2022 LEGISLATIVE REPORT
WATER USE MEASUREMENT AND REPORTING

OREGON
WATER RESOURCES DEPARTMENT

STATE OF OREGON

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OREGON WATER RESOURCES DEPARTMENT

Executive Summary

The Oregon Water Resources Department is the primary state agency in Oregon that looks at water supply and water use at a local, basin, or multi-basin scale. Thus, the Department plays a key role in the collection and sharing of water use and availability data in Oregon. The Department's 2015 Statewide Long-Term Water Demand Forecast estimated that, approximately 85 percent of all the water *diverted* from rivers, streams and aquifers in Oregon is used for irrigation. The remaining water is divided between cities, commercial and industrial users, and associated other small users. High volume water users, such as irrigation districts and other governmental entities, are required to measure their monthly water use and report the use annually to the Department, via the Water Use Reporting database. Currently, there are about 15,000 water rights that are required to measure and report water use, making up around 17 percent of the total number of water rights in the state. The Department received water use data for approximately 12,000 water rights in 2020, meaning roughly 80 percent of those with a water-use reporting requirement submitted a water use report.

Some water rights issued since the 1990s include conditions that require the installation and maintenance of a water measurement device before water use begins. If not required at time of issuance, the condition allows the Department to require devices in the future. In other cases, water use measurement data can be required as a condition of a water right transfer, typically in anticipation of water management needs by the watermaster. This data is usually reported to the watermaster and not in the water use reporting database. In addition to data that is reported to the Department, where watermasters frequently need to regulate and distribute water, a watermaster can require the water user to install and maintain a water use measuring device. This device helps the watermaster regulate water use, resolve disputes over water use, and assist with water distribution.

Water use data is either reported to the Department or collected at the measurement device by Department staff, landowner, or partner agency. Reported data into the Water Use Reporting Database is coordinated through the Department's Water Use Reporting Program. One Water Use Reporting Program coordinator oversees and maintains the program.

Water use collected data are used and collected by a variety of Department staff. Watermasters and assistant watermasters go to points of diversions to check diversion rates frequently during regulation and distribution. At the end of the annual irrigation season, hydrogeologists and field staff collect flow meter readings from water use observation wells to quantify how much groundwater each well pumped from the aquifer system.

The Department maintains several databases that house water use data. Reported water use data for both surface water and groundwater are stored in the Water Use Reporting database. In addition, the Department measurements of pumped groundwater use are typically stored in the Groundwater Information System, or groundwater and surface water measurements may be recorded at the measurement device and used for in-season water management and regulation, depending on need and water right conditions.

The Department uses a variety of strategies to fund measurement devices across the state. The Water Measurement Cost Share Program provides 75% of the cost of purchasing and installing a water use measurement device. Stream gage installation and operation are funded primarily through General Funds. Gages are generally owned and operated by the Department or cooperators such as counties, irrigations districts, or cities. In some instances, the Department may enter cost-share contracts with federal and local partners where there is a shared interest in understanding streamflows. All water use observation wells are owned and maintained by landowners. There are agreements in place that grant access to the Department for measurement, however, some water use observation wells are dependent on granted voluntary access.

The Department also began to employ the use of remote sensing technology to measure evapotranspiration on irrigated lands to estimate consumptive use and apply it to basin studies more accurately and efficiently. This data is different and distinct from water use data measured at the point of diversion and is not an appropriate substitution for measurement data, but rather an additive tool to help the Department better understand our water resources.

Water use measurement data can help the Department protect existing water right holders, facilitate planning for future water supplies, maximize the beneficial uses for both instream and out-of-stream uses, and minimize time-consuming and costly conflicts over water use. The 2021 to 2023 biennium brought many new initiatives to the Department that require improved or expanded water use data, namely groundwater budgets and basin studies. Understanding water use is critical for these efforts as any solutions developed to address water shortages will need data to determine how best to address these management challenges. Along with these new efforts, many existing programs in the Department will greatly benefit from better and more accurate data.

This report provides a variety of recommendations for improving the collection and use of water use data, including:

- Improve Water Use Reporting Database Functionality and Public Access.
- Integrate Accurate, Transparent Statewide Water Use Summaries.
- Invest in Evapotranspiration Monitoring and Programs.
- Invest in Water Use Measurement Devices in Priority Watersheds.
- Expand Reporting Authorities to include Areas of Scientific Interest.
- Groundwater Observation Wells.
- Increase Understanding of Water Use Statewide through Investments in Field and Technical Staff.

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Chapter 1: Water Use Measurement and Reporting

Under Oregon law, all water belongs to the public. With some exceptions, cities, irrigators, businesses, and other water users must obtain a permit or other authorization from the Oregon Water Resources Department (Department) to use water. Often, water rights include conditions or requirements that help the Department manage, regulate, and understand Oregon's water resources.

The Department can require water use measurement and reporting through permits or other statutory authority. Water use data are used for a variety of purposes, including water planning, water budgets, water management and distribution, and regulation. In addition, the data can also help water users track their own water use. Understanding water use across different sectors in Oregon is critical to managing water resources and making decisions on future allocation.

The Department is the primary state agency in Oregon that looks at water supply and water use at a local, basin, or multi-basin scale, and thus the Department plays a key role in collection and sharing of water use and availability data. For the purposes of this report, it is important to distinguish between water use data collected by the Department and water use data that is reported to the Department. Water use data that is generally collected at the point of diversion by Department staff allows the Department to understand the amount of water being diverted at that moment – essential information for a watermaster distributing water. Water use data that is reported to the Department, generally provides the amount of water diverted over a period of a prior month and is typically provided at the end of the year. Water use data versus water use reported data are distinguished by the Department's authority to require reporting, where the data are stored, and the purpose or use of the data.

Reported Water Use Data (Water Use Reporting Database)

It is estimated that 85 percent of all the water diverted from rivers, streams and aquifers in Oregon is used for irrigation. The remaining water is divided between cities, commercial and industrial users, and associated other small users. Typically, high volume water users, such as irrigation districts and other governmental entities, are required to measure and report on their water use. Reported water use data that is stored in the water use reporting database are typically monthly volumes of water used and reported on an annual basis by the water right holder. Currently, there are about 15,000 water rights that are required to measure and report water use, making up about 17 percent of the total number of water rights in the state. With some exceptions, reporting is coordinated through the Department's Water Use Reporting Program. Most of the data are submitted by the water user through an online water use reporting tool (see table for more information) or paper forms. Table 1 describes the general programs or requirements that would trigger a water right holder to report water use measurement data to the Water Resources Department.

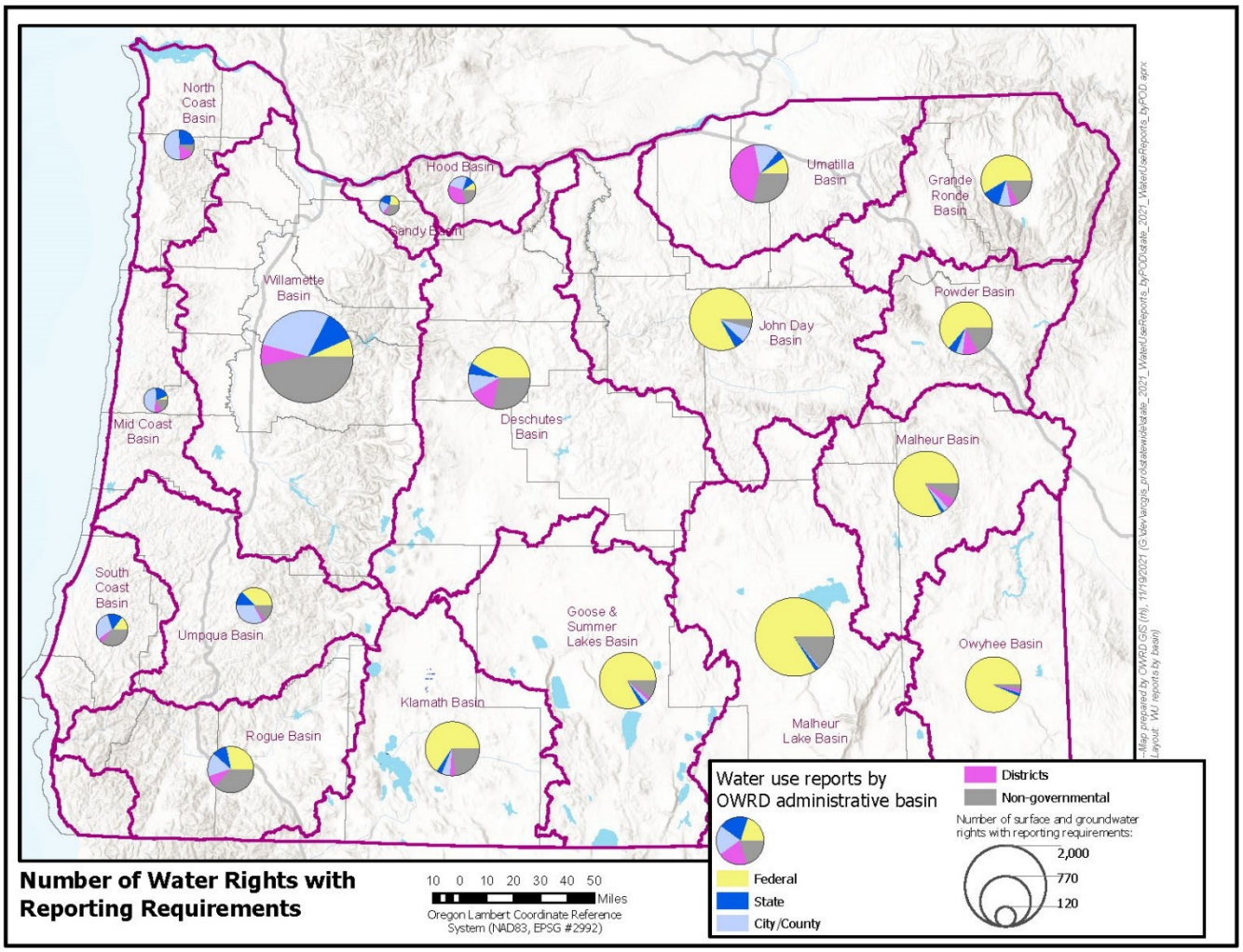
Table 1. Authorities where water use measurement data can be required to be reported to Department's Water Use Reporting database.

Program or Requirement	Description
Governmental entities *ORS 537.099* *OAR 690-085-0010*	Federal and state agencies, cities, counties, schools, irrigation districts and other special districts are required to annually report their water use. In 2020, there were an average of 756 unique governmental entities reporting water use.
Critical Groundwater Area (CGWA) *ORS 537.780*	The Department has the authority to enforce uniform standards for the scientific measurement of water levels and of groundwater flowing or withdrawn from wells. This authority is typically utilized in certain sub-areas within CGWAs. Currently, water use reporting is required for approximately 150 basalt water rights in the Butter Creek and Stage Gulch CGWAs.
Serious Water Management Problem Area (SWMPA) *ORS 540.435* *OAR 690-085-0020*	The Commission may adopt a rule to designate an area as having serious water management problems and may order any affected water right holders to submit annual water use reports. Currently, there is one SWMPA designation in the Walla Walla basin. Approximately 100 permitted basalt well users are required to report water use annually.
Water right conditions *ORS 537.153(1)* *ORS 537.211* *ORS 537.343* *ORS 537.629* *ORS 390.835* *OAR 690-320* *ORS 537.147(4)(b)*	In the early 1990s, the Department began adding water measurement and/or reporting conditions to most new water right permits, based on the amount of water proposed for diversion, storage, or withdrawal. About 3,400 water rights within the state are required to report water use solely because of this requirement (e.g., not public, no CGWA or SWMPA designation). In general, water rights authorizing small quantities include a condition stating that water measurement may be required, while larger quantities have a condition requiring a measurement device, monthly recording, and annual reporting. Measurement device requirements may also be included in a water use permit, based upon management needs. Other water right conditions that require measurement and reporting include surface water uses for human consumption needs (i.e., cooking, drinking, and sanitation) located within or above a state scenic waterway; nursery use; and use of stored water.
Water Project Grants and Loan recipients whose funded water projects divert and use water *ORS 541.692(3)* *OAR 690-93-0150(5)*	The Department makes the final determination regarding the method, timing, frequency, and location of measurement. Whenever possible and appropriate, the Department utilizes other required water use measurement and reporting to avoid duplicative effort by the grantee. This condition applies to 22 of 28 projects awarded funds to date. Projects are typically required to report monthly water use on an annual basis.

The approach used to require water use reporting has led to an uneven distribution of reported data across the state. For example, areas with a high concentration of governmental entities, such as federal projects, irrigation districts, or municipalities, may result in a higher number of water rights required to report water use, as compared to a rural area with small individual users, which often do not have reporting requirements. See Table 2, Map 1, Figure 1).

Table 2. Approximate number of water rights required to annually report water use measurement data to the Department's Water Use Reporting database, by entity.

Entity Required to Measure and Report Use	Approximate Number of Water Rights	Approximate Number of Acres (irrigation rights only)
Federal	8,050	60,160
State	1,020	2,700
City or County	1,920	121,620
Irrigation or Special District	1,260	1,855,400
Non-governmental*	3,430	634,900
* Non-governmental required to report use is 7% of total non-governmental permits statewide		



Map 1. Geographic distribution for water rights with conditions requiring the measurement and reporting of water use to the Department and the general make up of designated reporting entities by administrative basin. The size of each pie chart represents the approximate number of surface and groundwater rights with reporting requirements.

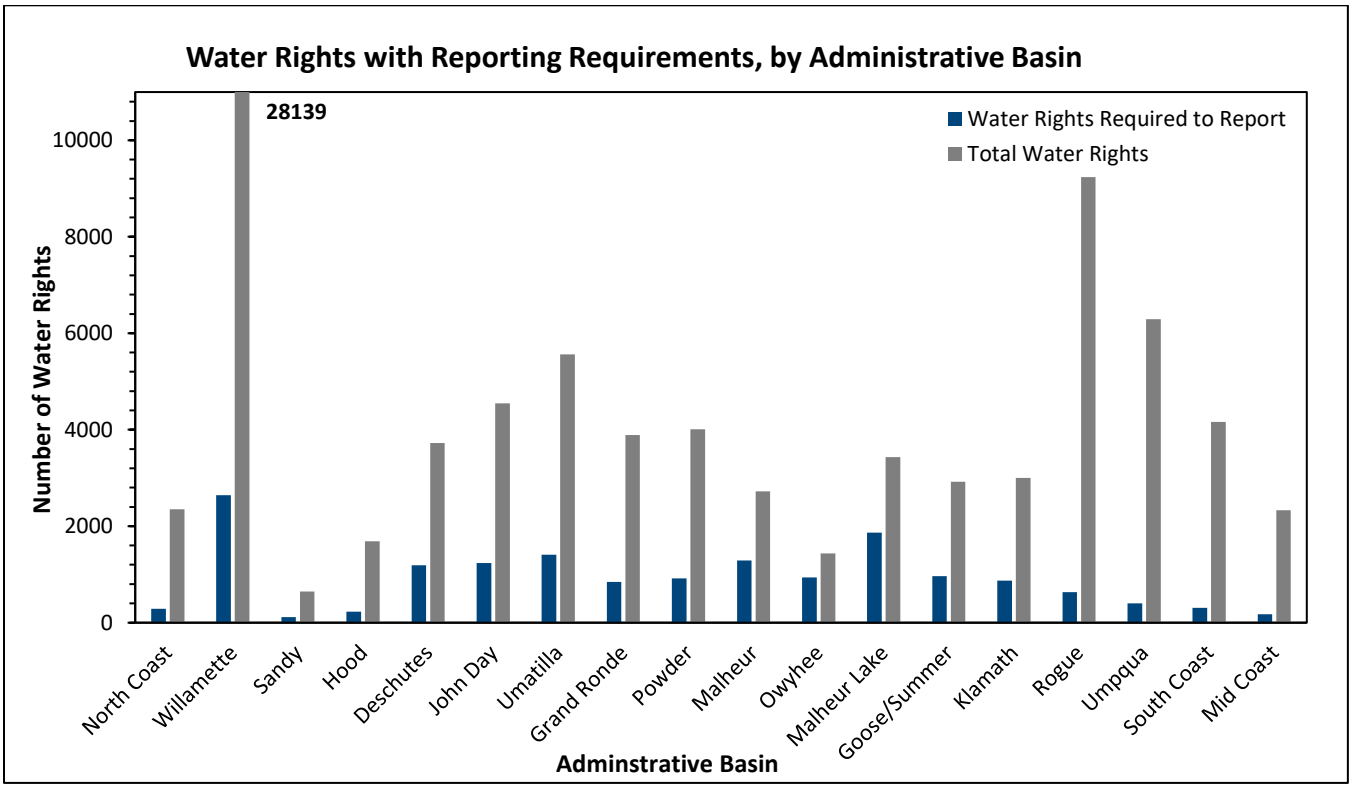


Figure 1. Water rights with water use reporting requirements, compared to total water rights, by administrative basin.

Reported Data Storage and Accessibility

The Department maintains the Water Use Reporting database, which houses reported water use data for both surface water and groundwater. The Water Use Reporting database is housed, managed, and maintained by the Department and is a platform for water users to submit their annual water use reports. Yearly, reporters submit a water use recording and reporting form (Figure 2), either electronically or via mail, for each point of diversion that requires reporting.

2020 **Water Use Recording and Reporting Form** 2021

Water Right Holder's Name	Water Right Holder's Business Name or Entity Name	User ID#
Water Right Holder's Email	Water Right Holder's Complete Mailing Address	Phone Number

Well or POD name / → Report ID number				
	Permit: - Other:	Permit: - Other:	Permit: - Other:	Permit: - Other:

Describe the units of measurement as **AF** (acre-feet), **G** (gallons), **KG** (thousand gallons), **MG** (million gallons), **CF** (cubic feet), or **MCF** (million cubic feet)

OCTOBER 2020				
NOVEMBER 2020				
DECEMBER 2020				
JANUARY 2021				
FEBRUARY 2021				
MARCH 2021				
APRIL 2021				
MAY 2021				
JUNE 2021				
JULY 2021				
AUGUST 2021				
SEPTEMBER 2021				
OCTOBER 2021				
NOVEMBER 2021				
DECEMBER 2021				
TOTAL				
Unit of Measurement (Volume)	☐G ☐AF ☐KG ☐CF ☐MG ☐MCF	☐G ☐AF ☐KG ☐CF ☐MG ☐MCF	☐G ☐AF ☐KG ☐CF ☐MG ☐MCF	☐G ☐AF ☐KG ☐CF ☐MG ☐MCF
Measurement Method (meter, staff gage, rate x time, etc.)				
Number of acres irrigated from this well or POD, if applicable				

I certify this information is true and accurate to the best of my knowledge.

Signature x _____ Date _____ Phone Number _____

Name and Title (print) _____ Company _____

WURR Form- Rev 2/17

Figure 2. Annual Water Use Recording and Reporting form

The Water Use Reporting database allows for systematic integration with other Department databases, including the Water Availability Reporting System, the Water

Right Information System, and the Groundwater Information System. The system also allows users to search for and visit their past water use reports (Figure 3) to better understand their own water use.

Entity Water Use Report

SHELLEY FLUTER
U.S. FISH AND WILDLIFE SERVICE

Records per page: 10

			Acre-feet (AF) of Water Used													
Water Year*	Report ID	Facility	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total Water Used	Irrigated Acres
2020	253	EAGLE CR NFH	1336.70	1245.82	1276.70	1469.95	1488.76	1563.61	1483.61	1516.09	1392.34	1253.34	1135.33	1088.60	16250.85	
2020	254	EAGLE CR NFH	1133.55	924.86	1005.05	1253.34	1309.18	1399.46	1354.32	1399.46	1292.94	1011.58	752.80	631.90	13468.44	
2020	255	EAGLE CR NFH	1.20	1.20	1.20	1.20	1.10	1.20	1.20	1.20	1.20	1.20	1.20	1.20	14.30	
2020	257	EAGLE CR NFH	1666.76	1497.28	1493.12	1486.78	1374.52	1491.53	1280.86	1345.81	1371.35	1449.36	1226.81	928.42	16612.60	
2020	259	EAGLE CR NFH	1.20	1.20	1.20	1.20	1.10	1.20	1.20	1.20	1.20	1.20	1.20	1.20	14.30	
2020	260	EAGLE CR NFH	1.80	1.80	1.80	1.80	1.70	1.80	1.80	1.80	1.80	1.80	1.80	1.80	21.50	
2020	497	UMATILLA NWR	0.00	0.00	0.00	0.00	0.00	25.00	26.00	71.00	73.00	37.00	44.00	13.00	289.00	
2020	498	UMATILLA NWR	0.00	0.00	0.00	0.00	0.00	0.00	12.00	34.00	66.00	108.00	118.00	51.00	389.00	
2020	501	UMATILLA NWR	41.00	0.00	0.00	0.00	0.00	62.00	62.00	132.00	150.00	175.00	175.00	115.00	912.00	
2020	502	UMATILLA NWR	6.60	0.00	0.00	0.00	0.00	25.00	27.00	66.00	87.00	101.00	58.00	58.00	428.60	

1 2 3 4 5 6 7 8 9 10 ...

*The water year is named for the calendar year in which it ends. Example: the 2014 water year begins Oct. 1, 2013 and ends Sep. 30, 2014.

Figure 3. Example results from water use report query from Department database.

Reporting Timelines

Typically, water use reported data are collected by the water right holder during the year and then reported directly to the agency at the end of the year. In general, water right holders with reporting requirements must submit their water use report annually to the Department by December 31, for the prior water year. A water year is the 12-month period from October 1 through September 30. Annual reports typically consist of monthly water use values. Data are stored in the Department's Water Use Reporting database.

Recipients of grant or loan funding from the Water Project Grants and Loans funding opportunity whose funded water projects divert and use water are required by statute to regularly report water diverted and used by the project. This requirement of the funding is included as a condition in the grant agreement. Per administrative rules, the Department makes the final determination regarding the method, timing, frequency, and location of measurement. To make the determination, the Department considers the measurement approach proposed in the application, any other ongoing measurement and reporting by the water right holder, best water use measurement practices, and other information from the grantee about the project. These data are both stored in the corresponding grant file and the Department's Water Use Reporting database if their water right requires.

Reporting Compliance

The Department received water use data reports during the year 2020 for approximately 12,000 water rights. In that water year (October 2019-September 2020), 81 percent of water users with a water-use reporting requirement submitted a report to the Department (Figure 4). Of the 19 percent that did not submit a report, approximately 28 percent were non-governmental entities, 20 percent were irrigation or special districts, and the remainder were governmental entities. Lack of compliance is often linked to a lack of equipment or staff resources to contact those not in compliance.

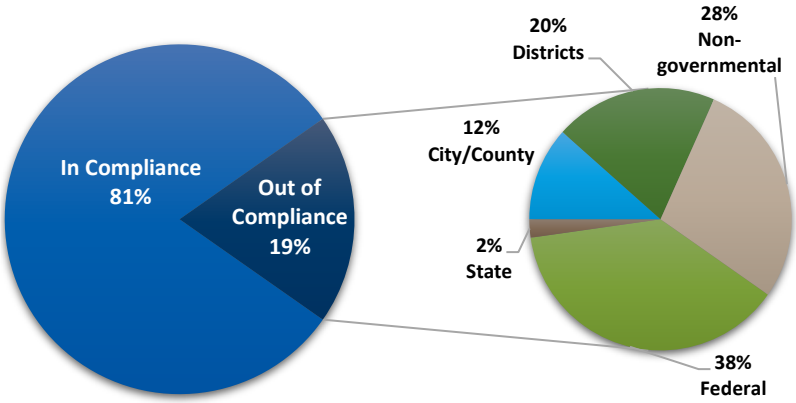


Figure 4. Compliance rates for water rights required to report water use, by reporting entity.

Many water right holders have multiple PODs on a single water right. Water use reports are submitted based on the POD on the water right. For the purposes of this report, compliance is defined as at least one report within the year for at least one point of diversion/point of appropriation/reservoir for each reporting entity; this is consistent with the calculations used for reporting on key performance measures. For this reason, calculated compliance numbers may be higher than actual compliance.

Water Use Reporting Staff

Department staff is necessary to ensure timely intake and processing of data and that water right holders are demonstrating compliance with permit conditions, providing an annual check-in with water users to maintain good quality data collection, and providing up-to-date information for basin investigations. The Department has funding for one position (Water Use Reporting Program coordinator) to oversee and maintain the Water Use Reporting program. This is the only position responsible for assisting water right holders with submission of data and maintaining information in the water use reporting database. There is some support from an additional position in the Surface Water Section. Both positions are funded by the General Fund. Staff in the Information Services section are responsible for the development and maintenance of the database structure. There are other sections of the Department that support the integration of water use measurement and reported data into other processes and databases.

Water use reporting program staff conduct annual outreach, provide customer support to those reporting their water use, and ensure consistent collection of data; these efforts are imperative to compliance with reporting requirements. During 2007, the Department had no Water Use Reporting Coordinator because of budget constraints and received 20 percent of the required reports. In 2008, the Program Coordinator position was re-authorized and raised reporting results to 65 percent. In 2020, the compliance rate was 80 percent.

The program coordinator also provides in-house technical expertise to better serve customers and ensure minimum quality control and quality assurance measures. The position identifies potential data entry errors based on knowledge of local water conditions and provides support for water users in understanding their measurement devices, the measurement data, and the connection of that data to their water rights and their requirements.

Other Water Use Data – (Not included in Water Use Reporting Database)

For water users not subject to measuring and reporting requirements as a condition of their water right (see Reported Water Use Data), measurement and collection of water use data can still be required. Many water rights issued since the 1990s require the installation and maintenance of a water measurement device. To help landowners navigate this process, watermaster staff will often work with water users to select the correct measurement device, identify the best location to install the device, assist with the cost-share program, and discuss access to the measuring device for future visits.

In areas where watermasters frequently need to regulate and distribute water, a watermaster can require the water user to install and maintain a water use measuring device (ORS 540.310). Watermasters can require measurement as a tool to help regulate water use, resolve disputes over water use, and assist with water distribution. Depending on the device or water right requirement, data may or may not include a record of the volume of water diverted. The information is typically accessed by staff at the measuring device, as opposed to transmitting diversion data to the Department; this means that staff time and resources are needed to access and utilize the data.

In some cases, water use collected data can be required as a condition of a water right transfer. Typically, if measurement is conditioned on a water right permit or transfer, the condition is made in anticipation of water management needs by the watermaster, to prevent injury or enlargement, or where regulation and distribution commonly occur.

In some cases, water users may be required to provide the water use data to a watermaster. This requirement, unlike water rights required to report to the Water Use Reporting database, is applied on an individual basis.

In reviewing the table below, it is worth noting that water measurement is a tool to provide the Department with the ability to allow the water right holder to change their use of the right while preventing injury to other water right holders due to the change. As such, water use data can be an important tool for innovative water management approaches and fully appropriated systems.

Table 3. Programs or requirements where measurement device installation and water use data collection can be required.

Program or Requirement	Description
Limited licenses *ORS 537.143(3)*	The record of water use shall include an estimate of the amount of water used, the period of use and the categories of beneficial use to which the water is applied. During the period of the limited license, the record of use shall be available for review by the Department, upon request.
Water Right Transfers and Groundwater Registration Modifications *ORS 540.530* *OAR 690-380-4010(3)(b) & -5000(1)* *ORS 537.610(4)* *OAR 690-382-0700(2) & (3)*	Water right transfers, including groundwater registration modifications, may be conditioned to require water use measurement and annual, or more frequent, reporting to the watermaster to prevent enlargement of the transferred right and injury to other existing rights. Reporting may be required in some cases.
Allocations of Conserved Water *ORS 537.470* *OAR 690-018-0050(4)*	Allocations of conserved water can be conditioned to require water use measurement and annual reporting to the watermaster in order to ensure the conserved water will result in a reduced diversion for the uses allowed under the original water right and will not result in harm to other existing rights.

Purchased, leased, or gifted water rights for conversion to in-stream water rights *ORS 537.348(3)(b)* *OAR 690-077-0079(3) & (4)*	A lease of all or a portion of an existing water right for use as an instream water right may allow the split use of the water between the existing water right and the instream water right, provided the holder of the water right measures and reports water use, as prescribed by the local watermaster, to the Department in order to prevent enlargement of the water right involved and injury to other existing rights.
Water Distribution and Management *ORS 540.310*	In areas where watermasters frequently need to regulate and distribute water, a watermaster can require the water user to install and maintain a water use measuring device. The information is typically accessed by staff at the measuring device, as opposed to transmitting diversion data to the Department.
Significant Points of Diversion *ORS 540.310(2)*	Watermasters work with water users to install measurement devices on significant diversions, which are in watersheds with streamflow restoration needs. The measurement device provides the water user with information about how much is being diverted, and whether they are diverting more or less than allowed by the water right. In some cases, the Department does not check the device once installed; in other instances, it is used by the watermaster for water distribution and management.

Data Collection, Storage, and Accessibility

Conditional Reporting: Transfer or Watermaster

In cases when either a watermaster or transfer imposes conditions for reporting, a water right holder may be required to install measurement devices and report their water use on a designated schedule or upon request by the Department. Some water rights and short-term authorizations require annual, or more frequent, water use diversion and/or measurement reporting to a local watermaster. In the case of a water right transfer, conditions requiring water use measurement and reporting are necessary in order to ensure that water use under the transfer does not exceed authorized quantities of water use under the right (i.e., does not result in enlargement of the right) nor injure other existing water rights.

These data are typically collected and stored with the watermaster and are not submitted to the Department's Water Use Reporting database. These data are typically not stored in a manner that is accessible by other staff or the public and therefore its utility is primarily for the watermaster. In the case of a water right transfer, conditions requiring water use measurement and reporting are necessary in order to ensure that water use under the transfer does not exceed authorized quantities of water use under the right (i.e., does not result in enlargement of the right) nor injure other existing water rights.

Water management needs in some basins require more frequent measurement that is either collected by or reported to a watermaster. As an example, management of stored water releases from McKay Reservoir in Umatilla County utilize a detailed accounting system to track releases, diversions, and ending storage balances, all of which are shared with local irrigation districts and the U.S. Bureau of Reclamation. This system is highly staff intensive, requiring staff time and resources to implement, as staff must go to each point of diversion every month during the irrigation season to read each the meter.

Department Data Collection

When reporting is not required of the water right holder, Department field and technical staff are the primary data collectors of water use data. The reasons for collecting this water use data vary widely, and range from an immediate, short-term use of a measuring device during regulation season to verify compliance with the water right and distribution/regulation, all the way to devices for capturing long-term baseline data for tracking water

use, groundwater level, or stream discharge trends over years or decades. Technical and field staff measure and collect, often at the point of diversion or appropriation, groundwater and surface water diversion rate and volume data (water use data), reservoir stage and storage volume data, and stream discharge data (commonly called streamflow data).

Regulation

Watermasters and assistant watermasters check water measurement devices to determine diversion rates frequently during regulation and distribution, and when checking for compliance with water right conditions. Watermasters visit measurement devices for the purposes of regulation, taking readings of water use at the meter/flume/weir for surface water or meter for groundwater (see Measurement Devices and Methodology) and will regulate accordingly (adjust diversion rate or regulate water off) in accordance with the water rights of records and the prior appropriation system.

The presence of accurate measuring devices allows watermaster staff to drive to a location and then quickly (usually within several minutes) and accurately check diversion rates, adjust as needed, and move on to the next point of diversion. Without a measuring device, staff are left to calculate a number of factors to estimate the diversion rate for pumped systems, or conduct an open channel measurement for ditch diversions, both of which take time (up to an hour) and are less accurate. These data are used for real-time regulation, however, this instantaneous diversion rate data is seldom recorded or stored in a centralized database for use by other staff within the agency.

Building Long-term Datasets

For larger diversions, gaging stations are often needed to collect information on the amount of water diverted. Measurements of canals or other diversion structures are critical to the distribution of surface water in real-time as well as for gaining a long-term understanding of the amount of water used within a distribution system for basin studies and analysis of water availability. Many of the Department's gages (on canals or streams) are operated using telemetry and transmit data to the Department once every hour, and these data are processed, quality checked, and saved within the Department's stream gage database.

Operating the Department's gaging network for canals or streams requires trained hydrographic technicians to keep the equipment operating properly, to conduct regular measurements at various gages, and to input the collected information into a central database. Hydrographics staff review the data, make corrections based on field conditions, including the hydraulics of the channel and past measurement patterns, and finalize the records to meet computation standards established by the USGS. As such, gaging stations are another staff intensive approach for collecting data.

Similarly, for groundwater, both hydrogeologists in the Groundwater Section and field staff collect flow meter readings (pumpage data) from approximately 1,000 privately owned water use observation wells. Groundwater use data are entered into the Groundwater Information System and then analyzed with groundwater level data from the aquifer system to help quantify aquifer response from the developed groundwater uses, and can also inform annual allocations where there is a critical groundwater area.

Measurements taken for critical groundwater areas and basins being actively studied are typically made annually, while measurements to quantify seasonally how much groundwater was pumped from the aquifer system by each well may be made every quarter. Measuring pumpage data takes less than five minutes to

complete, once staff are at the well site. Travel between sites can take multiple hours and often requires overnight travel for wells in rural parts of the state. To make effective use of time and resources, pumpage data are gathered with groundwater level data when both can be measured at the same well (see Chapter 2: Using Other Measurement Data to Understand Water Use). While collecting water use data from wells can be staff intensive, the accuracy of the data is often better that reported data as staff are trained in how to read various types of meters.

Use of Water Use Data

Water use measurement data typically fall into one of two groups; 1) data reported and stored in the water use reporting database and 2) other collected water use data. The information below presents a high-level description of how the reported water use data are used as well as some examples of how collected data are used by the Department. It is also important to specify the unique differences between the data:

1) Reported: monthly water use data reported by the water user/water right holder to the Department's Water Use Reporting database on an annual basis; and
2) Collected: water use collected data, where water use measurement is required, but data is collected by Department staff, in partnership with other entities, or a water user/right holder. Reporting requirements if they exist, including frequency and units of measurement, under this category are typically established on an individual basis and are not stored in the Water Use Reporting database.

Water use data can help the Department protect existing water right holders, facilitate planning for future water supplies, maximize the beneficial uses for both instream and out-of-stream uses, and minimize time-consuming and costly conflicts over water use. It is important to note that the data characteristics largely influences how it can be used. Below are examples of how water use data can be used to support our understanding and management of water resources.

Understanding Water Resources

Water use data can be utilized in basin groundwater studies to assist with characterizing the groundwater model input data which supports long-term management of aquifers, including critical groundwater areas. Additionally, water use data can be used to help refine the Department's surface water availability model, a tool used for evaluating new water right applications.

Planning for the future

Water use data can be used to help inform water supply needs/demands on both groundwater and surface water sources, a key data need for water planning efforts at the individual, community, and basin scale. Water use data is needed to develop 20-year demand projections for a municipality's or district's Water Management and Conservation Plan.

Water Management & Distribution

Real-time water use measurement information aids watermasters in efficiently distributing and regulating water use for the protection of senior water rights, resolving disputes among water users, and ensuring use is within the limits of the water right.

Review of Water Right Transactions

Water use measurement data provides evidence of use for water right permit holders to prove up and obtain a water right certificate, or for purposes of a water right transfer, to demonstrate that a water right has been beneficially used within the past five years. Historical water use data supports injury determinations for water right transfers, permit amendments, exchanges, and voluntary instream leases. Water use data for water use efficiency projects and conservation projects can help demonstrate or support an entity's progress in reducing its water demands through implementation of conservation benchmarks.

Management by Water Users

For water users, water use data increases awareness of the amount of water they use and provides a basis for self-regulation. Water use data also help water users identify system inefficiencies, track stored water, reduce power costs, measure conservation benefits, develop improvements in their business operations, and plan for future needs. In addition, water use data provide evidence for a water right holder to prove up on a water right, rebut allegations of forfeiture for non-use, or demonstrate the validity of water rights to potential buyers.

Table 4. Description of how water use reported, and water use collected data are used by the Department.

Data Category	Program Area or Requirement	How are the Data Used?
Reported Data in Water Use Reporting Database	Required reporting for government entities Reported data from SWMPA and CGWA Reporting from conditions of a permit or certificate Reported as a requirement for funding from Water Supply Development Account 	• Water Management and Conservation Plan (WMCP) Review and Oversight of Development Limits: Water use reported data are used to validate data in WMCP to ensure that the numbers reported in the WMCP match what is being reported. Discrepancies may help Department staff identify when permit diversion rates or development limitation rates are being exceeded by the permit holder. • Evaluation of past water use and water demand: Inform evaluation of 20-year water supply planning projections and requests made in a WMCP to access remaining quantities of water allowed under an extended water use permit upon which development limitation conditions are imposed. • District Water Management Flexibility: (ORS 540.570) Irrigation District Pilot Project allows districts and the Department to demonstrate compliance with statutory requirement to have a full and accurate measurement of the water diverted. • Place-Based Planning: Used to develop non-irrigation estimates of water use at different spatial scales to develop water budgets and discover when there is water available or when there are deficits in certain months. It is also used to verify/validate assumptions made to develop estimates of water used by irrigated agriculture within the planning areas. The municipal water use data reported to the Department have proven helpful for planning purposes. The lack of water use measurement on many irrigation diversions and industrial uses has created the need to make broad assumptions about actual use, and therefore, reduced the accuracy of water budget calculations. There is generally not sufficient water use reported by agricultural producers to rely on it exclusively. • Water Availability Reporting System: Municipal data were used as an input in development of the model. Limited agricultural data were used due to the limited amount of data. More data are now available, and the Department intends to use the data as much as possible when the water availability model is updated in the future. • Proving up on Water Rights: If a permit/transfer required water use reporting, staff check reporting data. • Willamette Reservoir Reallocation Study: Reported agricultural water use data were one of the approaches explored to estimate demand. Agricultural reported water use data were not selected as the preferred method due to too few diversions being required to report, resulting in an insufficient sample size. • Groundwater and Basin Studies: Harney Basin Groundwater Study and Deschutes, Klamath, and Willamette Groundwater Studies and Models used reported data as part of the data to develop simulations of pumping for flow models.

		• Informs water user on their personal water use. • USGS Water Use Census: Reported state water use data are used in USGS reports. These are shared with other collaborative organizations (e.g. Western States Water Council). • Groundwater Complaints: Reported data are referenced during investigations of groundwater interference complaints.
Collected Data [See also Reported Data in Water Use Reporting Database above for additional uses]	Critical Groundwater Area (CGWA) 	• Sustainable yield estimations: Basis to compare variation in annual use to annual changes in spring static water levels, thereby allowing estimates of sustainable yield. • Annual allocations to water rights up to the sustainable annual yield.
Collected Data [See also Reported Data in Water Use Reporting Database above for additional uses]	Serious Water Management Problem Area (SWMPA) 	• Cooperative Basin Study: Define basin water budget and calibrate numerical flow models of the Walla Walla groundwater system. • Sustainable yield estimations: Compare amounts of groundwater pumped from the aquifer each year to water level changes in the aquifer, to estimate how much groundwater can be pumped annually without causing groundwater level declines.
Collected Data	Water Right Transactions and Permit Conditions/Watermaster requested 	• Verify Use for Processing Transfers, Leases, and Other Transactions: Data is sometimes used by staff to help verify water use within the past 5 years; it is not always necessary if other supporting documentation clearly demonstrates that water was used within that timeframe, such as dated aerial photographs. • Monitoring Drought Permits: The data is used to monitor groundwater appropriation under emergency drought permits, primarily in the Klamath Basin. • Permit/Transfers Conditions: When a watermaster requests a measurement condition, the condition is made in anticipation of a water management need either to prevent injury or enlargement or due to a system being fully appropriated.
Collected Data	Water Management in the Field: Watermaster Required Measurement 	• Management: Required by the watermaster to resolve disputes over water use; ensure a right is being used within the terms and conditions of the water right; to assist with water distribution, particularly in basins fully appropriated/insufficient supply for all users; to determine if unauthorized use is occurring. • Groundwater Complaints: Data are referenced during investigations of groundwater interference complaints.
Collected Data	Significant Points of Diversion 	• Provides water user with information about how much water is diverted. • In some cases, the Department does not check device once installed; in other instances, it is used by the watermaster for water distribution and management. Whether watermaster returns to the device and uses the data is dependent on whether it meets one of the criteria in the Water Measurement Devices Required by Watermaster for Management above.

Water Use Data Collection Methods and Financing

Measurement Devices and Methodology

This section describes the variety of measurement devices used to quantify water use across the state. Various types of meters and devices can be used to collect water use data. All measurement devices described here can be used to collect information about how much water is used and/or stored, though exactly what is measured and over what time periods varies widely. The devices vary by use, the quality of the data, difficulty of collecting the data, and the cost to the Department or water user associated with maintaining and collecting data from the device. See Table 6 for more information.

Totalizing flow meters

A flow meter is used to measure the flow rate or quantity of a liquid (water) flowing through a pipe. A totalizing flow meter provides the *total volume and instantaneous flow rate*. Flow meter sensors work in different ways, but with the same end goal: provide the most accurate and repeatable flow measurements for a specific application. Flow meters are typically used on wells and piped surface water diversions. The unit of measurement –acre feet, gallons, cubic feet – varies by meter.

The meters are typically read in person though there are options available to use telemetry to have the readings sent to a computer via cell, radio, or satellite. The cost of operations includes the meter, installation, and periodic calibration, maintenance, and upkeep. There are different types of flow meters – common types include mechanical (e.g., propeller) and magnetic (Figures 5 and 6).

The most common and economical type of water flow meter are the mechanical types, which measure flow through turbine rotation with a propeller, shunt, or paddle wheel design. These mechanical water flow meters work by measuring the speed of flowing water running through the pipe that causes a turbine or piston to rotate. The downside with mechanical water flow meters for water measurement is that they may clog up when the water is dirty or has larger particles. Fixing these increases maintenance costs. Mechanical water meters also don't work well with a low flow of water or in unpressurized pipes.

Figure 5. Propeller flow meter. (Credit: McCrometer Inc.)

Figure 6. Magnetic flow meter. (Credit: McCrometer Inc.)

Canal or stream gages with data loggers

A typical stream gage uses a data logger and a pressure transducer, float tape or radar to measure the canal or stream's water level at a fixed frequency, usually every 5 to 15 minutes. The recorded water level is then converted into a flow reading based on a rating curve, which is a simple model relating

water level to flow. This model is developed from manual discharge measurements made at various water-level readings.

For most streams and some canals, the relationship between water level and flow rate changes with time due to erosion or deposition of sediment and debris. To account for the changing relationship, flow, and water level must be checked manually every 4-6 weeks using a velocity meter. Gages are used to quantify water use by either directly monitoring a canal or creek that acts as the major diversion from a larger stream, or by monitoring flows directly upstream and downstream of a major diversion, and subtracting the values to compute the diverted rate and volume for a single diversion. In most cases, gages are not an affordable substitute for water use measurement devices and data quantifying individual diversions. In some cases, a flume or weir is installed so the rating remains relatively constant with time, though these sites still require visits to ensure the devices are operating as designed. As noted previously, gages typically require field staff to maintain and hydrographics staff in Salem to process the record.

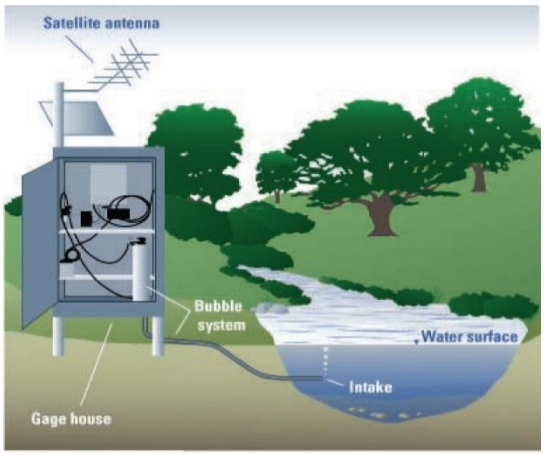


Figure 7. Diagram showing a stream gage installation with a bubbler system used to measure stream stage. (Credit: L.S. Coplin, USGS)

Figure 7 is a diagram of a typical stream gage. The gage house contains a logger and a type of pressure transducer commonly referred to as a "bubbler system" because of the slow train of bubbles it releases into the stream as it monitors changes to the water level. A solar panel provides supplemental power. A satellite antenna allows data to be transmitted from the site and shared on a near real-time basis.

Staff plates on weirs and flumes

Flumes and weirs are open-channel flow metering devices that are designed to measure the volumetric flow rate of surface water in a stream or canal. A Parshall flume is a common example of one such device (Figure 8). With knowledge of the flume's geometry and proper installation at the correct slope, a reading of the water depth at the upstream end of the flume can be converted to a flow rate using a standard table or equation. To verify that the flow rates determined from a flume or weir are accurate, discharge measurements should be made periodically using a velocity meter. Weirs or flumes do not record and store data unless a transducer and data logger are installed. Weirs and flumes are generally a less expensive way to be able to tell whether a diversion is diverting the rate of water allowed under the water right; however, it does require the water user or Department to physically visit the device.

Figure 8. Parshall flume with staff plate. (Credit: Azcom Inc.)

Staff plates and/or stage gage and elevation-capacity curves

Figure 9. Staff plates in a reservoir. (Credit: National Weather Service)

Staff plates are large rulers fixed in stable locations in a water body to measure water level. Water level data is collected by someone reading the staff plate and recording the value. The most common way to measure the volume of water in a reservoir or pond is with the use of a staff plate and a capacity curve table to understand the water level and relationship of that to the volume of the reservoir (Figure 9). The capacity curve is made by computing the volume of water in the reservoir at incremental water heights (e.g. every 0.1 feet). The capacity curve table must be specific for the reservoir/pond; it is correlated to the staff plate. If more frequent water level data is required, a stage gage - similar to a stream gage, but placed in a reservoir instead of a stream, can be used to record hourly water level data. For large reservoirs or lakes, this information is gathered through elevation and bathymetric surveys of the reservoir or lake. The staff gage must be read in person. Reading the staff plate and correlating it to the storage capacity table provides the instantaneous storage (typically in acre-feet). There is the cost of the staff plate and installing it and a cost to create the capacity curve table; this cost will vary depending on the size and intricacy of the reservoir. Staff costs are incurred to visit the plate to take a reading.

More in depth information on each device can be found below in Table 6.

Table 5. Commonly used water use measurement devices, appropriate applications, accuracy (USGS guidelines (Excellent (<5%), Good (<10%), Fair (<15%), Poor (>15%)), frequency of data and collection, technical expertise required to collect data, and costs associated with each device.

Device Characteristics	Totalizing flow meters#	Canal or stream gages, weirs, and flumes, with data loggers	Staff plates on weirs and flumes, w/o data loggers	Stage gage and elevation-capacity curve with data logger	Staff plate and elevation-capacity curve w/o data logger
Type of Data Collected	Cumulative total volume of water used and instantaneous flow (acre-feet, gallons, or cubic feet; data collected only with visual inspection; unit of flow varies, (e.g.: acre-feet, gallons, or cubic feet.)	Mean daily flow (cubic feet per second; data collected every 15 min, 24 hrs/day); provides data for computing the total volume of water used and variability in use over time.	Instantaneous flow (cubic feet per second; data collected only with visual inspection); provides flow at the time the staff plate is read.	Mean daily volume (acre-feet; data collected every 15 min, 24 hrs/day); provides data for computing the total volume of water used and variability in storage over time.	Instantaneous storage (acre-feet; data collected only with visual inspection); provides volume at the time the staff plate is read, if an elevation capacity curve exists.
Appropriate Use	Pipes for surface water or wells	Open channels, e.g. ditches and streams	Open channels, e.g. ditches and streams	Reservoirs or Ponds	Reservoirs or Ponds
Accuracy of Device*	Poor to Excellent	Poor to Excellent	Poor to Excellent	Poor to Fair	Poor to Fair
Data Collection Methodology	Devices are read in person; remote telemetry is available with additional resources.	Often data are telemetered via satellite, radio, or cell phone to a database, but data can also be	Devices are read in person; no electronic data collection.	Often data are telemetered via satellite, radio, or cell phone to a database, but data can also be	Devices are read in person, no electronic data collection.

		downloaded from the gage.		downloaded from the gage.	
Specialized Equipment Cost (range)	$150 - $20,000 (depends on size and type); average range $1,000-$3,000 this does not include installation costs	$5,000 - $20,000 (depends on standards and telemetry; includes gage and velocity meter)	$5,000 - $10,000 (depends on size and installation; includes staff plate and velocity meter)	$1,000 - $20,000 (survey of reservoir $100 – $10,000)	$10 - $10,000 (survey of reservoir $100 – $10,000)
Maintenance to ensure continued accuracy of data collected	Requires monthly visits to read the meter, to verify it is functioning and not leaking. Calibration per the manufacture's requirements or Ultrasonic calibration check. NIST calibration for flowmeters ($6k). Can require parts maintenance and/or replacement $500-$2,000 as needed.	Requires visits every 6 weeks to measure streamflow to maintain data quality. Calibration checks on gage equipment performed at each visit, velocity meter calibrated annually. Annual survey of elevation of staff plate to maintain rating curve.	Requires maintenance every 6 weeks to measure streamflow to maintain data quality. Velocity meter calibrated annually. Annual survey of elevation of staff plate to maintain rating curve.	Calibration checks on gage equipment performed at each visit (6-8 times a year). Annual survey of elevation of staff plate to maintain rating curve. For reservoirs and ponds, a new survey may need to be run periodically due to deposition of sediment.	Visits to read staff plate monthly or as water is spilled. Annual survey of elevation of staff plate to maintain rating curve. For reservoirs and ponds, a new survey may need to be run periodically due to deposition of sediment.

[#] some totalizing flow meters now come with data loggers and transmitters and can record information about rate of use (volume per 15 minutes)

**assuming devices are properly calibrated, installed, and maintained and associated field work is collected*

There are several ways to estimate water use when measurements are unavailable. **While estimating water use is often simple, the resulting estimations are typically poor in quality** due to necessary estimation assumptions (e.g. system inefficiencies, power used to pump water). An example of a common type of estimating method is the use of a power meter to estimate monthly water use. This requires monthly readings of power meters, estimates of hours pumped during a month, and an understanding or assumption of the application rates of irrigation systems.

Additionally, remotely sensed evapotranspiration (ET) measurement methods can be used to quantify consumptive use from irrigated crops and fields. Consumptive use is less than the amount of water diverted and is the amount of water lost from the system by the use. Consumptive use is important for developing water budgets; however, it is less useful for water distribution. Water rights are issued based on the amount of water that can be diverted, not based on consumptive use. Consumptive use cannot be used to directly measure how much water was diverted, and therefore, cannot be used to meet permit condition requirements for reporting water use, though many researchers and interest groups are working on developing reliable means for estimating diversion rates from remotely sensed ET data (see Remotely Sensed Evapotranspiration).

Measurement Device Financing

Water Use Measurement Cost-Share Fund

The Department's Water Measurement Cost Share Program (see ORS 536.021) provides resources to offset the cost of voluntary installation of water use measurement devices. Funding can be used for new, replacement, or repaired water use measurement devices. The fund reimburses up to 75% of the cost of purchasing and installing a water use measurement device. Devices purchased include totalizing

flow meters, weirs, flumes, staff plates, pressure transducers and data loggers. Watermasters coordinate with landowners and assist them with a simple application form and help determine the most appropriate type of measuring device for a given point of diversion or well. Staff may spend 2-4 hours assisting with the process for a simple installation; whereas more difficult diversions to measure can take significantly more time to plan and install. In the case of weirs or flumes, staff may assist with the installation to ensure specifications are met.

The cost-share fund may also support installation of the measuring devices for the Significant Point of Diversion (SIGPOD) program. In 2000, the Water Resources Commission developed a strategic measurement plan focused on diversions of surface water with the greatest impact on streamflows in areas with the greatest needs for fish. A statewide inventory was conducted, helping to identify approximately 2,300 "significant diversions" within nearly 300 high priority watersheds across the state. Staff have installed 1,109 measuring devices on significant points of diversion in basins across Oregon. Many of the devices installed have benefitted from the cost share program to reduce costs to the water users.

Funding is not available if a measuring device is required as part of the water right permit conditions, or if the Department issues a measuring device order - a last step if the water user does not voluntarily comply with a request to install a measuring device.

Canal and Stream Gages

Gage installation and operation for the Department is funded primarily through General Funds with gages generally owned and operated by the Department or cooperators such as counties, irrigation districts, or cities. The Department often enters cost-share contracts with federal and local partners for gage installation and operation in areas where there is a shared interest in understanding canals or streamflows. The cost for a standard gage is significant – approximately $16,000 per year to operate each gage and $22,000 to install; gages on average are replaced once every 10 years. This cost includes operation of stream gages up to USGS standards, involves 12-16 visits per year (each 2-4 hours including drive time) to make measurements of streamflow and maintain the equipment, process streamflow data, develop and maintain rating curves, and publish data when required. Most of the stream gages operated by the Department do not quantify water use, but instead capture streamflow conditions to inform in-season distribution decisions or studies of water supply or other basin investigations. For a discussion of the use of gages for streamflow, see Chapter 2: Using Other Measurement Data to Understand Water Use.

Water Use Observation Wells

All *water use* observation wells are owned and maintained by landowners. Most water use observation wells are pumped under groundwater rights that require the holder to grant access to the Department for measurement. However, some water use observation wells are dependent on voluntary access granted by a person or entity in cooperation with the Department. Maintenance of water use observation wells and the associated measurement hardware is the responsibility of each well owner, and when it is neglected, wells may become inaccessible for water level measurement. A significant amount of technical staff time is spent diagnosing these issues and working with well owners to address them. Additionally, the cost of this work is increased when water right holders do not properly maintain a water use observation well. The Department also maintains a network of *water level* observation wells that is discussed in Chapter 2: Using Other Measurement Data to Understand Water Use.

Water Project Grants and Loans (Water Supply Development Account)

The Water Project Grants and Loans Program provides funding for projects that help Oregon meet its instream and out-of-stream water supply needs and produce economic, environmental, and social/cultural benefits. This competitive funding opportunity is meant for implementation-ready projects. Grants and loans are offered on an annual basis, with the applications due each spring. If necessary, for the implementation of a funded project, water use measurement devices can be purchased as part of grants awarded through the Water Project Grants and Loans funding opportunity. While water use measurement devices are allowable or eligible costs for this funding opportunity, one cannot solely apply for funds to purchase a measurement device.

Remotely Sensed Evapotranspiration

The use of evapotranspiration (ET) data developed from satellite imagery is an emerging measurement tool that to determine the location, timing, and quantity of irrigation water use. Evapotranspiration is water that transpires from the leaves of plants and evaporates from soil and plant surfaces. ET data can show the amount of water consumed by irrigated agriculture and by other lands.

In irrigated agriculture, water is diverted from the source (measured by meters, flumes, weirs, gaging stations), delivered to the field (water loss can occur during conveyance via evaporation or seepage into the ground or nearby stream), then applied to the field (additional on-farm water loss may also occur due to irrigation inefficiencies), and crop ET consumes the remaining portion lost from the system to the atmosphere (Figure 10). The ET portion is measured by remote sensing.

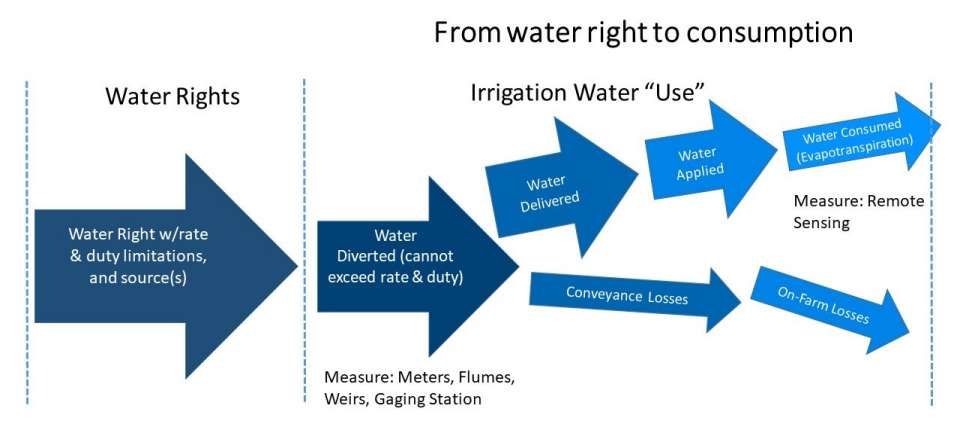


Figure 10. Difference between water rights duty/rate, diverted water, and consumptive use evapotranspiration measurements of water use.

Unlike measuring devices that measure the amount of water diverted, satellite-based remote sensing of ET provides a mechanism to measure the portion of the diverted water that is consumed via evapotranspiration on irrigated croplands over large areas and time periods, with the ability to quantify consumptive use for a particular place of use. Satellite imagery captures field conditions and spatial and temporal variability in crop growth, stress, management, and ET.

How does remotely sensed evapotranspiration data relate to water use data?

Many water resource studies involve understanding how changes in water use over time and space impacts the resource. Direct estimates of past water use for irrigation, such as metered pumpage data from groundwater wells and gaged or metered diversions from surface water sources, are typically

limited or non-existent and thus, may need to be estimated indirectly. For fields that don't have measuring devices, ET data can help estimate water consumption. Where available, satellite-based ET data can be used to calculate and estimate field-scale crop water use estimates; this requires some calibration and ground truthing with the aid of some actual measured water use data and local weather stations, such as AgriMet stations. If properly calibrated and calculated, satellite-based ET can be used to calculate the amount of water diverted, by comparing measured water use data to the satellite-based ET data, which can be used to extrapolate diverted water use across a basin for time periods and fields where measured water use records do not exist. Satellite-based ET methods are a cost-effective approach for estimating past consumptive use and application rates at the basin-scale over long time periods of time. It can also be used to quantify crop water use for the previous several months or irrigation season, which can inform efforts for irrigators and water managers to track water use. With latency times of typically 1-3 months to process the ET data, however, this data is not intended for real-time management, which require data for the recent day or week.

Measuring all diversions in Oregon is not practical or feasible. In applications like basin studies and water budgets, the remotely sensed ET data can be used to quantify consumptive uses. For remotely sensed ET data, such as OpenET, to be used as an acceptable estimation method for reporting water use, the Department would need to update its rules (OAR 690-085-0015) and complete additional work to test the OpenET data for Oregon, including developing and applying adequate ground-truthing approaches.

OWRD has begun to employ the use of remote sensing technology (which more accurately and efficiently estimates crop ET and irrigated acres) to improve estimates of water diverted and consumed and apply it to basin studies. Field-scale ET data can be available for a continuous record back to 1984 providing a long-term historical record of consumptive water use for irrigated fields at a scale not possible from site-specific water use measurements. This long-term dataset of spatially distributed consumptive water use data is required to develop robust, transient water budgets and inform groundwater models used for future management and planning. This leads to an understanding of the linkages between water use/pumping amounts and groundwater levels and the groundwater-surface water interactions over time. This data is different and distinct from water use data measured at the point of diversion.

The Department has been partnering with OpenET for this data. The OpenET public launch occurred in October 2021, and field scale ET data is now available for the last six years (2016-2021) across Oregon and the entire western US. Department surface water staff currently have a contract with the Desert Research Institute to develop and use agricultural field boundaries and OpenET data to support the Oregon Irrigation Consumptive Use Project (Statewide ET).

Limitations of Open Evapotranspiration

Accurately measured and reported water use measurements (e.g., meters) from irrigation water rights are necessary in order to ground-truth remotely sensed evapotranspiration data, such as OpenET, and confidently estimate basin-scale groundwater pumpage or surface water diversion volumes using OpenET data. In addition, data from OpenET is not immediate (there is a delay in processing the data by about a month) and does not distinguish if the ET on a field is from surface water irrigation, groundwater irrigation, or a different source (sub irrigation, precipitation, etc.), which is important for

real-time management and regulation in order to understand if the rate diverted is in compliance with the regulation and water distribution.

Evapotranspiration data, such as OpenET, can only measure water used for irrigation. It is not a helpful tool for measuring water uses that do not have a clear evaporative loss component, such as manufacturing, industrial, commercial, or portions of municipal uses.

Chapter 2: Using Other Measurement Data to Understand Water Use

Understanding Water Use at a Basin Scale

A water budget is an accounting of water stored within, and water exchanged among, the hydrologic components of a distinct hydrologic area. Water budgets provide a means of evaluating the availability and sustainability of a water supply, ultimately addressing the question "How much is where?". Water budgets can vary in scale from global to local and can focus on specific components of the hydrologic cycle. As show in Figure 11, a complete water budget includes information from stream gages (A), observation wells (B), and a measurement of consumptive use of water (C).

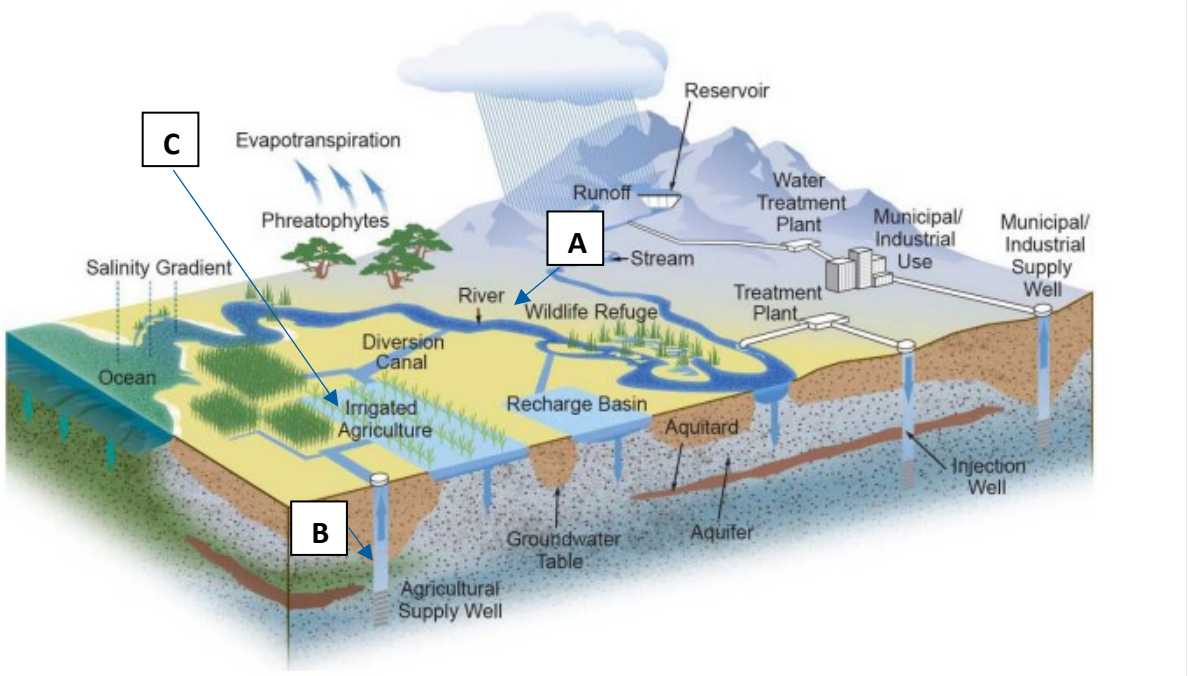


Figure 11. Components of a water budget that need to be measured or estimated (Source: California Department of Water Resources, "*Handbook for Water Budget Development: With or Without Models*")

Stream Gages

What is measured at stream gages? See A in Figure 11.

Stream gages measure the amount of water in a stream channel flowing past a point. The water measured at that point is a product of all upstream impacts and inputs, including return flows, seepage losses, diversions, and precipitation and runoff. During 2020, the Department operated or supported operation of a total of 245 gages, with another approximately 200 gages run by the USGS, counties, and other partners throughout Oregon (Figure 12). Some stream gages have been operating in Oregon since prior to statehood, with over half of all stream gages operated having periods of record of 15 years or less, and approximately 470 gages having been run for 5 years or less (Figure 13). Note that the period of record for any given gage may not be continuous – counting only the initial and final year of operation for this report.

Appendix A displays the geographic location and operation status of all stream gages in the state, by administrative basin. Figure 16 in Appendix A also provides an approximate historical record of the number of active stream gages in each administrative basin since 1900.

State stream gages are operated either by Department or county staff that work closely with the Department through the Department's Field Services Division offices. Streamflow data are processed by the Surface Water Section at the Department whose work focuses on processing 20-30 measurements a day, developing and updating streamflow records, providing QA/QC for all gage data, and working closely with field staff to ensure gages are operating properly. The Department faces challenges in ensuring that it has enough hydrographers and field staff to provide quality assurance of the data and to maintain the statewide gage network.

Streamflow data are useful for many aspects of characterizing water resources. Gages operated upstream of most development in a basin provides important information on natural flow, which is critical to develop hydrologic models such as those used in basin groundwater studies and the Department's water availability program. For example, these gages are used to model natural flow in similar ungaged basins in the water availability program. Additionally, gages that monitor natural flow can help examine long-term trends in streamflow as well as variation in groundwater to surface water exchanges attributable to climate change. When quantifying water needs for various uses, stream gage records help explain the relationship between flow and availability of habitat for aquatic organisms or recreational uses within an area. Gages downstream of major areas of surface water development can help to quantify outflows from a basin over time, a key component of a water budget and hydrologic modeling. Finally, as stated earlier, gages operated on diversions provide critical information required for developing basin water budgets and hydrologic models. These diversion gages help inform estimates of irrigation efficiencies, distribution losses, and on-farm deliveries, when coupled with other information.

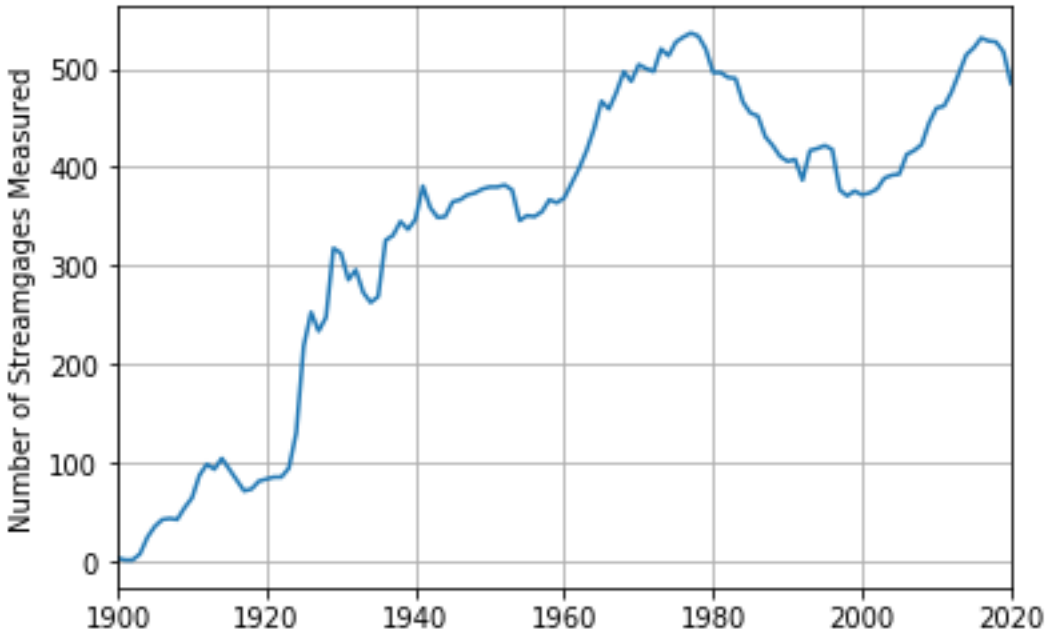


Figure 12. Count of total stream gages measured in Oregon, over time. This graph includes both stream gages operated by OWRD and those operated by partners. Stream gages were considered "active" if they had a day of data within a year.

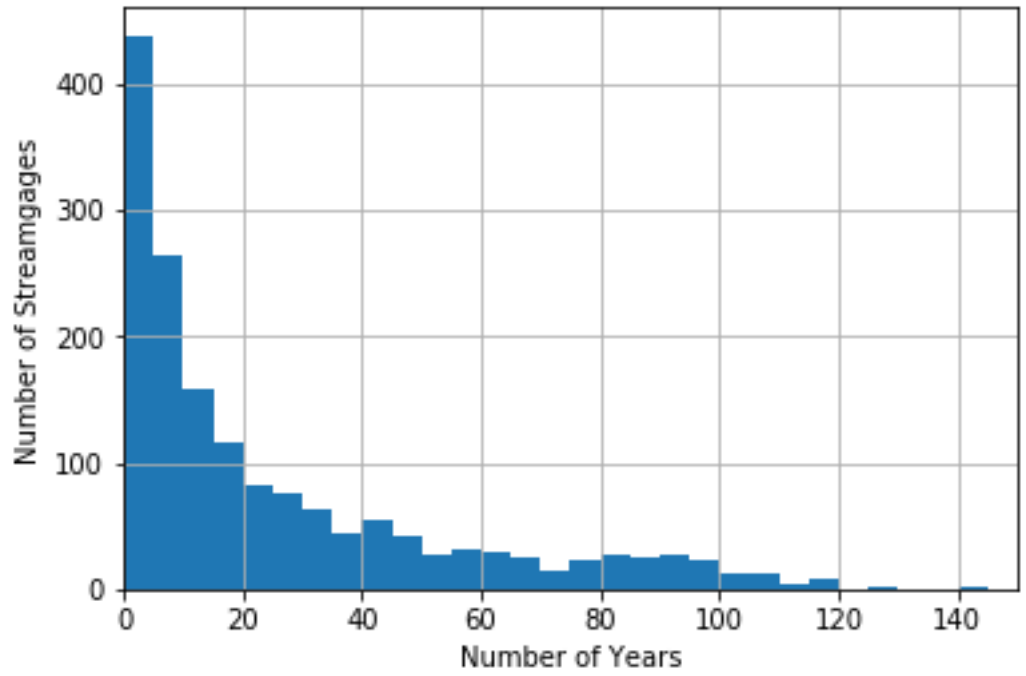


Figure 13. Period of operation for all stream gages in Oregon.

How does stream gage data relate to water use data?

Most stream gages are not used to quantify water use for a single water right. They can serve this purpose if placed on a canal, or if gages are placed upstream and downstream of a canal to quantify the

diversion. Gaging diversions shows how much water is diverted; not what water was consumed by the user. This is also a much more costly approach, compared to measurement devices attached to diversions. See discussion in Chapter 1. In some places in the state, the stream gage network is dense enough that water use within that sub-basin can be estimated. Currently this density exists only where stored water and natural flow is managed in partnership with the Bureau of Reclamation in part of the Umatilla Basin. Where stream gages have been operated for several decades and are placed on major streams or rivers, they can be used to measure total water into and out of the basin, but not water use by any specific user (except in the case of some canals).

Water Level Observation Wells

What is measured at water level observation wells (see B in Figure 11)?

The Department monitors or receives reported data for groundwater levels and/or pumped groundwater use from nearly 7,000 wells. Wells that are used to monitor water level data are referred to as water level observation wells (about 3,300 wells; Figure 14), and wells from which water use is either measured or reported are referred to as water use observation wells (about 5,500 wells). About 1,800 wells are measured for both groundwater levels and water use, and these wells are considered both water level observation wells and water use observation wells. More information on water use observation wells can be reviewed in Chapter 1. Of the 3,300 active water level observation wells, approximately 43% are measured only by Department staff, 54% are reported by water right holders, and 2% have water use both measured by Department staff and reported by water right holders.

Water level data are useful for many aspects of characterizing groundwater resources. Measurements are made most often quarterly, or at the beginning and end of the season of use. Year-to-year changes in spring high water levels reflect the balance of groundwater recharge and discharge in an aquifer. Additionally, short-term changes in groundwater levels in response to nearby pumping can be used to estimate aquifer properties.

Generally, the most useful groundwater level records are those measured consistently over decades. However, building these long-term records is difficult due to obstacles that make wells inaccessible, such as changes in well construction and land access via agreement with landowners. In addition, many wells that submit water level are only required to do so for a limited duration. Due to these changes, there are approximately 9,700 inactive water level observation wells, far more than the 3,300 active wells. Of the active wells, approximately 18% (600) have been measured for fewer than 5 years, while only 16% (520) have been measured for 40 years or longer (Figure 15). That contrast highlights the value of establishing dedicated water level observation wells, especially those drilled specifically for the purpose. Appendix B displays the geographic location and operation status of all groundwater level observation wells in the state, by administrative basin.

Figure 14. Number of active water level observation wells each year. A drop in measurements in 2020 primarily reflects the impact of safety considerations for COVID-19.

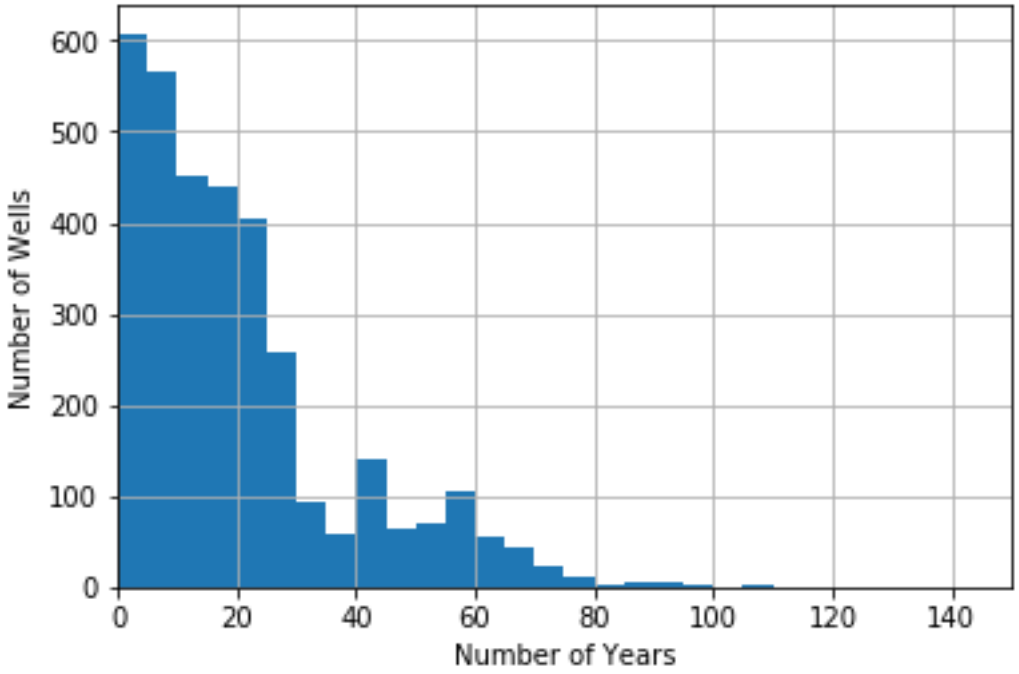


Figure 15. Period of observation for active water level observation wells.

How do water level data relate to water use data?

Changes in groundwater levels over time may be impacted by water use, but the relationship is complex and uncertain enough that water levels are generally not useful for quantifying water use. Rather,

significant declines in annual groundwater levels over multiple years are considered an indication of use beyond the capacity of the groundwater resource.

The groundwater level in a well reflects the balance of recharge into and discharge from the aquifer(s) accessed by that well. When discharge (including pumping) exceeds recharge, water levels fall as water is removed from storage in the aquifer. Falling water levels drive groundwater flow from areas of high to low potential, drawing in water from the surrounding aquifer and/or capturing water from hydraulically connected surface water sources. Because these responses somewhat counteract water level declines, water use is often difficult to quantify with water level measurements alone.

Chapter 3: Agency Recommendations

A Future for Water Use Measurement and Reporting

The 2021 to 2023 biennium brought many new initiatives to the Department that require improved or expanded water use data, namely groundwater budgets and basin studies. Understanding water use is critical for these efforts because water use is the component of the water cycle that people can manage. Solutions developed to address water shortages can target the areas with the best chance of making an impact. Along with these new efforts, many existing programs in the Department will greatly benefit from better and more accurate data. To successfully implement these initiatives and programs, the Department needs water use data. Here we describe recommendations for achieving needed improvements.

Improve Water Use Reporting Database Functionality and Public Access

There are a variety of updates that need to be made to improve the water use reporting database and expand public access to water use data, each of which are discussed below. The Department anticipates 1.0 FTE application developer is needed to develop and implement the following information technology proposals, as well as other initiatives described under other recommendations.

Integrated Department Data

Currently, water use reported and collected data are not stored in the same location. The Department sees value in integrating these data to increase accessibility to water use data across the state and maximize the use of data collected by staff. Integration of these data would require significant modifications to the current Water Use Reporting database to accommodate different types, frequency, and volume of water use data. This work would likely be a multi-year effort.

Improve Web Interface for Water Use Reporting

Adding different reporting and data search options would make it more convenient for water use reporters. For example, adding dropdown menus for more fields, allowing pictures of meters, and entry of flow meter readings. Allowing for the entry of flow meter data would require more in-depth software programming and is relatively intensive but would lead to higher quality data and more functionality for users. Higher-quality data is more useful to the Department as well as planning efforts.

Develop and Implement Additional QA/QC Features

Most water use data are self-reported either through an online reporting system or through a paper form which staff then enter in the Water Use Reporting (WUR) database. The Department has tools and processes for quality assurance and quality control (QA/QC), however it does not have a formal QA/QC plan for water use reporting. In addition, QA and QC that does occur are currently limited in scope, primarily by staff resource availability.

Automate and Integrate Internal Notices and Tools

There are several internal processes, such as tracking changes made to reporting requirements over the life of a water right, that are currently done manually and could be automated if additional IS staff were available. Additionally, there is an opportunity to integrate the Water Use Reporting database more fully with other agency databases, (e.g. Water Availability System) and create links to existing water use data

(e.g. gaging station data and reservoir data). There are also improvements that could be made to the existing utilities to improve process, efficiency, clarity, and accuracy.

Improved Accessibility of Reported Water Use Data

Currently, water use data can be searched, but the outputs are limited. Adding additional search options, resources, and information to the website, such as a graphing function that shows monthly water use for individual water users and additional fact sheets could make the data easier to understand and access.

Integrate Accurate, Transparent Statewide Water Use Summaries

Many needs for water use data will require individual water-right estimates of water use for water rights statewide. Specifically, efforts such as basin studies and water budgets, which quantify the status of water supplies in a basin, rely on accurate accounting of what water is being used and when. Additionally, planning efforts in basins across the state need to understand how water use has impacted water supplies and what water users are important to be involved in which solutions to water issues– many recent Place-Based Planning efforts described this as a major data gap. Staff are necessary to utilize the datasets described in this report to create reliable estimate of water uses across the state, as well as improve the way we document and store data.

Current collaborative efforts between the Department, the Mid-Coast Place-Based Planning group, and the Oregon Explorer resulted in the development of the Oregon Mid-Coast Water Planning Map Viewer. The Department is also working with Oregon Explorer for a statewide Water Planning Map Viewer and landing page which are expected to be completed mid-2022. This web-based mapping platform displays and generates reports based on aggregate water data, including water quality, quantity, water use, infrastructure, and natural hazard databases, for a selected area of interest. This tool, along with a robust and continued water use dataset, will be useful for planning efforts across the state. A more robust water use data set could include:

- Summary data of water use by water right.
- Reports every 5 years on water use by watershed including cross-boundary watersheds.
- Supplemental data sets that support modeling efforts used in many planning initiatives (e.g., irrigation type).
- Alignment of data type, quality, and coverage with USGS Water Use Data program to support integration of state-wide data into regional and national reporting on water use.

Additionally, other efforts, such as the Regional Water Planning and Management Workgroup and the Department of Environmental Quality's Integrated Data Platform, both authorized during the 2021 legislative session, will offer collaborative opportunities to discuss integrated data platforms and sharing between agencies.

In addition to the information system specialist 5, described above to develop and program the software infrastructure to expand the water use reporting database, funding is needed to contract with Oregon Explorer to add water use summaries to the Water Planning Explorer.

Invest in Evapotranspiration Monitoring and Programs

Estimation of consumptive water use for irrigation is best measured through satellite monitoring of evapotranspiration (ET) from irrigation crop fields, which remains the largest use of diverted water in the state. Ultimately, OpenET data can support science-based decision-making.

Ongoing financial and staffing support for integration of the OpenET program into Department work will be key in understanding aspects of consumptive water use. In the near-term, a contractor will be assessing gaps in station-based measurements of ET. These stations provide ongoing data critical for calibration of the remotely sensed data. The stations require funds for purchase or lease, operation, and significant time for data processing. The Department is scoping out the most affordable option to operate these stations but will require ongoing monitoring dollars to operate these stations.

The Department estimates $200k in the next biennium to establish new stations, likely in partnership with either USBR Agrimet or other entities with capacity to run and operate appropriate stations. The Department recommends continued support for federal investment in the OpenET program and requires a continued investment of $570k per biennium for a federal cost-share to establish partnerships with the USGS and external partners for ongoing OpenET work.

Invest in Water Use Measurement Devices in Priority Watersheds

Water use is estimated using a combination of reported values, direct measurements, and indirect or remotely sensed methods. When used in conjunction with other tools such as remote-sensed ET, installing measurement devices at select points of diversion generates more accurate water use estimates to refine water availability models. In watersheds where planning activities, basin studies, water budget development, or other water use studies are underway, strategic efforts that couple remote sensed ET and direct water use measurement to quantify water use and availability within the basin can help local communities and the Department plan for current and future instream and out-of-stream use. To provide responsive support to water users during basin studies or similar work, the Department recommends 2 FTE additional assistant watermasters for each basin study, or 4 FTE NRS 2 assistant watermasters total.

Expand Reporting Authorities to include Areas of Scientific Interest

The Department has a variety of authorities it may exercise to require water use reporting; however, the Department lacks authority to require reporting in areas where data would be beneficial for ongoing or upcoming studies unless the area meets the standards for designation of a Serious Water Management Problem Area. Whether for water budgets or groundwater studies, understanding water use from non-governmental entities is important data that helps the Department calculate how much water is leaving the system. Although the Department has some authority to require measurement and reporting through a Serious Water Management Problem Area designation, providing clear authority to require reporting in areas of current or upcoming water resources studies could be helpful.

Support Groundwater Observation Wells

Expansion of the network of observation wells that has been authorized by General Fund allocation during the 2021 legislative session will increase the availability of high-resolution groundwater level data as each newly installed dedicated observation well will be fitted with a pressure transducer and data logger. In the case where existing pumped wells are volunteered for inclusion in the observation well network, staff may measure both groundwater level and groundwater use from these wells, if the well is

outfitted with a totalizing flow meter. Wells should be prioritized for measurement based on the value of either type of data they could provide. Identifying candidate observation wells and communicating with the well owners to gain and maintain access is time consuming but necessary to collect diverted groundwater use data and groundwater level data. In addition to collecting raw readings from flow meters and power meters, OWRD staff must analyze and process these readings. The Department has been resource constrained in its efforts to collect and process these data, but investments by the 2021 Oregon Legislature are expected to support both expansions of the Observation Well networks and data interpretation to support decision making.

Increase Understanding of Water Use Statewide through Investments in Field and Technical Staff and Adjustments to Existing Programs

Every year watermaster staff across Oregon regulate to protect senior instream and out-of-stream uses. Increased water use measurement improves staff efficiency and the accuracy of adjusting diversions. Increased streamflow monitoring with telemetered gaging stations can improve protection of senior water rights and instream water rights by giving advance notice to watermaster staff that streamflow is declining to a point that regulation will be needed. Additionally, an integrated Water Use Reporting database, as discussed above, would be beneficial for field staff for real-time and long-term management.

The access to near-real time data over the last decade has been a significant improvement in monitoring and managing surface water in Oregon, but the operation and maintenance of over 250 gaging stations requires dozens of trained staff each year and represents a significant part of the workload of the field staff and Surface Water Hydrology Section staff. Additional hydrologists and hydrographers would allow for more timely data analyses, gaging station network refinement, and more timely awareness of developing issues, like declines in baseflow due to sustained droughts or groundwater pumping.

While the Department has authority to require measuring devices for water management purposes, field staff need improved information technology tools to be able to systematically record information in a manner that may be useful for staff in other sections of the agency. In addition, the significant points of diversion program and associated Key Performance Measure would benefit from an update, with appropriate staff resources. More specifically, the Department finds that there is limited benefit to pursuing many of the remaining significant points of diversion. Having staff resources to develop a new approach for identifying and prioritizing diversions could be beneficial and maximize the use of staff time on points of diversions where water measurement will benefit water management and distribution. Further, revising the Department's KPM to include all measuring devices installed, instead of only focusing on significant points of diversion, would be a key indicator of the Department's continued progress and efforts to install measuring devices. Finally, it is important to recognize that watermasters need access to water use measurement devices to effectively distribute water. Continuing to provide funding assistance and associated staff resources for efforts to install measurement devices can be beneficial in advancing these efforts, reducing the burden of water use measurement on water users.

Appendix A: Stream Gages in Oregon

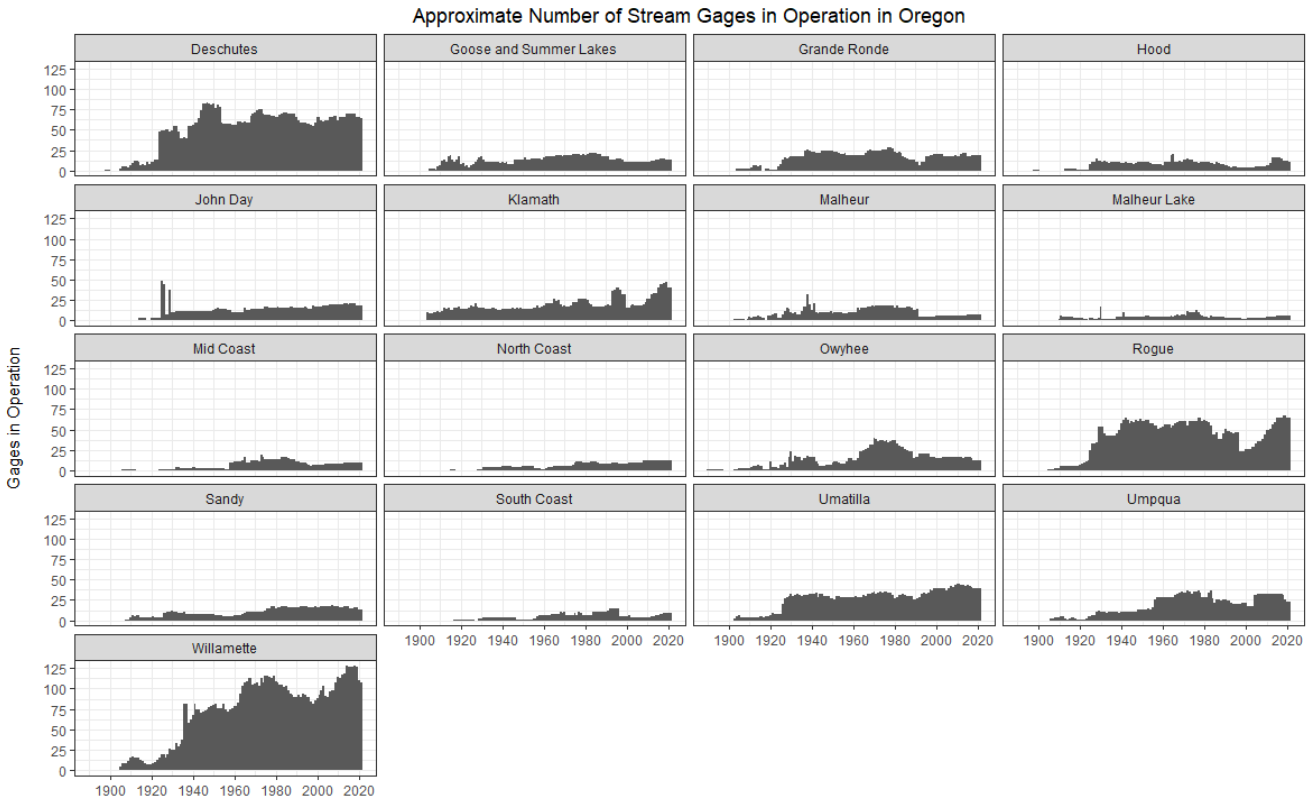
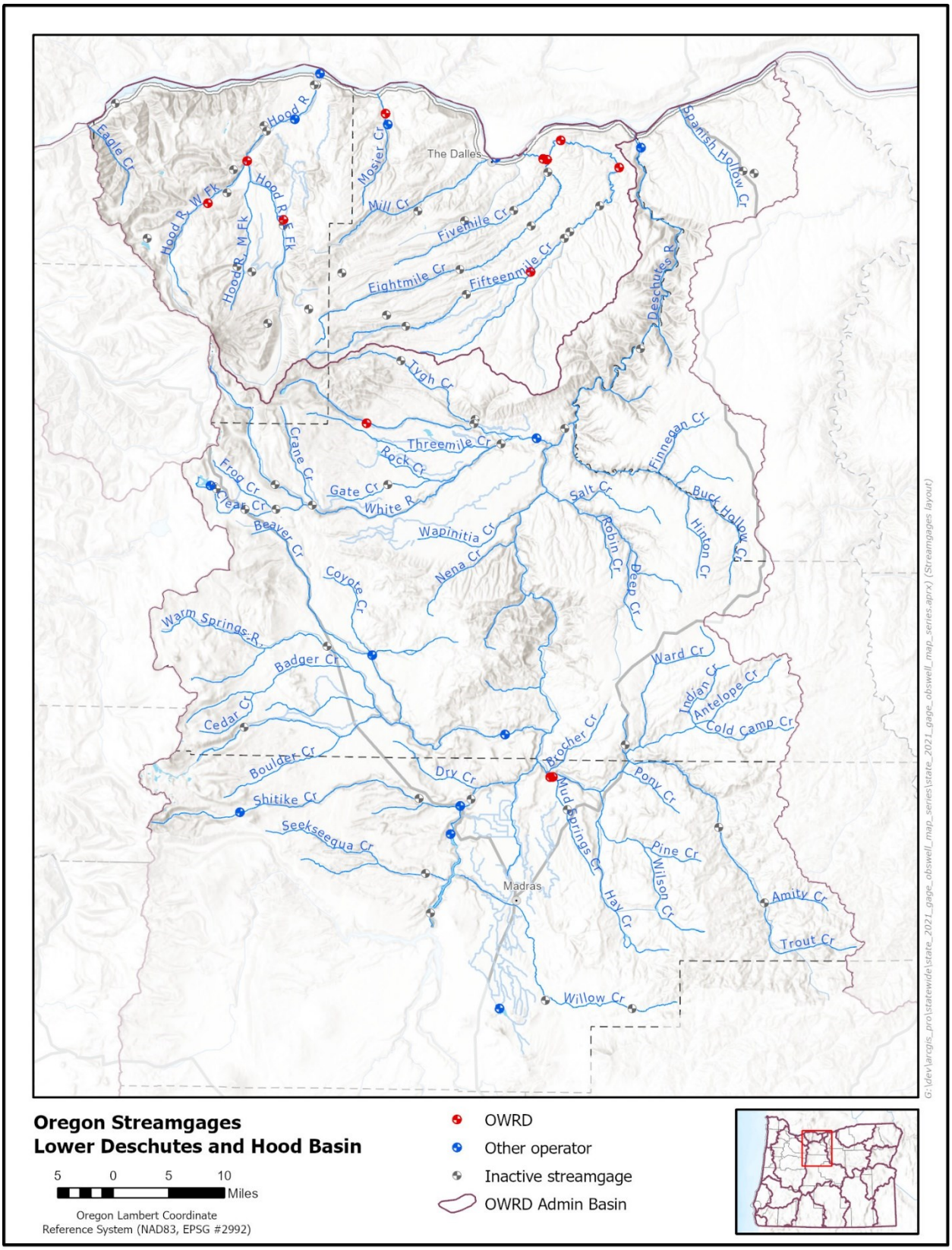
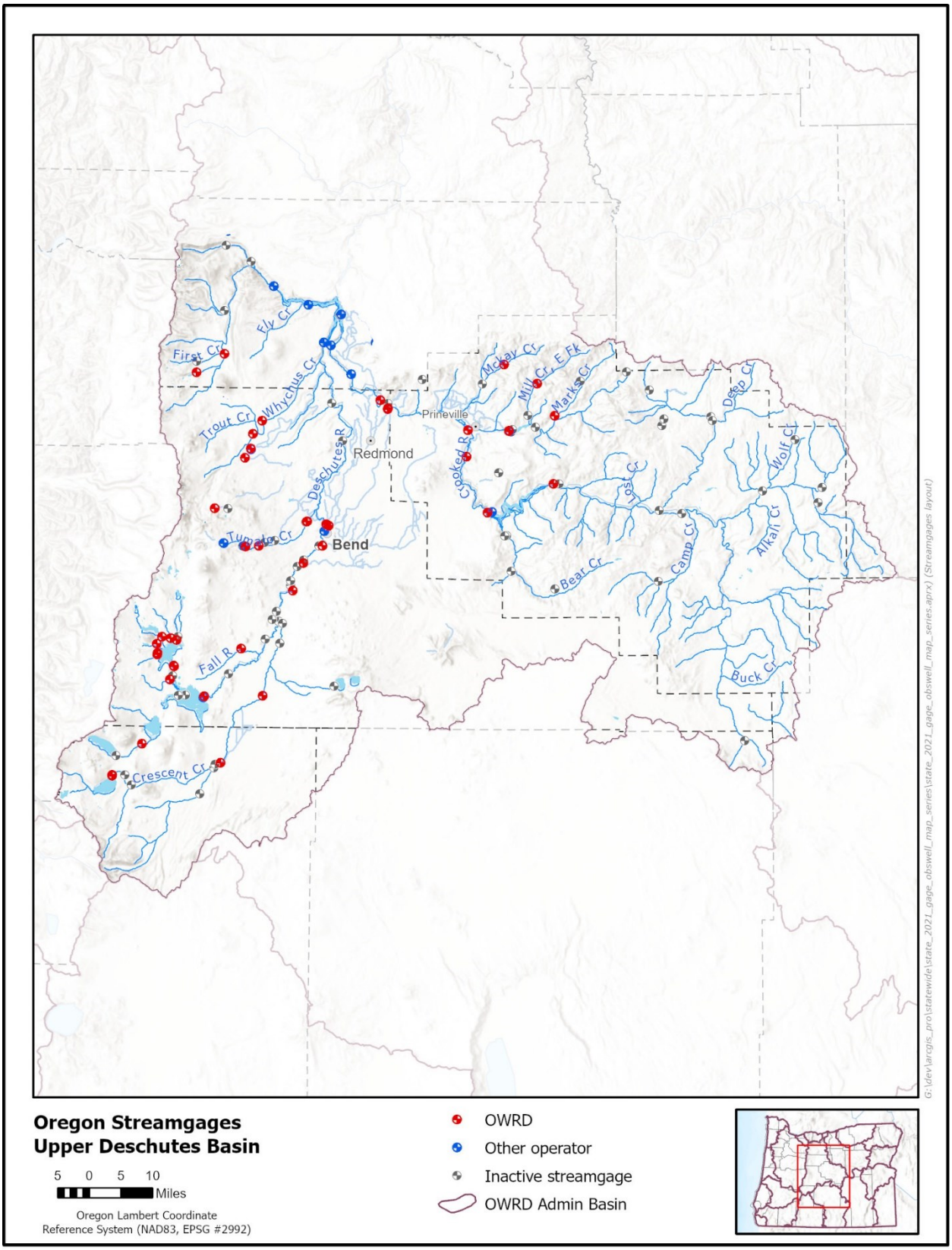


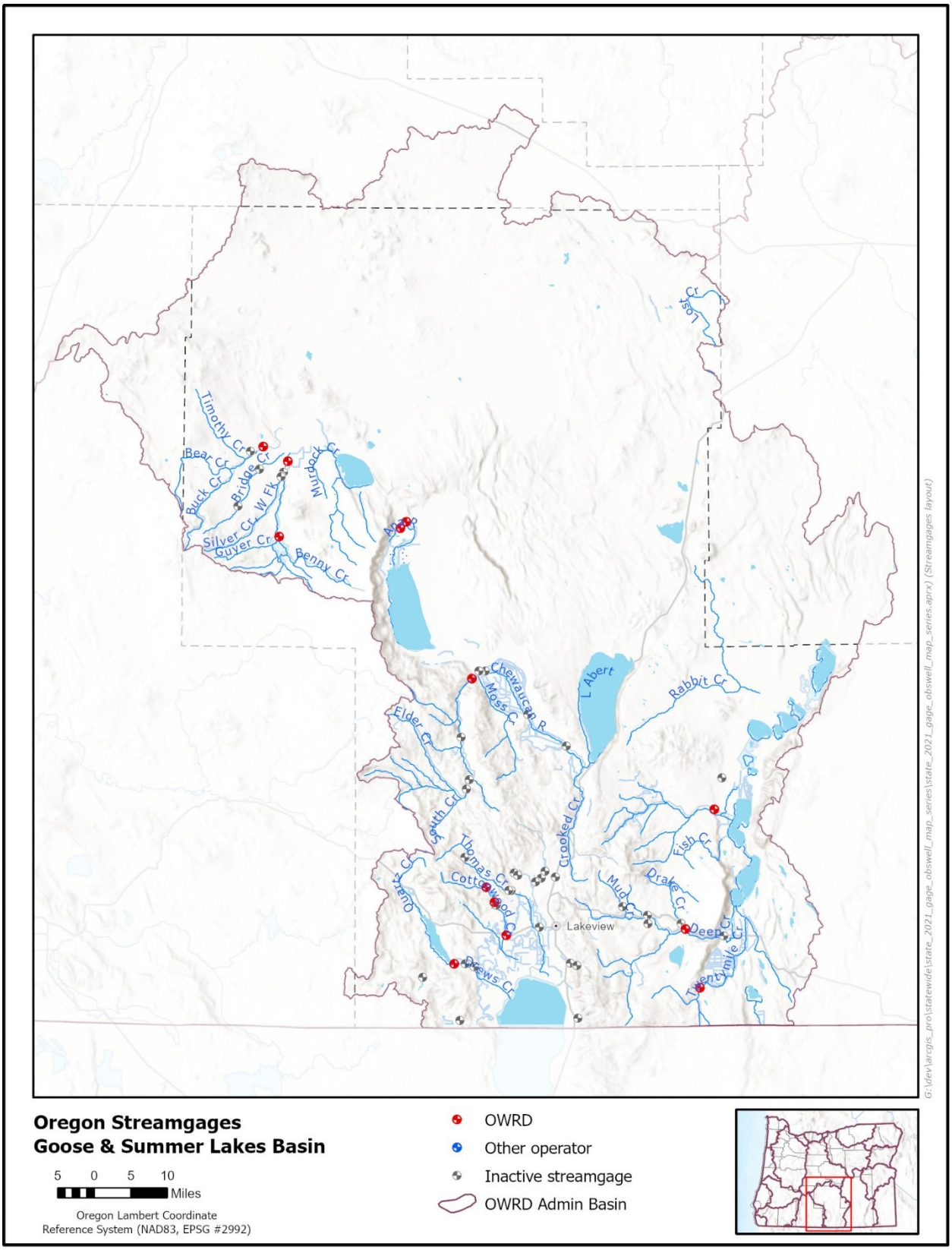
Figure 16. Approximate number of stream gages in operation over time, by administrative basin. Gages may be operated by OWRD, USGS, or other cooperators operating gages using USGS standards.



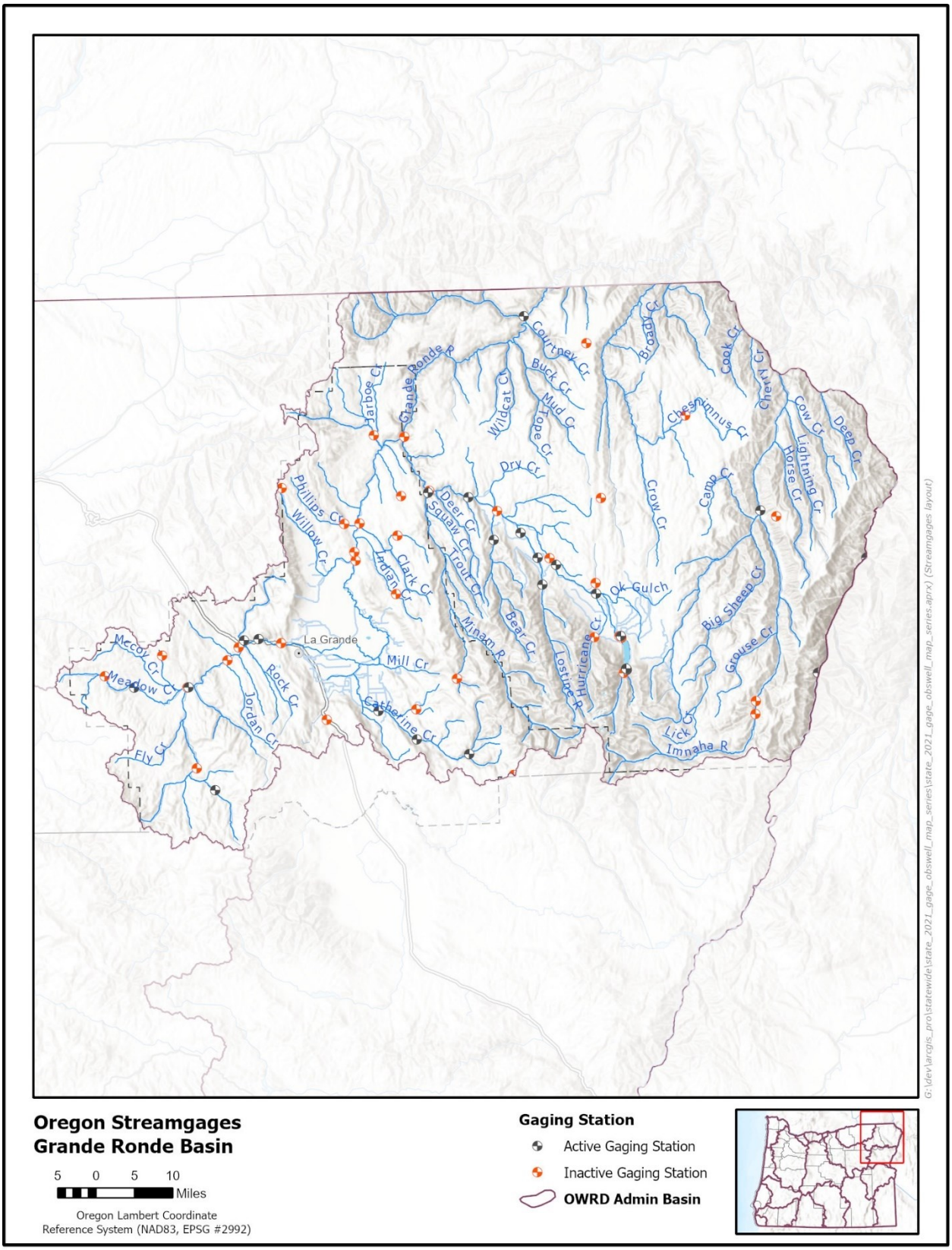
Map 2. Lower Deschutes and Hood Basin Stream Gages



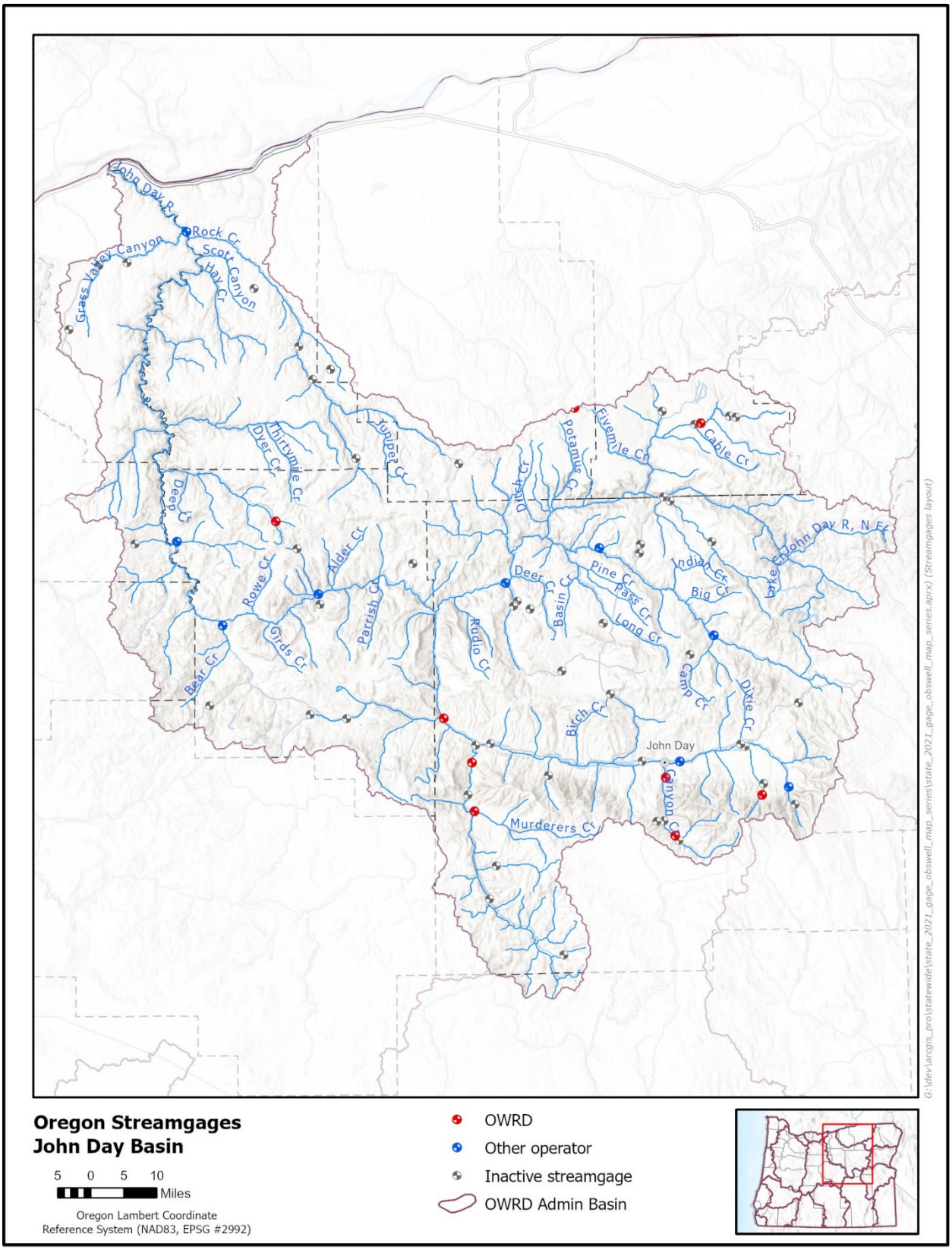
Map 3. Upper Deschutes Basin Stream gages



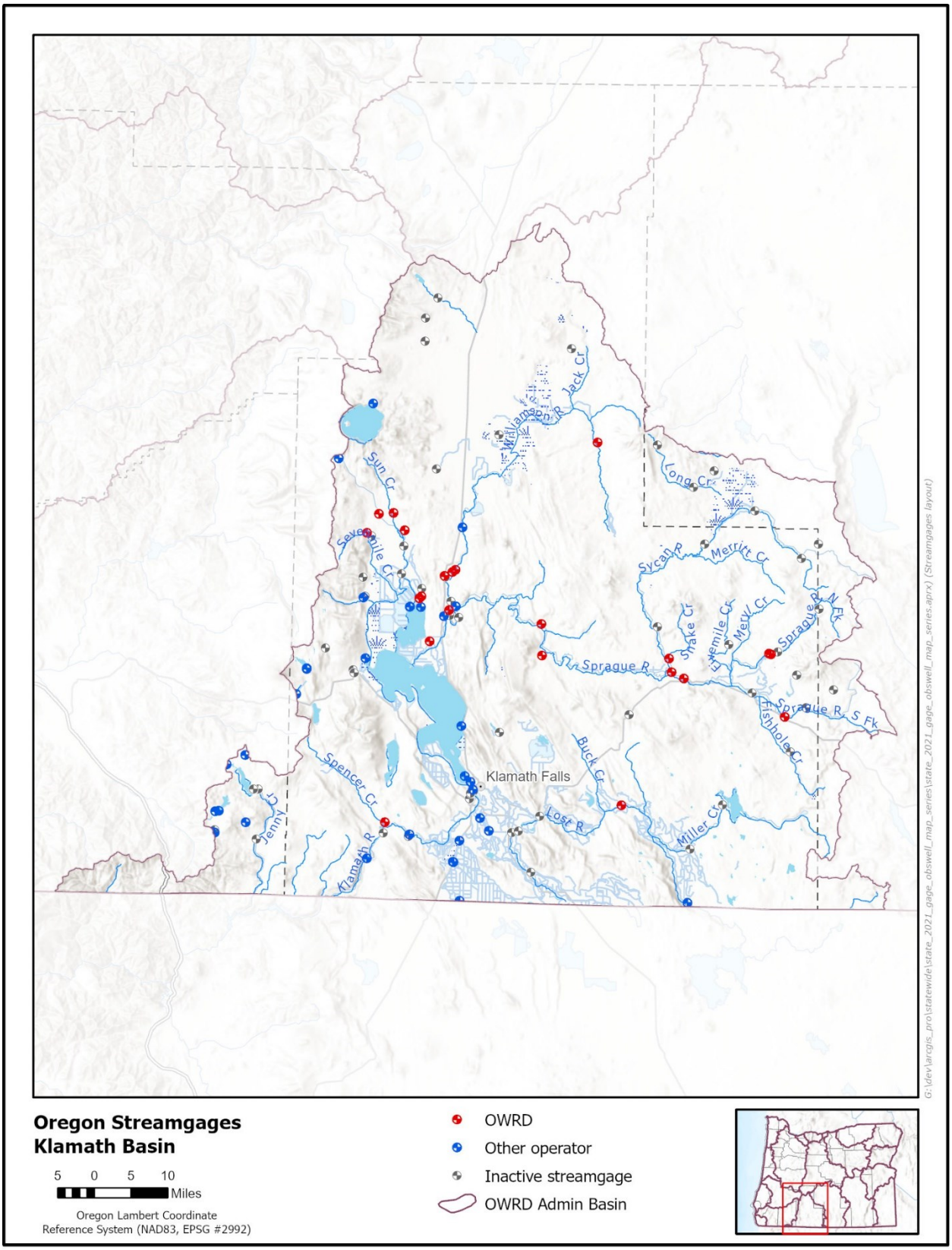
Map 4. Goose and Summer Lakes Basin Stream Gages



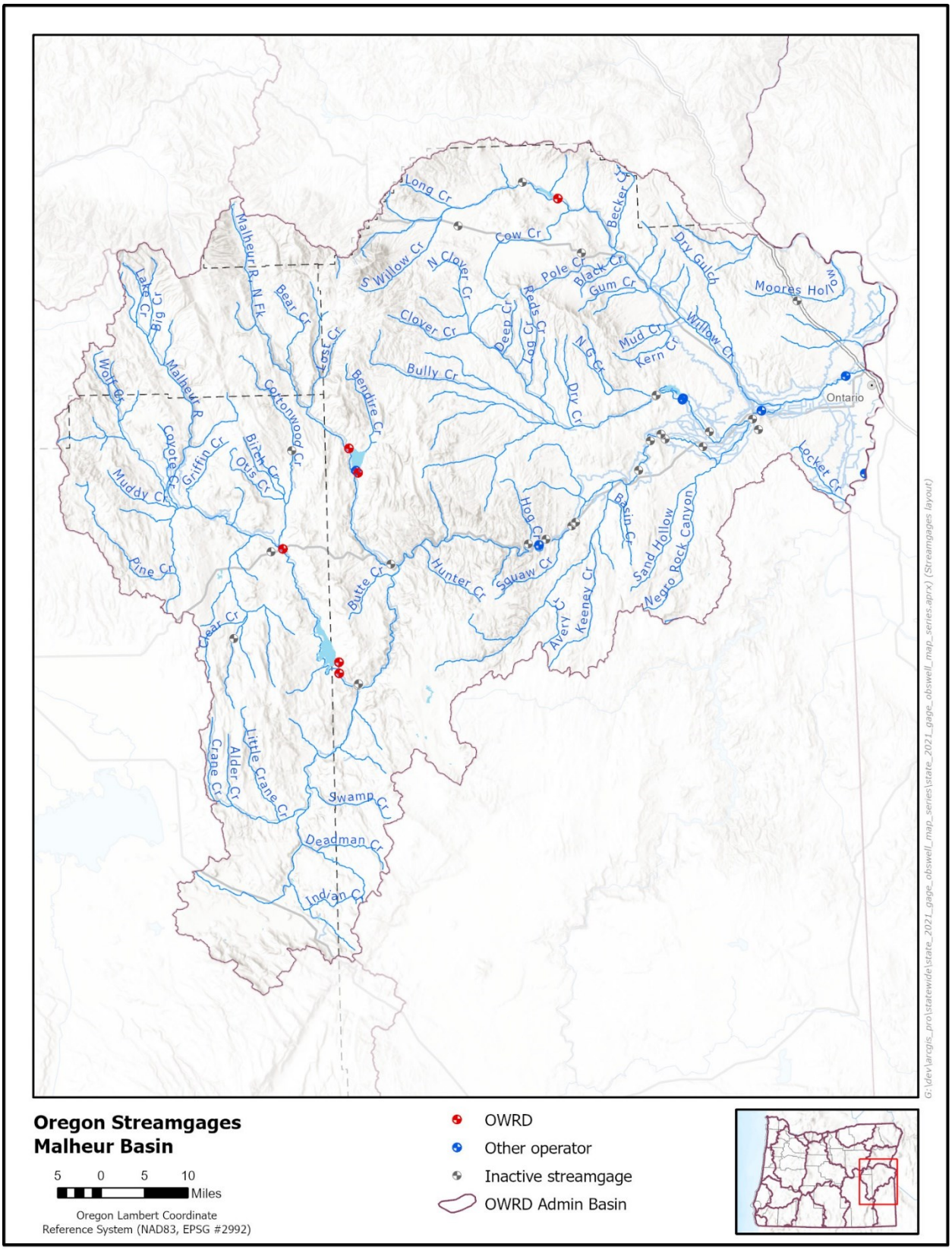
Map 5. Grande Ronde Basin Stream Gages



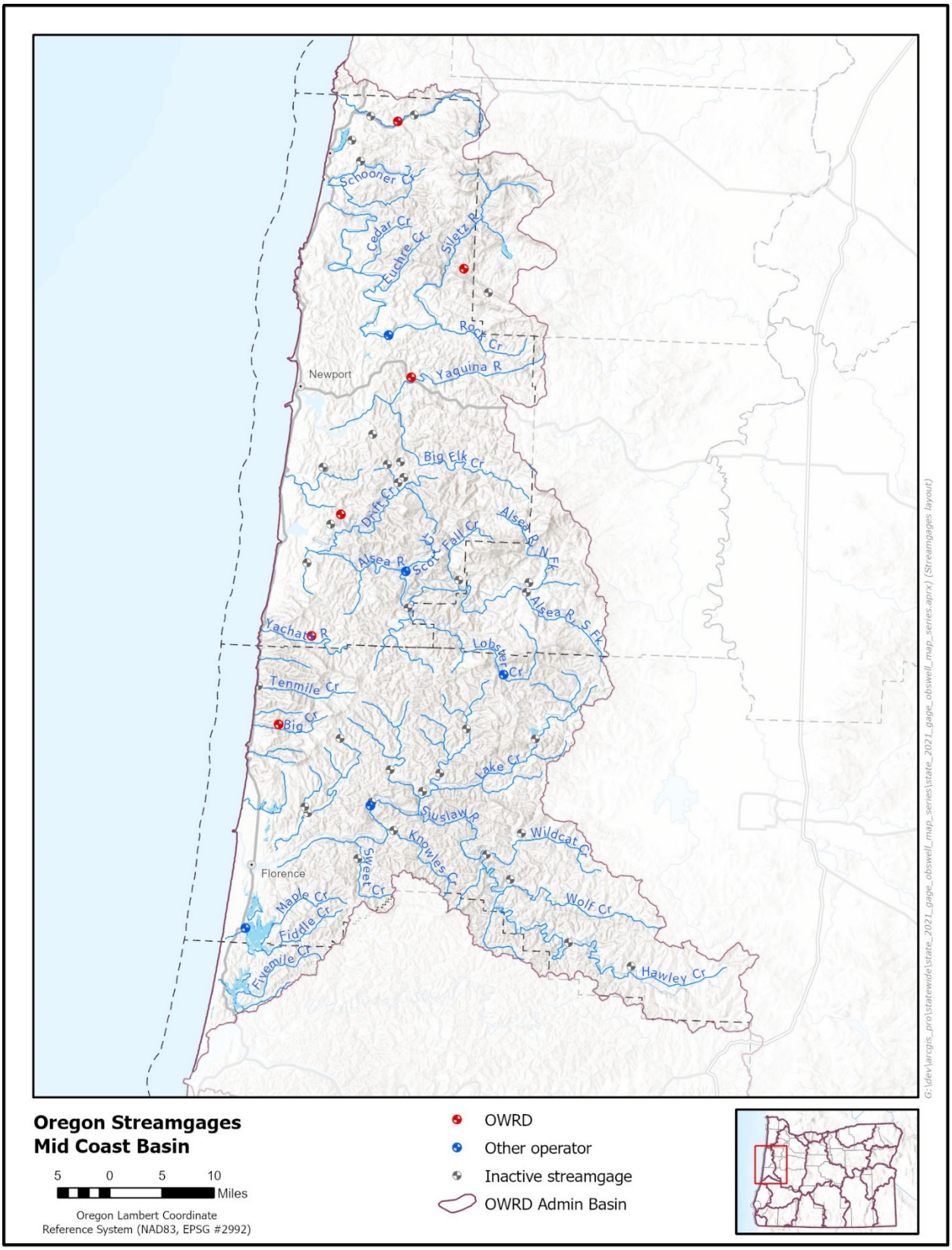
Map 6. John Day Basin Stream Gages



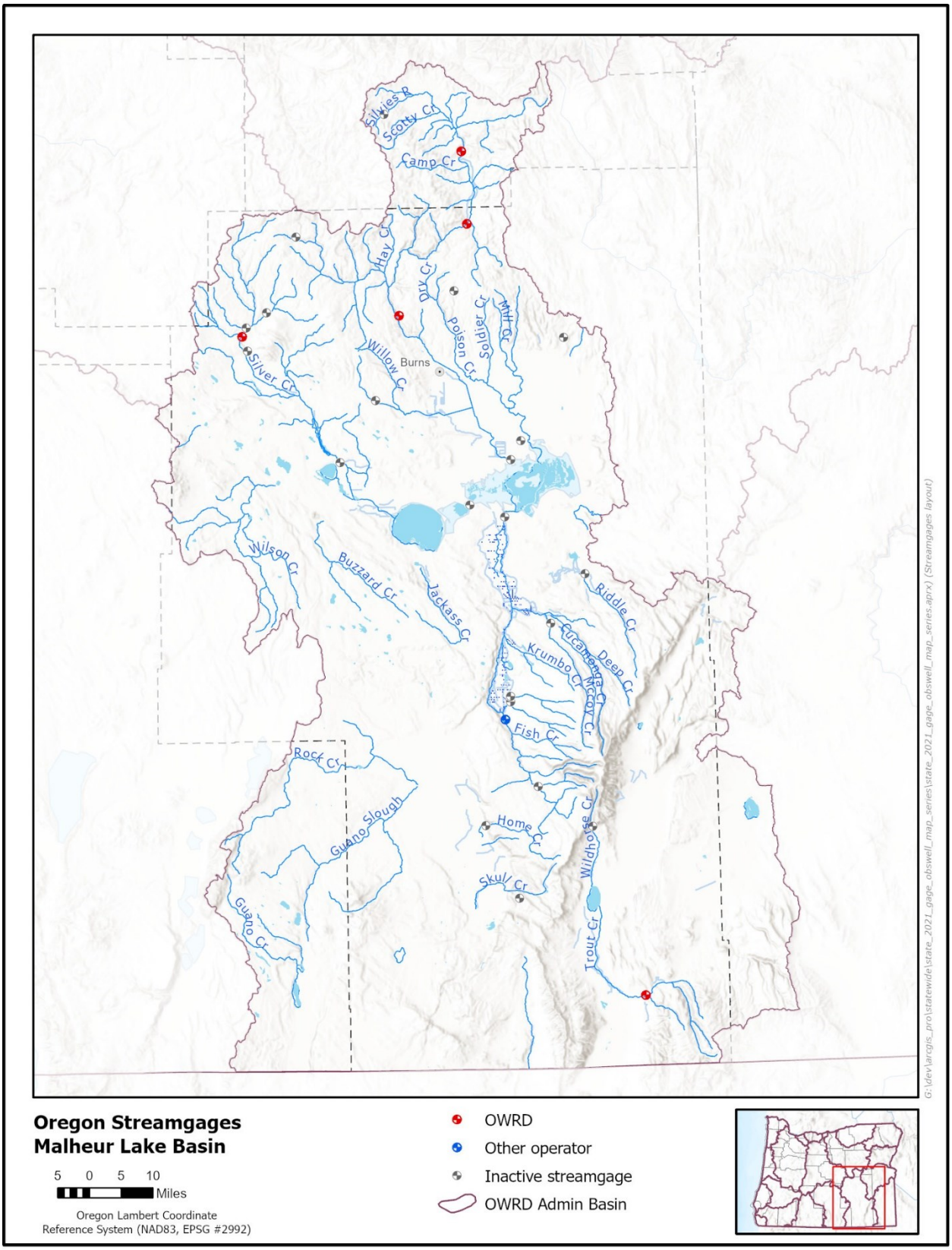
Map 7. Klamath Basin Stream Gages



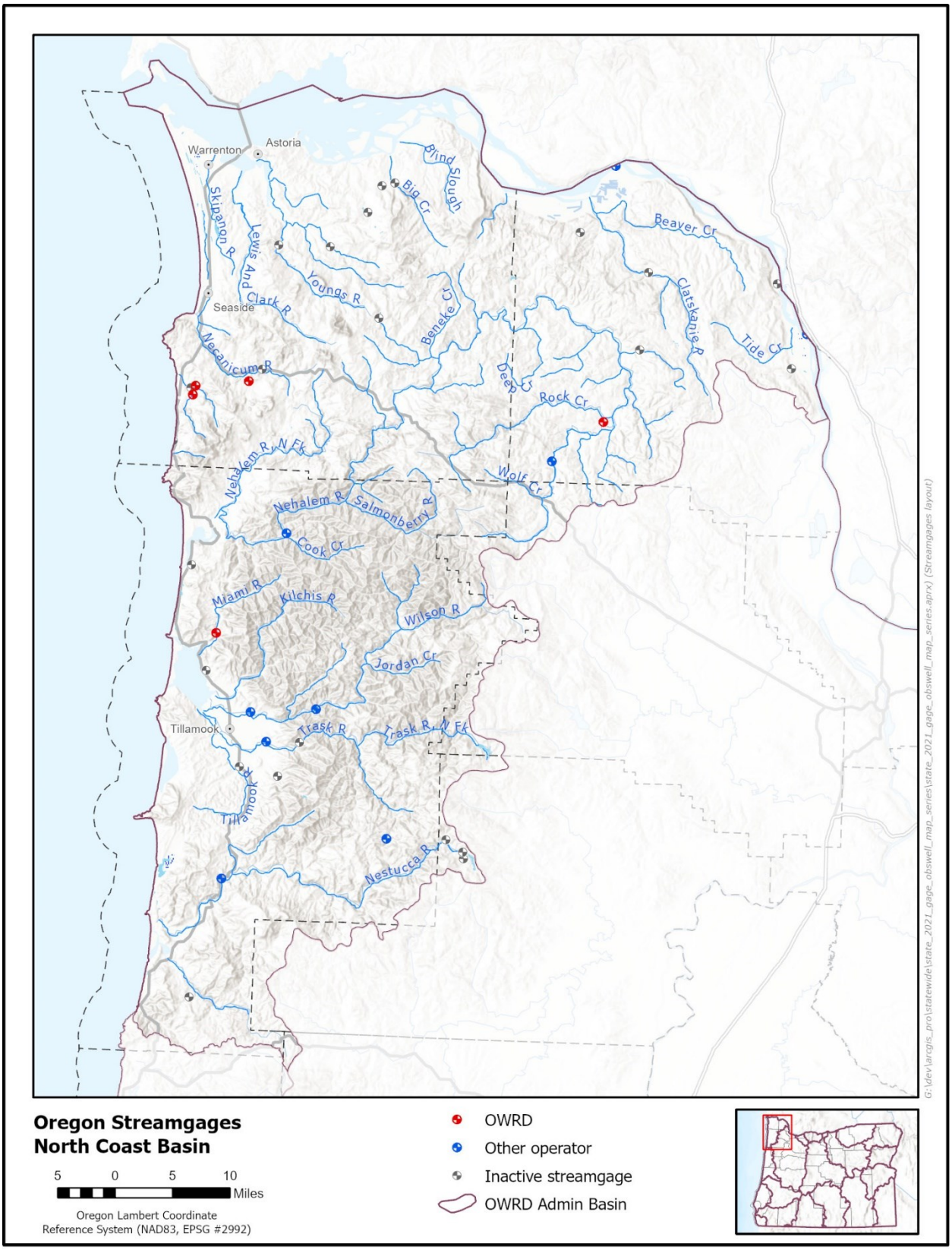
Map 8. Malheur Basin Stream Gages



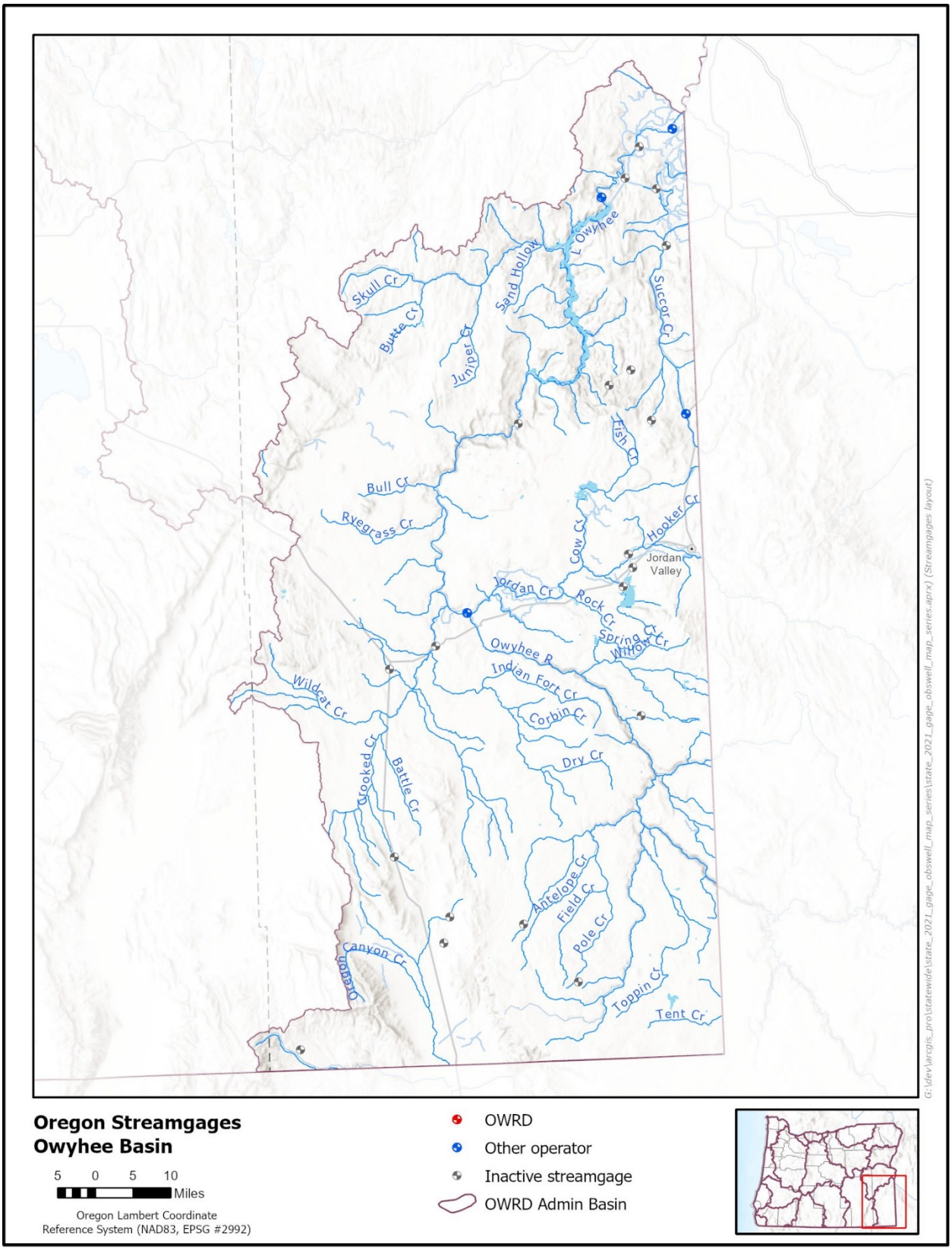
Map 9. Mid Coast Basin Stream Gages



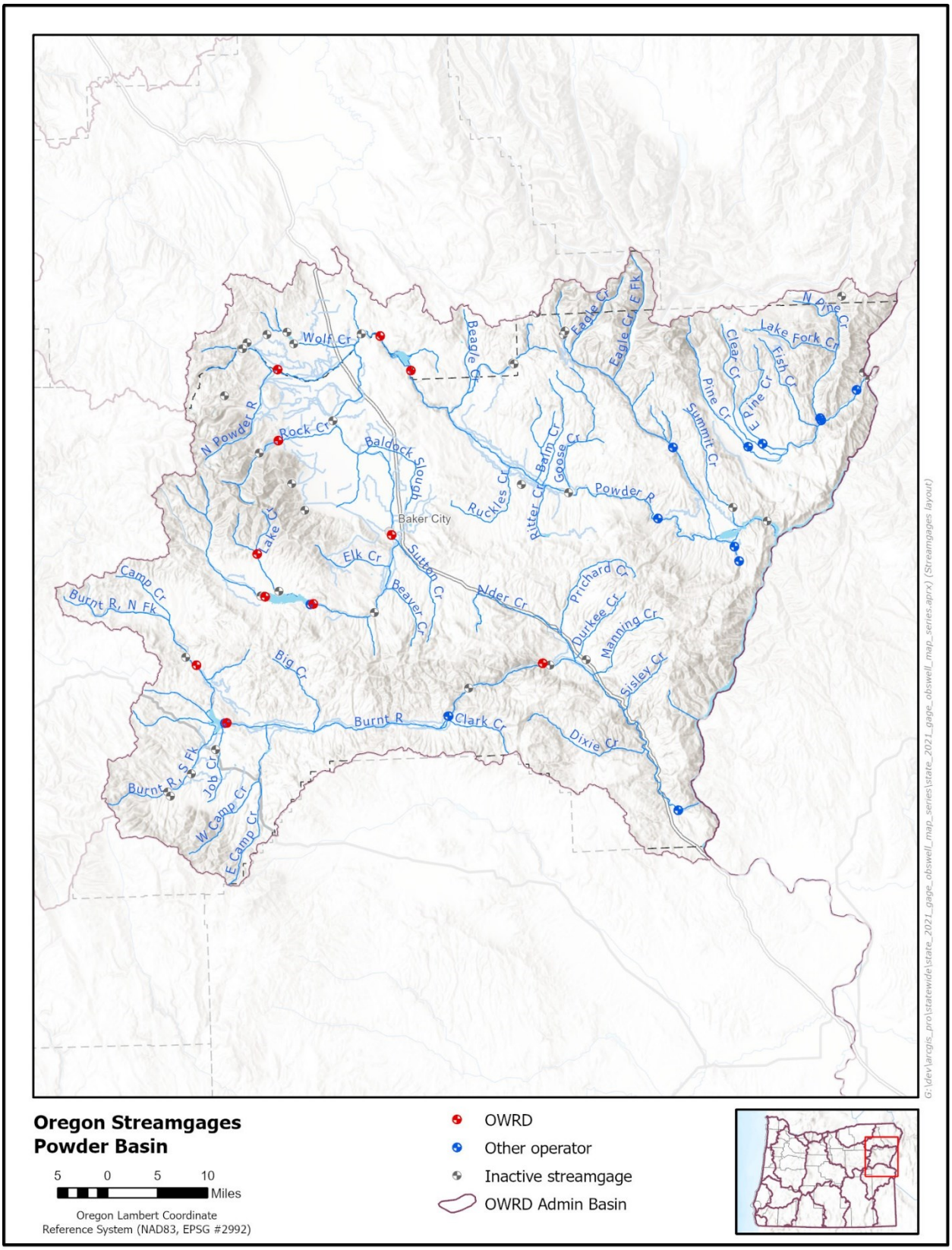
Map 10. Malheur Lake Basin Stream Gages



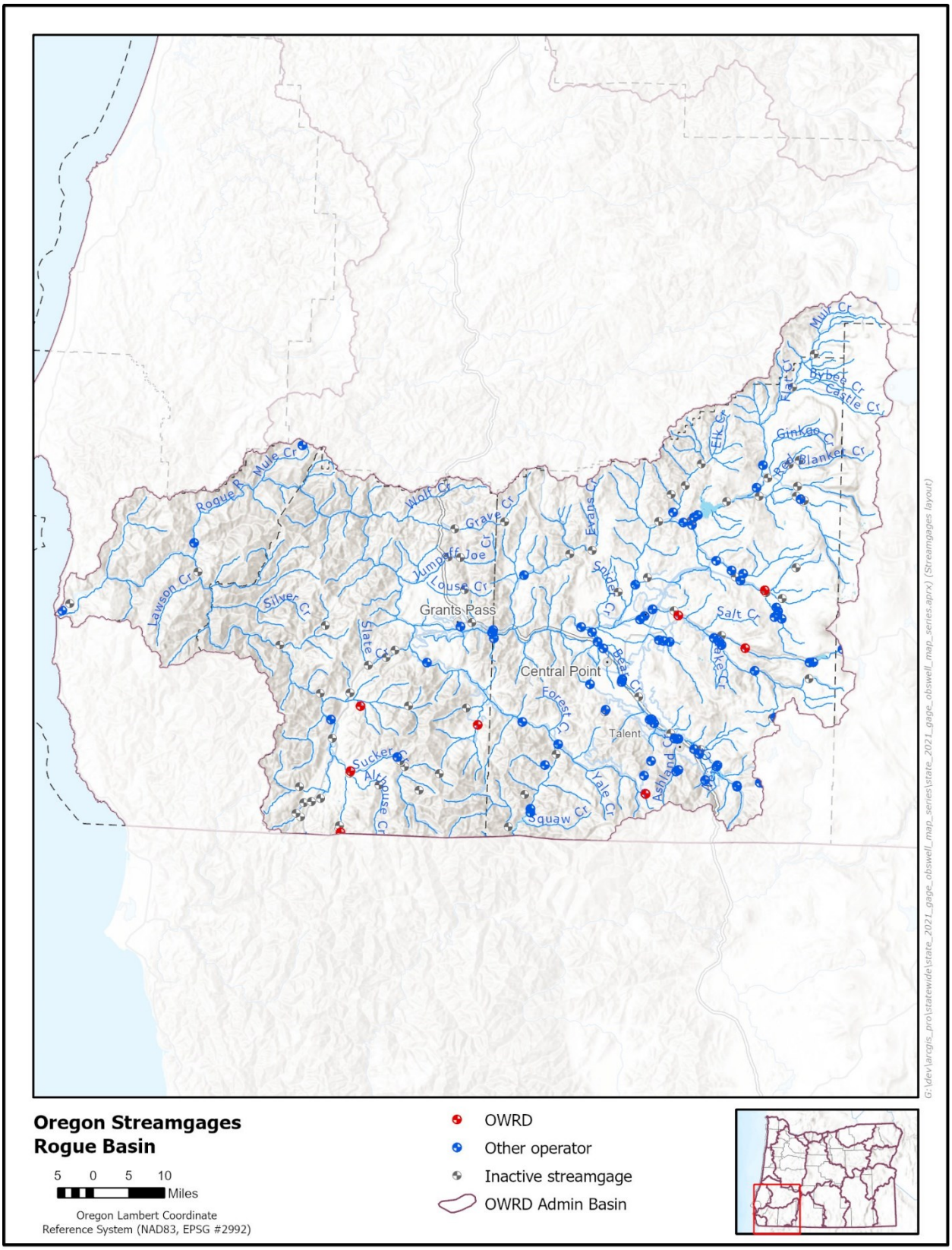
Map 11. North Coast Basin Stream Gages



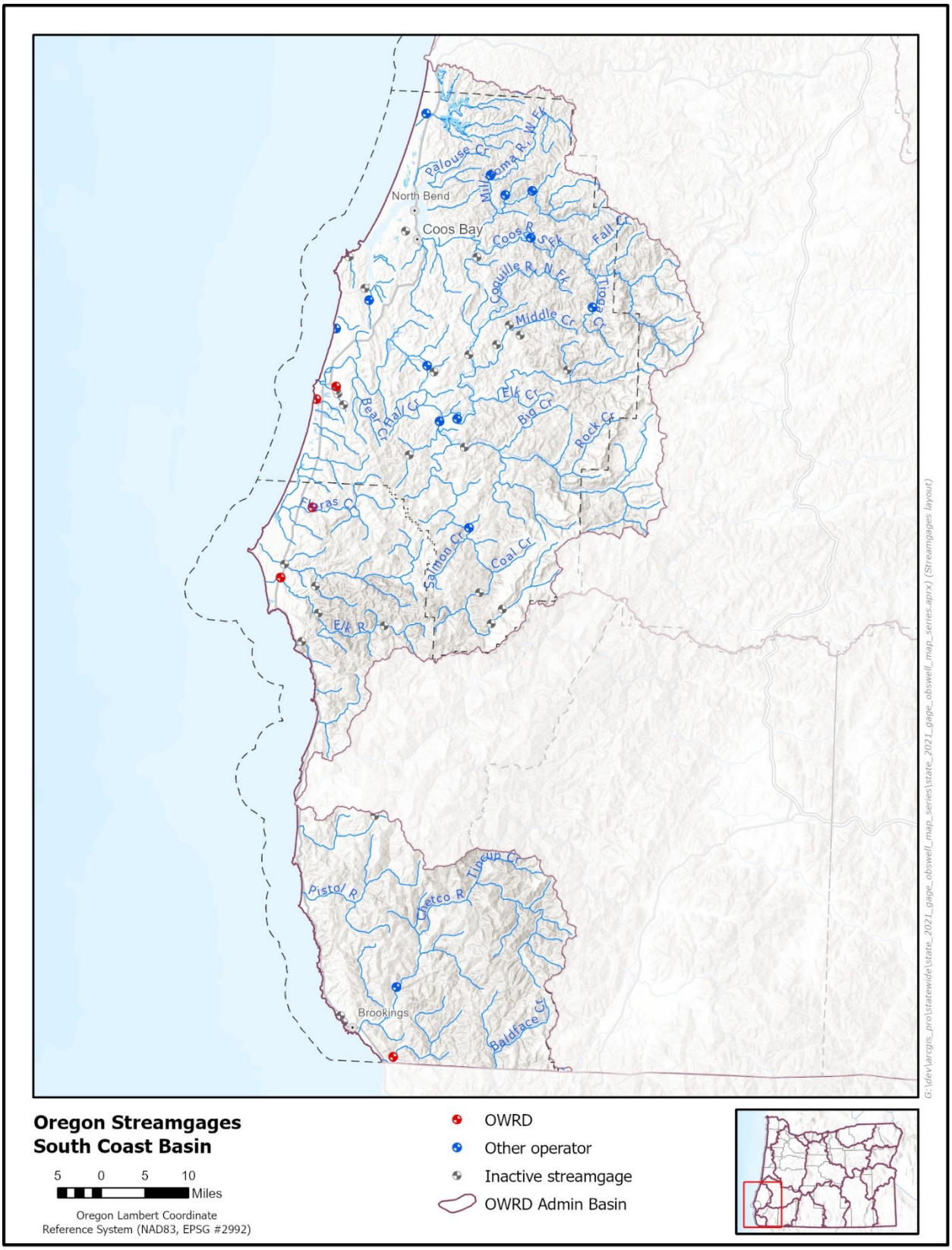
Map 12. Owyhee Basin Stream Gages



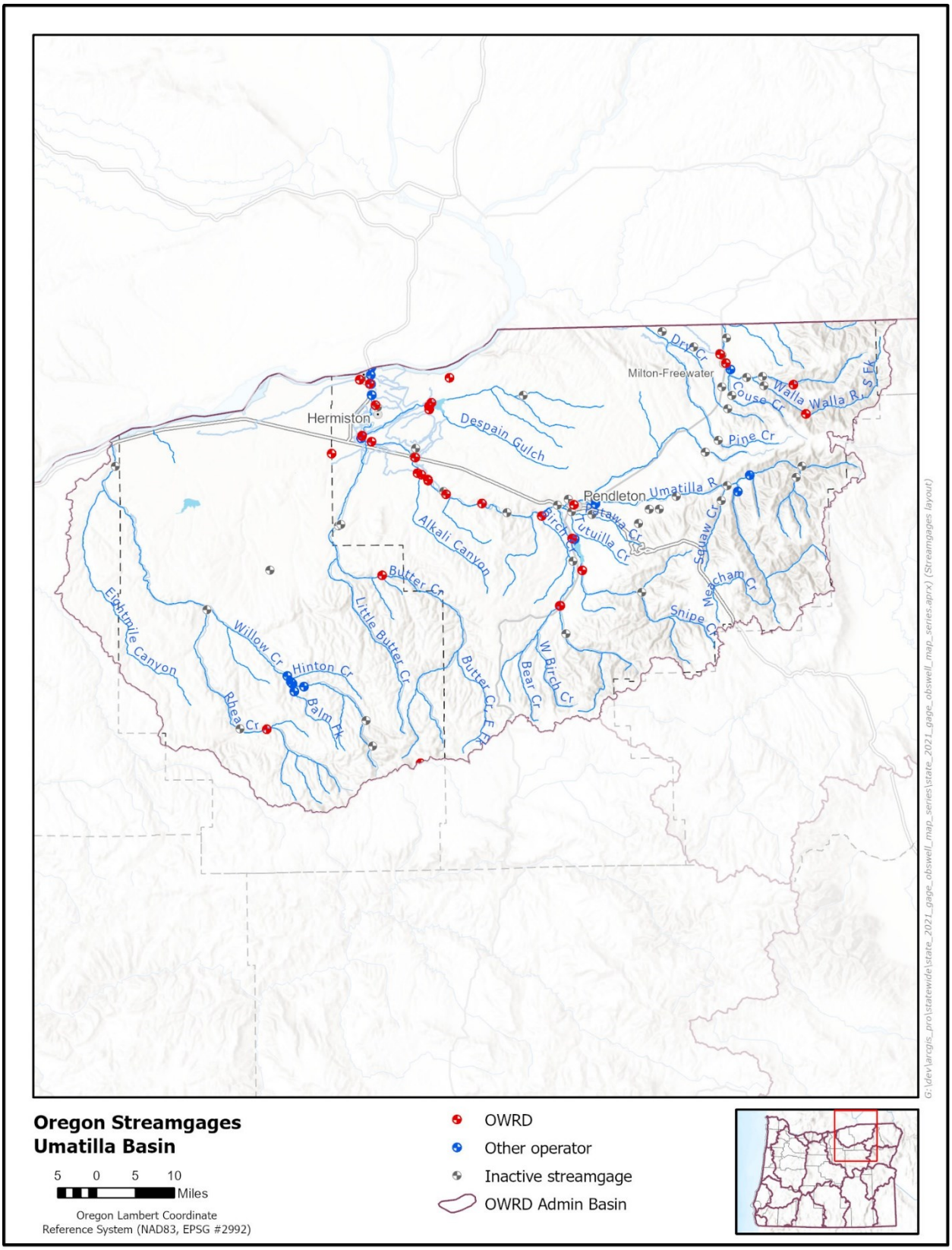
Map 13. Powder Basin Stream Gages



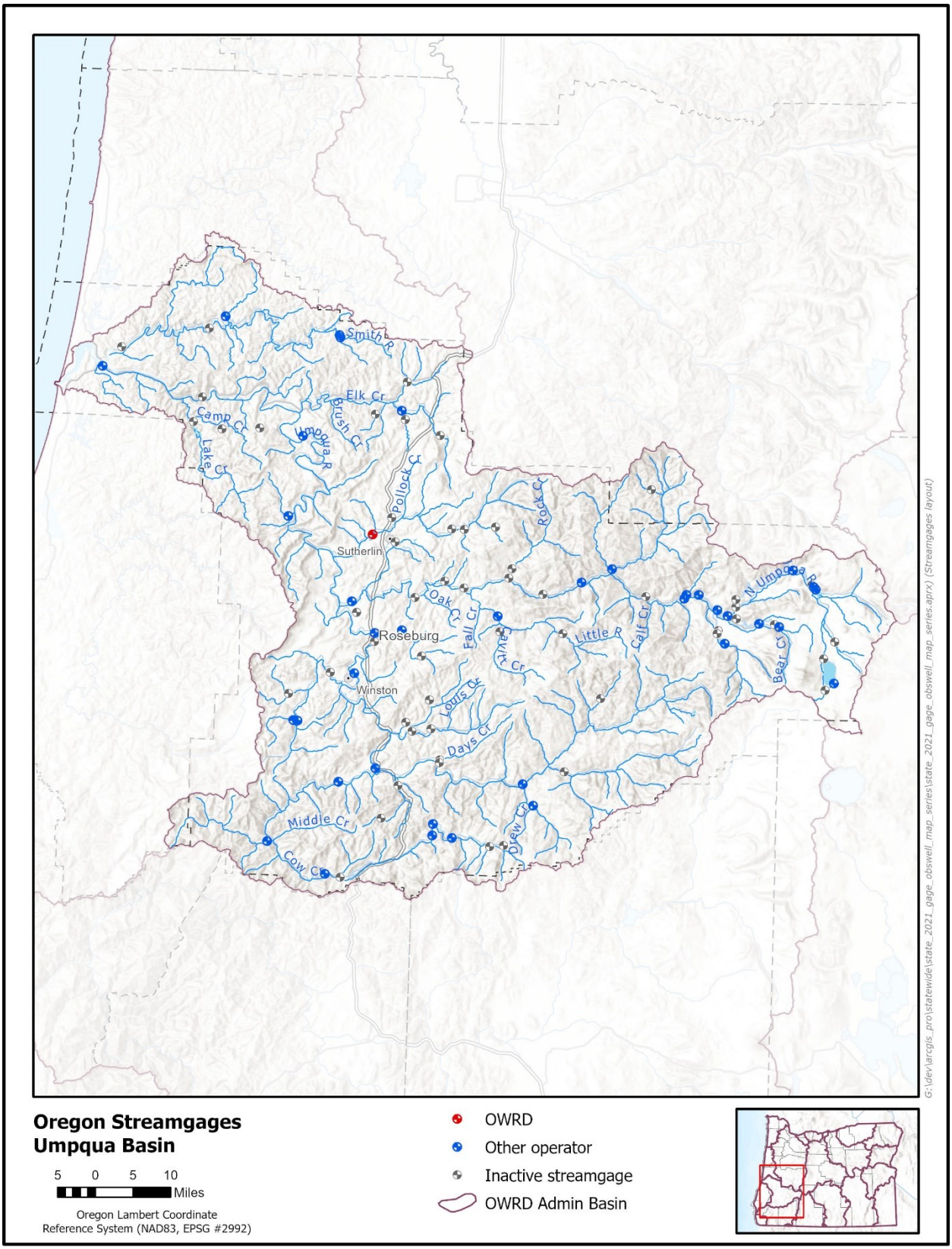
Map 14. Rogue Basin Stream Gages



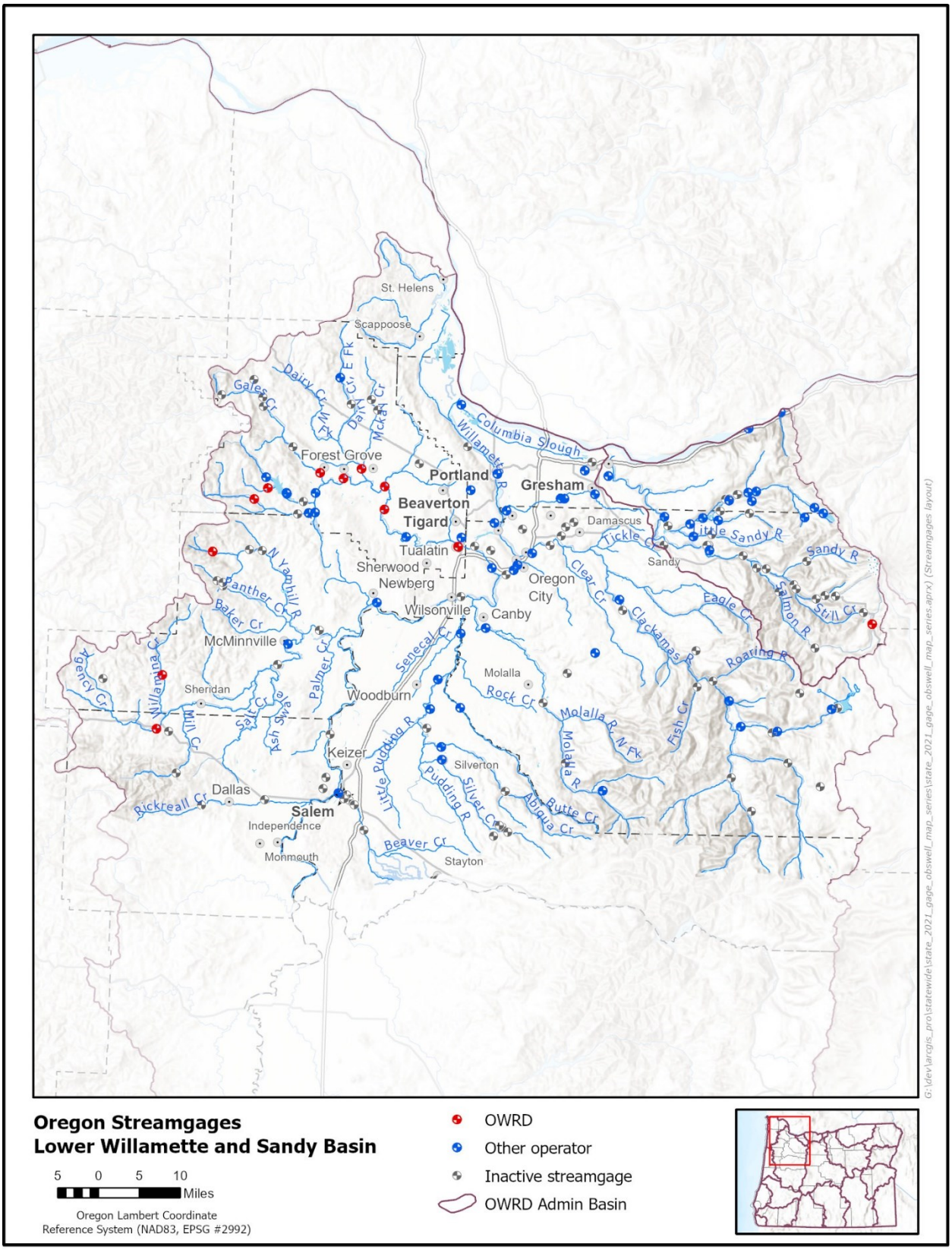
Map 15. South Coast Basin Stream Gages



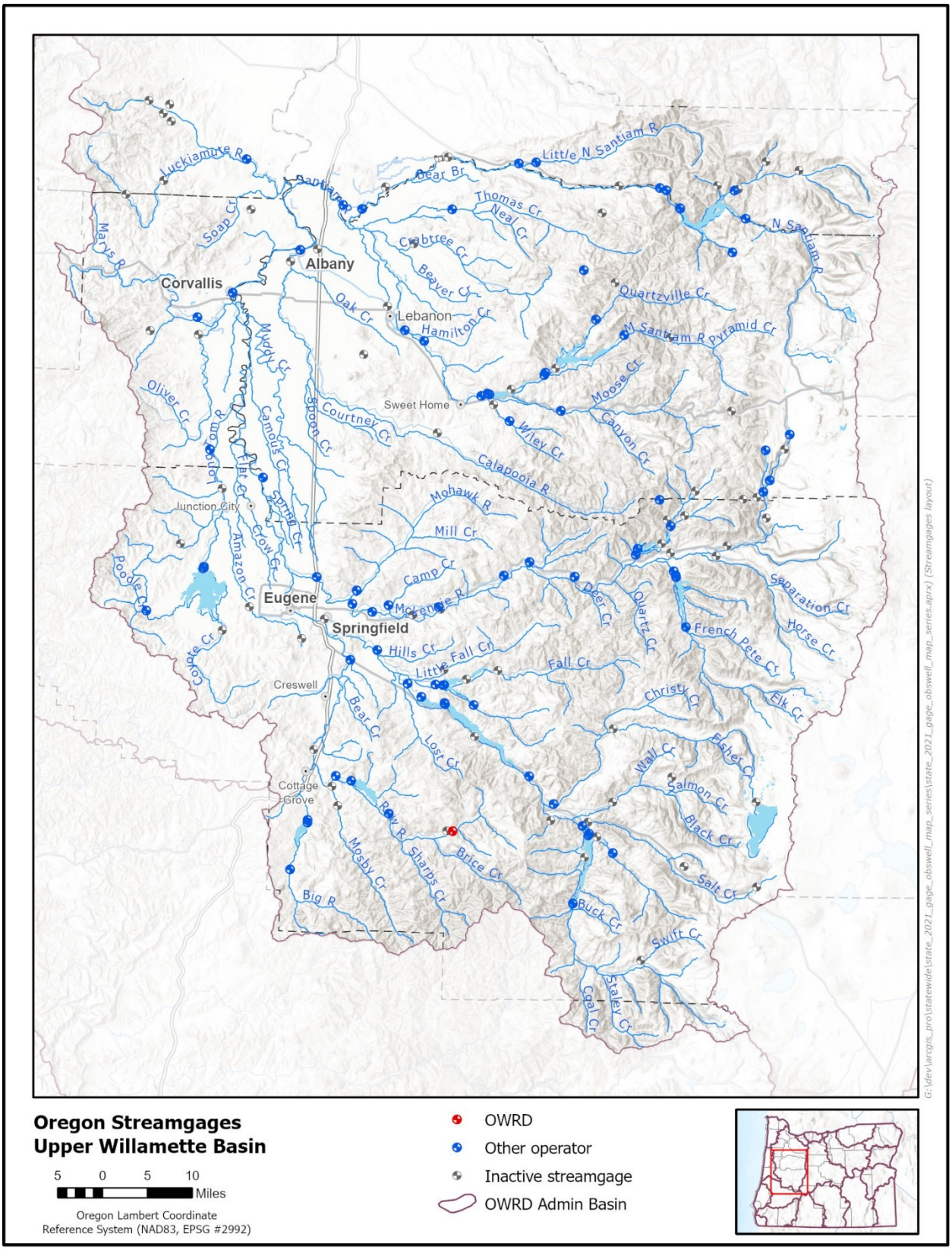
Map 16. Umatilla Basin Stream Gages



Map 17. Umpqua Basin Stream Gages

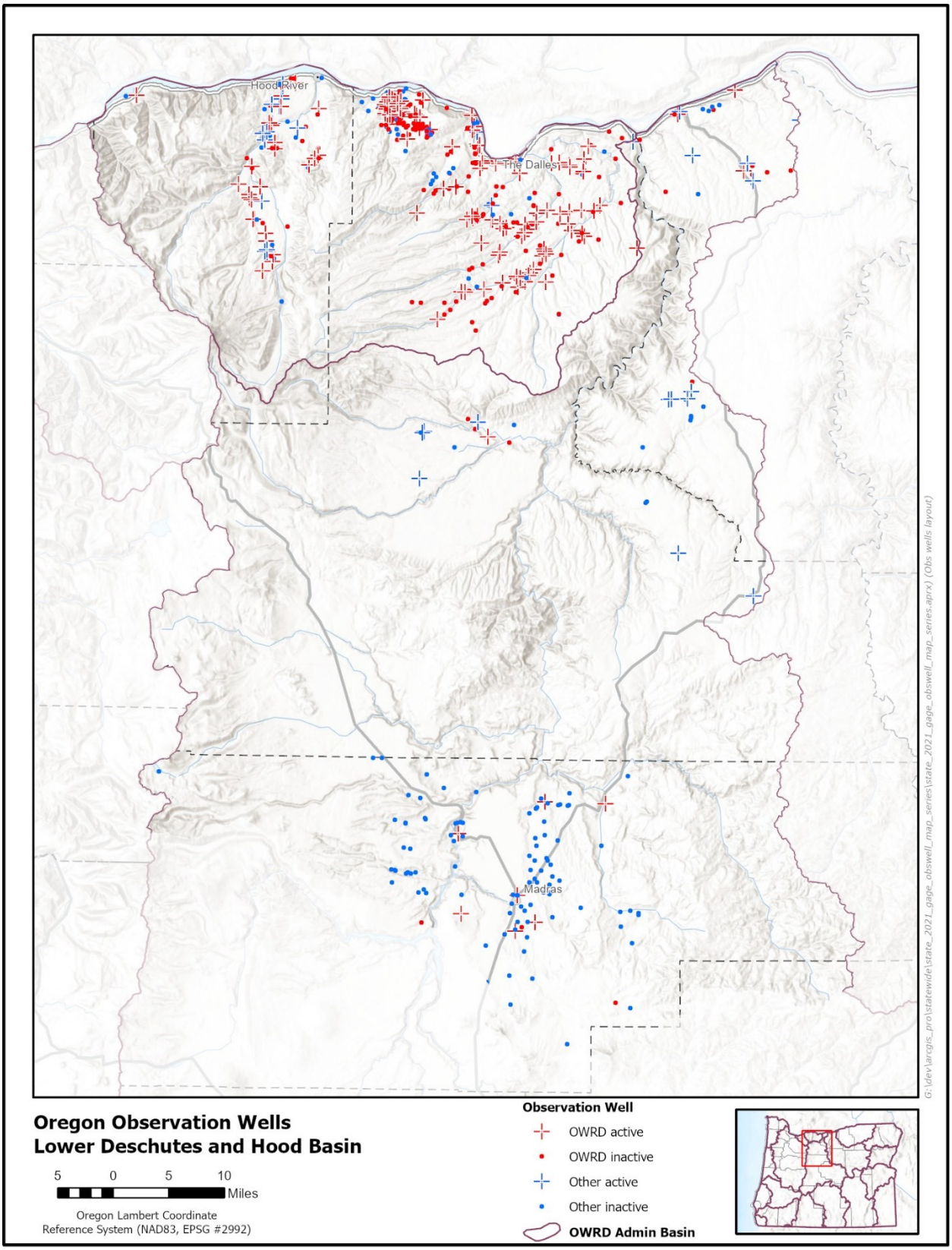


Map 18. Lower Willamette and Sandy Basin Stream Gages

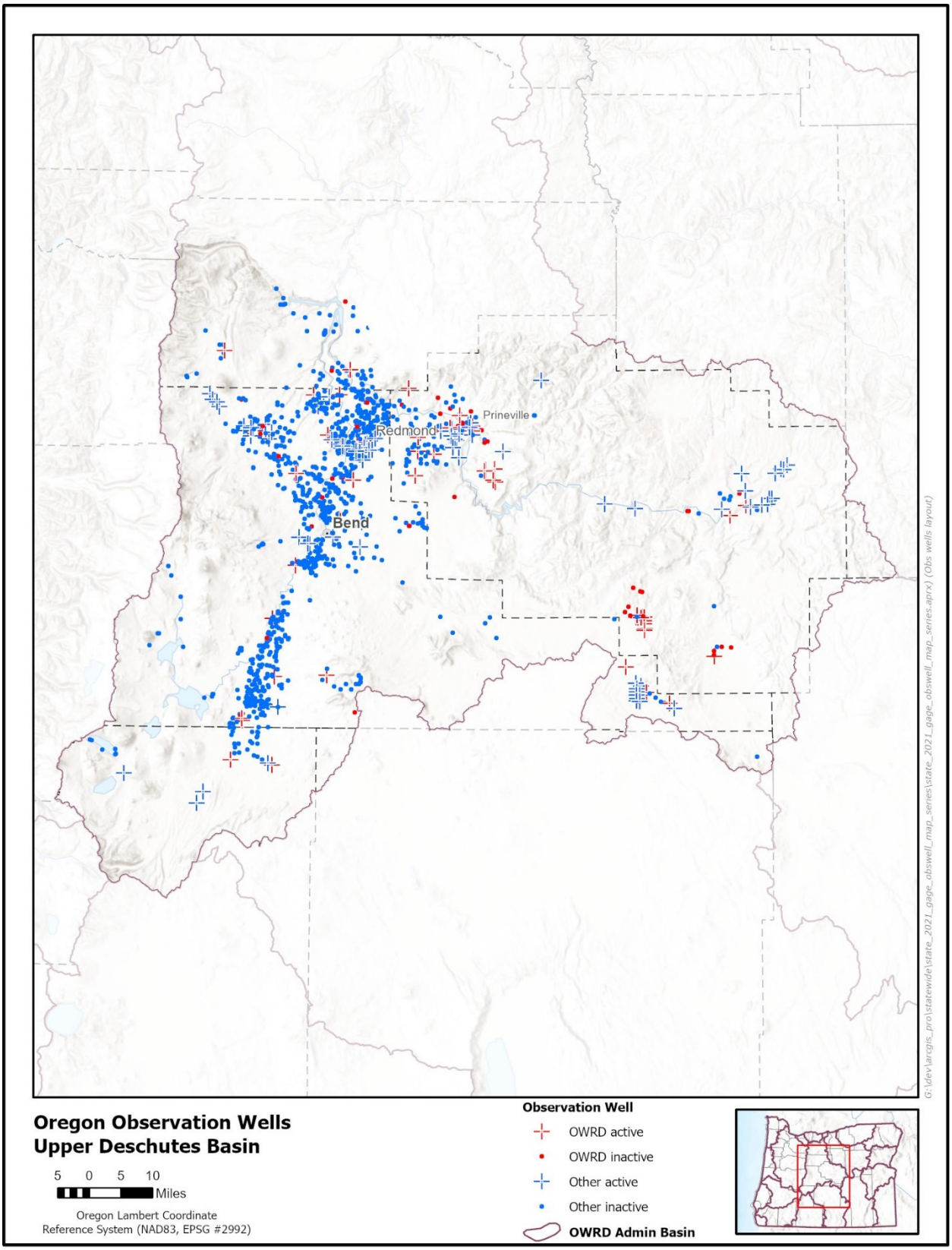


Map 19. Upper Willamette Basin Stream Gages

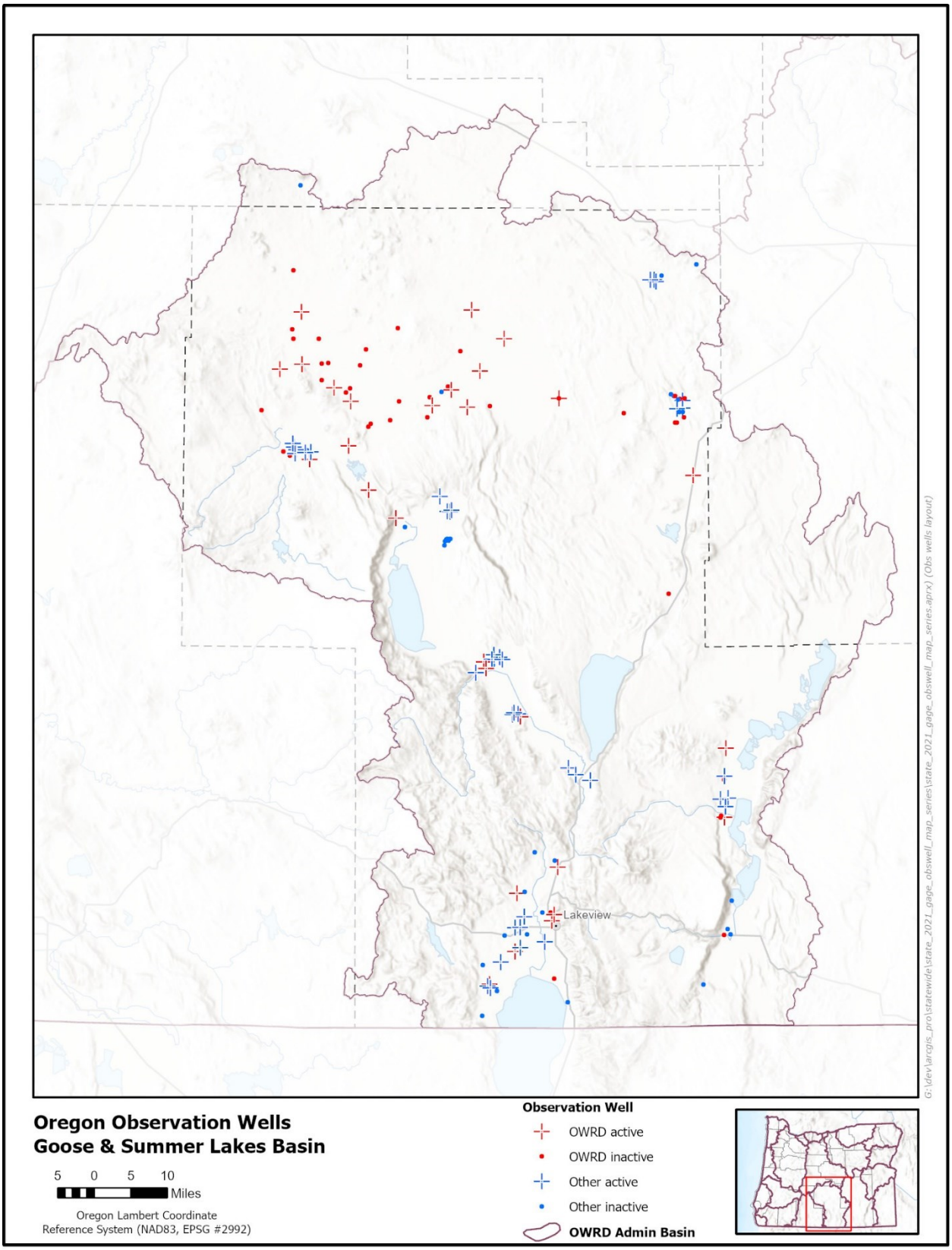
Appendix B: Water Level Observation Wells in Oregon



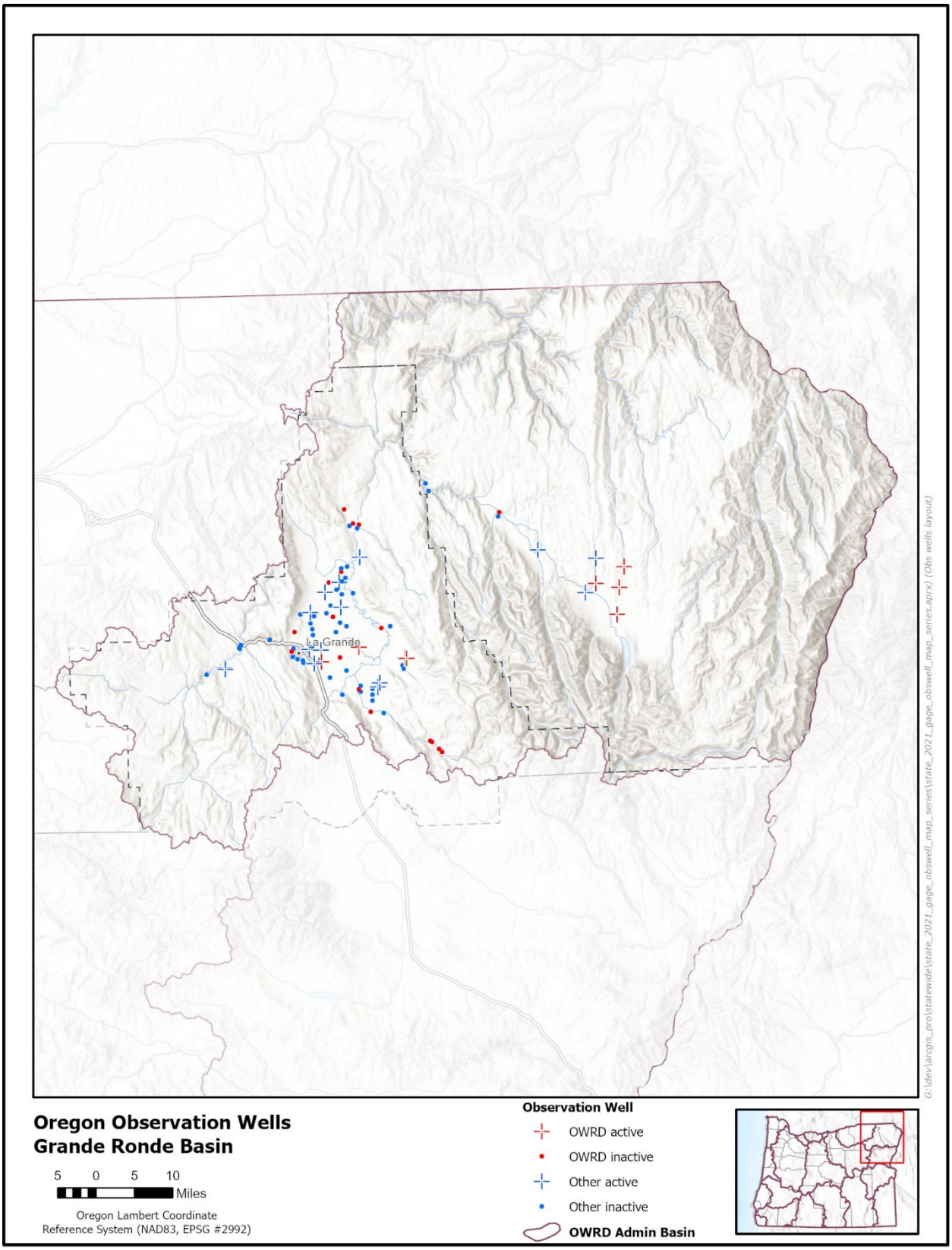
Map 20. Lower Deschutes and Hood Basin Water Level Observation Wells



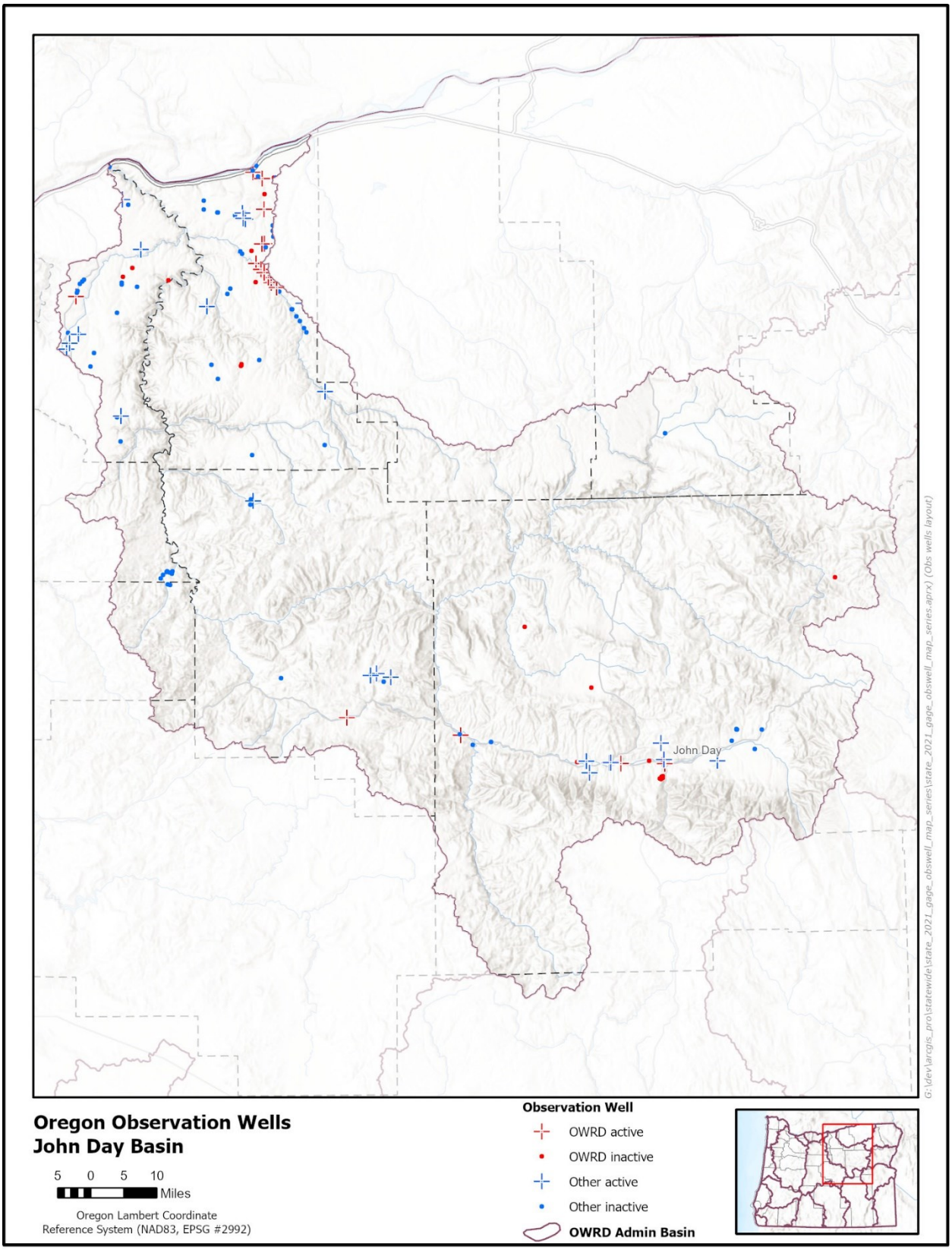
Map 21. Upper Deschutes Basin Water Level Observation Wells



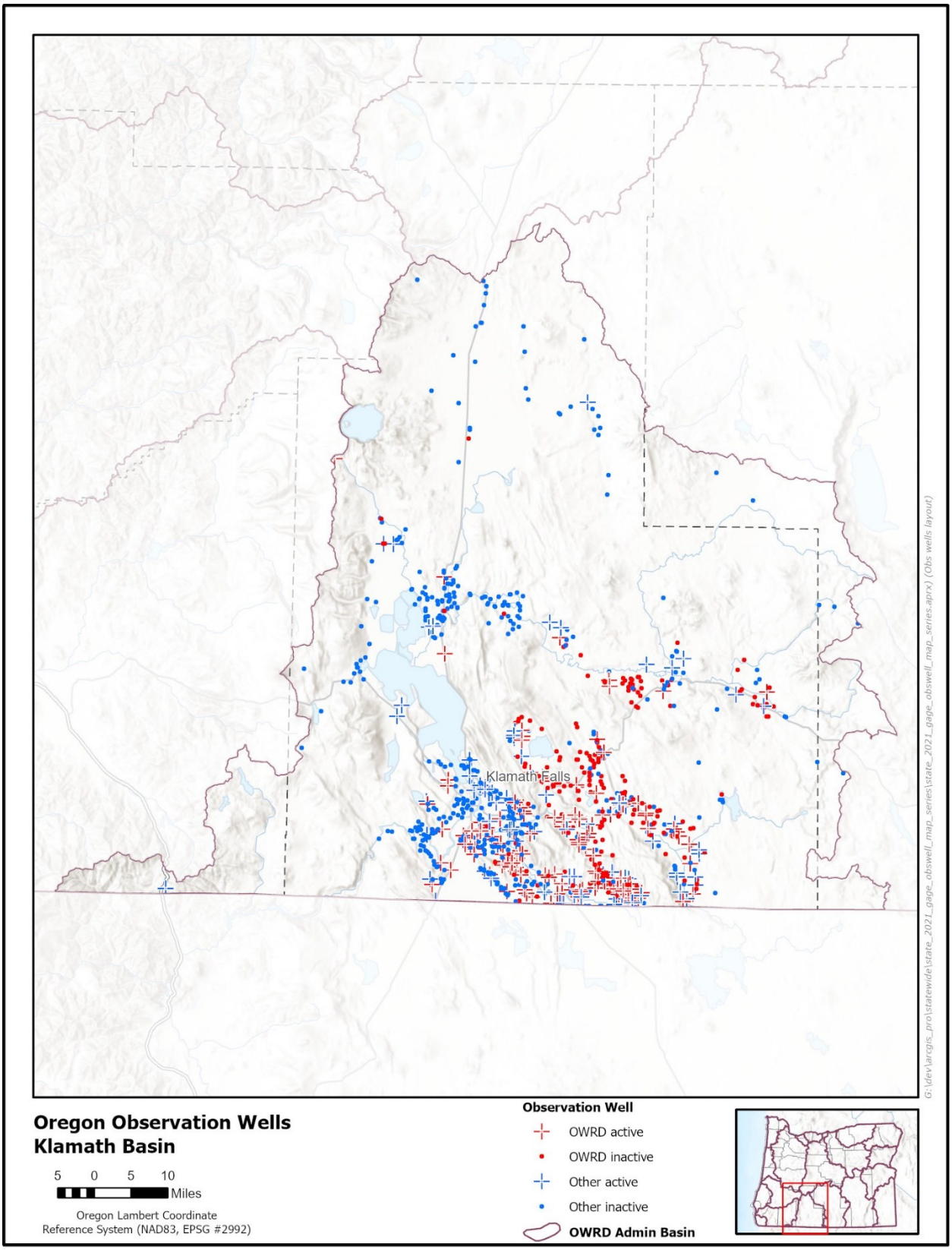
Map 22. Goose and Summer Lakes Basin Water Level Observation Wells



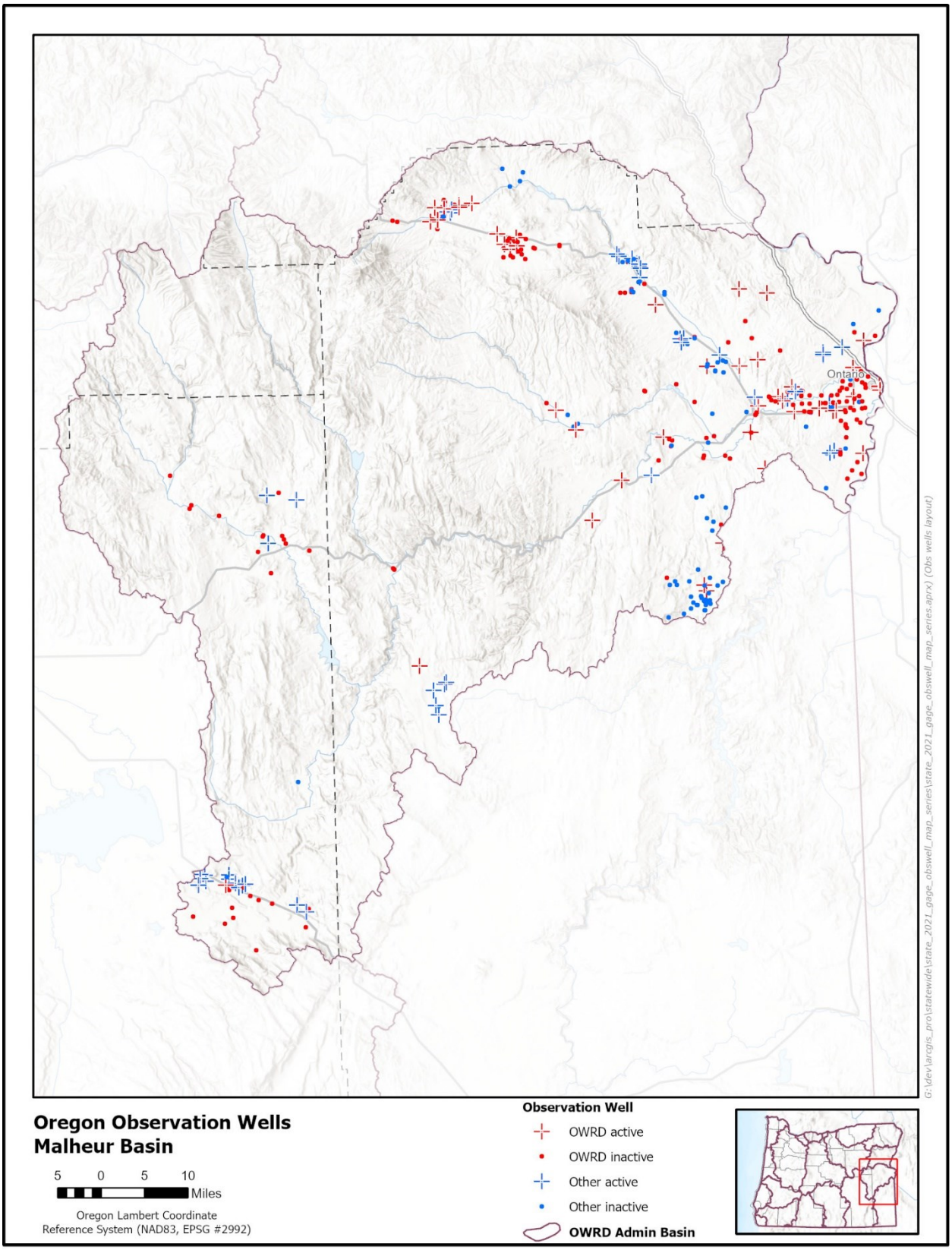
Map 23. Grande Ronde Basin Water Level Observation Wells



Map 24. John Day Basin Water Level Observation Wells

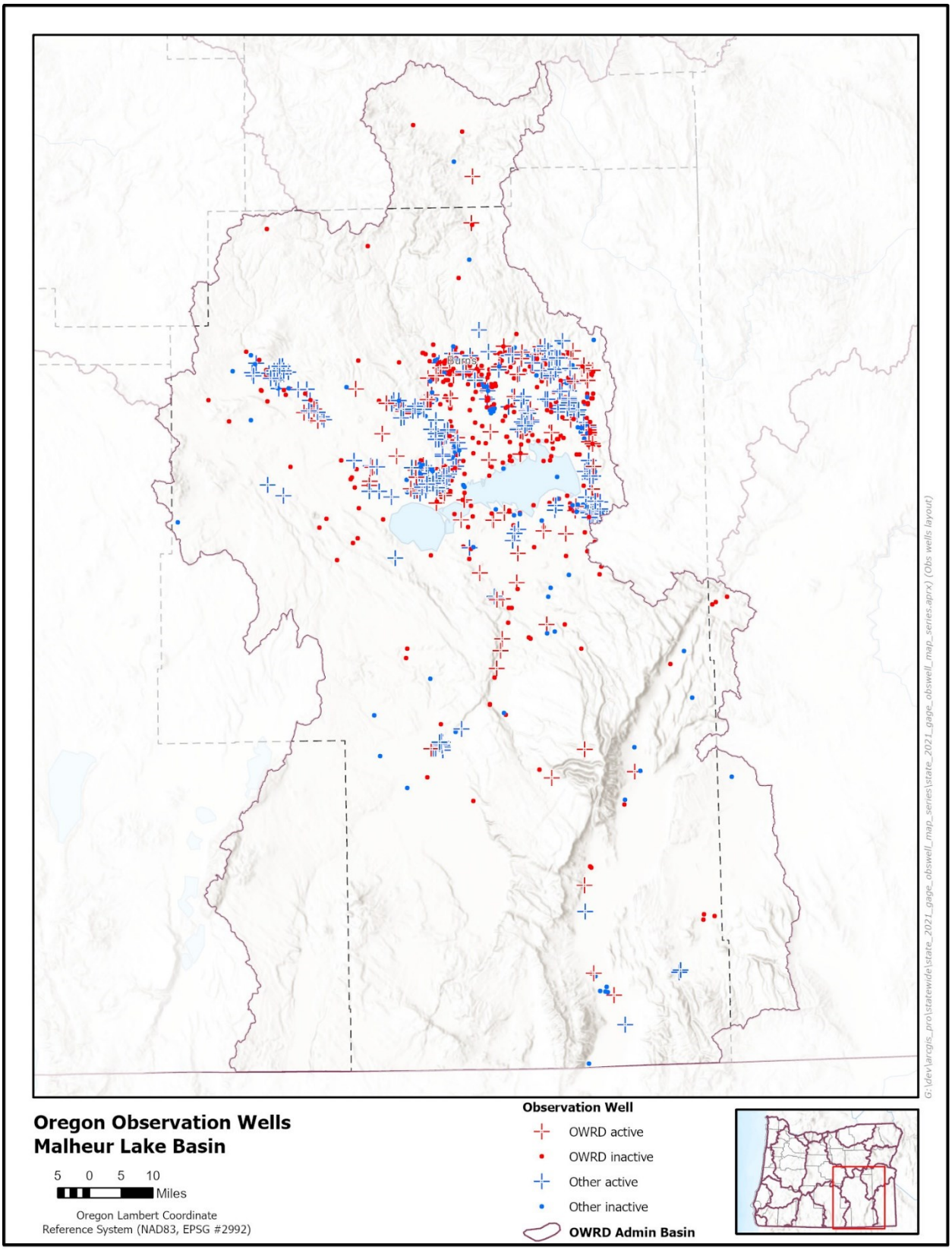


Map 25. Klamath Basin Water Level Observation Wells



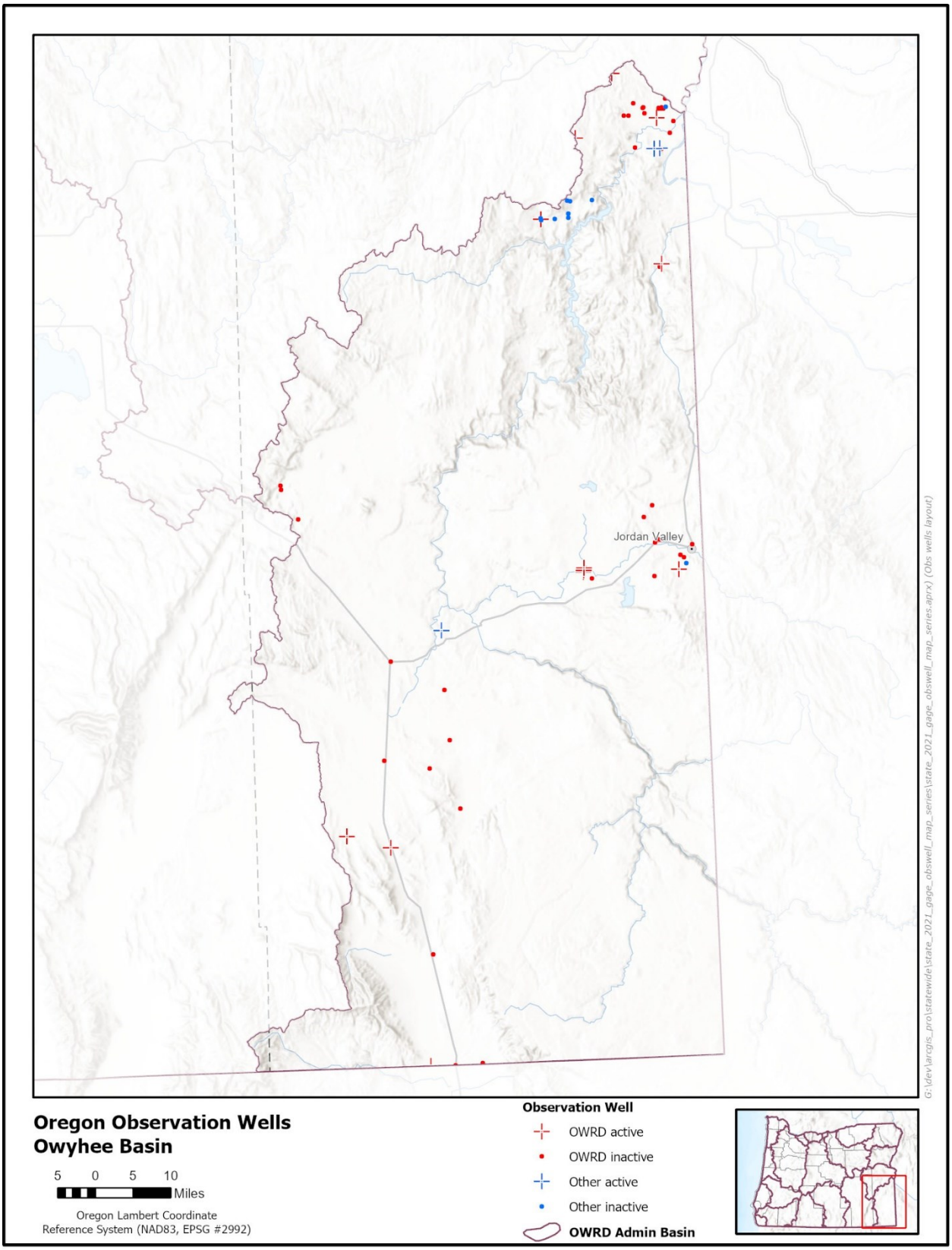
Map 26. Malheur Basin Water Level Observation Wells

Map 27. Mid Coast Basin Water Level Observation Wells

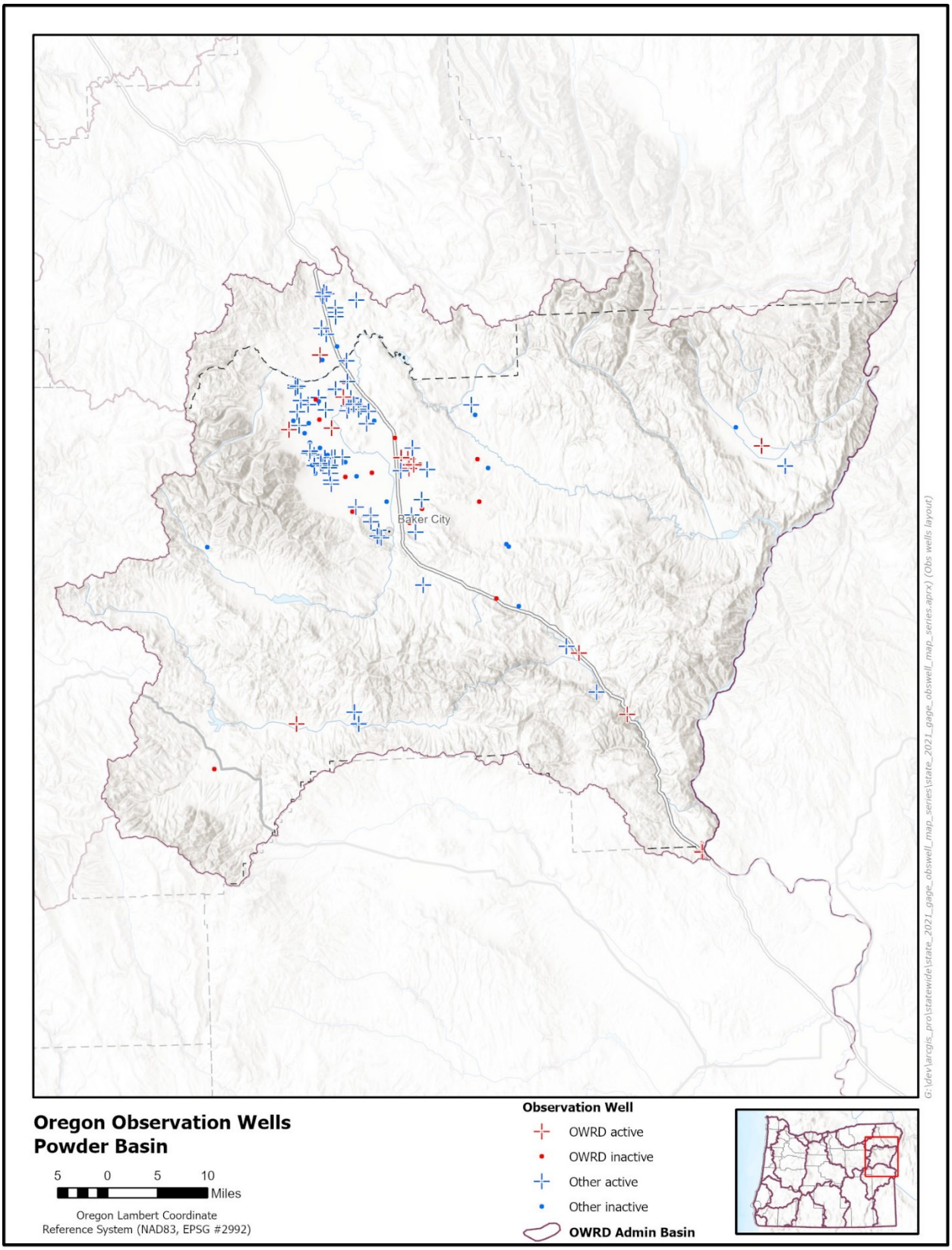


Map 28. Malheur Lake Basin Water Level Observation Wells

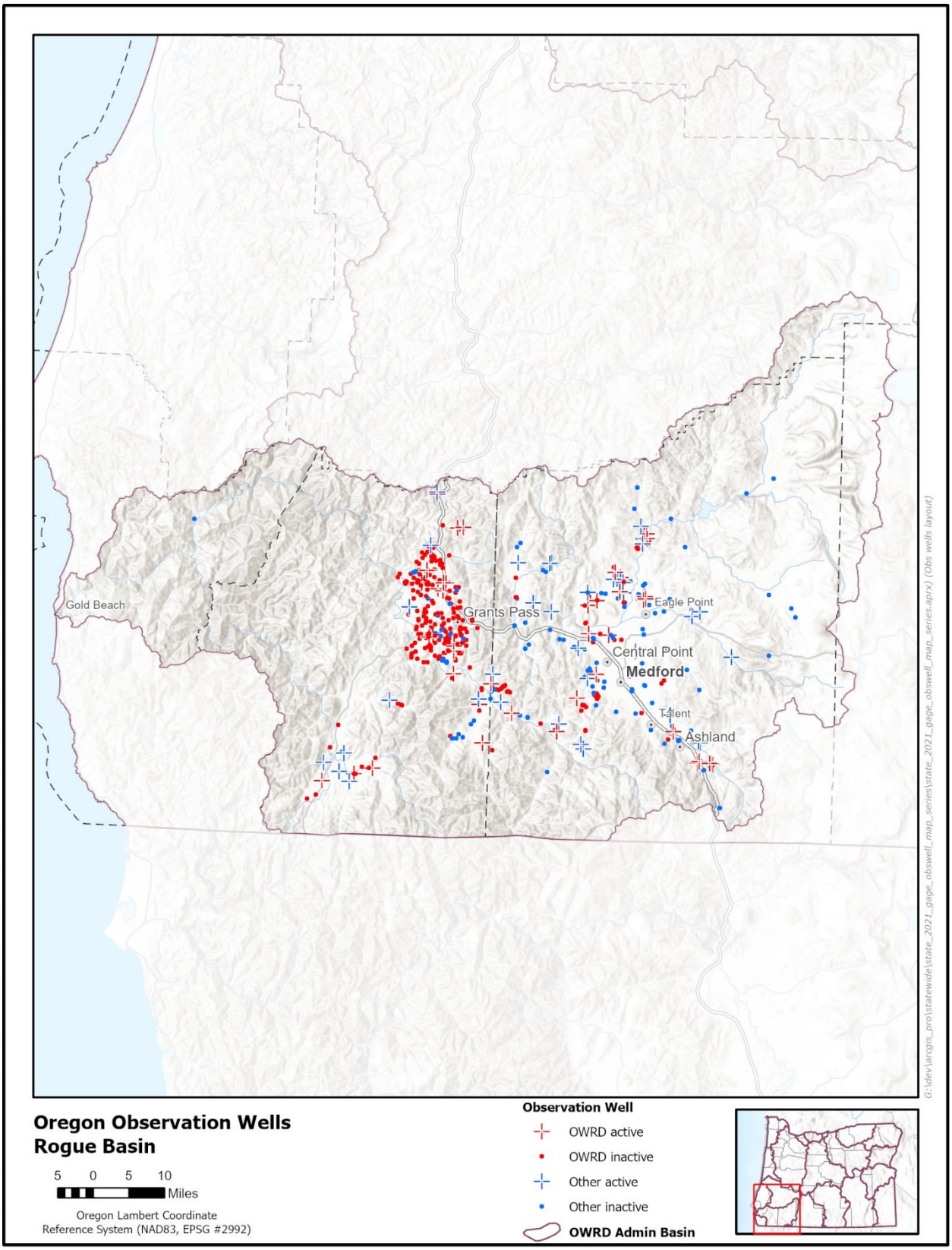
Map 29. North Coast Basin Water Level Observation Wells



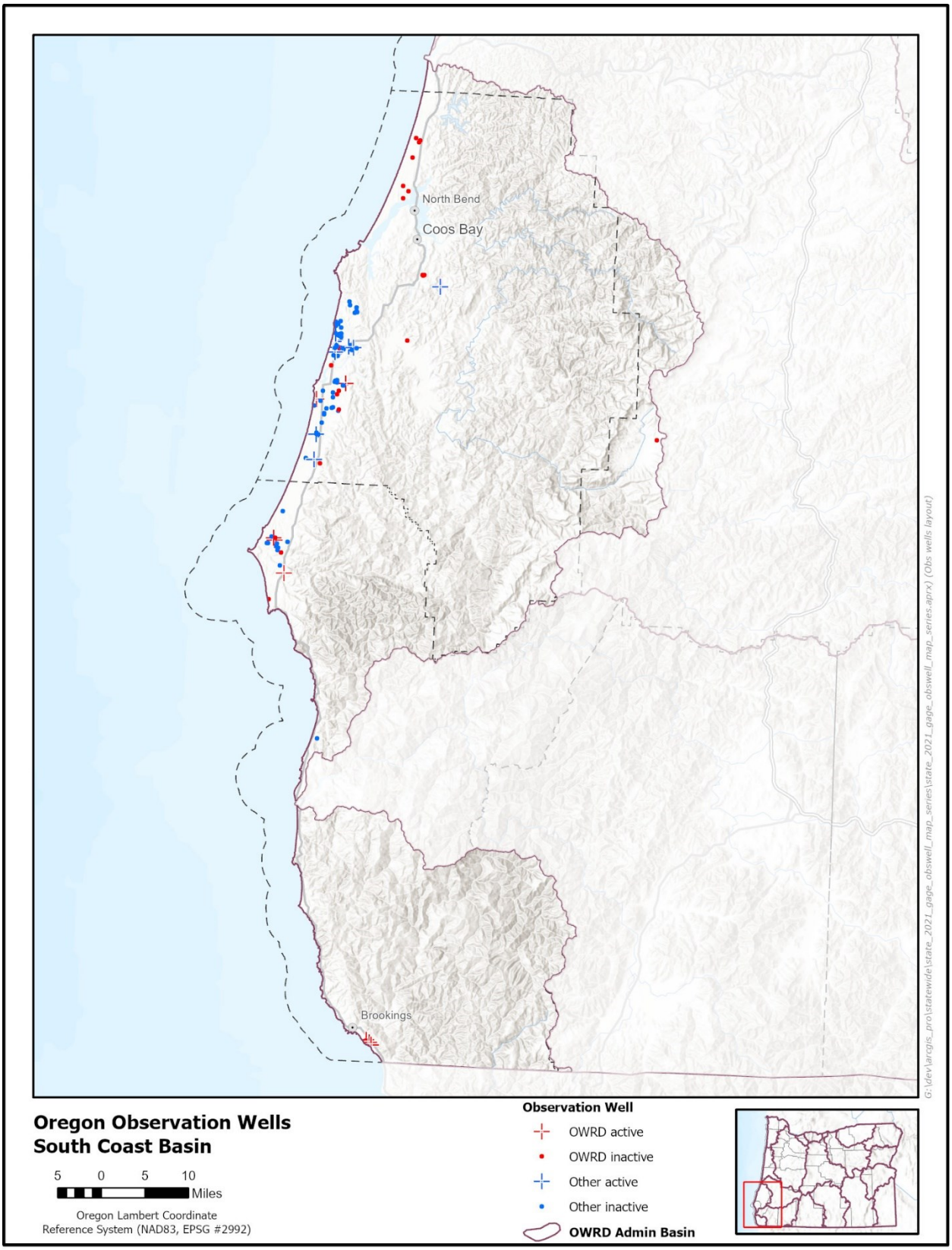
Map 30. Owyhee Basin Water Level Observation Wells



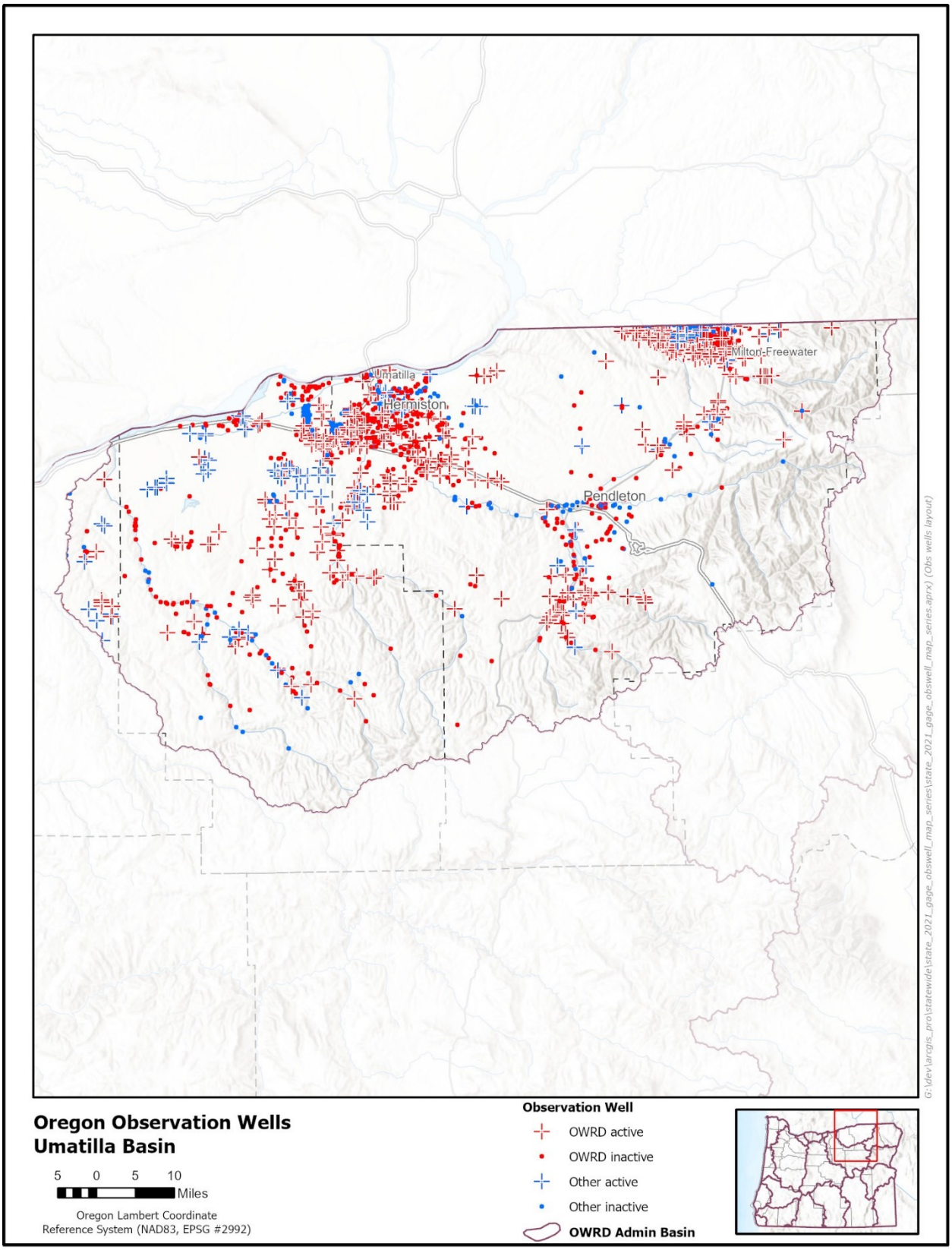
Map 31. Powder Basin Water Level Observation Wells



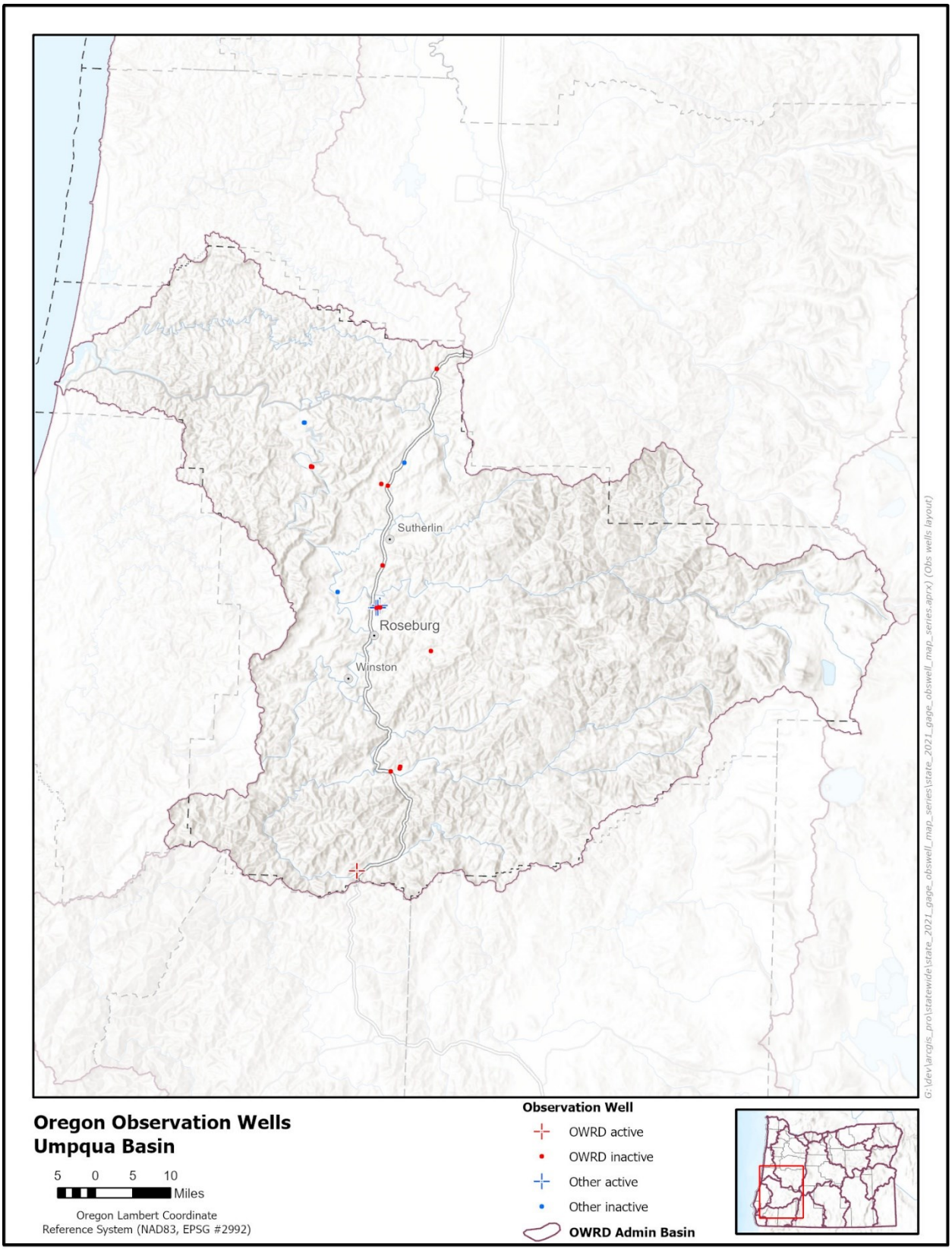
Map 32. Rogue Basin Water Level Observation Wells



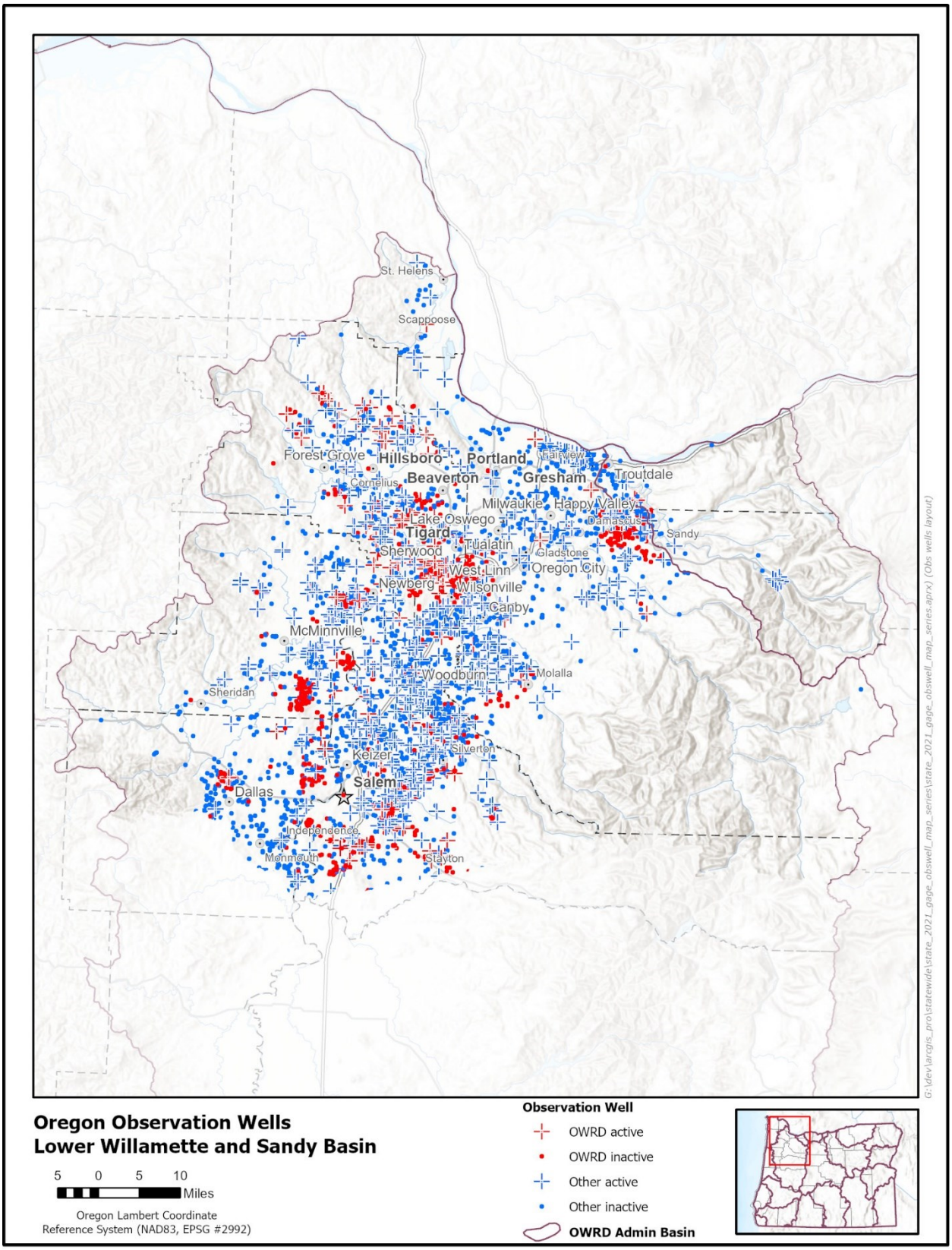
Map 33. South Coast Basin Water Level Observation Wells



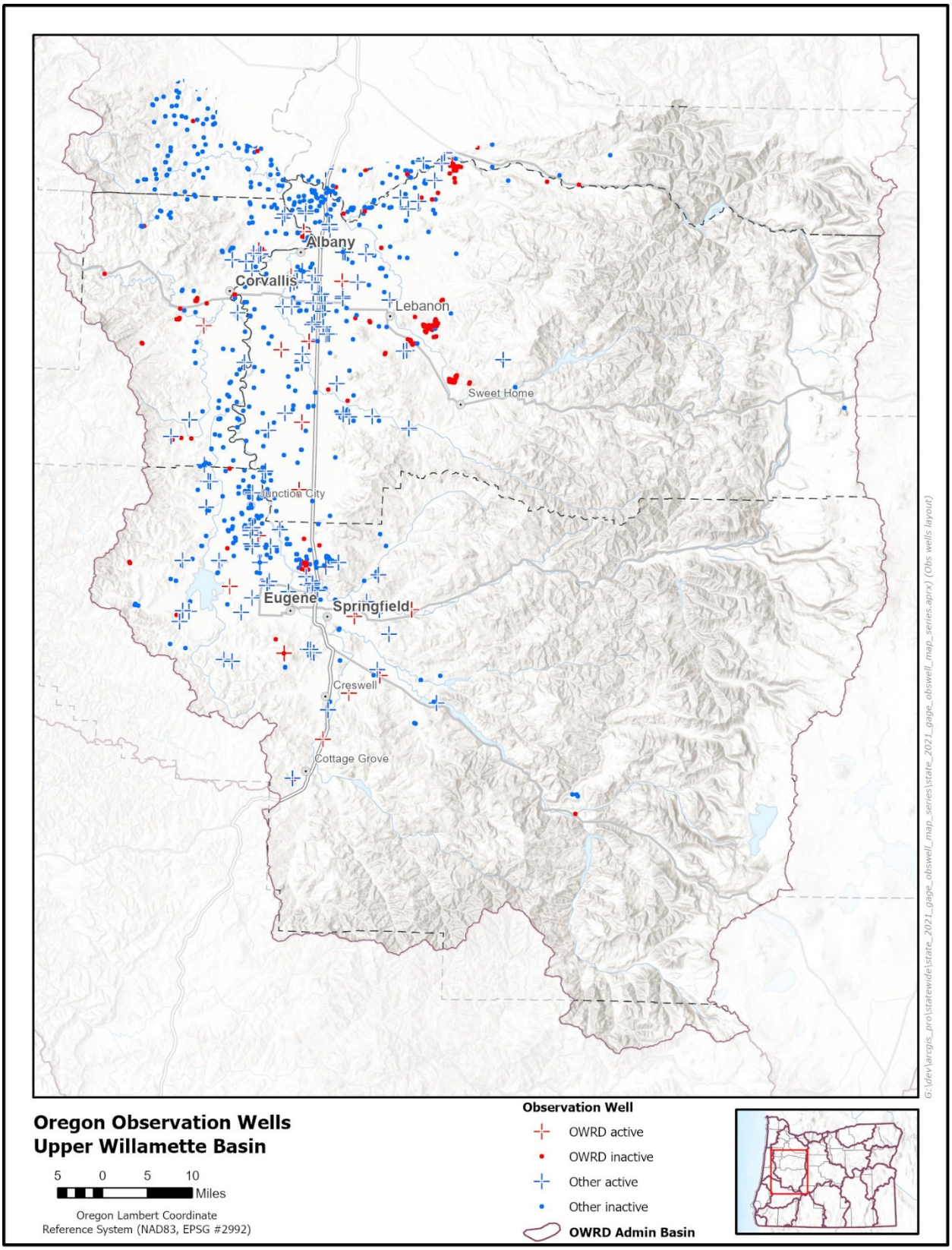
Map 34. Umatilla Basin Water Level Observation Wells



Map 35. Umpqua Basin Water Level Observation Wells



Map 36. Lower Willamette and Sandy Basin Water Level Observation Wells



Map 37. Upper Willamette Basin Water Level Observation Wells