Washington State Department of Ecology Principal Aquifer

Water Level Monitoring Network: Final Report

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Background

In 2016, the Washington State Department of Ecology (Ecology) entered into a two-year cooperative agreement with the United States Geological Survey (USGS) to become a new data provider to the National Groundwater Monitoring Network (NGWMN). The goal of the NGWMN is to establish a national long-term groundwater quantity and quality network by using existing federal, state, and local groundwater monitoring programs. Ecology became a data provider because it routinely collects groundwater level measurements from a series of well networks that are used to support water use permitting activities and planning related to ambient groundwater level status and trends.

Groundwater monitoring data is loaded into the Environmental Information Management System (EIM) database maintained by Ecology. As a data provider, Ecology agreed to:

(1) Build and maintain a web service between the Ecology database and the NGWMN.
(2) Identify and submit candidate groundwater monitoring sites stored in the Ecology Environmental Information Management System (EIM) to the NGWMN that are consistent with the selection criteria outlined by the NGWMN documentation (ACWI, 2013).
(3) Cross-walk all available data elements for the appropriate well services. The current effort is to provide general well information, well construction, lithology, and water level data. The water quality service is not included in the scope of this current effort.

To date, a total of 61 groundwater wells have been submitted to the NGWMN by Ecology.

Project Activities List

There are a specific set of tasks (Table 1) that are identified for each of the two years of this project. The statuses of the tasks for year one are provided in the first year progress report (Sinclair, 2017). This document is the final project report that summarizes the statuses of all tasks identified in the cooperative agreement for completion for both years.

During the first year, a core working group within Ecology established the web service between EIM and NGWMN and created a cross-walk for data elements between EIM and NGWMN. Six wells were identified and entered into the NGWMN system for the State of Washington. During the second year, an additional 55 wells were submitted to the NGWMN for a total of 61 wells.

Table 1. Project Activities List

Year One	Status
Identify and convene business team members with appropriate expertise.	Complete
Document field and data management practices that have been used in operation of the network, including any deviations from the SOPs	Complete
Describe existing Ecology (and USGS) monitoring points in comparison (overlay) with principal aquifers.	Complete
Review NGWMN well categories and determine candidate wells based on length of record, frequency of measurement, and location with respect to principal aquifer.	Complete
Crosswalk data and metadata elements/requirements between EIM and NGWMN; conduct data gaps analysis.	Complete
Map candidate sites	Complete
Populate the NGWMN Well Registry with site and network information.	Complete
Develop a web service and stored procedure to supply data for selected wells and connect it to the NGWMN Portal.	Complete
Prepare a summary progress report.	Complete

Year Two	Status
Maintain current NGWMN sites, add new sites, and maintain web service	Complete
Create electronic files from lithologic paper files	Complete
Cross-walk drillers lithologic logs to NGWMN lithologic elements	Complete
Establish lithologic web service	Complete
Enter historical continuous water-level data into agency database	On-going
Prepare final project report	Complete

Well Network

Groundwater level monitoring activities in Washington are performed by Ecology's Water Resources Program (WR) at each of the four Ecology geographic regions (NWRO, SWRO, CRO, and ERO). The Ecology Regions are outlined in Figure 1. The well networks were initially designed to serve the data needs of water rights managers. However, Ecology now collects groundwater level monitoring data primarily to support water rights permit decisions and long-range planning. The data are also collected for the statewide assessment of groundwater level status and trends as well as drought impacts.

Manual water levels in more than 2,279 wells have been monitored for the time of record from which groundwater monitoring has been performed in Washington. For the years 2015, 2016, or 2017, water levels were measured in a total of 340 wells across the State. In any single year, water level measurements are collected at about 200 wells. In addition to the manual measurements, water levels are collected at wells that are instrumented with pressure transducers. There are 29 transducer-equipped wells identified in the Ecology EIM for which there are data for the years 2010 and later.

Water level data are collected from multiple types of wells that include dedicated monitoring wells, irrigation wells, domestic water-supply wells, and public water-supply wells. Except for the dedicated monitoring wells, many of the wells will exhibit known or suspected changes due to anthropogenic effects (pumping, irrigation return flows).

Water levels in the majority of the wells are manually measured once during the year, while some wells in Ecology's Central Region (CRO) are measured twice each year. Groundwater monitoring activities typically occur in the spring and fall—once between March and April when water levels are at their highest and again between September and October when water levels are at their lowest.

Standard Operating Procedures – Ecology

There are multiple methods by which water levels are measured at groundwater wells. Ecology has Standard Operating Procedures (SOPs) in place to standardize the process and establish quality standards for data collection. Groundwater level measurements are addressed by two SOPs for (1) manual measurements (Marti, 2018) and (2) transducer measurements (Sinclair and Pitz, 2018). Manual measurement methods include electric tape, steel tape, and air-line. At wells where a pressure transducer is used, the water level is confirmed at least once each year using a manual tape measurement. The purpose of manual measurement at the transducer-equipped wells is to check for possible vertical change in position caused by cable slippage or instrument drift.

Annual groundwater monitoring is performed by the Water Resources Program from Ecology. The plan that describes how the program will conduct groundwater monitoring and adhere to quality assurance requirements is provided in the *Integrated Statewide Groundwater Monitoring Strategy* (Culhane, 2017).

Ecology's field measurement and data processing procedures are generally consistent with the methods outlined in the framework document for the NGWMN (SOGW ASCI 2013). However, due to chronic understaffing in our groundwater monitoring program, we have historically visited our instrumented/trend sites only once or twice per year as opposed to the 4+ times per year recommended in the framework document.

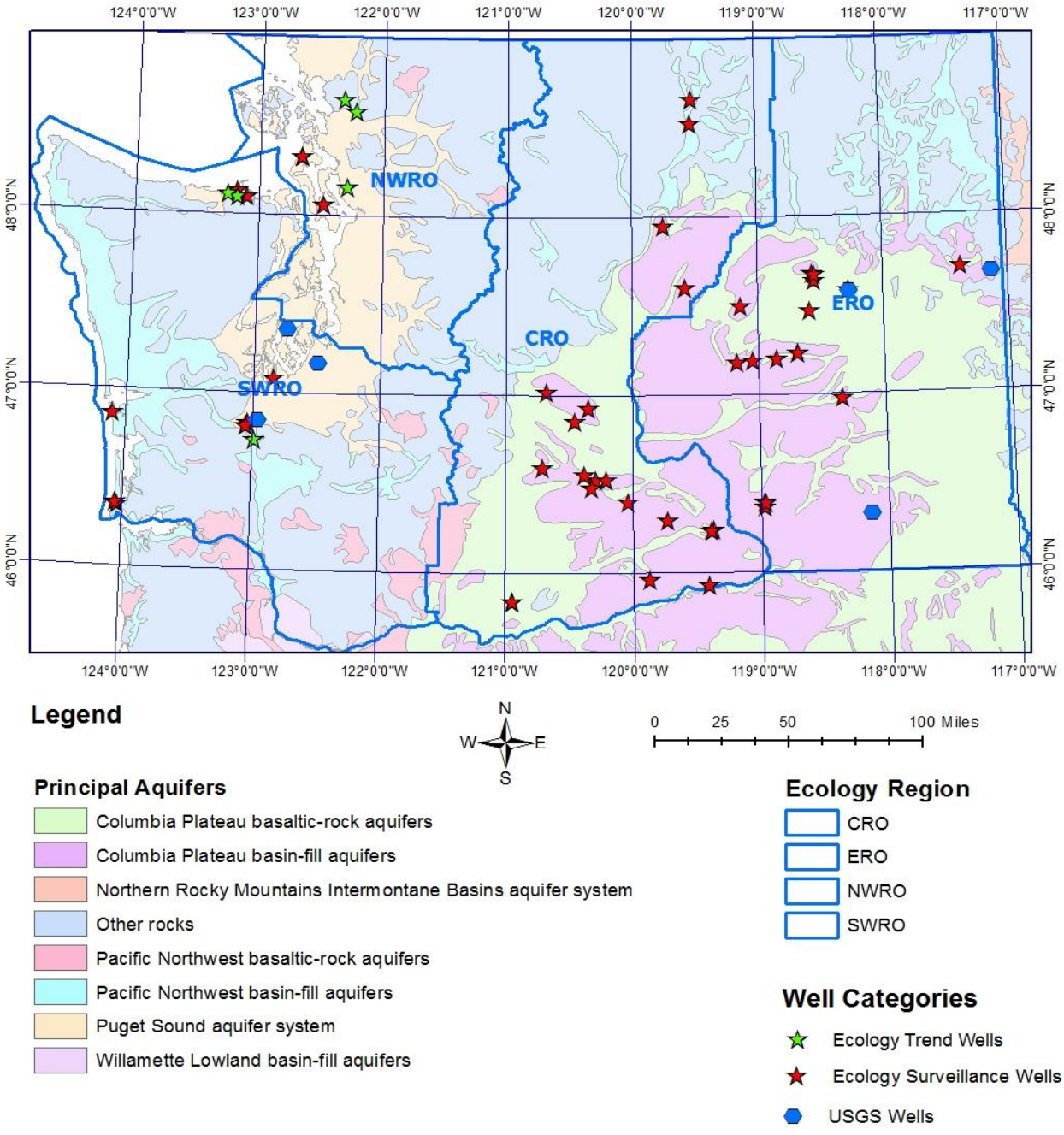

Figure 1. Washington State Groundwater Wells and Principal Aquifers

Selection Process

These were the general criteria for selection of wells to include in the NGWMN submissions:

- Ensure there are more than five years of water-level data to establish baseline conditions.
- Confirm well was actively measured within the years 2015, 2016, or 2017.
- Ensure wells are spatially distributed throughout the state to maximize coverage.
- Provide wells for both categories of surveillance (long-term) and trend (frequent) monitoring.
- Select wells that represent subnetworks of background conditions, suspected changes, and known anthropogenic effects to describe the evolving state of the aquifer.
- Select wells in geographic regions that represent specific (1) geologic environments, (2) climate, and (3) water-use demands.

Surveillance monitoring describes periodic water level measurements at selected wells. The periodic water level measurements represent long-term trends and do not provide the more frequent measurements collected by trend monitoring. Surveillance wells are typically visited on an annual or biannual cycle (once or twice per year). Trend monitoring wells track long-term data, but also include monitoring of seasonal variation of water level. Trend wells are typically used to collect water-level data with high measurement frequency data logging pressure transducers.

Background wells provide water level data for monitoring wells with no anthropogenic effect. Suspected wells include monitoring wells that have suspected or anticipated anthropogenic effects. Documented changes refer to monitoring wells that have documented anthropogenic effects.

A total of 61 wells were selected and submitted to the NGWMN through the web service during the two years of this project. Each well is identified in Appendix A by a location ID and is referenced to the corresponding site number, subnetwork, category, and principal aquifer. The location of each groundwater well submitted to the NGWMN portal is overlain on the principal aquifer map coverage in Figure 1. The spatial coordinates and State Region for each well is listed in Appendix B. The coordinate system and regional extents are also shown in the Figure 1.

The USGS operates a small network of six climate response wells in Washington. The spatial distribution of wells in this network and the principal aquifers in which they are located is shown in Figure 1.

From the available well sites where water level is regularly measured, Ecology will continue to identify wells in principal or major aquifers with hydrogeologic locations and data records appropriate for the purposes of the NGWMN.

Principal Aquifers

The principal aquifer system, or national aquifers, are defined as regionally extensive aquifers or aquifer systems that have the potential to be used as a source of potable water. Eight principal aquifer systems are present within Washington State.

Washington is divided into eastern and western regions by the Cascade Mountain Range, which divides the geologic and climate environments of the state. Ecology-monitored wells in the aquifers on the east side are primarily completed in volcanic basalts, while the wells in the aquifers on the west side are primarily completed in glacially deposited sediments.

The principal aquifers, their relative location throughout the state, and the number of submitted wells that are completed in each respective aquifer are listed in the Table 2.

Table 2. List of Principal Aquifers, Location and Well Count.

Principal Aquifer Name	Aquifer Code	Description	Location	No. of Wells
Columbia Plateau basaltic-rock aquifer	N600CMBPLV	Basaltic volcanic rocks	Eastern Washington	35
Columbia Plateau basin-fill aquifer	N100CMBPLB	Unconsolidated to semi-consolidated sand and gravel	Eastern Washington	4
Northern Rocky Mountains Intermontane aquifer system	S100NRMTIB	Unconsolidated to semi-consolidated sand and gravel	Eastern Washington	
Pacific Northwest basin-fill aquifer	N100PCFNWB	Unconsolidated to semi-consolidated sand and gravel	Statewide	5
Pacific Northwest volcanic-rock aquifer	N100PCFNWV	Basaltic volcanic rocks	Western Washington	
Puget Sound aquifer system	S100PGTSND	Unconsolidated to semi-consolidated sand and gravel	Western Washington	17
Willamette Lowland basin-fill aquifer	N100WLMLWD	Unconsolidated to semi-consolidated sand and gravel	Southwest Washington	
Other rocks	N9999OTHER	Sedimentary, volcanic, metamorphic	Statewide	

The wells submitted by Ecology to the NGWMN web service are completed in four of the eight aquifer systems. These four aquifers are the most aerially extensive in the state, so they are most likely to have wells completed in each of them.

The well count for categories (trend or surveillance) and subnetworks (background, suspected, change, known change) for each principal aquifer are listed in Table 3.

Table 3. Wells by Category and Subnetwork in each Principal Aquifer.

	Category		Subnetwork		
Aquifer	Trend	Surveillance	Background	Suspected Change	Known Change
N600CMBPLV	0	35	13	13	9
N100CMBPLB	0	4	0	4	0
N100PCFNWB	2	3	2	1	2
S100PGTSND	4	13	9	1	7

Well Type

Water level monitoring data is collected at wells that serve many different purposes. These include irrigation, dedicated monitoring, public water supply, domestic water supply, and other well types. The type and number of wells submitted to the NGWMN portal are listed in the Table 4.

Table 4. Number of Wells Based on Well Type

Well Type	No. of Wells
Monitoring	35
Water Supply	14
Irrigation	11
Other	1

Water levels in surveillance wells are manually measured once per year during the spring (March–April), except for in the Central Region where they are measured twice per year, spring and fall (September–October). Transducer-instrumented wells record water levels at intervals that are determined for each well. The instrumented wells are also manually measured annually to check for instrument drift or cable slippage. Standard operating procedures that apply to collecting water level data include Marti (2018) and Sinclair and Pitz (2018).

Climate

The Cascade Mountain Range serves to create a rain shadow on the east side of Washington State. The rain shadow results in a wet and cool western side that is bordered by the Pacific Ocean on the west and a warm and dry eastern side that is bordered by the Rocky Mountains to the east. The effect of the rain shadow is reflected in the vegetation on each side of the Cascade Range. The west side consists of temperate forests while the south and central regions of eastern Washington consist of semi-arid, shrub-steppe grasslands.

Environmental Information Management System

The Environmental Information Management System (EIM) is Ecology's central database for environmental monitoring data. EIM contains records on physical, chemical, and biological analyses and measurements. Supplementary information about the data (metadata) is also stored, including information about environmental studies, monitoring locations, and data quality. Information in the database is available to the public for search and downloading at Ecology's web portal, https://fortress.wa.gov/ecy/eimreporting/Default.aspx.

All groundwater monitoring network data collected during annual water level monitoring activities is entered in the EIM System using Study ID "GWDB" (Groundwater Database). Within EIM, there are 2,279 manually measured groundwater wells that have been identified as having contributed to the GWDB data set. For any particular year, about 10% of these wells are measured during each annual groundwater monitoring cycle. There are also 72 pressure-transducer-equipped wells that have or have had continuously monitored groundwater measurements for both long-term (greater than 5 years) and short-term intervals submitted to the GWDB Study ID.

As a data provider to the NGWMN, Ecology has created a web service that will pass groundwater monitoring well data for specific wells from EIM to the NGWMN site.

Web Services

Web services have been developed to link Ecology's enterprise database, the Environmental Information Management System (EIM), to the NGWMN network. Ecology has submitted 61 wells to date to the NGWMN network.

The NGWMN portal supports web service modules for (1) registry, (2) water level, (3) well construction, (4) lithology logs, and (5) water quality. Ecology has developed the XML scripts to migrate information for all of the services except for water quality. Table 5 shows the requested elements and the equivalent elements in the Ecology database. For those requested elements for which there is no Ecology equivalent, a value of "unknown" is passed back to the web service.

Table 5. NGWMN-EIM Cross-walk

NGWMN element	EIM equivalent	Remarks
Required data for all sites		
Name of Agency that collects data (R)	NA (Field collector at result level in EIM)	
Site Number (R, C, WL, WQ, L)[1] Database key (alphanumeric, can't contain spaces or special characters)	Well Tag ID or Location ID	
Site Name (R) (reviewed so that no Personally Identifiable Information (PII) is present)	Location Name or Location ID	
Country (R)	none	Input manually into the well registry
State (R)	State	
County (R)	County	
Latitude (decimal degrees) (R)	Latitude Decimal Degrees	
Longitude (decimal degrees) (R)	Longitude Decimal Degrees	
Horizontal Datum (R)	Horizontal Datum	
Horizontal Location method (R)	Horizontal Coordinate Collection Method	
Horizontal Location Accuracy (R)	Horizontal Coordinate Accuracy	
National Aquifer Code (R)	none	Input manually into the well registry
Local Aquifer Code (R)	none	Input manually into the well registry
Type of site; Well/Spring (R)	Groundwater Location Type	
Confinement Status; Confined/unconfined (R)	none	Input manually into the well registry
Lithology (L)		
Lithology ID (L)	Lithology	EIM does not contain the lithology data in the standard database. The lithology logs were transferred to electronic files and loaded into an auxiliary database
Description of Lithology of the unit (L)	Description of Lithology	
Observation Method (L)	Observation Method	
Beginning depth of lithologic unit (L)	Beginning Depth of Lithology	

[1] R = Register, C = Well Construction, WL = Water Level, WQ = Water Quality, L = Lithology

NGWMN element	EIM equivalent	Remarks
		that is accessible by the NGWMN portal.
Ending depth of lithologic unit (L)	Ending Depth of Lithology	
Well Construction Information		
Land Surface Altitude (R)	Elevation of, and Elevation	
Vertical Datum (R)	Elevation Datum	
Well Depth (R)	Well Completion Depth	
Well Depth Units (R)	Well Completion Depth Units	
Top depth of Screen interval (C)	Well Open Interval Upper Depth	
Bottom depth of Screen interval (C)	Well Open Interval Lower Depth	
Depth of Screen interval unit of measure (C)	Well Open Interval Units	
Screen interval material(C)	none	Well screen and casing information is not loaded from the Ecology database, but can be accessed by a link included in the well registry web service.
Top depth of Casing interval (C)	none	
Bottom depth of Casing interval (C)	none	
Depth of Casing interval unit of measure (C)	none	
Casing interval material (C)	Well Casing Material	
Required data for Water-level Sites		
Land surface altitude with Metadata (R)	Elevation of, and Elevation	This service has been implemented
Altitude Units (R)	Elevation Units	
Altitude Accuracy (R)	Elevation Accuracy	
Method of altitude measurement (R)	Elevation Collection Method	
Date/Time/Time Zone of water-level measurement (WL)	Field collection start date / field collection start time / NA	
Depth to Water (WL)	Result value	
Water-level units (WL)	Result value units	
Method of water-level measurement (WL)	Result method	

NGWMN element	EIM equivalent	Remarks
Accuracy of water-level measurement (WL)	Water level accuracy	
Required data for Water-Quality Sites		This service is not currently supported.
Date/Time/Time Zone of sample (WQ)	Field collection start date / field collection start time / NA	
Analyte Name (WQ)	Result Parameter Name	
Analyte value (WQ)	Result value	
Parameter unit (WQ)	Result value units	
Sample Fraction (WQ)	Fraction analyzed	
Chemical Identification Number (WQ)	Result parameter CAS number	
Chemical Classification System (WQ)	Result parameter CAS number	
Method (WQ)	Result method	
Analytical Method System (WQ)		

The lithology data is present in EIM as a link to a PDF copy of the well log. To support the lithology web service, Ecology has migrated the well log information for the selected wells into a database file that is compatible with the NGWMN protocols. The lithology data has been added to an auxiliary database that links the lithology web service to the NGWMN.

The database structure and data flow from Ecology to the NGWMN portal are depicted in the figure below. The figure shows the data exchange process for the lithology web service. The other web services (water level and well construction) will have the same established structure and flow path.

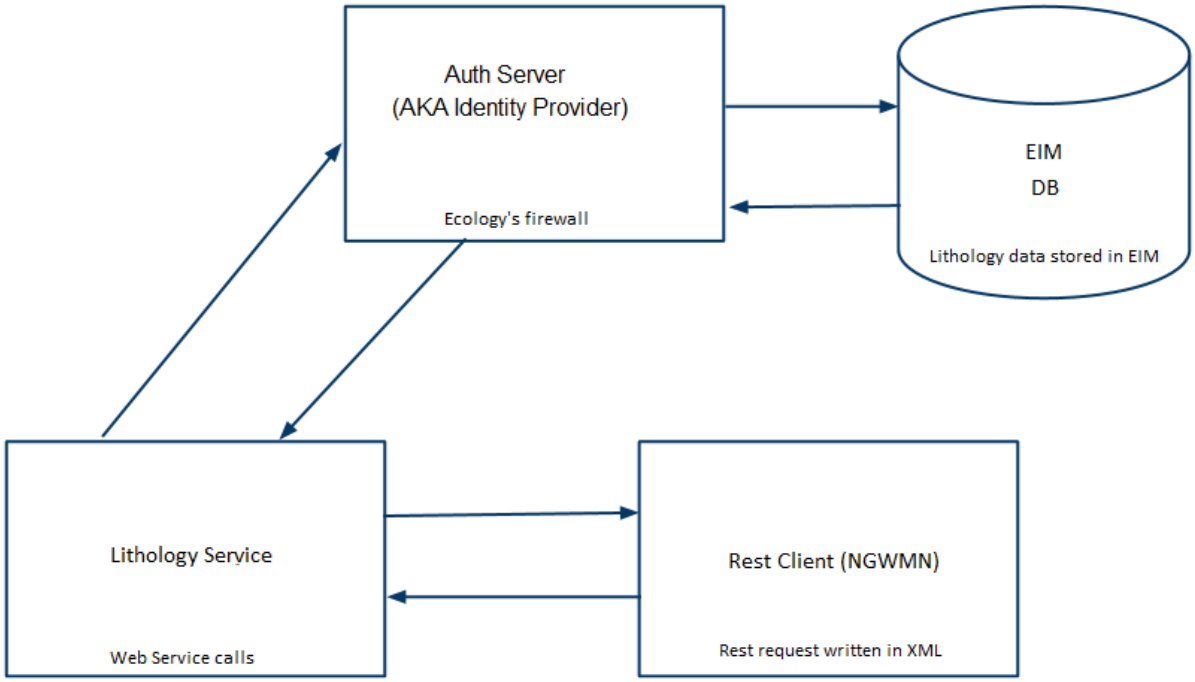

Figure 2. EIM-NGWMN data exchange network structure (lithology web service).

The script below shows the parameters and protocols used to pass values between the Ecology EIM system and the NGWMN portal. The XML script used for passing values for the lithology web service is provided below. The other web services will have the same layout, but with parameters that are specific to each web service.

NGWMN API: Rest API written using MVC in C#

Web service calls:

Name: GetView_NGWMN_Lithology()

Description: Returns all lithology in EIM

Parameters: None

Response in XML:

LithologyID	int
StationID	int
StationUserIdentificationCode	string
LithologyCode	string
LithologyDescription	string
ObservationMethod	string
BeginningDepth	int
EndingDepth	int
DepthUnits	string

Name: GetView_NGWMN_Lithology()

Description: Returns lithology in EIM of specific well

Parameters: Id of well (int)

Response in XML:

LithologyID	int
StationID	int
StationUserIdentificationCode	string
LithologyCode	string
LithologyDescription	string
ObservationMethod	string
BeginningDepth	int
EndingDepth	int
DepthUnits	string

Summary

The objective of National Groundwater Monitoring Network (NGWMN) is the implementation of a long-term national groundwater quantity and quality monitoring network (ACWI, 2013). This is achieved by engaging other organizations who collect groundwater data and establishing a cooperative agreement with them. These data are shared through a web service that transfers the organization data to a common data portal. The cumulative data from all contributors is made available through a map-based interface. A defined set of data elements are requested from each of the contributors so that the ensemble product shows a consistent and uniform output from all contributors.

The Washington State Department of Ecology (Ecology) entered into a cooperative two-year agreement to provide groundwater quantity data to the NGWMN starting in 2016 and ending in 2018. These are the tasks defined in the agreement:

- Convene a work group with the necessary skills to identify, extract, and build the web service to transfer data from Ecology to the National network.
- Identify and cross-walk the data elements between the Ecology database and National network portal.
- Select wells that draw from multiple principal aquifers at different depths that meet specific category and subnetwork characteristics, and are spatially distributed.
- Connect to and maintain the web service to the data portal
- Document the process and content of the data transfer between the Ecology database and the National portal.

Ecology organized a group including IT support staff and hydrogeologists to work through building the software and assembling the data necessary to support the National network. The staff identified data elements in the Ecology database to cross-walk to the National network. Basic groundwater well data are entered into the well registry. A web service was developed to support data transfer to the water level, well construction, and lithology modules of the National portal.

A total of 61 Washington State groundwater wells were linked to the National portal through the web service. The well categories included 6 trend wells and 55 surveillance wells. The number of subnetwork wells include 24 Background, 18 Known Change, and 19 Suspected Change (Table 3). The wells were completed in principal aquifers that include 35 in the Columbia Plateau Basalt, 4 in the Columbia Plateau fill, 5 in the Pacific Northwest basin fill, and 17 in the Puget Sound aquifer system (Table 2).

Data elements for the water level and well construction web services are present in the EIM database. The lithology data is generally available from a hyperlinked text file. As part of the web service development, Ecology created an electronic database of the lithologic logs for each of the groundwater wells submitted to the National Portal. The data elements were cross-walked from the Ecology database to the National Portal and the web service was created. The web service for water quality was not pursued for this project.

Two reports were required during this project. The first was a progress report that was submitted in June of 2017. The second required document is this report that constitutes the final project report.

All tasks listed in the original agreement have been successfully completed and the web service is currently active and providing data to the NGWMN portal.

References

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Appendix A
List of wells submitted by Ecology to the NGWMN portal

The following table contains the Ecology-specific "Location ID" as well as the "Site Number," which is the identification number used to cross-walk the data for each well between the Ecology database and the NGWMN portal. The table also lists the respective subnetwork, category, and principal aquifer associated with each well.

Location ID	Site No.	Subnet	Category	Principal Aquifer Code
AAB714	9123490	Known Change	Surveillance	S100PGTSND
AAB715	223490	Known Change	Surveillance	S100PGTSND
AAB716	1223490	Known Change	Surveillance	S100PGTSND
AAB731	7323490	Known Change	Surveillance	S100PGTSND
AAB735	9323490	Known Change	Surveillance	S100PGTSND
AAB740	4423490	Known Change	Surveillance	S100PGTSND
AAB746	543290	Known Change	Surveillance	N100PCFNWB
AAB749	7170982	Suspected Change	Trend	N100PCFNWB
AAB772	8133490	Background	Surveillance	N100PCFNWB
AAB855	6443490	Known Change	Surveillance	S100PGTSND
AAE567-PZ-A	74998420	Suspected Change	Surveillance	N100CMBPLB
AAE567-PZ-B	62841829	Suspected Change	Surveillance	N100CMBPLB
AAE567-PZ-C	81824625	Suspected Change	Surveillance	N600CMBPLV
AAE567-PZ-D	31302656	Suspected Change	Surveillance	N600CMBPLV
AAE571-C01	86201787	Background	Surveillance	N600CMBPLV
AAE573	90383767	Background	Surveillance	N600CMBPLV
AAE575	78923638	Background	Surveillance	N600CMBPLV
AAF381	5563490	Known Change	Surveillance	N100PCFNWB
AAL542	976992339	Known Change	Surveillance	N600CMBPLV
AKB696	3405243	Suspected Change	Trend	S100PGTSND
APS724	100054068	Background	Trend	N100PCFNWB
CRGWDB-200012	77890906	Known Change	Surveillance	N600CMBPLV
CRGWDB-200033	94986759	Suspected Change	Surveillance	N600CMBPLV
CRGWDB-201557	50304236	Suspected Change	Surveillance	N600CMBPLV

Location ID	Site No.	Subnet	Category	Principal Aquifer Code
CRGWDB-201989	130006	Known Change	Surveillance	N600CMBPLV
CRGWDB-202108	91726238	Background	Surveillance	N600CMBPLV
CRGWDB-202780	63730198	Suspected Change	Surveillance	N100CMBPLB
CRGWDB-203103	46480406	Known Change	Surveillance	N600CMBPLV
CRGWDB-207470	54350019	Suspected Change	Surveillance	N100CMBPLB
CRGWDB-210990	32816210	Known Change	Surveillance	N600CMBPLV
CRGWDB-211015	48646931	Background	Surveillance	N600CMBPLV
CRGWDB-211043	59375458	Suspected Change	Surveillance	N600CMBPLV
CRGWDB-211249	36477765	Known Change	Surveillance	N600CMBPLV
CRGWDB-211269	27683253	Background	Surveillance	N600CMBPLV
CRGWDB-211284	50375036	Suspected Change	Surveillance	N600CMBPLV
CRGWDB-211305	61359423	Suspected Change	Surveillance	N600CMBPLV
ECY_GREEN_MW11	100033897	Background	Trend	S100PGTSND
ECY_GREEN_MW6	100033896	Background	Trend	S100PGTSND
ECY_GREEN_MW7	100033895	Background	Trend	S100PGTSND
GWDB_BHT056	57622694	Suspected	Surveillance	N600CMBPLV
GWDB_ERO117	77553344	Suspected Change	Surveillance	N600CMBPLV
GWDB_ERO198	2139868	Suspected Change	Surveillance	N600CMBPLV
GWDB_ERO219	592215009	Known Change	Surveillance	N600CMBPLV
GWDB_ERO332	13597587	Known Change	Surveillance	N600CMBPLV
GWDB_ERO372	18830629	Suspected Change	Surveillance	N600CMBPLV
GWDB_ERO544	88795068	Background	Surveillance	N600CMBPLV
GWDB_ERO556	8021066	Suspected Change	Surveillance	N600CMBPLV
GWDB_ERO581	16117182	Known Change	Surveillance	N600CMBPLV
GWDB_ERO583	78073728	Suspected Change	Surveillance	N600CMBPLV
GWDB_ERO626	13624395	Background	Surveillance	N600CMBPLV
GWDB_ERO671	73918135	Background	Surveillance	N600CMBPLV
GWDB_ERO691	36562041	Background	Surveillance	N600CMBPLV
GWDB_ERO697	56376479	Background	Surveillance	N600CMBPLV

Location ID	Site No.	Subnet	Category	Principal Aquifer Code
GWDB_ERO705	94980366	Background	Surveillance	N600CMBPLV
GWDB_ERO782	58510113	Background	Surveillance	N600CMBPLV
IC_TH2P1	100033878	Background	Surveillance	S100PGTSND
IC_TH2P2	100033879	Background	Surveillance	S100PGTSND
IC_TH2P3	100033880	Background	Surveillance	S100PGTSND
IC_TH2P4	100033881	Background	Surveillance	S100PGTSND
IC_TH5P1	100033892	Background	Surveillance	S100PGTSND
IC_TH5P2	100033893	Background	Surveillance	S100PGTSND

Appendix B

List of Washington State Wells and Spatial Information.

The following table contains the "Location ID" for each well, which serves as the cross-walk between the Ecology database and NGWMN portal, and the latitude, longitude, and associated Department of Ecology Region for each of the wells. This location data can be used in conjunction with the map above to locate the specific wells within the state.

Location ID	Latitude_Decimal_Degrees	Longitude_Decimal_Degrees	Region
AAB714	46.8213	-123.0381	SWRO
AAB715	46.8213	-123.0381	SWRO
AAB716	46.8213	-123.0381	SWRO
AAB731	46.8075	-123.0548	SWRO
AAB735	46.3421	-124.0310	SWRO
AAB740	46.3527	-124.0505	SWRO
AAB746	48.1269	-123.1717	SWRO
AAB749	48.1068	-123.2485	SWRO
AAB772	46.8570	-124.1040	SWRO
AAB855	47.0773	-122.8436	SWRO
AAE567-PZ-A	45.8357	-120.9382	CRO
AAE567-PZ-B	45.8357	-120.9382	CRO
AAE567-PZ-C	45.8357	-120.9382	CRO
AAE567-PZ-D	45.8357	-120.9382	CRO
AAE571_C01	46.8529	-120.4588	CRO
AAE573	47.6718	-118.5649	SWRO
AAE575	46.9269	-120.3478	CRO
AAF381	48.0936	-123.0991	SWRO
AAL542	46.2420	-119.3680	CRO
AKB696	46.7271	-122.9785	SWRO
APS724	48.0961	-123.1691	SWRO
CRGWDB-200012	46.5240	-120.2951	CRO
CRGWDB-200033	46.5207	-120.2075	CRO
CRGWDB-201557	46.4755	-120.3250	CRO
CRGWDB-201989	46.2936	-119.7326	CRO
CRGWDB-202108	46.4007	-120.0374	CRO
CRGWDB-202780	48.5213	-119.5221	CRO
CRGWDB-203103	46.2353	-119.3881	CRO
CRGWDB-207470	48.6568	-119.5162	CRO
CRGWDB-210990	46.5930	-120.7094	CRO
CRGWDB-211015	46.5497	-120.3806	CRO
CRGWDB-211043	47.0164	-120.6812	CRO

Location ID	Latitude_Decimal_Degrees	Longitude_Decimal_Degrees	Region
CRGWDB-211249	45.9635	-119.8732	CRO
CRGWDB-211269	45.9306	-119.4110	CRO
CRGWDB-211284	47.5999	-119.5777	CRO
CRGWDB-211305	47.9460	-119.7455	CRO
ECY_GREEN_MW11	48.5823	-122.2245	NWRO
ECY_GREEN_MW6	48.6497	-122.3245	NWRO
ECY_GREEN_MW7	48.1553	-122.2893	NWRO
GWDB_BHT056	47.4951	-119.1378	ERO
GWDB_ERO117	46.9751	-118.3420	ERO
GWDB_ERO198	47.1794	-119.1706	ERO
GWDB_ERO219	47.1952	-118.8494	ERO
GWDB_ERO332	47.4650	-118.5833	ERO
GWDB_ERO372	47.1889	-119.0433	ERO
GWDB_ERO544	47.6951	-117.3745	ERO
GWDB_ERO556	46.3661	-118.9647	ERO
GWDB_ERO581	46.3956	-118.9708	ERO
GWDB_ERO583	46.3875	-118.9600	ERO
GWDB_ERO626	47.2295	-118.6848	ERO
GWDB_ERO671	47.2295	-118.6848	ERO
GWDB_ERO691	47.5782	-118.2749	ERO
GWDB_ERO697	47.5782	-118.2749	ERO
GWDB_ERO705	47.6329	-118.5492	ERO
GWDB_ERO782	47.6694	-118.5462	ERO
IC_TH2P1	48.3254	-122.6548	NWRO
IC_TH2P2	48.3254	-122.6548	NWRO
IC_TH2P3	48.3254	-122.6548	NWRO
IC_TH2P4	48.3254	-122.6548	NWRO
IC_TH5P1	48.0587	-122.4822	NWRO
IC_TH5P2	48.0587	-122.4822	NWRO