IPRO It takes a team INTERPROFESSIONAL PROJECTS PROGRAM

IPRO 302
Zero Liquid Discharge

HydroPure
Clean Water. Clean Energy. Clean Living.

Sponsored by: Sargent & Lundy LLC

Overview

- Problem
- Project
- Goals
- Water Balance
- Options/Cases
- Final Costs
- Conclusion

Visit to Midwest Generation Plant

Our Problem

- Finding the most economical Zero Liquid Discharge system
  - It is difficult to obtain permits to discharge process waste water from facilities that generate electricity.
  - How can we eliminate the power plant’s waste water discharge stream?

Team Organization

Advisors: Don Chmielewski, Myron Gottlieb **Sponsor**: Sargent & Lundy

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Team Leader: William Pattermann

Preliminary Research Teams

1. **Evaporation Pond**
   - Angela Ng (L)
   - Alex Ong
   - Danny Beissinger
2. **Deep Well**
   - Will Pattermann (L)
   - James Lai
   - Mitchell Isoda
3. **Brine Concentrator**
   - Ray Ballard (L)
   - Sahar Ashrafi
   - Woo Sung Shin
4. **Emerging Technology**
   - Ross Hill (L)
   - Catherine Latour

Extensive Research Teams

1. **Physical Team**
   - Alex Ong (L)
   - Angela Ng
   - Woosung Shin
2. **Regulatory Team**
   - James Lai (L)
   - Danny Beissinger
3. **Technological Team**
   - Sahar Ashrafi (L)
   - Ray Ballard
   - Catherine Latour
4. **Financial Team**
   - Mitchell Isoda (L)
   - Ross Hill

Final Teams

1. **Final Presentation Team**
   - Ray Ballard (L)
   - Angela Ng
   - Will Pattermann
   - Ross Hill
2. **Final Report Team**
   - Sahar Ashrafi (L)
   - Mitchell Isoda
   - Catherine Latour
3. **Poster Team**
   - Danny Beissinger (L)
   - Woosung Shin
4. **Brochure Team**
   - Alex Ong (L)
   - James Lai

Project Challenges

- Fully understanding the problem given by Sargent & Lundy
- Difficulty finding extensive research
- Finding the time to do all research and presentations

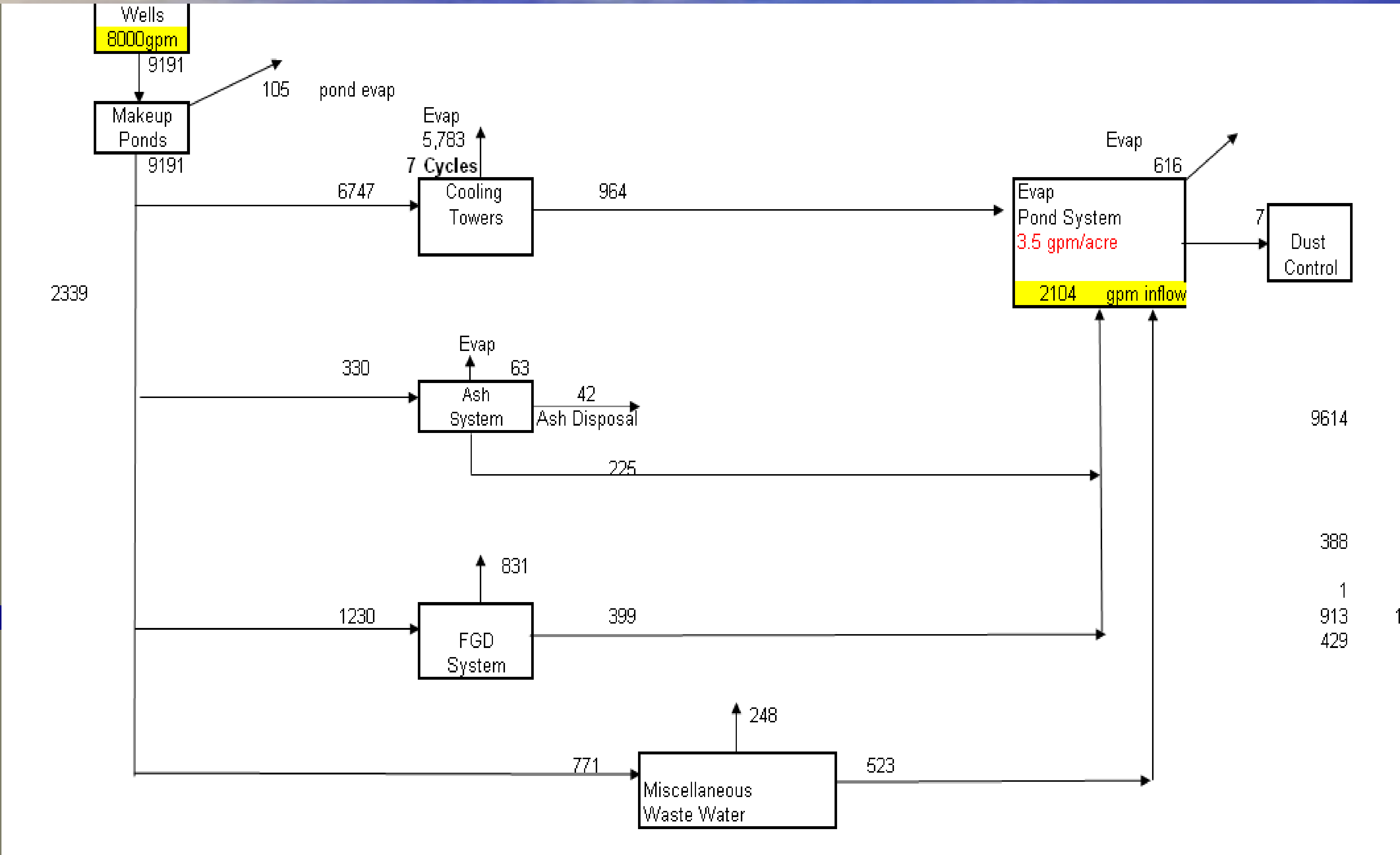
Team Ethical Challenges

- How to deal with uncooperative team members
- Determining how in depth research should be distributed
- Communication among members

Our Goal

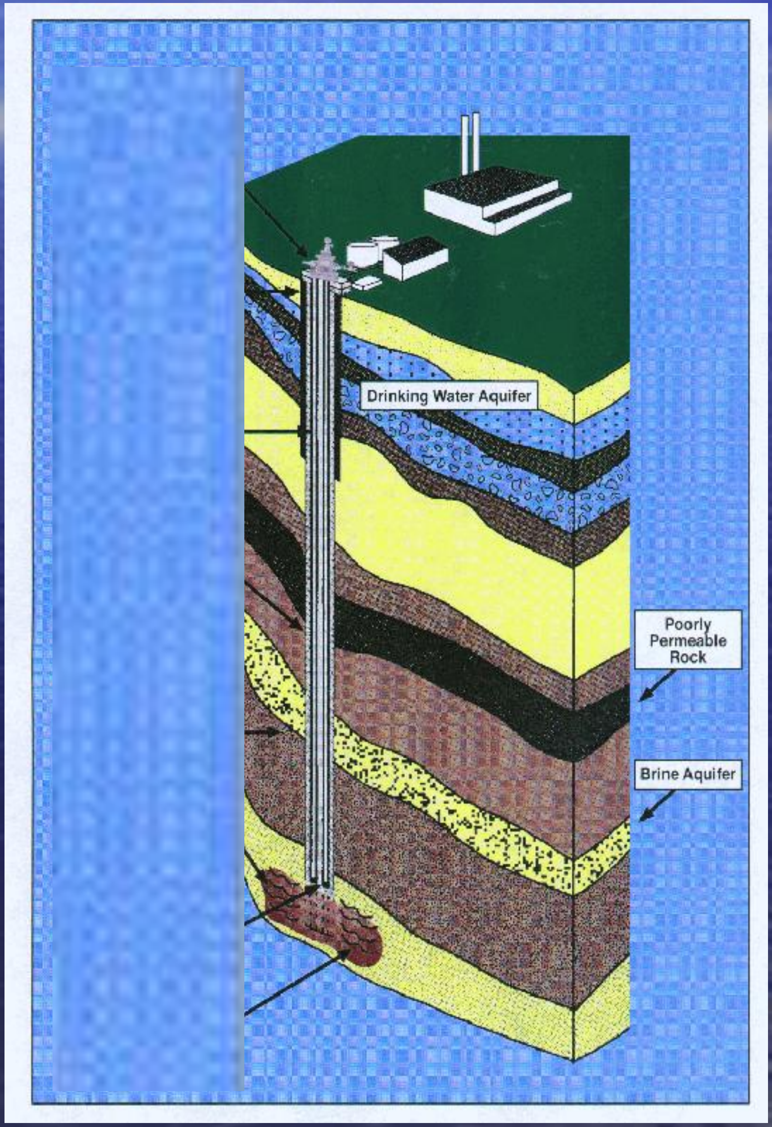
- Identify, evaluate, and prioritize technologies that can be used to eliminate waste water output
  - Water balance of power plant in Nevada
  - Finding options for reusing and treating discharge water
  - Size, capital cost and operating cost

Water Balance Assumptions



Deep Well

- **Definition**: Man-made wells to inject fluid into the ground, either for disposal or to extract other material from the ground.
- **Goal**: Assess how a deep well could help reduce waste water discharge from a coal power plant.
- **Resolution**: Deep wells are not a feasible solution for zero discharge in Nevada --- all possible injection wells are prohibited by Nevada law



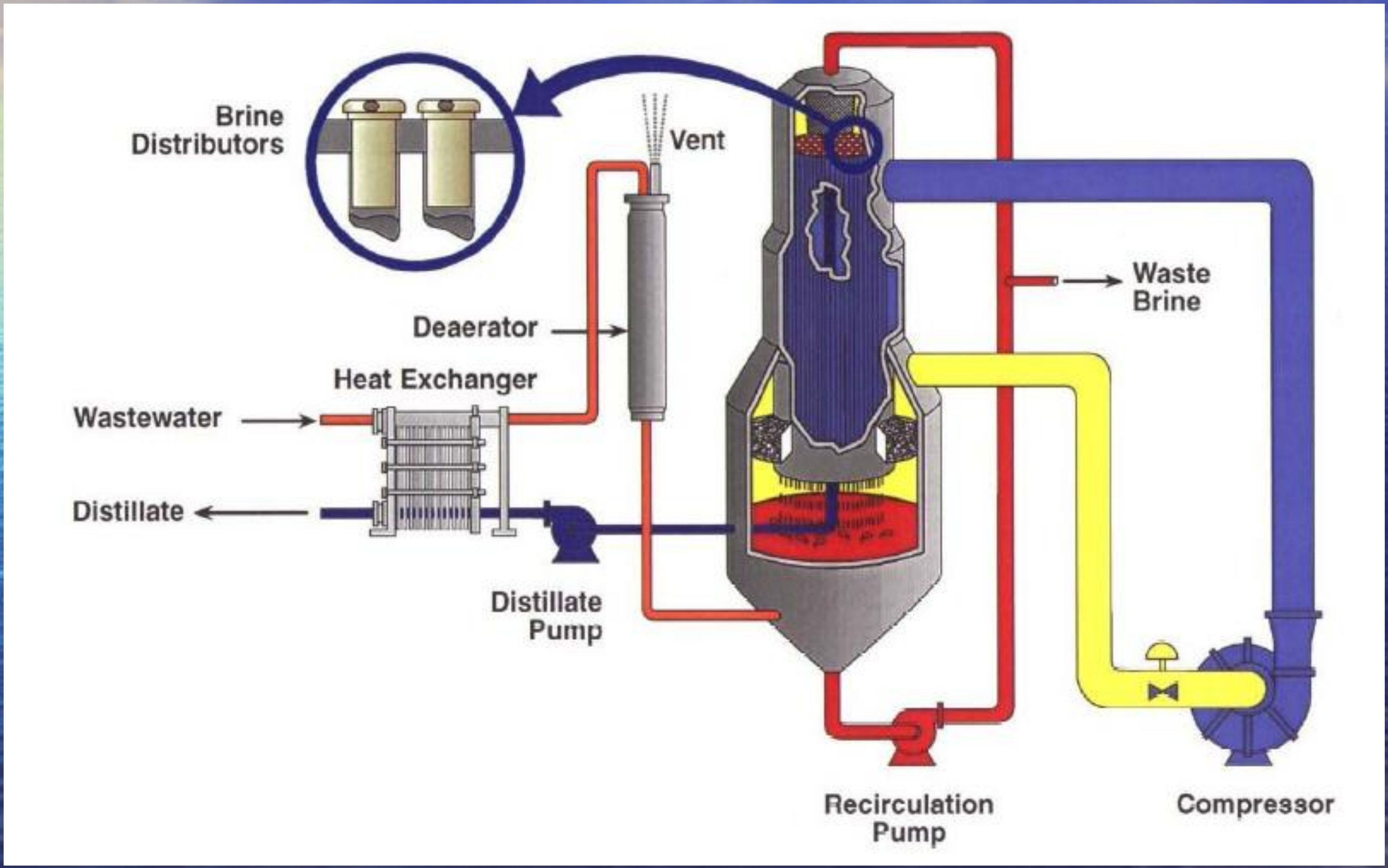
http://www.epa.gov/ogwdw/uic/pdfs/study_uic-class1_study_risks_class1.pdf

Evaporation Pond

- **Definition**: Shallow dugout with very large surface areas to evaporate water by sunlight and exposure to ambient temperatures.
- **Pros**:
  - Relatively cheap compared to other technologies
  - Easy to maintain
- **Cons**:
  - Land consuming
  - Threaten wildlife
  - Low feasibility
  - Lining cost

http://tailings.info/images/pics/content/reclaimponds.jpg

Brine Concentrator



http://www.tundrasolutions.ca/files/casestudies/Deer%20Creek%20Paper%20CIPC_06_16_05.pdf

Brine Concentrator

(Vapor Recompression Evaporator)

- **Definition:** Takes waste water and separates it into outlet streams of clean water and sludge
- Pros:
  - Recovers 95% of plant wastewater
- Cons:
  - High capital Costs
  - High maintenance costs

http://www.tundrasolutions.ca/files/casestudies/Deer%20Creek%20Paper%20CIPC_06_16_05.pdf

Reverse Osmosis (RO)

- **Definition**: Membrane based filtration system used to separate waste system into clean water and concentrated sludge
- Pros:
  - Minimal maintenance
  - 40%-60% of water recovery per unit
  - Low risk of malfunction
- Cons:
  - High initial cost
  - Membrane clogging

http://www.nayagara.net/images123/pictures/reverse%20osmosis%20system.jpg

Evaporation Pond

- Design equation
  - Amount of water entering/evaporation rate = A
  - Depth of pond = 3 ft = D
  - Total Area = 1.2*A (1+0.155*D) / √ A
- Total Design Cost
  - land area
  - drainage pump and pipe
  - primary 80 mil, geonet, and secondary 60 mil liners
  - Bird netting; turtle & perimeter fencing

http://www.geosynthetic.co.uk/images/civil-engineering/large/Evaporation-lagoon-1.jpg

Brine Concentrator

- Compressor & Evaporator
  - Cost based on the flow needed
- Design Constants
  - Used to calculate other costs
- Total Design Cost
  - Capital Cost
  - Materials
  - Labor
  - Indirect Expenses
  - Construction Prices
  - Contractor Expenses

Cb := e^[7.2223+0.8(ln(PC))]

Cs := 10,800*A^[0.55]

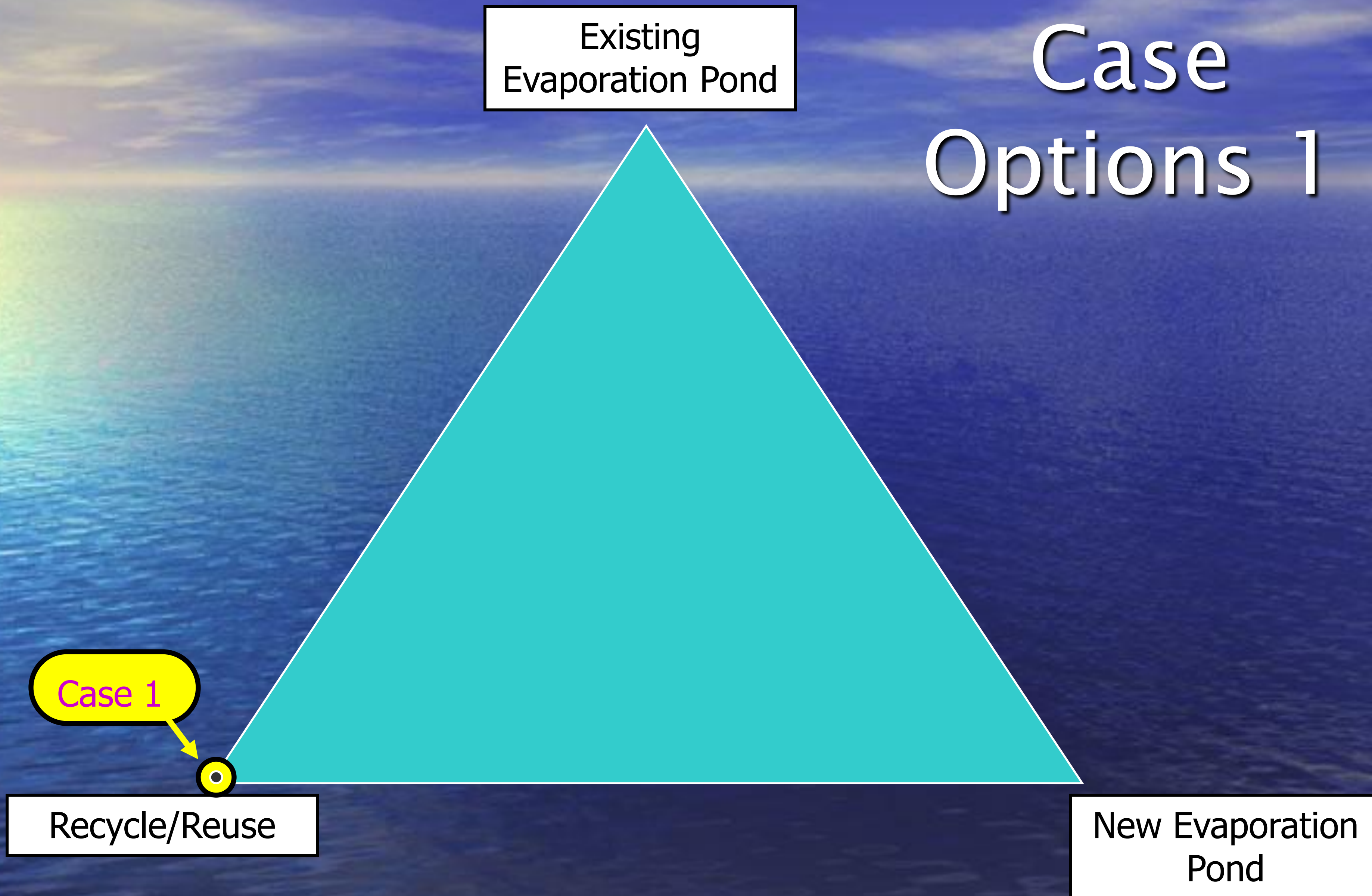
Cp := Fd*Fm*Cb

Seider, Seader, Lewin Product & Process Design Principles 2e, 1999

Reverse Osmosis

- Based on flow needs
- Design equation
  - from Perry's Chemical Engineers' Handbook
  - $E = (0.724 - 1000) x (ΔP)($/kWh)/(CR)(Ef)
  - $A = (0.423)($/m^2)/CR-J-T
  - Total operating cost = $A + $E
- Total Design Cost
  - Capital
  - Operating
  - Installation
  - Material/piping

Case Options 1



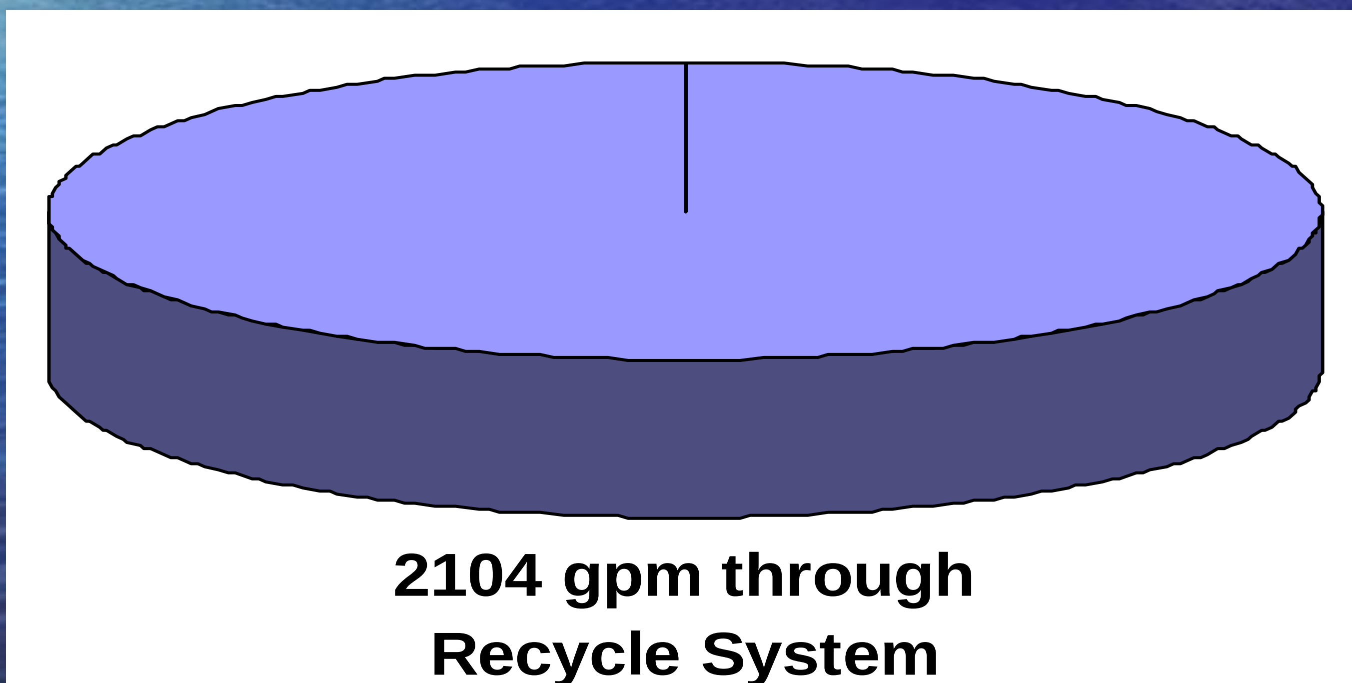
Case Scenario 1

Case 1

Reverse Osmosis = $122,280,924

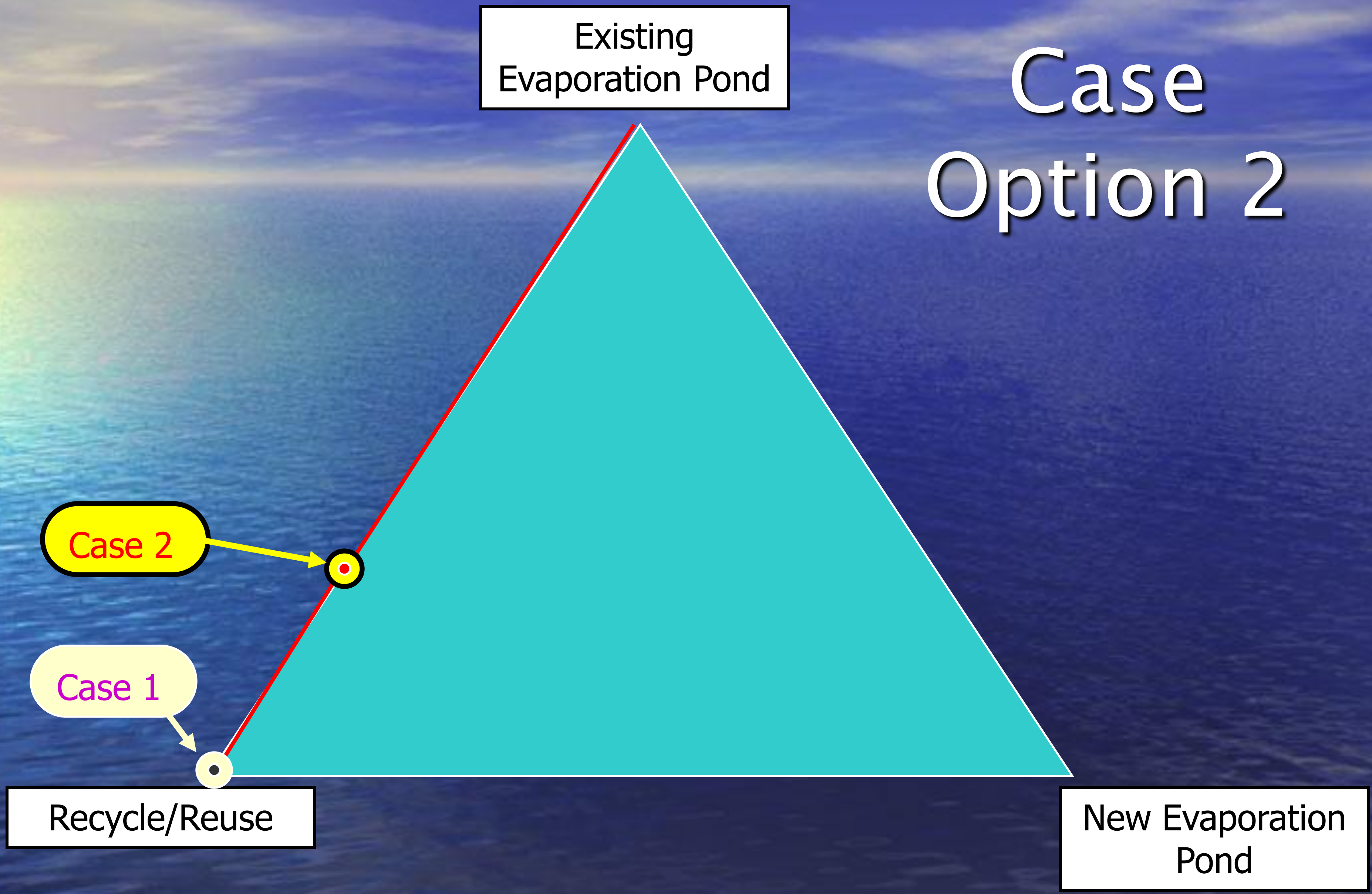
Brine concentrator = $175,442,083

Evaporation Pond = $0



Interest Rate: 12% APR, Life: 15 years

Case Option 2



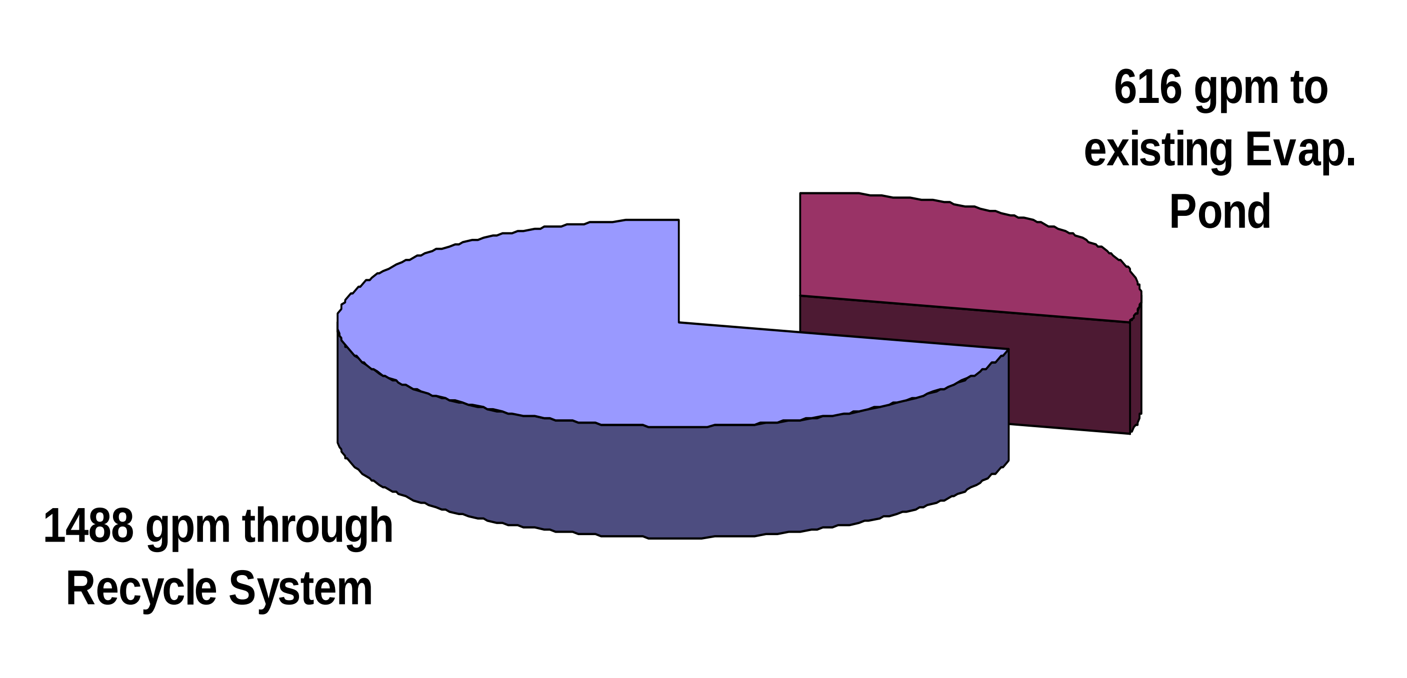
Case Scenario 2

Case 2

Reverse Osmosis = $86,480,045

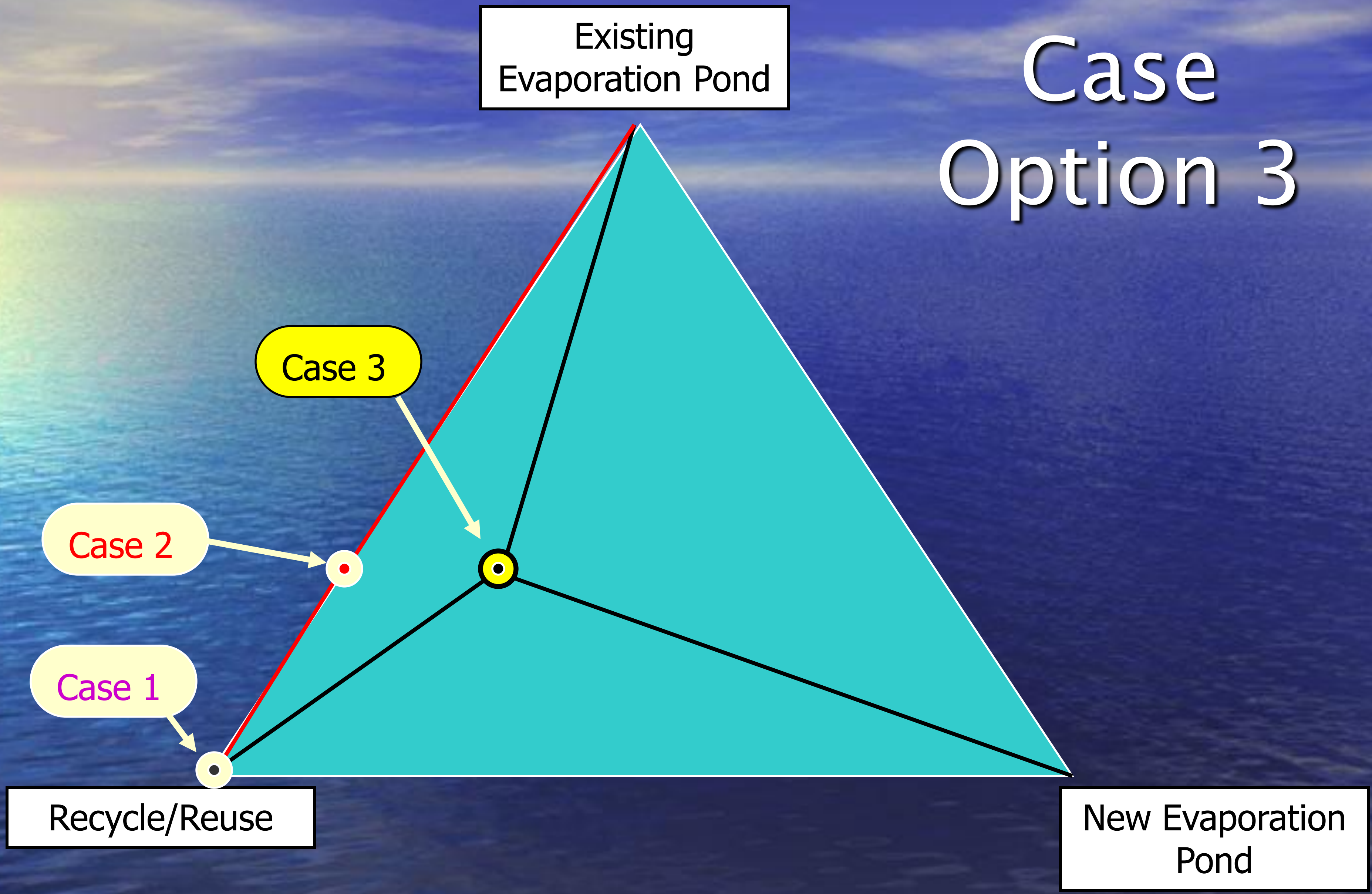
Brine concentrator = $133,239,424

Evaporation Pond = $0



Interest Rate: 12% APR, Life: 15 years

Case Option 3



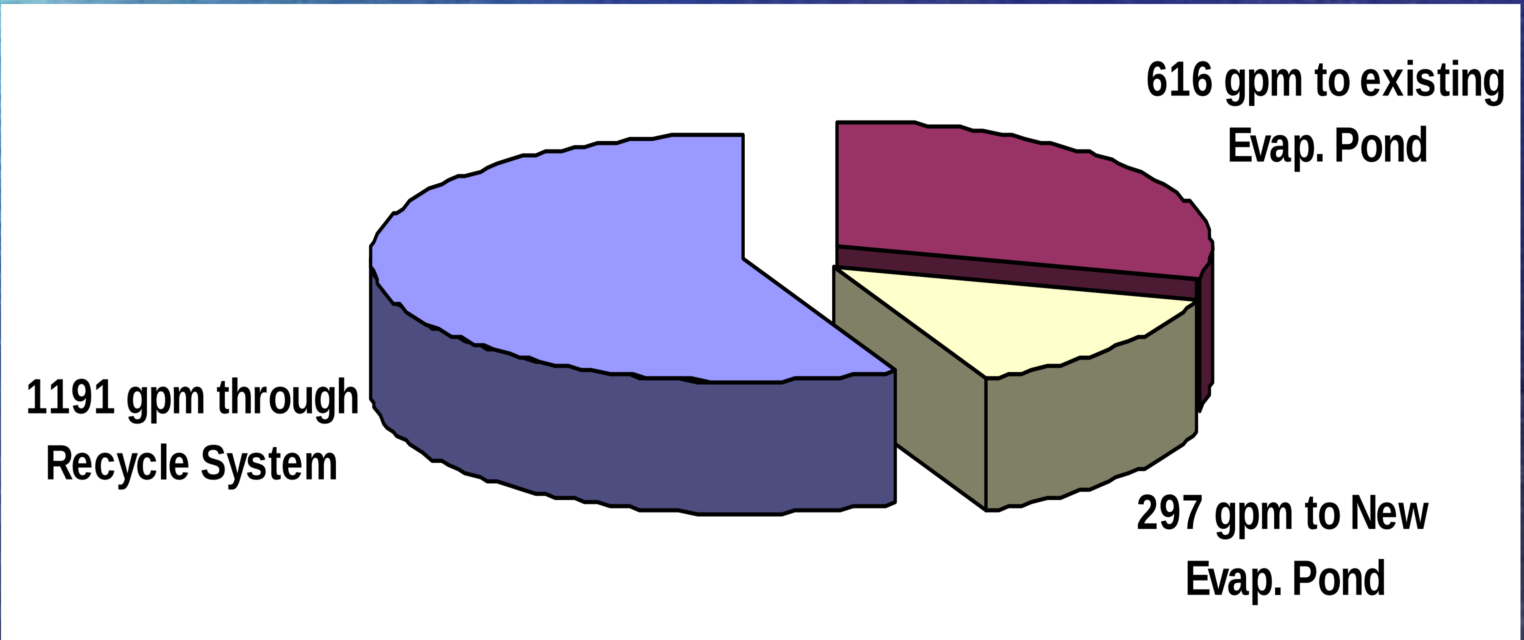
Case Scenario 3

Case 3

Reverse Osmosis = $69,218,907

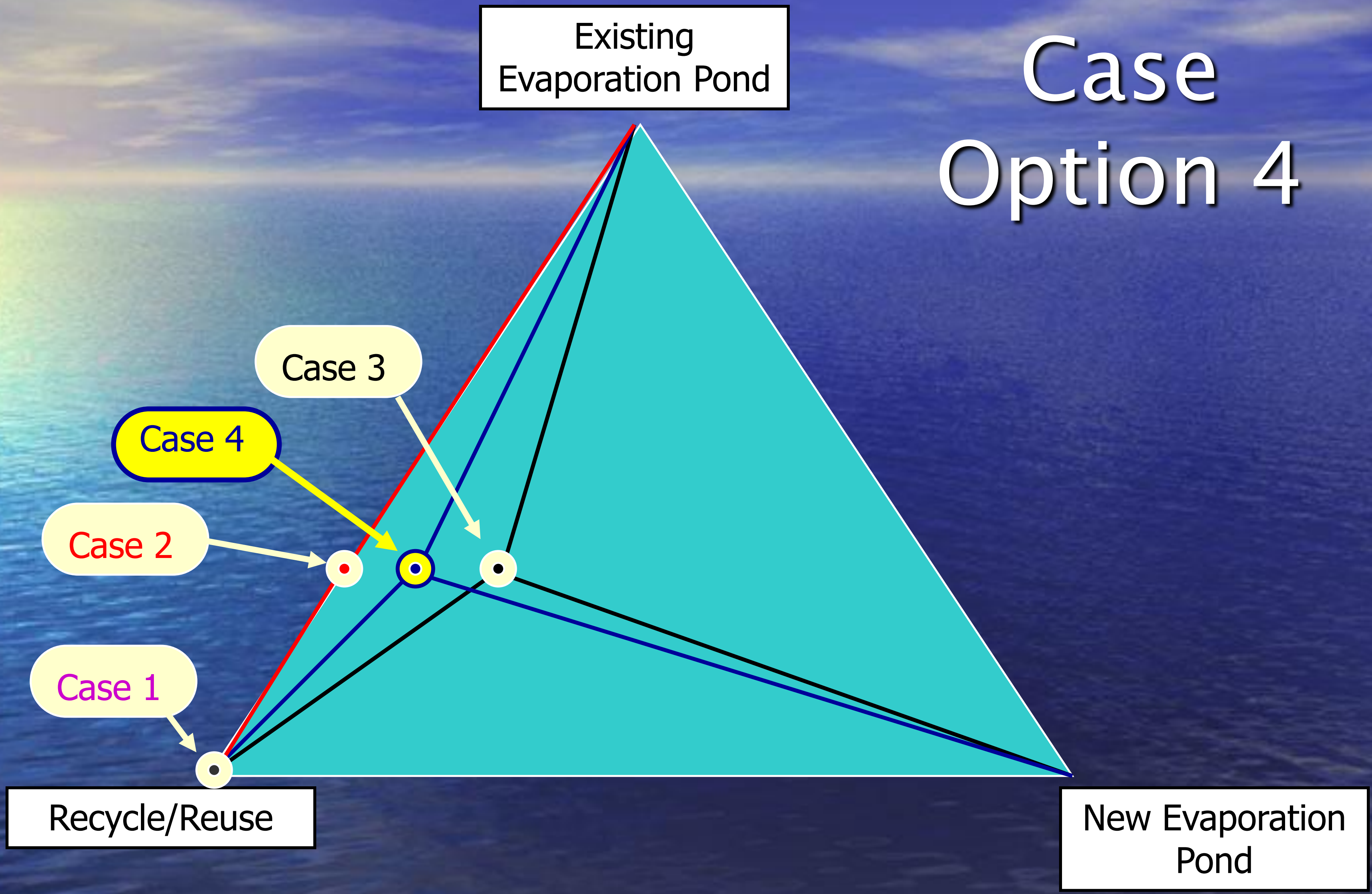
Brine concentrator = $111,652,263

Evaporation Pond = $2,292,282



Interest Rate: 12% APR, Life: 15 years

Case Option 4



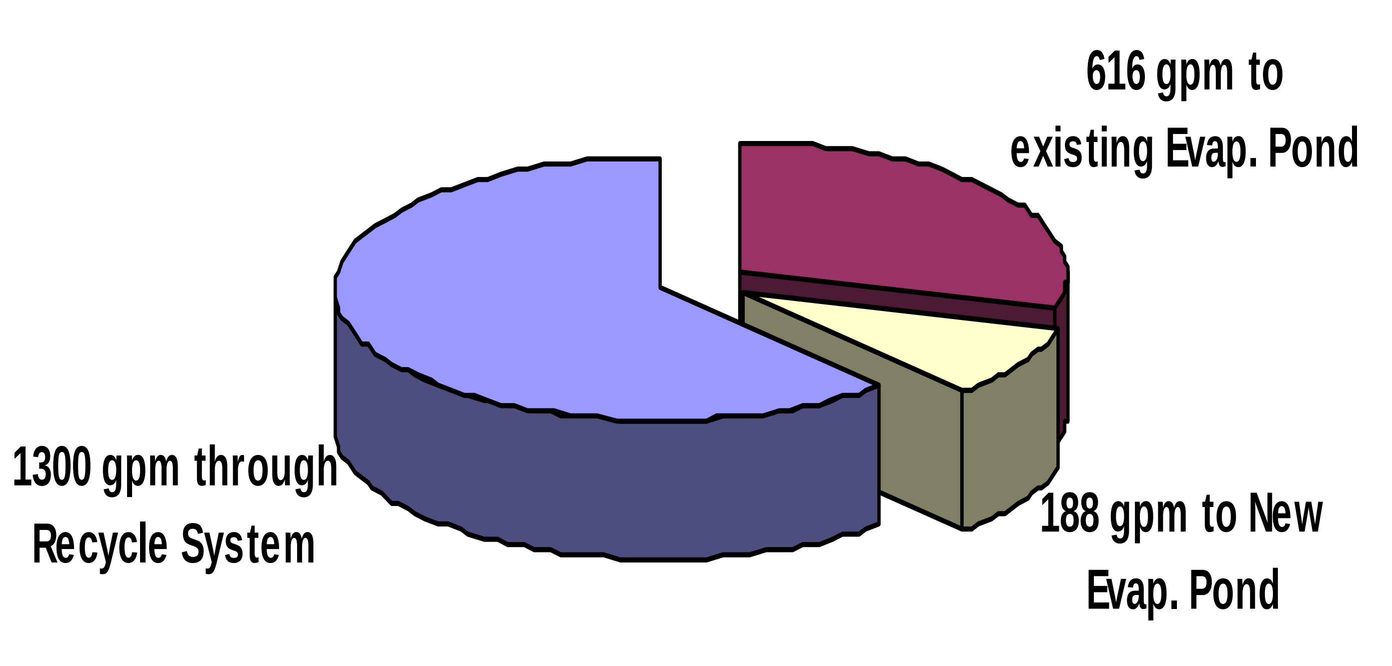
Case Scenario 4

Case 4

Reverse Osmosis = $75,533,803

Brine concentrator = $119,689,985

Evaporation Pond = $1,841,824



Interest Rate: 12% APR, Life: 15 years

Conclusion

- Best cost case scenario is Case 3
  - Use a Reverse Osmosis recycle system to recycle 1191 gpm of wastewater
  - Use the original evaporation pond of 616 gpm and create an additional evaporation pond for 297 gpm of wastewater

Total Cost: $71,511,189

Our IPRO Family

- Expectations
- IPRO Experience
- What We Learned

Any Questions?