Summary of Aquifer Storage Recovery for
Montana Water Policy Interim Committee
March 12, 2008
John Metesh, Montana Bureau of Mines and Geology

These notes are based on personal attendance at the Aquifer Storage and Recovery and Artificial Recharge in Oregon: Overcoming Technical, Regulatory, and Social Challenges, Co-Convened by OSU Institute for Water and Watersheds and Oregon Water Resources Department February 28, 2008 Oregon State University, Corvallis, Oregon. The content is based on notes taken during presentations, conversations with attendees and presenters, program abstracts, and presentation slides. This summary is presented to the Water Policy Interim Committee and is intended to highlight the considerable volume and quality of work by the conference presenters; any errors or misunderstanding of the material are responsibility of this author.

Presentations were not given in the order shown here. Authors and/or presenters with the title of the talk are underlined for each section.

Cat Shrier, Watercat Consulting, LLC

On the national level, the National Academies has completed a 3-year study and report: "Prospects for Managed Underground Storage of Recoverable water". The report will be presented at a one-day forum on March 19 in Washington DC. A live webcast may be available.

Managed Underground Water Storage by other names

Artificial Recharge (AR): intentional banking and treatment of water in aquifers.

Artificial Recharge and Recovery (ARR): recharge to and recovery of water from an aquifer, that is, both artificial recharge of the aquifer and recovery of the water for subsequent use.

Managed (or Management of) Aquifer Recharge (MAR): intentional banking and treatment of water in aquifers (synonymous with AR).

Dry/vadose/drainage well: a well constructed in the interval between the land surface and the top of the static water level and designed to optimize infiltration of water

Underground Storage and Recovery (USR): similar to MUS; any type of project whose purpose is the artificial recharge, underground storage, and recovery of project water.

Aquifer Storage Recovery (ASR): injection of water into a well for storage and recovery from the same well.

Aquifer Storage Transfer and Recovery (ASTR): injection of water into a well for storage and recovery from a different well, generally to provide additional water treatment.

Sustainable Underground Storage (SUS)

R. David G. Pyne, P.E., ASR Systems
"Approximately 80 operational ASR well fields in the United States as of October 2007"

ASR Operating Ranges:

Well depths:	30 to 2700 feet
Storage interval thickness:	20 to 400 feet
Storage Volumes:	100 to 270,000 Acre-feet
Bubble radius:	less than 1000 feet
well capacity:	up to 8 million gallons per day (mgd)
well field capacity:	up to 157 mgd

from case studies presented:

Beaverton, OR (David Winship, City of Beaverton)

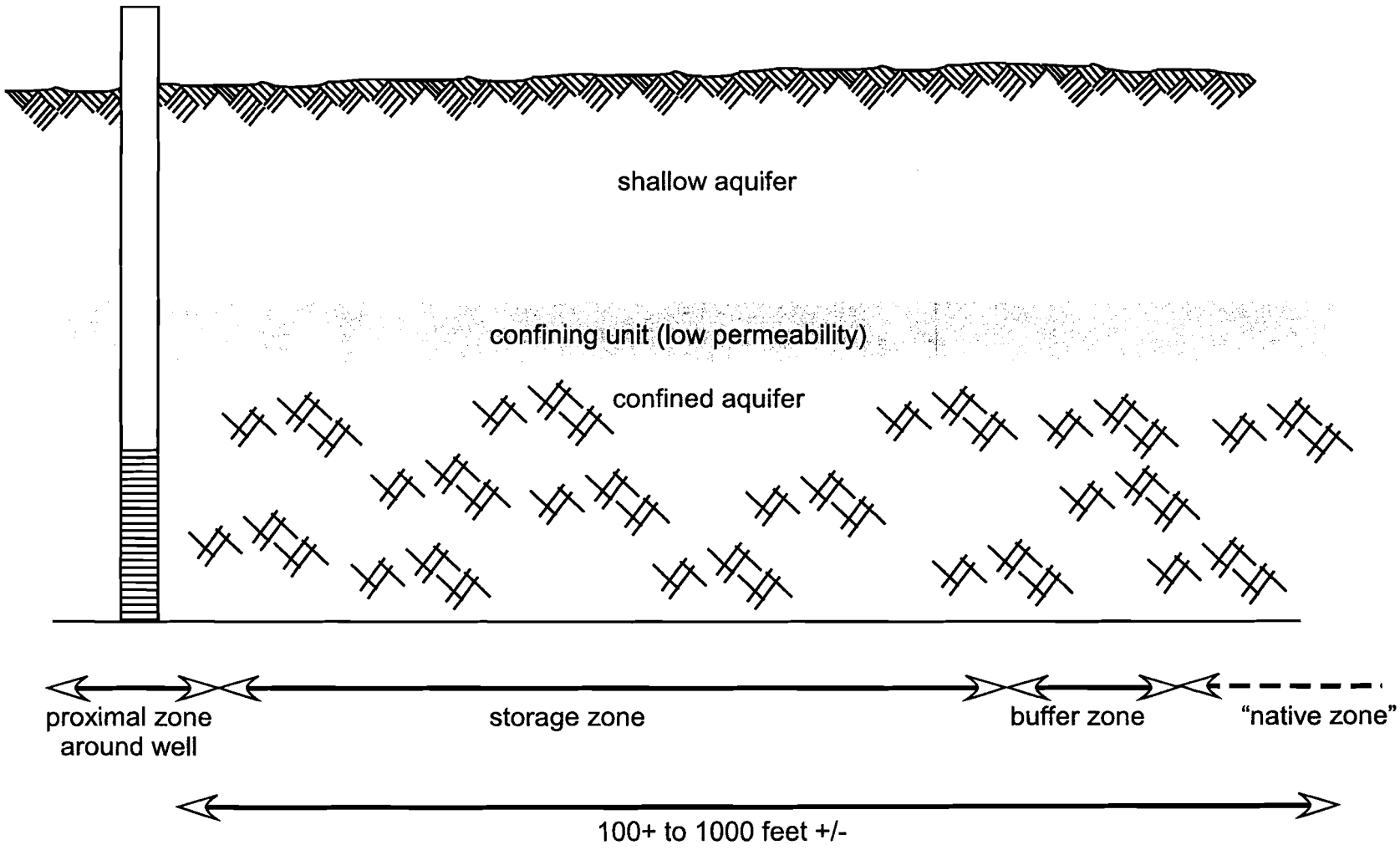
population:	67,000
demand:	7 to 14 mgd
ASR capacity:	3 wells at about 4 mgd

Salem, OR (Jason Pulley, City of Salem Public Works)

population:	183,000
demand:	30 mgd (average)
ASR capacity:	4 wells 2.4 to 12 mgd

Total Storage Volume (TSV) is the sum of the stored water volume plus the buffer zone volume
Well >>>proximal zone>>>stored water>>>buffer zone>>>native ground water (see figure)
TSV radius typically a few hundred feet.

typical(?) aquifer storage recovery components
from R. David G. Pyne, P.E., ASR Systems



Kent R. Madison, Madison Farms, Echo, Oregon: Reclaiming High Volume Low Quality Winter Flood Flows for Peak Season Demand Using AR and ASR Systems

AR/ASR system components:

- winter flood surface waters to ditches, ponds to
- "non-agricultural" flood zones (AR) with subsurface drain for filtration to
- shallow collection well pumps to
- deep injection well (ASR) for
- electrical generation(!?) and storage

cost reduction through use of "3R downhole control valve"

Jen Woody, Oregon Water Resources Department

Oregon (13 ASR sites):
Average transmissivity = 16,000 feet^2/day
Average depth to water =85 feet

Nationwide (~37 ASR sites):
Average transmissivity = 14,000 feet^2/day
Average depth to water = 90 ft
confined aquifers are the rule - unconfined, unconsolidated aquifers are rarely used, yet

Montana
Madison Limestone (near Great Falls) =500 to 20,000 feet^2/day
Eagle Sandstone (near Billings) = 200 feet^2/day
alluvium (Gallatin Valley) = 20,000 feet^2/day,
deeper deposits (Gallatin Valley) = 1,000 feet^2/day
alluvium (Beaverhead Valley) = 5,000 to 180,000 feet^2/day

Assessment method: ASR Metric (by Woody)

> "The ASR metric is a ratio of aquifer storage to the rate at which surface water is available for injection, with a result greater than one indicating sufficient aquifer storage. The site rating index evaluates aquifer hydraulic parameters as well as economic and engineering factors, and produces a percentage of ideal conditions. While economic and engineering factors can determine ASR feasibility, transmissivity, depth to static groundwater level and the desired injection rate are the controlling hydraulic parameters for hydrogeologic ASR suitability. However, these factors have a flexible relationship; for example, high transmissivity can compensate for small depth to groundwater and vice versa."

Assessment method: Brown's Rating System
1.Pass Fail criteria:
- Less than 3 miles to source water
- Land use is not: lakes, landfill, wetland, protected habitat

2.Rate parameters from 0 to 2, find percentage of ideal conditions for ASR:
- Ecological Suitability
- Well Density
- Source Water Quality
- Ground Water Quality
- Transmissivity
- Distance to Source Water
- Hydraulic Gradient
- Aquifer Thickness

Phil Richerson, Nonpoint Source Hydrogeologist, Oregon Department of Environmental Quality

Decision Tool Used To Select Final Analyte List of Pesticides For Artificial Recharge Source Water Testing:

(1) Estimate Amount and Timing of Pesticide Use
(2) Compile and Record Physical Properties
(3) Compile and Record Toxicity Information
(4) Calculate a Pesticide Movement Rating
(5) Calculate a Physical Property Risk Factor
(6) Flag Potential Analytes
(7) Rank by Number of Flags
(8) Develop Potential Analyte List
(9) Refine Potential Analyte List
(10) Identify Analytical Capability
(11) Determine Tier 1 and Tier 2 Analytes

Dennis Nelson, Groundwater Coordinator, DHS/Drinking Water Program
ASR and Water Compatibility, Geochemistry of Aqueous Solutions

This discussion highlighted the need for baseline data, monitoring data, and evaluation of all components of the ASR system.

geochemical equilibrium modeling
rock-water interaction
mixing of waters (background and injected) +/- precipitation/dissolution

...additional thoughts (JM)

- the amount of data required for geochemical models (pH, redox, chemistry) can be considerable and should be decided up front
- may need to couple geochem models with ground-water flow modeling or contaminant transport modeling

Regulatory and management considerations

Douglas Woodcock,Ground Water Hydrology Manager and Donn Miller, Hydrogeologist, Oregon Water Resources Department

AND

Martha O. Pagel, Schwabe Williamson & Wyatt

The intended application must be well defined. Aquifer recharge versus aquifer storage recovery versus other applications are regulated quite differently.

OR requires a limited license for 5 years to test before issuing a permanent permit

Guidelines (grossly simplified):

- considered a beneficial use; no change in priority date; no increase in volume or rate of use (injection)
- pre-application conference is required for all applications
- existing water rights are used for the source water (artificial recharge requires a new permit)
- use of stored water MUST be same as that for the existing right (i.e. irrigation to municipal use would not be allowed[?])
- period of use does not change (for injection or both injection and withdrawal?)
- well injection only (no gallery)
- drinking water standard must be met (or 50% of established levels)
- recovery can be 100%, but is often less; 2 to 5% is "taxed" to allow for water lost
- a ground-water level and water-quality monitoring plan (called a work plan) is required
- testing (demonstration?) is required; a limited license is issued for 5 years