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THE ABC'S OF APPLES, BEES, AND CONNECTIONS HYDROLOGIC

Garth Taylor, Bryce Contor, and Joel Hamilton
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Exploding municipal, energy, agricultural and environmental water demands are colliding with limited or declining supplies. New infrastructure to increase water supplies has become economically prohibitive and environmentally indefensible. Environmental issues and changing patterns of water use are forcing water managers to search for new ways to reduce demand and redistribute supply. Agriculture, being the least valued and largest water user—over 80% of water diversions in the West—is often viewed as the principal target of reallocation. While the prior-appropriation no-harm rule addresses many third-party impacts, there is no comprehensive methodology for addressing the economic and hydrologic connections that result from the changes in the form, place, and timing of water supply and demand that accompany water reallocation. The result exacerbates conflict in water reallocation, symptomatic of market failure.

Defining Hydro/Economic Externalities

Economic externalities occur when the activities of one entity affect the activities of another entity and no pecuniary remuneration occurs. The divergence between private and social benefit/cost resulting from externalities results in price/market institutions failing to sustain desirable activities or curtail undesirable activities (Bator, 1958). Using the classic example of apples and honey, Meade(1952) illustrated the concept of interrelated production functions and externalities. A bee-keeper whose bees obtain nectar from apple blossoms is the recipient of a one-way positive externality. However, the bees reciprocate by fertilizing the blossoms for an apple grower. Thus the apple grower also benefits from a reciprocal positive externality. In Meade's example, the effects are externalities because the interrelated production relationships are unpriced and uncompensated, that is, the property-rights are not assigned.

Similarly, surface/groundwater connections can result in either one way or reciprocal externalities. The surface water to groundwater hydrologic connection can recharge aquifers via canal seepage and/or in-field percolation. When the aquifer is nothydraulically connected to the water course—river, reservoir, or canal—water passively seeps through an unsaturated zone, providing water to groundwater pumpers. If the passive seepage is unpriced, the pumper is the recipient of a one-way positive externality. The interrelated function that defines this one-way externality is that demand for canal water, and therefore canal delivery quantities, partially determines the groundwater supply for the pumper.

When the aquifer intercepts the zone of saturation of the canal, surface water is hydraulically connected to groundwater. The interaction is no longer one-way, but two-way; lowering of the water table by groundwater pumping induces additional seepage from the canal. Noting the water temperature differential between canal and groundwater, these connected wells are aptly labeled “warm water wells” (Strauch, 2009). With a reciprocal externality, groundwater pumpers not only enjoy the positive externality of passive seepage which is independent of pumping, they reciprocate by inflicting induced additional canal seepage by pumping water from the aquifer. The interrelated functions that define this reciprocal externality are that demand for canal water partially determines the groundwater supply for the pumpers while demand for well water partially determines water supply to the canal water users. Reciprocal externalities exist upon specific reaches of canals and many riparian aquifers.

We should caution that a negative or positive hydrologic externality depends solely on the production function of the externality recipient not on the externality producer. When canal seepage raises the water table and pumping costs are reduced, the externality is positive. When the rise in water table saturates soil and damages crops, the externality is negative. As an historical note, construction of many canal projects throughout the West was soon followed by construction of extensive drain systems to alleviate the negative externality of water logging.

Aquifers created or sustained by incidental recharge from unlined canals extend over vast areas in every western state. In the mammoth aquifers of Idaho’s Snake River Plain and California’s Central Valley, the increased recharge is virtually all from “infiltration of irrigation water” (Alley, Healy, LaBaugh, and Reilly, 2002). And the principal source of recharge to the Snake River Plain Aquifer is from canal seepage. Similarly, aquifers in Nebraska’s North Platte, Washington’s Columbia River Basin, Idaho’s Boise Valley and others are created and/or sustained by canal seepage.

A Market Failure Example—"Buy and Dry"

A classic case of market failure with a hydro/economic externality is illustrated in the “Buy and Dry” of agricultural to urban water markets. An irrigation district, supplied by a canal, sells its water right to a distant city; water deliveries through the canal decrease or cease and the aquifer sustained by canal seepage declines. The groundwater pumper, even though she holds an adjudicated right, is damaged. Whom does she sue—the farmers that sold the water, the city that purchased it, or the state that allowed the transaction?

Lacking legal recourse, the groundwater user could seek redress through a water market. Here the market fails. The amount of water conveyed down the canal is determined solely by the demand and adjudicated right of the surface water users. A market failure is defined as a wedge or disparity between social and private benefits. The private beneficiaries are the surface water users because the water supplied through the canal is priced. The groundwater users, the recipients of the positive externality of canal seepage, wishing to dodge paying for seepage water, do not have their values for water represented in the price mechanism of a market. The market fails in that the amount of water conveyed down the canal is less than the social optimum—the sum of both surface water and groundwater users.

The market failure is perpetuated when water is sold to the city. When the marginal benefit of groundwater pumpers are excluded from the calculus in the water sale, the quantity of water sold to the city will be greater and priced less than the social optimum. Inviting the groundwater users into the sale negotiations would correct the failure by internalization of groundwater user benefits. However, from the canal user’s perspective, the groundwater pumpers have been the beneficiaries of free water since construction of the canal. The costs of canal operation and maintenance, the costs of canal and storage construction, purchase of water from various suppliers, and damages resulting from warm water wells have been borne entirely by the surface water users. Further, inclusion of the groundwater users would not be in the city’s interest. With the groundwater users represented at the sale, the socially optimal amount of water sold to city will decrease and the price the city pays for water will increase. Groundwater users fall through cracks of a failed legal system and market that does not address hydrologic externalities.

Remedies for Hydrologic Externalities

There are four general policy responses to remedy externality caused market failures: (1) Pigouvian tax on a negative externality or subsidy on a positive externality, levied to align the market price with the social price; (2) technological elimination; (3) markets or internalization through pricing; (4) regulatory or administrative fiat.

Idaho's Eastern Snake River Plain Comprehensive Aquifer Management Plan (CAMP) included language to "recognize the value of incidental recharge [from surface-water irrigation]." To fund the reallocation through buyouts or other means and increase water supplies from aquifer recharge, increased storage, or other ways, CAMP proposed a fixed per-acre rate charge. The highest rate was set for groundwater users—a rudimentary fixed rate Pigouvian tax, to discourage pumping damage on surface water. Ironically, funding of CAMP was legislatively blocked by some of the very canal companies who might have become subsidy recipients.

Canal lining is a widespread prescription to conserve water by technologically eliminating seepage. The touted benefits are decreased diversions, with the assumption that the "saved" water will be dedicated to other uses. Benefits must be weighed against the explicit costs of construction and the foregone benefits of seepage to groundwater users. However, deliberations typically ignore the reduction of recharge and the resulting impact upon aquifer users. In Oregon for instance, a portion of “conserved” water can be used to expand irrigation or transferred to other consumptive uses. Economically sound analysis requires that benefits be weighed not only against construction costs but also against the foregone benefits to groundwater pumpers and spring users. However, the U.S. Bureau of Reclamation (BOR) mandate is to provide surface water and private canal companies are authorized to assess for deliveries of surface water. Since the benefits to groundwater users are external to the mission and/or revenues of decision makers, groundwater users’ benefits are likewise generally external to deliberations.

Internalization through pricing requires ownership and control of the priced commodity. In the Grant County Blacks Sands Irrigation District, Columbia Basin of Washington, the BOR is attempting to assert ownership of groundwater, where that water can be directly attributed to canal seepage (Family Farm Alliance, 2010). Internalization by ownership would pave the way for pricing the benefit generated by seepage. However, this potential remedy for externalities, contravenes a long standing principle of prior appropriations; once one loses physical control of water—whether through surface returns or percolation to aquifers- the water reverts to public ownership.

Following the legacy of the prior appropriation, regulatory fiat is perhaps the most often invoked mechanism to remedy externalities. Within each of the past three years in Idaho, junior groundwater pumpers in the Eastern Snake River Plain have been “called out”—subjected to prior-appropriation regulation. However, when calls are stayed by legal action, the market failure persists. Another example of attempting to address externalities by fiat is Oregon's practice of regulating groundwater pumping " in unconfined alluvium—sands and gravels—within 1/4 mile of the banks of a stream or water surface." (Oregon Department of Water Resources). As with any regulatory remedy, arbitrary set back regulations implicitly rank the damages of induced seepage incurred by surface water users as greater than the economic benefit of groundwater users within the setback band. An additional problem with regulatory fiat is the lack of comprehensive consideration of all externalities and hydrologic effects. In Idaho, for instance, aquifer calls and conjunctive management rules have attempted to address the externality that groundwater pumping imposes upon surface water, but the larger externality of recharge from surface water irrigation was ignored until CAMP.

Hydrologic Externalities Can No Longer Be Ignored

Areas where the ground water aquifer is created or sustained by surface water irrigation are global. While hydrologists have a thorough understanding of the surface and groundwater connection, laws and property rights, and water policy have lagged in recognizing that connection. Following the legacy of prior appropriation doctrine, current water policy approaches are largely regulatory. We are all aware of the horror stories, where the legal and regulatory enforcement or litigation costs exceed the value of the water. In the forthcoming seismic shifts in water use, continued reliance upon regulation of hydrologic externalities will only increase the potential for catastrophic market failures or inefficient water use that a water scare society can no longer afford. Having framed the surface to groundwater hydrologic connections as economic externalities, we offer the power of economics as remedies: (1) Pigouvian taxes on pumping or subsidies for canal conveyance, (2) internalization by pricing or markets, or (3) negotiated payments between pumpers and surface diverters. At the very least, we must identify and explicitly consider all the producers and recipients of hydrologic externalities.

For More Information

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Garth Taylor (gtaylor@uidaho.edu) is Associate Professor of Agricultural Economics, University of Idaho, Moscow, Idaho. Bryce Contor (bcontor.uidaho@gmail.com) is Research Hydrologist, Idaho Water Resource Research Institute, University of Idaho, Idaho Falls, Idaho. Joel Hamilton is Emeritus Professor of Agricultural Economics, University of Idaho, Moscow, Idaho.