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Pilot Tests of CBM Produced Water Desalination: Navajo Dam, NM

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Water Disposal from Coal-Bed Methane Wells is Costly

- **Coal bed methane (CBM) supplies ~7% of US natural gas; expected to double in next decade**
- **To access methane, large volumes of brackish water must be removed *(water must be* disposed of or treated)**
- **Disposal Cost: $3-4+/bbl for producers in northern NM due to remoteness, lack of infrastructure, away from the electric grid**
- **To lower cost, methods for treating/reclaiming water sought**

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Primary Project Goal

- **Desalinate produced water from a ConocoPhillips coal bed natural gas well in the San Juan Basin, using optimum technology, and, at the same time provide desalinated water for beneficial use meant for:**
  - **Riparian improvement (Joel Brown/USDA, Jornada Experimental Range, Las Cruces)**
  - **Rangeland improvement/Revegetation of Disturbed Land (Rick Arnold, Agricultural Science Center, Farmington)**
- **Produced water from the Coal Bed Methane Natural Gas will be desalinated by reverse osmosis in a pilot operation.**

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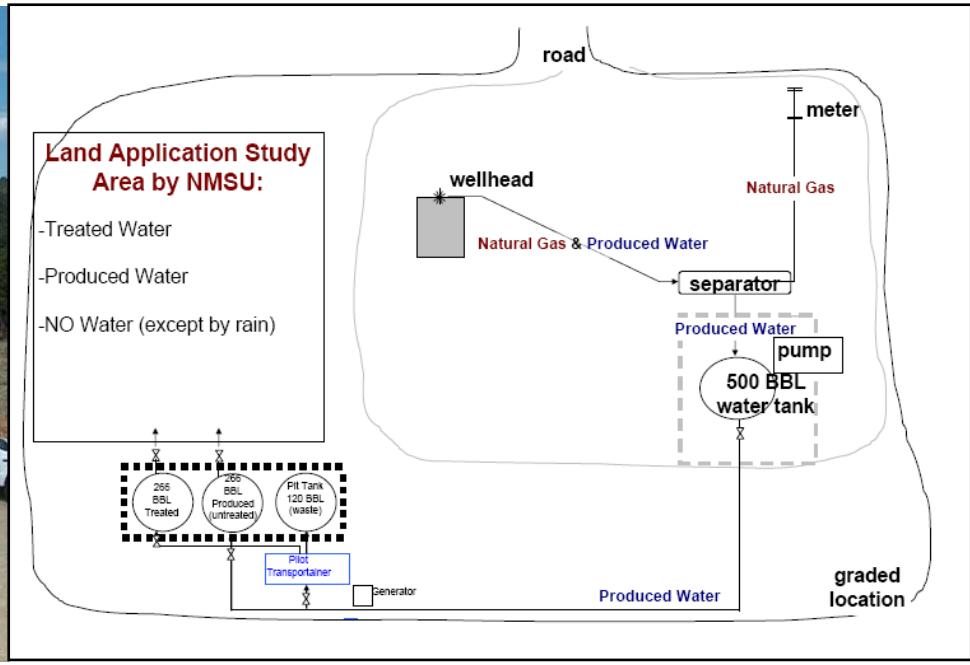
Equipment & Layout at ConocoPhillips CBM Well Pad



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Equipment at ConocoPhillips CBM Well Pad

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Produced Water Chemistry

Analyte	Units	average
Specific Conductance	μS/cm	17,326
Total Dissolved Solids (@ 180 °C)	mg/L	10,696
TDS (calculation)	mg/L	14,468
pH	units	8
Temperature	deg C	16
Total Suspended Solids	mg/L	150
Chloride	mg/L	2,087
Fluoride	mg/L	1
Nitrate	mg/L	1
OrthoPhosphate, as P	mg/L	13
Phosphorous, Total as P	mg/L	13
Sulfate	mg/L	3
Silica	mg/L	10
Total Alkalinity	mg/L	7,785
Calcium	mg/L	27
Iron	mg/L	0
Magnesium	mg/L	6
Potassium	mg/L	23
Sodium	mg/L	4,515

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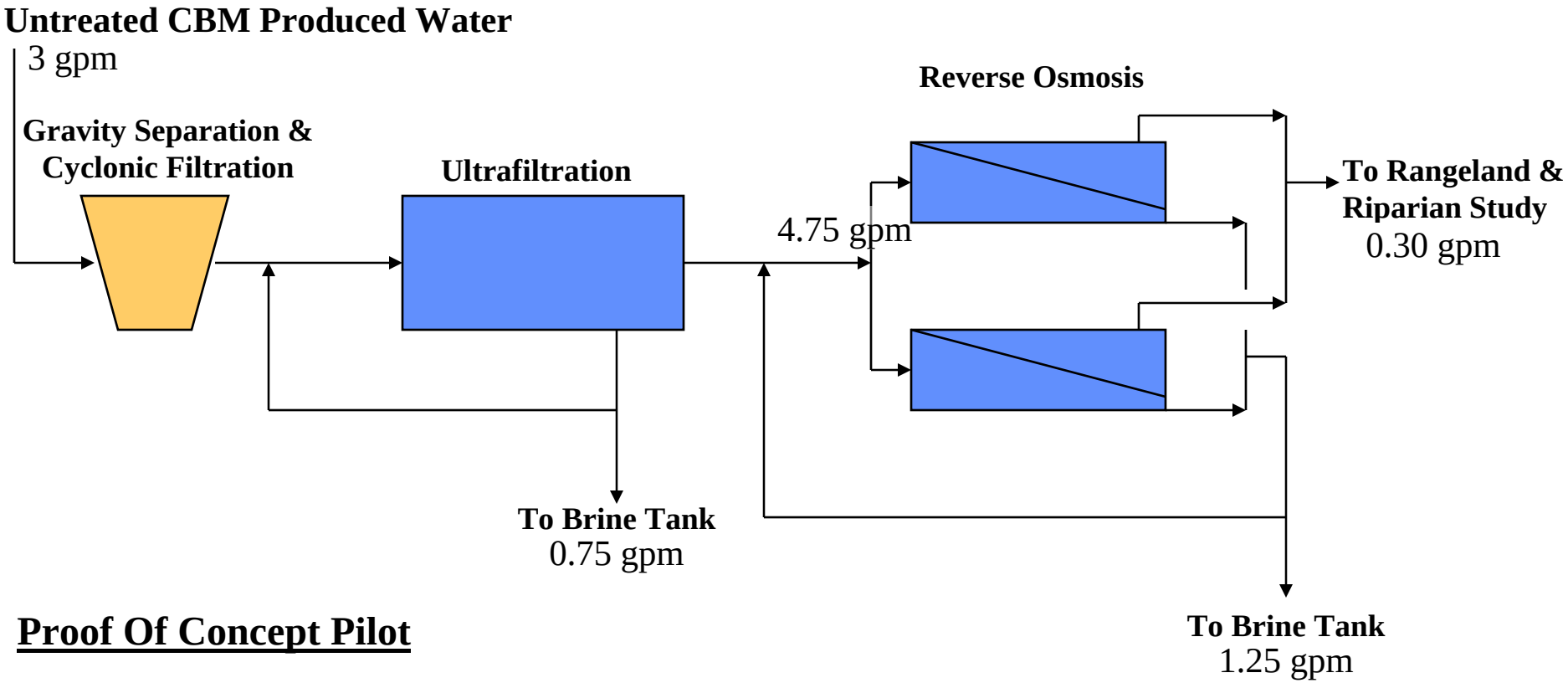
2007 Simplified Pilot Flow Diagram



Proof Of Concept Pilot

- **10% overall efficiency (more membrane surface area required to improve)**
- **UF system: 75% efficiency**
- **RO system: 15-20% efficiency**

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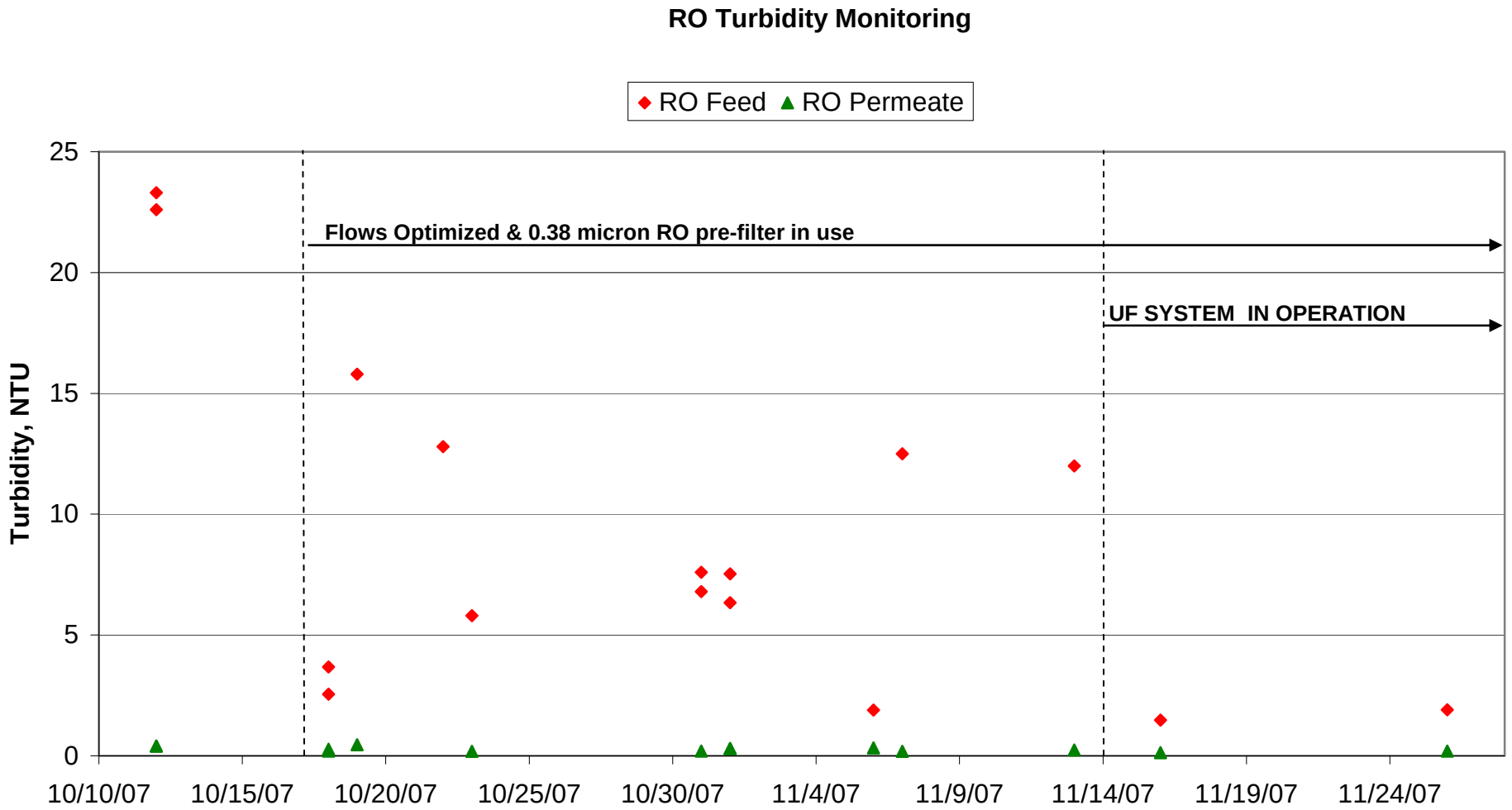
2007 Pilot Data: Turbidity Removal



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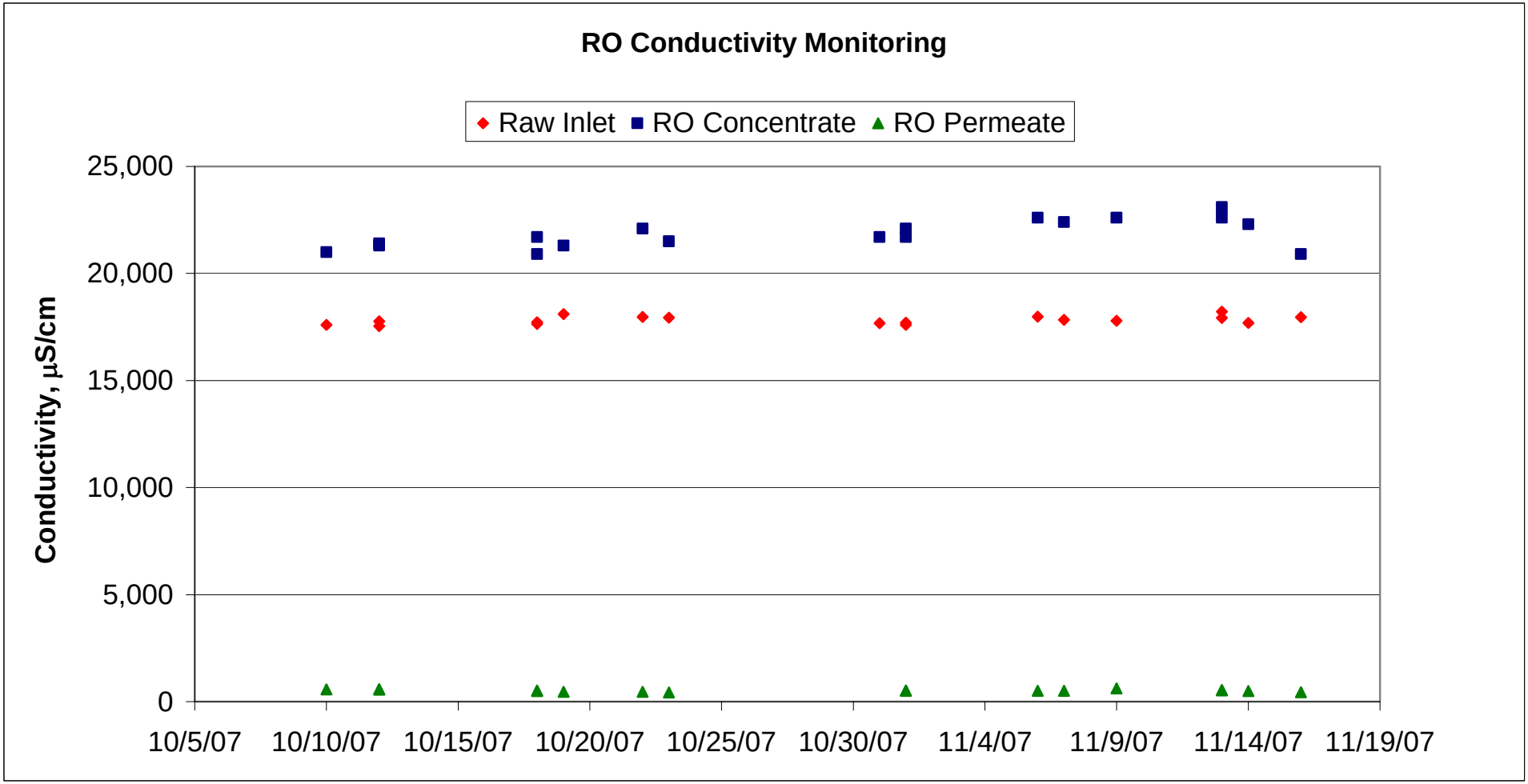
2007 Pilot Data: Turbidity Removal



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2007 Pilot Data: Reverse Osmosis Summary

	RO Concentration Factor (Conc/Raw)		RO Removal Efficiency	
Analyte	10/9/07	11/28/07	10/9/07	11/28/07
Specific Conductance (@ 25°C)	1.14	1.18	98%	98%
Total Dissolved Solids (@ 180°C)	1.11	1.22	98%	98%
TDS (calculation)	1.20	1.26	98%	98%
Total Suspended Solids	0.67	1.07	27%	53%
Chloride	1.06	1.48	98%	97%
Sulfate	1.00	0.67	100%	44%
Silica	1.10	0.76	97%	88%
Total Alkalinity	1.26	1.23	98%	99%
Calcium	0.80	1.15	100%	98%
Iron	3.96	1.68	96%	74%
Magnesium		0.21		100%
Potassium	0.90	1.26	100%	99%

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NMSU/USDA Rangeland & Riparian Improvement Study (2007 & 2008)

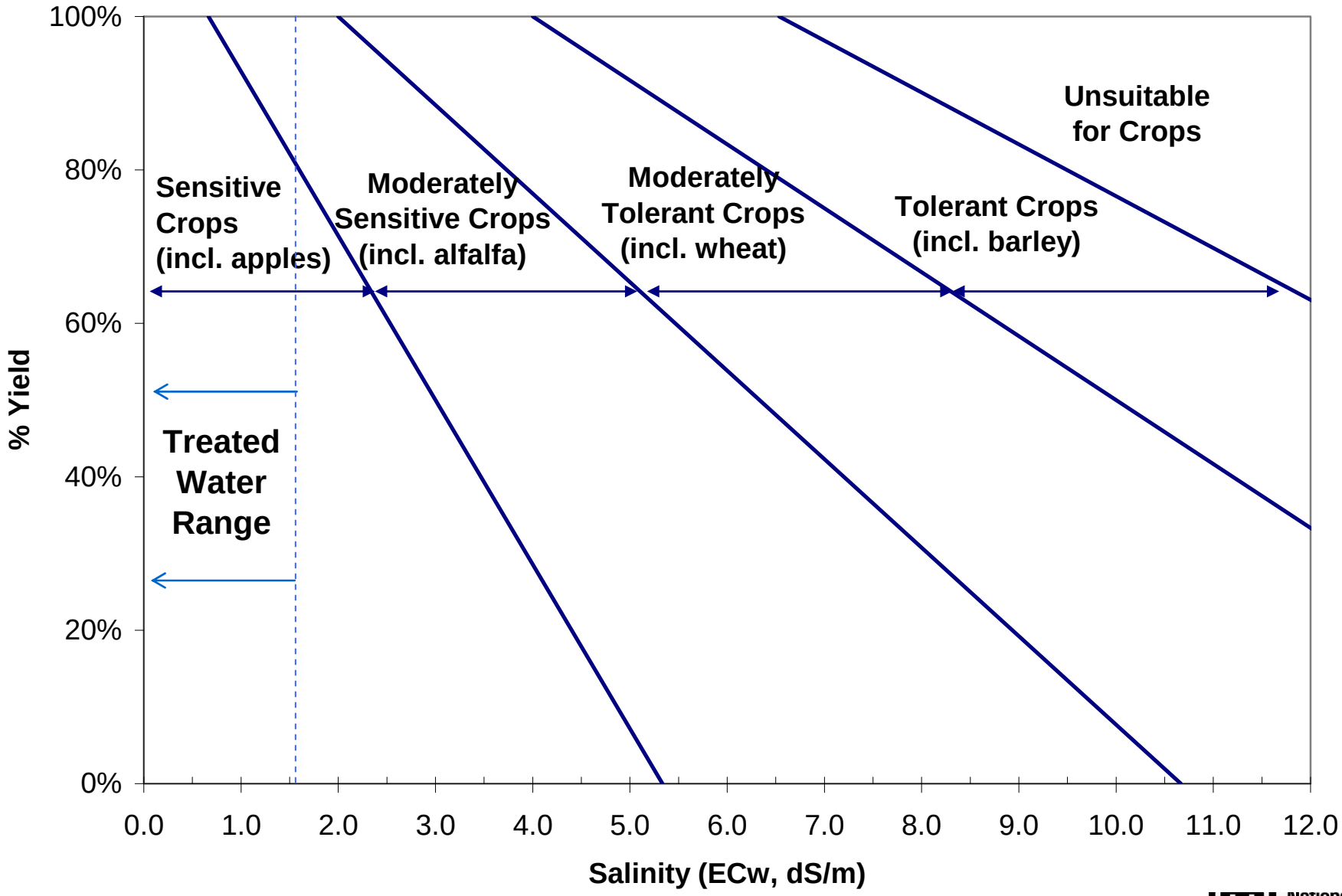
Existing grasses on the San Juan well pad to be treated in the following manner:

~ 1/3 will spot watered with treated/desalinated water

~ 1/3 will spot watered with untreated produced water

~ 1/3 will receives no additional watering

Salinity Tolerance of Crops



Modified from: Ayers and Westcott 1994, "Water Quality for Agriculture"

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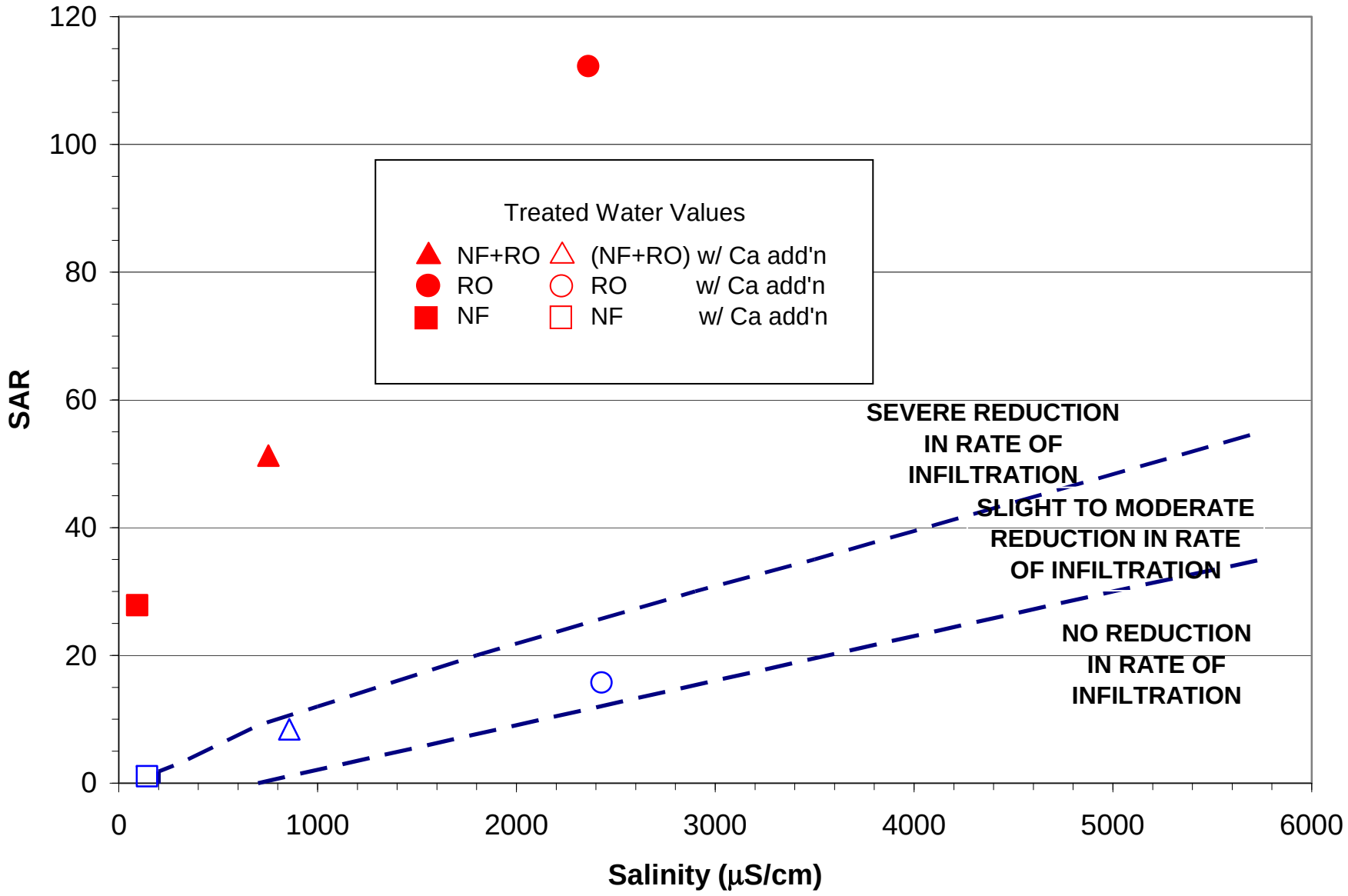
Infiltration Effects: SAR & TDS



Modified from: Ayers and Westcott 1994, "Water Quality for Agriculture"

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Watering grasses of COPC San Juan Well Pad with Untreated Water

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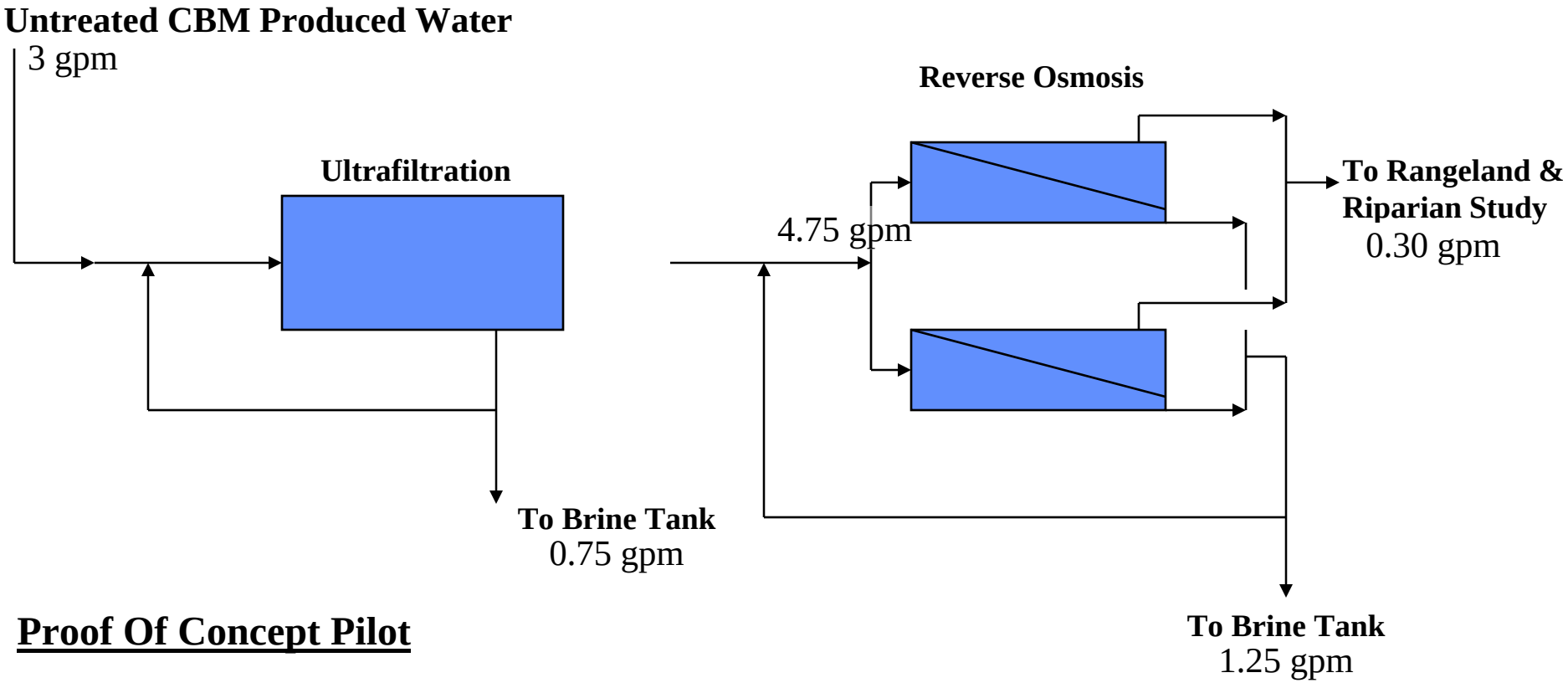
2007 Simplified Pilot Flow Diagram



Proof Of Concept Pilot

- **10% overall efficiency (more membrane surface area required to improve)**
- **UF system: 75% efficiency**
- **RO system: 15-20% efficiency**

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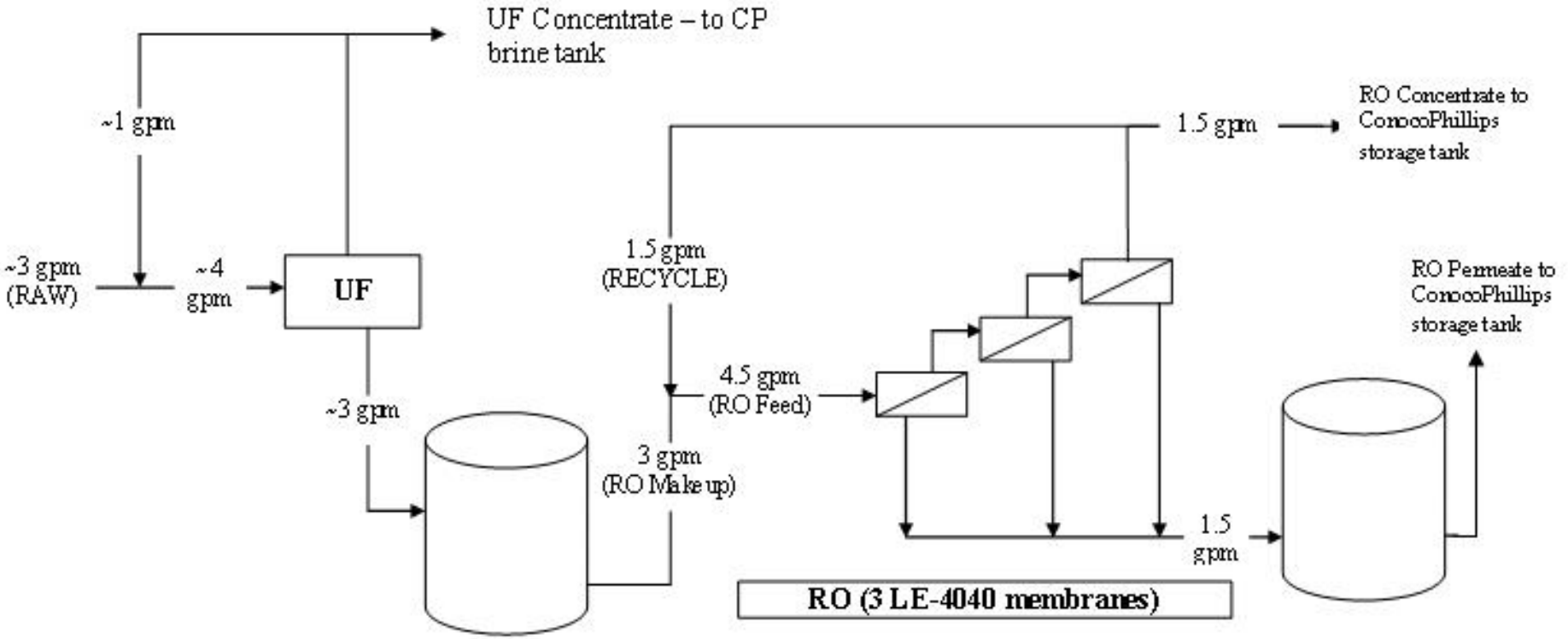
2007 Simplified Pilot Flow Diagram



2008 Pilot

- **50% overall efficiency (more membrane surface area required to improve)**
- **UF system: 75% efficiency**
- **RO system: 33% efficiency**

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Recreation Hall, Sauna, Hot Showers and Club Room

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