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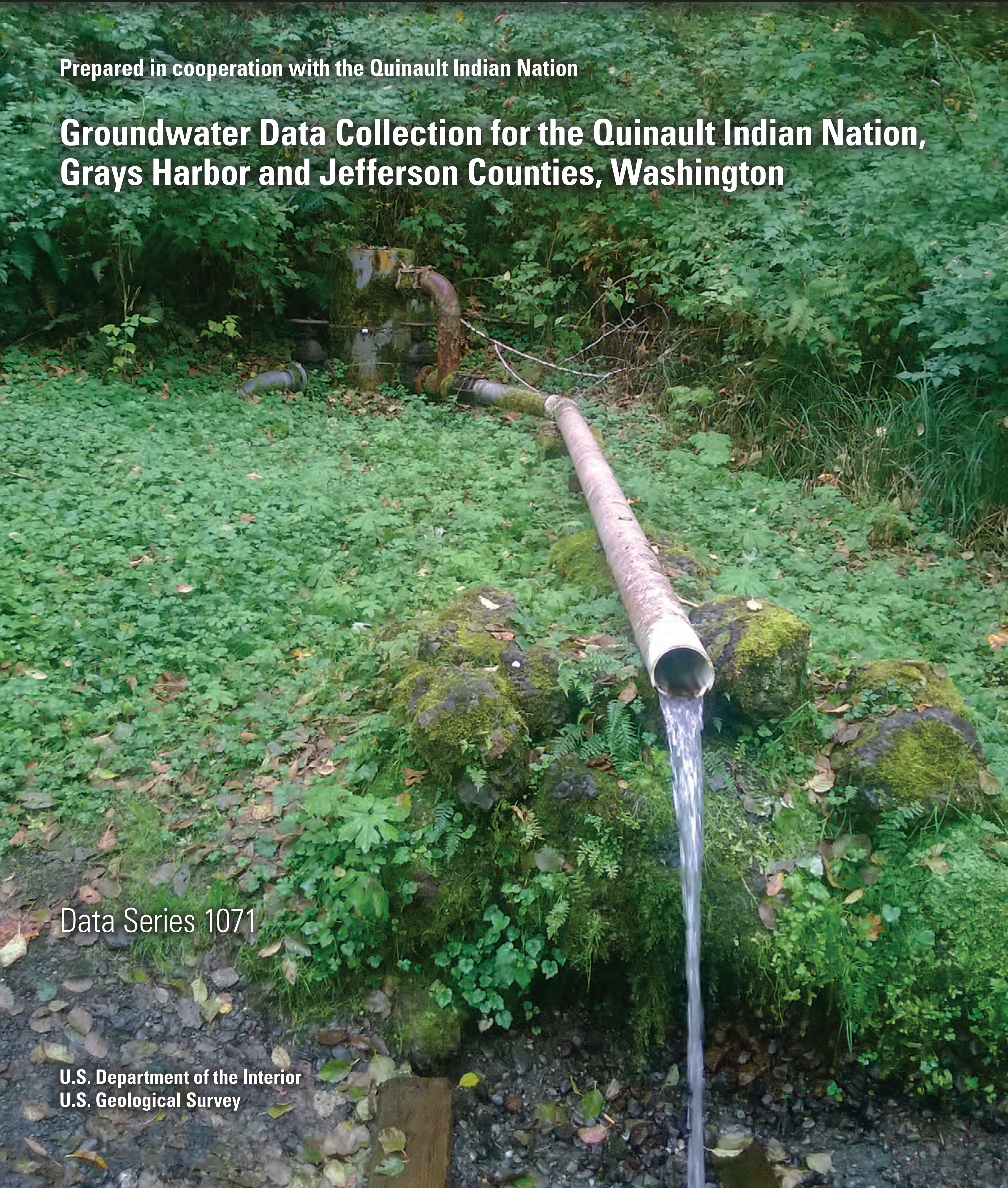
Groundwater Data Collection for the Quinault Indian Nation, Grays Harbor and Jefferson Counties, Washington



Data Series 1071

U.S. Department of the Interior
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Cover: Unnamed spring near Moclips Highway, Quinault Indian Reservation, Grays Harbor County, Washington. Photograph by Elisabeth Fasser, U.S. Geological Survey, October 3, 2016.

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U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
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Contents

Figures

Table

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32.$$

Datums

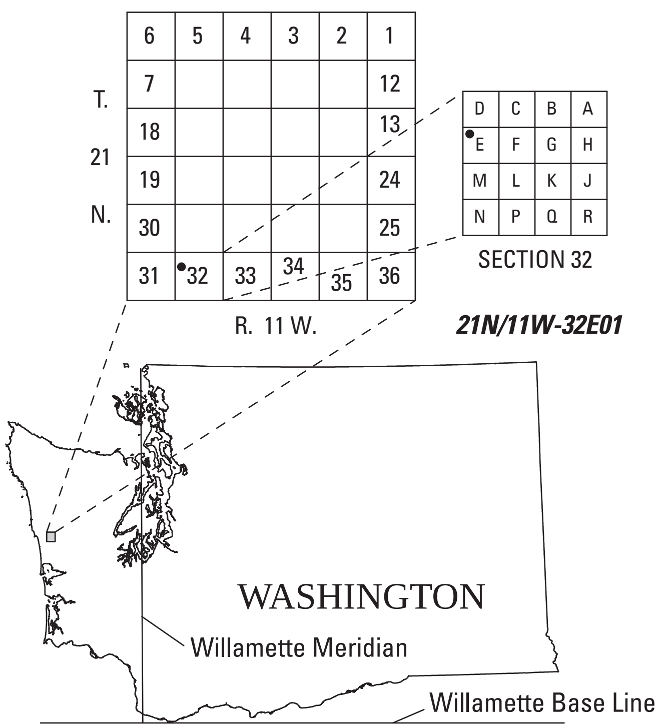
Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Well Numbering System

In Washington, wells are assigned numbers that identify their location in a township, range, section, and 40-acre tract. For example, well number 21N/11W-32E01 indicates that the well is in township 21 north of the Willamette Base Line, and range 11 west of the Willamette Meridian. The numbers immediately following the hyphen indicate the section (32) in the township, and the letter following the section (E) gives the 40-acre tract of the section. The two-digit sequence number (01) following the letter indicates that the well was the first one inventoried in that 40-acre tract. In the illustrations of this report, wells are identified individually using only the section and 40-acre tract, such as 32E01. The townships and ranges are shown on the map borders.



Groundwater Data Collection for the Quinault Indian Nation, Grays Harbor and Jefferson Counties, Washington

By Sue C. Kahle, Elisabeth T. Fasser, and Theresa D. Olsen

Abstract

Groundwater data were collected on the Quinault Indian Reservation to provide the Quinualt Indian Nation (QIN) with basic knowledge of the existing wells and springs on the reservation, and to establish a water-level network to be monitored by QIN to begin building a long-term groundwater dataset. The 327 mi^2 Quinault Indian Reservation is located within the heavily forested Queets-Quinault watershed along the west-central coast of Washington and includes the coastal communities of Taholah and Queets, and the inland community of Amanda Park. Groundwater data were collected or compiled for 87 sites—82 wells and 5 springs. In October 2016, a field inventory was done to locate the sites and acquire site data. Groundwater levels were measured in 15 of the field-inventoried wells and 3 of those wells were observed as flowing (artesian). A monthly groundwater-level monitoring network of 13 wells was established by the U.S. Geological Survey in March 2017, and the network was transferred to QIN in June 2017 for continued measurements.

Several data needs were identified that would provide a more complete understanding of the groundwater system of the Quinault Indian Reservation. The collection of monthly water-level data for multiple years is an important first step in understanding seasonal and long term changes in water levels. Additionally, the collection of baseline groundwater chemistry and quality data across the reservation would help with future efforts to monitor existing and potentially changing groundwater quality conditions. Development of a water budget of the Queets-Quinault Watershed and the reservation within that area would provide water users with a better understanding of this important resource and provide needed information about the competing demands on local water sources.

Introduction

The Quinault Indian Reservation is located along the west-central coast of Washington State (fig. 1). The reservation includes 23 mi of Pacific Ocean coastline and coastal communities of the Quinault Indian Nation (QIN), including Taholah and Queets. Healthy streams and groundwater supplies are vital to the wellbeing of the QIN. Groundwater is the sole source of fresh drinking water on the reservation, and is supplied from community or single-family wells. Groundwater also helps sustain summer streamflows on the reservation that are essential for salmon. Before this study, groundwater levels were not being monitored routinely.

Climate change can directly affect groundwater throughout the watershed, and is particularly worrisome in vulnerable coastal aquifers (Snover and others, 2013). The Queets-Quinault watershed has already experienced a significant loss of glaciers, and snowmelt is the primary source of streamflow and groundwater recharge throughout most of the watershed. During low snow years such as 2015 with typically higher than normal temperatures, the reduced snowpack results in declines in groundwater recharge and summer/fall streamflow. Any coincidental increases in winter rainfall will be unable to sustain summer and fall streamflows that are already affected by reduced snowpacks in the headwaters of the Queets-Quinault watershed. The effects of climate change may also include changing patterns in precipitation, sea level rise, and saltwater intrusion in coastal aquifers.

Streamflow is monitored by U.S. Geological Survey (USGS) at three sites on the Queets and Quinault Rivers (fig. 1). The QIN is pursuing collection of groundwater data to obtain baseline information that will help with future efforts to monitor trends in groundwater conditions and to augment hydrologic data on the reservation. Monitoring groundwater levels in conjunction with streamflow is necessary to understand groundwater and surface-water interactions, such as sustenance of summer stream flows while maintaining adequate drinking water supplies.

The QIN requested that the USGS conduct an initial groundwater study with the primary goal of making an inventory of the existing water wells on the reservation and to assist in the development of a groundwater-level monitoring network. This work is intended to be followed by subsequent studies that would provide additional information to more fully characterize the groundwater system of the reservation.

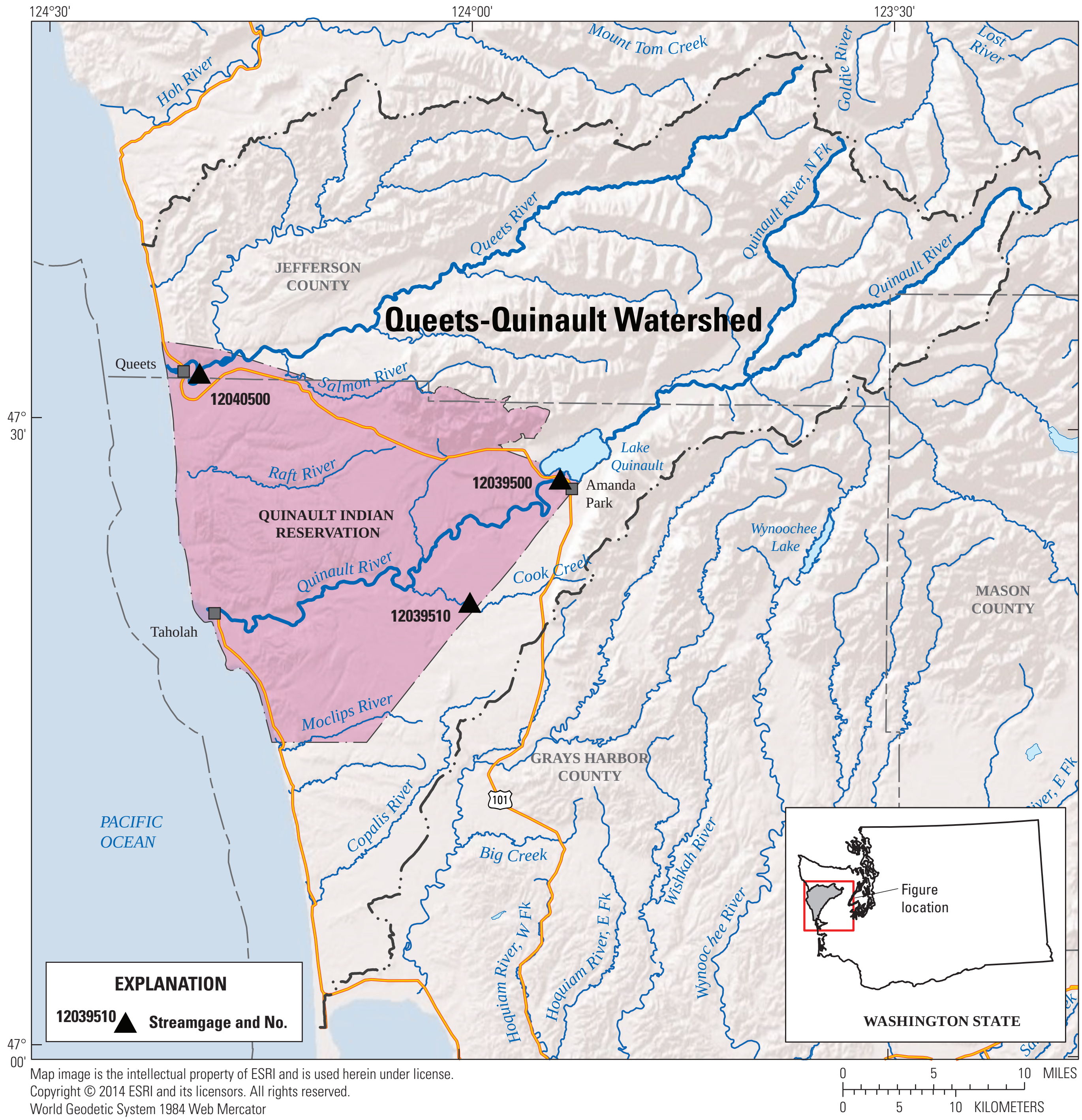


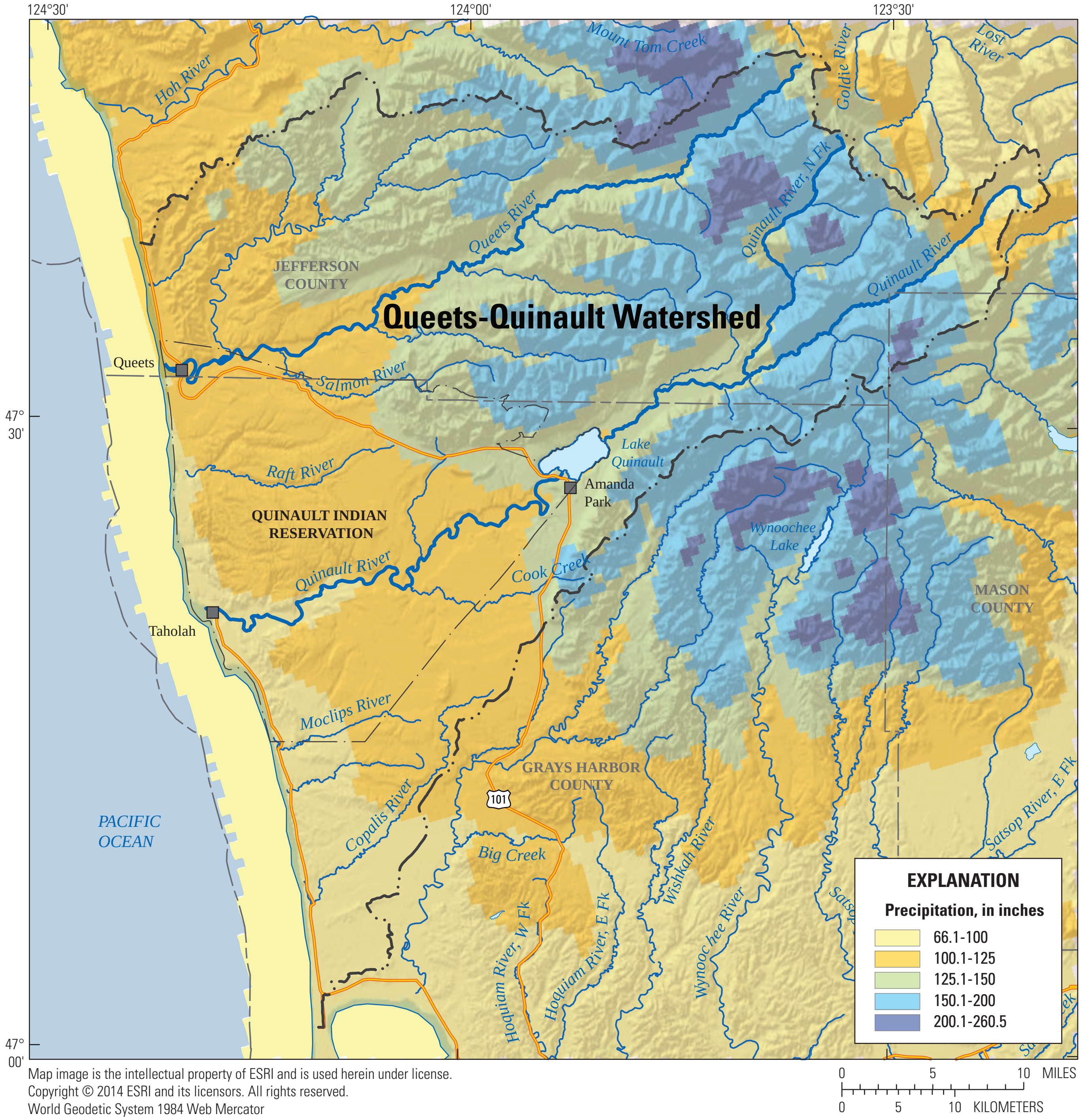
Figure 1. Location of the Quinault Indian Reservation and U.S. Geological Survey streamgages, Grays Harbor and Jefferson Counties, Washington.

Purpose and Scope

The purpose of this report is to describe the results of the groundwater data collection on the Quinault Indian Reservation in 2016 and 2017. The topics covered in this report include introductory and background information, and a description of the process and methods of the initial field well inventory, and subsequent monthly groundwater level measurements. Specific products of this report include maps of the well locations, average annual precipitation, and simplified surficial geology, and a table of selected physical and hydrologic data for the project wells.

Description of Study Area

The 327 mi² Quinault Indian Reservation is located within the heavily forested Queets-Quinault watershed along the west-central coast of Washington (fig. 1). The easternmost part of the reservation includes Lake Quinault, a glacial-moraine-dammed lake, which separates the upper and lower reaches of the Quinault River (fig. 1). The lower Quinault River flows southwest across the entire reservation from the outlet of Lake Quinault to the Pacific Ocean. The Raft River flows west across the northern part of the reservation, whereas the Queets, Salmon, and Moclips Rivers cross only parts of the reservation (fig. 1). The terrain is mountainous and altitudes range from more than 2,700 ft in the northeastern most part of the reservation down to sea level at the coast. Average annual precipitation is high and ranges from 66 in. near the coast to more than 150 in. near Lake Quinault (fig. 2).



World Geodetic System 1984 Web Mercator

Figure 2. Average annual precipitation for the Queets-Quinault watershed, Washington.

The geologic units in the study area are mostly Tertiary volcanic (Tv) and marine sedimentary (Tm) rocks overlain by a veneer of much younger Pleistocene alpine glacial drift (Qad) and Quaternary alluvium (Qa). The geologic map of the study area was compiled from the digital geologic map database (1:500,000 scale) for Washington (fig. 3; Schuster, 2005).

Previous Investigations

Seawater intrusion into coastal aquifers of Washington was first addressed on a regional basis by Walters (1971), for conditions from 1966 through 1968, and later by Dion and Sumioka (1984), for conditions in 1978. Other investigations related to groundwater on or near the Quinault Indian Reservation, are mostly limited to water supply for the town of Taholah. The water-supply studies convey the difficulty in finding freshwater (non-saline) sources of drinking water in the nearshore location of Taholah where shallow wells are often influenced by seawater intrusion and deeper wells reportedly have poor water-quality and (or) low yields (Drost, 1985).

The USGS conducted limited monitoring in 1979 to evaluate saltwater intrusion in Taholah (Drost, 1985), as the community of Taholah, the headquarters of the QIN, was growing and the demands for good quality water for domestic and commercial use were increasing. In 1978 the QIN drilled two wells (21N/13W-1C01 and 1C02; table 1 and fig. 4) to provide additional water sources for growth. However, within hours of pumping, a salty taste in the water was detected and follow up testing indicated high chloride concentrations. The subsequent USGS study involved installing test holes and monitoring water levels and chloride concentrations during a tidal cycle to determine the depth and source of the seawater intrusion.

The identification of reliable sources of good quality water was further investigated by Stay (1988). His work identified three major sources of water with advantages and disadvantages of each, as well as estimates of operation and maintenance of each source. These recommendations included the continued use of springs (21N/13W-01J05S1, -01J06S2, 01J07S3; table 1 and fig. 4), as Taholah's principle water source, creating an infiltration gallery adjacent to the river, and the drilling of additional wells in more optimal locations.

In the early to mid-1990s, Robinson and Noble, Inc., investigated potential new sources of drinking water for Taholah and described their findings in two engineering reports (Robinson and Noble, Inc., 1994, 1995). Through installation and testing of new wells, Robinson and Noble, Inc. described water-bearing and water-quality potential, as well as limitations, at various well sites. In the early 2000s, Robinson and Noble, Inc. contracted and supervised the drilling and testing of several supply wells in the new Moclips River Estates southeast of Taholah (Robinson and Noble, Inc., 2003, 2005).

Effects of climate change including sea-level rise, storm surge, and changes in amount and timing of precipitation have been described in various documents. Snover and others (2013) summarized research since 2007 and prepared a state of knowledge report about the likely effects of climate change on Washington and the Pacific Northwest. The National Research Council (2012) reported on trends and uncertainties associated with sea-level rise, and extrapolated recent data into the future for coastal Washington, Oregon, and California. They also noted that sea level at any given place and time depends on the global sea level and the net contribution of atmospheric, oceanographic, geologic, and anthropogenic processes operating in the area. Huppert and others (2009) describe the effects of climate change on the coasts of Washington and noted stressors including inundation of low-lying areas by high tides as sea level rises; flooding of coasts during major storm events, especially near river mouths; accelerated erosion of coastal bluffs; and saltwater intrusion into coastal freshwater aquifers. Mote and others (2008) provide a summary and calculations of sea-level rise projections for the coastal waters of Washington based on four main forces, (1) thermal expansion of the ocean; (2) melting of land-based ice; (3) local changes in wind, which push coastal waters toward or away from shore; and (4) local movement of the land itself, due primarily to tectonic forces.

Walsh and others (2000) developed a tsunami hazard map of the southern Washington coast based on simulated tsunami inundation from a Cascadia Subduction Zone earthquake. Although the map was prepared to aid local governments in designing evacuation or relocation plans for areas at risk from potentially damaging tsunamis, it is also helpful to identify areas where existing water wells might be inundated with sea water during such an event.

World Geodetic System 1984 Web Mercator

0 5 10 MILES
0 5 10 KILOMETERS

EXPLANATION

Geologic unit

Qa	Quaternary alluvium
Qls	Quaternary mass-wasting deposits
Qgd	Quaternary continental glacial drift
Qad	Quaternary alpine glacial drift
QTc	Quaternary-Tertiary continental sedimentary rocks and deposits
Tn	Tertiary near-shore sedimentary rocks
Tm	Tertiary marine sedimentary rocks
Tv	Tertiary volcanic rocks
Tv(c)	Tertiary volcanic rocks, Crescent Formation
Ti	Tertiary intrusive rocks
ice	Ice
wtr	Water body

Figure 3. Geologic units of the Queets-Quinault watershed, Washington.

Groundwater Collection Methods

Available groundwater records were compiled and evaluated to plan and conduct field inventory of wells and springs on the Quinault Indian Reservation. The records included drillers' logs, historical groundwater levels, and geologic maps; and available groundwater level and spring records. During the field inventory, wells and springs were located, and the depth to water in wells was measured depending on accessibility. Based on available wells with measurable water levels, a monthly groundwater-monitoring network was established and QIN personnel were trained to monitor the groundwater network.

Available well and spring records were compiled and sites were located in the field during autumn 2016. Well selection was generally based on the availability of a drillers' report for the well (obtained from the Washington Department of Ecology or other sources), the availability of lithologic and construction information on the drillers' report, and permission from the owner or tenant to visit the site. At the time of inventory, the groundwater level was measured if feasible and a field form was completed noting the location, well construction information, and water level at each site. The depth to water in wells was measured using tape-down procedures. The documentation of technical procedures for groundwater data-collection activities is contained in the USGS Techniques and Method report 1-A1 "Groundwater Technical Procedures of the U.S. Geological Survey" (Cunningham and Schalk, 2011). This report provides detailed, illustrated instructions for the implementation of common field methods for collecting groundwater data. Global Positioning System (GPS) hand-held units were used during the inventory to determine the latitude and longitude of each site with a horizontal accuracy of one-tenth of a second (about 10 ft). Land-surface altitude for each well and spring was obtained from a digital elevation model with 10-m square cells using the latitude and longitude for each site. All water-level measurements were measured by USGS personnel according to standardized techniques of the USGS (Cunningham and Schalk, 2011; Kozar and Kahle, 2013). Information for all sites (wells and springs) was entered in the USGS National Water Information System database (https://waterdata.usgs.gov/).

Water levels in wells were measured with steel tapes or electronic tapes. If the tape required a correction based on an accompanying calibration table, the correction was noted on the field sheet. All measurements were confirmed—taken twice, with at least 3–5 minutes between measurements. The confirmation measurement needed to be within 0.02 ft to be considered a static water-level measurement. If the initial measurements were not in agreement, additional measurements were made until the water level status was determined (for example, recovering or pumping).

The location of wells and springs as determined by GPS were documented with latitude and longitude values reported in ddmmss.ss (degrees, minutes, seconds). The latitude and longitude were read and recorded on the field sheet after water-level measurements were completed, to give sufficient time for GPS readings to stabilize. Values between the GPS unit and the field sheet were double-checked before departing the site. A sketch map showing location of the well or spring was made on the field sheet. This map is intended for future visits and can include measured distances (vehicle odometer) from road intersections and estimated or paced distances from identifiable site features (such as, buildings, driveways, creeks, or fences).

All hydrologic data collected during this study was compiled and entered into the USGS National Water Information System (NWIS) database (https://waterdata.usgs.gov/). Geospatial data was compiled and entered in a newly created Geographic Information Systems (GIS) database for the project.

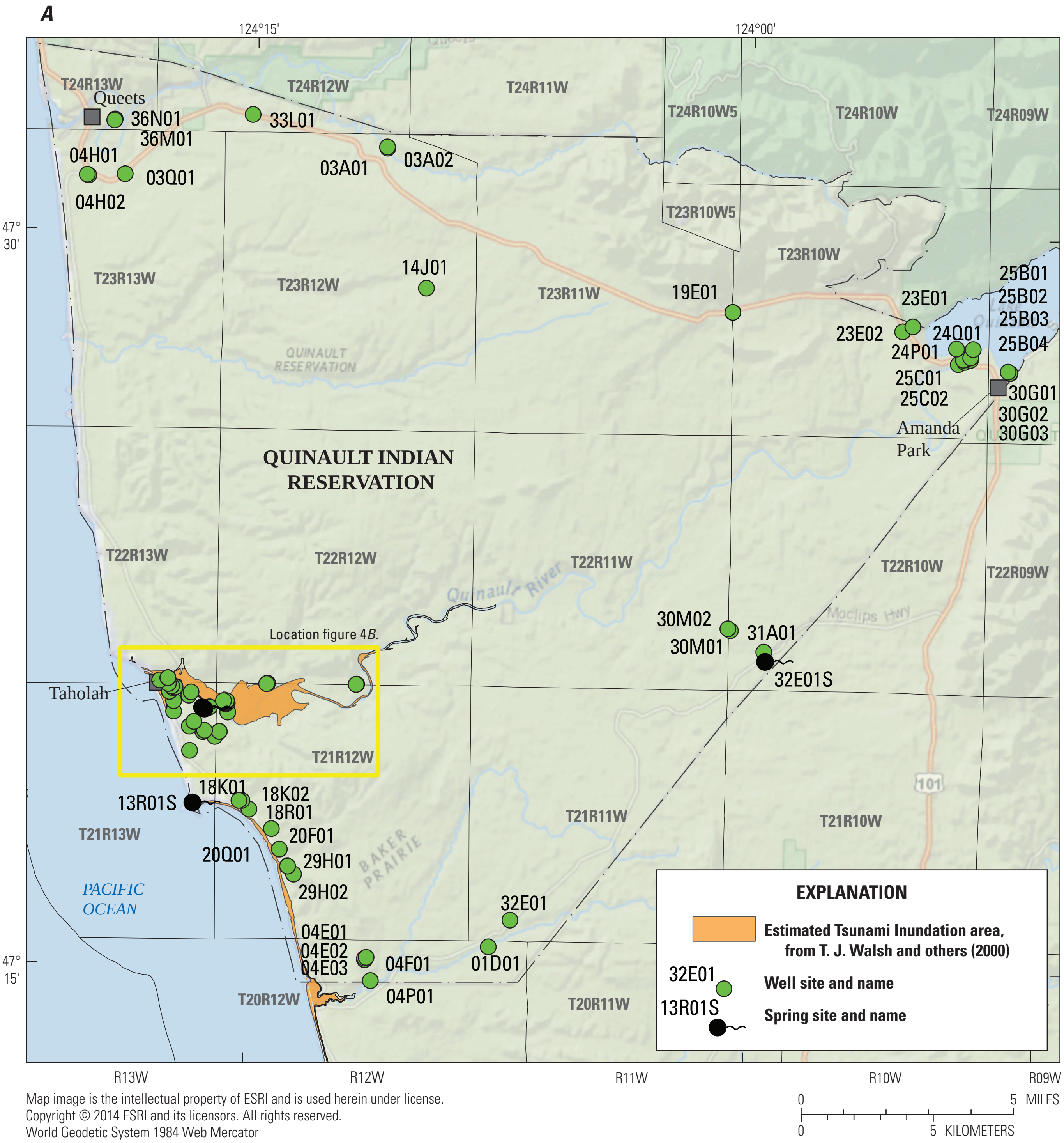
Data Collection Results

The primary components of this investigation—a field inventory of wells and springs, establishing a monthly water-level network and the training of QIN personnel to maintain the network, and the identification of data gaps that would need to be addressed to fully characterize the groundwater system are described below.

Field Inventory

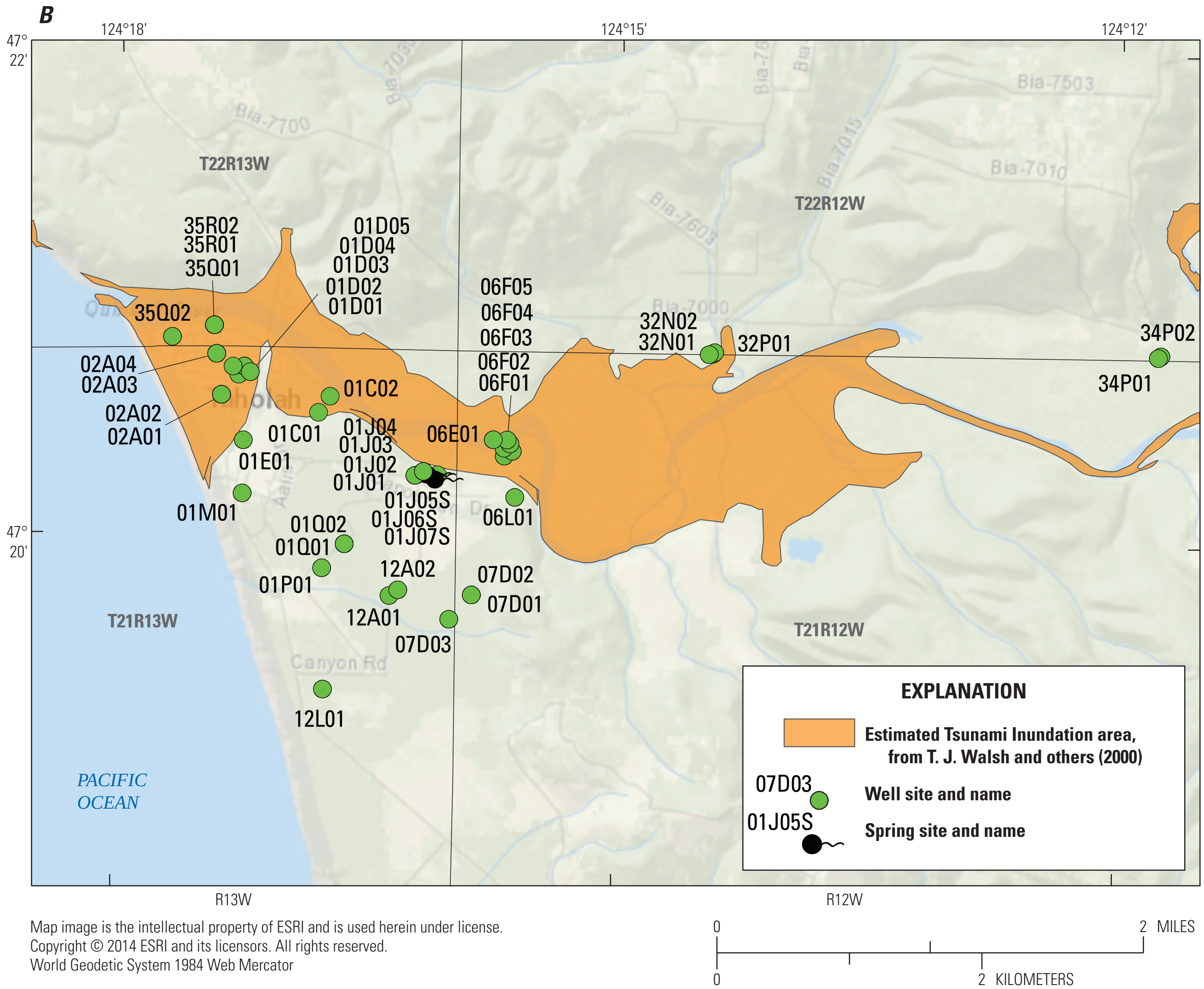
The project dataset includes 87 sites—82 wells and 5 springs. In October 2016, a field inventory was done to field locate the sites and to acquire site data including measuring depth to water in as many wells as possible. The location and associated information for wells on the reservation were obtained from past reports, the Washington Department of Ecology, Washington Department of Health, Indian Health Services, and personnel from the QIN. The intent of the field inventory was to collect data from wells and springs evenly distributed throughout the reservation. This was not possible in all areas because of lack of development on much of the reservation, or lack of permission to access some sites. Locations of the inventoried wells and springs are shown on figure 4*A* and *B*, and selected physical and hydrologic data for the wells are provided in table 1. Table 1 includes historical water levels as well as those collected for this study.

Most of the project sites are concentrated in or near the town of Taholah, along the coast south of Taholah, in Amanda Park, and in Queets (fig. 4*B*). The sites concentrated in Taholah include 25 test holes or monitoring wells (table 1) utilized during water supply and seawater intrusion studies done in the late 1970s to mid-1980s (Drost, 1985; Stay, 1988). Most of these sites have been destroyed and only one monitoring well (21N/13W-12A01 TW-07; fig. 4*B* and table 1) was located during the field inventory.



World Geodetic System 1984 Web Mercator

Figure 4. (*A*) Location of project wells and springs, including (*B*) a detailed view of locations near Taholah and surrounding areas, Quinault Indian Reservation, Washington. For explanation of well numbers, see section, "Well Numbering System."



World Geodetic System 1984 Web Mercator

Figure 4.—Continued

Table 1. Selected physical and hydrologic data for the project wells and springs, Quinault Indian Reservation, Washington.

[**USGS site ID:** Unique numerical identifiers used to access site data (http://waterdata.usgs.gov/nwis). **Site name:** Local well name used in this study. See report section, "Well Numbering System," for naming convention explanation. **Site Type:** GW, groundwater well; GW-TH, groundwater test hole; SP, springs; LA-SH, land soil hole. **Latitude** and **Longitude:** Referenced to North American Datum of 1983 (NAD83) , in degrees, minutes, seconds. **Water level status:** F, flowing; R, recently pumped; –, no data available. **Abbreviations**: BLS, below land surface; ft, foot; ft^3/s; cubic foot per second]

USGS site ID	Site name	Site type	Latitude (NAD83)	Longitude (NAD83)	Hole depth (ft)	Well depth (ft)	Construction date	Water level date	Water level (ft BLS)	Water level status	Discharge (ft^3/s)	Remarks
471527124074001	20N/12W-01D01	GW	471527	1240740	112	–	10-17-2000	-	-	-	-	Destroyed
471509124112301	20N/12W-04E01	GW	471509	1241123	–	–	–	–	–	–	–	No log, test well
471509124112201	20N/12W-04E02	GW	471509	1241123	315	305	09-05-2002	10-16-2002	170.4	–	23	Abandoned
471511124112301	20N/12W-04E03	GW	471511	1241123	320	317	12-18-2002	01-28-2003	106	–	50	Active, Moclips PW-3
471512124112001	20N/12W-04F01	GW	471512	1241120	320	315	09-12-2005	10-06-2005	87.6	-	64	Abandoned/removed
471444124111201	20N/12W-04P01	GW	471444	1241112	222.6	220.6	04-18-2000	05-13-2000	–	F	100	River well
471601124070201	21N/11W-32E01	GW	471601	1240702	222	99	08-07-1980	06-01-2017	42.31	R	–	Seed orchard
472025124154001	21N/12W-06E01 TW-09	GW-TH	472024	1241545	77	–	01-23-1980	–	–	–	–	Not located, presumed destroyed
472025124153501	21N/12W-06F01 TW-08	GW-TH	472024	1241540	77	70	01-22-1980	–	–	–	–	Not located, presumed destroyed
472021124153601	21N/12W-06F02 TW-10	GW-TH	472020	1241541	70	68.8	01-23-1980	01-24-1980	8.3	–	–	Not located, presumed destroyed
472024124153401	21N/12W-06F03 TW-11	GW-TH	472023	1241539	47	–	01-23-1980	–	–	–	–	Not located, presumed destroyed
472022124154101	21N/12W-06F04	GW	472022	1241541	32	30.7	08-28-1986	09-02-1986	8	–	120	Well head reported to be buried under silt
472022124153801	21N/12W-06F05	GW	472022	1241538	62	55.1	08-25-1986	08-27-1986	8.25	–	120	Unused; buried well head
472011124153201	21N/12W-06L01 TW-12	GW-TH	472010	1241537	62	-	01-24-1980	–	–	–	–	Not located, presumed destroyed October 2016
471947124154701	21N/12W-07D01 TW-04	GW-TH	471946	1241552	64	64	08-10-1988	10-05-1988	38.16	–	–	Auger hole 04 - not located, presumed destroyed
471947124154702	21N/12W-07D02 TW-05	GW-TH	471946	1241552	23	23	08-10-1988	–	–	–	–	Auger hole 05 - destroyed
471941124155501	21N/12W-07D03 TW-06	GW-TH	471940	1241600	80	75	08-11-1988	10-05-1988	37.27	–	–	Auger hole 06 - not located, presumed destroyed
471825124151001	21N/12W-18K01	GW	471822	1241514	-	50	01-01-1901	06-01-2017	14.85	–	–	No log
471823124150401	21N/12W-18K02	GW	471822	1241509	50	50	05-10-1968	05-10-1968	35	–	15	–
471812124145601	21N/12W-18R01	GW	471812	1241456	270	270	12-01-1989	06-01-2017	42.13	–	–	Seedling storage
471747124141001	21N/12W-20F01	GW	471748	1241415	264	264	01-28-1966	01-28-1966	–	F	30	–
471724124135501	21N/12W-20Q01	GW	471723	1241400	90	79	07-28-1979	–	–	–	20	–
471703124134401	21N/12W-29H01	GW	471703	1241344	240	233.25	04-28-2002	–	–	–	–	Well head welded shut
471653124133401	21N/12W-29H02	GW	471653	1241334	250	250	12-04-2001	–	–	–	–	Location from drillers log - not field located
472031124164301	21N/13W-01C01	GW	472030	1241648	105	36	04-13-1978	04-13-1978	17.6	–	150	Reported to have high chlorides
472035124163901	21N/13W-01C02	GW	472034	1241644	28	28	04-12-1978	04-12-1978	17.5	–	150	
472042124171002	21N/13W-01D01 TW-05D	GW-TH	472041	1241715	52	52	10-01-1979	01-21-1980	12.1	–	–	Not located, presumed destroyed
472042124171001	21N/13W-01D02 TW-05S	GW-TH	472041	1241715	34	30.2	10-02-1979	01-21-1980	12.7	–	–	Not located, presumed destroyed
472040124171201	21N/13W-01D03	LA-SH	472039	1241717	34	–	04-04-1978	04-04-1978	7.5	–	–	No casing, destroyed
472042124171401	21N/13W-01D04	LA-SH	472041	1241719	34	–	04-04-1978	04-04-1978	15	–	–	No casing, backfilled
472042124171003	21N/13W-01D05	GW	472040	1241712	51	51	01-01-1979	06-01-2017	13.22	–	100	Unused
472024124171001	21N/13W-01E01	GW	472023	1241715	202	202	07-01-1931	–	-	–	–	Unknown to tribe, presumed destroyed -1980

Table 1. Selected physical and hydrologic data for the project wells and springs, Quinault Indian Reservation, Washington.—Continued

USGS site ID	Site name	Site type	Latitude (NAD83)	Longitude (NAD83)	Hole depth (ft)	Well depth (ft)	Construction date	Water level date	Water level (ft BLS)	Water level status	Discharge (ft^3/s)	Remarks
472016124160801	21N/13W-01J01 TW-07	GW-TH	472015	1241613	72	69.2	10-03-1979	11-15-1979	42.1	–	–	Not located, presumed destroyed October 2016
472017124160501	21N/13W-01J02 TW-06A	GW-TH	472016	1241610	87	–	09-27-1979	10-01-1979	56	–	–	Not located, presumed destroyed October 2016
472017124160502	21N/13W-01J03 TW-06B	GW-TH	472016	1241610	57	57	09-28-1979	11-15-1979	49.5	–	–	Not located, presumed destroyed
472016124160802	21N/13W-01J04	GW	472015	1241613	384	384	07-29-1980	–	–	–	–	–
472015124160501	21N/13W-01J05S1	SP	472015	1241605	–	–	–	–	–	–	–	Data/location from Drost,1985
472016124160601	21N/13W-01J06S2	SP	472016	1241606	–	–	–	–	–	–	–	Data/location from Drost, 1985
472014124160201	21N/13W-01J07S3	SP	472014	1241602	–	–	–	–	–	–	–	Data/location from Drost, 1985
472011124171001	21N/13W-01M01	GW	472010	1241715	175	175	03-14-1977	03-14-1977	30	–	1	Reported as abandoned/removed
471953124164101	21N/13W-01P01 TW-03	GW-TH	471952	1241646	99	97	08-09-1988	10-05-1988	90.28	–	–	Auger hole 03 - not located, presumed destroyed
471959124163301	21N/13W-01Q01 TW-01	GW-TH	471958	1241638	13.7	13.7	08-08-1988	–	–	–	–	Auger hole 01 - not located, presumed destroyed
471959124163302	21N/13W-01Q02 TW-02	GW-TH	471958	1241638	72	72	08-08-1988	–	–	–	–	Auger hole 02 - not located, presumed destroyed
472035124171802	21N/13W-02A01 TW-03D	GW-TH	472034	1241723	87	84.9	09-24-1979	01-22-1980	12	–	–	Not located, presumed destroyed
472035124171801	21N/13W-02A02 TW-03S	GW-TH	472034	1241723	38.6	36.6	09-25-1979	01-22-1980	11.5	–	–	Not located, presumed destroyed October 2016
472045124172002	21N/13W-02A03 TW-02D	GW-TH	472044	1241725	62	59.2	09-25-1979	01-21-1980	12	–	–	Not located, presumed destroyed October 2016
472045124172001	21N/13W-02A04 TW-02S	GW-TH	472044	1241725	32	29.7	10-02-1979	01-21-1980	12	–	–	Not located, presumed destroyed
471945124161501	21N/13W-12A01 TW-07	GW-TH	471946	1241621	34	20.7	08-12-1988	–	–	–	–	Auger hole 07 - located October 2016
471947124161801	21N/13W-12A02	GW	471947	1241618	130	97	08-12-1994	–	–	–	–	Abandoned/destroyed test well
471923124164501	21N/13W-12L01	GW	471923	1241645	51	51	11-11-1994	06-01-2017	31.25	–	–	Location only
471819124162001	21N/13W-13R01S1	SP	471819	1241620	–	–	–	–	–	–	–	Minimal data
472201124003601	22N/10W-30M01	GW	472201	1240036	200	39.5	01-20-1997	06-01-2017	27.15	–	10	–
472159124003201	22N/10W-30M02	GW	472159	1240032	–	–	–	10-17-2016	13.61	–	–	No log found
472130123593001	22N/10W-31A01	GW	472133	1235931	300	291.3	01-01-1901	10-03-2016	–	F	30	–
472122123591101	22N/10W-32E01S1	SP	472122	1235911	–	–	–	–	–	–	–	Local use as ‘clean’ water source
472046124142801	22N/12W-32N01	GW	472046	1241428	75	71.2	11-08-1994	12-07-1994	8.7	–	102	TW-B2- capped since 1994
472046124142501	22N/12W-32N02	GW	472046	1241426	79	64.5	11-21-1994	12-07-1994	10.6	–	150	TW-B2- capped since 1994
472046124142601	22N/12W-32P01	GW	472046	1241426	98	97	10-24-1994	12-07-1994	12.4	–	67	TW-B2- capped since 1994
472047124114501	22N/12W-34P01	GW	472047	1241145	94	62.3	04-24-1995	05-03-1995	18.87	–	200	Taholah 1
472047124114601	22N/12W-34P02	GW	472047	1241146	55	53	07-06-1995	07-06-1995	16	–	–	Taholah 2
472049124173602	22N/13W-35Q01 TW-04D	GW-TH	472051	1241726	57	49.9	09-26-1979	01-21-1980	8.1	–	–	Not found, presumed destroyed October 2016
472049124173601	22N/13W-35Q02 TW-04S	GW-TH	472048	1241741	33	30.5	10-02-1979	01-21-1980	6.95	–	–	Not located, presumed destroyed October 2016
472052124172102	22N/13W-35R01 TW-01D	GW-TH	472051	1241726	53.5	53.5	09-26-1979	01-21-1980	11	–	–	Not located, presumed destroyed
472052124172101	22N/13W-35R02 TW-01S	GW-TH	472051	1241726	33	32.4	10-02-1979	01-21-1980	10.7	–	–	Not located, presumed destroyed October 2016
472718123521201	23N/09W-30G01	GW	472718	1235212	43	43	02-11-2015	06-02-2017	13.85	–	–	–

Table 1. Selected physical and hydrologic data for the project wells and springs, Quinault Indian Reservation, Washington.—Continued

USGS site ID	Site name	Site type	Latitude (NAD83)	Longitude (NAD83)	Hole depth (ft)	Well depth (ft)	Construction date	Water level date	Water level (ft BLS)	Water level status	Discharge (ft^3/s)	Remarks
472719123521201	23N/09W-30G02	GW	472718	1235212	80	80	12-17-2014	06-02-2017	13.65	–	–	Not used October 2016, will be used again
472720123521601	23N/09W-30G03	GW	472720	1235216						–	–	Not complete - no lid on casing, no log
472030124003001	23N/10W-19E01	GW	472829	1240035	98	98	01-01-1965	06-01-1965	16	–	–	–
472815123550401	23N/10W-23E01	GW	472814	1235509	-	105	01-01-1955	01-01-1955	83.7	–	–	–
472815123550301	23N/10W-23E02	GW	472808	1235527	124	124		07-01-1956	79	–	–	Buried well head but shown location
472748123534901	23N/10W-24P01	GW	472748	1235349	–	–	–	–	–	–	–	No log found, buried well head
472747123531901	23N/10W-24Q01	GW	472747	1235319	–	–	–	–	–	–	–	No log
472734123532401	23N/10W-25B01	GW	472734	1235324	–	–	–	06-02-2017	11.82	–	–	No log
472734123533301	23N/10W-25B02	GW	472734	1235333						–	–	No log
472731123533401	23N/10W-25B03	GW	472731	1235334	58	58	11-07-2006	06-02-2017	50.27	–	–	–
472737123532301	23N/10W-25B04	GW	472737	1235323	56	54	05-26-2015	05-26-2015	19	–	–	Data from log, no contact
472728123534601	23N/10W-25C01	GW	472728	1235346	180	178.5	03-20-1984	06-02-2017	111.75	–	–	–
472734123533701	23N/10W-25C02	GW	472734	1235337	270	147	07-18-2000	08-13-2000	71.6	–	–	Location only-possible two tags/wells AEP639-AGF013
473145124110401	23N/12W-03A01	GW	473145	1241104	–	–	–	–	–	–	–	No log found - unused, reported killed fish in past
473146124110401	23N/12W-03A02	GW	473146	1241104	–	–	–	06-02-2017	11.27	–	–	Used for domestic water only- no log
472854124095001	23N/12W-14J01	GW	472854	1240950	99	99	04-30-2015	04-30-2015	70	–	–	Location only
473108124185801	23N/13W-03Q01	GW	473108	1241858	201.5		08-30-1985			–	–	Not a well, grounding hole
473107124200701	23N/13W-04H01	GW	473107	1242007	167.5	167.5	08-06-1996	08-06-1996	74	–	–	Queets 2
473106124200401	23N/13W-04H02	GW	473106	1242004	175	159	02-20-2003	03-04-2003	72.67	–	90	Queets 1
473223124150801	24N/12W-33L01	GW	473223	1241508	–	–	–	06-02-2017	68.8	–	–	No log found - WDOH location
473211124192101	24N/13W-36M01	GW	473215	1241918	25	25	12-16-1983	–	–	–	–	Old Queets 1, buried
473214124191901	24N/13W-36N01	GW	473214	1241919	22	22	12-29-1983	–	–	–	–	Old Queets 2, buried

Depth to water (water level) was measured in 15 of the field-inventoried wells (table 1) using an electric tape or graduated steel tape, using methods previously described. Three wells were observed as flowing (artesian) (table 1), meaning that the water level was above the land surface altitude at the well. At many sites, water levels were not measured because of access issues including buried well heads, welded well caps, or a lack of permission to measure.

Monthly Network

After completion of the well and spring inventory, 13 of the field-located wells were selected for use in a monthly groundwater-level monitoring network. Starting in March of 2017, the USGS established a monthly network, and USGS personnel measured the wells through June 2017 (table 1) before training QIN personnel and transferring the network to the QIN for continued measurements. The USGS provided guidance to the QIN on procuring necessary equipment and provided field sheets to allow for adequate long-term data collection to be comparable to past records. In late June 2017, the USGS led a 2-day hands-on training of the water level protocol and the monthly network. This training included introductions to well owners, well locations, use of new equipment, and data requirements to have a complete long-term record of water levels. The USGS followed up with QIN in August 2017 on data collection procedures and maintenance of data to ensure that records are complete.

Data Needs

During the course of this study, several data needs were identified that, if filled, would provide a more complete understanding of the groundwater system of the Quinault Indian Reservation, along the west-central coast of Washington State. The collection of monthly water-level data is an important first step in understanding changes in seasonal and long-term water levels. Additionally, the collection of baseline water chemistry and quality across the reservation would help with future efforts to monitor existing and potentially changing groundwater quality conditions. An immediate benefit would include identification of possible anthropogenic contaminants such as nutrients and naturally occurring contaminants such as chloride, sulphur, and arsenic. Freshwater sources of the reservation are susceptible to deterioration from a variety of factors including those related to climate change such as changes in amount and timing of groundwater recharge and sea level rise and storm surge. Nearshore groundwater sources are also susceptible to contamination from catastrophic inundation from tsunamis. A baseline understanding of existing groundwater conditions (water levels and water quality), possible threats to those conditions, and perhaps prediction of effects through computer modeling may assist the Quinault Indian Nation in managing these critical resources through time.

The development of a water budget of the Queets-Quinault watershed and the Quinault Indian Reservation would provide water users a better understanding of this resource and provide necessary information about the competing demands on local water sources. An important component of a water budget is the measurement of stream discharge throughout the watershed during low-flow conditions which would help identify gaining and losing stream reaches, and further the understanding of groundwater and surface-water interactions in the watershed.

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