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MEMORANDUM

TO: Water Resources Commission

FROM: Kim Fritz-Ogren, Planning, Collaboration, and Investments Manager
Alexandria Scott, East Region Engagement Coordinator

SUBJECT: Agenda Item F, June 15, 2023
Water Resources Commission

Groundwater Portion of Harney Community-Based Water Planning Collaborative's Place-Based Integrated Water Resources Plan

I. Introduction

The Harney Community-Based Water Planning Collaborative (Collaborative) will present on the groundwater portion of their integrated plan and share inter-agency support for this key milestone and the ongoing surface water planning. This is an informational report.

II. Background

Undertaking place-based integrated water resources planning (place-based planning) is recommended action 9A of Oregon's Integrated Water Resources Strategy (IWRS). This planning is a voluntary, locally initiated and led effort in which a balanced representation of water interests within a basin or watershed work collaboratively and in partnership with the state to complete a five-step planning process to: 1) Build a collaborative and integrated process; 2) Characterize water resources, water quality, and ecological issues; 3) Quantify existing and future needs; 4) Develop integrated solutions for meeting long-term water needs; and 5) Adopt and implement the plan.

A planning group can choose to seek state recognition for their place-based integrated water resources plan. The Draft Guidelines call for state agencies review to the plan and make a recommendation to the Commission on whether to recognize a plan. The core IWRS agencies, and others as appropriate, review the plan to evaluate if it is consistent with the Draft Guidelines and IWRS principles. The Department developed the 2019 Planning Step 5 DRAFT Guidance to aid the planning groups and state agencies through this evaluation process.

The planning group then presents their plan to the Commission with the accompanying state agency recommendation and asks the Commission to recognize the plan on behalf of the State of Oregon. To date the Commission has recognized three place-based integrated water resources plans:

- Upper Grande Ronde River Watershed Partnership's Place-Based Integrated Water Resources Plan (March 2022, Item F)

- Mid-Coast Water Planning Partnership's Water Action Plan (June 2022, Item E)
- Lower John Day Place-Based Partnership's Integrated Water Resources Plan (June 2022, Item I)

III. Discussion

Since 2016, the Collaborative has conducted place-based planning in partnership with the state, following the 2015 Draft Place-Based Planning Guidelines. The Collaborative approached place-based planning differently from the other groups piloting place-based planning, splitting groundwater and surface water planning. The Collaborative completed the groundwater portion of their integrated water resources plan, outlining their planning progress to date, key findings, and more than two dozen strategies developed by the Collaborative to help address groundwater declines and related issues in the planning area.

Representatives from the Department, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Department of Agriculture, and the Oregon Watershed Enhancement Board reviewed the draft groundwater plan and determined by consensus that a number of improvements to the plan were required to receive an agency recommendation for state recognition. The Collaborative has either addressed these items or noted how they intend to address them through their surface water planning. Because of the unique nature of the Collaborative's approach, these state agencies want to acknowledge that the work done to date on the groundwater portion of their plan is in alignment with the requirements for state-recognition. The Collaborative still needs to complete the surface water portion of their plan to receive state recognition but are interested in sharing progress with the Commission.

As the Department updates the Division 512 rules governing groundwater use and allocation in the Malheur Lake Administrative Basin, the Collaborative would like to share with the Commission the groundwater strategies proposed in the now complete groundwater portion of their place-based plan. The Collaborative will also share an update on some of their strategies that already being implemented. The conveners of the group will share their thoughts and the process for addressing the interagency plan review team feedback they received.

IV. Conclusion

In their review of the groundwater portion of the Collaborative's place-based integrated water resources plan, the state agencies found the groundwater portion of the plan, both in terms of content and development process, was in alignment with the requirements to receive state recognition upon the completion of the surface water portion of the plan. The Department anticipates returning to the Commission later to request that the integrated plan be recognized and to provide periodic updates on the status of these initiatives. The Department will continue to engage with the Collaborative and people in the basin to chart a pathway forward to address groundwater declines and other issues in the basin.

Attachments:
1. Groundwater Portion of the Harney Community-Based Water Planning Collaborative Place-Based Integrated Water Plan

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Harney Basin Groundwater Portion of Integrated Water Plan

Harney Community-Based Water Planning Collaborative

A sustainably managed supply of quality water for people, the economy, and the environment.

April 2023

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Abbreviations

CBWP	HARNEY COMMUNITY-BASED WATER PLANNING
CC	COORDINATING COMMITTEE
cfs	CUBIC FEET PER SECOND
CREP	CONSERVATION RESERVE ENHANCEMENT PROGRAM
DEQ	OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
GDE	GROUNDWATER-DEPENDENT ECOSYSTEMS
GHVGAC	GREATER HARNEY VALLEY AREA OF CONCERN
gpm	GALLONS PER MINUTE
GWSAC	GROUNDWATER STUDY ADVISORY COMMITTEE
OAR	OREGON ADMINISTRATIVE RULES
ORS	OREGON REVISED STATUTES
OWRC	OREGON WATER RESOURCES COMMISSION
OWRD	OREGON WATER RESOURCES DEPARTMENT
PBP	PLACE-BASED INTEGRATED WATER RESOURCES PLANNING
RAC	RULES ADVISORY COMMITTEE
ST	STRATEGY TEAM
USGS	UNITED STATES GEOLOGICAL SURVEY
WSMP	CITY OF BURNS WATER MASTER PLAN

Plan at a Glance: Executive Summary

The Harney Community-Based Water Planning (CBWP) Collaborative consists of diverse stakeholders working together to plan for future groundwater management in the Harney Basin. The planning process followed Oregon Water Resources Department's (OWRD) place-based planning (PBP) steps. In general terms, those steps are: 1) Build a Collaborative, 2) Examine Existing Basin Conditions, 3) Characterize Future Water Needs, 4) Develop Solutions and 5) Implement. The planning process was conducted within the framework of existing statutes and rules.

Like much of the western United States, the Harney Basin faces increasing pressure on its water resources. The Harney Basin must balance its thriving agricultural economy that helps support a vibrant community with an arid climate, declining water table, and the drinking water wells and groundwater dependent ecosystems that rely on the aquifer. Currently, groundwater discharge, majorly used for irrigation purposes, exceeds the amount of natural recharge the Harney Basin receives. This, and other influences, prevent some instream and out-of-stream water needs from being met. Multi-stakeholder and cross-agency coordination, and sufficient funding, are critical to meet the challenges facing the Harney Basin.

This report describes the Groundwater Section of the Harney Basin's Integrated Water Resource Plan. The CBWP Collaborative details 33 critical groundwater issues identified that impede the Harney Basin's ability to meet both instream and out-of-stream water needs. Along with each critical issue is a set of strategies that will address or help to overcome the critical issue of concern and ultimately support the CBWP Collaborative's vision: *A sustainably managed supply of quality water for people, the economy, and the environment.*

The CBWP Collaborative identified the following eight themes in their list of 33 critical groundwater issues: Overallocation/Groundwater Level Declines, Effects on Ecosystems, Water Security for Groundwater Users, Groundwater Governance and Accountability, Community Economic Stability, Climate Change/Cycle Effects on Groundwater, Information Gaps, and Community Understanding.

The CBWP Collaborative identified 31 strategies to help address these critical groundwater issues. Strategies were organized as foundational, operational, tactical, or organizational/informational.

Key findings of the CBWP Collaborative include:

- Many domestic, stock, and irrigation wells are adversely affected by declining groundwater levels.

- The Collaborative has helped to initiate programs to improve irrigation technology, reduce irrigation acreage, and assist domestic well owners that have been affected by groundwater level declines. The collaborative has cooperated with Harney County Court in the exploration of alternative ways to provide domestic water including a community well in the Crane community.

- The Collaborative has identified strategies to implement over time to reduce the rate of use of stored groundwater.

- Oregon Water Resources Department has issues groundwater permits for some 304,000 acre-feet/year in the Harney basin. Current estimates of use totals some 152,000 acre-feet/year (Garcia et al., 2022). This indicates that there has been significant allocation of groundwater beyond current estimated use and recharge rates.

- Groundwater discharge in the lowlands of the Harney Basin exceeds recharge by an estimated 110,000 acre-feet each year (Garcia et al., 2022).

- There are areas of serious decline in the groundwater table associated with a concentration of groundwater pumping and highly transmissive geology (Garcia et al., 2022).

- All groundwater deeper than approximately 100 feet appears to be ancient, stored water from previous climatic conditions (Gingerich et al., 2022).

The findings and solutions as well as other components found in this plan are based on a multi-year, multi-stakeholder effort committed to community input, engagement and a balanced approach. Agricultural stakeholders, landowners, tribal representatives, rural and municipal residents, conservation groups, and local, state, and federal agencies participated in identifying the critical issues and in developing strategies or actions that will help improve conditions. Evidence to support the critical issues and strategy development was gathered from peer-reviewed science, local knowledge, and data, and is documented throughout the plan. Support was provided from state and federal agency experts and scientists from regional conservation organizations. Collectively, the CBWP Collaborative's information and findings from Steps 2 to 4 support the strategies and recommendations in this Plan.

Introduction

Planning Purpose

Place-based integrated water resources planning (PBP) is a voluntary, locally initiated and led effort in which a balanced representation of water interests works in partnership with the state to understand and meet their instream and out-of-stream water supply needs. The program was established by SB 266 (2015) which provides broad requirements. By collaboratively developing a shared vision for the future and anticipating and addressing specific water-related challenges, PBP gives those who live, work, and play in a community and care about it deeply a stronger voice in their water future, which in turn will provide a pathway for building the political and public support needed for water resource projects. Furthermore, communities that undertake a PBP approach can help inform statewide efforts. In summary, PBP allows communities and groups interested in water resources of an area to identify the water resource needs and then partner with the state and others to develop solutions and tools that will help meet those needs now and into the future.

The Harney Basin PBP process began in 2016 to address the water resource issues in the watershed. While PBP is meant to be integrated, because of the current crisis of overallocation and over-use of groundwater in the basin, the Harney Community-Based Water Planning (CBWP) Collaborative decided to focus their efforts on groundwater first; this plan reflects the process, results, and findings for groundwater only. A subsequent process is underway and focused on surface water.

Geographic Scope

The Harney Basin is in southeastern Oregon in the northern Great Basin. This cold desert region is characterized by flat basins surrounded by block faulted and other mountains. Being on the northern edge of the Great Basin, the northern and northwestern boundary of the basin is composed of volcanic mountain ranges of the High Lava Plains and Blue Mountains. The Harney Valley makes up a significant portion of the Harney Basin (Figure 1). This relatively flat area is the focus of agriculture and is the population center for the basin. The basin lies between the Blue and Ochoco Mountains to the north and northwest and the Steens Mountain to the south. The Harney Basin is dominantly within Harney County but includes small portions of Lake, Malheur, and Grant Counties.

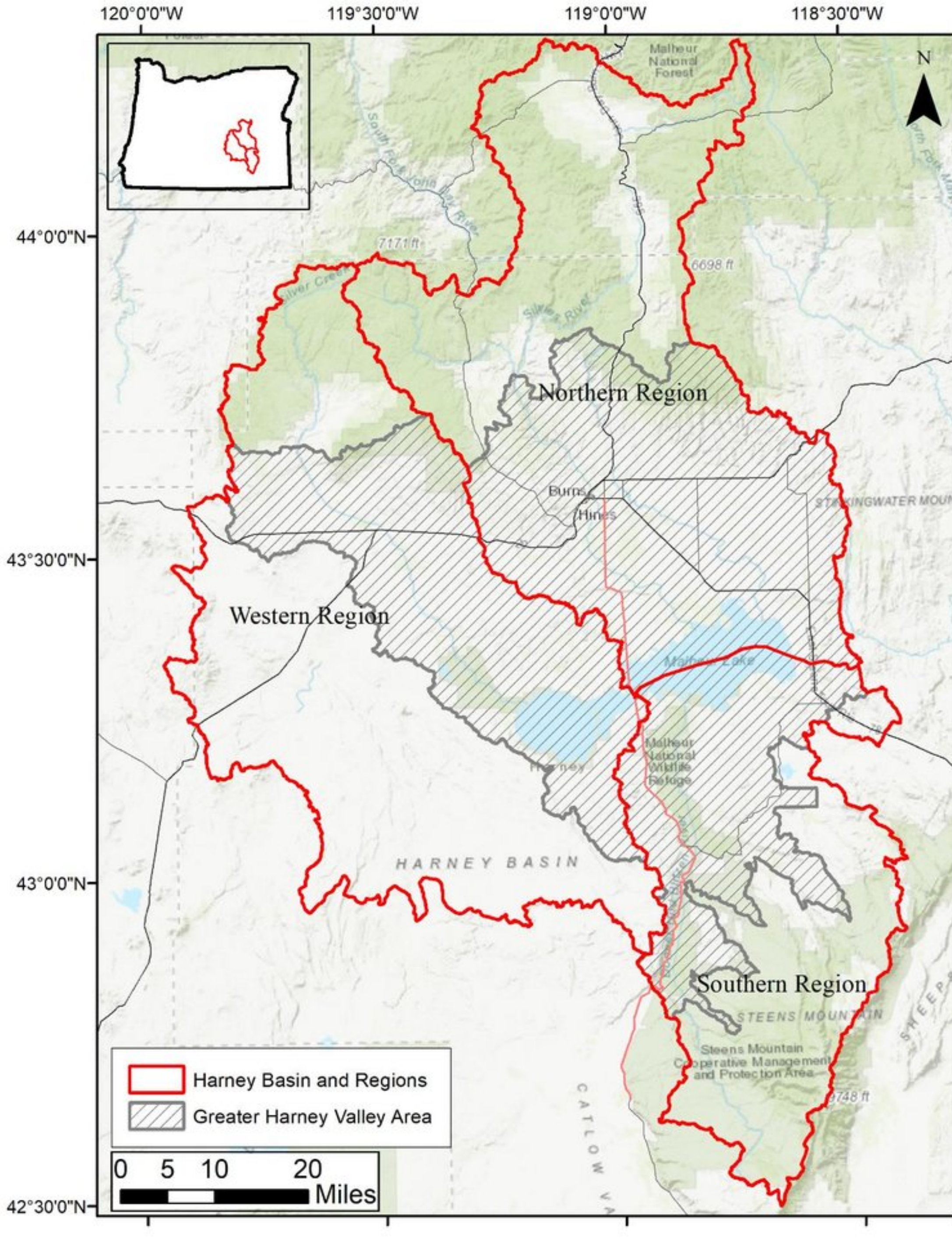

Figure 1. Harney Basin Study Area (From Beamer and Hoskinson, 2021)

The basin climate is semiarid with long, cold winters and short, dry summers. The growing season, based on temperature, for most of the county is quite short, generally only from June to September (Gomm, 1979). Gingerich and others (2022) report; "The monthly mean temperature for 1981–2010 varied little by location and elevation, ranging from 27 degrees Fahrenheit (°F) in December to 67 °F in July at the Malheur Refuge Headquarters near Malheur Lake (Malheur Refuge Headquarters, Oregon [355162]; elevation 4,100 ft) and from 25 °F in December to 65 °F in July at the Fish Creek SNOTEL station on Steens Mountain (elevation 7,660 ft)" (U.S. Department of Agriculture Natural Resources Conservation Service, 2020; Western Regional Climate Center, 2020)" The basin has a very wide diurnal temperature range, particularly during the summer months. Easterly flows of dry air in the summer result in high temperatures and low humidity.

Much of the precipitation falls in the form of snow. Precipitation in the form of rainfall is quite variable both in timing and location and occasional, localized intense storms can bring as much as an inch of rain in an hour. Regional studies of predicted snowpack change in the future (Klos et al., 2014) estimate a significant reduction in snowpack and increased incidence of rain in the basin.

The Oregon Water Resources Department (OWRD)/US Geological Survey (USGS) Groundwater Study (Gingerich et al., 2022) compared the study period (1982-2016) precipitation to the longer record (1900-2016) to determine if the range of values was comparable to the long-term record. The analysis showed that the 1980's and 1990's generally were wetter than the 2000's.

Plan Organization

The following Groundwater Portion of the Integrated Water Resource Plan (Step 5) is a summary of the Harney Basin's background and findings from the Collaborative's Step 1 (commenced in 2016) through Step 4 (completed in 2021).

- Chapter 1 describes background information from the Collaborative's work (Step 1).
- Chapter 2 summarizes the Collaborative's planning process (Step 1).
- Chapter 3 highlights the current groundwater conditions and trends (Step 2).
- Chapter 4 summarizes groundwater uses in the Harney Basin (Step 2).
- Chapter 5 outlines the critical groundwater issues identified throughout the planning process (Step 3).
- Chapter 6 details the desired groundwater conditions for the Harney Basin (Step 3).
- Chapter 7 details the suite of tools and strategies developed to address critical issues and achieve goals as well as a categorization approach (Step 4).
- Chapter 8 outlines the data needs identified throughout the planning process (Step 4).

- Chapter 9 outlines the CBWP Collaborative's approach for implementation (Step 5).
- Chapter 10 offers the importance of adaptive management principles while in the implementation phase (Step 5).
- Chapter 11 concludes the plan and provides a narrative on plan recognition

Chapter 1: Background and Context

Greater Harney Valley Groundwater Area of Concern

Groundwater in the Harney Basin is critical for municipal, domestic, industrial, commercial, agricultural irrigation, stock water, and for supporting several groundwater dependent ecosystems. With the closure of the Hines Mill in 1980, irrigated agriculture has become an important source of income and employment for the Harney Basin. Along with cattle production, hay produced primarily by groundwater irrigation is the main cash income for the area's private agricultural sector. In 2015, the OWRD presented analysis of groundwater level data, aquifer recharge estimates and groundwater allocations that indicated annual groundwater use and other discharge significantly exceeded the estimated annual recharge in the Greater Harney Valley Area. Areas of significant groundwater level decline were identified and some domestic well users were losing access to groundwater in their existing wells.

The OWRD, in consultation with the Harney County Court, then began significant outreach to the local community to build awareness of the situation, seek input, and initiate efforts to address water needs for the area. The OWRD also formed a Rules Advisory Committee (RAC) to address changes to the Oregon Administrative Rules (OAR) that govern water management in the basin (OAR Chapter 690). After significant deliberation, the Oregon Water Resources Commission (WRC) established the Greater Harney Valley Groundwater Area of Concern (GHVGAC) in the Malheur Lakes Basin Program Rules in OAR Chapter 690 as Division 512 on April 15, 2016. The rule closed the GHVGAC to new groundwater permit applications (with specific exceptions in two sub-areas); provided a pathway for issuance of permits for applications pending as of April 15, 2016, if offset water was provided; specified certain conditions for any new permits issued under the rules; and otherwise limited new groundwater use to exempt uses. The rules specify that within one year of the publication of the USGS/OWRD Groundwater Study (which also commenced in 2016), a RAC will be convened to "explore whether there is a need for updates or changes" to the rules. The goal of the rules was to address the fact that additional groundwater allocations would exacerbate groundwater declines and avoid further overallocation. The rules did not limit development that could legally occur under existing but undeveloped permits. At the time of the designation there were 85 undeveloped permits to irrigate some 20,000 acres and 38 pending groundwater irrigation applications (OWRD Staff Report Attachment 6, April 13, 2016).

Harney Basin Groundwater Quantity Studies

There have been several groundwater studies of the Harney Basin starting with a 1939 study of "Geology and Ground Water Resources of the Harney Basin, Oregon" by USGS. In 1970, the Oregon State Engineer in cooperation with USGS completed the "Ground-Water Resources in Harney Valley, Harney County, Oregon" report. These studies provide the background of predevelopment conditions of the basin.

The Harney Basin groundwater decline issue was presented at a Harney County public meeting on May 26, 2015. On June 18, 2015, the issue was presented to the WRC. Since 2016, the OWRD and USGS have been working cooperatively to better understand the groundwater system in the Harney Basin. Additionally, a Groundwater Study Advisory Committee (GSAC) as required in the basin administrative rules adopted in 2016 was convened by the OWRD in coordination with the Harney County Court to create a forum where groundwater scientists could share data and analyses and Advisory Committee members could share local knowledge and data throughout the investigation. The final meeting of the Advisory Committee was held on December 12-13, 2019. At this meeting the USGS presented the preliminary findings and conclusions from the scientific study.

In April 2022, the USGS published "Groundwater Resources of the Harney Basin, Southeastern Oregon (Gingerich et al., 2022), and "Hydrologic Budget of the Harney Basin Groundwater System, Southeastern Oregon (Garcia et al., 2022). Supporting studies by OWRD include Grondin et al.,(2021) "Methods and Results for Estimating the Hydraulic Characteristics of the Subsurface Materials in the Harney Basin"; (Boschmann (2021) "Generalized Geologic Compilation Map of the Harney Basin"; Beamer and Hoskinson (2021) "Historic Irrigation Water Use and Groundwater Pumpage Estimate in the Harney Basin, Oregon 1991-2018"; and Grondin (2021) "Method and Results for Estimating Groundwater Pumped, Returned, and Consumed for Non-irrigation Uses in the Harney Basin, Oregon".

Some key results from the groundwater study include:

- Historically, the groundwater budget was in balance which means what entered the basin through natural recharge was nearly equal to what left the basin through natural discharge (e.g., evaporation, transpiration from plants, discharge to streams and springs, etc.). The average annual recharge in the Harney Basin is estimated at 288,000 acre-feet in the uplands. Some 49,000 acre-feet/year of groundwater moves from the uplands to the lowlands (Garcia et al., 2022). The average annual upland discharge to streams and springs totals about 239,000 acre-feet/year. Some 116,000 acre-feet/year of surface water enters the lowlands (159,000 acre-feet of natural streamflow and flooding and 57,000 acre-feet/year of flood irrigation from surface water) (Garcia et al., 2022).

- The groundwater budget was essentially in balance until people started using water. The amount of groundwater used by people is close to the amount that we are out of balance (110,000 acre-feet). Between 2016-2018, people removed 140,000-150,000 acre-feet per year for irrigation use (Beamer and Hoskinson, 2021), non-irrigation use added another 7,000 acre-feet pumped with about 6,000 acre-feet consumed and 900 acre-feet returned to groundwater (Grondin, 2021).
- Groundwater users are predominantly using (removing) "stored" groundwater, which is water that had been stored in the pore space around subsurface rocks and sediments for hundreds or thousands of years (Gingerich et al., 2022).

Applicable Law and Policy

Under Oregon Law, all water belongs to the public. With few exceptions, any person wishing to use surface water or groundwater must first obtain a permit from the OWRD. The water right, once developed, is attached to the land where it was established. The place of use of a water right can be moved through a permit amendment process (ORS 537.211 and OAR 690-380-2110) or transfer following the procedures of Oregon Water Law (ORS 540.505 to 540.580 and OAR Chapter 690, Divisions 380 and 382). In Oregon, landowners with water flowing past, through, or below their property do not automatically have a right to use that water.

Oregon's water laws are based on the principle of "prior appropriation." This means that the first person to obtain a water right to a water source is the last to be regulated off in times of low water availability. In water-short times, water users with the oldest water right have a right to the amount specified in their right regardless of the needs of junior users. If regulation occurs, water rights are regulated off in order of priority, with the most junior first. If there is a surplus beyond the specified amount of the senior right holder, the right with the next oldest priority date can take their specified amount as necessary to satisfy their appropriation under their right and so on down the line until there is no further water available. State law has required issuance of a water permit for surface water use since 1909; groundwater has been subject to statewide permitting requirements since 1955. Apart from water uses established prior to permit requirements, the date of application for a permit is the priority date of the right. Oregon's water code contains four basic provisions:

- Except for certain exempt uses, surface or groundwater may be legally diverted only if it is used under the terms of a valid water right for a beneficial purpose.
- Among groundwater uses not requiring a permit are domestic use and stockwater use.

- The more senior the water right, the more likely water is available in a time of shortage.
- Water permits and water right certificates specify, among other conditions, the land to which the permitted water may be applied. The permit or certificate is attached to that land but may move through an approved amendment (for permits) or transfer (for certificates) if certain standards are met. To avoid forfeiture, subject to certain exceptions, a water right must be used at least once every five years for its intended purpose. If the right is unused for five consecutive years, subject to certain exceptions, it is presumed forfeited and is subject to cancellation.

Groundwater use in the Harney Basin requires permits for agricultural, municipal, and other uses under Oregon Law. In addition to statewide permitting statutes and rules, groundwater permitting for the basin is governed by the GHVGAC discussed above (OAR 690-512-0020).

Chapter 2: The Planning Process (Step 1)

Drivers for Planning

The Harney Basin groundwater clearly has become over-allocated, and some local wells are seeing declines in static water level by as much as 140 feet (Gingerich et al., 2022) and some shallow wells have gone dry. Groundwater development has increased over time (Figure 2) with spikes in the 1970's and since 2000.

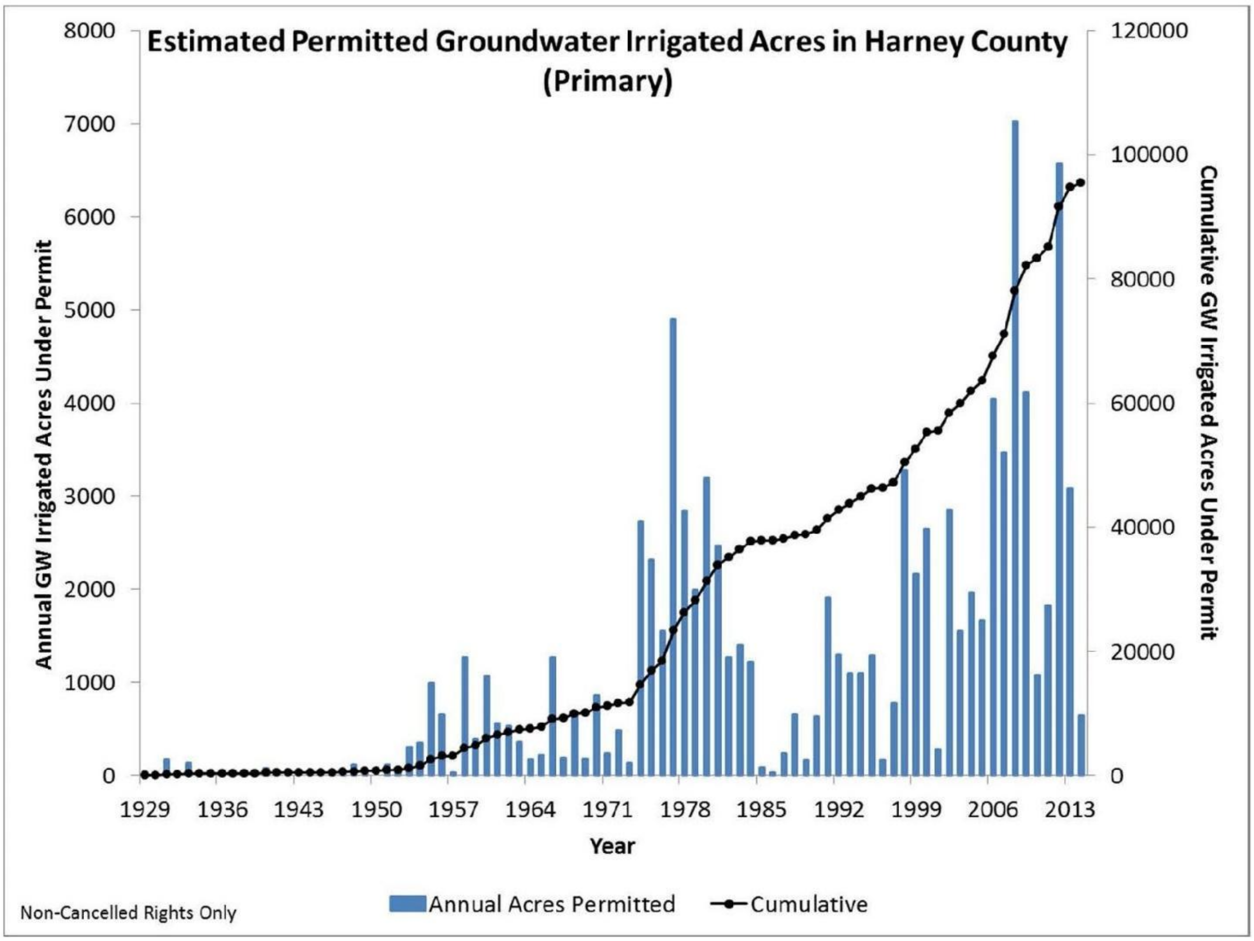

Figure 2. Permitted Groundwater Irrigation in the Harney Basin (OWRD, 2016)

The issue became statewide news in 2016. The public attention, administrative challenges to new permits, and the measurement of groundwater declines led to subsequent regulatory action by the Oregon Water Resources Department to limit issuance of new additional groundwater permits.

The Harney Basin CBWP Collaborative (Collaborative) has been working on the development of information about groundwater declines and management strategies to address those declines for nearly 6 years.

The Harney Basin has a rich history, which has been shaped by its limited water resources in an arid region. As the community faces complex challenges and a significantly over-appropriated groundwater supply, managing the use of this essential resource will be key to the future. The Basin's groundwater-related challenges are formidable.

Participants

Harney County is a community of less than 7,500 people; however, the resources of the basin attract parties throughout the state and beyond that care and have concerns about the ecological and economic integrity of the community. During Step 1 (Build a Collaborative) of the CBWP's PBP process, the conveners invited people that represent a full suite of interests to participate in the effort. A Working Agreement (Appendix A) was then drafted to offer guidelines and sideboards for the Collaborative's decision-making, disagreements, and discussion protocols. The Working Agreement provided that only those parties who attended at least 2 of the last 4 Collaborative meetings AND signed onto the Working Agreement could participate in consensus decisions.

The parties that participated and signed on to the Collaborative's Working Agreement include representatives from the following groups:

- Harney County Court representative (County Government)– co-convener
- Harney County Watershed Council representative (Conservation)– co-convener
- Bureau of Land Management (Federal Government)
- Burns Paiute Tribe (Tribal Government)
- Ducks Unlimited (Recreation)
- Harney County Cattlewomen (Agriculture Association)
- Hines Common Council (City Government)
- Landowners (Resident)
- Malheur National Wildlife Refuge (Federal Government)
- Municipal Water Users (Community)
- Numu Allottee Association (Tribal Government)
- Oregon Department of Environmental Quality (State Government)
- Oregon Farm Bureau (Agriculture Association)
- Oregon State University Extension Service (State Government)

- Oregon Water Resources Department (State Government)
- Audubon Society of Portland (Conservation)
- Rural Domestic Well Users (Resident)
- Stock Well Users (Resident)
- The Nature Conservancy (Conservation)
- U.S. Forest Service (Federal Government)
- Water Right Services, LLC (Business)
- WaterWatch of Oregon (Conservation)

The parties that participated without signing on to the Collaborative's Working Agreement include representatives from the following groups:

- Farm Service Agency (Agriculture Association)
- Harney County Soil and Water Conservation District (State Government)
- Natural Resources Conservation Service (Federal Government)
- Oregon Department of Agriculture (State Government)
- Oregon Department of Fish and Wildlife (State Government)

The parties who were invited to the process but did not end up participating or participated sporadically and did not sign on to the Collaborative's Working Agreement include municipal governments (city government) and senior water rights holders (resident). Representatives from municipalities did attend a handful of meetings, but never became regular participants as they communicated that their water supply is not of concern. CBWP project staff kept municipalities updated on the Collaborative's progress and the City of Hines did end up reviewing this plan. Senior water rights holders were invited but did not attend regularly, despite significant outreach efforts from the project manager, co-conveners, and Collaborative members. Such outreach efforts included emails, phone calls, and the development of Harneyswaterfuture.com (created by the Collaborative for general information on irrigation practices and ways to reduce groundwater use for the community). During development of the website, a few Collaborative members formed the Irrigator Working Group to generate targeted outreach materials to reach other irrigators in the Harney Basin. A water rights professional that represents many of the water right holders in the basin was a regular participant and signatory of the Working Agreement.

Outreach

The Collaborative used a variety of communication methods to engage the public and maintain an open and transparent process. The project manager compiled and regularly updated an email list of all CBWP meeting attendees. At the end of the CBWP's groundwater planning phase, that email list included over 160 contacts. Meetings announcements and materials were sent to all contacts on that email list and advertised in the local newspaper and radio, on the Harney County Watershed Council's website and Facebook page, and on Harneyswaterfuture.com. During CBWP meetings, attendees, both new and regular, were always welcomed to the process.

After each meeting, summaries, recordings, presentation slides, and decision outcomes were circulated to the email list and were posted on the Harney County Watershed Council's website. The project manager kept open availability for Collaborative members to call and/or email with any questions or concerns. Additionally, a member of the Collaborative maintained a blog for some time before her untimely death.

Process and Timeline

The general Collaborative planning process is illustrated below (Figure 3). Because groundwater issues are acute, the Collaborative chose to separate the place-based planning process into two phases and focus the early efforts on groundwater. The intention is to complete the groundwater planning in 2022 and take up surface water and surface-groundwater interactions after that. The timeline was initially driven by the potential of the groundwater study being completed in 2020 which would trigger a revisitation of the basin rule that established the GHVGAC. Unforeseen delays (COVID 19, etc.) have led to timeline slippage; however, the intention is to complete the integrated plan in 2023.

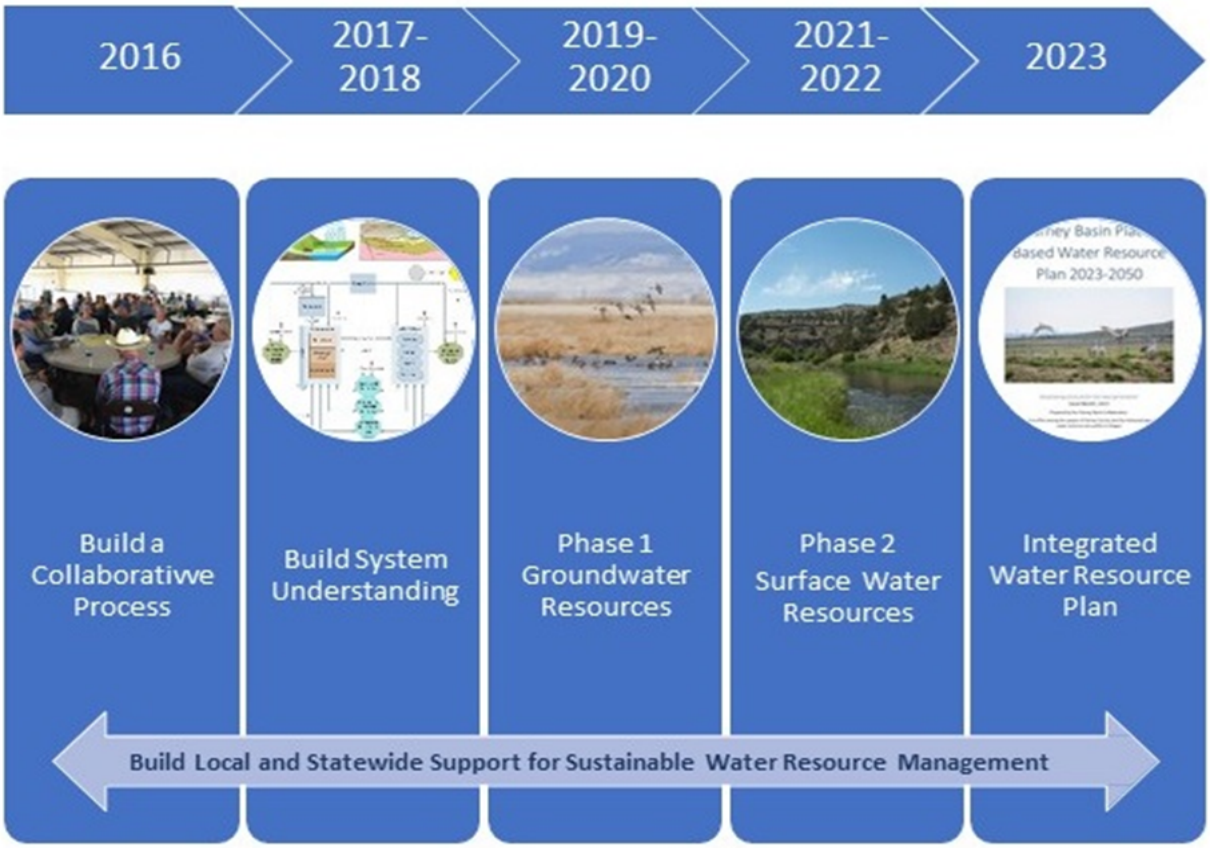

Figure 3. Harney Basin Community-Based Integrated Water Planning Program

During Phase 1, the Collaborative had a Coordinating Committee (CC) and a Strategy Team (ST) to take care of process details. The CC, composed of Collaborative members, provided input on meeting agendas, shaped discussions, and reviewed meeting materials to ensure productive Collaborative meetings and clear processes. The CC met on a biweekly basis throughout the planning process. Outcomes from CC meetings were regularly communicated with the Collaborative.

The ST, composed of the co-conveners, consultants, facilitator, and OWRD planning coordinator, helped the project manager maintain partnerships, sequence certain discussion topics, and communicate with OWRD and other partners. The ST met on a biweekly basis for much of the planning process but moved to an *as-needed* schedule in 2022. Outcomes from ST meetings were shared with the CC, and the Collaborative ultimately, when sensible.

Questions, comments, or concerns from Collaborative members on meeting materials, reports, presentations, summaries, etc. were first organized by the project manager according to the document. The project manager then developed a plan for working through those questions, comments, or concerns. In some cases, the project manager alone could address all questions, comments, or concerns to the commenter's satisfaction. In other cases, the project manager would bring those questions, comments, or concerns to the ST and CC for guidance on how to best address them. Sometimes a work group, composed of Collaborative members, would form to work through questions, comments, or concerns. In all cases, comments and any changes made to documents were shared with the Collaborative to ensure transparency.

The process for Phase 2 is still being planned but will likely look like Phase 1.

From First Draft to Final Draft: CBWP Process, Public Comment, Interagency Review of Groundwater Plan, and Plan Adoption

The first iteration of the Groundwater Plan was made available to the Collaborative in January 2022, the second in March 2022, the third in April 2022, the fourth in May 2022, and the fifth in July 2022. It went through several rounds of editing and updates by Collaborative members and has been informed by the OWRD/USGS Groundwater Study, which was released in April 2022. Collaborative members were asked to review the first two iterations of the Plan and provide input and comments which project staff would then incorporate into the next iteration. All comments were compiled by the project manager and put into one document for project staff to review and consider. After each round of editing, a clean version of the Plan would be circulated to the Collaborative and would be reviewed at the following Full Collaborative meeting.

The process outlined above made tracking complicated for Collaborative members as it became increasingly difficult to see where comments and suggestions were integrated into the next version of the Plan. As a result, the editing process shifted to make tracking changes more straight forward. Instead of circulating a clean version of the Plan, a redline, tracked changes version was sent out. Project staff directly responded to any comments on the redline version so that Collaborative members could see where their suggestions were integrated/ how they were considered. This proved to be a better approach and made the review process much easier for all.

Draft 4 of the Groundwater Plan became available in April 2022. Project staff planned for a consensus event in May 2022, but it became evident during the May Full Collaborative meeting that the Plan would benefit from one more round of editing. Draft 5 was circulated to the Collaborative in June 2022

In July 2022, 14 eligible collaborative members participated in a consensus event on the recommendation to circulate Draft 5 of the Groundwater Plan for public comment and to also submit it to the Interagency Review Process. A consensus tool of 1-5 (see below) was used to determine the decision.

1. I enthusiastically agree (Eight Collaborative member votes)
2. I agree (Four Collaborative member votes)
3. I am on the fence, have questions, or am neutral (Zero Collaborative member votes)
4. I have serious questions or concerns, but am not willing to block forward movement of the group (Two Collaborative member votes)
5. I object and will block forward movement of the group (Zero Collaborative member votes)

Those who voted with a 4 voiced their concerns during the July Full Collaborative meeting. The Collaborative ultimately decided to continue moving forward with their approval.

The Collaborative then opened a one-month public comment period for their Groundwater Plan from October 1-31, 2022. During this time, the project manager also gave a presentation on the Groundwater Plan to the County Court and Water Resources Commission. Few comments were received from the public, but all were considered by the Collaborative.

The Collaborative and OWRD worked together to develop an interagency review process for this Groundwater Plan to verify that both the Plan and process to date is on the path to receive state recognition, pending completion of surface water planning.

All Required Improvements received by the Plan Review Team (PRT) were integrated into this Plan and were then discussed with the PRT during a follow up meeting. The project manager then discussed such improvements with the Coordinating Committee and made a few necessary updates to the Plan based on the conversation with the PRT. The project manager then re-submitted the Groundwater Plan to the PRT and shared the updated plan in a tracked changes version with the Collaborative. The Collaborative was given 30 days to provide their input on the tracked changes version. After addressing input from Collaborative members, the project manager circulated the final version of the Groundwater Plan to the list-serv.

Chapter 3: Current Groundwater Conditions/Trends (Step 2)

The Hydrological Cycle Model

A model of the hydrology of the Harney Basin was developed to guide planning. The model identifies the major elements and pathways of water flow throughout the basin. This model is being used to identify and keep track of the different factors to consider when managing water in the basin.

Groundwater in the basin is only a portion of the hydrological cycle (Figure 4). It includes soil water, a recharge zone, natural discharge to springs and phreatophyte vegetation, and storage. The groundwater portion of the hydrological cycle depends on precipitation in all forms. Use of groundwater for agriculture, municipal and industrial uses, domestic and stock water uses, and the support of groundwater dependent ecosystems all come from recharge and storage. As uses increase beyond recharge, groundwater is taken from storage resulting in groundwater level declines.

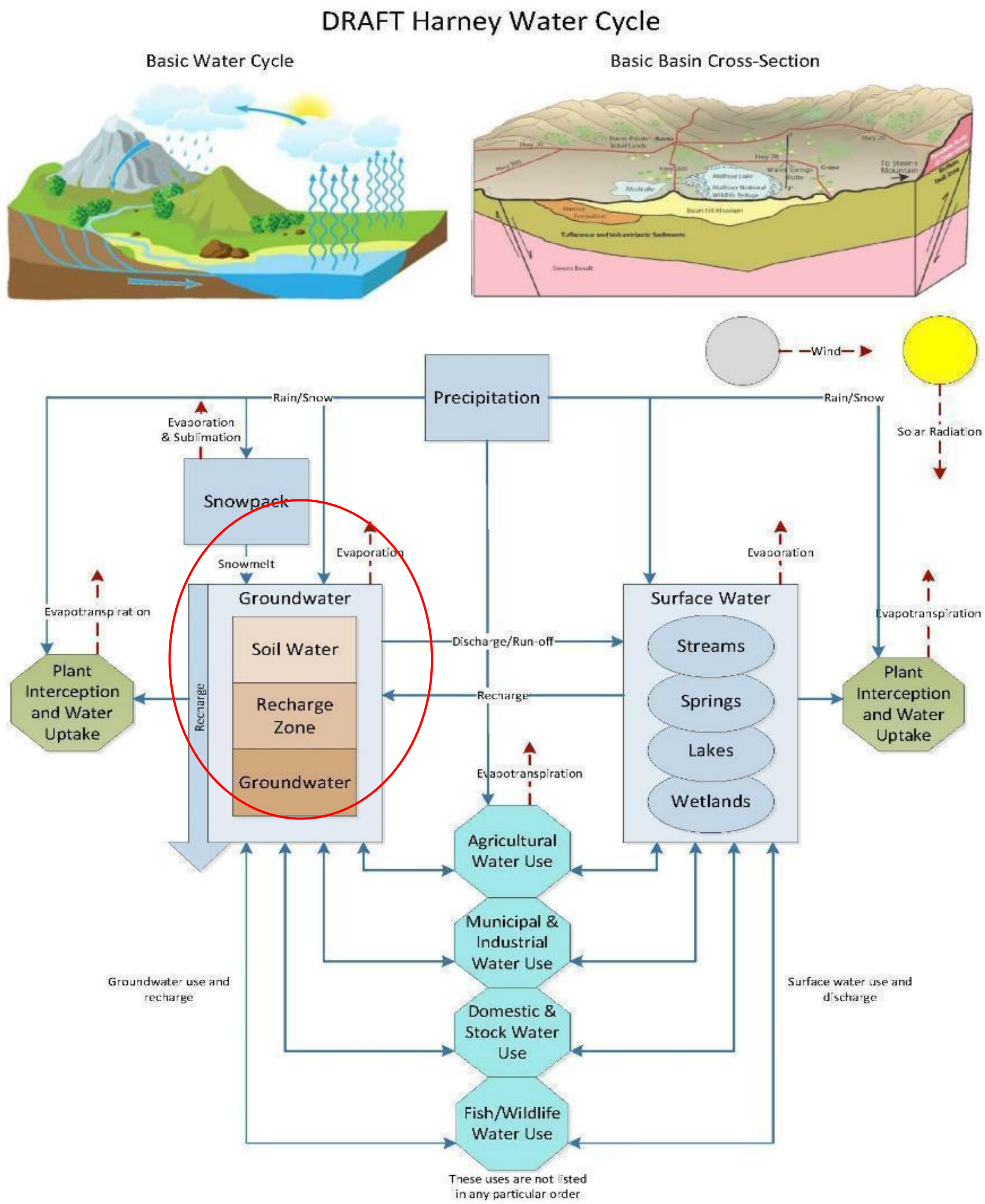

Figure 4. Harney Basin Hydrology Model Highlighting the Groundwater Portion

Before any wells were drilled and water was taken out of the ground, the inflow typically balanced the outflow with variations from climate and weather inputs (Garcia et al., 2022). In a developed groundwater system, water pumped from the ground must be balanced by some combination of 1) removal of water from storage, 2) increase in recharge, or 3) a decrease in discharge (Figure 5). To date, depletion in the Harney Basin is primarily from storage. The effects of aquifer development are evidenced by declining groundwater levels in areas where pumping is significant and reduction of discharge to groundwater dependent ecosystems.

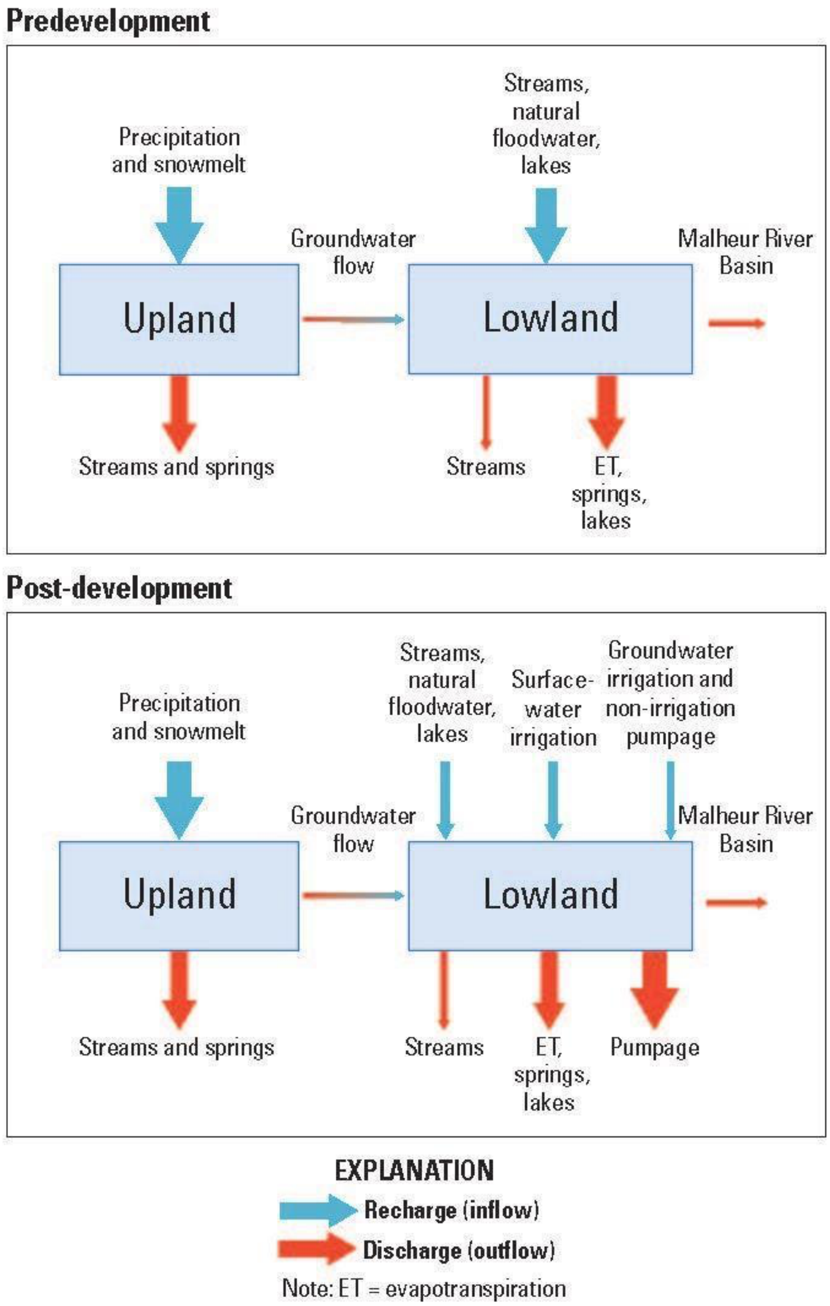

Figure 5. Simplified predevelopment and post-development groundwater recharge and discharge components of the Harney Basin hydrologic budget, southeastern Oregon (Garcia et al., 2022)

The Harney Basin is a closed surface water basin. Surface water and groundwater generally flow toward the marshes and lakes on the Malheur National Wildlife Refuge. Inputs and outflows identify the movement of water through the groundwater system and are used to calculate the groundwater budget. The groundwater budget is an estimate of the inflows outflows of groundwater.

The driver of recharge is inflow from uplands (typically through rivers and streams). Surface flow that is not diverted for surface irrigation or recharged to groundwater flows to Malheur or Harney Lakes. Losses of groundwater include evaporation from all surfaces, uptake by plants, irrigation uses, and groundwater pumping for all other uses. Evaluating these parameters is how a groundwater budget is estimated (Figure 6).

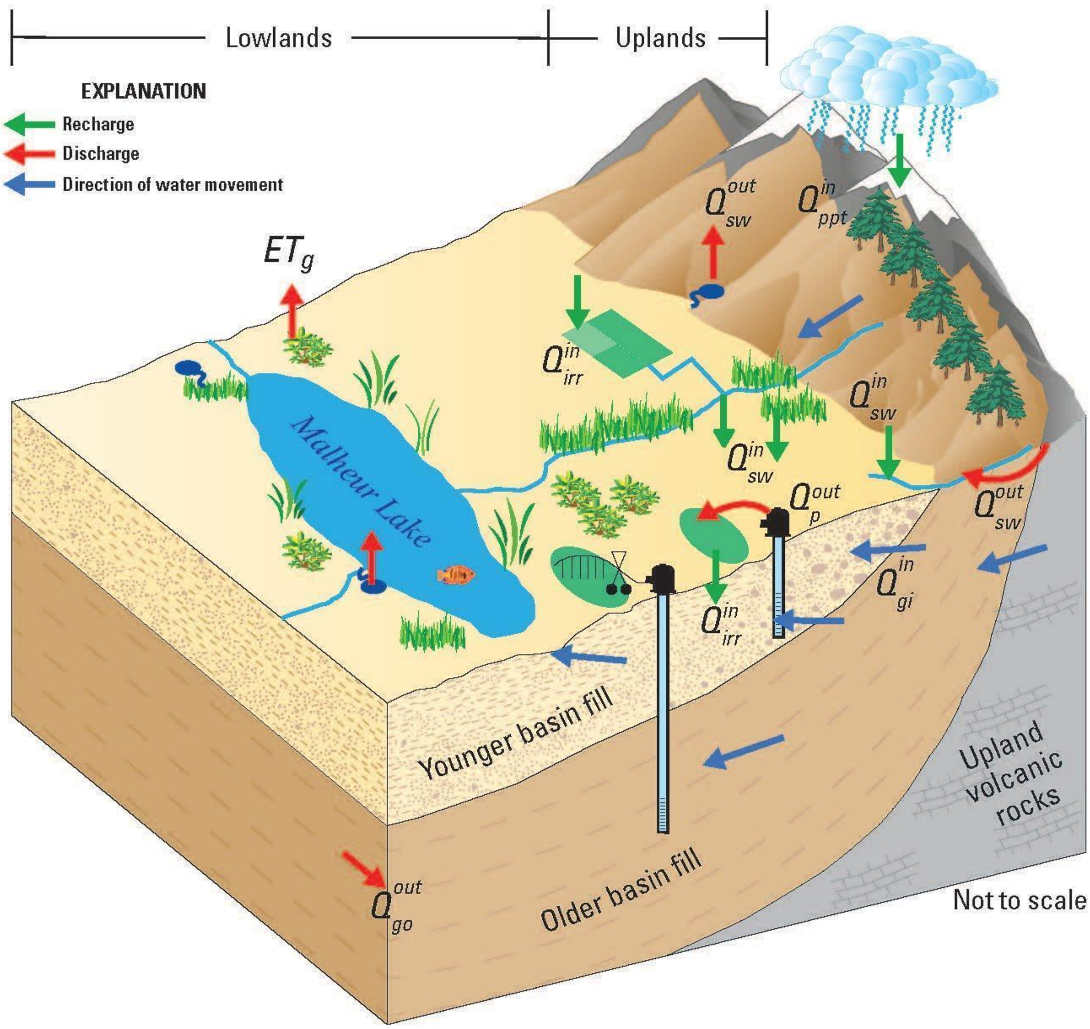

Figure 6. General Model for Harney Basin Groundwater Budget (from Garcia et al., 2022). Recharge and discharge components include: Q ppt in , upland recharge from precipitation and snowmelt; Q gi in , groundwater inflow from uplands to lowlands; Q sw in , lowland recharge from surface water; Q irr in , lowland recharge from irrigation water and other non-irrigation water use; E T g , groundwater discharge

through evapotranspiration; $Q_{sw\ out}$, groundwater discharge to surface water; $Q_{p\ out}$, groundwater discharge through pumpage; and $Q_{go\ out}$, groundwater outflow to the Malheur River Basin.

Hydrogeology/Geology

The geology of the Harney Basin has a significant effect on the availability and storage of groundwater. The uplands of the basin are dominated by low-permeability rocks both in the Blue Mountains and the Steens Mountain area. Faults and volcanic intrusions present different flow paths for groundwater. The Harney Valley is composed of deep sedimentary layers from both stream runoff and lake deposits. The generalized geology of the Harney Basin was compiled by Boschmann (2021). Evaluations of aquifer properties associated with different geologic conditions for the basin by OWRD have been published by Grondin et al. (2021).

The Harney Basin mountains are composed of basalt and andesite from lava flows and ash-flow tuff. These interlayered materials form the uplands of the Harney Basin. The basin floor is composed primarily of lacustrine and fluvial sediments deposited from modern streams and Pleistocene pluvial lakes. Figure 6 provides an idealized block diagram of the basin.

The Harney basin is a geologically diverse area composed of volcanic flow and ash deposits and interfingered basin fill underlain by ancient crystalline and metamorphic rocks. Gingerich et al., 2022 describes the three physiographic provinces of the basin: Blue Mountains, Basin and Range, and High Lava Plains and the geological features of each. The generalized geology of the study area is compiled by Boschman (2021) and the information is used to identify nine hydrostratigraphic units (Grondin et al., 2021) that are used to characterize the transmissivity of rock units.

Groundwater Recharge

The Harney Basin is a semi-arid basin that receives groundwater recharge from surrounding mountain recharge and recharge in the lowlands from flooding and irrigation. Recharge is dependent on precipitation, dominantly snowpack. Mean annual precipitation varies from 25-50 inches in the mountains to around 9 inches in the arid basin floor. Climate change is affecting the amount and location of snow that will affect recharge and recharge timing. Precipitation in the form of rainfall is quite variable both in timing and location and occasional, localized intense storms can bring as much as an inch of rain in an hour. Groundwater recharge in the lowlands is dominantly at the interface between the hillslope and valley bottom. Total upland recharge has been estimated to total 288,000 acre-feet/year (Garcia et al., 2022).

The Silvies River, Silver Creek, and multiple creeks along northern Harney Valley are losing streams (surface water discharges to groundwater) in the lowlands. The Blitzen River is a gaining river (groundwater discharges to surface water) from Frenchglen to Diamond Lane and a losing river (surface water discharges to groundwater) from Diamond Lane to the lakes.

Lowland recharge has been estimated from flooding, flood irrigation, groundwater irrigation and other sources at 124,200 acre-feet/year. Groundwater from the uplands adds approximately 49,000 acre-feet/year. The bulk of lowland recharge comes from flood irrigation and spring freshet flooding (Figure 7).

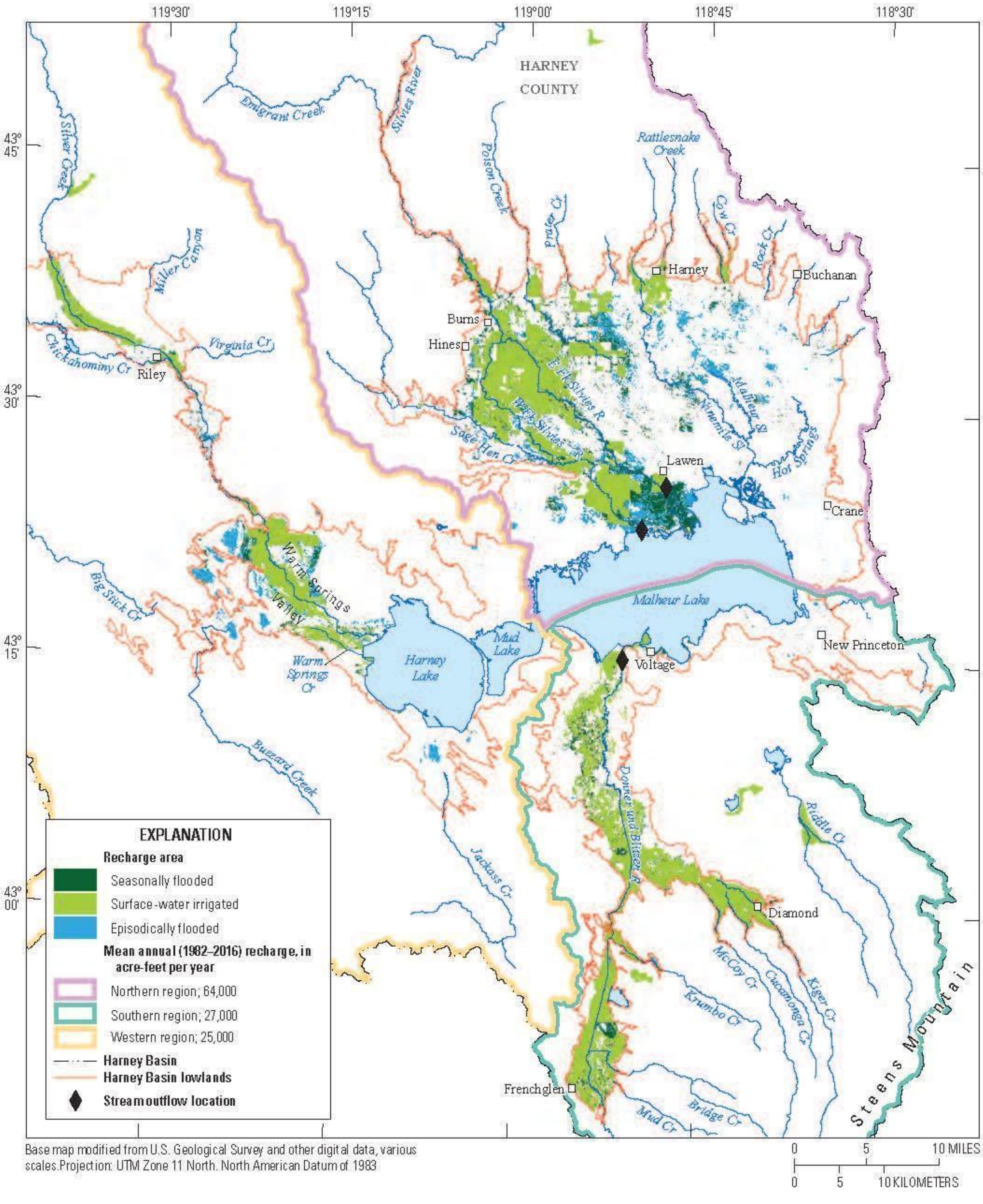

Figure 7. Locations of groundwater recharge from streams, seasonal and episodic floodwater, and surface-water irrigation, Harney Basin, southeastern Oregon (from Garcia et al, 2022)

Groundwater Discharge

Groundwater discharge is the term used to describe the movement of groundwater from the subsurface to the surface. There is natural discharge which occurs into lakes, streams, and springs as well as human discharge, which is generally referred to as pumping. In the Harney Basin natural discharge includes groundwater surfacing as springs, stream flow, lake supply and the support of phreatophyte vegetation. Groundwater discharge into the uplands can contribute to groundwater recharge of the lowlands. In the uplands the greatest discharge of groundwater is through the contribution to base flow of streams. Garcia et al. (2022) estimated that 225,000 acre-feet/year is contributed to streamflow from groundwater. An additional 14,000 acre-feet/year is estimated to be contributed to spring flow in the uplands (Garcia et al., 2022).

Lowland discharge is dominated by groundwater pumping (estimated at 152,000 acre-feet/year) but includes an additional 119,000 acre-feet/year discharged to evapotranspiration and some 8,900 discharged from springs in the lowlands (Garcia et al., 2022). A small amount of groundwater (estimated at 3,100 acre-feet/year) is discharged to the Malheur River basin through Virginia Valley.

Groundwater Storage

Leonard (1970) estimated the storage in the 56 square mile northern area portion of the Silvies River alluvial fan at some 400,000 acre-feet in the 100-foot zone. He indicated that there was insufficient data to make a valid estimate of the volume of water stored in the rest of the basin. Safe yield was estimated by Piper and others (1939) for the “Silvies subarea” as 32,500 acre-feet/year. There is no recent estimate of groundwater storage in the Harney Basin because of the lack of information on the depth of the aquifer.

Groundwater Budget

The Harney Basin groundwater budget has been calculated by the USGS to be out of balance by 110,000 acre-feet annually (Figure 8). USGS calculated that recharge is approximately equal to natural discharge in the uplands, but discharge greatly exceeds recharge in the lowlands.

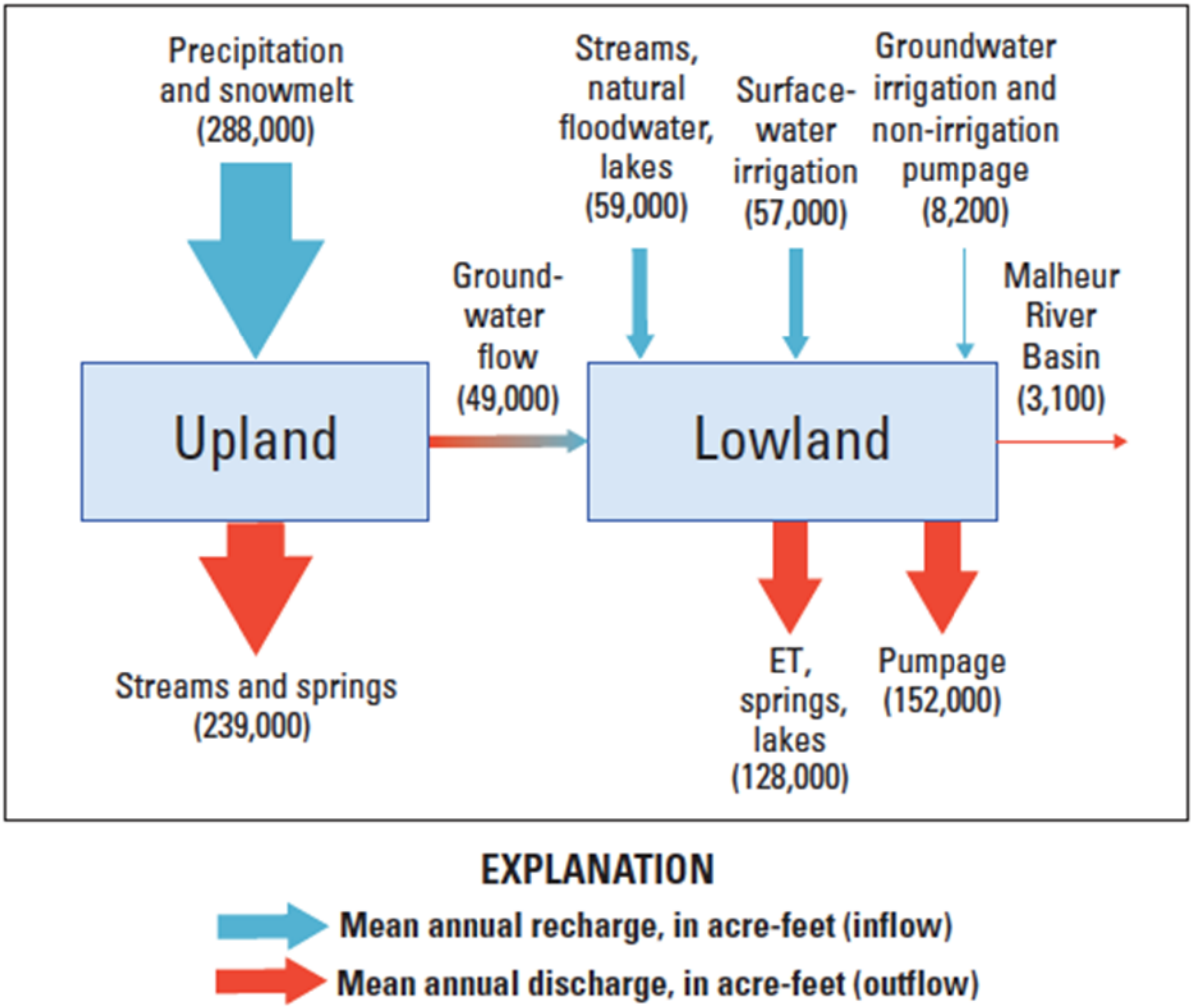

Figure 8. Estimated mean annual upland and lowland groundwater budgets in the Harney Basin (1982-2016) (from Garcia et al., 2022)

Estimated irrigation usage for most years between 2014 and 2018 is around 140,000 acre-feet/year (Beamer and Hoskinson, 2021) with all exempt use of approximately 6,000 acre-feet/year (Grondin, 2021). The excess discharge (irrigation use) is from depletion of groundwater storage in the aquifer. Most of the use is from the area of Silvies River floodplain and around Harney and Malheur Lakes (Figures 9 and 10).

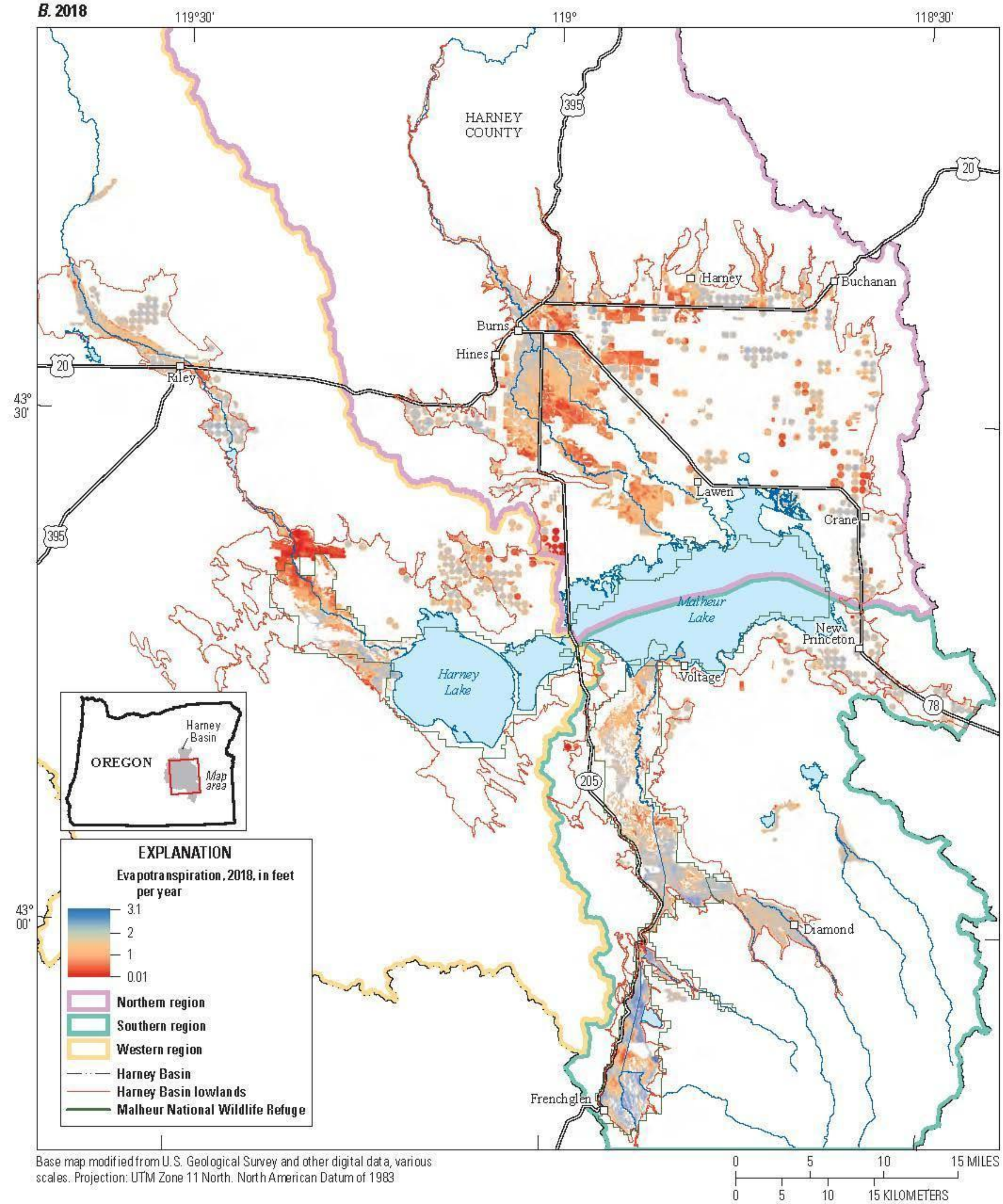

Figure 9. Maximum extent of irrigated areas and evapotranspiration of irrigation water (ETirr) from May to September 2018, Harney Basin, southeastern Oregon (from Garcia et al., 2022)

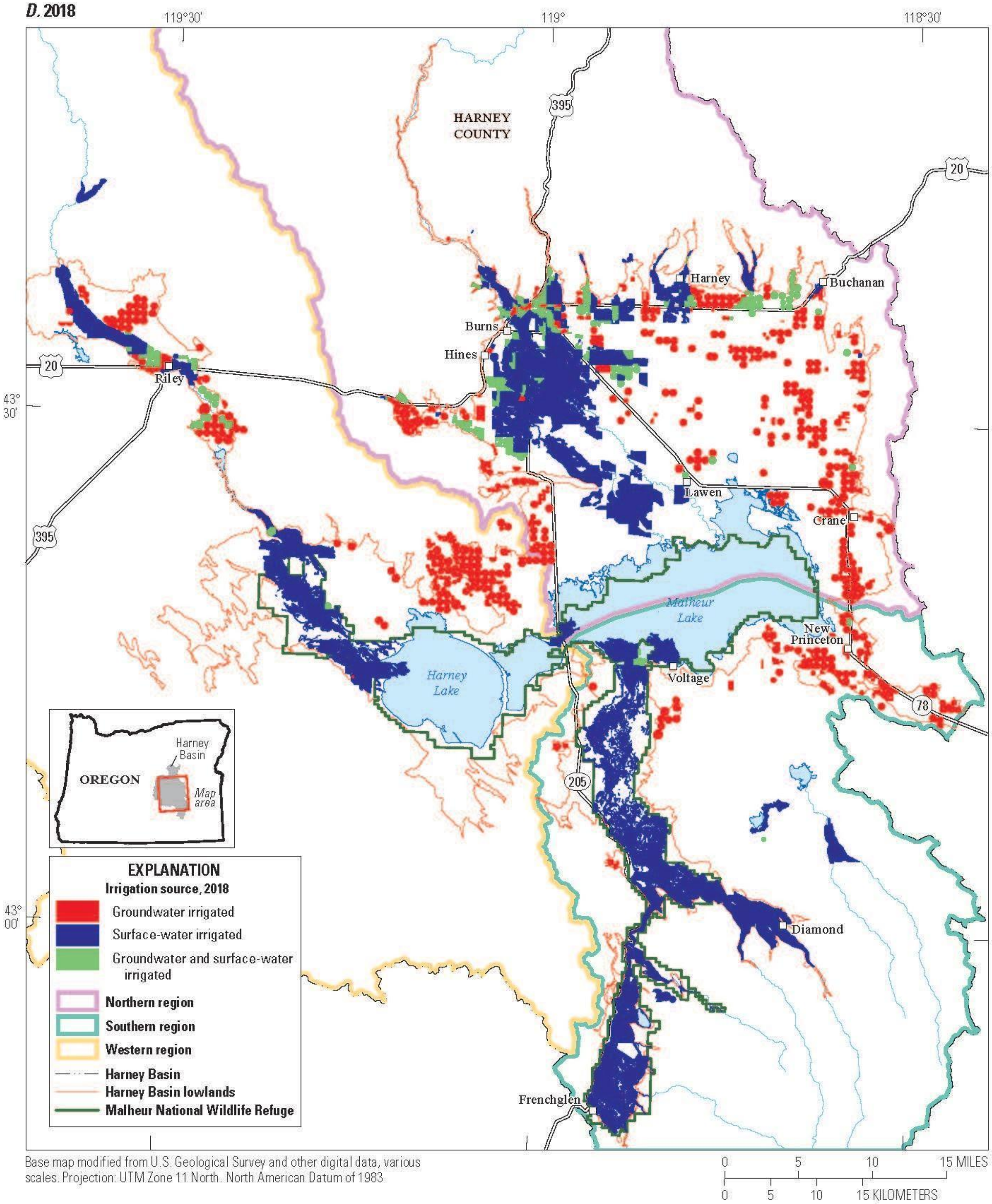

Figure 10. Irrigated fields by irrigation source type in 2018, Harney Basin, southeastern Oregon (from Garcia et al., 2022)

Groundwater Level Changes

Groundwater level changes are variable around the basin. There are cones of depression in both the deep and the shallow parts of the groundwater system (Figure 11). The variability in groundwater level change with location is due to a combination of factors including the amount of groundwater development and the hydraulic property of the subsurface deposits being tapped. Less drawdown does not mean less depletion from storage. A small drawdown spread over a large area can have the same depletion as a large drawdown over a smaller area. Interactions between groundwater and surface water as outlined in Figure 11 will be covered during Phase 2 of the Collaborative's planning process.

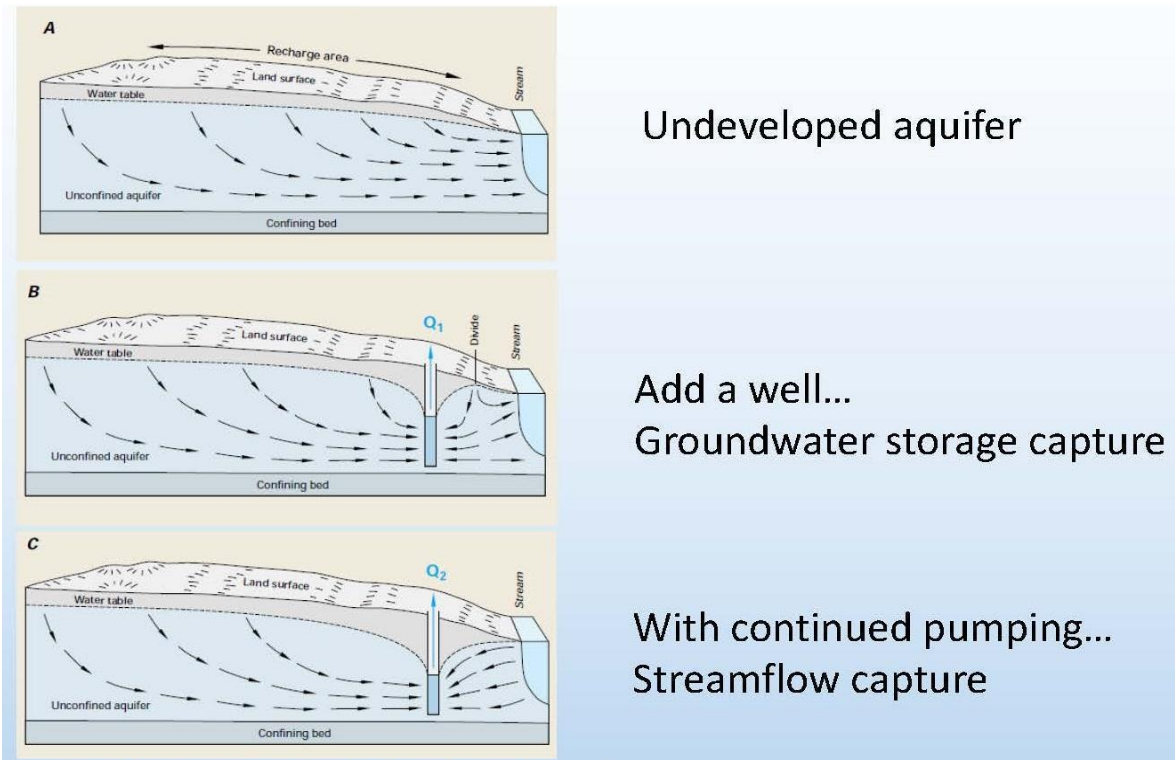

Figure 11. A cross-section of the development of a cone of depression (from OWRD presentation to Oregon Water Resources Commission December 3, 2021)

The recent OWRD/USGS Groundwater Study identifies "three areas in the basin have experienced groundwater declines exceeding 40 feet: Weaver Springs/Dog Mountain area, in the northeastern floodplains along US 20, and near the community of Crane. A small area of the basin has experienced groundwater level declines of more than 140 feet, and some shallow wells have gone dry. Areas of more modest groundwater level decline (about 10 feet) were identified in the Virginia Valley area and the Silver Creek floodplain north of Riley. Smaller localized areas of groundwater level decline have also formed around individual wells or groups of wells throughout the Harney

Basin lowlands" (Gingerich et al., 2022). The areas of decline are areas of concentrated groundwater pumping and in areas of geology that allow high-capacity wells that far exceed recharge into the areas surrounded by low permeability geology. The OWRD/ USGS Groundwater Study (Gingerich et al., 2022) provides maps of the groundwater table and levels for wells deeper than 150 feet. These plates show the cones of depression in the shallow and deeper groundwater table.

The OWRD/USGS Groundwater Study (Gingerich et al., 2022) describes the flow paths of groundwater for Low-Permeability Uplands, Donner und Blitzen River Floodplain, Silver Creek Floodplain: Suntex to Harney Lake, Weaver Spring/Dog Mountain, Silvies River and Poison Creek Floodplains, Floodplains from Prater Creek to Mahon Creek, Crane, and Virginia Valley. The differences and distinct characteristics of each area are described and can be related to observed groundwater level conditions.

Groundwater Age

The Groundwater Study determined that much of the deep groundwater in the uplands and most of the groundwater in the lowlands was recharged about 30,000 to 5,000 years ago when climatic conditions were cooler and wetter (Gingerich et al., 2022). Upland groundwater less than 150 feet deep is predominantly modern (recharge after 1953). Most groundwater pumped from the lowland areas, including the three largest decline areas, was recharged more than 12,000 years ago. Modern groundwater in the lowlands is generally limited to major river and stream floodplain areas to depths no greater than 100 feet. Away from the major river and stream corridors, water at the groundwater table is pre-modern (pre-1953 recharge).

Groundwater Quality

Groundwater quality data in the Harney Basin is limited. In 2018, the Oregon Department of Environmental Quality (DEQ) cooperated with local well owners to sample groundwater from throughout the basin (Figure 12). The study was compiled in a report "Statewide Groundwater Quality Monitoring Program: Harney County" available at https://www.oregon.gov/deq/wq/Documents/gwHarneyMonitorRep.pdf. The following is from the Executive Summary of the document (Haxton-Evans and Brown, 2021).

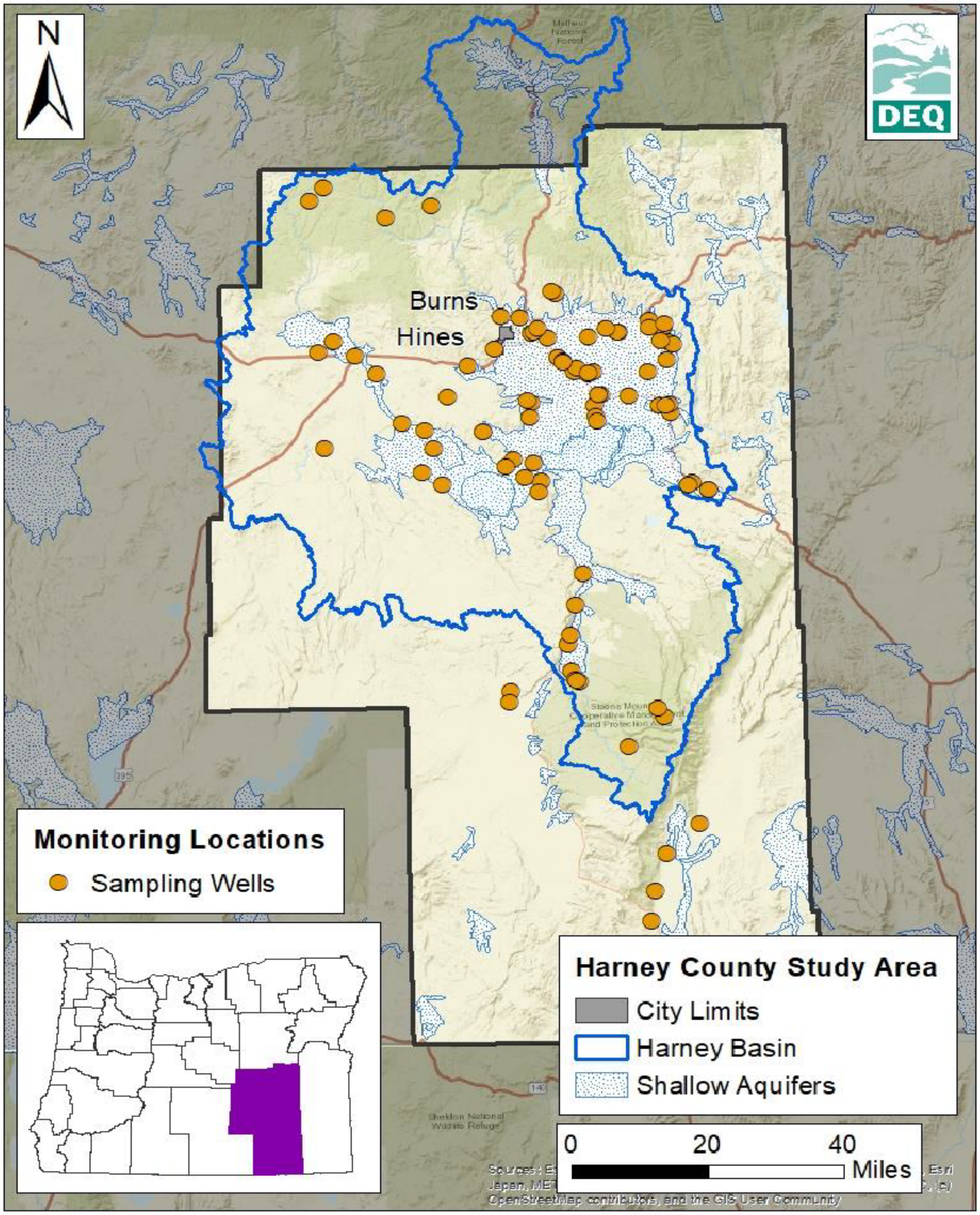

Figure 12. DEQ Harney County Study Area

"Ninety-one wells were selected for the study. Sixty were sampled in the spring 2018. Twenty-one of those wells were resampled in the fall along with an additional 31 new wells. Resampled wells were used to compare seasonal changes in detections. The water samples were analyzed for 42 chemicals or water chemistry parameters.

Of the 91 wells sampled, 58% had one or more contaminants posing a human health concern by exceeding a maximum contaminant level or other human health-based benchmark for drinking water. These wells tap into the same groundwater system with different hydraulically connected geologic units within Harney County, and are a mix of private drinking water wells, irrigation wells, stock watering wells, and static water level monitoring wells. Nitrate detections were widespread but not at levels concerning to human health. Fifty-seven out of 91 wells (62%) had detections of nitrate ranging from 0.0065 - 5.48 mg/L. Seven wells had detections elevated above natural background levels of 3 mg/L. There were no wells exceeding the EPA Maximum Contaminant Level (MCL) of 10 mg/L. Arsenic was detected in 80% of wells tested, and in some cases at levels concerning to human health. Seventy-eight wells (80%) had detections of arsenic, widespread throughout the county. Detections ranged from 0.25 µg/L to 655 µg/L.

Twenty-eight wells (31% of well sampled) exceeded the EPA Maximum Contaminant Level of 10 µg/L. Sixteen wells (18%) tested positive for total coliform, and three of those wells also contained E. coli. Detections of bacteria in groundwater wells suggest a vulnerability in the well infrastructure that may enable other sources of contamination.

Relatively few pesticides were detected, and all detections were below applicable human health screening levels. Nine different pesticide related chemicals, derived from seven different parent pesticides, were detected in this study. A total of 137 pesticide related chemicals were analyzed in the collected samples. Eighteen wells (20%) had detections of at least one current use or legacy pesticide, and five wells had two or more pesticides detected. The most commonly detected pesticide was 2,4-D detected in nine wells, followed by atrazine compounds detected in five wells. Dieldrin was the only legacy pesticide detected. No detections of any pesticide related chemicals were close to their applicable health related screening levels2. 2,4-D accounted for ten out of the eleven highest pesticides detections measured.

Boron was detected in 93% of wells, with twenty-three wells exceeding the Longer-Term Health Advisory Level for children of 2000 µg/L. Six wells exceeded the Lifetime Health Advisory for adults of 6000 µg/L. Vanadium was detected in 58% of wells with only one well (118 µg/L) exceeding the EPA Maximum Contaminant Level of 86 µg/L. Manganese was detected in 63% of wells sampled. Eight wells had detections above the EPA Lifetime Health Advisory of 300 µg/L. Aluminum was detected in 24% of wells sampled. Three wells exceed the Agency for Toxic Substances and Disease Registry (ATSDR) Health-based guidance for chronic exposure in children of 7000 µg/L. Selenium, a new analyte to this study, was detected in 4% of wells sampled, none exceeding the EPA Maximum Contaminant Level.

There was no statistical difference in detected concentrations of nitrate or pesticides between wells sampled in the spring versus the fall, and when comparing shallow (<100ft) and deeper wells, there was no statistical difference between detected concentrations of bacteria, nitrate or pesticides."

Chapter 4: Instream and Out-of-Stream Groundwater Uses (Step 2)

Out-of-Stream Groundwater Uses

Residents of the Harney Basin have a strong dependence on groundwater for many purposes. Groundwater for domestic purposes (washing, drinking, cooking, etc.), municipal purposes for the communities of Burns and Hines, industrial purposes (airport, etc.), and stock water is particularly important to the people of Harney County. Groundwater is also important for supporting groundwater dependent ecosystems throughout the basin, including springs, wetlands, lakes and cold-water inputs to rivers and streams.

By volume, the dominant consumptive use of groundwater in the Harney Basin is agricultural irrigation. Recent estimates of agricultural groundwater use, based on remote sensing of evapotranspiration, local measurement of evaporation, and well records (Beamer and Hoskinson, 2021) supplants earlier estimates from OWRD. Total pumpage for irrigation has increased from about 54,000 acre-ft/year during 1991–92 to 145,000 acre-ft/year during 2017–18 (Garcia et al. 2022).

Non-irrigation groundwater use estimated by Grondin (2021). Domestic residential use estimates are similar to estimates developed by Working Groups of the Collaborative, based on data from residential households. Table 1 shows the range of values estimated for different groundwater uses. Grondin (2021) provides a unique estimate for stock water use. The municipalities of Burns, Hines, and Seneca measure water provided to households and businesses. Commercial uses and community systems also report usage annually.

Table 1. Estimated groundwater pumpage (acre-feet/year) according to type of use

Groundwater Use	Estimated Use	Source
Agriculture (pumpage)	145,000 acre-feet/year	Garcia et al., 2022
Agriculture	140,000 acre-feet/year	Beamer & Hoskinson, 2021
Domestic	1,100 – 1,200 acre-feet/year	Grondin, 2021

Domestic	825 acre-feet/year	Collaborative Work Group
Livestock	1,417 acre-feet/year	Grondin, 2021
Municipal	2,205 acre-feet/year	Grondin, 2021
Municipal	1,585 -2,335 acre-feet/year	Collaborative Work Group
Community Systems	80 acre-feet/year	Grondin, 2021
Commercial/Industrial	2,037 acre-feet/year	Grondin, 2021
Total Estimated pumpage	152,000 acre-feet/year	Garcia et al., 2022

The total non-agricultural groundwater pumped amounts is between 5,944 and 7,069 acre-feet/year or between 4% and 5% of the use of groundwater pumped and used in the basin. Garcia et al. (2022) used estimates of 2018 pumpage for all groundwater uses in computing the groundwater budget.

Agricultural Irrigation Use

Groundwater pumping for irrigated agriculture is the dominant use of groundwater in the basin. Some 95% of groundwater discharge is pumped for irrigated agriculture. Using 2016-2017 data it is estimated that some 145,000 acre-feet/year is pumped for irrigation (Beamer and Hoskinson, 2021; Garcia, 2022). With the estimated increased demand the over appropriation is more than evident and reductions in irrigation pumpage is the major area for reducing the out of stream use of groundwater.

Domestic Use

There are between 1,100 and 1,200 domestic wells or household's dependent on groundwater for domestic purposes (Figure 13). The estimates of water use vary but the average household of 2.3 persons/household in Harney County suggests that more than 2,500 people depend on their personal well for water for the household. Disruption of the supply of domestic water has a significant effect on the quality of life for the resident. A survey of domestic well users in Harney County (OSU, 2019) identified that nearly 30% of the respondents had experienced a reduction in yield of their domestic wells. Of these 137 well owners, some 62% of the people experiencing a decline in yield over the previous 10 years made a change to their well including drilling a new well. The effect of declining groundwater levels on domestic wells has been of concern to many in the community.

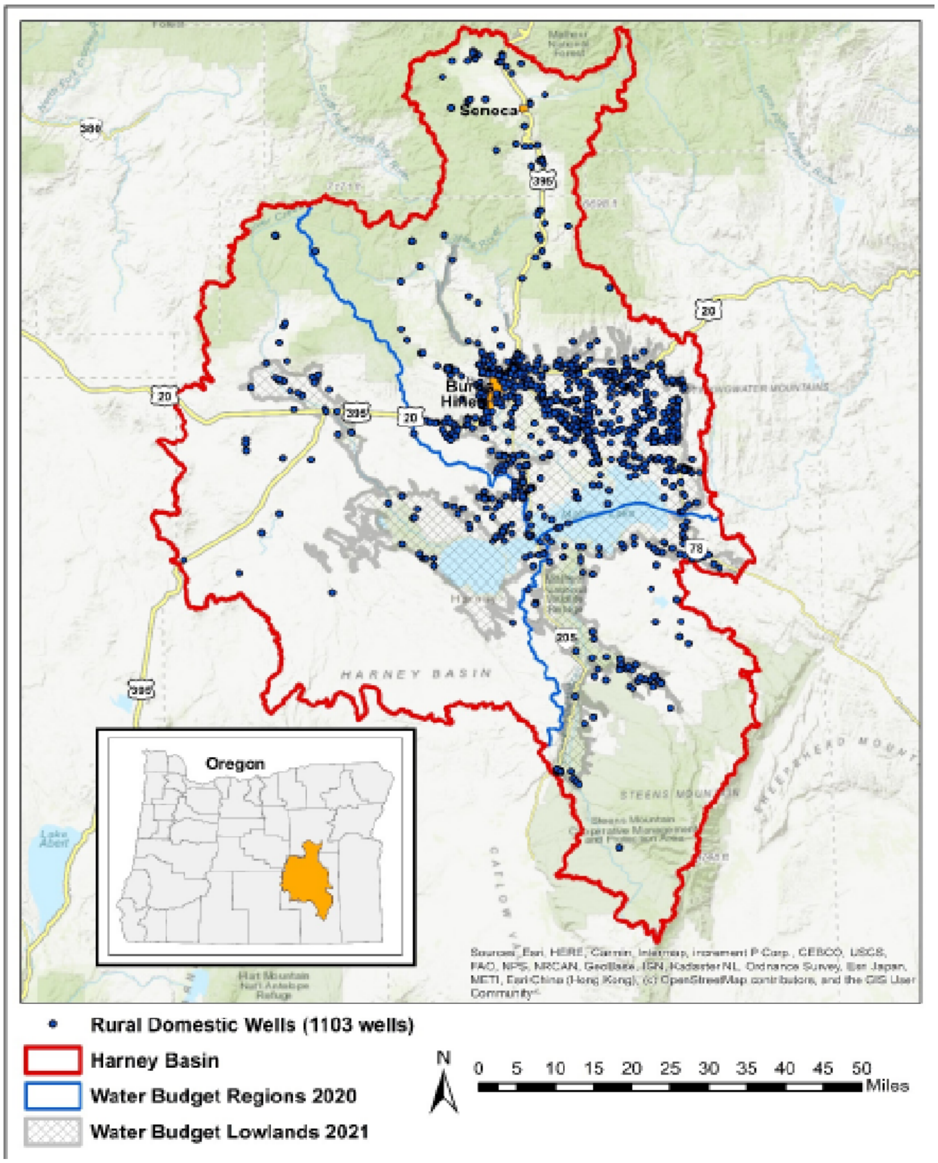

Figure 13. Rural Domestic Wells in the Harney Basin (Grondin, 2021)

Stockwater Use

While there are only estimates of livestock water use (Grondin, 2021) and little is known about the conditions of livestock wells (Figure 14), it is presumed that those in the lowlands are similar to domestic wells with a significant number affected by declines in yield or other effects over time and especially in areas of rapid groundwater level decline. During the collaborative conversations, residents have reported loss of shallow stockwater wells as an issue.

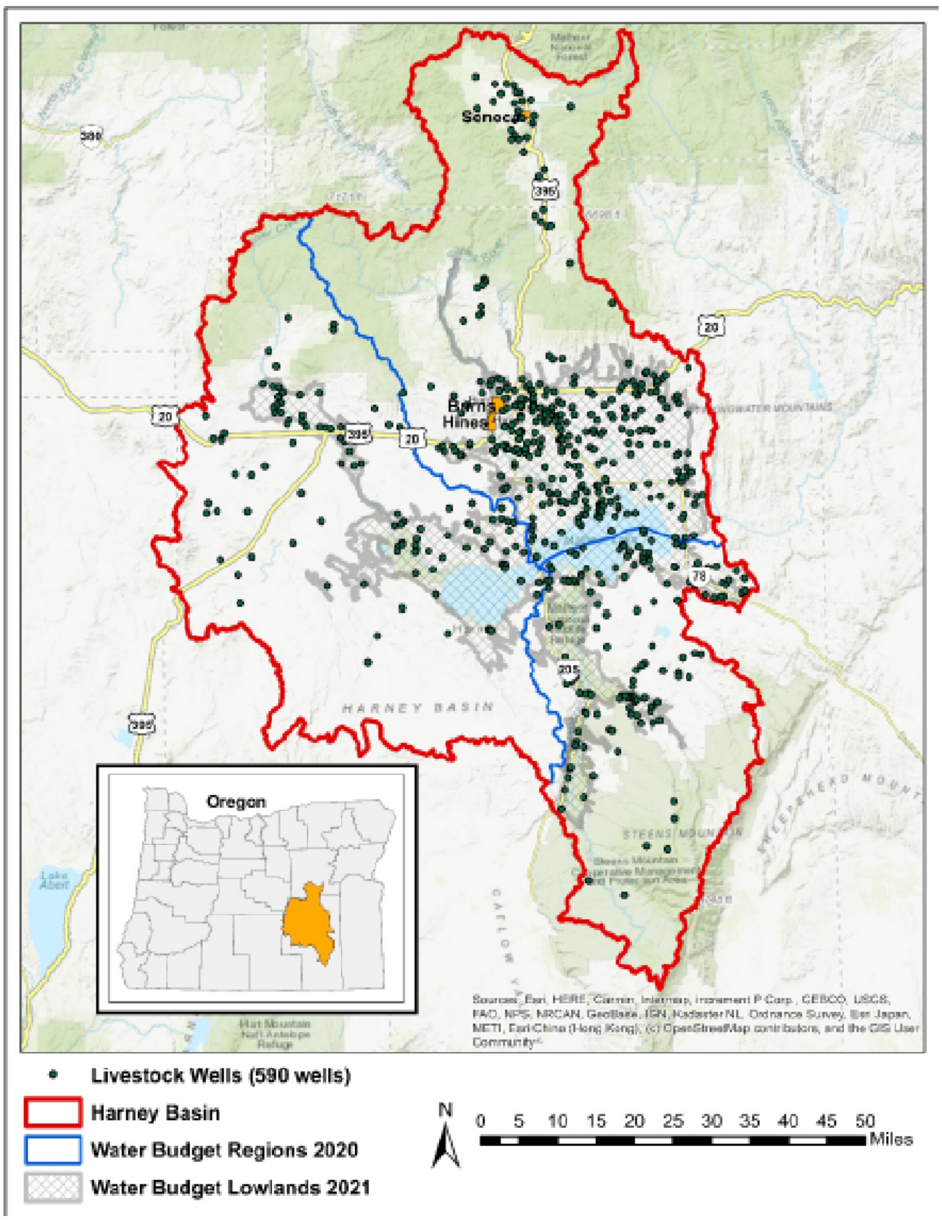

Figure 14. Harney Basin Livestock Wells (Grondin, 2021)

Municipal Use

The Towns of Seneca, Burns and Hines supply water to their respective communities from groundwater. The annual groundwater volume pumped from the 10 wells for public municipal supply generally fluctuated from 2,000 to 2,500 acre-feet from water-year 1993 to 2010 and was generally near 2,000 acre-feet annually from water-year 2010 to 2018 (Figure 15).

Seneca lies in the Bear Valley in the upper Silvies River drainage in Grant County. The community of slightly less than 200 people, has two municipal wells: one for domestic uses and another for park and golf course irrigation. Certificate 10146 is for a well with an appropriation of 1.33 cfs (963 acre-feet/year). Water use reporting data from 1993 to 2018 (Figure 14) shows municipal use ranging from 16 to slightly more than 100 acre-feet/year. Park and golf course water use ranges from 0 to around 30 acre-feet/year. Water use is significantly less than the certified right to groundwater.

Burns has 5 municipal wells that were drilled between 1930 and 1977. The wells are between 250 and 300 feet deep with a total capacity of 5,500 gallons per minute or 7.92 million gallons/day (8,871 acre-feet/year). Capacity-measured water use by the City of Burns varied between 985 and 1,521 acre-feet/year in the years of 2009 to 2017. The City of Burns Water Master Plan (WSMP) was completed in 2021 (Anderson Perry and Associates, 2021). The Master Plan summary of water supply states: "*The current capacity of the City's five groundwater wells is approximately 4,720 gallons per minute (gpm) or 3,540 gpm if the wells are operated 18 hours per day, as recommended in this WSMP. This capacity is anticipated to exceed the City's peak daily supply demands for the 20-year planning period. Due to the City having adequate water for the 20-year planning period, no additional water supply is needed at this time. The only recommended improvements related to the City's water supply system currently are an additional backup motor generator and well transducers to monitor water levels in the City's wells.*"

Hines has four wells; 3 are active wells while the 4th (Snow Mountain Road), which has not been in use since 2009. OWRD monitored this well in October 2017 and documented static water level at 17 feet. Measured water use by the City of Hines ranged between 595 and 809 acre-feet/year between 2009 and 2017. Hines completed a thorough study of its water system and report on upgrades needed. Upgrades of approximately $6.2 million for new storage, repairs to water tower, replacement of old piping, and addition of new fire hydrants have been implemented in the last few years.

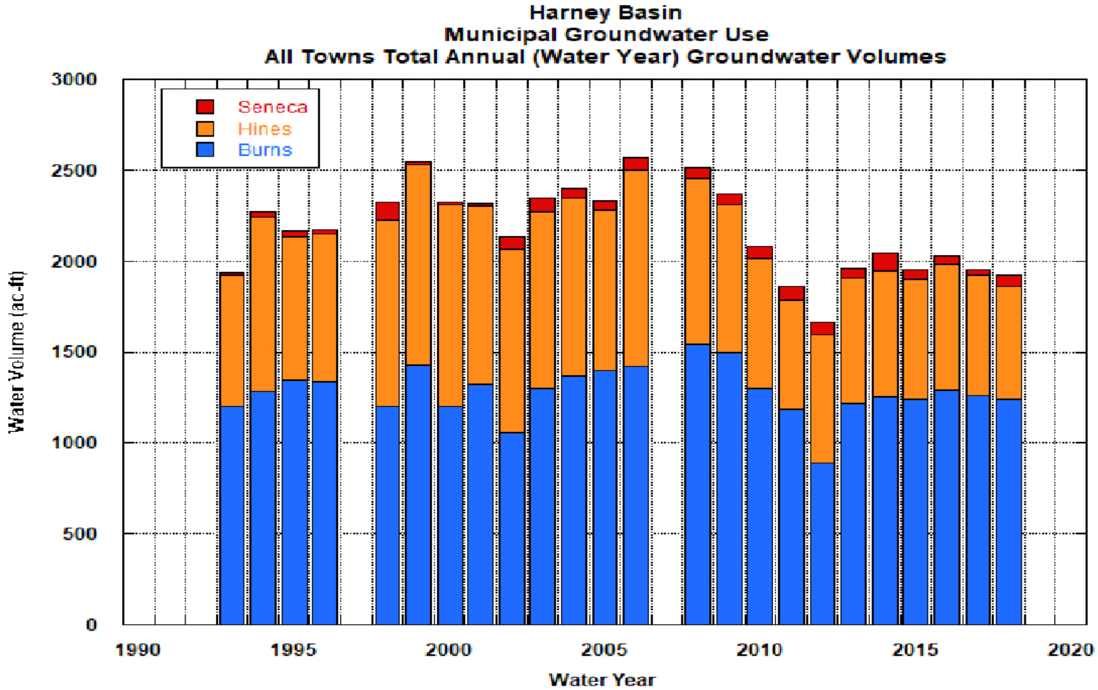

Figure 15. Annual Municipal Groundwater Use in the Harney Basin (Grondin, 2021)

Other Uses

There are twenty-five small community water systems (non-municipal, non-irrigation) water systems in the Harney Basin supplied by 29 active wells that are registered with the Oregon Health Authority. These water systems serve schools, motels, restaurants, stores, campgrounds, field stations, a rest stop, an airport, and an unincorporated neighborhood of 30 household connections. In total, the estimated groundwater pumped annually from these wells is estimated at 80 acre-feet/year (Grondin, 2021).

There are three industrial facilities served by wells for commercial, industrial, or geothermal uses. The estimated maximum groundwater discharge for commercial-industrial use from May through August is about 2,037 acre-feet (Grondin, 2021).

Water supply for the Burns Paiute Tribe's Reservation was secured after the reservation was restored in 1972. The tribe has water rights from three wells for both irrigation and domestic use (Table 3). The water rights were changed in a transfer application in 2008 to use the groundwater for quasi-municipal purposes and some of the surface right as supplemental irrigation right.

Table 2. Burns Paiute Tribal Water Rights

Well No.	Depth (feet)	Permit No.	Certificate No.	Priority Date	Volume (cfs)	Beneficial Use
1		G 12610		07/15/1991	1.40	Irrigation
2		U 223	20244	10/20/1947	0.32	Irrigation
3		U 223	20244	10/20/1947	0.26	Irrigation
4		U 223	20244	10/20/1947	0.26	Irrigation
5	252	U 126	20245	09/23/1940	2.00	Domestic & Irrigation

A Tribal representative indicated: "The Burns Paiute Tribe pumps approximately 1,353,666 gallons annually (4.15 acre-feet/year) for municipal use. This covers all well use besides agricultural operations on the reservation at Foley Field."

Beyond groundwater use for irrigation, the water resources of the Harney Basin have cultural significance to the people of the Burns Paiute Tribe. The water resources of significance to the tribe are dominantly surface water expressions. Malheur Lake has been of significant to Great Basin Paiute people for millennia (Elston, et al., 2014). The Burns Paiute Tribe has identified culturally significant plants, animals, and other cultural materials in their Aboriginal Territorial Protection Policy adopted as Tribal Council Resolution No. 2006-12. Malheur Lake and its shoreline is identified as a Sacred Place and Traditional Cultural Properties of the Burns Paiute Tribe by Tribal Council Resolution No. 2016-01. While groundwater contributes only a small amount to Malheur Lake (Garcia et al., 2022), the lake conditions are important to a broad range people and have particular significance to the Burns Paiute Tribe.

Malheur Lake is also of significance as one of the early National Wildlife Refuges, created by executive order of President Theodore Roosevelt in 1908, which at the time was a shallow marsh dominated by emergent beds of tule and bulrush. When surface water considerations are developed the issues associated with these culturally important resources will be more thoroughly addressed.

Summary of Out-of-Stream Groundwater Uses

All non-agricultural consumptive uses amount to less than 5% of all use at the most. Even if non-irrigation uses double, the effect on groundwater levels and groundwater storage would be insignificant. Agricultural irrigation accounts for more than 95% of all groundwater use. The use of groundwater in the Harney Basin is based on estimates for some 95% of the total use. Use of groundwater by municipalities, for commercial and a small number of other uses are measured and reported. There is some measurement and reporting of agricultural irrigation use but it is insufficient to provide a full measure of use. The estimates of groundwater use by domestic wells shows the range given different estimating methods, the same holds true of stockwater use. Likewise, estimates of agricultural irrigation use varies between 120,000 and 150,000 acre-feet/year for the period between 2014 and 2018 (Beamer and Hoskinson, 2021). Garcia et al., (2022) used an estimate of 152,000 acre-feet as groundwater Pumpage for irrigated agriculture in the groundwater budget.

Future Estimates of Out of Stream Uses

Agricultural Irrigation Use

Harney County is anticipated to need an additional 50,000 ac-ft/yr of irrigation to support current agricultural production in the basin for all surface- and groundwater-irrigated crops by the year 2050 (OWRD 2015), which is an 11.4% increase in water demand. Assuming the increased demand is distributed evenly (i.e., the proportional increase to total demand is the same proportional increase to groundwater-irrigated crops), then about 16,500 additional ac-ft/yr will be needed for groundwater-irrigated crops by 2050.

Domestic Use

On a county scale, changes to per-capita water demand for domestic use are negligible (OWRD 2015) and Harney County's total population is expected to stay nearly identical by 2072 (Chen et al., 2022). Therefore, unless the distribution of domestic wells vs. municipal water supply changes, future domestic groundwater demand is likely to remain very similar to current demand.

Stockwater Use

Stockwater use is currently estimated at 1,417 acre-feet per year (Grondin, 2021). With full CREP enrollment there could be added the demand for some additional 380-400 acre-feet/year in demand.

Municipal and Industrial Use

Municipal and industrial water use is expected to decrease by 1.6% among all water sources by 2050 (OWRD 2015). Assuming that decrease is distributed evenly, then municipal demand will shrink by approximately 32 ac-ft/yr and industrial demand will decrease by approximately 33 ac-ft/yr.

Instream Groundwater Uses

Groundwater Dependent Ecosystems and Species

Groundwater-dependent ecosystems (GDEs) are ecosystems for which the structure, composition, and function are reliant on a supply of groundwater (Kløve et al., 2011). Springs, rivers, streams, wetlands, and lakes can be considered GDEs.

There are 2,858 springs in the Harney Basin overall (Figure 16), but most are found at high elevations (> 4,200 ft MSL). Only 18.5% (528) of all springs in the basin are within the GHVAC (Figure 15). However, these figures should be considered a lower boundary to the actual number of existing springs (Freed et al., 2019). Current conditions suggest that Sodhouse Spring[1] is no longer flowing in recent years, potentially because of groundwater withdrawal.

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[1] Sodhouse Spring is on Malheur National Wildlife Refuge headquarters and is the source of the wildlife viewing pond at the refuge

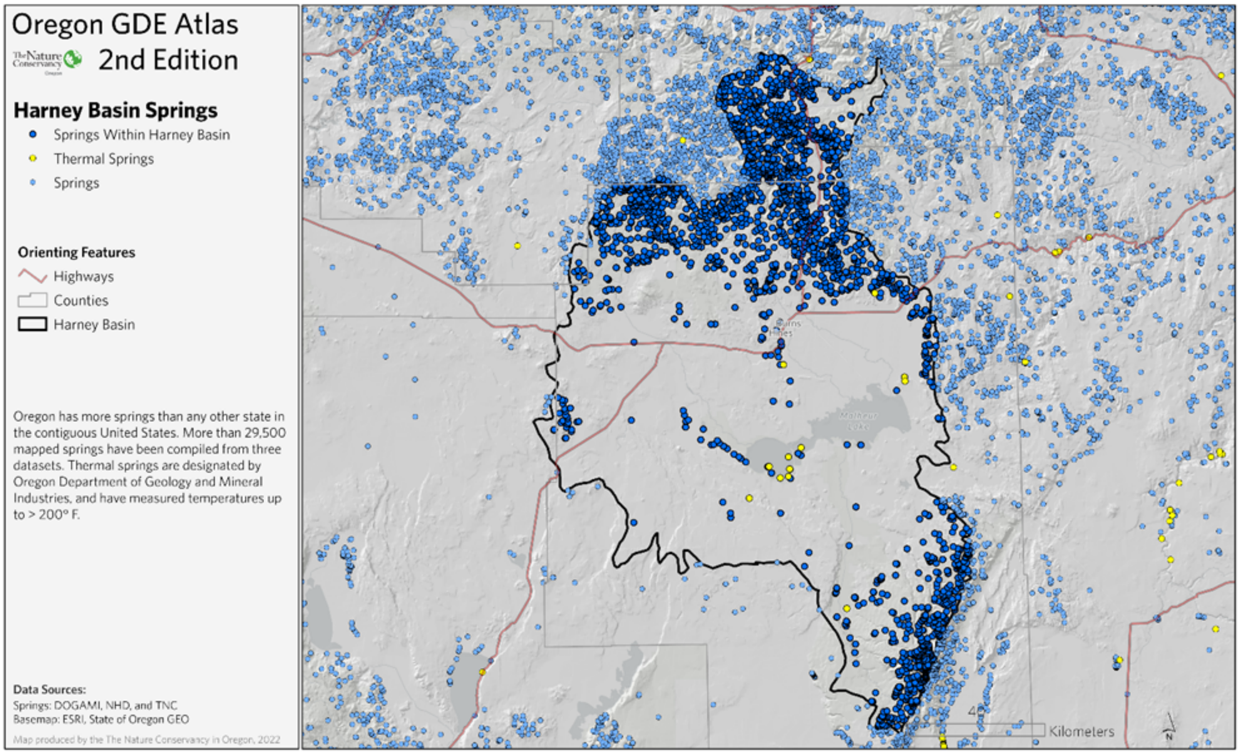

Figure 16. Groundwater dependent springs in the Harney Basin (from Freed et al., 2022)

There are about 1,650 miles of groundwater dependent rivers in the basin, including the Donner und Blitzen River (Brown et al., 2009) and most headwater tributaries to the Silvies River and Silver Creek (Freed et al. 2022). However, tributary streams supplied by headwater springs in the Silvies River, and Silver Creek watersheds provide cold-water refuges that are important for local fish species such as red-band trout.

Groundwater dependent wetlands provide perennial water for wildlife forage and resources for migratory birds. There are at least 38,200 acres of likely groundwater-dependent wetlands (Figure 17). Freed et al., 2022 has mapped known groundwater dependent ecosystems for the basin.

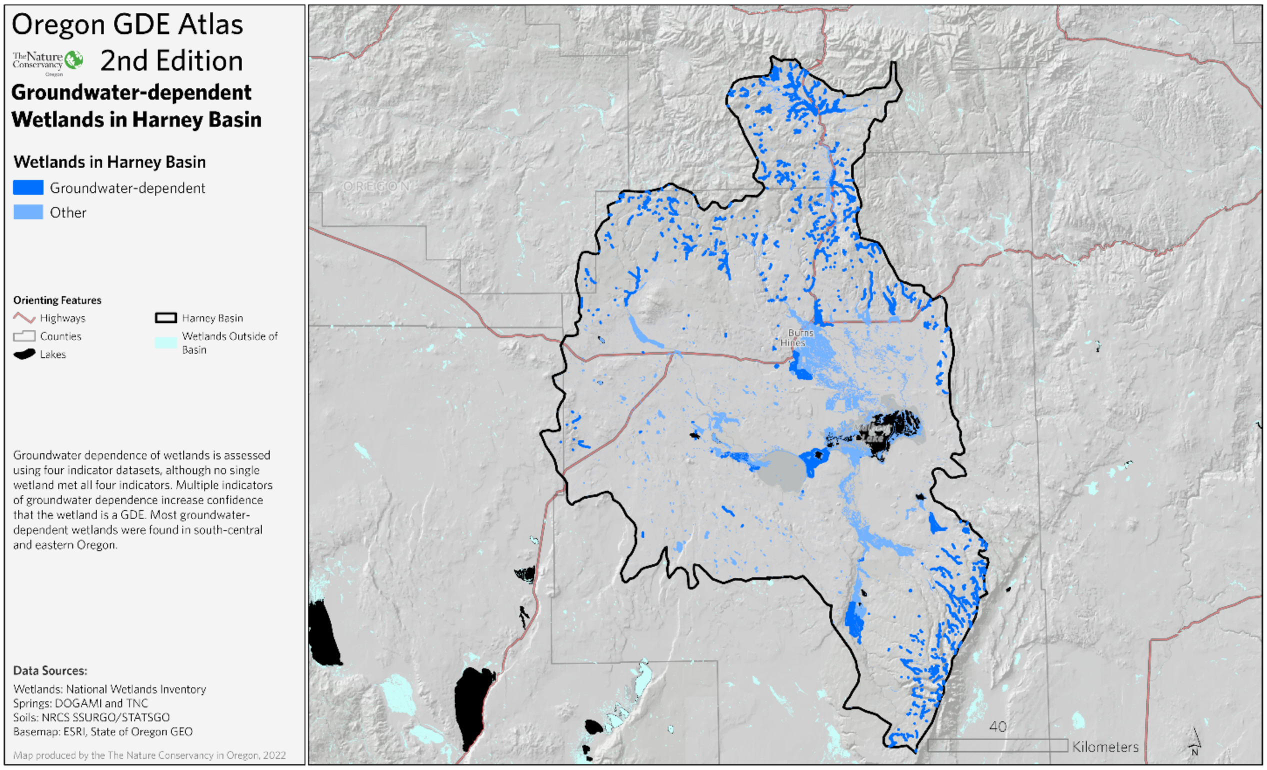

Figure 17. Groundwater Dependent Wetlands (from Freed et al., 2022)

Several high-discharge, low-elevation springs drain directly into Harney Lake. In addition, Sodhouse Spring near the Malheur National Wildlife Refuge Headquarters flows into Malheur Lake, which was deemed the only "appreciable" source of groundwater inflow (Hubbard, 1975). Stinking Lake is a well-documented groundwater dependent lake, dependent on spring flow. Groundwater-dependent portions of Harney, Malheur, and Stinking lakes combine with other small lakes in the basin to a total of nearly 81,300 acres of groundwater dependent lakes (Freed et al., 2022).

Species can be either obligately groundwater-dependent (meaning they must have access to groundwater for all or some of their life cycle) or facultatively groundwater-dependent (meaning they likely utilize groundwater but could also persist in surface-water environments). There have been confirmed observations of 16 obligate groundwater-dependent species within the Harney Basin, including plants, invertebrates, and vertebrates. There are 27 more likely obligate groundwater-dependent macroinvertebrates, and 78 likely facultative taxa of invertebrates occupying Harney Basin springs. In total, there are over 121 unique groundwater-dependent species found in the basin (Freed et al., 2022). Many breeding and migrating bird species depend on springs, playas, and other groundwater dependent ecosystems in the Harney Basin. These species will be discussed more in-depth in the surface water portion of this planning process.

Plant species that primarily or exclusively rely on groundwater are termed phreatophytes, which can be either riparian/mesic phreatophytes (dependent upon near-surface groundwater) or xeric phreatophytes (utilizing deep taproots to access groundwater in the aquifer). Like other groundwater-dependent species, phreatophytes can be obligate or facultative. There are at least three obligate and likely many more facultative riparian/mesic phreatophytes, such as persistent sepal yellowcress and Williams combleaf. There are at least three obligate and many more facultative xeric phreatophytes, including greasewood, rabbitbrush, and sagebrush.

Summary of Instream Groundwater Uses

The published information currently available regarding the condition of Harney Basin GDEs is scarce. The primary source of available data specific to GDEs is two documents done on a statewide scale (Brown et al., 2009, Freed et al., 2022). Field observations of GDEs remain necessary to gain even a fundamental understanding of their characteristics and condition. Significant data gaps exist for quantifying the water needs and ecological condition of each type of groundwater-dependent ecosystem. However, existing resources are clear that there are abundant ecosystems within the Harney Basin that rely on groundwater

Future Estimates of Instream Uses

There is a significant lack of information on the groundwater needs for springs and other GDEs. Improved monitoring of GDEs through a changing climate and a changing water management context. For beneficial ecosystem outcomes to occur, we need to understand whether ecological water availability is changing because of management or because of climate—and to do that, we need better monitoring. This is a significant data gap in understanding groundwater in the basin.

Chapter 5. Critical Groundwater Resource Issues (Step 3)

Overview

The Collaborative identified critical groundwater resource issues in three ways; first the Collaborative created Working Groups that focused on Agricultural Use, Ecological Resources, and Exempt Uses with an emphasis on Domestic Water Supply to examine and explore issues associated with their focus; second, through a facilitated conversation "summit," Collaborative members developed a list of strategies and issues early in the process (January 2019); third, after the drafting of Current Groundwater Conditions (Step 2) and Future Groundwater Needs (Step 3), additional groundwater resource issues were identified through the Collaborative process.

Since groundwater cannot be directly observed, issues arise from: 1) direct effects felt by groundwater users such as loss of domestic well production, loss of sufficient water to irrigate, loss or reduction of production of stockwater, 2) lack of information on the groundwater resource and its uses and management, and 3) concerns about the management and equitable use of groundwater.

The Critical Groundwater Resource Issues can be generally categorized as: overallocation/groundwater level declines, ecosystem health and protection, water security for groundwater users, groundwater governance and accountability, infrastructure improvements and necessary upgrades, agricultural and community economic sustainability, climate change and cycles effects on groundwater, and incomplete information about groundwater conditions and resources.

Overallocation/Groundwater Level Decline

The concern about overallocation is more about the effects of overallocation which creates cones of depression in static groundwater levels and general static groundwater levels declining. In some areas, "groundwater-level declines exceeding 140 feet compared to pre-development conditions have been identified. The Weaver Spring/Dog Mountain area, in the northeastern floodplains along Highway 20, and near Crane" were identified in the study of areas with the greatest declines. Shallow wells have gone dry in areas of significant groundwater level decline. "Areas of more modest groundwater-level decline (about 10 feet) were identified in the Virginia Valley area and the Silver Creek floodplain north of Riley" (Gingerich et al., 2022). The overallocation of groundwater rights and development of permitted groundwater use for irrigation has led to a significant number of the conflicts/issues identified by groundwater users and others. The designation of the GHVGAC, which stopped the Oregon Water Resource Department from processing new groundwater permit applications, with limited exceptions, was only one element of the WRC decision. The rules did not prevent development of permits that had already been issued. Thus, when residents saw new irrigation facilities being developed, questions and concerns were raised. As the groundwater study proceeded, the data shared with the GWSAC began to document the imbalance of recharge to pumping use of groundwater. The OWRD/USGS Groundwater Study (Gingerich et al., 2022) estimates that some 110,000 acre-feet/year of groundwater is discharged more than is recharged.

Effects on Ecosystems

The distribution and abundance of groundwater dependent ecosystems of the Harney Basin have been estimated among three efforts (Appendix A; Brown et al. 2009, Freed et al. 2022). However, the condition of groundwater-dependent ecosystems is poorly understood, especially in relation to groundwater declines. Known effects include loss of flow at Sodhouse Spring and a shift in the lowest level of static groundwater from beneath Harney Lake to the area of Weaver Springs. The basin-wide ecological effects of the changes in groundwater levels are not yet apparent but will be cumulative and have long-term impacts to the unique ecosystems associated with shallow groundwater. Garcia et al. (2022) report that: “Declining groundwater levels at depth across many parts of the Harney Basin lowlands indicate that pumpage is depleting aquifer storage and is likely capturing a small amount of natural groundwater discharge to springs and ET in some lowland areas. If pumping continues, aquifer storage depletion will continue until the capture rate of natural discharge to springs and ET is equal to the pumping rate.” This means that over time, groundwater pumping will reduce spring flow and dry up springs while also taking groundwater that supports plants. The prolonged drought in the west has led to the decline of wetlands and other groundwater dependent ecosystems throughout the intermountain west, creating increased dependence on these ecosystems in the Harney Basin by migrating and breeding waterbirds.

Water Security for Groundwater Users

Declines in domestic and stockwater wells from lowering groundwater levels is a problem for landowners in the basin. Concern about the cost to replace a reliable supply of water and the assurance of that supply is significant to those facing the potential loss of water supply. There is also a concern about the effects of declining groundwater levels on property values. Associated with concerns about changing groundwater availability is the concern about groundwater quality.

The basin has significant arsenic (naturally occurring) and other harmful materials in the sediments that affect groundwater quality, but the distribution and location of these materials is not well known. The concern about groundwater quality is coupled with the concern about groundwater availability under declining groundwater levels.

Groundwater Governance

Until recent planning and groundwater investigations, there has been limited enforcement of groundwater regulations. Collaborative members and other citizens have expressed concerns about use of groundwater without valid permits and/or certificates, non-compliance with permit conditions, wells being drilled improperly, and other results of limited State oversight of groundwater development. There is a recognized limitation on the accessibility of information from the OWRD on groundwater permit compliance and other information. There has been an expressed concern that too few wells are measured to tell how much groundwater is being used. This concern is because the requirement to measure groundwater use has only been established for permits issued in the recent past and because required measurement and reporting does not always occur. Water use measurement and reporting is a critical component of water management for compliance, accountability, and adaptive management.

Community Economic Stability

Agriculture is a very important pillar of the local economy. The estimated gross revenue from lands irrigated with groundwater is approximately $51.6 million (ECONorthwest, 2021). The estimated net cash farm income on these lands is $12.6 million (ECONorthwest, 2021). The estimated property tax payments from these lands is $1.7 million (ECONorthwest, 2021). The income and employment from groundwater irrigated agriculture (25%) is critical for the local economy and tax base (ECONorthwest, 2021). Uncertainty over the continuing availability of groundwater irrigation creates instability in the investment in production agriculture. Both the rate of change and the magnitude of change that will be required to have a long-term supply of groundwater and a sustainable agricultural industry are of significant concern to the community. Adaptation to change in groundwater use and availability requires diverse options for all landowners.

Declining groundwater levels also impact community economic stability in a number of ways that includes impacts to rural residents, stock water wells, groundwater dependent ecosystems and the recreational economy that results from them. Loss of domestic water affects both the livelihood and value of rural residences. The current and potential future economic impacts to these residents and the community have not been studied.

Climate Change/Cycle Effects on Groundwater

While Harney Basin has highly variable weather, the region has experienced severe drought over the last few years and increasing variability may be a consequence of climate changes. The long-term effects of climate change (Figure 18) in the Harney Basin will likely include: increased evapotranspiration, decreased snowpack and changed timing of snow melt runoff, more intense and concentrated precipitation events, reduced groundwater recharge, and longer, hotter dry seasons.

When the groundwater model is developed by USGS and OWRD the effects of climate change on groundwater recharge rates, levels and uses can be examined. Even without the groundwater model all available information indicates that the basin will receive less effective precipitation due to raising temperatures.

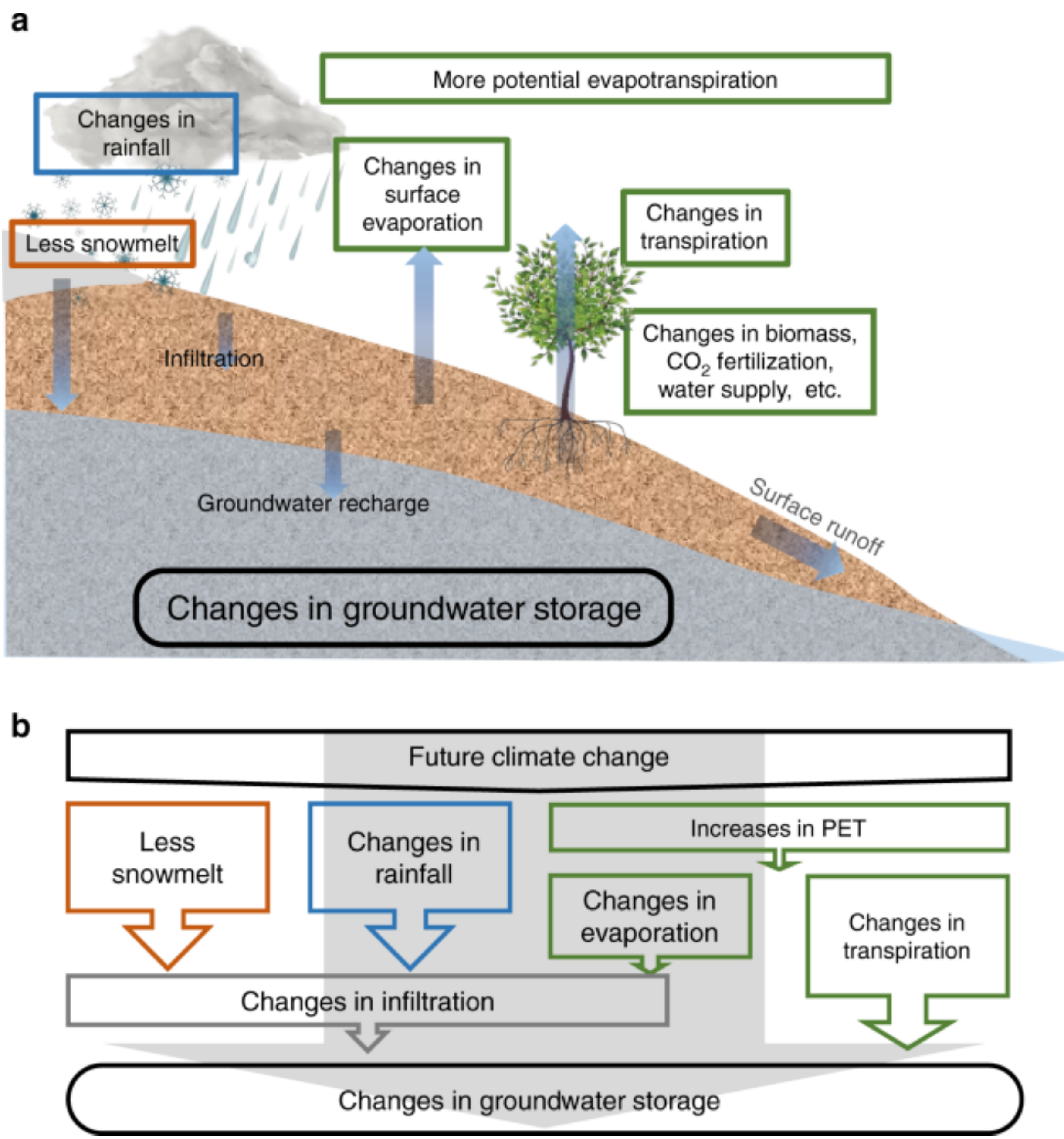

Figure 18. An illustration of some of the potential changes to groundwater storage from climate change (Wu et al., 2020)

Information Gaps

The economic effects of changing groundwater use either through reduction of permits and certificates, regulation or other means is poorly understood. While there is some information on the impacts of groundwater level declines on domestic groundwater wells, there is little information on the economic impacts of these declines, including impacts to population, property values and effects on property tax revenue. Additionally, there is only anecdotal information on the impacts of lowering groundwater levels on stock water wells. There is limited information on groundwater dependent ecosystems and the effects of groundwater level changes on them. One of the more significant information gaps is the distribution and changes in groundwater quality especially as it relates to domestic groundwater use. Also not studied are the potential economic impacts to the community if groundwater dependent ecosystems, including those that support wildlife and parts of the Malheur National Wildlife Refuge, are impacted by declining groundwater levels. A reduction in groundwater use for agricultural irrigation will have effects on property tax revenue, and the economic support for agriculture in the community. The potential changes have not been evaluated.

Additional information gaps are discussed in Chapter 8 and in the Step 2 and Step 3 documents found in the appendices.

The recent USGS groundwater study (Gingerich et al., 2022) identify additional monitoring and research needs. Among the suggestions are: monitoring groundwater levels and pumpage rates and volumes, additional monitoring wells, increased number of stream gages, increased understanding of intermittent streams, flow measurement of springs, detailed geologic data collection, better understanding of groundwater declines in shallow aquifers, and study of changes under climate change scenarios. The development and use of a numerical groundwater flow model is recommended with a list of questions that such a model could address.

Community Understanding

The complexity of Oregon water law and the procedures established to implement it makes it difficult to understand by many residents. Further, the complexities of groundwater movement and availability and the “hidden” nature of groundwater makes it more difficult to predict outcomes of any intervention. For example, some community members believe that when pumping is reduced or halted the groundwater level will rise in a relatively short time. The response to management of groundwater use can be slow and variable depending on the aquifer properties. The expectations of concerned community members are often not met. There is also a lack of available information on groundwater conditions in plain language for the public; the technical information is often expressed in terms and descriptions not easily grasped or understood. To date, a common understanding of the groundwater conditions in the Harney basin is somewhat elusive.

For a complete list of critical groundwater issues, refer to Appendix C.

Chapter 6. Desired Conditions: Meeting Instream and Out-of-Stream Groundwater Uses (Step 3)

Overview of Desired Conditions

Throughout the PBP process, the CBWP Collaborative had countless community conversations regarding their thoughts on desired conditions in the Harney Basin. These conversations were informed largely by the reports of the GWSAC, CBWP Working Groups, presentations from various agency (OWRD, DEQ, USGS, etc.) staff members, insights from community members, and the critical issues identified throughout the PBP process. While there are many components of PBP that the Collaborative addressed, one overarching theme has remained; **the CBWP Collaborative wants a sustainably managed supply of quality water for people, the economy, and the environment.** This notion is supported by the desired conditions for groundwater supply, quality, and uses.

Groundwater Supply

Recharge

Early on in their process, the CBWP Collaborative identified the topic of recharge to be more fitting with surface water conversations. Surface water topics are not covered in this portion of the plan, but recharge came up during numerous Collaborative discussions; we would be remiss to not include the importance of recharge in terms of the desired groundwater conditions for the basin. All things considered, one of the Collaborative's intentions is to rebalance the groundwater budget. As discussed in Chapter 5, recharge is currently less than discharge meaning the groundwater budget is out of balance by approximately 110,000 acre-feet/year. The Collaborative wants this deficit to be reduced. In the surface water portion of the process, we will be investigating and discussing potential opportunities to increase groundwater recharge.

Groundwater Storage

The Harney Basin recharges the lowlands from the uplands by approximately 108,000 acre-feet/year from groundwater flow and streams and other natural flow. Another 57,000 acre-feet/year is contributed by flood irrigation. This recharge is slightly more than the 152,000 acre-feet/year that is pumped for groundwater irrigation. Natural discharge accounts for 128,000 acre-feet/year to springs, lakes, streams and rivers, and natural ET (including support of native plants). The groundwater pumped for irrigation is pumped from storage in the aquifer, much of which was stored millennia ago. Since agricultural groundwater use dominates the discharge of groundwater, adjustment of this use will have the greatest impact on the groundwater budget and reduce the draw on storage. The result is a significant deficit between recharge and discharge (some 110,000 acre-feet/year) (Garcia et al., 2022).

Groundwater Level Change

Desired conditions for groundwater level changes depend entirely on location in the basin since changes are variable. In general terms, the Collaborative wants to implement approaches and strategies outlined in this plan in appropriate sub areas of the basin to help stabilize deep and shallow groundwater. The Collaborative recognizes that the tools and strategies needed to address groundwater declines will likely not be uniformly applied across the basin. The Collaborative also recognizes that the OWRD has tools available (e.g., designation of Critical Groundwater Areas, Serious Water Management Problem Area designation, Basin Rule revision, etc.) that are outside of the scope of PBP but may be applied basin-wide or in parts of the basin where there are acute declines. In other areas of the basin that show slight declines over time or fluctuating rises and declines in groundwater levels, CBWP Collaborative strategies and approaches might be sufficient to ensure a sustainable groundwater supply.

Groundwater Quality

The CBWP Collaborative wants the groundwater in the Harney Basin to be of adequate quality for municipal, domestic, irrigation and stockwater purposes and to support groundwater dependent ecosystems and species.

Understanding groundwater quality in the Harney Basin would benefit from implementing a regular monitoring regime. The recent groundwater quality monitoring effort (Haxton-Evans and Brown, 2021) sampled wells to establish an "ambient baseline conditions" and to detect "certain contaminants" to detect the "potential for human health impacts". While a large scale baseline has been established and some 58% of the sampled wells had some contaminant at a level that posed a human health concern. The dominant contaminant was arsenic. While there is limited information on the distribution of naturally occurring drinking water contaminants (e.g. arsenic, boron, manganese, aluminum, etc.), it is clear that additional information is required.

Groundwater Uses

Out-of-Stream Groundwater Uses

Agricultural Irrigation Use

Beamer & Hoskinson (2021) estimate agricultural groundwater use to be approximately 140,000 acre-feet/year and the OWRD/USGS Groundwater Study (Gingerich et al., 2022) estimates some 145,000 acre-feet/year for the 2017-2018 timeframe. Agricultural irrigation is the dominant use of groundwater in the basin. The CBWP Collaborative's Agricultural Working Group has highlighted the urgent need to reduce agricultural groundwater use and outlined ideas for how to do so. These include increasing irrigation efficiency, fallowing fields, and changing crops to less water intensive crops (Appendix B). A Conservation Reserve Enhancement Program (CREP) has been proposed for the basin which could fallow up to 20,000 acres of actively irrigated cropland over a 15-year period. Full enrollment could conserve between 40,000 and 60,000 acre-feet/year, nearly reducing the budget deficit by half with this strategy alone.

With the tools outlined in this plan, the CBWP Collaborative sees the need for agricultural users to reduce their groundwater use considerably; this reduction in use would likely be more significant in the area(s) of acute decline. There was significant discussion, albeit no consensus decisions, regarding identification of an appropriate time frame for reductions that would allow for economic transformation of agricultural uses, while also recognizing the need to stabilize groundwater levels and address impacts to other uses of the groundwater (domestic uses and groundwater dependent ecosystems) from continued groundwater pumping for irrigation. The Collaborative wants to maintain a vibrant agriculture community.

Domestic Uses

The CBWP Collaborative's Exempt Uses Working Group identified the primary need for domestic groundwater in the Harney Basin as finding ways to assure domestic water users a stable supply of clean water. The projected demand for domestic water use is not a significant amount in the context of basin groundwater Pumpage. OWRD (2015) estimated domestic water use as 700 acre-feet/year. and projected it to be static over the next few decades. The Working Group report estimated domestic water use to be 825 acre-feet/year and Grondin (2021) estimated 1,100 -1,200 acre-feet/year (Appendix B). Domestic users want a reliable water supply, assurance that water depths will not decline below a certain depth, awareness of the steps to take to ensure their water quality meets safe drinking water standards and access to available educational and financial resources to support their wells. The primary desired condition is to have domestic water available at depths that are affordable to drill to assured water production, and water quality that meets drinking water standards.

Stockwater Use

Little is known about the conditions of stockwater wells, though it is likely that yields have declined especially for shallow wells located on the basin floor, similar to the trend in domestic wells. More information is needed to assess the well conditions and the groundwater needs of stockwater users. It is assumed that stockwater well owners want an adequate quantity and quality of groundwater on a year-round basis.

Municipal Use

Work done by the Exempt Uses Working group highlights the following: *Both Burns and Hines Public Works directors have indicated that they have sufficient supplies for the foreseeable future. The communities are in a hydrogeological area that benefits from the inflow of shallow, young water into the groundwater. Groundwater levels in the area of the communities have not declined through time. The Cities have water rights sufficient for growth.* That said, the CBWP Collaborative wants to ensure the towns of Burns and Hines can maintain their consistent, safe supply of quality drinking water, to ensure that supply meets both present and future needs of residences and businesses within their jurisdictions. The recent engineering analyses of water supply for Burns (Anderson Perry & Associates, Inc., 2021) and Hines (Anderson Perry &

Associates (2020) both state that there is sufficient supply for the foreseeable future (20 years) with current permits.

Groundwater Use in Unincorporated Areas

We define an unincorporated areas as any area that is not supplied water by municipalities. Examples of unincorporated areas in Harney County are Crane and Lawen. Harney County Court contracted with Anderson & Perry engineers to explore ways to maintain access to domestic water of sufficient quality and quantity. The engineers identified limited areas where a community well or connection to municipal supplies could eliminate personal use wells in exchange for a community well or municipal supply. The CBWP Collaborative reviewed the reports and discussed what legal rights and financial assistance might be required to drill community wells if deemed necessary. It would be important to ensure that such alternative domestic water supplies did not result in increased groundwater use.

Commercial and Industrial Use

Current groundwater use for commercial and industrial purposes is some 2,037 acre-feet/year (Grondin, 2021). This use compares to the use in the 1980's of some 10,618 acre-feet/year when the Hines Mill was operating (Grondin, 2021). Burns and Hines' recent Water System Management Plans indicate sufficient supply for future commercial and industrial uses (Anderson and Perry, 2021).

Burns Paiute Tribal Uses

The Burns Paiute Tribe currently uses only a small amount of groundwater (Chapter 4) on the reservation. Assurance that a supply of groundwater both in quality and quantity for the Tribe is important. Since the reservation is near the upland-lowland boundary the likelihood of groundwater declines affecting the supply for the Burns Paiute Tribe reservation appear to be lower than other areas at this time. Nothing in this plan affects the Burns Paiute Tribe's rights or independent sovereign authority. Regardless of whether they participate in this plan, water use and need on the reservation, support to enable future meaningful engagement throughout the process, and acknowledgement of tribal rights should be incorporated in future community water planning.

Tribal Uses on Allotted Lands

There are approximately 11,000 acres of land in the Harney Basin composed of 71 parcels allotted to individual tribal members from the public domain. Owners of these lands include descendants of the original allottees, and many participate in the Numu Allottee Association. While the allottees have not developed groundwater, they may retain federal reserved groundwater rights that date to pre-1900. These rights may need to be determined through adjudication of all the groundwater rights in the basin. The complexity of the legal and factual considerations of allottee water rights with application to Allotments in the Harney Basin are discussed in Schaff and Lohman (2020).

Other Permitted Groundwater Uses

The Collaborative acknowledges that there are permits that have been issued for other groundwater uses for activities such as fish cultures, wildlife, recreation, etc., but did not explore these in depth during this planning process.

Instream Groundwater Uses

Groundwater Dependent Ecosystems (GDEs) & Species

Information in the Ecological Working Group's report highlights that groundwater dependent ecosystems and the species that rely on them hold significant ecological importance. Therefore, *the most urgent requirement for the conservation of groundwater dependent ecosystems is to reduce the rate of decline of groundwater and to monitor spring discharge in a consistent manner* (Appendix B). Additionally, the CBWP Collaborative wants GDEs to be protected, restored, and maintained now and in the future.

Chapter 7. Groundwater Objectives, Strategies and Recommended Actions (Step 4)

Strategy Development

Early on in their endeavors, Collaborative members submitted their ideas for solutions to groundwater issues and approaches to achieve desired conditions. More than 70 concepts were submitted. The concepts were organized by topic into "bins" of concepts addressing similar issues (Reducing Agricultural Irrigation, Addressing Domestic Well Issues, Conserving Groundwater Dependent Ecosystems, Measuring and Reporting Groundwater Use, Improving Accountability, and Collecting and Sharing Information). The Collaborative discussed all ideas by bin and then decided whether to develop them further into strategies. Once developed and in list form, the Collaborative spent a significant amount of time refining, editing, and wordsmithing language to ensure the intention of each strategy was clear and based on both community knowledge and the best available science. In addition to strategies, the Collaborative also drafted objectives and recommended actions to highlight the overarching goals of and potential paths to achieve said goal for each strategy. In December 2021, the Collaborative achieved consensus[2] on the Strategy List included in this plan. The list includes 31 strategies, objectives, and sets of recommended actions[3] (See Appendix D). The following discussion organizes the proposed strategies following an approach used for the Great Salt Lake (Clyde Snow Jacobs, 2020).

Purpose and Need

From all recent evidence of declining groundwater levels and analysis of recharge compared to use, groundwater in the Harney Basin is severely over allocated. The strategies proposed focus on reducing the effects of overallocation and the use of groundwater to sustainable levels. More than a list of strategies, it is important to look at them as an integrated set of efforts. While each of the strategies represent a potential helpful groundwater management tool or application, they do not exist in the abstract or alone. Their effectiveness is impacted by existing conditions of water availability, water allocation, water law, and customary uses. Also, while each of the individual strategies can improve groundwater management, none of the strategies alone can ensure

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[2] The CBWP Collaborative is working with OWRD to finalize language on one strategy that OWRD did not provide their support on. Refer to the Strategy List in Appendix D for further details.
[3] The CBWP Collaborative continues to provide clarity on the recommended actions to ensure they coincide with the intent of the strategy and objective. Refer to the Strategy List in Appendix D for further details

groundwater uses will reach sustainable levels. Some of the strategies focus on addressing immediate effects of overallocation, while others try more to address root causes.

While each individual strategy is important, an overarching and integrated approach to applying the strategies to conserve groundwater in the Harney Basin has been developed.

The Collaborative discussed each strategy separately and focused on intent and recommended actions. While there are significant differences in the amount of detail and coherence among the strategies, they have all been approved by the Collaborative by consensus. For purposes of categorizing and prioritizing the strategies a shortened name for each strategy is being used. For ease of viewing, the tables below use short-hand names to identify the strategies; Appendix D contains the strategy language and detail discussed and agreed to by the Collaborative. As the Collaborative moves from planning to implementation, the detail of the recommended actions may change or be refined as experience is gained.

Categorization Approach

By categorizing strategies as Foundational, Operational, Tactical, or Organizational/Infrastructure (see side bar) the relationships between strategies is apparent. The proposed logic is that ***Foundational*** strategies are those that protect a balance of groundwater uses. ***Operational*** strategies provide the information that enables decisions to be made and can facilitate transactions. ***Tactical*** strategies are those that propose specific actions to address individual issues associated with the overallocation of groundwater in the Harney Basin. It is useful to consider how the different strategy types fit together (Figure 19). Cutting across the action strategies (Foundational, Operational, and Tactical) are the needed ***Organizational/Infrastructure*** strategies to support, coordinate, provide oversight and enforcement to ensure the active strategies accomplish the goal of sustainable groundwater conditions.

Strategy Type Definitions

Foundational – Strategies that protect a balance of uses.

Operational – Strategies that inform decisionmakers and facilitate transactions that incentivize groundwater conservation.

Tactical – Strategies that incentivize individual water users to reduce groundwater use.

Organizational/Infrastructure - Strategies that are critical for support, oversight, and enforcement of actions taken to reduce groundwater use.

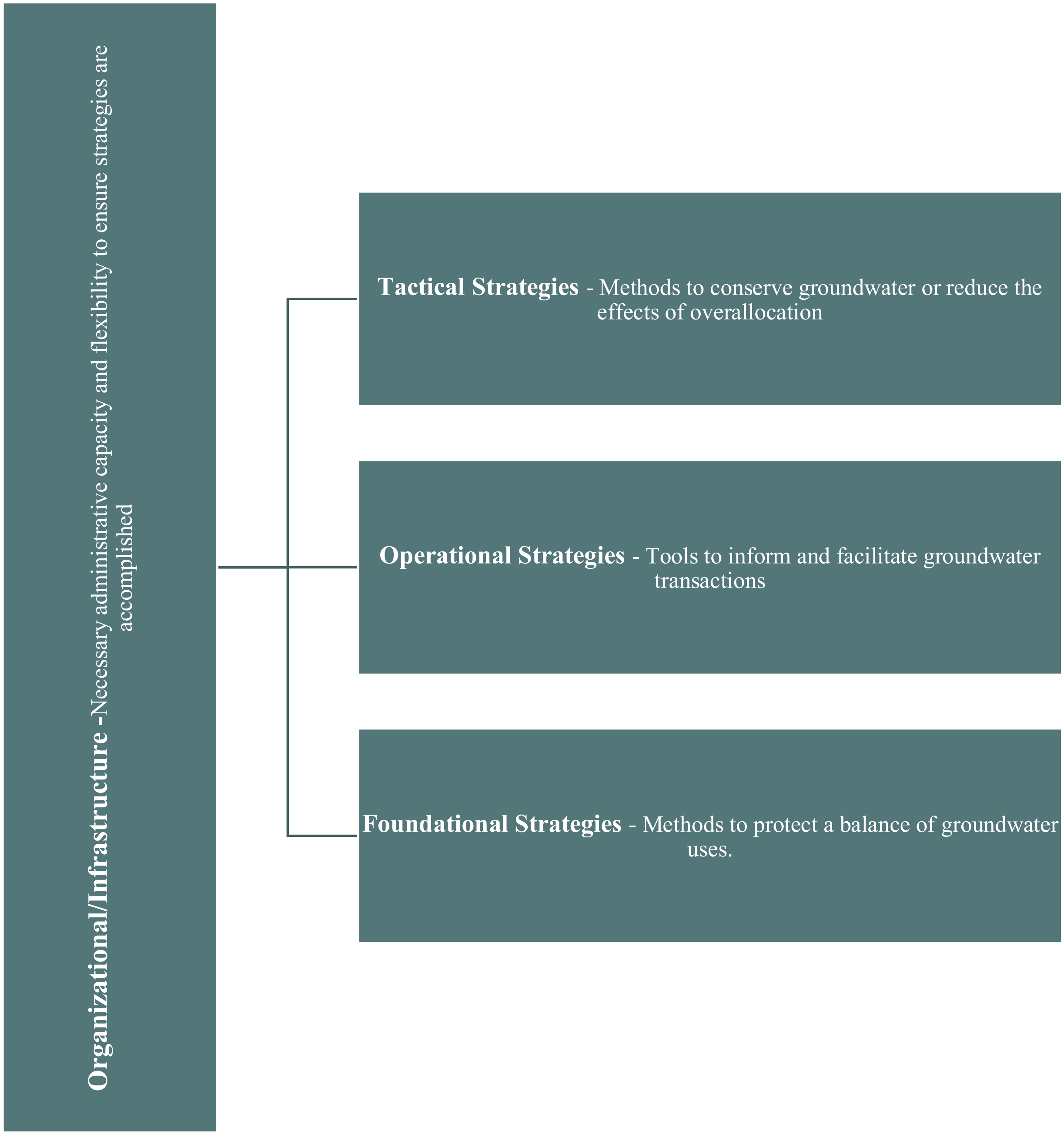

Figure 19. Functional Categories for Strategies to Reduce Groundwater Use in the Harney Basin (taken from Clyde Snow Jacobs, 2020)

Foundational Strategies

The foundation for managing groundwater is Oregon Water Law. Oregon Revised Statutes (ORS) at 537.110 states: "All water within the state from all sources of water supply belongs to the public." This is the foundation for water management. Groundwater policy is articulated at ORS

537.525. The policy allows for “beneficial use without waste, within the capacity of the” resource and specifies; “Adequate and safe supplies of ground water for human consumption be assured, while conserving maximum supplies of ground water for agricultural, commercial, industrial, thermal, recreational and other beneficial uses.” These legislative policy directions also include the standard that: “Reasonably stable ground water levels be determined and maintained.”

Foundational Strategies provide approaches necessary to support groundwater conservation in the Harney Basin. Each strategy is an attempt to address a critical question raised by the Collaborative on how to accomplish the policy goals given current state of law, traditions, knowledge, and resource conditions.

The CBWP Collaborative has identified two strategies that appear to be foundational to groundwater conservation in the Harney Basin (Figure 20):

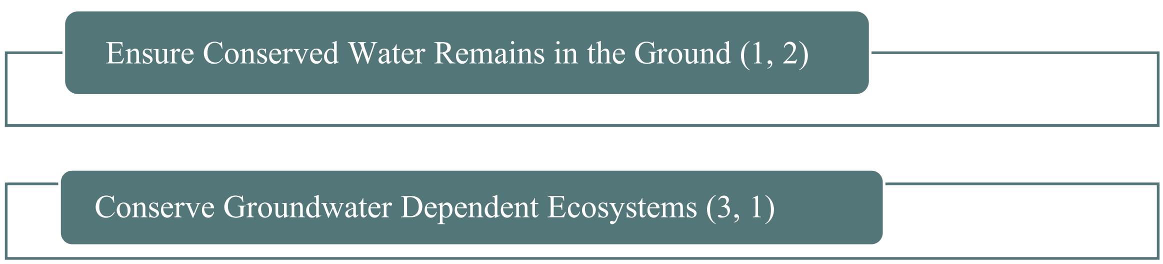

Figure 20. Foundational Strategies for Harney Basin Groundwater Management. Numbers in parentheses refer to the strategy’s section number and strategy number on the Strategy List, which can be found in Appendix D.

Operational Strategies

Operational strategies are those that provide a pathway or information for decisionmakers to take action. The CBWP Collaborative has identified thirteen Operational Strategies (Figure 21):

- Protect Water Rights when Reducing Groundwater Use (1, 1)
- Develop Alternative Crops (1, 4)
- Develop a Drought Plan (1, 6)
- Increase Understanding of Groundwater Rights (1, 7)
- Monitor and Inventory Groundwater Dependent Ecosystems (3, 2)
- Explore Remote Sensing of Groundwater Use (4, 2)
- Measure Groundwater Use (4, 3)
- Develop an Abandoned Well Safe Harbor Program (5, 3)
- Explore Groundwater Use Fees (5, 6)
- Continue Groundwater Studies (6, 1)
- Assess the Economic Value of Groundwater in the Harney Basin (6, 4)
- Establish a Groundwater Quality Monitoring Program (6, 6)
- Expand Groundwater Quality Knowledge (6, 7)

Figure 21. Operational Strategies for Harney Basin Groundwater Management. Numbers in parentheses refer to the strategy's section number and strategy number on the Strategy List, which can be found in Appendix D.

Tactical Strategies

Tactical strategies are those strategies that can result in direct action to address groundwater issues in the basin. The collaborative has identified eight tactical strategies (Figure 22):

Figure 22. Tactical Strategies for the Harney Basin Groundwater. Numbers in parentheses refer to the strategy's section number and strategy number on the Strategy List, which can be found in Appendix D.

Some tactical strategies have progressed during the Collaborative's groundwater planning process. These include the Conservation Reserve Enhancement Program (CREP) and the Domestic Well Remediation Fund. The Collaborative also worked with Aspect Consulting to explore what a groundwater market could look like in the Harney Basin and worked with Anderson Perry and Associates to explore alternative water delivery for rural residents.

Organizational/Infrastructure Strategies

Cutting across all other strategies are those that improve communication and accountability. To make progress on reducing groundwater use, it is critical to have both information and organizational capacity to ensure that requirements are met, and violations are dealt with. For the public to have confidence in any proposed action, they need to be confident that all requirements of

Oregon Water Law are met and applied uniformly recognizing that some areas of the basin may require different approaches.

Groundwater rights in the Harney Basin are held by individuals (including corporations) not districts. Thus, the primary interactions to address water use considerations are one-on-one between OWRD staff and irrigators. The complexity of the situation requires up to date information that is easily accessible and cooperation between public agencies. The organizational approach also needs to focus on how to achieve sustainable levels of groundwater. This is a shift in emphasis and additional staff and support will be needed within the basin.

There are eight Organizational/Infrastructural Strategies identified by the Collaborative (Figure 23).

- Recommend OWRD Take Actions in Short-term to Reduce Irrigation Groundwater Use, Including Permit Compliance (1, 8)
- Improve Well Construction and Permit Standards (5, 1)
- Ensure CBWP Representation in Rulemaking (5, 2)
- Improve Citizen Engagement in OWRD Decisions (5, 4)
- Work with OWRD to Address Abandoned Wells (5, 5)
- Identify and Utilize Best Available Science (6, 2)
- Improve Community Information about Groundwater Conditions (6, 3)
- Build Understanding of Voluntary Agreements (6, 8)

Figure 23. Cross-cutting Organizational/Infrastructure Strategies for the Harney Basin. Numbers in parentheses refer to the strategy's section number and strategy number on the Strategy List, which can be found in Appendix D.

Some organization strategies have progressed during the Collaborative's groundwater planning process. These include improving community information on groundwater conditions and working with Culp & Kelly LLP and the Environmental Defense Fund to build an understanding of voluntary agreements.

Summary and Implications of Strategy Categorization Approach

With the strategy categorization approach described above, the CBWP Collaborative was able to better articulate sequencing and interrelationships of strategies and therefore understand how strategies might be linked in time.

One approach that the groundwater study (Gingerich et al., 2022) recommends and is part of the study plan is to use a groundwater model to test the effectiveness of identified strategies. Since the groundwater model has not been developed and the availability is uncertain, this could be a strategy in the future. An additional influence on which strategies are prioritized could be regulatory action by the Oregon Water Resources Commission.

The Regulatory Setting

While the Collaborative has focused on strategies that the community could take within Oregon Water Law to address groundwater overallocation, there are actions the Oregon Water Resources Department and Commission can take to address the issue as well. The range of agency actions are an important backdrop for the planning effort. There is a requirement in the Malheur Lake Basin Rules [OAR 690-512-0020 (12)] that "within 1 year after the Groundwater Study has been published by the Department, the Department will convene a Rules Advisory Committee (RAC) to explore whether there is a need for updates or changes to these rules." The OWRD/USGS Groundwater Study, which was released April 12, 2022, triggers the one-year timeline for OWRD to convene a RAC to explore whether there is a need to update or change the rules that established the Greater Harney Valley Groundwater Area of Concern. Additionally, the groundwater study has documented groundwater declines that could trigger the designation of a Critical Groundwater Management Area (ORS 537.730- 537.742) for specific area or areas showing serious declines in the groundwater levels. Another tool the Oregon Water Resource Department has is to designate all or a portion of the Harney basin as a Serious Water Management Problem Area (OAR 690-085-0020).

Chapter 8. Data Needs (Step 4)

While compiling the Groundwater Plan several data needs were identified by the Working Groups and Collaborative members. The data and information needs are summarized in the following table along with ideas on how they may be filled. Many of the data needs for groundwater management are identified as strategies in the plan, however not all are. This information can inform future actions by the Collaborative or individual organizations in the collaborative.

Table 3. Data needs identified throughout the CBWP Phase 1 planning process and suggestions for how they could be addressed.

Data Need	How data need could be addressed
Management	
Amount of groundwater pumpage	Require Measurement through a SWAMPA or CGMA
Number of unused/uncapped wells	Work with OWRD and the public to identify potential abandoned wells
Status of livestock wells	Survey well owners to get information on stock wells
Use of supplemental groundwater amount and timing	Survey owners of surface water rights that have supplementary groundwater rights
Groundwater permit compliance	Work with OWRD to ensure staff is reviewing compliance
Actual water use v. permitted use information	Compare Measurement with permitted use
Location of unpermitted uses	Review aerial information to identify areas being irrigated that are not under permit
Distribution of groundwater contaminants	Work with DEQ to develop more comprehensive evaluation
Additional monitoring wells throughout the Harney Basin to enable adaptive management of water management strategies	Work with OWRD and USGS to identify appropriate locations for additional monitoring wells
Scenarios model to estimate the impact of different water management strategies on groundwater levels	Use the groundwater model being developed by USGS and OWRD to explore potential scenarios
Groundwater System	
Distribution and rates of groundwater recharge in the Silvies floodplain	Explore funding for a study of recharge rates by soil type and other characteristics of the floodplain
Groundwater movement in the Silver Creek area	Increase the monitoring well array in the Silver Creek subbasin
The role of faults in groundwater flows	Explore funding to study to flow characteristics in the Brothers Fault zone in the Silver Creek subbasin
More monitoring to determine the relationship between shallow and deep groundwater flow system	Explore funding to study the connections between shallow and deeper groundwater

Better surface water flow information	Add stream gauges to the Silvies River in strategic management locations, Silver Creek and Poison Creek
More information on the contributions of intermittent streams to groundwater recharge	Explore funding to study the water budgets of the intermittent streams on the east side of the basin
Consistent and long-term time-series measurement of spring flow	Explore funding to ensure a consistent sample of spring flow will be measured
Better geological information	Work with DOGAMI to update geological information to improve the groundwater model
Projected impacts of future climate conditions to groundwater recharge and discharge	Use the groundwater model and water management scenarios to evaluate potential changes in climatic inputs
Groundwater Dependent Ecosystems	
Volume and rate of groundwater needed to support GDEs and application of the Framework for Ecological Responses to Groundwater Regime Alteration	Find funding for studies to experimentally determine GDE hydrologic thresholds using pump tests. Work with OWRD to assess opportunities for monitoring of springs and GDEs and use empirical data to assess ecohydrologic thresholds.
Short- and long-term impacts of groundwater withdrawal on Harney Basin GDEs	Work with OWRD to assess opportunities for monitoring of springs and GDEs as a method of assessing strategy success
More complete understanding of the distribution of Harney Basin GDEs	Find funding for additional studies of GDEs including seepage runs, piezometer clusters associated with lakes and wetlands, and surveys of groundwater-dependent species.
Consistent and long-term time-series monitoring data on GDE location and status	Identify dedicated funding sources and capacity to install, maintain, and operate pressure transducers and/or temperature loggers with continuous hourly data for a subset of GDEs likely to be impacted by water management decisions.
Application of the Framework for Ecological Responses to Groundwater Regime Alteration	Once the above data gaps are filled, incorporate ecohydrologic thresholds into USGS water management scenarios to assess likely benefits or unintended consequences of water management decisions on GDEs.
Lack of information regarding riparian habitats	Explore funding to inventory riparian areas throughout the Harney Basin

Chapter 9. Implementation (Step 5)

Implementation Framework

This Implementation Framework comes out of a compilation (see Appendix E) of: critical issues, strategies (with their category: foundational, operational, tactical, organizational) that address the issue, the desired outcome of each strategy, the recommended actions of each strategy, budget and funding opportunities to support implementation of each strategy, responsible parties to carry out each recommended action, timing of implementing strategy, status of the strategy (i.e., ongoing, completed, not started, etc.), whether the strategy is applicable to the Harney (Malheur Lakes) Basin Rule Advisory Committee/ rule-making process, performance metric for the strategy (i.e., how the strategy will be measured to track progress and determine if the action has been successfully implemented), and monitoring metric for the strategy (i.e., ways in which performance metrics can be measured).

The development of the Implementation Framework helped the CBWP Collaborative determine its proposed approach for implementation of its strategies. All information housed in the framework is for consideration by the Collaborative and its partners and should be regularly updated.

An Approach for Implementation of Strategies

Given the number and breadth of proposed strategies it is important to develop a general notion of which strategies to implement at what times. The designation of near term, mid-term and long term is a relative timeframe for taking actions to reduce groundwater pumping. It will be important to make progress on several fronts to accomplish levels of reduced groundwater pumping that can make a difference given the severity of the issue. The Collaborative recognizes that significant reduction of overpumping of groundwater is necessary. It is difficult to evaluate the cost effectiveness or cost benefit of the strategies, though this was considered during development of this approach. More work will need to be done to evaluate costs to implement strategies once this plan is approved by the Commission.

Given the situation of overallocation of groundwater the focus of implementation is on those strategies that can make the most difference in the shortest time. The significance of reducing irrigation groundwater use is also balanced with protecting the other benefits from groundwater dependent uses (domestic use, stockwater use, and groundwater dependent ecosystems).

Near-Term Strategies

In the near-term, the strategies that will make the most difference will be those strategies already initiated or have the possibility of being initiated in the next 3 years. There has been an ongoing NRCS Conservation Implementation Strategy for Saving Groundwater in the Harney Basin Using Efficient Irrigation Technologies to incentivize irrigation efficiency through technology. By conversion from MESA to LESA it is estimated that converting 62,428 acres of groundwater irrigated land with a savings of 20% when fully implemented could cut groundwater irrigation use by some 37,456 acre-feet/year (NRCS, undated). This is an optimistic estimate, however recent information suggests that some 13,750 acres have been converted as of 2021. The water savings has not been measured or reported; however, the conversion has likely conserved a significant amount of groundwater.

Near-term implementation of the Harney Valley Groundwater CREP program will provide incentives for reducing an estimated 40,000 to 60,000 acre-feet/year of groundwater use with full enrollment of 20,000 acres.

It is important to recognize that these strategies are not likely to realize the full benefits in the near-term, for example the CREP program could take a 15-year period to achieve full enrollment. The NRCS irrigation technology Conservation Implementation Strategy was started in 1999 and is funded through 2023 and will not likely meet the projected targeted savings. Reduction in groundwater use (and reduction in overallocation by cancelling permits/certificates) through the CREP program will be dependent on willingness to participate. Since the program is voluntary, it is also impossible to determine where reductions in pumping will occur. The program is not designed to focus on areas of most significant decline but to reduce groundwater pumping in the basin and reduce the overallocation of permits/certificates.

In a similar manner funding to assist domestic well users affected by lowering groundwater levels has been approved and is only waiting for the OWRD to implement the program. This mitigation measure is an important near-term measure to address the effects of lowering groundwater table at some locations.

While these three strategies are developed and being implemented, other strategies will require attention over the next few years. Table 3 lists the near-term strategies to address Harney Basin groundwater issues.

Table 4. Near-Term Strategies for Addressing Harney Basin Groundwater Issues

Strategy	Status
Explore Long-Term Approaches to Assist Domestic Water Users	Ongoing
Conserve Groundwater Dependent Ecosystems	Ongoing
Protect Water Rights when Reducing Groundwater Use	Ongoing
Develop Alternative Crops	Ongoing
Monitor and Inventory Groundwater Dependent Ecosystems	Not Started
Explore Remote Sensing of Groundwater Use	Ongoing
Measure Groundwater Use	Not Started
Continue Groundwater Studies	Ongoing
Identify and Utilize Best Available Science	Ongoing
Use Less Water Through Technology	Ongoing
Support a Groundwater CREP Program	Ongoing
Develop a Domestic Well Remediation Fund	Completed
Advocate for Groundwater Permit Compliance	Ongoing
Ensure CBWP Representation in Rulemaking	Ongoing
Improve Community Information about Groundwater Conditions	Not Started
Build Understanding of Voluntary Agreements	Ongoing
Improve Well Construction and Permit Standards	Ongoing

Each of these strategies is important to move the groundwater conditions in the basin towards a sustainable level. The strategies to explore voluntary agreement requirements and to reduce agricultural irrigation use are important to the local community and will require focused attention. Considerations of increasing accountability of groundwater use through measurement or estimating approaches are important for the long-term adaptive management and assurance of compliance of any groundwater management approaches. The strategies to inventory and monitor groundwater dependent ecosystems will require funding and capacity by state agencies as will the effort to expand the Extension Service capacity in the basin to include an alternative crops specialist.

A critical element for improving community communications is to make the recently published OWRD/USGS Groundwater Study available and provide as much accessible summary information as possible in different formats. Clear communication and widespread availability of information in the near term is important to help build community understanding of the groundwater situation. It will be important to have both a condition summary and a summary of the potential consequence for the community to consider.

Mid-Term Strategies

In the next decade (years 4 to year 10) there will need to be significant progress on the strategies that result in decreased groundwater use. As the early efforts take place there will be a better understanding of the effects of voluntary and regulatory approaches. Table 4 lists the mid-term strategies for addressing Harney Basin groundwater issues.

Table 5. Mid-Term Strategies for Addressing Harney Basin Groundwater Issues

Strategy	Status
Develop a Drought Plan	Not Started
Increase Understanding of Groundwater Rights	Ongoing
Develop an Abandoned Well Safe Harbor Program	Not Started
Assess the Economic Value of Groundwater in the Harney Basin	Not Started
Establish a Groundwater Quality Monitoring Program	Not Started

Expand Groundwater Quality Knowledge	Not Started
Develop Alternative Water Delivery for Rural Residents	Ongoing
Evaluate Well Standards for the Harney Basin	Not Started
Explore a Groundwater Market	Not Started
Integrate Water Use in Land Use Decisions	Not Started
Improve Citizen Engagement in OWRD Decisions	Ongoing
Work with OWRD to Address Abandoned Wells	Ongoing

Each of the mid-term strategies will require the development of a specific plan for development and implementation. Implementation of these mid-term strategies will depend on the record of effectiveness of the near-term strategies and what is learned from their implementation or issues developed when trying to implement them. Some mid-term strategies may become more important as conditions change either in Oregon Water Law, economic drivers, effectiveness of near-term strategies, climate change, regulatory action or other events affecting the use of groundwater. Other adjustments could be made based on how effective the Collaborative is at fund raising for the necessary support (see above).

Long-Term Strategies

Over the long-term (10 years out and beyond) there are strategies that will either take longer to develop support for or need more deliberation. Table 5 lists the strategies and identifies the currently known limitation to earlier development and implementation.

Table 6. Long-Term Strategies to Address Harney Basin Groundwater Issues

Strategy	Status
Ensure Conserved Water Remains in the Ground	Not Started

Explore Groundwater Use Fees	Not Started

Considerations to Implementation

It is important to ensure that groundwater is available for domestic, municipal, and ecosystem support purposes along with providing necessary agricultural use. Since the basin is overallocated, the challenge is how to ensure the most vulnerable uses (domestic and ecosystem support) are protected while reducing the most abundant uses (agriculture). This challenge is exacerbated by the economic significance of agricultural production from groundwater use. There are several considerations necessary to approach this problem, namely what is essential for the community? what can be done that will have the greatest impact in the near term which will ultimately have effects in the long term? How can a balance of uses be provided for in the long term?

The recently completed groundwater budget for the Harney Basin (Gingerich et al., 2022 and Garcia et al., 2022) documents an estimated deficit of approximately 110,000 acre-feet/year. The estimate of current use of groundwater for irrigation is approximately 152,000 acre-feet/year. Further, OWRD has issued permits to pump more than 304,000 acre-feet/year (Mertz and LovellFord, 2017). The information identifies a clear problem that is being evidenced by local groundwater declines that are severe in several locations and more general declines throughout the basin. The primary driver for the Harney Basin PBP Groundwater Plan is to find ways to reduce the use of groundwater for irrigation and protect other uses. The challenge is to identify the strategies that have the most significant impact within the shortest time frame.

Chapter 10. Adaptive Management (Step 5)

Adaptive management is the process of learning while doing. It is dependent on monitoring outcomes of interventions (implemented strategies) and is based on a planning process that produces strategies that have expected outcomes. As specific strategies are implemented the expected outcome should be identified and the timeframe to accomplish those outcomes should be identified.

Central to any adaptive management program is monitoring the effects of implemented actions (strategies). Only by monitoring and evaluating the outcomes of implemented actions can judgements be made about progress towards goals. Monitoring demonstrates progress or lack thereof during critical milestones and allows for strategies to be adjusted for maximum efficacy. This process requires: 1) a commitment to identifying the expected outcomes in some measurable manner and the timeframe the expected outcome will likely respond, 2: regular monitoring of the indicator of the expected outcome, 3) reporting on the monitoring results, 4) Evaluation of the effectiveness given the expected timeframe for response, and 5) a commitment to adjust strategies based on feedback from monitoring and evaluation.

The adaptive management cycle (Figure 19) involves applying interventions (Tactical Strategies), monitoring outcomes, and adjusting tactics as outcomes indicate is necessary. Strategies to address the elements of the adaptive cycle have been identifies by the Collaborative.

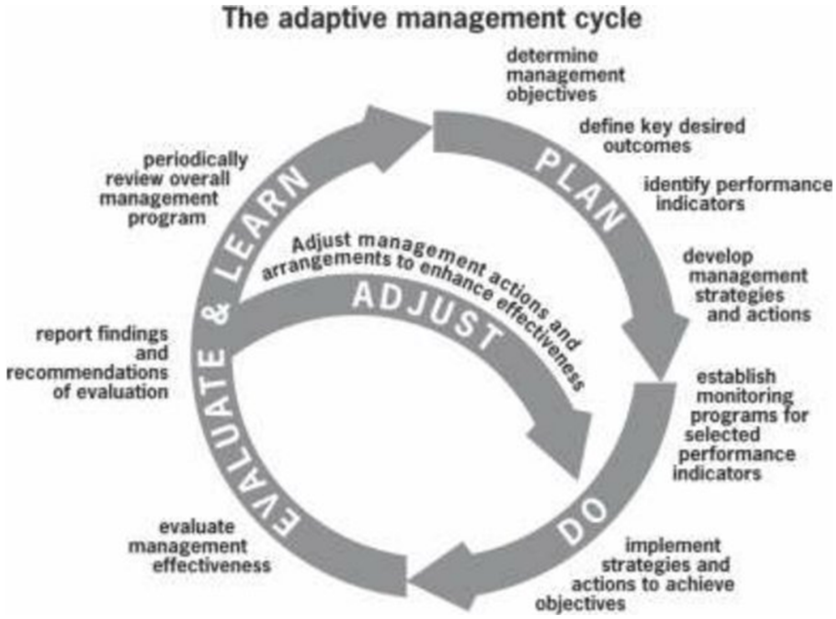

Figure 24. The Adaptive Management Cycle

Since there is no single strategy to address the groundwater declines in the Harney basin, it is important to evaluate the Tactical Strategies as they are implemented, document the goals and identify measurable benchmarks and measure progress against the desired benchmarks and report the results on a regular basis. The commitment to continued monitoring of groundwater levels by OWRD is an important first step, however, developing an effective method of monitoring and reporting groundwater use is critical to evaluate strategies proposing to reduce use. To be accountable, many of the Operational Strategies need to be in place to provide the information needed to evaluate the effects of Tactical Strategies. To make these adjustments in how groundwater use is managed in the basin several Organizational/Infrastructure Strategies need to be in place. Organizational/Infrastructure Strategies are particularly important for accountability.

What the above implies is that there are major changes necessary to reduce groundwater use to sustainable levels and that there is uncertainty about the outcomes of any given strategy. To “learn as we go” there needs to be a thoughtful way to identify the expected outcomes and a commitment of resources and establishment of capacity to measure and evaluate progress.

An additional consideration that is critical in managing groundwater is that the groundwater system does not react to changes uniformly or rapidly. Expectations of rapid change needs to be tempered by improved sharing of information about groundwater response times and variations throughout the basin. It is hoped that the groundwater model being developed can be used to test scenarios to optimize where strategies can be implemented to have the maximum impact. The model runs should be reiterated over time as strategies are implemented to inform adaptive management.

Gleeson et al. (2012) highlights that "adaptive management to changing conditions (e.g., population growth, cultural or climate change, better theory or understanding, new measurements) allows for more resilient long-term management and potentially provides a bridge within and across generations for addressing the longer-term issues of groundwater sustainability"

A significant number of the Strategies identified by the Collaborative address the consideration of changing conditions and preparing for them (Drought Planning Strategy, Alternative Crops Strategy, GDE resources Strategy, Inventory Unused Wells), Improving understanding of groundwater conditions Strategies, and to determine the value of groundwater in Harney County Strategy). As these strategies are implemented, they can lead to changes that affect tactical approaches to managing groundwater.

Chapter 11. Conclusions

Following more than 5 years of deliberation and study and the formal publication of the Harney Basin Groundwater study (Gingerich et al., 2022; Garcia et al., 2022), the community has wrestled with strategies to reduce groundwater use. The groundwater study documents areas of the basin with groundwater declines, estimates that the groundwater budget is out of balance by more than 110,000 acre-feet/year, and that much of the groundwater used for irrigation is ancient water from storage. The steps necessary to change the amount of groundwater use and address the areas of critical decline remain. The Collaborative has gleaned a significant number of strategies through community input and involvement from organizations interested in the public's water. Implementation of the strategies will make progress towards reducing the amount of groundwater used to start reducing the rate of decline. The community will focus their efforts on near-term implementation and look for ways to reduce groundwater irrigation use that protects domestic water users and groundwater dependent ecosystems while minimizing the economic impact to the community.

Meaning of State Recognition to the CBWP Collaborative

While the pilot program for Place-Based Planning requires interagency review and Oregon Water Resources Commission recognition, there is only limited information on what recognition by OWRC means. For the CBWP Collaborative, implementation and State recognition of the plan go hand in hand. First and foremost, the collaborative is optimistic that support of this plan means the CBWP Collaborative's vision- *A sustainably managed supply of quality water for people, the economy, and the environment-* is also supported. The Collaborative is hopeful that achieving State recognition of a plan reflects positively on the ability of the plan's components, including strategy implementation, adaptive management, effectiveness monitoring and community engagement, to successfully compete in available funding programs. Through State recognition, the Collaborative would also like the State to recognize that this plan has been broadly discussed and agreed to by the Collaborative, which includes a balanced set of interests. The Collaborative is hopeful that the State will support the components of the plan and will incorporate those into its management where suitable. The Collaborative would like to see adequate agency staffing and guidance on how OWRD plans to maintain partnership with the Collaborative, an essential piece of the implementation puzzle. The Collaborative has also expressed a desire to work with OWRD during the upcoming rule-making process for the basin, which would be helpful for navigating the implementation phase.

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Appendices

Appendix A. Working Agreement

Appendix B. Working Group Reports

B.1 Ecological Working Group

B.2 Agricultural Working Group

B.3 Exempt Uses Working Group

Appendix C. Critical Groundwater Resource Issues List

Appendix D. Groundwater Strategy List

Appendix E. Implementation Framework (Decision Support Tool)