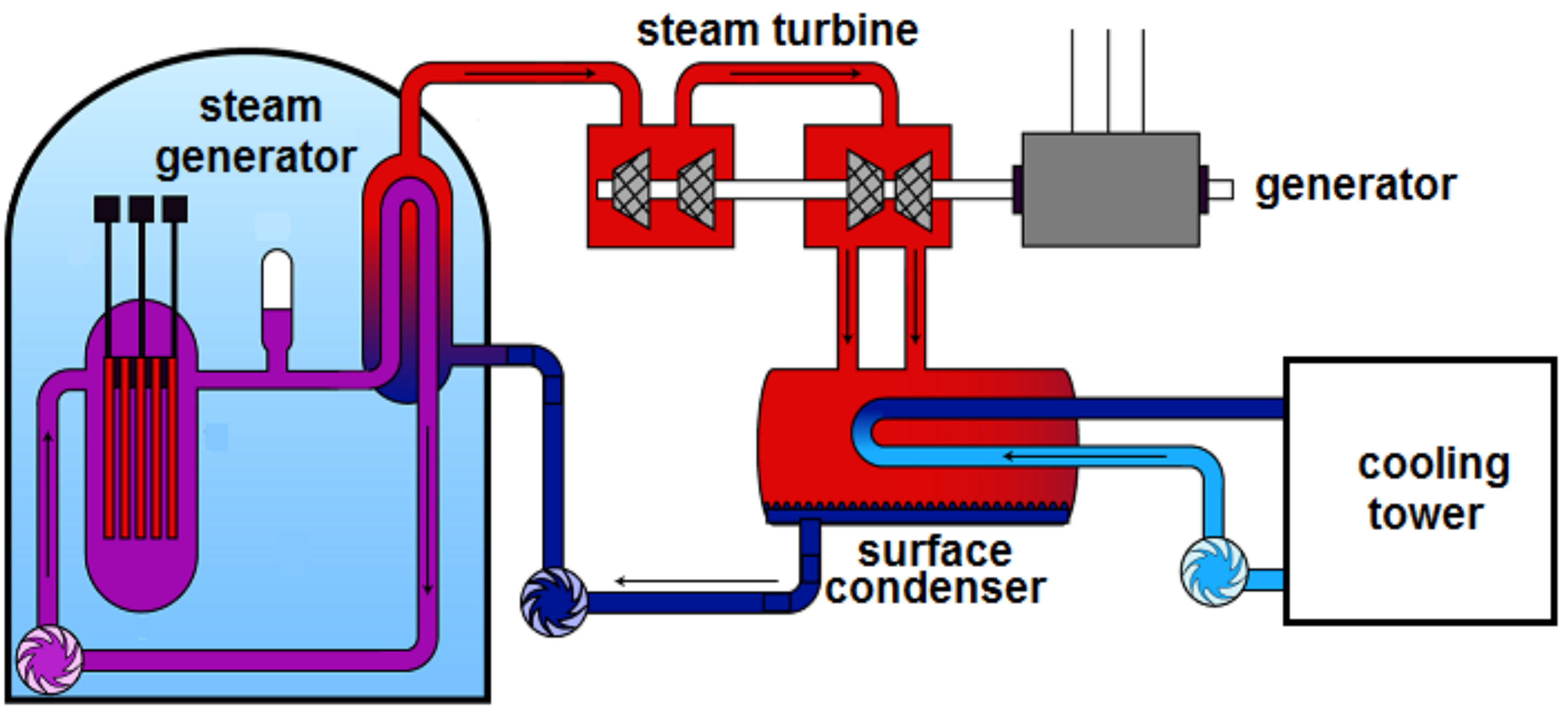


Water Use

- Average cooling water intensity
  - 760 gallons/MWh
- Average cooling water make-up
  - 73,000 acre feet
- Cooling water cycles
  - 23 – 25
- Cooling tower blowdown
  - 3,000 Acre Feet (>5%)

Nuclear Plant Water Use

Secondary Loop

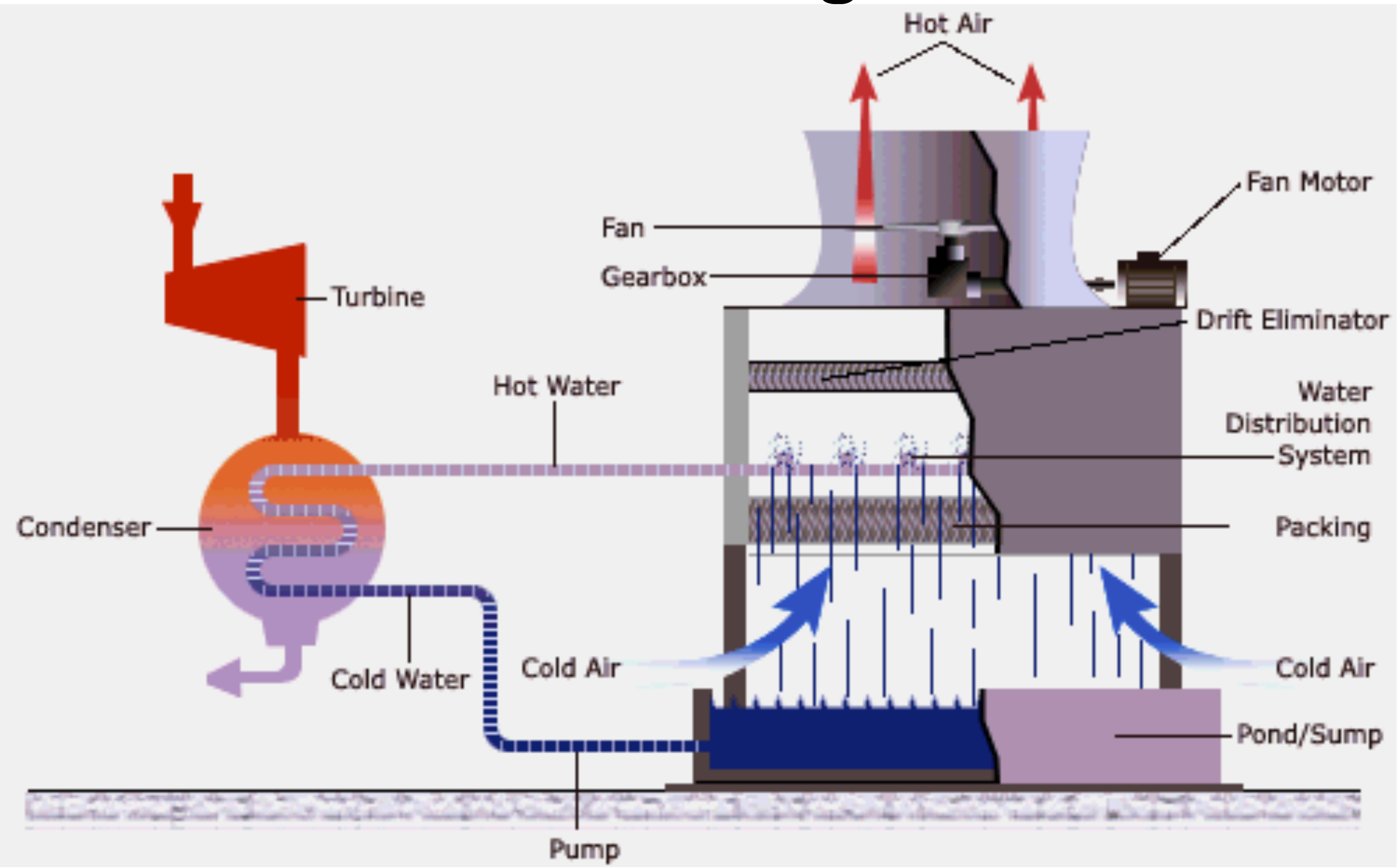


Primary Loop

Tertiary Cooling Loop

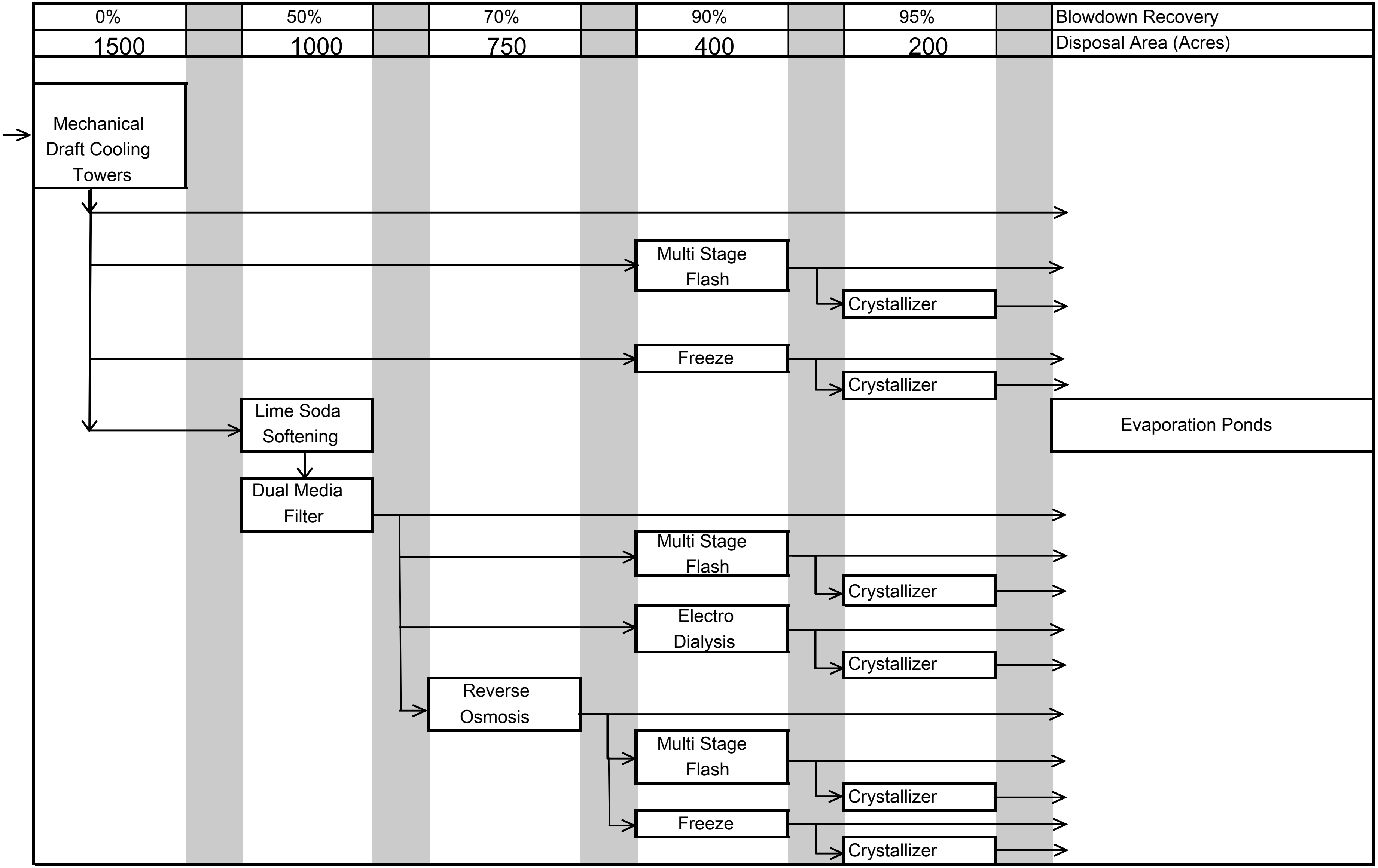
16

Mechanical Draft Cooling Tower



Mechanical Draft Towers → wet cooling standard for power plants

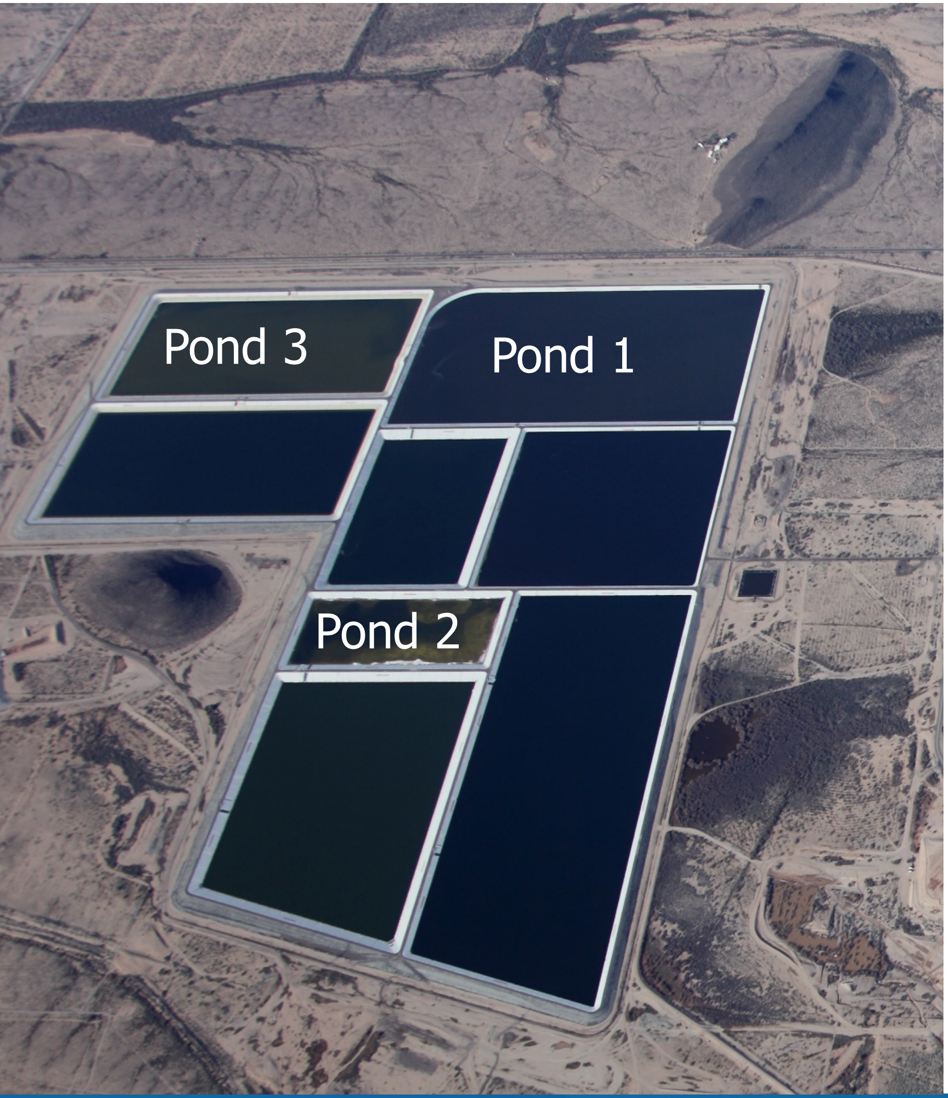
Blowdown Recovery Options



Regulatory Requirements

- **Must achieve 15 cycles of concentration in cooling towers**
- **And, cooling tower circulation water cannot exceed 30,000 mg/l TDS**
  - **Therefore, influent cooling water cannot exceed 2000 mg/l TDS and still be concentrated the required 15 times**
  - **15 cycles (2000 mg/l) = 30,000mg/l**
  - **And, Palo Verde strives to exceed the 15 cycles in order to better conserve water, goal is approximately 23-25 cycles.**
  - **At 25 cycles, the influent water cannot exceed 1500 mg/l TDS, or the circulation water TDS limit will not be met**
  - **Influent water quality can exceed 1500 mg/l TDS in summer**
- **TDS of PVNGS influent must be monitored**

Evaporation Ponds



- Pond 1
  - Constructed 1980
  - 250 Surface Acres
  - Liner failure in 1987
  - Relined & Segmented 2013
  - Volume 5,218 AF
- Pond 2
  - Constructed 1987
  - 220 Surface Acres
  - Relined & Segmented 2011
  - Volume 5,009 AF
- Pond 3
  - Constructed 2009
  - 180 Surface Acres
  - Volume 6,542 AF

Evaporation Pond Characteristics

- Blowdown TDS 25,000 – 29,000 ppm
- Typical TDS ~100,000 – 200,000 ppm
- No mixing occurs
- 12" – 18" solids after 20 years of service

Solids Deposition in Evaporation Pond 3

- **Solids from EP#2 was pumped to EP #3A & B**
- **Ponds were filled and liquid was allowed to evaporate**
- **As concentration increased solids deposition occurred**

Impacts of Solids Deposition on Liner

- Leakage has been identified in sumps
- Pond level is being lowered
- Material will have to be removed to determine impact to liner
- Method has to be developed to mitigate further liner damage

PALO VERDE

aps

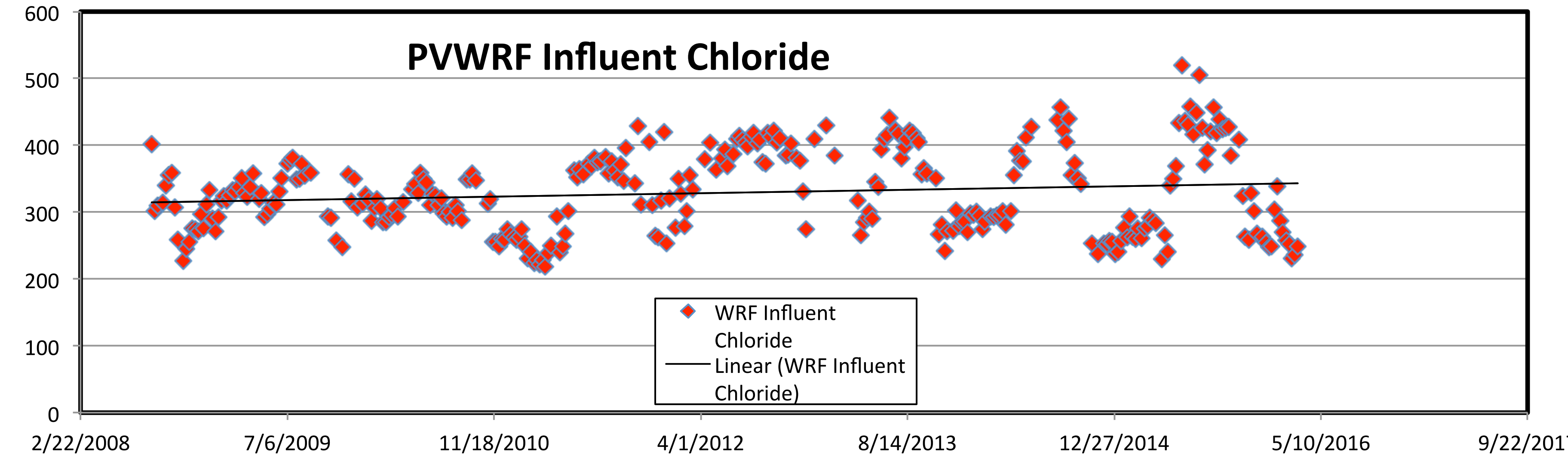
Cooling Water Treatment

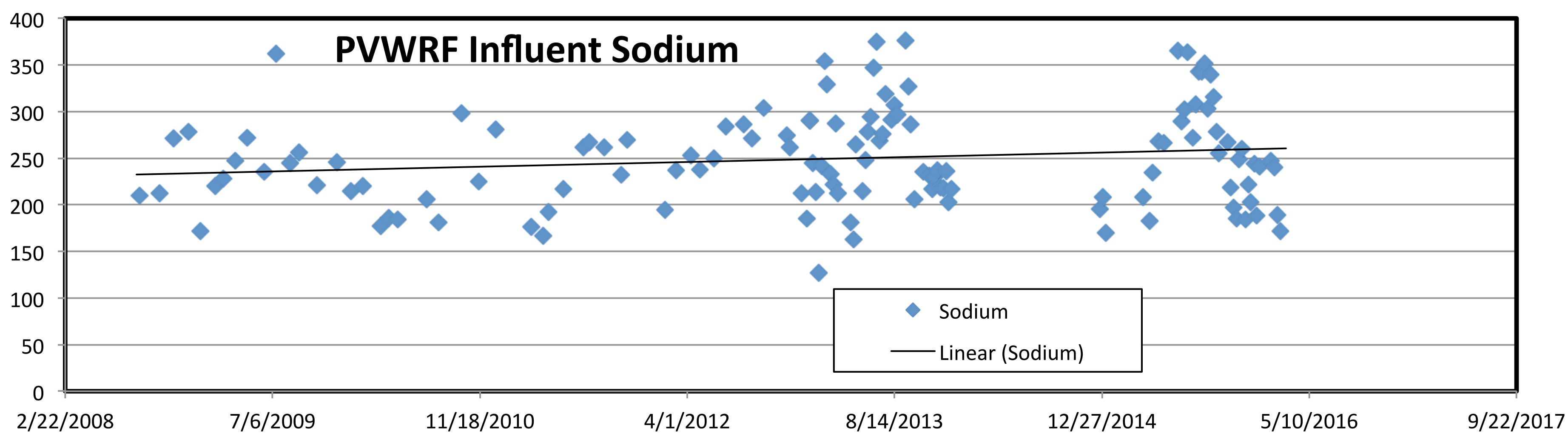
- Softening of wastewater treatment plant (WWTP) effluent is a necessity in order to minimize scaling potential and minimize quantity of water required

Palo Verde Water Qualities			
Parameters	Palo Verde Influent (Secondary Treatment)	Palo Verde Effluent (Tertiary Treatment)	Palo Verde Unit Cooling Towers (Targets)
Ca (mg/l)	178.9 (as $CaCO_3$)	87.84 (as $CaCO_3$)	500-2500 (as $CaCO_3$)
Mg (mg/l)	145.7 (as $CaCO_3$)	23.26 (as $CaCO_3$)	100-750 (as $CaCO_3$)
Na (mg/l)	259.1	292.79	3,000-10,000
NH_3 -N (mg/l)	0.2	0.13	
SO_4 (mg/l)	179.5	215.24	5,000-8,500
Cl (mg/l)	349	355.96	5,500-10,000
NO_3 (mg/l)	4.4	6.34	200-350
PO_4 (mg/l)	9.3	0.23	<10
SiO_2 (mg/l)	17.8	4.27	130-150
PH	7.5	9.2	6.9 – 7.4
TDS (mg/l)	900 - 1200	971.57	15,000-25,000
Hardness (mg/l)	300 (as $CaCO_3$)	110 (as $CaCO_3$)	600-3,250 (as $CaCO_3$)
Alkalinity (mg/l)	166.2 (as $CaCO_3$)	30.05 (as $CaCO_3$)	30-60 (as $CaCO_3$)
TSS	25.6	2.18	40-100
Turbidity		2.87	15-40
Conductivity	1763.7	1697.59	15,000-30,000

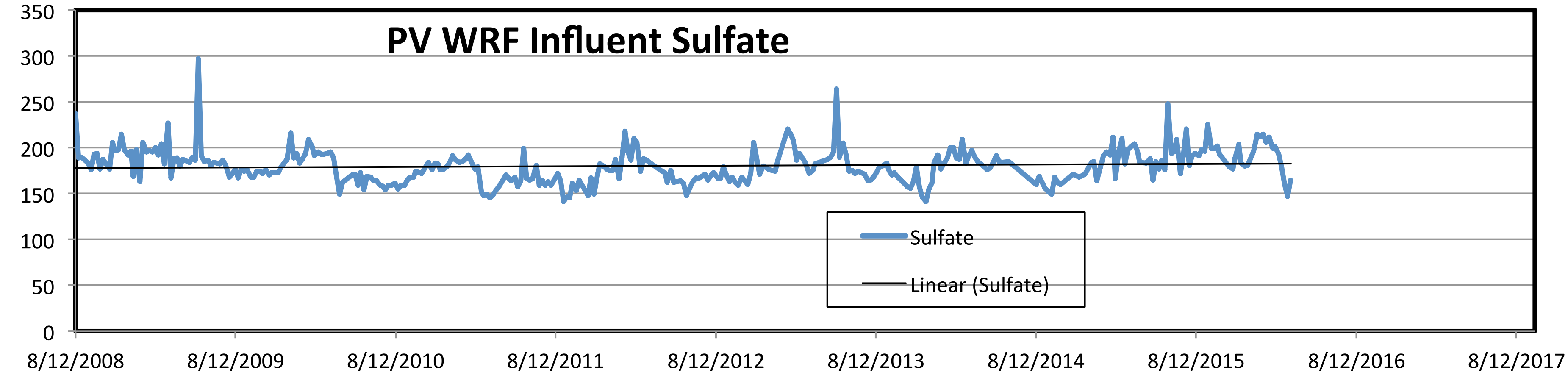
Influent and Effluent values are 2013 actuals

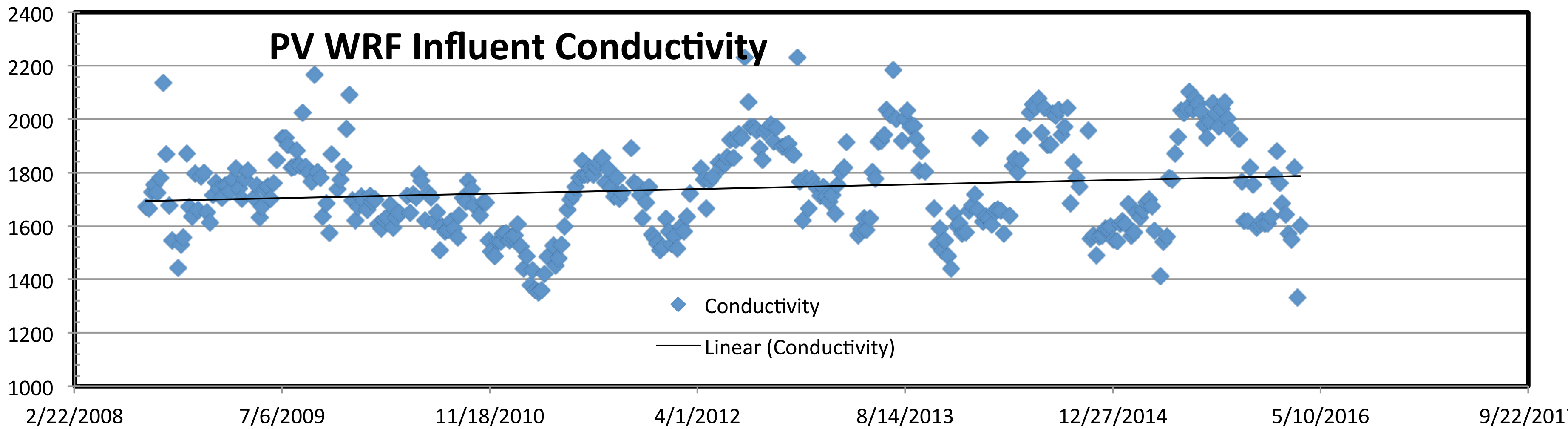
PV WRF Water Quality

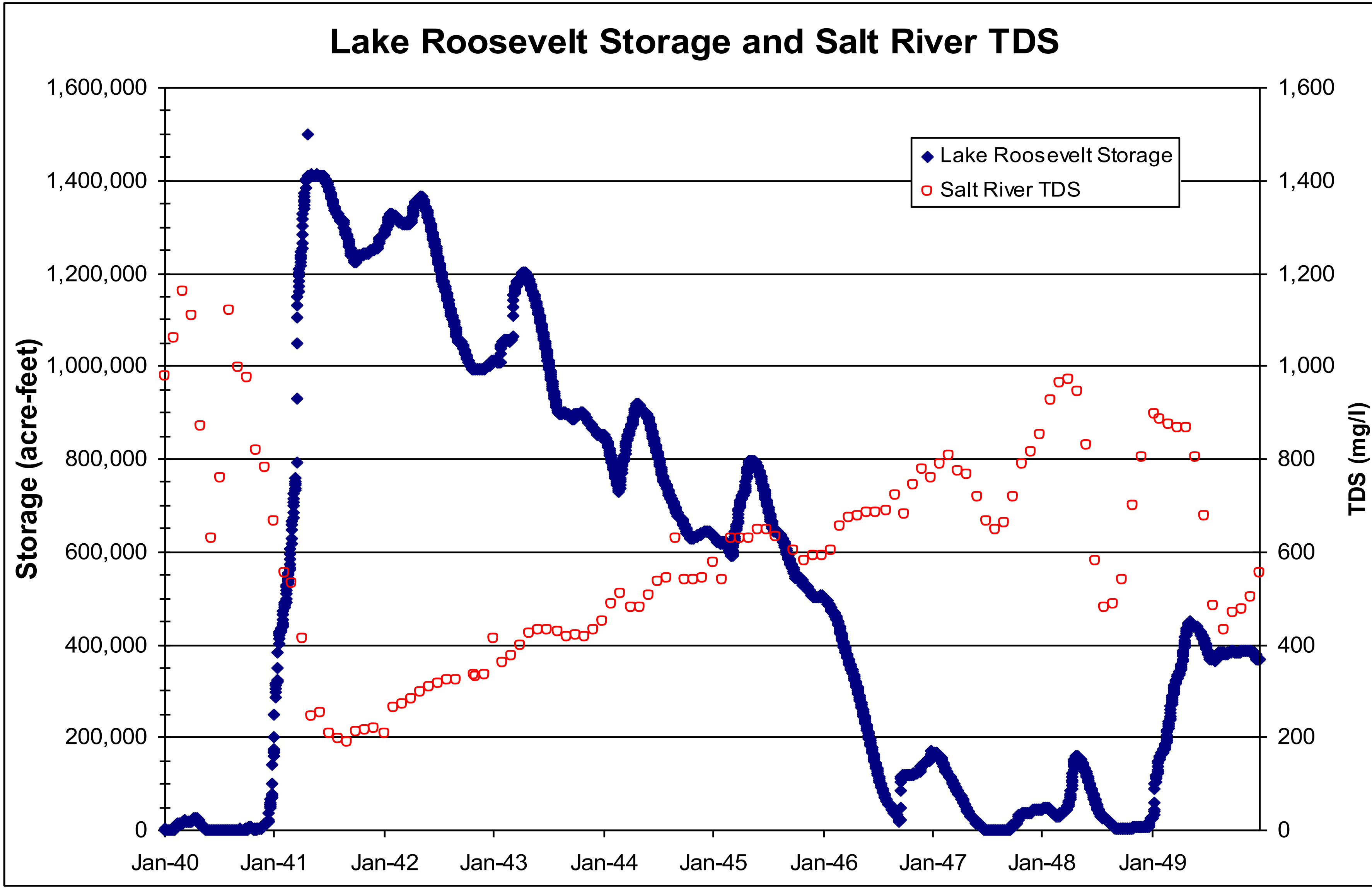




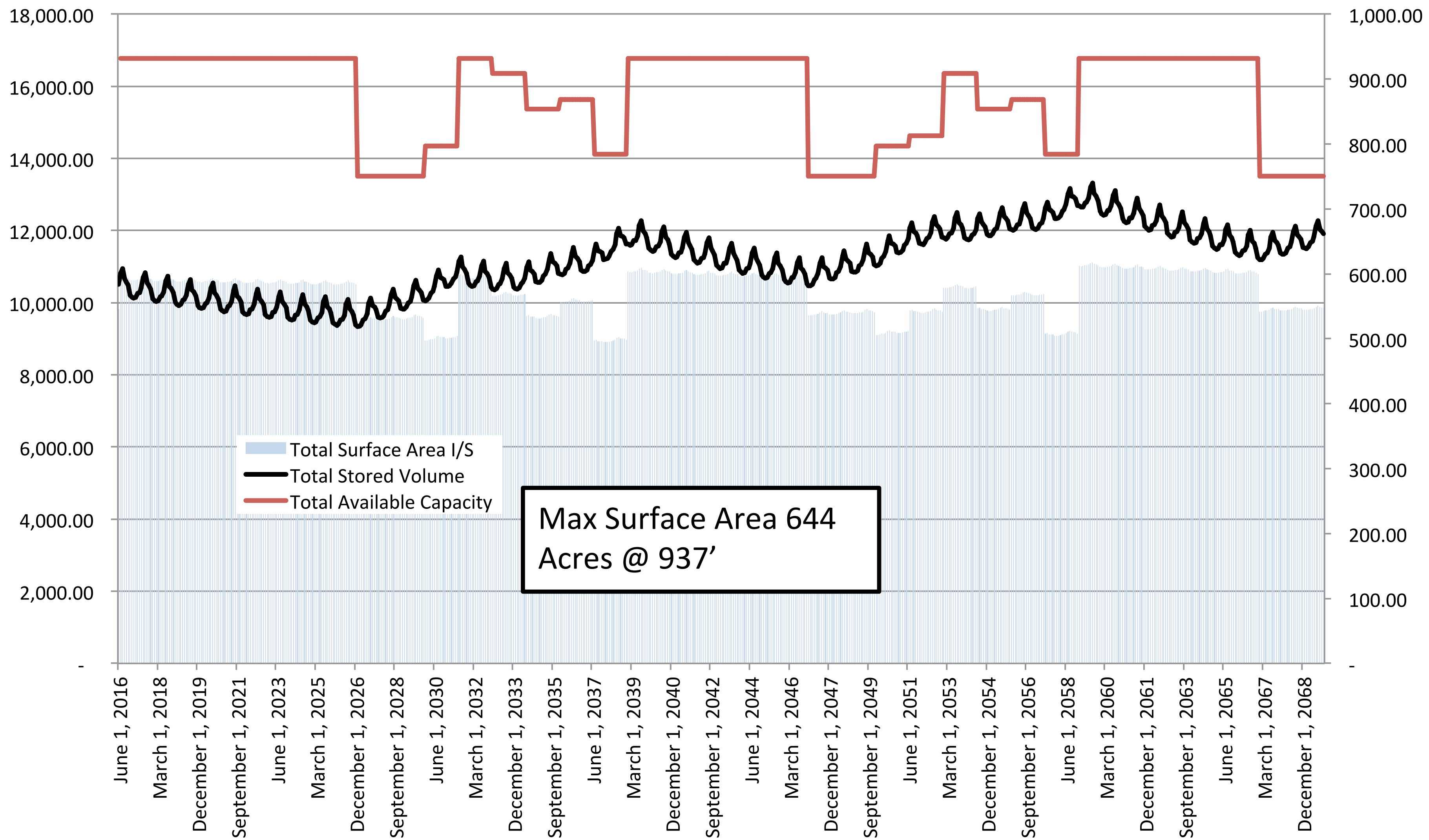
PV WRF Water Quality



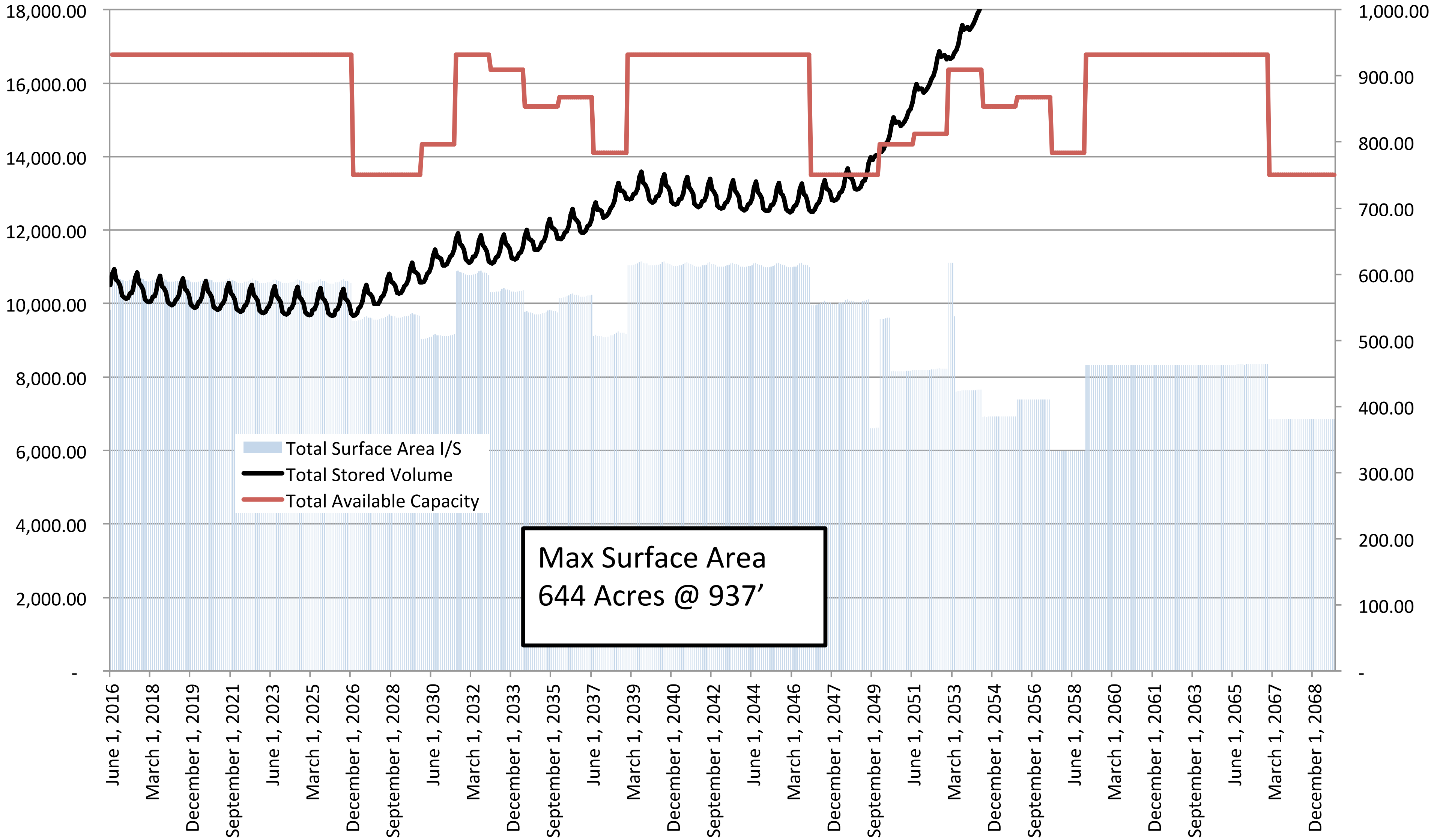



Lake Roosevelt Storage and Salt River TDS
Storage (acre-feet)
TDS (mg/l)
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1,600
1,400
1,200
1,000
800
600
400
200
0
Jan-40
Jan-41
Jan-42
Jan-43
Jan-44
Jan-45
Jan-46
Jan-47
Jan-48
Jan-49
Lake Roosevelt Storage
Salt River TDS

Evaporation Pond Trending



Water Quality Impact of 0.2%



Future Considerations

- With Adequate Long Range Planning These Options May be Considered
  - Alternative Cooling Technology
  - Blowdown Recovery/Side Stream Treatment
  - Improve Heat Transfer Efficiency
- Without
  - Future Evaporation Ponds

Additional Impacts to Consider

- **High Chloride Water Impacts on Concrete Structures**

Cooling Tower Support Beams

WRF Clarifier Feed Sump

Conclusions

- Influent TDS trends must be monitored for two reasons:
  - WRP is not designed to remove TDS
    - Increases in influent TDS may require advanced treatment
  - To ensure current evaporation pond capacity is sufficient
    - Addition of new pond capacity requires extended planning time and capital expenditure
- Cost of a new pond is approximately $8–10/square foot
  - Excavation, sideslope armoring, leachate collection
  - 650 surface acres
  - 30,000,000 square feet of total pond area
    - 60-mil HDPE primary liner
    - drainage geonet
    - 60-mil HDPE secondary liner
    - geotextile liner

GOOD NEWS - BAD NEWS

- If it rains, salinity will decrease

- We live in a desert