Groundwater Recharge to Support Wildlife and Water Users: The Heyborne Ponds Project, Sedgwick County, Colorado

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ABSTRACT The Heyborne Ponds Recharge Project is a multibenefit project that simultaneously seeks to promote wildlife conservation, to address threatened and endangered species recovery, to support recreation, and to facilitate water availability for agriculture. The project delivers water from the South Platte River to recharge ponds to provide habitat for migrating birds while concurrently providing a mechanism for water to infiltrate into the alluvial aquifer and return to the river at a later time. This temporal shift in the timing of flows in the river provides several benefits. Under Colorado law, groundwater users can pump out of priority only if they augment surface water flows. Further, Colorado has interstate commitments to augmenting downstream flows in the Platte River. Multiple-benefit projects such as Heyborne Ponds represent an untapped opportunity for diverse interests to work together in implementing managed aquifer recharge.

KEYWORDS groundwater, managed aquifer recharge, governance, institutions

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INTRODUCTION
The Heyborne Ponds Project is small-scale managed aquifer recharge (MAR) project that delivers water from the South Platte River to recharge ponds on private land that provide habitat for migrating birds. Water released into the ponds infiltrates into the alluvial aquifer and returns to the river at a later time. The effect is to retine flows of water in the river, increasing flows during dry-season months. In doing so, the project supports a multistate agreement for South Platte River flows and provides a mechanism enabling water users to mitigate impacts of out-of-priority water withdrawals. The Heyborne Ponds Project demonstrates the multibenefit potential of MAR, as the project simultaneously promotes wildlife conservation, supports recreation, addresses threatened and endangered species recovery, and facilitates water availability for agriculture. The project also provides lessons as to how public–private partnerships can be developed to support MAR development and the importance of state-level regulatory regimes in supporting MAR implementation.

CASE EXAMINATION
Methods
This case study forms part of the journal’s special collection entitled “Institutional Dimensions of Groundwater Recharge.” The collection examines empirical examples of MAR from across the United States to provide insights on the institutional structures and motivations of MAR implementation. An in-depth description of the special collection and its objectives, along with a discussion of the wider context of groundwater management concerns that MAR aims to address, is included in Miller et al. [1]. Each of the case studies in the collection examines a different physical and institutional design for MAR. Case studies were developed through an analysis of documents and expert interviews. Documents reviewed include reports from agencies implementing the MAR projects, permits and reports from regulatory agencies, state laws and regulations, academic literature and technical reports, and news articles. Semistructured interviews were conducted with key individuals involved in the development of each project including government officials, regulators, and project implementers. Interviewees provided firsthand knowledge of information not included in written documentation on the project, including details on process for development and challenges in implementing the project.

Geographic and Regulatory Context
The Heyborne Ponds Project is located near the town of Ovid, in Sedgwick County, CO, several miles upstream from the Nebraska state line. Rainfall averages approximately 18 inches per year. Consequently, much of the region’s agriculture and ranching depends on irrigation via surface water diversions, primarily from the South Platte River, or groundwater pumping from the alluvial aquifer. The South Platte River joins the North Platte to create the Platte River, which flows eastward across Nebraska to the Missouri River. Although the South Platte River carries over 1 million AF of water through the valley annually, growth of municipal, industrial, and agricultural water use has strained supplies and created decades of tensions between Colorado and Nebraska, its downstream neighbor, and within Colorado between more senior and junior appropriators [2]. These tensions are heightened by the need to ensure instream flows that support several federally recognized threatened and endangered species located in the Platte River in Nebraska [3]. As described below, MAR projects such as Heyborne Ponds have been emerged in response to these tensions, as such projects provide a physical means for increasing the availability of water in the river during periods of high demands and a legal means for complying with state and federal laws and regulations.

LEGAL SETTING FOR GROUNDWATER USE IN COLORADO
Water uses in the South Platte River are governed under Colorado’s water rights system, as well as legal requirements stemming from interstate agreements with Nebraska and Wyoming and the federal government. Water rights in Colorado follow a system of prior appropriation, which governs both surface water and tributary groundwater.1 Groundwater in the South Platte River basin is considered tributary, and thus, groundwater users in the basin must comply with this water rights

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1. Notably, in Colorado, the water rights system is administered by water courts, who issue appropriation and augmentation decrees, as well as oversee disputes.
As most groundwater uses developed after surface water uses, groundwater users in Colorado tend to be junior to surface water users. Agricultural and urban areas in Colorado that have grown more recently by relying on groundwater extractions therefore typically stand exposed to the prospect of being curtailed or shutdown when water supplies are insufficient to meet all senior water users’ (usually surface water users’) requirements [4, 5].

Colorado’s 1964 Water Rights Determination Act and a subsequent statute, the 1969 Water Rights Determination and Administration Act, allow junior appropriators to protect their diversions from potential calls by senior appropriators by augmenting stream flow [2]. In 2003, the Colorado Legislature passed a bill requiring all groundwater users to obtain Colorado Water Court approved plans for augmentation by December 31, 2005 [6]. The augmentation plan process works as follows: Junior appropriators must develop a plan that includes identifying a source of water available to the river at the time and place where groundwater pumping would have impacted a senior appropriator. This proposed “augmentation plan” must be approved by a Colorado water court. The application must detail where the water will be extracted and used, the amount of water being pumped, the augmentation water source, where and when this augmentation water will needed, how much augmentation water it takes to replace depletions, and technical details. If the augmentation plan is approved by the court, the resulting “decreed augmentation plan” certifies that a junior appropriator’s actions will mitigate the impacts of groundwater pumping on surface water and provides permission for groundwater to be pumped according to the details in the augmentation plan. In the South Platte River basin, the magnitude of existing water rights appropriations, decreed augmentation plans approved by the water court are central to enabling groundwater use [7].

SOUTH PLATTE RIVER COMPACT AND THREE STATE COOPERATIVE AGREEMENT. In addition to Colorado water rights laws, water in the South Platte River basin is governed by interstate agreements. Under the 1923 South Platte River Compact between Colorado and Nebraska, between April 1 and October 15, if the mean flow at the interstate stream gauging station is less than 120 cfs, Colorado water users below the Washington County line (Water District 64) with water rights junior to June 14, 1897, must either curtail diversions or augment (replace) their depletions [8].

Even with this agreement, in the Platte River, low flows have led to degraded habitat for several federally recognized threatened and endangered species: the piping plover, whooping crane, interior least tern, and pallid sturgeon [9]. In 1997, Colorado, Nebraska, Wyoming, and the U.S. Department of the Interior signed the “Three State Cooperative Agreement” [10, 11] and subsequently, in 2007, the Platte River Recovery Implementation Program (PRRIP), which aims to restore and maintain the Platte River and habitat by increasing water flows [12–15]. Milestones for the PRRIP include decreasing dry-season flow shortages in the river using flow retiming water projects [16]. In order to achieve this goal, each state drafted its own Plan for Future Depletions that outlines the components and regulations of the PRRIP [17].

To aid in this process in Colorado, a group of municipal, industrial, and agricultural water users formed a nonprofit organization called the South Platte Water Related Activities Program, Inc. (SPWRAP). SPWRAP is a member-based organization that collectively pools risks and resources to support South Platte River flows in order to avoid members from having their water uses cut back or shut down by the state. SPWRAP reviews proposed projects, assists or undertakes recharge and augmentation projects on behalf of its members, and advocates for its members’ interests [18]. Prior to commencing any new water-related activity in the South Platte River basin, Colorado law requires the implementing party involved to obtain an SPWRAP membership, committing the water activity to Colorado’s Plan for Future Depletions [18].

Membership in SPWRAP also provides other benefits. By providing an umbrella for many landowners and water users in the region, SPWRAP serves as a collective buffer for those individuals from federal regulators. In recognition of SPWRAP’s role in reviewing projects and helping

2. Any wells in existence before June 30, 1997, and the water used to augment those wells were deemed to be “existing uses of water” as long as those wells did not result in increased irrigation acreage. Wells not meeting these criteria required demonstration that augmentation would not increase consumptive use in Colorado (see Three State Cooperative Agreement, below).

3. There are seven water courts throughout the state of Colorado, which handle determination of water rights, use of water, administration, and other water issues. Each court covers a particular watershed within the state (https://www.courts.state.co.us/Courts/Water/).
the State of Colorado maintain its downstream obligations, the federal government is willing to forego individual project-by-project certification (Section 7 review) under the Endangered Species Act.

The Heyborne Ponds Project

The aforementioned geographic and regulatory context created the impetus for a set of public and private entities to join together in development of the Heyborne Ponds Project.

The partnership included Ducks Unlimited (DU), South Platte River Ranch LLC, the Lower South Platte Water Conservancy District (LSPWCD), and the South Platte Water Recovery Activities Program (SPWRAP). The Heyborne Ponds Project provides benefits to each organization while capitalizing on their varying overlapping motivations and complementary strength.

- DU is a nonprofit organization that seeks to support and sustain waterfowl habitat throughout the United States. Healthy habitat during the spring migration is critical for maintaining a long-term population of waterfowl, as it enables them to reach their breeding grounds in the best condition possible. Development of wet and maintenance of water levels in them improves the availability of quality habitat and thus aligns with DU’s mission.
- South Platte River Ranch, LLC is a privately held ranch, the owner of which shares many of DU’s goals and was working with DU to identify mechanisms for protecting habitat on the property. The owner of the ranch enjoys recreation on the property in the form of waterfowl hunting and thus has an interest in the development of habitat on their property. Further, the project has an economic incentive, as South Platte River Ranch receives a portion of the augmentation credits produced by the project, which the Ranch can lease to partners who need well augmentation. South Platte River Ranch also placed a conservation easement on the land, thereby receiving a tax credit.
- The LSPWCD is a public, local governmental agency, created in 1964 to support local entities in the development and protection of water supplies. LSPWCD works to increase water availability in the, while keeping water users in compliance with state and federal laws and regulations. LSPWCD was seeking to support eight landowners whose wells were not covered by augmentation plans. Under Colorado law, these landowners risked having their wells shut down and were seeking assistance from LSPWCD in identifying water for and developing augmentation projects. LSPWCD receives a portion of the augmentation credits created by the Heyborne Ponds Project and distributes those credits to water users within the district, allowing those water users to withdraw water for beneficial uses, primarily agriculture.
- The SPWRAP is a nonprofit corporation formed by water users that assists its users and the State of Colorado in meeting PRRIP requirements. SPWRAP supports projects that enhance and maintain river flows in the South Platte River. SPWRAP was seeking additional water to support Colorado’s PRRIP flow commitments during summer months, and augmentation through the ponds supports those commitments.4

DU served as the project integrator, as it had existing relationships with each of the partners and had been actively involved in wetlands conservation in the region. DU also had extensive experience in project management and in soliciting grants and funding. LSPWCD had expertise in water development, including water rights and augmentation decrees. Further, LSPWCD’s relationship with agricultural water users and irrigation districts was instrumental to making the legal case for the project.5

SPWRAP also brought existing funding to the table.

RECHARGE PROJECT DESIGN. The Heyborne Ponds Project (figures 1 and 2) conveys water via a floating pump (figure 3) and underground pipeline to six recharge ponds on the property. Approximately 80% of the water is delivered to three southern ponds that lie furthest from the river because the longer lag time in accretions from

4. Several years before, the Tamarak Recharge Project had been completed by the Colorado Department of Natural Resources at the Tamarak State Wildlife Area. Although that project was a partnership between public entities, the outputs of that project, habitat protection, aquifer recharge, and flow augmentation, were similar, and thus, it served as a model for this partnership.

5. Notably, when the water court is reviewing an application for an augmentation project, project implementers have to demonstrate their demand for retimed water. Lower South Platte Water Conservancy District’s work with agricultural landowners and irrigation districts supported demonstration of beneficial use of the water as well as in demonstrating the need for the project.
the ponds reaching the river is more beneficial to local agricultural partners with the LSPWCD and to the Three States Agreement. The remaining 20% is delivered to the ponds nearest to the river for wildlife habitat and recreation.

As water conveyed to the ponds and the slough infiltrates and returns to the river, the project also provides streamflow augmentation benefits that are used (1) to make up for any out-of-priority diversions associated with the project, (2) to augment streamflow as per the PPRIP, and (3) for groundwater users in the basin who need to demonstrate streamflow augmentation.

Water for the ponds is diverted directly from the river via a lift station. A future slough may be created to support additional habitat for wildlife. Any water exposed during construction of the future slough will be administered as a well and constitutes groundwater. Availability of water for the diversion to recharge ponds is unproblematic, as diversions occur during winter months (November–April), when flows are high or the river is under free flow conditions. There are few Colorado water rights downstream of this project, and water rights for diversion have priority dates of early 1990s, so there are no conflicts with competing claims for flows during diversion periods. Water deposited in the ponds infiltrates into the alluvial aquifer and eventually flows back into the South Platte River, a gaining stream in this reach.

**ACCOUNTING FOR RECHARGE.** Tracking of flows is a key aspect of the project, as an accounting for the amount of water delivered to the ponds and percolation of that water back to the river is necessary in order to generate augmentation credits. The Lower South Platte Water Conservancy District’s augmentation decree approves the specific structures through which water withdrawals and augmentation occur, the quantities of water that can be used, and includes details on the accounting methods through depletions and accretions will be tracked. All diversions and the volume of water delivered to each pond are to be metered daily. Stream depletions and the lagged net monthly volume of recharge from the ponds and any future Heyborne Slough development are calculated using analytical methods.

Calculations of stream depletions and recharge are performed using Colorado’s Integrated Decision Support Alluvial Water Accounting System, which is widely used for augmentation plans across the state. For the future Heyborne Slough, evaporative losses would be calculated monthly using an adjusted reference evapotranspiration value. Daily volumes delivered to each recharge pond will be metered and the monthly inflows adjusted for evaporation, vegetation use, and spillage to determine net recharge.

During the start of the project, intensive monitoring confirmed water in the ponds was indeed resulting in recharge. For the Heyborne project, three monitoring wells down gradient of Pond No. 1 measure monthly depth to water. If shallow depths to the water table are measured, indicating reduced effective recharge,

6. The project’s augmentation decree limits withdrawals to a maximum of 4,200 AF/year.
7. For alluvial recharge/retiming projects, there are no water quality standards/requirements that have to be met.

8. Parameters for this analysis are specified through the augmentation plan and include consideration of the width of the aquifer on the side of the river where recharge or depletion is occurring, the distance from the river to the recharge or depletion structure, transmissivity of the aquifer, and specific yield of the aquifer. The values for these parameters were determined through a U.S. Geological Survey Publication entitled “Hydrogeologic Characteristics of the Valley-Fill Aquifer in the Julesburg Reach of the South Platte River Valley, Colorado.” For more on the Glover equation, see southplatte.colostate.edu/files/AGWT/Garcia.pdf.
10. (Augmentation Decree—Case No. 08CW24).
11. Evaporation is based on the maximum area of each pond that receives water, the number of days of delivery each month, the area of the pond covered in vegetation during the two calendar months following any month water is in the pond, and the specified consumption rates that vary by month.

**FIGURE 1.** One of the Heyborne recharge ponds in operation. Photo Source: Ducks Unlimited.
LSPWCD is required to either file an application to reduce the water levels in the ponds or face a reduction in recharge credits.

**PARTNER ROLES AND RESPONSIBILITIES.** Project management authorities and responsibilities are distributed across the multiple parties in the Heyborne Ponds partnership and reflect the complementary interests and capacities found in the partnership.

The project operates on property owned by the South Platte River Ranch, but primary management responsibilities lie with the other entities. South Platte River Ranch LLC provides the land that is used for the lift-station, pipelines, and recharge ponds. The ranch also owns equipment that is used for the project, though the equipment is operated by LSPWCD.

DU was responsible for the design and implementation of construction activities for the project including...
managing the budget and obtaining the necessary construction approvals and authorizations. DU also conducted an engineering inspection during the first 2 years of the project and is responsible for a biological and engineering inspection to be conducted every 3 years to assure biological and physical health of project. Finally, DU is responsible for the waterfowl management plan.

LSPWCD is responsible for operation of the project and holds the water rights decree. The district also provides monthly and daily water accounting to the Division Engineer’s office and the water court to demonstrate compliance with the augmentation plan and to calculate and track evapotranspiration losses and any out-of-priority pumping. LSPWCD receives a share of the recharge augmentation credits generated by the project and sells those to the landowners in its district.

SPWRAP and the Colorado Department of Natural Resources provided financial support and approvals for the project. SPWRAP, for example, pays the electrical bills associated with the project due to direct benefits to the Three State Agreement. SPWRAP also helps fund repairs and reconstruction of the project facilities if they are damaged by flood.

COSTS, FINANCING, AND BENEFITS. The project was financed by contributions from all project partners as well as by state grants. The SPWRAP allocated funds of US$215,000 from the North American Wetlands Conservation Act (NAWCA) Grant, US$100,000 of which contributed to building the project. Ducks Unlimited and the South Platte River Ranch jointly provided just under US$50,000, while the Colorado Department of Natural Resources contributed US$230,000. Finally, LSPWCD put forward US$53,000 from an already obtained grant under the NAWCA. Operations and maintenance costs are estimated at around US$27,000 per year, primarily related to electricity costs for pumping, though LSPWCD periodically has to perform maintenance for the ponds and has monitoring obligations.

Benefits from the project include augmentation credits for agricultural wells, augmented flows for the PRRIP program, habitat protection, and land conservation. The credits are divided among the partners based on a negotiated agreement. Of the 1,155 AF of recharge credits the project is expected to produce on an annual basis, 640 AF are contributed to SPWRAP for Colorado’s PRRIP program [19].12 SPWRAP receives credits only under special circumstances.13 The other 515 AF are dedicated to augmentation, with South Platte River Ranch receiving 20% and LSPWCD receiving 80%. If South Platte River Ranch does not need all of the credits allotted in a given year, it can lease the credits back to LSPWCD. Further, any recharge credits accruing to LSPWCD can be leased at market rate for other water users in the basin. Revenue accumulated by LSPWCD from leasing credits is put toward the costs of electrical, operation, and management bills. Any time leasing of credits does not cover expenses of daily operations, SPWRAP will reimburse LSPWCD for operations costs.

In addition to recharge credits and any potential revenue they create, the project creates value added by protecting habitat and conserving land. As part of the project, South Platte River Ranch entered into a conservation easement for the property. The easement created a tax benefit for South Platte River Ranch, and the habitat preservation has enabled excellent bird viewing in the spring and recreational waterfowl hunting in the spring.

DISCUSSION

The confluence of Colorado’s integrated system of surface and groundwater rights with an interstate water compact and broad mandates for environmental protection was

12. Of these recharge credits, 240 AF will contribute to the Platte River Recovery Implementation Program’s “Initial Contributions” (winter months) and 400 AF will contribute the “Future Depletion Plan” (May and June).

13. South Platte Water Related Activities Program, Inc. only receives credits when those credits are not needed for augmentation or for recharge from excess rather than out of priority diversions.
a critical element that brought the multiple parties involved in implementing the Heyborne Ponds Project together. Colorado’s law that requires augmentation for out of priority pumping that impacts surface water flows, combined with the state’s clearly defined method of accounting for augmentation, made it possible for project developers to quantify and directly benefit from implementation of the MAR project. The PRRIP, and the formation of SPWRAP to support implementation of the PRRIP, were also critical to initiation of the project, as they provided an additional source of funding for the project and had a role in facilitating administrative and financial cooperation across project participants.

Key to the success of this project was also the creativity and imagination of the project proponents, who were able to devise a collaboration that benefited all of the multiple parties. The match between their interests (habitat for waterfowl, land conservation, recharge augmentation, and augmentation of flows) created an opportunity for the project, yet aligning those interests and moving the project forward represented a significant accomplishment requiring leadership and vision. Each party contributed a key physical, financial, technical, or managerial resource. The spread of expertise across them facilitated the legal aspects of the project, in terms of water rights and augmentation decrees, with the well owners served by LSPWCD providing the motivating beneficial use for application of the water.

Resource availability and sharing are also important parts of the collaboration. Particularly important for project inception and development were the presence of a willing (conservation minded) landowner, who dedicated his land to the project, plus adequate funding to construct and operate the project. The LSPWCD’s capacity and willingness to manage water operations and SPWRAP’s willingness to pay the majority of the O&M costs are central to the project’s success.

Although the multiparty collaboration was essential to the development of the Heyborne Ponds Project, this collaboration was also one of the initial challenges. The efforts required to develop such a tightly integrated project are difficult to overstate and included significant upfront investment in interparty communication to develop the idea into a viable and actionable plan. Developing a multibenefit project required great effort to find a structure that balances the goals of the owner of the South Platte River Ranch, the quantified ecological benefits for DU, the trust of the LSPWCD, and fit within the complex framework for water use in the South Platte River Basin. Prior experiences and relationships between DU, SPWRAP, and LSPWCD, developed during another recharge project, and between DU and the owner of the South Platte River Ranch, provided a formidable backbone for the collaboration. Further, DU was able to serve as the project coordinator for all aspects of project development, which is critical for these types of endeavors. DU’s role as coordinator stemmed not only from their in-house engineering capacity which was needed for taking the project from start to finish but also because it had developed trusted relationships and social capital important for supporting collaboration.

Design of the project was an intensive process, as it took time to determine the technical details, such that the water available for augmentation, the lagged recharge time, and the habitat needs would all fit synergistically with one another. Soon after completion of the project, a flood damaged the pumping pond and repairs and adjustments had to be made. Further, the initial design included a closed pumping system. During initial operations, this system was blocked by debris and the system had to be reengineered and replaced with an open culvert. This new system requires increased routine maintenance and thus higher operations and maintenance costs. Although challenges related to operations and maintenance costs and to flood events may periodically manifest, overall the project is up and is running well. The location of the project (near the Nebraska border) ensures the long-term value of the project. Current participants are optimistic that the project operations have been well developed for stable long-term operation.

In sum, the Heyborne Ponds Project illustrates a remarkable multiparty collaboration, by which creative decision making and risk sharing enabled parties to achieve their mutual interests. It also illustrates the degree to which enabling institutions at a high level can drive local actions. The Heyborne Ponds is not the first multi-benefit MAR project in the region nor, given its success, will it be the last. SPWRAP, LSPWCD, DU, and other parties continue to pursue options for the development of similar projects. Development of enabling institutions, including Colorado’s integrated governance of surface and groundwater, and its well-defined accounting procedures...
would facilitate the implementation of similar MAR projects in other states.

**KEY TERMS AND ACRONYMS**

(AF) Acre-feet—A volume of water that would cover one acre at a height of one foot. Equivalent to 325,851 gallons or 1,233 cubic meters.

(DU) Ducks Unlimited—A nonprofit organization dedicated to the conservation of wetlands and associated upland habitats for waterfowl, other wildlife, and people.

(LSPWCD) Lower South Platte Water Conservancy District—A local governmental district created to support local entities in the development and protection of water supplies.

(MAR) Managed Aquifer Recharge—A project that intentionally induces water to flow into an aquifer.

(PRRIP) Platte River Recovery Implementation Program—A program developed collaborative between Colorado, Wyoming, Nebraska, and the Department of the Interior for the purpose of restoring habitat and supporting recovery of endangered and threatened species.

(SPRR) South Platte River Ranch—A privately owned property used for wildlife conservation and recreational hunting.

(SPWRAp) South Platte Water Related Activities Program—A member-based organization that pools resources to take actions that increase flows in the river.

**AUTHOR CONTRIBUTIONS**

AM researched and wrote the original draft. KG, AB, and WB contributed to research and writing.

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**COMPETING INTERESTS**

The authors have declared that no competing interests exist.

**REFERENCES**


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