Case Study: Heyborne Ponds Recharge Project

Incentivizing Groundwater Recharge

Case Study #4

Working Draft

September 3, 2019

Center for Law, Energy, and the Environment
UC Berkeley School of Law

This case study is part of a series focusing on incentives for Managed Aquifer Recharge, and the institutional context in which MAR projects are conducted. The series is being produced as part of a larger project examining this topic. A symposium on September 10, 2019 will highlight these and other projects. More information is available at law.berkeley.edu/recharge2019.

This working draft has not been finalized for publication. Please contact the authors if you would like to circulate or cite this piece.

Funding for this project is provided by Nestlé Waters North America.

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Heyborne Ponds Recharge Project

Incentivizing Groundwater Recharge – Case Study #4

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Overview

Location: Sedgwick County, CO
Motivation for MAR: Maintaining surface water diversions and groundwater pumping, while remaining in compliance with an interstate water rights compact and a federal agreement for downstream threatened and endangered species protection.
Groundwater Challenges: Effects of groundwater overdraft on connected surface waters
MAR Challenges: Initial multiparty collaboration; Colorado's Water Court process; occasional O&M costs related to flood events

Figure 1: One of the Heyborne recharge ponds in operation

Project Goals: Retiming of surface water from times of surplus streamflow to times of deficit to provide shallow water wetland habitat for migratory birds as well as to support downstream threatened and endangered species, and agricultural well pumping.
Key Actor(s): Ducks Unlimited, Lower South Platte Water Conservancy District (LSPWCD), South Platte River Ranch (SPRR), South Platte Water Related Activities Program, Inc. (SPWRAP)
Water Source: South Platte River
Start Date: 2009
Current Status: Operational
Average Annual Yield: 900 AF of recharge (2009-2018)
Cost: Estimated $27,000/year

1. Motivation and Goals

The Heyborne Ponds Recharge Project is a multi-benefit project that simultaneously seeks to address threatened and endangered species recovery, promote wildlife conservation, support recreation, and 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. In doing so, the project supports a multi-state agreement for South Platte River

flows and provides a mechanism enabling water users to mitigate impacts of out-of-priority water withdrawals.

2. Geographic and Historical Context

The Heyborne Recharge Project is located near the town of Ovid, in Sedgwick County, Colorado, several miles upstream from the Nebraska state line. Rainfall averages around 18 inches per year. Consequently, much of the region's agriculture and ranching depends on irrigation via surface water diversions or groundwater pumping. The South Platte River originates in Colorado and extends into Nebraska. In western Nebraska, the South Platte joins the North Platte flowing out of Wyoming to create the Platte River, which flows eastward across Nebraska to the Missouri. The Platte River in Nebraska is home to habitat for several federally recognized threatened and endangered species: the piping plover, whooping crane, interior least tern, and pallid sturgeon.[1]

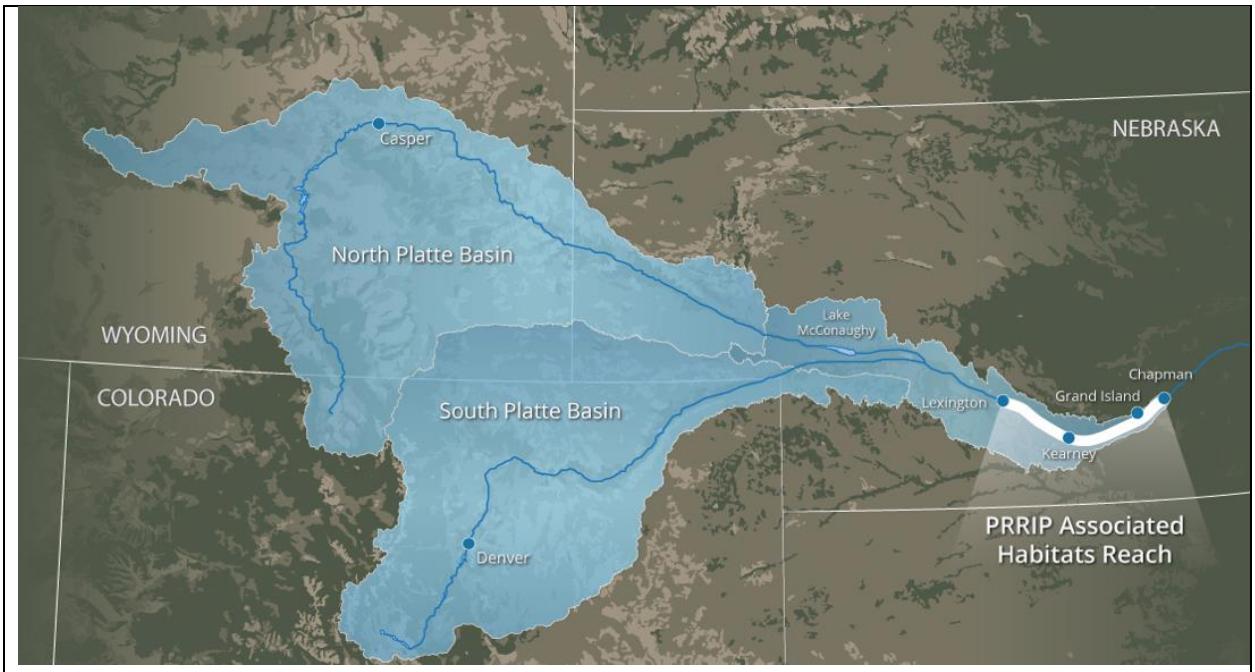

Figure 2. Platte River Basin as it traverses three states and the habitat reaches protected under the Platte River Recovery Program (Source: https://platteriverprogram.org)

Although the South Platte River carries over 1 MAF of water through the valley annually, and the South Platte Alluvial Aquifer has an estimated 8.3 million acre-feet of water storage,[2] the 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.[3] MAR projects such as Heyborne Ponds – also known within Colorado as augmentation projects – have grown out of those tensions. The volume of water recharged annually in the South Platte River basin in Colorado now exceeds total surface water reservoir storage (Figure 3).

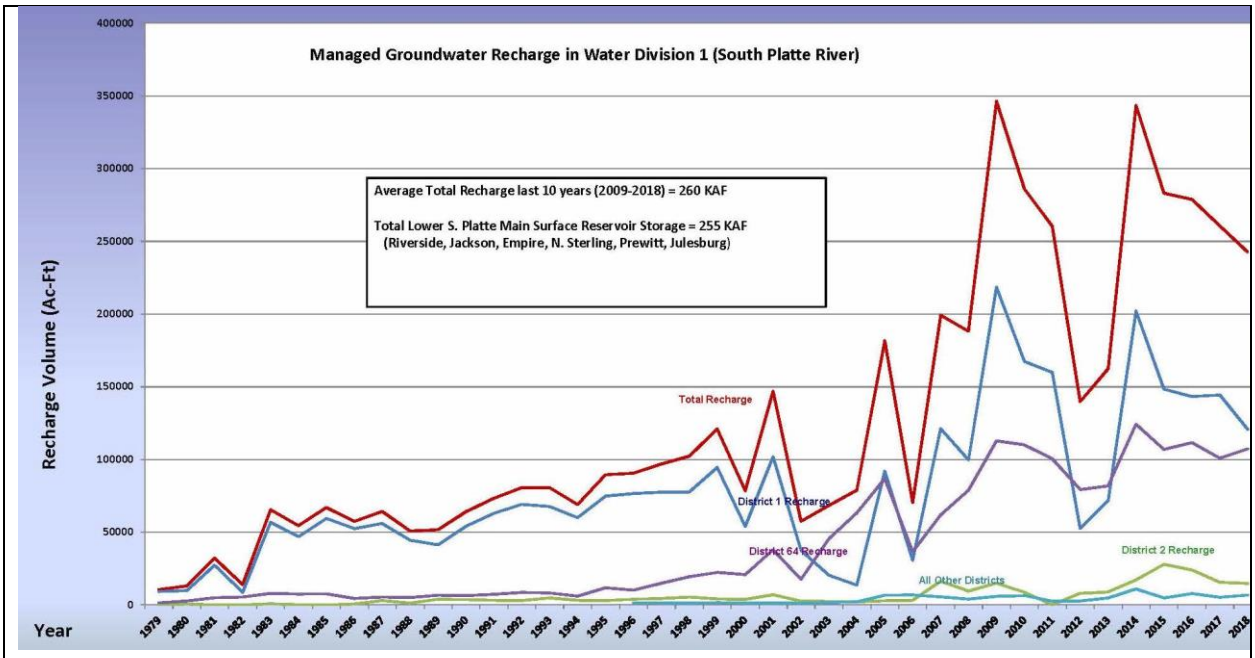

Figure 3. Managed Groundwater Recharge in Colorado. District 1 – the South Platte River (which includes The Heyborne Recharge Project) is illustrated by the blue line. Recharge across the state, and particularly in the South Platte River has increased substantially since 2005. (Source: Colorado Division of Natural Resources)

3. Regulatory Setting

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.

3.1. Water Rights in Colorado

Water rights in Colorado follow a system of prior appropriation. Senior water rights holders have priority. Junior rights holders have permission to withdraw and use water as long as supplies are sufficient and do not injure senior downstream water rights holders. During times of low flow, senior water right holders have the ability to put a "call" on junior water users and restrict their water use.[4,5] Such calls are handled through the State Engineer's office and its structure of Division Engineers (the South Platte basin constitutes Division 1). Disputes are resolved through Colorado's water courts, which are organized by the same geographic divisions.

Colorado stands out among western states that employ prior appropriation doctrine, because surface water and tributary groundwater in Colorado are covered by the same seniority system. Thus under Colorado law, tributary groundwater is subject to the rules of prior appropriation. The majority of the state overlies alluvial plain, and thus most groundwater thus falls under the appropriative water rights system.[6] As in most places, groundwater uses developed after surface water uses and therefore, with some exceptions, 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 shut down when water supplies are insufficient to meet all senior water users' (usually surface water users') requirements.[7]

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.[8] In 1974, water users in the South Platte River Basin agreed on a set of rules regulating wells. While these rules restricted new diversions, they allowed wells covered by court-approved and temporary augmentation plans to continue to operate. A drought in 2001-2002 inflamed tensions over these rules, and in 2003, the Colorado Legislature passed a bill requiring all groundwater users obtain Colorado Water Court approved plans for augmentation by December 31, 2005.[9,10]

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.[11] 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 appropriators' actions will mitigate the impacts of groundwater pumping on surface water.

Augmentation water to replace out-of-priority pumping can come from any legal location, such as augmentation wells, recharge ponds, reservoir storage releases, or ditch company shares.[12] Colorado judges will grant a decree if extracted water is being put to beneficial use and if the plan can successfully deliver water back to seniors in times of injury.[13] The decree can include two types of supplies. *Recharge augmentation supplies* encompass all water supplies that are diverted into recharge locations such as ponds or ditches, and provide lagged replacement of water to the river. *Surface augmentation supplies* refer to the water that is diverted from storage reservoirs to the river using augmentation stations, and provide rapid replacement to the river.[14] The Division Engineer will regularly survey the project on its effectiveness and contribution to the river's restoration.[15]

In the South Platte River basin, decreed augmentation plans approved by the water court are the main legal and administrative vehicle governing tributary groundwater.[16]

3.2. South Platte River Compact and Three State Cooperative Agreement

The impact of groundwater use on South Platte River flows is of particular concern in Colorado. Under the 1923 South Platte River Compact between Colorado and Nebraska, Nebraska is allotted 47,127 acre-feet per year. Between October 15 and April 1, Colorado is granted access to all water flow within its boundaries. Between April 1 and October 15th, Colorado water users below the Washington County line (Water District 64) with water rights junior to June 14th,

1897 must either curtail diversions or augment (replace) their depletions if the mean flow at the interstate stream gauging station is less than 120 cfs.[17]

Despite the agreement, water conflicts in the South Platte River basin continued to escalate. One result was degraded habitats for species along the South Platte and downstream in the Platte River, four of which eventually became listed under the federal Endangered Species Act as noted earlier. In 1997, Colorado, Nebraska, Wyoming and the U.S. Department of the Interior signed the "Three State Cooperative Agreement", to restore and maintain the Platte River and habitat by increasing water flows.[18, 19] The Cooperative Agreement led to the Platte River Recovery Implementation Program (PRRIP), the first phase of which began in 2007. [20, 21, 22, 23] Milestones for the PRRIP include decreasing dry-season flow shortages in the river by using flow re-timing water projects. Such projects would be voluntary for any individual landowner or water user, but the three states participating in PRRIP agreed to provide incentives to encourage participation.[24] In order to achieve this goal, each state drafted its own Plan for Future Depletions that outlines the components and regulations of the PRRIP.[25]

Each state is required to comply with the tracking guidelines laid out in the document, creating a uniform accounting system between the three states.[26] To aid in this process, a group of municipal, industrial and agricultural water users formed a non-profit 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 avoid members from having their water uses cut back or shut down by the state. To do so, SPWRAP reviews proposed projects, assists or undertakes recharge and augmentation projects on behalf of its members, and advocates for its members interests.[27] Prior to commencing a new water related activity, Colorado law requires the implementing party involved obtain a SPWRAP membership, committing the water activity to Colorado's Plan for Future Depletions. The amount of depletion dictates the form of SPWRAP membership a project can obtain: a one-time depletion membership or an ongoing depletion membership. Any depletion greater than 25 acre-feet per year is considered ongoing, requiring the party to pay an annual fee that fluctuates with varying depletion amounts.[28]

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

Overall, the regulatory setting for the Heyborne Ponds MAR project encompasses the combined effect of Colorado water law with the State of Colorado's federal and interstate obligations on the South Platte River. Absent some method of enhancing dry-season flows in the South Platte, Colorado would risk being out of compliance with its interstate compact with Nebraska and with the federal-interstate Platte River Cooperative Agreement and the PRRIP. If that were to happen, Colorado would have to restrict water uses along the South Platte. Colorado water

rights law dictates that this would mean cutting off junior appropriators – mostly groundwater users including the municipalities, farms and ranches, and other businesses that have developed in the South Platte River basin over the past half-century. The economic consequences of shutting down junior appropriators would be extreme. MAR projects in the form of augmentation plans have been the primary means of averting such a dire outcome in the South Platte basin.

4. Managed Aquifer Recharge through the Heyborne Ponds Recharge Project

The Heyborne Ponds Recharge Project was developed as a partnership between 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). DU is a non-profit organization dedicated to the conservation of wetlands and associated habitat for waterfowl and for people. South Platte River Ranch LLC is a privately held ranch, also used for recreational birding and hunting. LSPWCD is a public, local governmental agency, created in 1964 to support local entities in the development and protection of water supplies. SPWRAP is a nonprofit corporation formed by water users that assists its users and the State of Colorado in meeting PRRIP requirements, which are detailed below.

The partnership formed out of mutual interests between the parties involved:

- Ducks Unlimited (DU) is a non-profit 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.
- South Platte River Ranch, LLC shares many of DU's goals and was working DU to identify mechanisms for protecting habitat on the property.
- The Lower South Platte Water Conservancy District (LSPWCD) is a local governmental agency whose goal is to support water users and sustain water use within the district at the highest levels possible, while keeping water users in compliance with state and federal laws and regulations. LSPWCD was in discussion with 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.
- The SPWRAP (as described above) aims to support projects that enhance and maintain river flows in the South Platte River. SPWRAP was seeking additional water to support Colorado's PRRIP commitments.[29]

The overlapping motivations and complementary strengths of the parties involved facilitated the partnership. DU served as the integrator, as it had existing relationships with each of the partners and had been actively involved in seeking water 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, LSPWCDs

relationship with agricultural water users and irrigation districts was instrumental to making the legal case for the project.[30] SPWRAP also brought existing funding to the table.

4.1. Recharge

The Heyborne Ponds Project (Figure 4) conveys water via a floating pump (Figure 5) and underground pipeline to six recharge ponds on the property. Approximately 80% of the water is delivered to the three southern ponds that lie furthest from the river because the longer lag time in accretions from 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 pond nearest 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 i) to make up for any out-of-priority diversions associated with the project, ii) to augment streamflow as per the PPRIP and iii) for groundwater users in the basin who need to demonstrate streamflow augmentation.

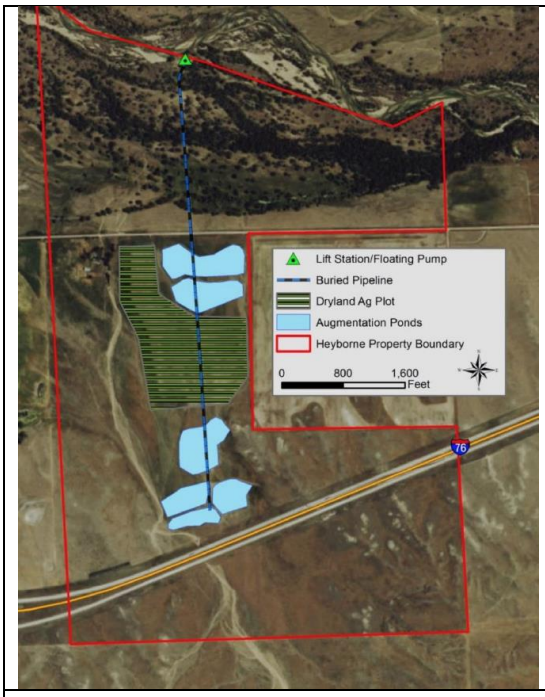

Figure 4. Schematic of the Heyborne Ponds Project

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 in the future slough will be administrated as a well and constitutes groundwater. There are few Colorado water rights downstream of this project, so the project can generally access surface water for recharge throughout the winter (November to April).[31] 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.[32]

4.2. Accounting

The Lower South Platte Water Conservancy'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 is 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.[33]

Calculations of stream depletions and recharge are performed using Colorado's Integrated Decision Support Alluvial Water Accounting System[34] (AWAS), which is widely used for

augmentation plans across the state.[35] 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.[36]

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. Shallow depths to the water table corresponding to reduced effective recharge trigger actions by LSPWCD to reduce the water level, or a reduction in recharge credits.

4.3. Recovery

Though no water is directly recovered from the project, the calculated volume of recharged water is converted into augmentation/recharge credits, which allow holders to pump groundwater. The project will convey approximately 395 AF of water to the ponds each month, delivering about 2,173 AF during the 5.5-month period from November 1 through the first half of April. Lagged groundwater accretions will produce 1,155 AF of credits. Due to adjustments during the first stages of the project, including a flood event, average annual accretions from 2009-2018 have been closer to 900 AF.

Figure 5. Heyborne Lift Station

5. Project Management

5.1. Institutional Arrangements

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 will be 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 supervision of all 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 two years of the project and is responsible for a biological and engineering inspection will be conducted every three years to assure biological and physical health of project. Lastly, 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.

5.2. Project Costs

The project was financed by contributions from all project partners as well as by state grants. The SPWRAP allocated funds of $215,000 from the North American Wetlands Conservation Act (NAWCA) Grant, $100,000 of which will contribute to building the project. Ducks Unlimited and the South Platte River Ranch jointly provided just under $50,000, while the Colorado Department of Natural Resources contributed $230,000. Lastly, LSPWCD put forward $53,000 from an already obtained grant from NAWCA. Operations and maintenance costs are estimated at around $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.

5.3. Project Benefits and Revenues

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, 515 AF of accretions will belong to LSPWCD and South Platte River Ranch and 640 AF will be contributed to the SPWRAP for Colorado's PRRIP program.[37, 38] SPWRAP receives credits only under special circumstances.[39] Of the credits developed for augmentation, South Platte River Ranch receives 20% credits, while LSPWCD receives 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. With the revenue accumulated from leasing credits, LSPWCD grants SPWRAP credit towards 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 South Platte River Ranch, and the habitat preservation has enabled for excellent bird viewing in the spring and recreational waterfowl hunting in the spring.

6. Analysis and Summary

6.1. Key Elements

The Heyborne Ranch illustrates a remarkable multi-party collaboration that reflects current water resources concepts of integration, cooperation, and achieving mutual interests through creative decision-making and risk sharing. It also illustrates the profound degree to which enabling institutions at a high level can come together to drive local actions, in this case the confluence of Colorado's integrated system of surface and groundwater rights with an interstate water compact and broad mandates for environmental protection.

Key to the success of this project is the creativity and imagination of the project proponents, combined with the collaboration across multiple different 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 part of the collaboration. Particularly important for project inception and development were the presence of a willing (conservation minded) landowner, willing to dedicate his land to the project and adequate funding to construct and operate the project. The local Conservancy District's capacity and willingness to manage water operations and SPWRAP's willingness to pay the majority of the O&M costs are the keys to long-term success.

6.2 Incentives and Benefits

While the project provides myriad benefits, a number of incentives supported development of the Heyborne Ponds project.

South Platte River Ranch receives a portion of the augmentation credits produced, 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. Further, the owners of the ranch enjoy recreation on the property in the form of waterfowl hunting when the site is operational.

LSPWCD receives augmentation credits from the Heyborne Ponds project that it can distribute to other water users within the district, allowing beneficial uses of water to be maximized within the district's service area while keeping the State in compliance.

SPWRAP receives funding from the State of Colorado, as well as augmentation credits, which it puts towards meeting Colorado's PRRIP obligations. Colorado water users in general, and SPWRAP members in particular, benefit from remaining in compliance with the Three States Agreement because they are exempt from Section 7 ESA consultation for new water projects development.

Perhaps the greatest incentive of all is that provided to the State of Colorado by the terms of the Platte River Cooperative Agreement and the PRRIP which allow Coloradans to continue South Platte water uses at levels that would otherwise be unsustainable and out of compliance. Northeastern Colorado is a vital economic engine and political constituency for state officials, and forcing major water reductions on water users in the region would have been both politically and financially disastrous.

6.3 Challenges and Future Considerations

While the multi-party collaboration was essential to development of the Heyborne Ponds project, this collaboration was also one of the initial challenges. The creativity and communication required to develop the idea for such a tightly integrated project is difficult to overstate, not to mention the significant upfront investment in inter-party communication to develop the idea into a viable and actionable plan. Developing a multi-benefit project required great effort to find a structure that balances the goals of the landowner, the quantified ecological benefits for the NGO, the trust of the water conservancy district, 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 through implementation of the Tamarack 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 is unique in that they have in-house engineering capable of taking the project from start to finish, as well as the 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 O&M costs. While 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.

Acknowledgements
Jason Roudebush (Ducks Unlimited), Joe Frank (LSPWCD) and Dan Gallan (SPWRAP) for taking the time to talk with us and for providing details, insights, corrections and photographs. Kirsten Bylo, University of Massachusetts, Amherst for her help with research and writing. Funding for this research project was provided by Nestlé Waters North America.

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[10] 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.[10] Wells not meeting these criteria required demonstration that augmentation would not increase consumptive use in Colorado (see Three State Cooperative Agreement, below).

[11] 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/

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[28] U.S. Fish and Wildlife Service (2007). ESA Consultations Involving Platte River Depletions. Information for Project Proponents in Colorado on the Platte River Recovery Implementation Program." Guidance document, issued August 9.https://www.fws.gov/platteriver/Documents/Colorado%20Guidance%202015.pdf
[29] Several years before, the Tamarak Recharge Project had been completed by the Colorado Department of Natural Resources at the Tamarak State Wildlife Area. While 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.
[30] Notably, when the water court is reviewing an application for an augmentation project, project implementers have to demonstrate their demand for retimed water. LSPCD's work with agricultural land owners and irrigation districts supported demonstration of beneficial use of the water as well as in demonstrating the need for the project.
[31] The project's augmentation decree limits withdraw to a maximum of 4200 AF/year.
[32] For alluvial recharge/retiming projects, there are no water quality standards/requirements that have to be met.
[33] 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*
[34] See http://www.ids.colostate.edu/projects.php?project=spmap&breadcrumb=SPMAP+-+South+Platte+Mapping+and+Analysis+Program+Tools for more details.

[35] (Augmentation Decree - Case No. 08CW24)
[36] 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.
[37] Altenhofen, Jon (2009). *Memorandum: Yield Analysis Memo for Heyborne Recharge and Wildlife Project (HRWP) Agreement.* Northern Water.
[38] Of these recharge credits, 240 AF will contribute to the PRRIP's 'Initial Contributions' (winter months) and 400 AF will contribute the 'Future Depletion Plan'(May and June)
[39] SPWRAP only receives credits when those credits are are not needed for augmentation or for recharge from excess rather than out of priority diversions.