United States

Capital city: Washington DC
Inhabitants: 328 Million

INSTITUTIONAL SETTING AND PURPOSE

The United States Geological Survey (USGS) Water Resources Mission Area is responsible for providing data and information about the groundwater resources of the United States. Groundwater programmes which USGS undertakes contain various monitoring networks: National networks like the National Ground-Water Monitoring Network (NGWMN), Active Groundwater Level Network and Climate Response Network; Regional Networks like the High Plains Aquifer Monitoring Program with the objective to monitor storage changes in the High Plains Aquifer; state-based networks that are designed to monitor state-wide groundwater conditions; and local networks designed to monitor pumping effects. Some of the national networks are described in the following section.

CHARACTERISTICS OF THE NETWORK

The National Ground-Water Monitoring Network (NGWMN) is a selection of groundwater monitoring wells from Federal, State and local networks across the nation. Currently (as October 2020) it includes 14,378 water level monitoring wells and 3,408 water-quality wells from 32 contributing agencies, Figure 1.

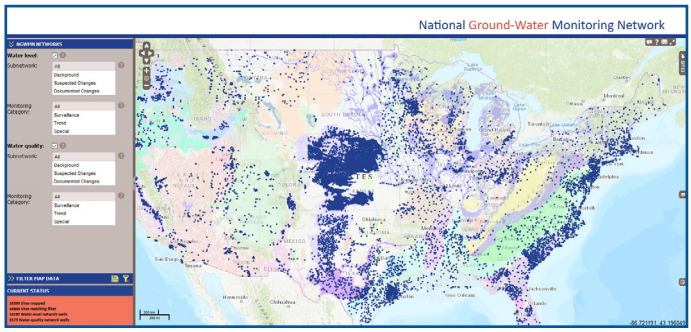


Figure 1 – National Ground-Water Monitoring Network. Source: USGS

The Active Groundwater Level Network contains data on water levels and well information from more than 18,340 wells. USGS or USGS co-operators take measurements at least once within the past 13 months, Figure 2.

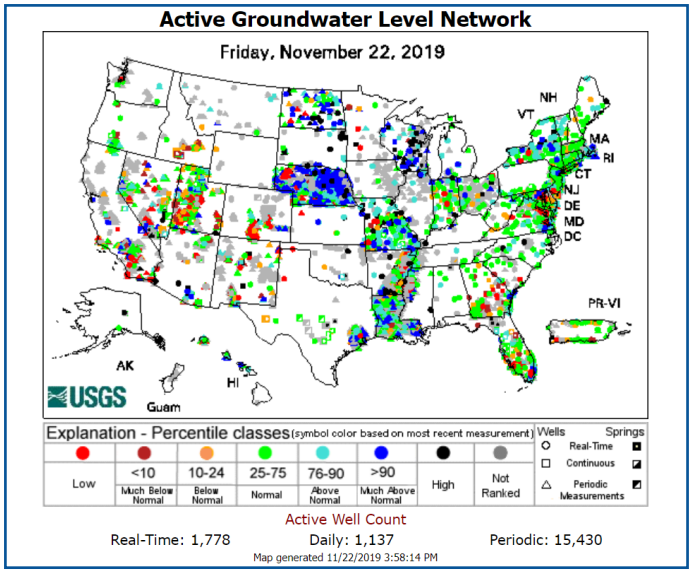


Figure 2 – Active Groundwater Level Network. Source: USGS

The Climate Response Network monitors the effects of droughts and other climate variability on groundwater levels and consisted of about 500 wells in 2006, Figure 3. Among them 280 wells were equipped with real-time data loggers, 59 continuous wells measured the level hourly (not available in real time); and about 214 wells measured the levels from monthly to quarterly. The water-level changes in the Network should primarily reflect climatic variability and not human influences.

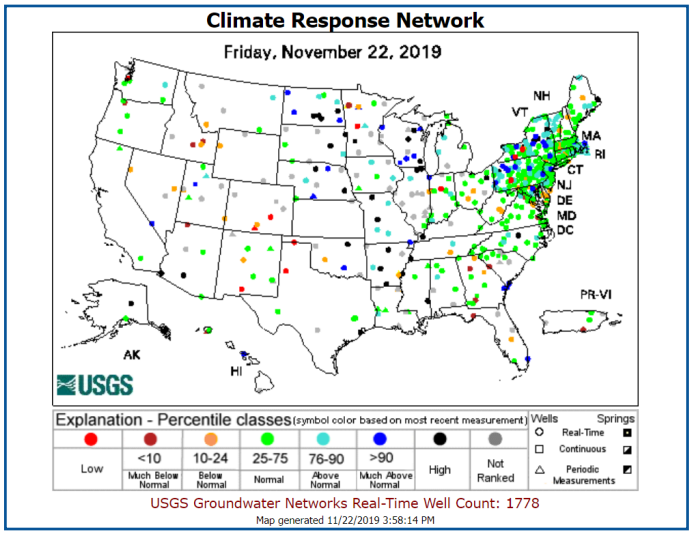


Figure 3 – Climate Response Network. Source: USGS

The Real Time Groundwater Level Network consists of 1,778 wells with "real time" data transmission instrumentation, Figure 4. Real-time data are recorded at 15-60-minute intervals. The data are stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. During critical events recording and transmission times may be more frequent. Data from real-time sites are sent to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival. All real-time data are provisional and subject to revision.

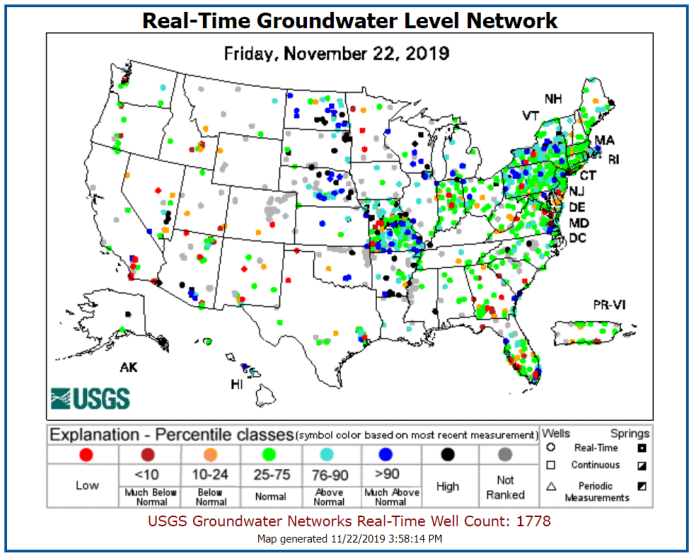


Figure 4 – Real-Time Groundwater Level Network. Source: USGS

The Below Normal Groundwater Level Network is aimed to analyse wells with groundwater levels below normal, Figure 5. The wells must be in an active measurement program, i.e. appears on the Active Groundwater Level Network, and must have 10 or more years of record in the month of the most recent measurement.

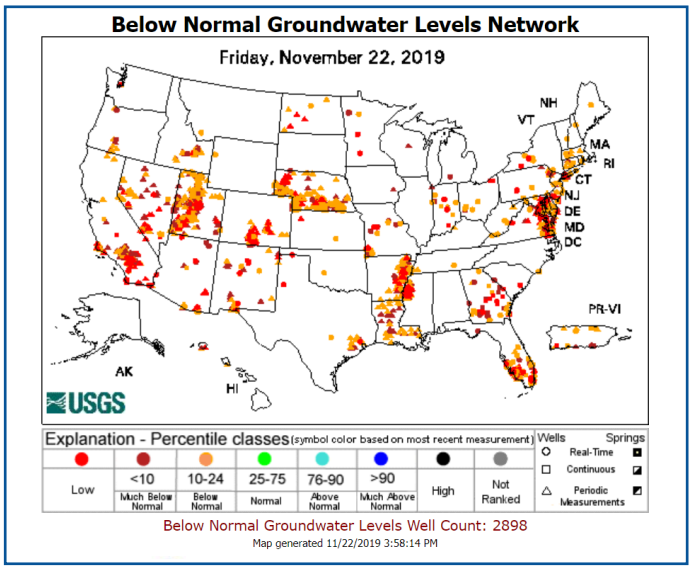


Figure 5 – Below Normal Groundwater Level Network. Source: USGS

PROCESSING AND DISSEMINATION

Data and information in a national information system are compiled from local/regional, distributed databases of the USGS. Information from all wells is served via the Internet through the National Water Information System Web (NWISWeb) Interface (https://waterdata.usgs.gov/nwis). NWISWeb provides all USGS groundwater data that are approved for public release. The large number of sites is not always user-friendly for all data retrievals in the networks.

Data from the NGWMN can be obtained via the NGWMN Data Portal, which is a web-based mapping application proving access to groundwater data from several databases. The portal contains current and historical data from both groundwater quantity and quality, lithology and well construction.

The USGS Groundwater Watch is an initiative of the Office of Groundwater that provides basic statistics about the groundwater levels collected by the USGS Water Science Centers and from customers through cooperative agreements. National, state and local networks can be accessed via the Groundwater Watch portal. It is noteworthy that this website is going to be deprecated on February 1, 2021, including all the associated network pages. However, USGS will continue collecting and serving data from all of the sites that are monitored as part of those networks, and they are in the process of building a replacement for the Groundwater Watch website which will have similar functionality. Currently, several networks are presented in beta viewers (see Sources).

Active Groundwater Level Network

The water levels (most recent measurements) are classified as much below normal (<10-percentile), below normal (between 10-24 percentiles), normal (between 25-75 percentiles), above normal (between 76-90 percentiles), and much above normal (>90-percentile). The symbol "High" indicates that highest median of the month of the most recent data value is the closest statistic to the most recent data value.

From the Groundwater Watch portal, a user can first select a state of the interest, then a new dialog opens with the map of that state and list of counties with all the monitoring sites for groundwater levels and spring discharges, Figure 6. The statistics of a selected well is available in a graphical form, Figure 7. Moreover, the information on daily and periodic groundwater data together with the whole period of records are included in the USGS Well Information section.

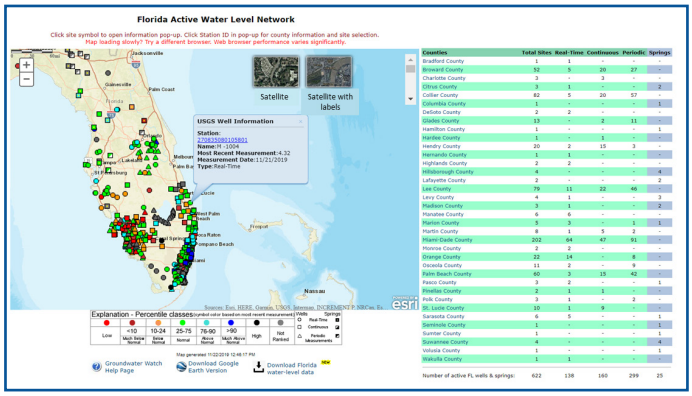
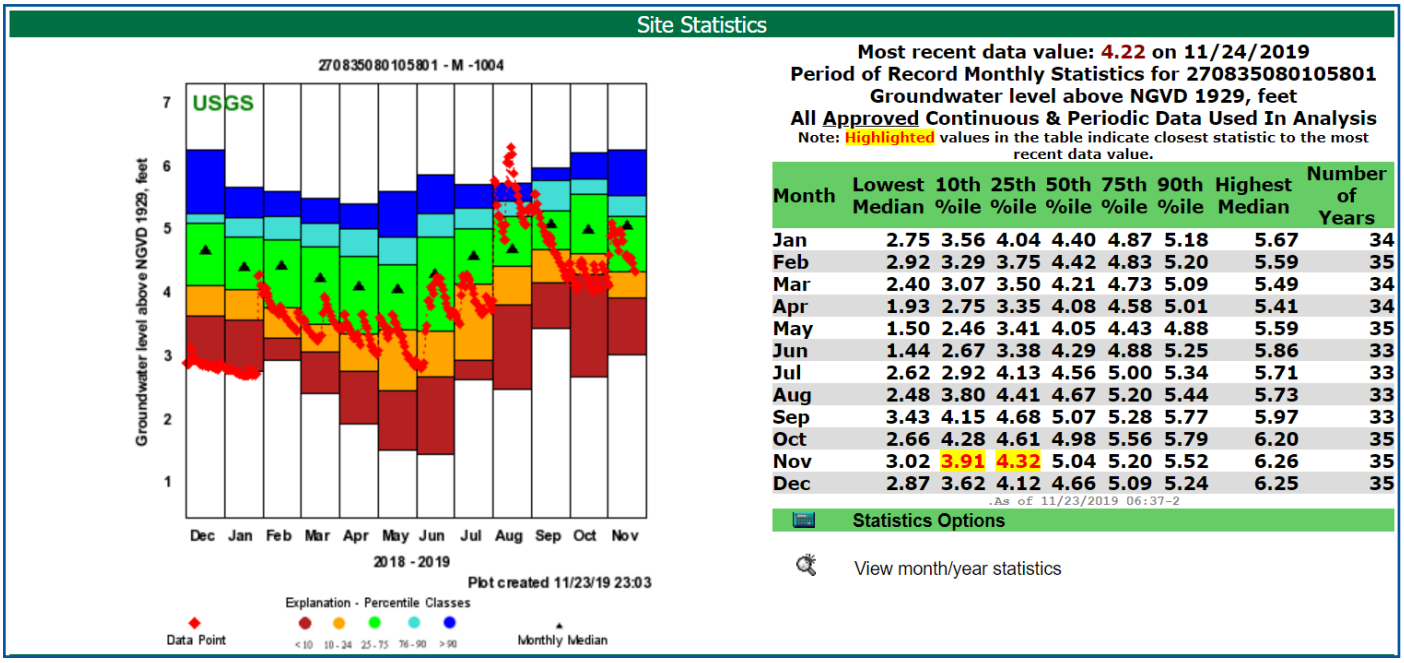


Figure 6 – Florida Active Groundwater Level Network (right) and list of counties in Florida with monitoring sites (right). Source: USGS



Month	Lowest Median	10th %ile	25th %ile	50th %ile	75th %ile	90th %ile	Highest Median	Number of Years
Jan	2.75	3.56	4.04	4.40	4.87	5.18	5.67	34
Feb	2.92	3.29	3.75	4.42	4.83	5.20	5.59	35
Mar	2.40	3.07	3.50	4.21	4.73	5.09	5.49	34
Apr	1.93	2.75	3.35	4.08	4.58	5.01	5.41	34
May	1.50	2.46	3.41	4.05	4.43	4.88	5.59	35
Jun	1.44	2.67	3.38	4.29	4.88	5.25	5.86	33
Jul	2.62	2.92	4.13	4.56	5.00	5.34	5.71	33
Aug	2.48	3.80	4.41	4.67	5.20	5.44	5.73	33
Sep	3.43	4.15	4.68	5.07	5.28	5.77	5.97	33
Oct	2.66	4.28	4.61	4.98	5.56	5.79	6.20	35
Nov	3.02	3.91	4.32	5.04	5.20	5.52	6.26	35
Dec	2.87	3.62	4.12	4.66	5.09	5.24	6.25	35

As of 11/23/2019 06:37-2

Figure 7 – Below Normal Groundwater Level Network. Source: USGS

The most recent water-level measurement that belongs to the 24-percentile in the month of measurements over the period of record of the well is used for the analysis. If the measurement is lower than the 10-percentile, the well will be classified as "much below normal".

Climate Response Network

The snap-shot map is available on the Groundwater watch platform. Only wells having at least 10 years of measurements in a given month are considered for analysis and coded with colours to ensure that the calculated percentiles are representative of historical conditions. There are eight categories of ground-water levels: a new high for the month (black), greater than the 90th percentile (dark blue), 76th–90th percentile (light blue), 25th–75th percentile (green), 10th–24th percentile (orange), less than 10th percentile (brown), and new record low for the month (red), Figure 3. The symbol is grey when the most recent measurement is more than 45 days old or less than 10 years of data are available.

National Aquifer Composite Hydrographs

As one of the methods composite water-level hydrographs are used to report on the United States' major aquifers in which water levels are declining, increasing or stable. Composite hydrographs provide a general overview of water levels in the Principal Aquifers, and they are useful to determine trends in them.

A composite water level is an average water level calculated from a group of index wells. It uses the median water level for the period of interest (annual or monthly) for each index well and then averages all index wells for the particular year or month. The composite water levels representing the average or mean water level of all the index wells is then presented on a hydrograph, Figure 8, left.

The composite hydrographs minimize the effects of local or random fluctuations. The identification of appropriate index wells is an important factor. The index wells should come from an area that is similar in some hydrologic condition.

To calculate the groundwater level composite hydrographs for the Principal Aquifers of the United States, different factors are taken into account:

- The period used for the analysis is a moving 30-year hydrograph from the most recent year of record;
- Only index wells with no missing records are used, i.e. every index well has at least one measurement for every year in the 30-year period;
- There must be at least 9 index wells for a Principal Aquifer that meet the period of record criteria and have a reasonable areal distribution through the aquifer. The reasonable areal distribution is defined qualitatively;
- The variable calculated for each index well is the median water level for the year. The annual median water level is always the median of daily values (if exist) and periodic measurements;
- Data are presented in Below Land Surface values.

The advantage of the method is that the applied criteria are simple and there is no need to assess each potential well in the aquifer system. The disadvantage is that the wells might not be evenly spaced, and monitored for specific stresses that are not appropriate to represent the whole aquifer. By normalizing the original hydrograph, the composite annual percent variation can be calculated, Figure 8, right. The example on how to calculate the normalized value for a single well, for one year is presented in Figure 9. Later, the mean or median will be calculated considering all the wells for every year, and the composite annual median percent variation graph will be generated.

California Coastal Basin Aquifer
Well: 340655117184005
Station Water-Level Index for Calendar Year 1988

$X = 64.74$
$X_{mean} = 156.01$
$X_{max} = 237.18$
$X_{min} = 64.74$

$$X_{norm} = (64.74 - 156.01) / (237.18 - 64.74) * 100 * (-1)$$

$$X_{norm} = (-91.27) / (172.44) * 100 * (-1)$$

$$X_{norm} = 52.93$$

Figure 8 – Calculation of a normalized value for the Well: 340655117184005

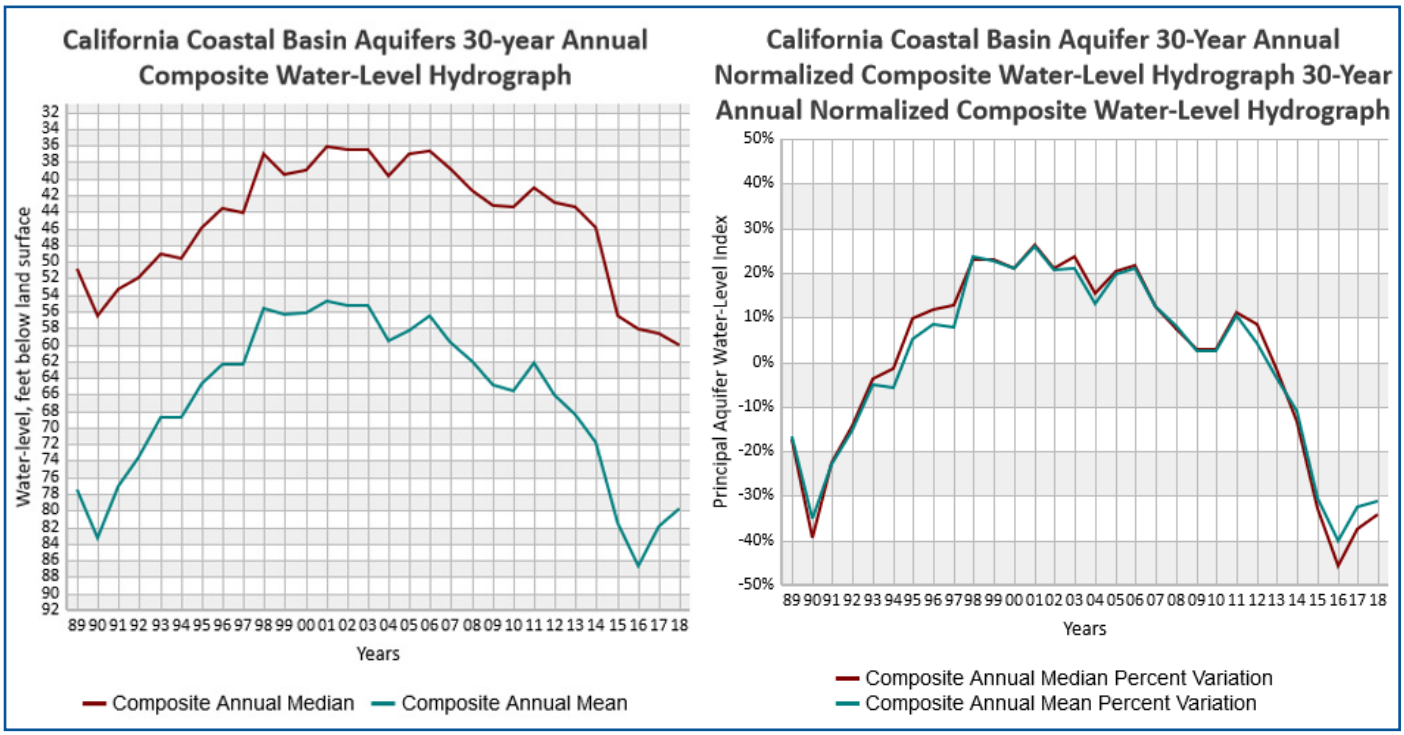


Figure 9 – Example of composite hydrograph (left) and example of normalized composite hydrograph (right). Source: USGS

Sources

- **Active Groundwater Level Network** - https://groundwaterwatch.usgs.gov/default.asp;
- **Active Groundwater Level Network** - https://waterdata.usgs.gov/networks/AGL/ (beta release);
- **Below Normal Groundwater Levels** - https://waterdata.usgs.gov/networks/LWL/;
- **Climate Response Network (Fact Sheet)** - https://pubs.usgs.gov/fs/2007/3003/pdf/2007-3003-lowres.pdf;
- **Climate Response Network** - https://waterdata.usgs.gov/networks/CRN/ (beta release);
- **Composite Water-Level Hydrographs (main page)** - https://groundwaterwatch.usgs.gov/compositehome.asp;
- **Composite Water-Level Hydrographs (complete description)** - https://groundwaterwatch.usgs.gov/composite/help/compositewaterlevels_helpdocument_7-7-2016.htm;
- **Composite Water-Level Hydrographs (alternative description)** - https://groundwaterwatch.usgs.gov/composite/help/CompositeGroundwaterLevelHelpDocument.docx.html;
- **Feedback from USGS, Water Resource Mission Area** - received on 01-10-2020;
- **National Ground-Water Monitoring Network (NGWMN), main page** - https://cida.usgs.gov/ngwmn/;
- **NGWMN Data Portal** - https://cida.usgs.gov/ngwmn/index.jsp;
- **USGS Groundwater Watch** - https://groundwaterwatch.usgs.gov/usgsgwnetworks.asp (interim version);
- **USGS Groundwater Watch. California Coastal Basin Aquifer Composite Hydrographs (as example)** - https://groundwaterwatch.usgs.gov/compositeaquifers.asp?ncd=CCB;
- **USGS Groundwater Watch. Site Number: 270835080105801 - M -1004 (as example)** - https://groundwaterwatch.usgs.gov/AWLSites.asp?mt=g&S=270835080105801&ncd=awl; and
- **USGS Water Data for The Nation Blog** - https://waterdata.usgs.gov/blog/.