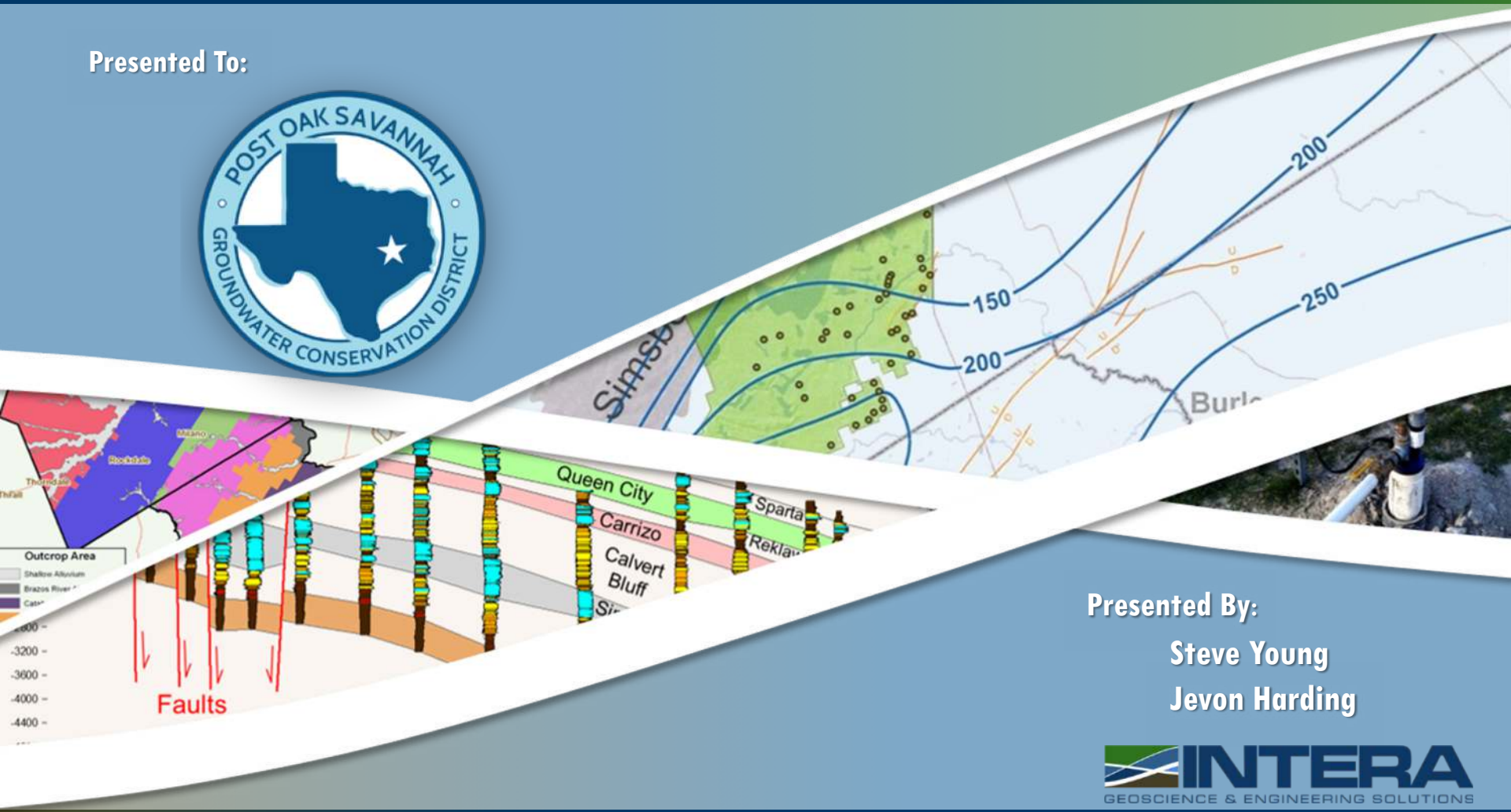
Update on POSGCD Research Projects: ASR

Presented To:



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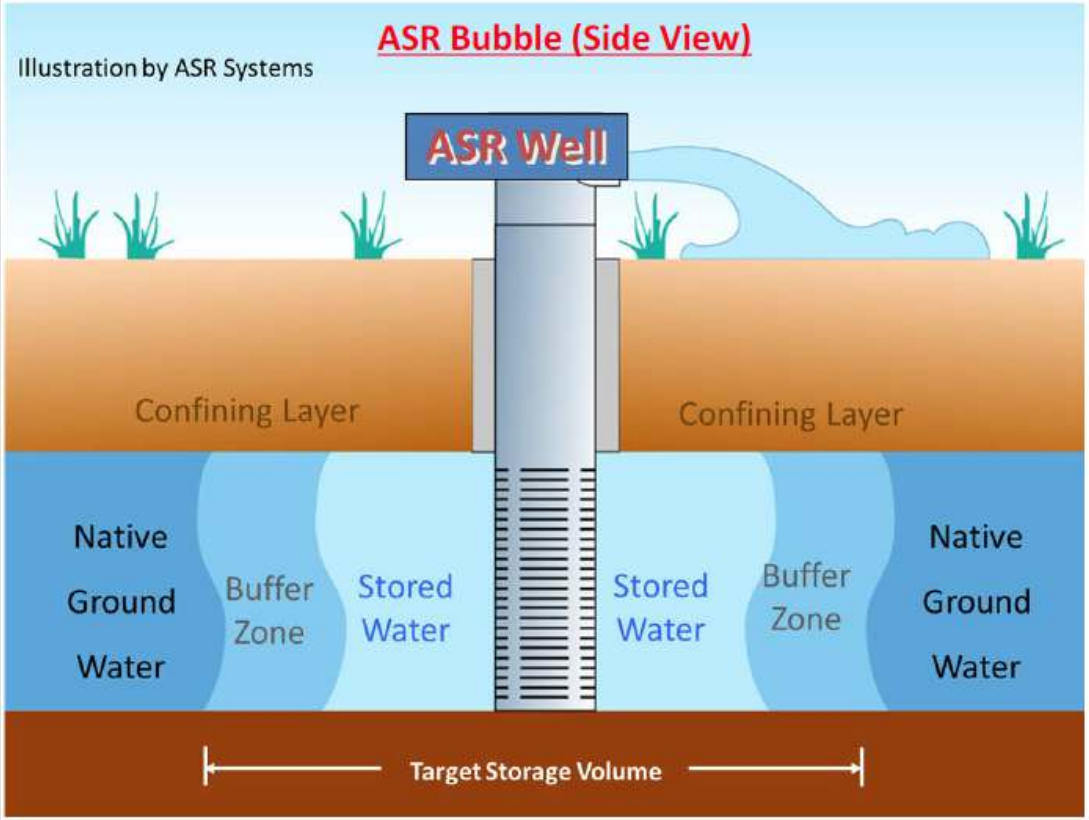
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

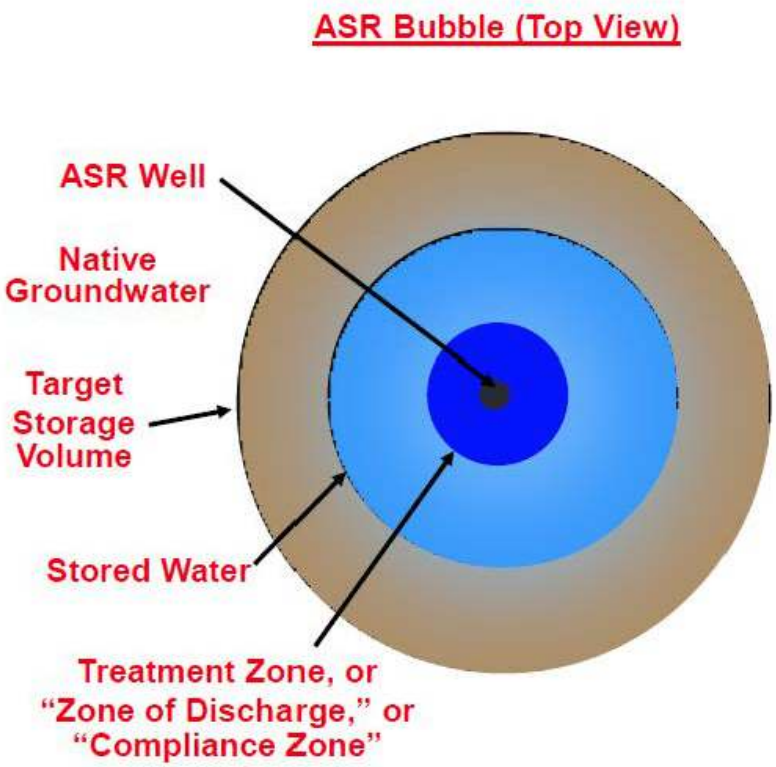
June 5, 2018

Outline

- Review Project Objectives
- Discuss Project Progress
- Present Simple Example of Modeling Results
- Discuss Planned Work for Real-world application

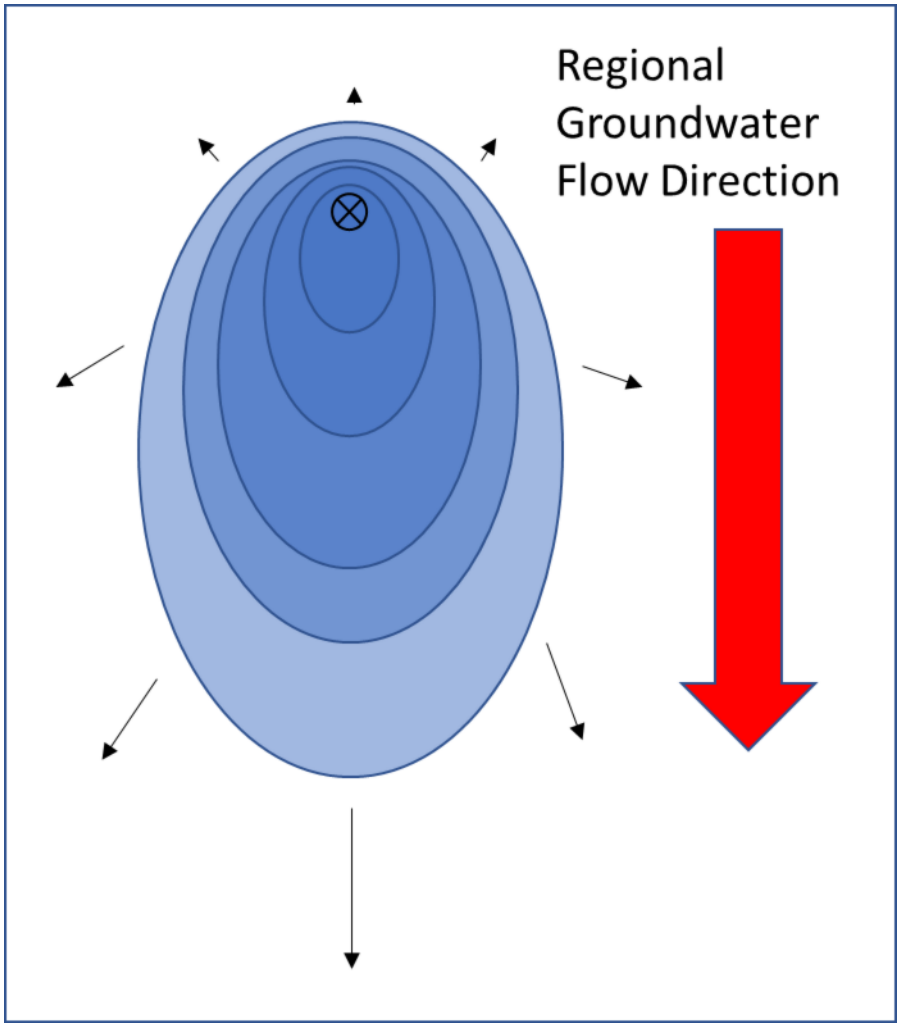
Review: Idealized ASR diagram



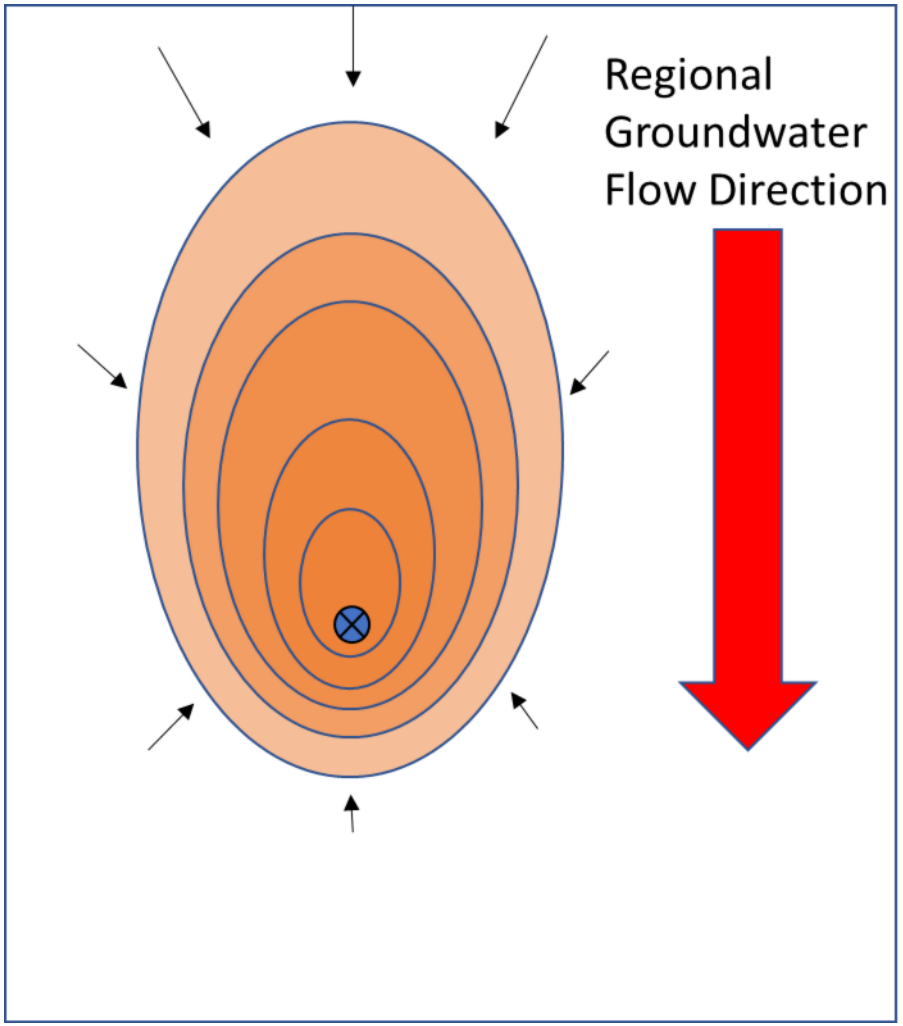


Aquifer Storage and Recovery Flow Fields

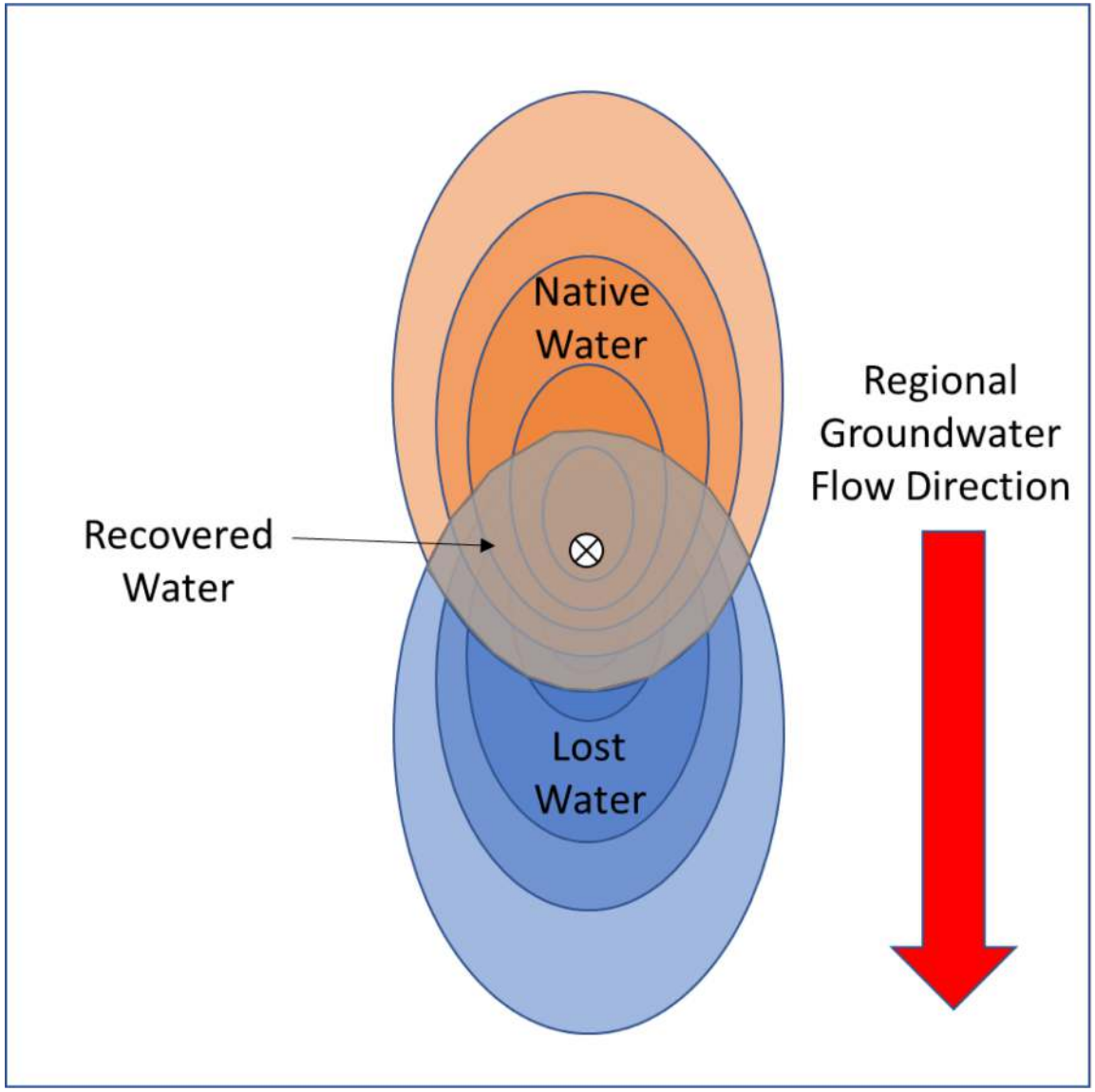
Injection



Recovery



Aquifer Storage and Recovery Recovered Water



TCEQ Application for Class V Underground and Injection Control (UIC) Well for ASR

Aquifer Storage and Recovery

Any permit or authorization issued by the TCEQ for an ASR project must be for aquifer storage and recovery in accordance with the following definitions in Title 30 of the Texas Administrative Code (30 TAC), Chapter 331:

> **Aquifer Storage and Recovery** [30 TAC §331.2(8)]: "The injection of water into a geologic formation, group of formations, or part of a formation that is capable of underground storage of water for later retrieval and beneficial use."
>
> **Aquifer Storage and Recovery Project** [30 TAC §331.2(11)]: A project involving the injection of water into a geologic formation for the purpose of subsequent recovery and beneficial use by the operator.

Section VIII. Demonstration of Recoverability*

In order for the commission to make a determination as to whether injection of water into a geologic formation will result in a loss of injected water or native groundwater, as required under TWC, §27.154(b), please provide an analysis of the volume of injected water that will be recovered. This analysis should consider the geologic, hydrogeologic, and hydrochemistry of the injection zone, the quality of the injected water, and the operational conditions proposed for the project. The commission anticipates that this analysis will require groundwater modeling. Please provide a detailed discussion of how the applicant estimated the percentage of injected water that will be recovered. If this estimated percentage of the injected water volume that is estimated is based on groundwater modeling, please describe the modeling performed, with justification for all assumptions and input parameter values.

* From TCEQ application

Key Aspects of Recoverability

- Recoverability is project and site specific
- Recoverability does not mean that ASR Facility can withdraw all that it injects
- The longer the time between injection and withdrawal, the less water that will be recovered
- High pumping to recover injected water over a short period of time could cause a large drawdown cone that adversely affects production at nearby wells
- ASR Facility needs a GCD Operating Permit to withdraw more than that Recoverability
- Injected water has potential to cause water quality issue such as a release of arsenic downgradient of ASR Facility
- **GCDs have the opportunity to influence the modeling and monitoring that TCEQ prescribes to determine and validate recoverability for a project**

Recovery Efficiency

- Recovery Efficiency (RE)

$$RE = \frac{V_r}{V_i} * 100\%$$

V_i is the volume injected

V_r is the volume recovered

- RE typically decreases with
  - -Increased density contrast
  - -Increased dispersivity
  - -Increased storage time
  - -Increased natural gradient
  - -Decreased bubble radius (thick aquifer and/or small storage volume)
  - -Poor vertical confinement
  - -Various geochemical issues may have an impact

Interaction with TCEQ

- TCEQ Contract with University of Texas
  - Prepare Guidance Document to help with preparation of applications
  - Develop an “Excel” level calculation to evaluate recoverability
- University of Texas Contract with INTERA
  - INTERA will share results of POSGCD work regarding the application of models to predict recoverability
  - INTERA will provide guidance of aquifer properties and assist with an Carrizo-Wilcox demonstration

Modeling Progress

- Develop and test approach for modeling ASR recoverability
- Approach will be used to perform the same test problems developed by UT
- Approach is valid for a much wider range of groundwater systems and aquifer types than UT approach
- Approach involves particle tracking

Particle Tracking

- Modeling in MODPATH software
- Assume well injects “particles” of water
- Track where the injected particles go in the subsurface
- Try to recapture particles with extraction well
- Evaluate recovery efficiency by how many particles get recaptured.

Hydraulic Gradient Analysis

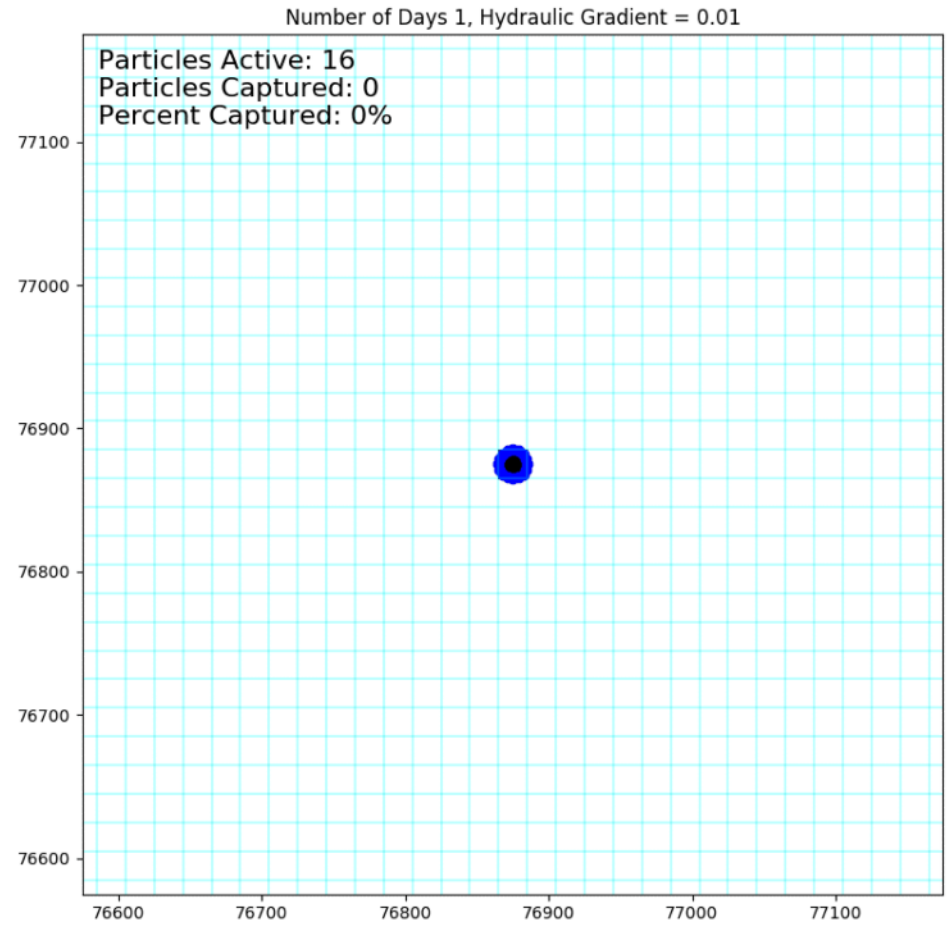
Inject at a constant rate and then extract at a faster rate - with single well

1) Injection (100 gpm) 11 months
2) Extraction (1100 gpm) 1 month
3) Repeat

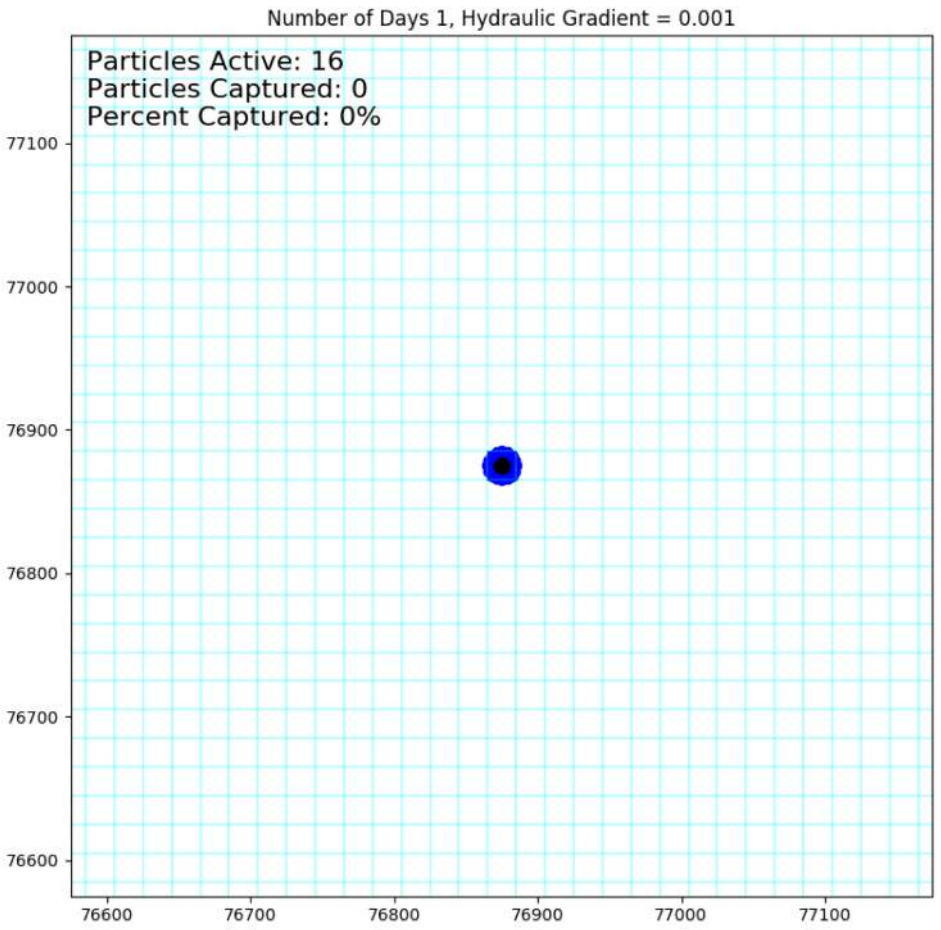
Rates are Selected so
Mass In = Mass Out

Hydraulic Gradient Analysis

High Hydraulic Gradient



Low Hydraulic Gradient



Hydraulic Gradient Analysis

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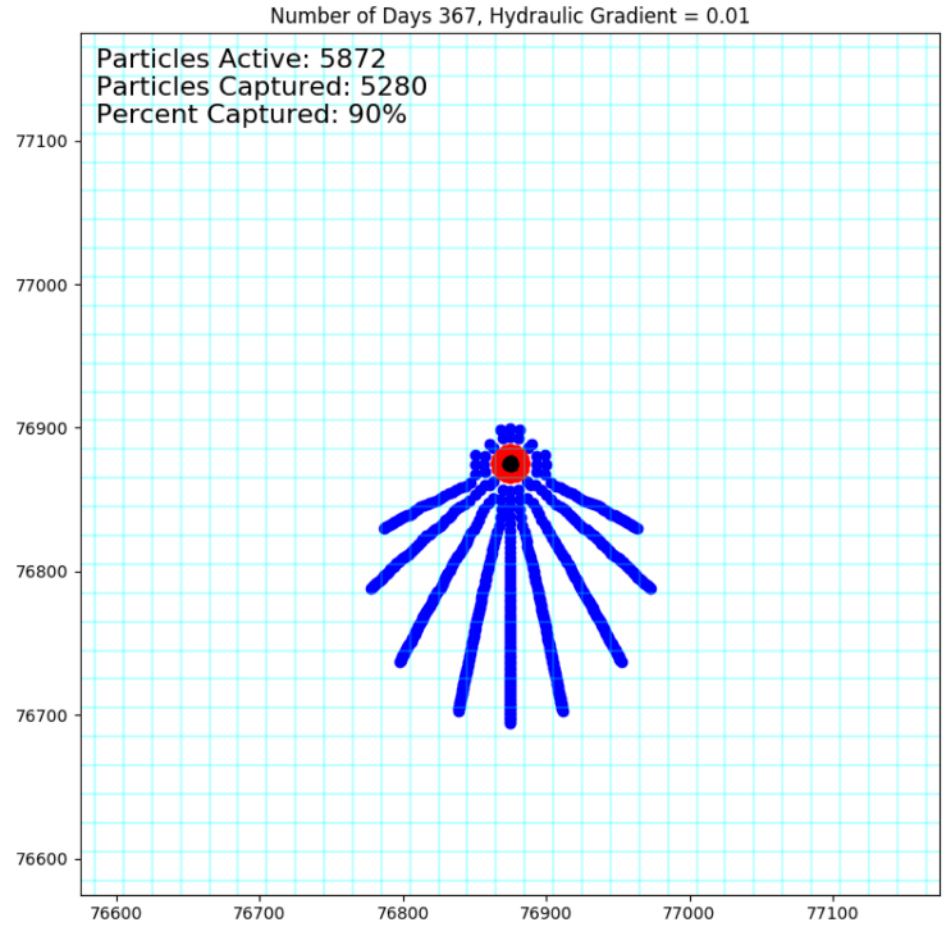

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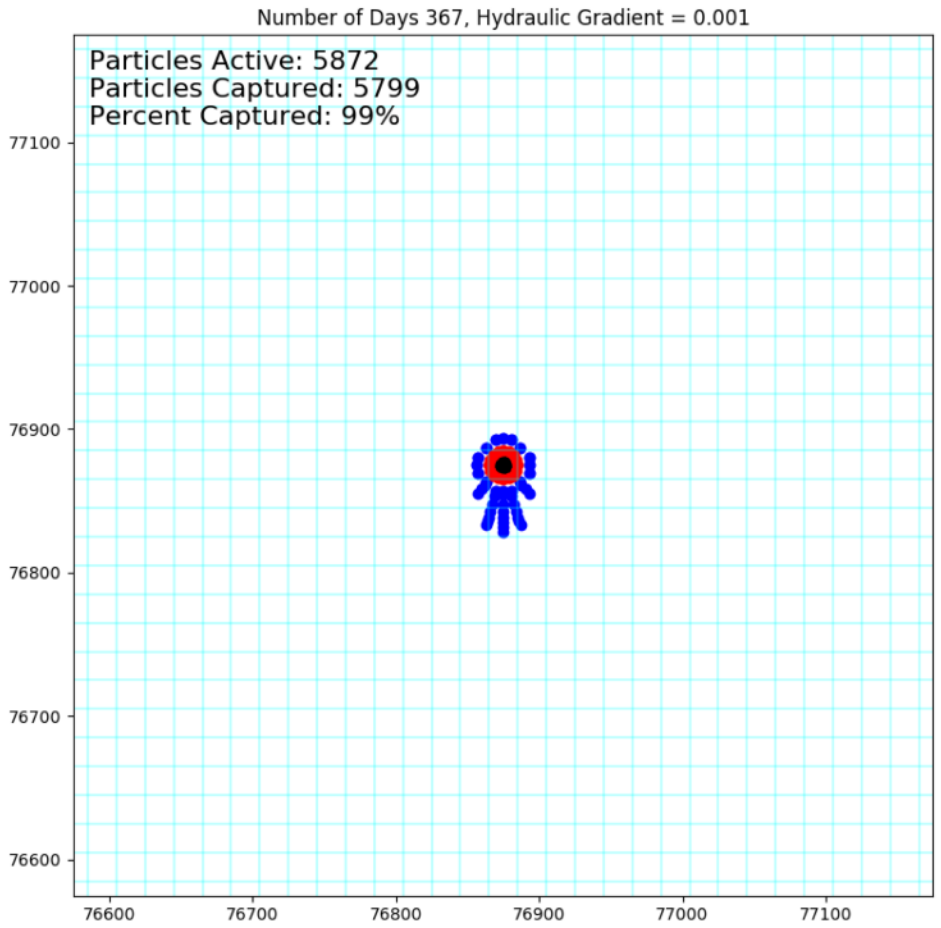


Loses more injected water downstream

Well Configuration Analysis

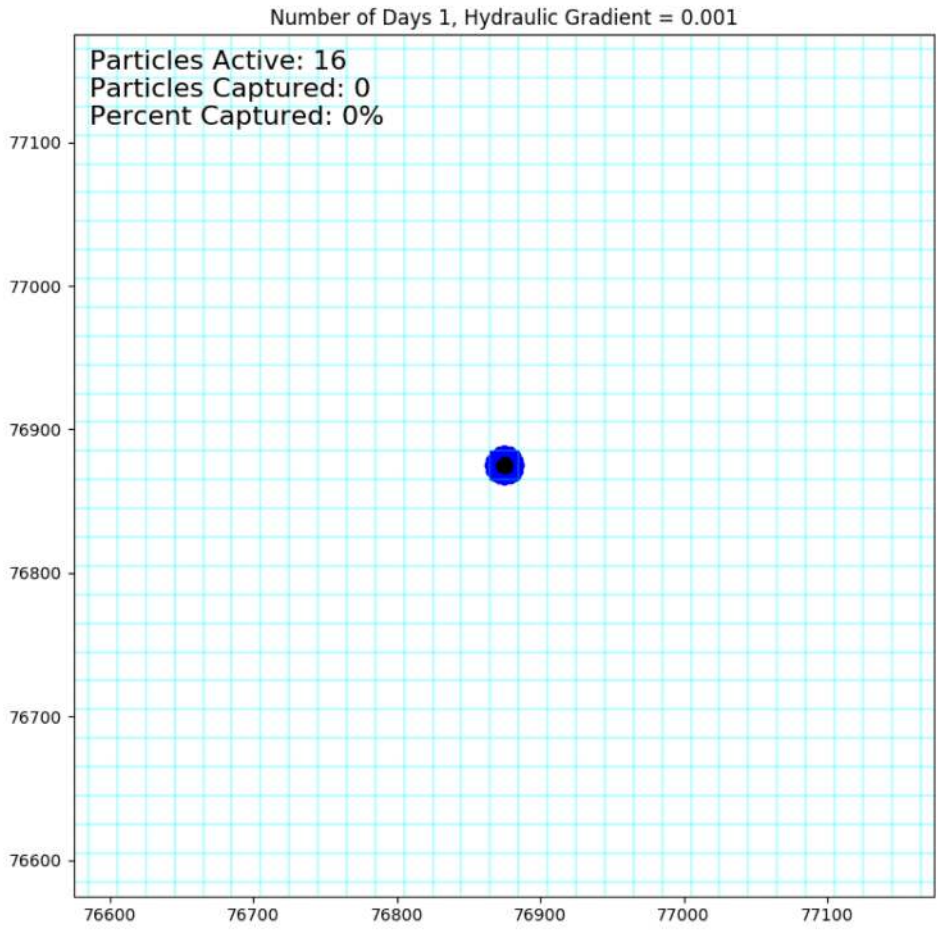
Inject at a constant rate and then extract at a faster rate - with multiple wells

1) Injection using 1 well (100 gpm) 11 months
2) Extraction using 3 wells (1100 gpm) 1 month
3) Repeat

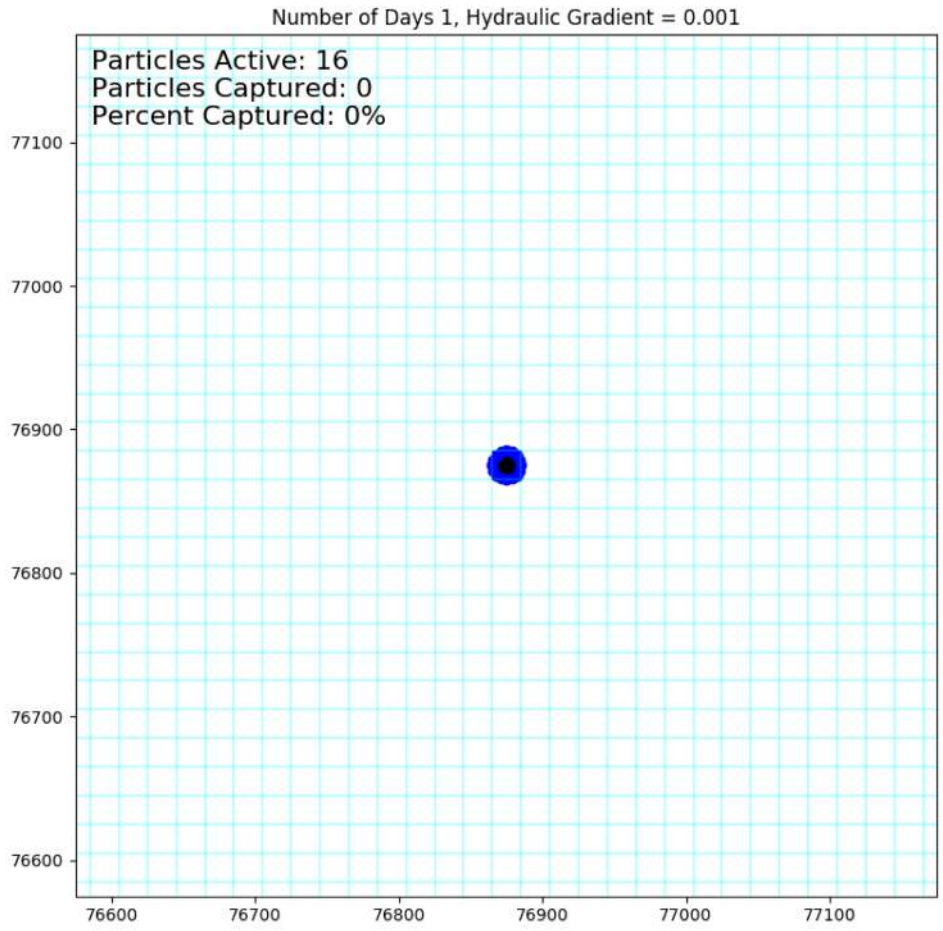
Rates are Selected so
Mass In = Mass Out

Well Configuration Analysis

Single Well

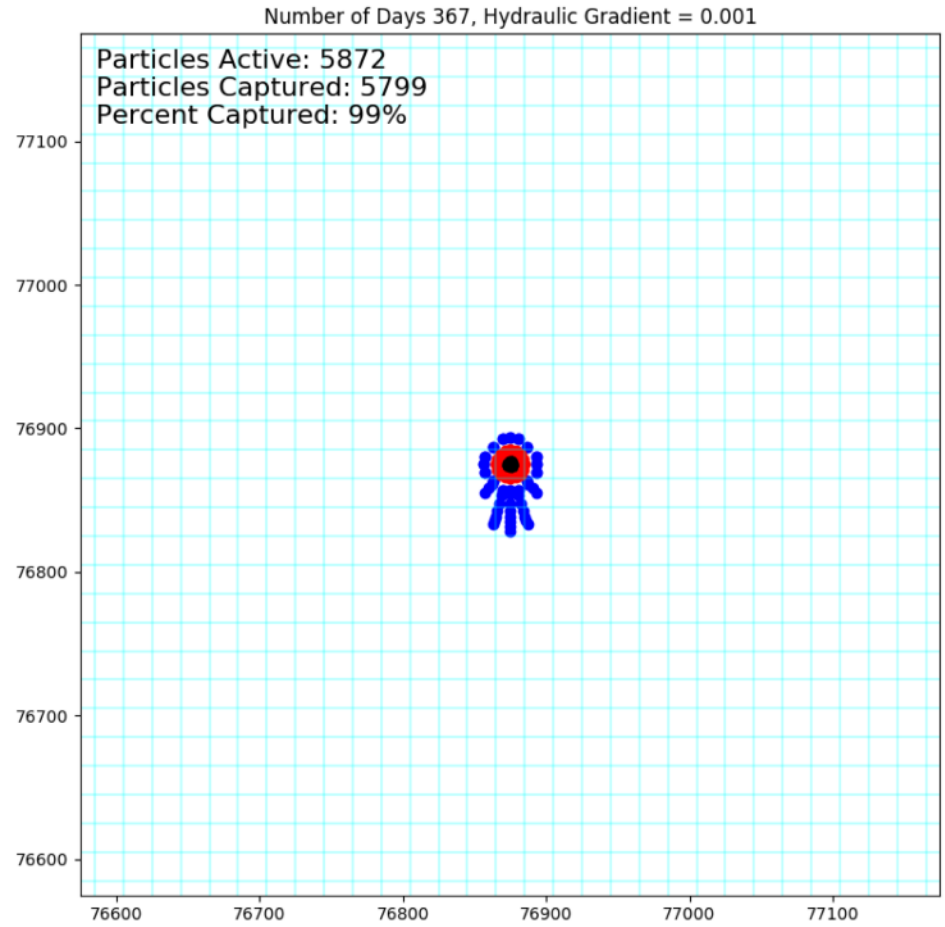


Multiple Wells

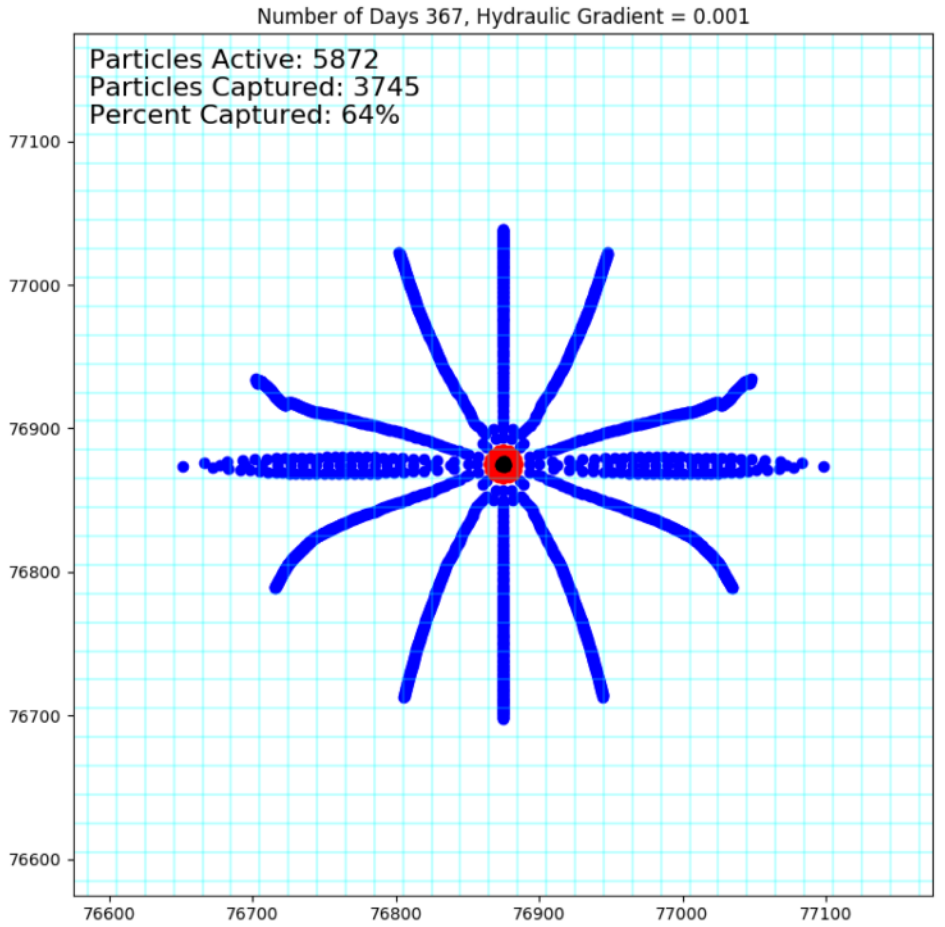


Well Configuration Analysis

Single Well



Multiple Wells



Loses more injected water from interference between wells

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Work in Progress: Three-Dimensional Application in Carrizo Wilcox

- Jointly Pick Location with POSGCD
- Jointly Pick ASR Pumping/Injection Scenarios with POSGCD
- Use Updated Sparta, Queen City, Carrizo-Wilcox for Initial Model
  - Aquifer properties
  - Recharge Rates
  - Nearby Pumping Wells
  - Hydraulic Gradients
- Model ASR System
- Develop Appropriate Monitoring Program