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Aquifer storage wellfield assessment and design through benefit-cost-sensitivity analysis

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A R T I C L E I N F O

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Benefit-Cost Analysis (BCA) of reservoirs is standard practice, though with much room for improvement, especially through creative and expanded, but still focused use of sensitivity analysis. The significant and growing scarcity of feasible reservoir sites and groundwater substitutes has led to greater interest in projects that would complement reservoirs and, at the margin, provide a substitute for increased reservoir capacity. An Aquifer Storage and Recovery (ASR) wellfield is one such possible complement-substitute for base-load reservoir capacity. It uses aquifer storage capacity to save wet-year allocations for the driest years, which reduces or avoids price increases and/or administrative curtailment of some water uses.

So, the objectives of the article are threefold: (a) to provide an initial examination of the general economics of ASR wellfields; (b) to provide an example; and (c) to demonstrate proposed improvements in BCA methodology.

"The main driving force behind the current rapid

implementation of ASR technology around

the world is water supply economics."

www.asrforum.com

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1. Introduction and overview

Benefit-Cost Analysis (BCA) has a long history of abuse and misuse, especially for water projects. Water project evaluation has seen newspaper exposes,[1] whole books [20,25], and presidential hit lists[2] recount manipulations to justify politically correct projects. A contributing factor was that primitive software and past approaches to BCA made it costly to create and discuss the full range of plausible scenarios that decisionmakers, and the people they are accountable to, should be aware of. Lacking the needed transparent basis to compare the numerous plausible scenarios, analysts would often succumb to project advocate pressure to manufacture favorable scenarios or 'cherry-pick' favorable data and assumptions to create official feasibility estimates that would justify a politically expedient decision that had been reached prior to the BCA. Of course that is contrary to the purpose of a formal BCA, which is to facilitate better decision-making and increased accountability of the decisionmakers. That common misuse of BCA to justify, rather than assess, created a lot of cynicism about it. It also created excuses to pursue the route of least accountability and project understanding; no BCA [13,14].

Fortunately, we have the technology and motivation of numerous historical failures to do water project assessment correctly to provide better information for the even more challenging Aquifer Storage and Recovery (ASR) wellfield decisionmaking; more challenging because ASR wellfield benefits are intermittent. According to the ASR Forum, as of April, 2009 (last update), the United States had 95 operational ASR wellfields. There were only three in 1983. They exist throughout the world, and they have enjoyed considerable media attention and scholarly study. David Pyne [19] ASR book is in a large second edition. However, despite the rapid pace of ASR wellfield adoption and the pronouncement that economic efficiency is the main reason, ASR projects have seen little economic analysis. David Pyne [19] provides detailed analysis of the non-economic aspects of ASR wellfield planning and design, but the economics content is little more than common sense advice. There are no articles on the economics of ASRs; especially stunning in light of the water project origin of benefit-cost analysis.[3]

The purpose of this article is to provide an economic analysis example and demonstrate how a revised, more user-friendly approach to benefit-cost analysis (BCA) can improve the basis for ASR wellfield project decision-making, including long-range project mix optimization. The next section discusses some economic fundamentals. Section 3 describes the BCA example, the ASR wellfield management issues, and the ASR wellfield example's supply-demand context. Section 4 uses the ASR wellfield management issues to compare the findings of a conventional BCA approach to the findings of a proposed, more user-friendly BCA approach. The latter discussion includes a review of the relevant literature. Section 5 contains a summary, recommendations, and concluding remarks.

2. Economic fundamentals

This article focuses on BCA for ASR wellfields that address water supply issues such as seasonal and annual fluctuations in supply and demand, especially the drought cycle of high supply, relatively low demand during wet seasons of the year, or entire multiple wetter years, and vice versa during seasonal or prolonged, multi-year drought periods. The economics of ASRs constructed for environmental reasons are outside the scope of the forthcoming discussions and analysis.

An ASR wellfield is a water supply project whose firm yield, which means its drought period output, depends on its storage capacity, the quantity injected into it in normal and wet years, and the recovery rate, including the infrastructure constraints on annual extraction rates. It may only supply water during drought periods. Indeed, ASR wellfields seem ideally suited to regions with large, opposing fluctuations in water supply and demand, with demand peaks greatly topping the

[1] Grunwald [5].

[2] President Carter in 1977, discussed by Welsh [25].

[3] Driesen [2], Flores and Strong [3], Griffin [4], Hahn and Dudley [6], Hanley and Black [8], Hanley and Shogren [9], Hanley and Spash [10], Haveman [11], Persky [16], Sen [21], Sunstein [22], Welsh [25], and [26].