Potential Performance Measures for ASR

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Implementing ASR

- Implementing ASR typically involves three phases:
  - Phase I – Higher-Level Feasibility Analysis
  - Phase II – Pilot ASR Testing
  - Phase III – Project Implementation
- The time estimated for completing all three phases may range from as few as 6 years to 11 years or longer, depending on assumptions about CEQA and permitting processes timelines

What Happens In Each Phase?

- Phase I: Higher Level Feasibility Analysis Tasks:
  - Develop and use groundwater model to support various ASR analytical and planning tasks in this phase and in the pilot testing phase
  - Identify/select existing wells for potential pilot ASR testing
  - Perform site-specific injection capacity analysis (paper evaluation)
  - Perform geochemical interaction modeling for three components
  - Develop a Pilot ASR testing Program
  - Identify sites for potential new ASR well

What Happens In Each Phase?

- Phase 2: Pilot Testing of ASR
  - Retrofit existing wells for pilot testing of ASR (add temporary facilities to do this)
  - Perform injection well hydraulic testing
  - Use results of injection well hydraulic testing to develop a multiple cycle injection-storage-recovery (ISR) testing program
  - Implement ISR testing program
  - Additional groundwater modeling of ASR scenarios
  - Develop basis-of-design for permanent ASR well facilities

What Happens In Each Phase?

- Phase 3: Project Implementation
  - Procurement of properties and rights of way for ASR facilities
  - Engineering design of ASR wells and facilities and infrastructure improvements that might be needed for the program
  - Complete CEQA for permanent ASR facilities and infrastructure
  - Drill and do production testing for ASR wells
  - Perform site-specific ASR demonstration testing and develop operational parameters

Phase I Performance Metrics
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Task	Focus for Potential Performance Measure
Develop and use groundwater model to support various ASR analytical and planning tasks in this phase and in the pilot testing phase	Model effectively predicts observed results based on historical data and operations (i.e., model is well calibrated and thus considered a dependable representation of what will actually happen) Modeling results show the target aquifers can sustain injection rates of up to 5 mgd without undesirable results, injected water will not be subject to excessive (greater than 20%?) loss due to leakage; and that the target aquifers can sustain the required recovery pumping without undesirable impacts to the aquifer or other private or municipal pumpers
Identify/select existing wells for potential pilot ASR testing	Suitable existing wells for pilot testing in target aquifers do not exist or cannot be identified

Phase I Performance Metrics
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Task	Focus for Potential Performance Measure
Perform site-specific injection capacity analysis (paper evaluation)	Results show that a preliminary average injection capacity of 250 gallons per minute (gpm) (360,000 per day) is unrealistic. A result that is 10% or more less than 250 gpm becomes a key constraint due to needing to increase the a potential increase in the number and potential siting challenges of wells required to achieve program goals and also associated costs
Perform geochemical interaction modeling for three components	Results show that undesirable geochemical reactions are likely. Undesirable reactions would include calcite precipitation or iron oxide development that could form and result in well plugging that impedes water flow to the well. Well fouling due to plugging is a fatal flaw. Addition issues would be dissolution of minerals in the aquifer soil matrix (due to introduction of low mineral surface water) that could result in water quality or treatment issues. The geochemical interaction modeling would need to be done for each target aquifer.

Phase I Performance Metrics
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Task	Focus for Potential Performance Measure
Develop a Pilot ASR testing Program	This task doesn't have a performance metric because it is an program design step.
Identify potential sites for new ASR well	Up to 10 to 15 sites may be needed The Beltz 12siting study included 4 main criteria for site selection: • Hydrogeological suitability, • Constructability, link to existing infrastructure, and operating requirements (e.g., power availability) • Environmental considerations • Ease of acquisition Another key criteria is no injury to or interference with other municipal or private pumpers. The map on the next page shows the locations of wells in the Soquel-Aptos basin.

Phase II Performance Metrics
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Task	Focus for Potential Performance Metric
Retrofit existing wells for pilot testing of ASR (add temporary facilities to do this)	No performance metric required for this step
Perform injection well hydraulic testing	Results show that a preliminary average injection capacity of 250 gallons per minute (gpm) (360,000 per day) is unrealistic. A result that is 10% or more less than 250 gpm becomes a key constraint due to needing to increase the a potential increase in the number and potential siting challenges of wells required to achieve program goals and also associated costs of additional wells. Unacceptable well plugging rates are observed. Typical impacts would be water level in the well rises too rabidly. Causes could include rapid particulate loading, gas evolution, chemical reactions creating precipitates. Back-flushing cannot fully mitigate plugging and maintain well performance.

Phase II Performance Metrics
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Task	Focus for Potential Performance Measure
Use results of injection well hydraulic testing to develop a multiple cycle injection-storage-recovery (ISR) testing program	No performance metric required for this step
Implement ISR testing program	Results show that long-term injection rates are not sustainable, and/or injection results in unacceptable aquifer water level response, and/or long-term recovery rates are not sustainable, and/or recovery results in unacceptable impacts to other basin pumpers and/or recovered water does not meet water quality standards and potential treatment requirements substantially increase program costs.

Phase II Performance Metrics
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Task	Focus for Potential Performance Measure
Additional groundwater modeling of ASR scenarios	Results show the target aquifers cannot sustain the required injection rates without undesirable impacts, and/or the target aquifers cannot store the required recharge volumes over the necessary duration without excessive losses, and/or the target aquifers cannot sustain the required recovery pumping without undesirable impacts
Develop basis-of-design for permanent ASR well facilities	Projected program costs developed in the basis-of-design work are significantly higher than projected.

See also companion document: "Example of ASR Pilot Test Program Operation Plan" for additional details about what occurs during some of the steps of pilot testing.

Phase III Performance Metrics
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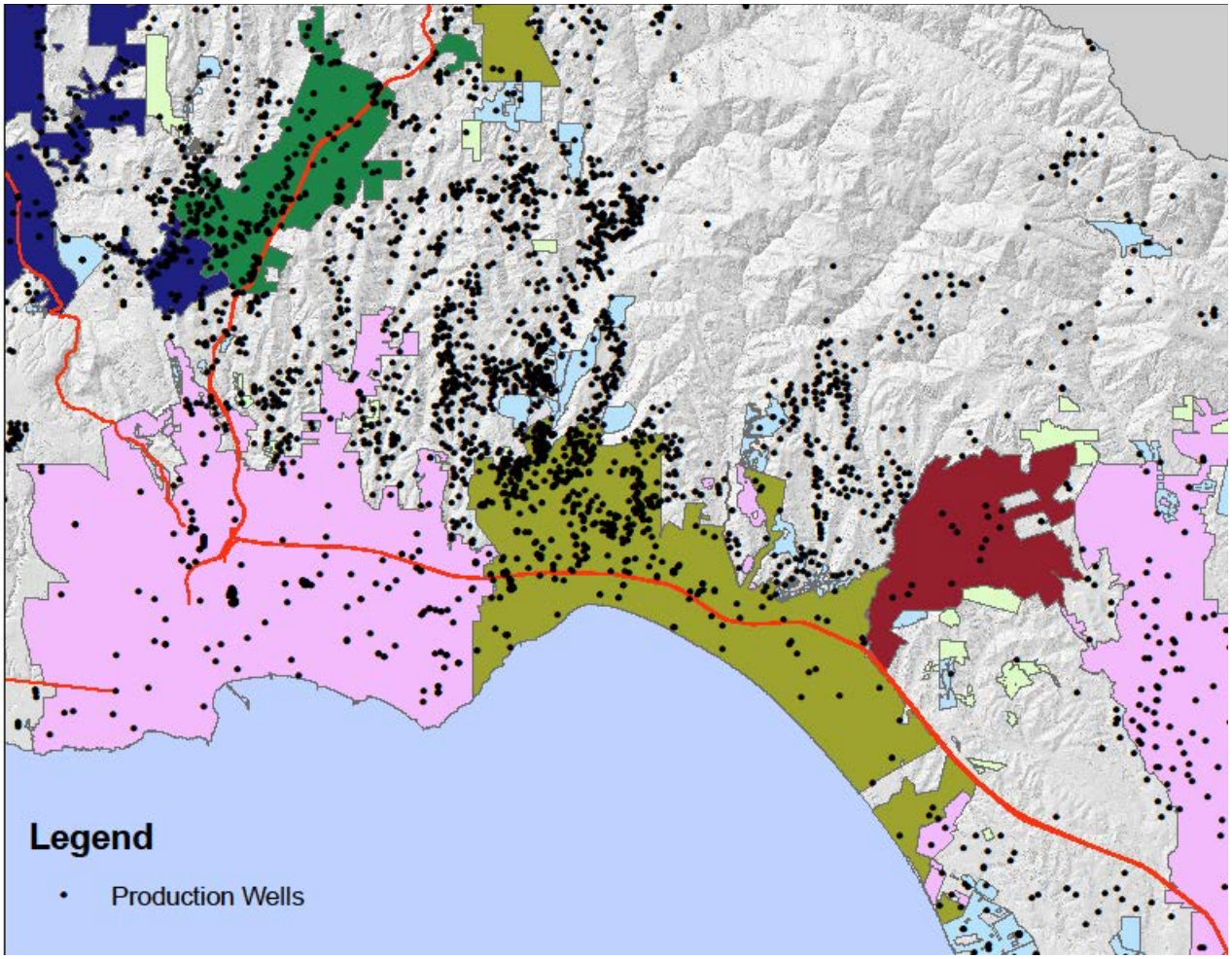
Task	Focus for Potential Performance Measure
Procurement of properties and rights of way for ASR facilities	Sufficient number of suitable well sites can not be located and/or cumulative cost of needed sites exceeds some affordability threshold
Engineering design of ASR wells and facilities and infrastructure improvements that might be needed for the program	Needed facilities can't be sited and/or exceed some affordability threshold
Complete CEQA for permanent ASR facilities and infrastructure	CEQA process cannot be completed without exceeding some affordability threshold for mitigation or litigation
Drill and do production testing for ASR wells	Well performance for some portion of recharge system is insufficient for program needs

Municipal and Private Wells in Mid and Northern Santa Cruz County



Phase III Performance Metrics
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Task	Focus of Potential Performance Metric
Perform site-specific ASR demonstration testing and develop operational plans and parameters	Drilling and production testing produce new information about feasibility or productivity at specific sites

EXAMPLE

ASR PILOT DEMONSTRATION TEST PROGRAM
OPERATIONS PLAN

1) Preliminary Well Injection Hydraulics Testing

a) Tests to be Performed:
   i) 100-minute pre-injection pumping performance test (2 x design injection rate).
   ii) 8-hr variable-rate injection test (50%, 75%, 100% and 125% of design rate).
   iii) Backflushing.
   iv) 24-hr constant-rate injection test (at design rate).
   v) Backflushing.
   vi) 7-day constant-rate injection test (at design rate)
   vii) 100-minute post-injection pumping performance testing (2 x design injection rate).

b) Injection Volume: xx million gallons (xx af)

c) Injection "Bubble" Zone Radius: xx feet

d) Storage Period: 0 days

e) Test Objectives:
   i) Establish injection well performance at varying recharge rates.
   ii) Establish sustainable continuous long-term injection rates.
   iii) Establish short-term plugging rates (active and residual).

2) ISR Cycle No. 1

a) Tests to be Performed:
   i) 7-day constant-rate injection test.
   ii) Backflushing.
   iii) Aquifer storage / water-level recovery period.
   iv) Recovery of 100% volume recharged

b) Injection Volume: up to xx million gallons (xx af)

c) Injection "Bubble: Zone Radius: xx feet

d) Storage Period: 7 days

e) Test Objectives:
   i) Monitor recharge hydraulics.
   ii) Establish longer-term well plugging rates (active and residual).
   iii) Monitor Ion Exchange Reactions.

3) ISR Cycle No. 2

a) Tests to be Performed:
   i) 14-day constant rate injection test.
   ii) Backflushing.
   iii) Aquifer storage / water-level recovery period.

iv) Recovery of 100% volume recharged

b) Injection Volume: up to xx million gallons (xx af)

c) Injection "Bubble" Zone Radius: xx feet

d) Storage Period: 30 days

e) Test Objectives:

i) Confirm longer term injection hydraulics.
ii) Monitor plugging rates (active and residual).
iii) Monitor Ion Exchange and Redox reactions.
iv) Evaluate water-quality changes during storage.
v) Monitor recovery efficiency.

4) ISR Cycle No. 3

a) Tests to be Performed:

i) 30-day constant-rate recharge test.
ii) Backflushing.
iii) Aquifer storage / water-level recovery period.
iv) Recovery of 150% volume recharged

b) Injection Volume: up to xx million gallons (xx af)

c) Injection "Bubble" Zone Radius: xx feet

d) Storage Period: 60 to 90 days

e) Test Objectives:

i) Monitor longer term well performance trends for injection.
ii) Monitor recharged water-quality stability and equalization in the aquifer.
iii) Monitor THM and HAA ingrowth and degradation.
iv) Quantify aquifer mixing/dispersion parameters.
v) Determine economics of pumping, recovery efficiency, backflush percentage.
vi) Monitor recovered water "post extraction" for re-chlorination and THM/HAA reformation.