Overview of the USGS Streamgaging Network

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U.S. Geological Survey
Ohio-Kentucky-Indiana Water Science Center

U.S. Department of the Interior
U.S. Geological Survey
What is a Streamgage?

- A device that can provide continuous information on streamflow, water level, water quality, and/or precipitation

- Streamflow is a volume of water that passes a point on a stream per unit of time
History

- 1879 — USGS founded
- 1889 — First streamgage

Embudo Personnel

John Wesley Powell
2nd Director of the USGS
1881–1894
U.S. Rivers from NHDPlus

Credit: Nelson Minar
USGS Monitoring Network

Over 8,500 USGS streamflow-gaging stations across the Nation. Over 95% are real-time!
USGS Network Features

- National network
- Uniform National standards
  - Data collection
  - Analysis
  - Storage
  - Delivery
- Long-term archive
- Real-time telemetry
By the Numbers (2017 Water Year)

- 10,330 gages
  - 8,580 monitored streamflow and water level
  - 1,750 monitored water level
- 80,000 measurements made by hydrographers
- Funding: $188 million
  - $55 million from Federal appropriation
  - $133 million from 1,410 partners
- 640 million requests made for streamflow info
  - 98% fulfilled through web services

USGS
Uses of the Data

- Planning, forecasting, and warning about floods and droughts
- Managing water rights and transboundary water issues
- Operating waterways for power production and navigation
- Monitoring environmental conditions to protect aquatic habitats
- Describing impacts to streamflow from changing land and water uses
- Assessing water quality and regulating pollutant discharges
- Determining if streams are safe for recreational activities
- Designing reservoirs, roads, bridges, drinking water and wastewater facilities
USGS Monitoring Network

- Kentucky Real-time
  - Surface Water Sites
  - Water Quality Sites
  - Ground Water Sites
  - Precipitation Gages
  - Lake/Reservoir Gages
  - 4 “Super” Gages 2019
Surface Water Gages
Data Collection

- Water Level Sensors
  - Stilling Well

[Diagram showing water level sensors and a stilling well with labeled parts like satellite radio antenna, recorder, shelf, floor, water surface, valves, and intakes.]

[Image of a water level sensor installation.]
Data Collection

- Water Level Sensors

  - Bubbler System

Diagram showing a streamgage installation with a bubbler system used to measure stream stage. (Credit: L.S. Coplin, USGS)
Data Collection

- Water Level Sensors
  - Radar
Selecting a Site Location

Cooperator’s Need

- Permit Requirements
- Flood Warning
- Regulatory
- Infrastructure Design

What type of data is needed?

- Flow data
  - Low Flow
  - High Flow
- Water Quality
  - Parameters Required
Site Selection

- Straight Reach
- Bridge
Site Selection

- USGS site naming

03260100 Elijahs Creek at Elijahs Creek Road nr Hebron, KY
03289200 Town Branch at Yarnallton Road at Yarnallton, KY
03285000 Dix River near Danville, KY

Traditionally “at” within 1 mile of town, “near” beyond 1 mile (but many towns grow)
Site Selection

- USGS site numbering
  - 03260100 Elijahs Creek at Elijahs Creek Road nr Hebron, KY
  - 03289200 Town Branch at Yarnallton Road at Yarnallton, KY
  - 03285000 Dix River near Danville, KY

Downstream order numbers
- "03" is Ohio River, "04" is Great Lakes, "05" is Illinois River, "07" is Mississippi, typically followed by 6 more digits (8-digits in all), but more digits to right if necessary.
- Sites have unique IDs. Must coordinate with neighboring states.
Site Selection

- **What if a gage is moved upstream or downstream?**
  
  (Priorities regarding data and view of data changes over time)
  - Reasons to keep same station number – keeps data together.
  - Reasons to change station number – different location, represents different site.

- **What if the gage stays at same location, but the nature of flow changes?**
  
  - Stage-discharge relation may undergo a major change
  - High/low range may change as total flow remains the same
  - New or different groups might use the data (hazard planning, water supply, etc.)
Gage Installation

- Readily accessible
  - Installation of Gage
  - Operation of Gage

- General course of stream should be straight

- Flow should be confined to one channel at all stages

- Streambed should not be subject to scour or fill

- Unchanging control

- Water measurement area in close proximity of gage
  - Bridge, high banks, cableway, wading

- Want the gage outside effects of backwater from other water bodies
Gage Installation

- Labor intensive process
- Often requires permitting
- Specialized equipment
Gage Installation

- Gage elevation surveyed using high accuracy GPS equipment
- Levels run to minimum of 3 independent reference marks
USGS Streamgages of Instagram
USGS Streamgages of Instagram
USGS Streamgages of Instagram
USGS Streamgages of Instagram
Data Collection

- Gage’s require constant maintenance
Data Collection

- Discharge Measurements
  - Wading
  - Bridge
Data Collection

- Discharge Measurements
  - Cableway
Data Collection

- Discharge Measurements
  - Manned Boat
  - Remote Boat
Data Collection

- Price AA Meter
Data Collection

- Acoustic Doppler Velocimeter (ADV)
Data Collection

- Acoustic Doppler Velocimeter (ADV)
Data Collection

- Series of measurements at set depths and widths

Diagram of channel cross section with subsections.

(Credit: S.A. Olson and J.M. Norris, USGS)
Data Collection

- Series of measurements at set depths and widths
Data Collection

- Acoustic Doppler Current Profiler (ADCP)
Data Collection

- ADCP’s provide velocity information for the majority of the cross-section
Data Collection

The elevation of the water surface in the stream channel, known as a stage or gage height, can be used to determine the discharge in a stream.

When used in conjunction with velocity and cross-sectional area measurements, stage can be related to discharge for a stream.
Data Collection

- Compute discharge from stage and cross-section area

- \( Q = VA \)
  - \( Q = \) discharge
  - \( V = \) velocity
  - \( A = \) area
DISCHARGE IS USUALLY MEASURED USING THE VELOCITY-AREA METHOD

Discharge = (Area of water in cross section) \times (Water velocity)
Channel cross section is divided into numerous sub sections.

Discharge of each sub-section = Area \times \text{Average Water Velocity}
Area of each sub-section determined by directly measuring width and depth

Area = Width x Depth
Water velocity in each sub-section is measured using a current meter at selected locations.
Stream discharge is sum of discharges in all sub-sections

Total Discharge =

\[ ((\text{Area}_1 \times \text{Velocity}_1) + (\text{Area}_2 + \text{Velocity}_2) + \ldots + (\text{Area}_n \times \text{Velocity}_n)) \]
Data Collection

How Are Streams Gaged? (cont’d)

Subsection Method (cont’d) – How is velocity measured?
Data Collection

How Are Streams Gaged? (cont’d)
Current Meters – ADCP (Acoustic Doppler Current Profiler)
Data Processing

How Are Streams Gaged? (cont’d)

Finally, discharge, or the volume of water flowing in a stream over a set interval of time, can be computed and plotted.
Data Processing

Accurate Gage Height is needed to collect the height of the stream at a set time interval to produce discharge. A Data Collection Platform (DCP) records Gage Height.
Examples of “staff” gages
Stage-discharge relations are often referred to as "Ratings".
Discharge measurements must be made throughout the entire range of stage to accurately define a rating.
A computer interpolates the stage discharge values between the defined points on the rating.
Data Processing

Discharge measurements are used to develop rating curves.
Data Processing

Discharge must be measured at all stages
Data Processing

- Ratings are never that simple!
Here is how to read a “rating table”.

<table>
<thead>
<tr>
<th>STATION NUMBER</th>
<th>Rating for Discharge (DCP) (cfs)</th>
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<tbody>
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<td>TYPE: stage-discharge</td>
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<tr>
<td>Offset: 0.00</td>
<td>EXPANSION: logarithmic</td>
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</table>

<table>
<thead>
<tr>
<th>Gage height, feet</th>
<th>Discharge (cfs)</th>
<th>Diff in Q PER 1 UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>1.8* 1.8 1.9 2.0 2.1    2.5</td>
<td>0.80</td>
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<tr>
<td>0.40</td>
<td>2.6 2.7 2.8 2.9 2.9    3.4</td>
<td>0.90</td>
</tr>
<tr>
<td>0.50</td>
<td>3.5* 3.6 3.8 3.9 4.1    4.9</td>
<td>1.6</td>
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<tr>
<td>0.60</td>
<td>5.1  5.2 5.4 5.6 5.8    6.7</td>
<td>1.9</td>
</tr>
<tr>
<td>0.70</td>
<td>7.0* 7.2 7.6 7.9 8.2    9.9</td>
<td>3.3</td>
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<tr>
<td>0.80</td>
<td>10.3* 10.7 11.2 11.7 12.1 14.7</td>
<td>5.0</td>
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<td>0.90</td>
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**OFFSET: 0.00**

**EXPANDED RATING TABLE**

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<th>Discharge (cfs)</th>
<th>Diff In Q PER</th>
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<tr>
<td>0.00</td>
<td>0.00 0.01 0.02 0.03 0.04 ... 0.09 0.1</td>
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</tr>
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**Gage Height = 0.62 feet**

**Discharge = 5.4 cubic feet per sec**
Control
Section Control

- Rock Riffle
- Weir
- Beaver Dam
Section Control

Identified by a break in the water surface downstream from the gage.

Water Surface
Flow Direction
Rock Riffle Control
Channel Control

Contained within the normal banks of the channel
Overbank Control

Flow into the floodplain
The shape of a rating is controlled by the channel and its features.
Data Processing

- Temporary changes to the control dictate shifts
Interpretation of a positive computed shift.

The gage height ($GH_Q$) = 0.89 ft.

For this gage height the rating table indicates that the discharge should be 6.8 ft$^3$/s.

Discharge measured = 7.5 ft$^3$/s.

The rating table says 7.5 ft$^3$/s is associated with a gage height ($GH_{Rating}$) of 0.95 ft.

The computed shift = +0.06 ft.

The control scoured ~0.06 ft.
Interpretation of a negative computed shift.

The gage height \((GH_Q) = 0.89\) ft.

For this gage height the rating table indicates that the discharge should be 6.8 \(\text{ft}^3/\text{s}\).

Discharge measured = 5.7 \(\text{ft}^3/\text{s}\).

The rating table says 5.7 \(\text{ft}^3/\text{s}\) is associated with a gage height \((GH_{\text{Rating}})\) of 0.80 ft.

The computed shift = -0.09 ft.

The control filled ~0.09 ft.
Data Processing SHIFTs

Since gage control conditions change, the stage-discharge relations must be adjusted.

- Shift adjustments are applied for temporary changes in the stage-discharge relation.
Data Processing SHIFTs

One reason negative shifts occur is due to fill on the control.
Data Processing SHIFTs

One reason negative shifts occur is due to fill on the control.
Data Processing SHIFTS

One reason negative shifts occur is due to fill on the control.

![Graph showing negative shift increases with additional fill.]
How can you determine if a shift was added?

This station managed by the Louisville District Office.

<table>
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<th>Available Period</th>
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<td>☑ Graph w/o stats</td>
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<tr>
<td>☑ 63680 Turbidity, Form Neph</td>
<td>2011-06-06</td>
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</table>

Summary of all available data for this site

Instantaneous-data availability statement
How can you determine if a shift was added?

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DESCRIPTION:
Latitude 39°04'47" N, Longitude 84°41'07" W
Boone County, Kentucky, Hydrologic Unit 05090203
Drainage area: 4.03 square miles
Datum of gage: 759.08 feet above NGVD29.

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Streamflow Measurements for the Nation

USGS 03260100 ELIJAH CREEK @ ELIJAH CREEK RD NR HEBRON, KY

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<th>Date</th>
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Available data for this site: [Link to data](#)

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Data is available for the following period:

- Data for the selected date range is available.
- Data for the selected date range is not available.

Contact Information:

- [Email](#)
- Phone: [Number]

For more information, visit the USGS website.
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### Streamflow Measurements for the Nation

**USGS 03260100 ELIJAH Creek @ ELIJAH Creek Rd NR Hebron, KY**

#### Station Data
- **Location**: Boone County, Kentucky
- **Drainage Area**: 4.43 square miles
- **Stage Datum**: 755.08 feet above NGVD29

#### Measurement Table

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Quality Assurance

- All data go through 3 levels of computation and review
- Hydrographic analysis performed with nearby sites
- Outside reviews conducted every 3 years by the USGS Office of Surface Water
Make Measurement

Input into SMART

SMART applies GH corrections and shifts

Archives the data in database

Using GRSAT to check ART

Develop ratings and shifts

Work/Check the Record

Review the record

NO

Publish the Record

Yes
SIMS allows the Hydrographer to document information throughout a time period at a site.
RMS-Records Management System

RMS is a Process that Allows Hydrographers to keep record working tractable.
Groundwater Gages
Groundwater

- Collect water level
- Network relatively small with a goal towards growth over the next 2 years
- No water quality collected at this time
- Water-supply evaluations
- Drought prediction and monitoring
- Long-term hydrologic perspective
Water Quality Gages
Water Quality Gages

- NAWQA sampling 26 times per year at Sugar Creek at New Palestine
  - Pesticides, nutrients, and sediments

- Continuous Data
  - Temperature
  - Specific Conductance
  - Dissolved Oxygen
  - pH
  - Turbidity
The major objective of the NASQAN program is to annually monitor and assess concentrations and loads of selected constituents delivered by major rivers to the coastal waters of the United States.

Monitor and identify major source areas in select inland sub-basins that contribute significantly to adverse conditions in receiving waters.
Water Quality - Sampling

NASQAN – National Stream Quality Accounting Network (cont’d).

- 33 National NASQAN monitoring stations
- 20 monitoring stations in the Mississippi River Basin
Precipitation Gages

- “Temporary Data”
- Measure intensity and depth of accumulation
Precipitation Gages

- Used by NWS for river flood forecasting
- Drought monitoring
- Non-published data only available for 30 days
“Super” Gages

- 4 gages in Kentucky
- Continuous nitrate, Specific Conductance, Temperature, pH, DO, and Turbidity

Super gage equipment at Ohio River at Olmsted, KY
“Super” Gages in Indiana and Kentucky
USGS GOES near real-time Data Collection System

- GOES
- DOMSAT
- LRGS
- Data Access and Processing System (DAPS), Wallops Island, VA and EROS Data Center in Sioux Falls, SD
- National Water Information System (NWIS)
- NWIS Web site
Web Tools

- Water Data
- Water Watch
- Water Alert
- Flood Inundation Mapper
USGS 09380000 COLORADO RIVER AT LEES FERRY, AZ
PROVISIONAL DATA SUBJECT TO REVISION

Station operated in cooperation with the Bureau of Reclamation and the USGS.

Precipitation Data Disclaimer ▲

This station managed by the Flagstaff Field Office; USGS AS 01423000.

Available Parameters

☐ All 10 Available Parameters for this site
☑ 000310 Temperature, water
☑ 000310 Temperature, water [TK's YSI Sonde]
☑ 00045 Precipitation
☑ 00060 Discharge
☑ 00065 Gage height
☐ 00095 Specific cond at 25°C [TK's YSI Sonde]
☐ 00095 Specific cond at 25°C
☐ 00300 Dissolved oxygen [TK's YSI Sonde]
☐ 00301 Diss oxygen, %saturation [TK's YSI Sonde]
☐ 61035 Voltage [TK's YSI Sonde]

Summary of all available data for this site
Instantaneous-data availability statement

USGS 09380000 COLORADO RIVER AT LEES FERRY, AZ

Discharge, cubic feet per second

--- Provisional Data Subject to Revision ---

△ Median daily statistic (97 years) — Discharge
Monitoring location 09380000 is associated with a STREAM in COCONINO COUNTY, ARIZONA. Current conditions of DISCHARGE, GAGE HEIGHT, PRECIPITATION, and MORE are available. Water data back to 1884 are available online.

Streamflow, ft$^3$/s

13100 ft$^3$/s - Sep 10, 2019 02:00:00 PM MST

Discharge, cubic feet per second

Sep 04  Sep 05  Sep 06  Sep 07  Sep 08  Sep 09  Sep 10

Current:  Orange  Provisional
Median:  1922 - 2019
Water Watch

- Flood information across the country
- Individual station information available
Water Watch

- Streamflow archive by hydrologic unit map

- Streamflow measurements can be retrieved from this site.
  - Shift information
  - Discharge

Archive of streamflow maps (United States)

Choose one of the following options to view a map:

- Time Period:
- Year:
- Month:
- Day:

Map Type: Hydrologic Unit Map

Monday, September 03, 2012

Explanation - Percentile classes

- Low: Much below normal
- 10-24: Below normal
- 25-75: Normal
- 76-90: Above normal
- >90: Much above normal

High
Water Watch

- Duration hydrograph builder
- Daily, 7-day, 14-day, and 28-day options
Water Watch

- Creates table that ranks flood peak vs. period of record
Water Watch: Raster-Hydrograph Builder
Water Watch: Raster-Hydrograph Builder

Raster hydrograph of daily flow at USGS 03377500 WABASH RIVER AT MT, CARMEL, IL

Flow (ft³/s)

- 200000
- 100000
- 50000
- 20000
- 10000
- 5000
- 2000
- No data
Water Alert

- Provides alerts via text or email
- No limit on the number set up
- Daily updates or real-time.
- Surface Water, groundwater, WQ, or precipitation

https://maps.waterdata.usgs.gov/mapper/wateralert
Water Alert

- Flood stage provided at many gages
- Can specify >, <, inside, or outside a range of your choosing
Flood Inundation Mapping

- Collaborative project of Silver Jackets Hazard Mitigation Task Force

![Flooded areas with Silver Jackets logo and USGS icon]
Flood info – from a point on the landscape to geospatial products

USGS Real-time streamgage data

FIMI

National Weather Service flood forecasts

High-water marks

http://las.depaul.edu/geography/images/Misc_Images/gis.jpg
Flood Inundation Mapper Tool
Ohio Kentucky Indiana Water Science Center

How has pesticide use changed over time?
Atrazine Pesticide Use Map, 2012

Home
Welcome to the Ohio-Kentucky-Indiana Water Science Center. In October 2017, the three Water Science Centers were merged to become one "Integrated" Science Center. We look forward to helping you achieve your goals by providing water quantity and quality information, as well as scientific tools and understanding, when and where they are needed by citizens, businesses, and public officials!

Message from the Director

Flood Inundation Maps

Current Conditions Map

Current Data
This data was formerly known to most as the "Realtime Data" in table format. Although the format has not changed, we now refer to it as "Current Conditions".
Ohio Current Streamflow Data
Kentucky Current Streamflow Data
Questions?
For more information

- WaterWatch: https://waterwatch.usgs.gov/
- WaterAlert: https://maps.waterdata.usgs.gov/mapper/wateralert/
- WaterNow: https://water.usgs.gov/waternow/
- Techniques and Methods 3–A8—Discharge Measurements at Gaging Stations: https://pubs.usgs.gov/tm/tm3-a8/