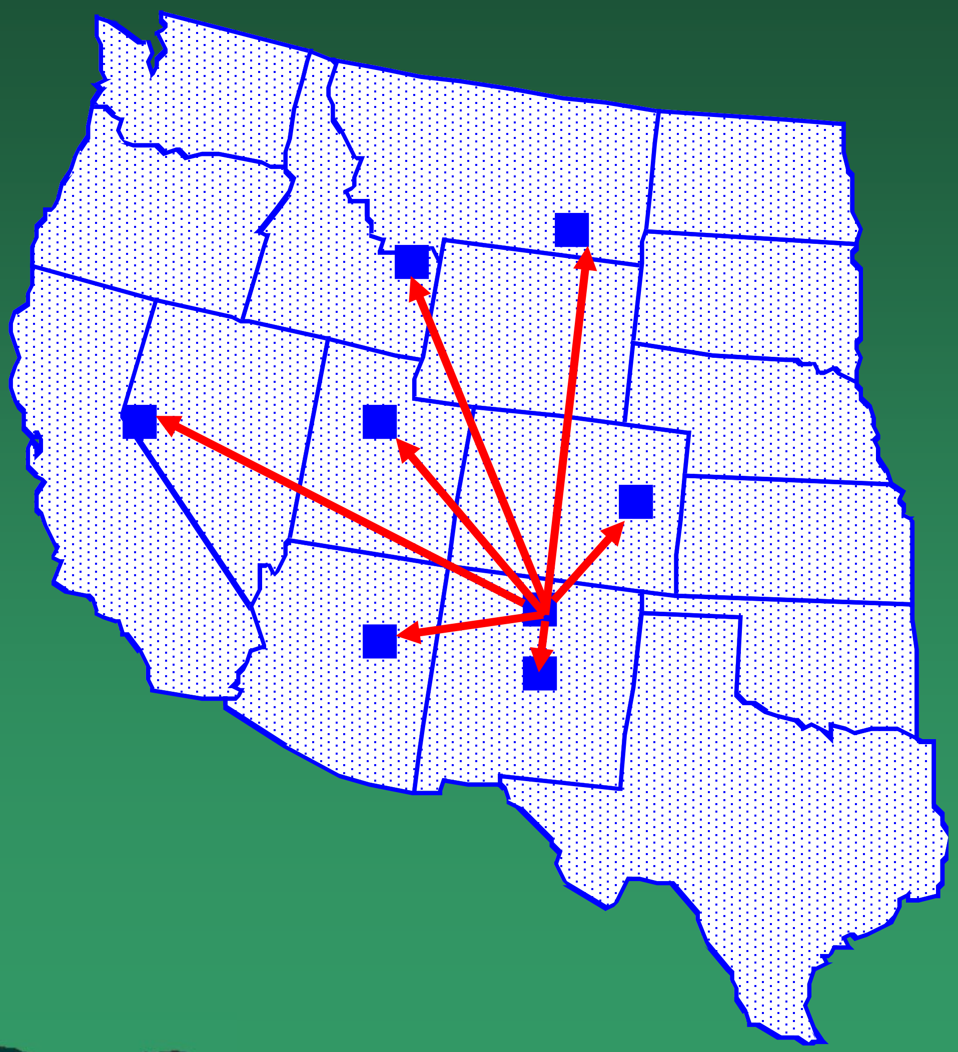
Data collection at U.S. Geological Survey Streamgages

Snake River near Moran, WY

USGS science for a changing world

The first USGS gaging station was established on the Rio Grande River near Embudo, New Mexico in 1889.

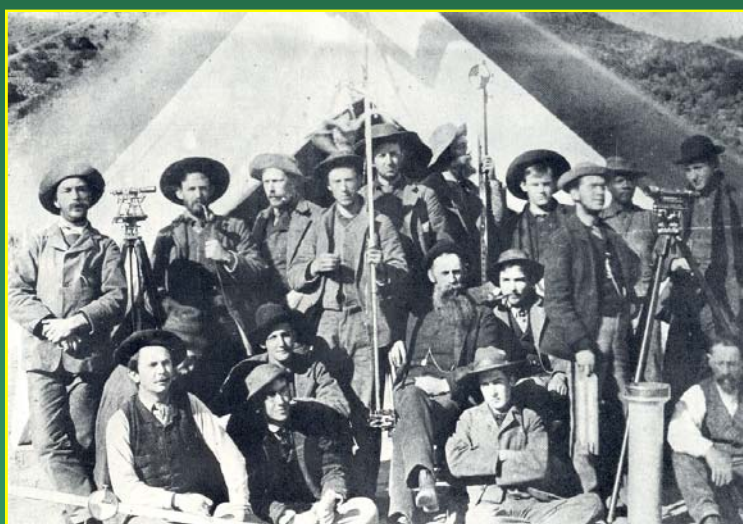
Embudo trainees immediately dispersed to collect data in other western locations

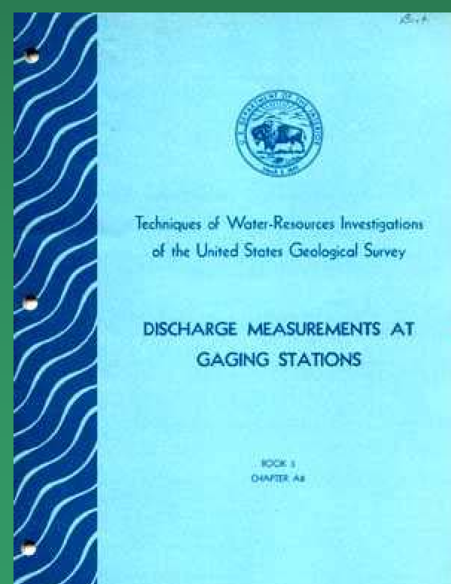


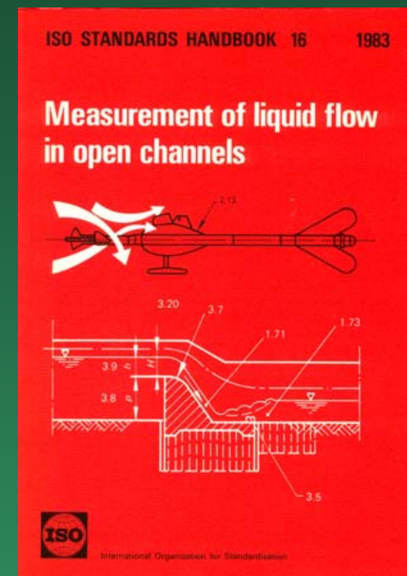
The Embudo Legacy

Data collected using nationally consistent, prescribed standards

http://wwwrcamnl.wr.usgs.gov/sws/fieldmethods/

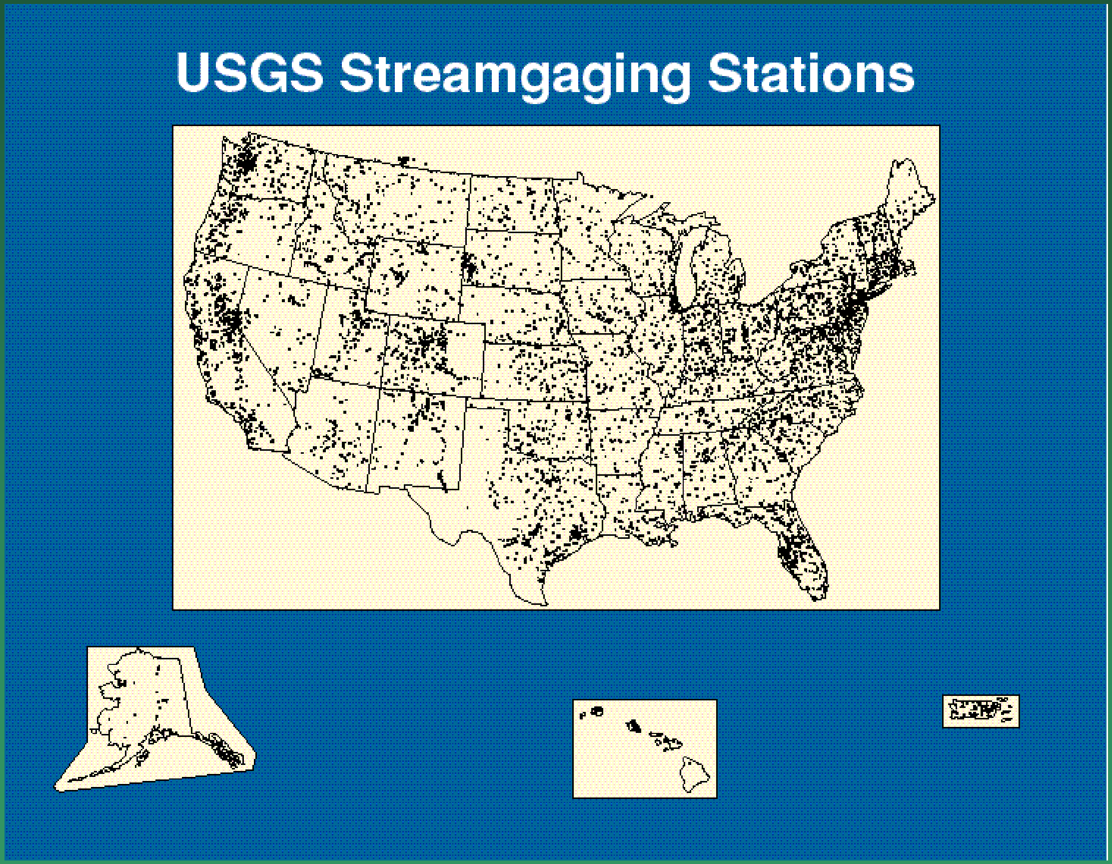






USGS
science for a changing world

The U.S. Geological Survey currently collects streamflow data at over 7,000 sites

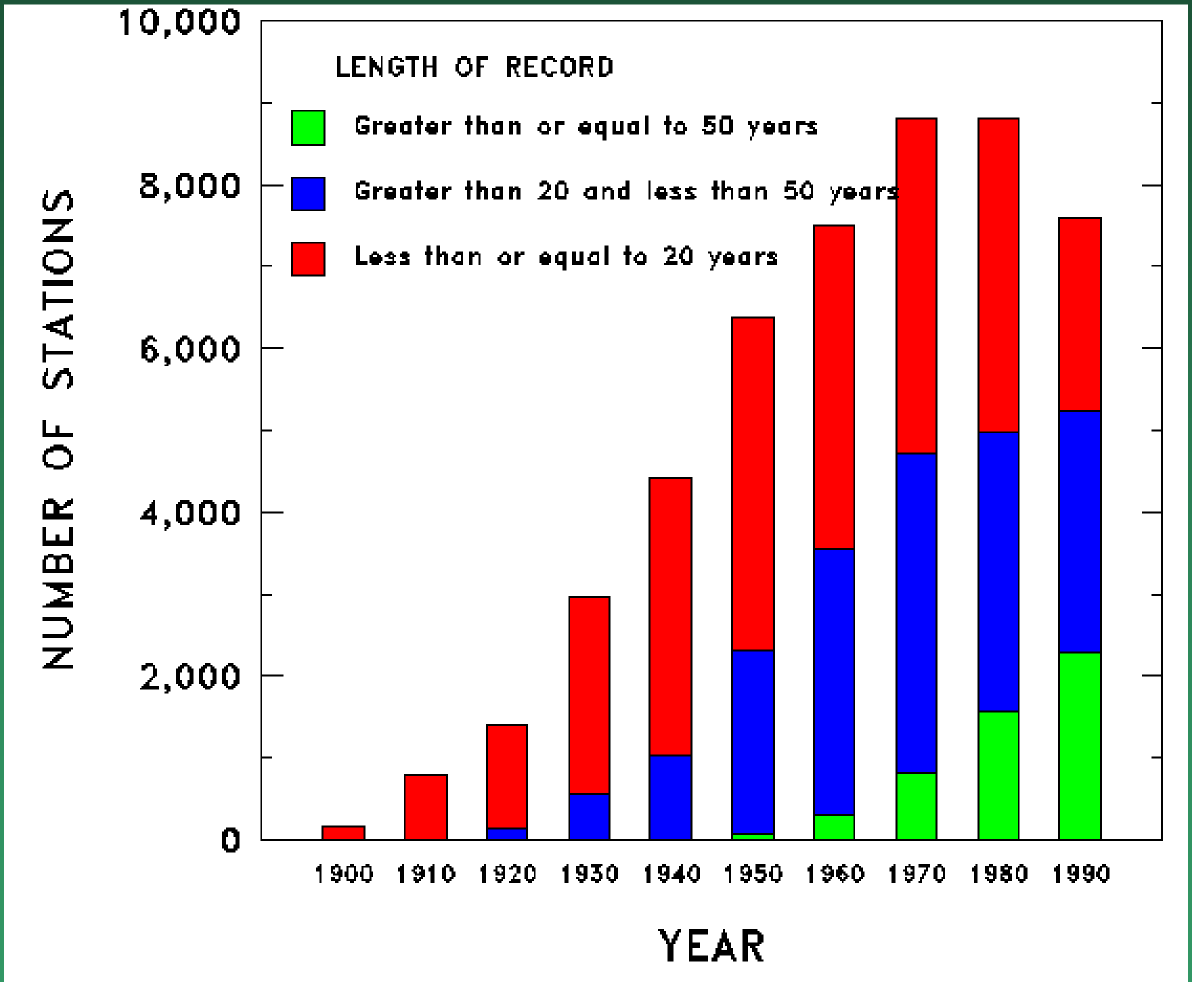


San Francisquito Cr.
nr. Stanford, CA

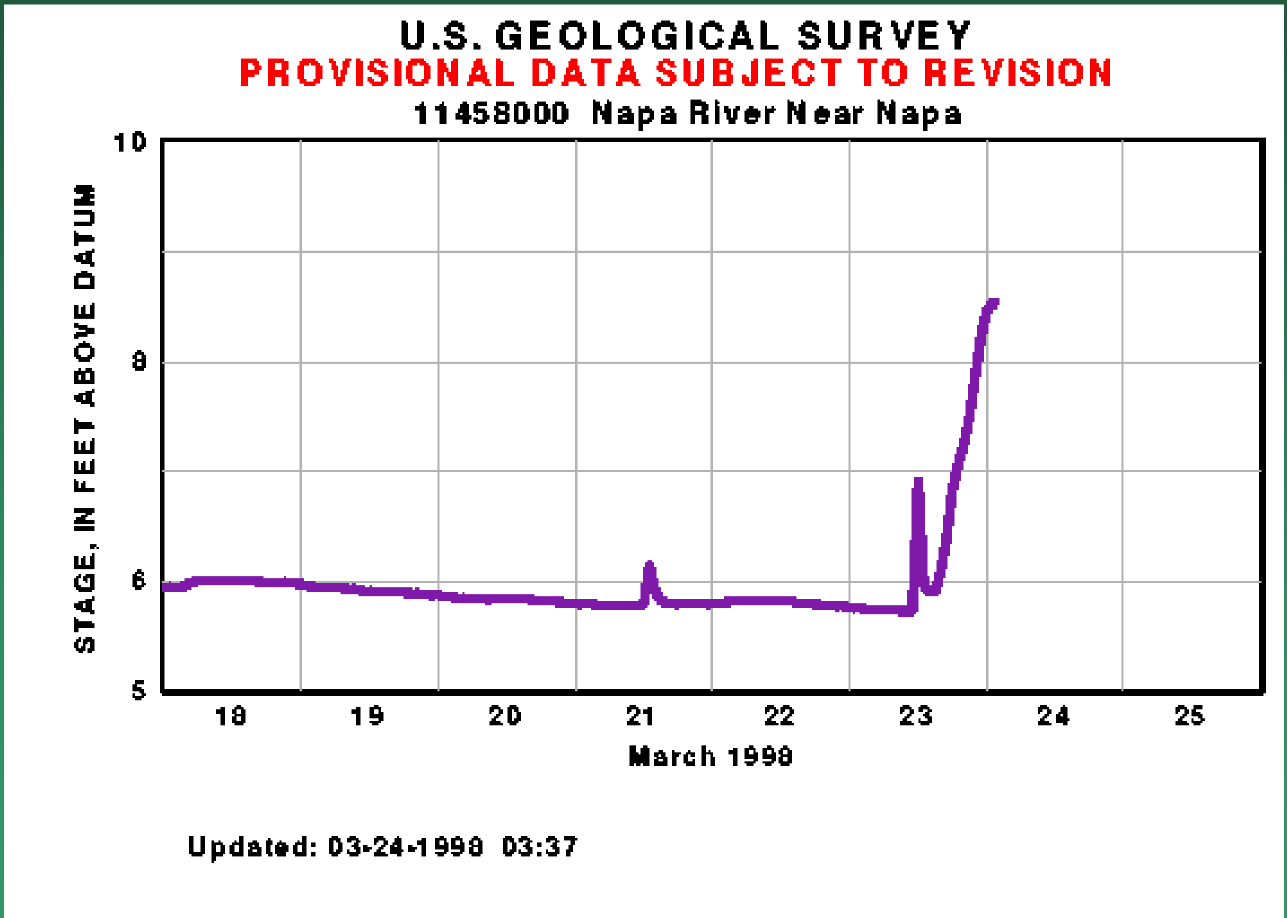
Pacific Cr. nr Moran, WY

USGS
science for a changing world

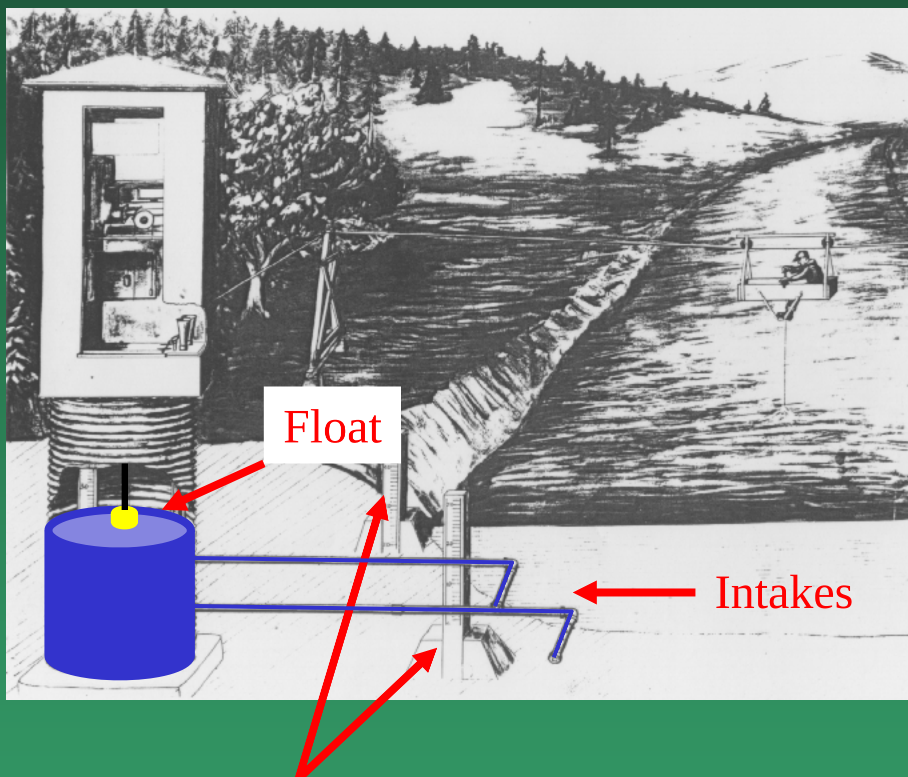
Historic data from over 18,500 locations can be analyzed with confidence

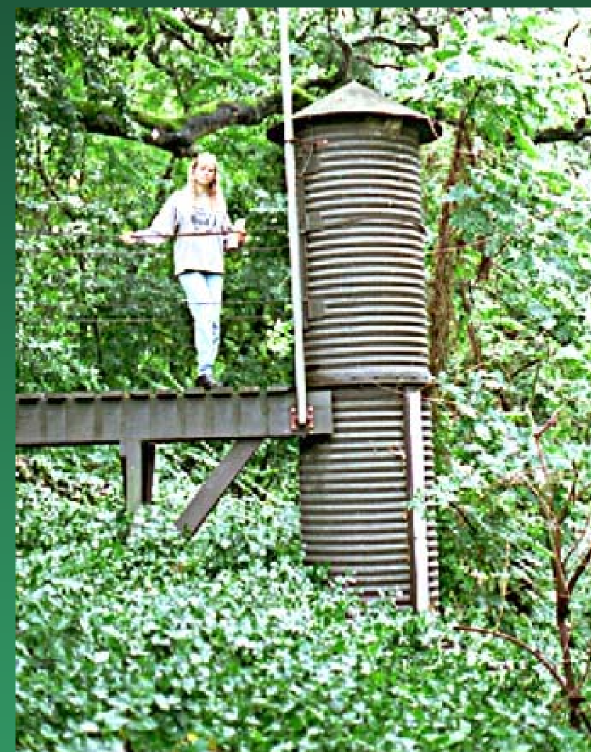


The basic piece of data collected at gaging stations is Stream Stage



Stage can be sensed using STILLING WELLS



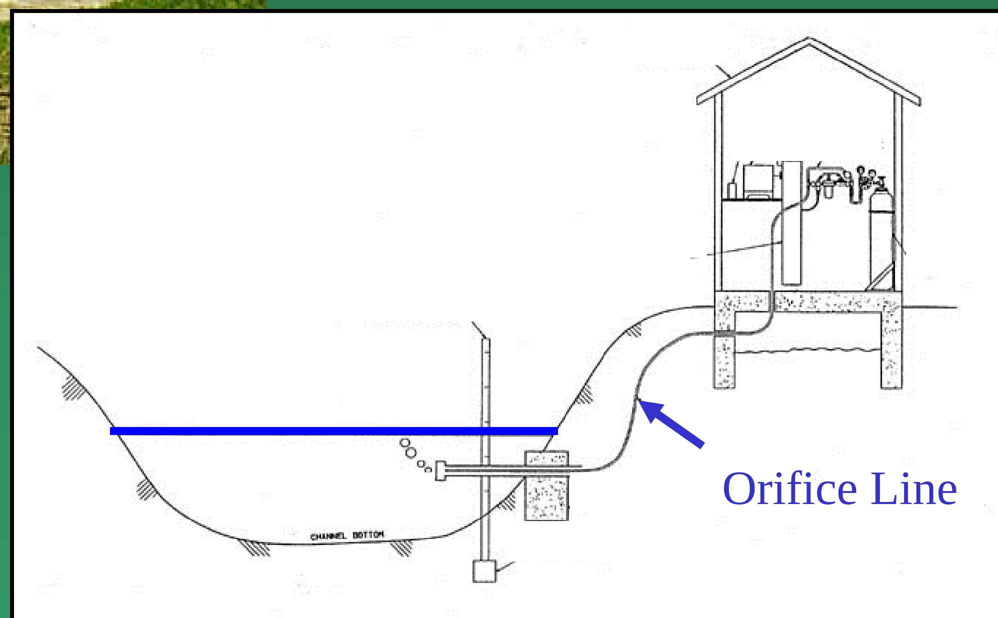


San Francisquito Cr. at Stanford, CA

USGS
science for a changing world

Stage can also be sensed using PRESSURE TRANSDUCERS

Pacific Cr. near Moran, WY



USGS
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Stage is usually:

•Measured to an accuracy standard of:

"either 0.01 ft or 0.2 percent of the effective stage being measured" -- USGS, Office of Surface Water memorandum 93.07

Basic Data Recorder

•Recorded every 15 minutes

USGS science for a changing world

Most users of streamflow information need to know the discharge of the stream

Discharge Measurement
Brian Loving, Salt Lake City

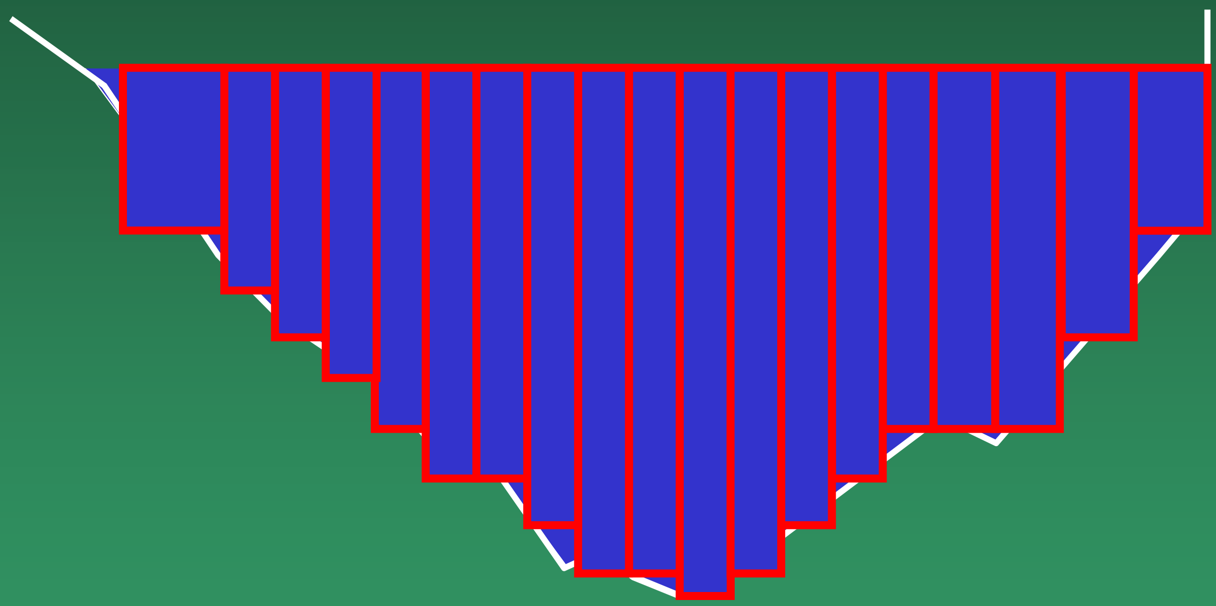
DISCHARGE IS USUALLY MEASURED USING THE VELOCITY-AREA METHOD

Discharge = (Area of water in cross section) x (Water velocity)

x Water Velocity

Cross section area

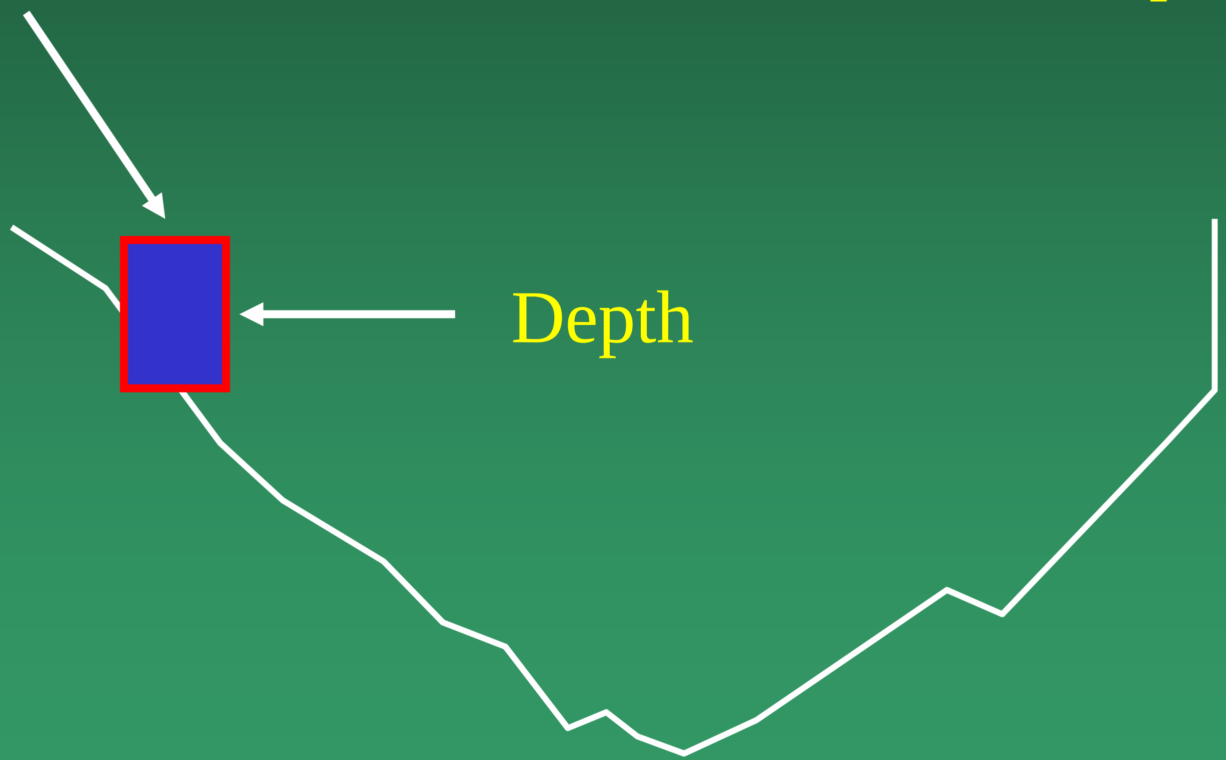
Channel cross section is divided into numerous sub sections



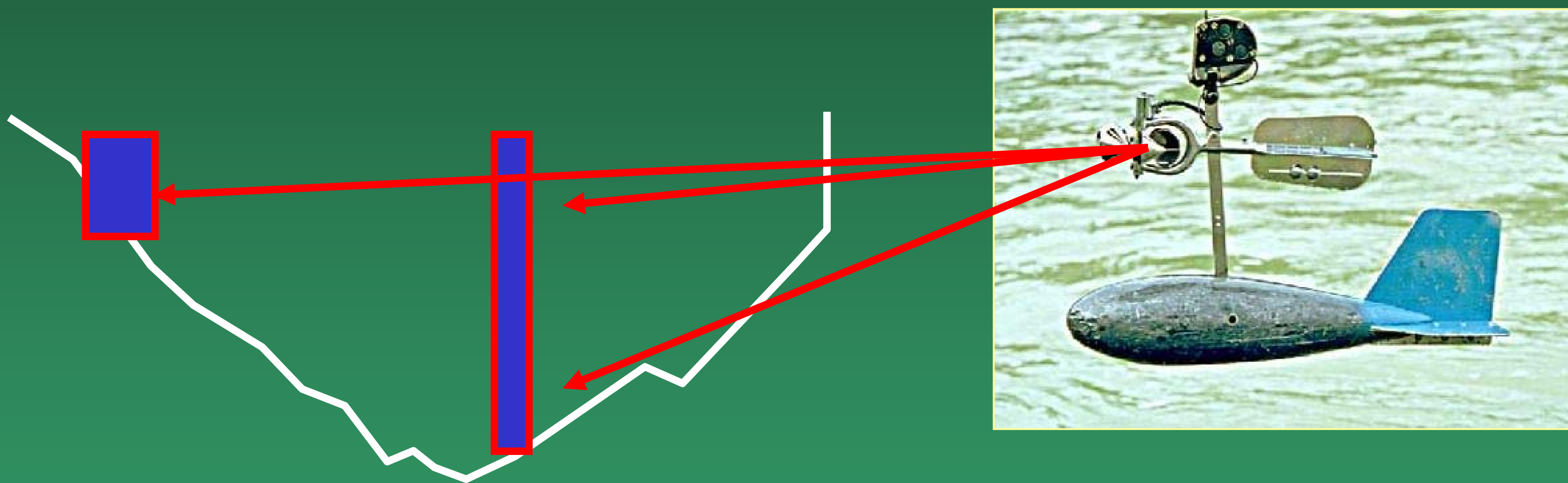
Discharge of each sub-section = Area x Average Water Velocity

Area of each sub-section determined by directly measuring width and depth

Area = Width x Depth

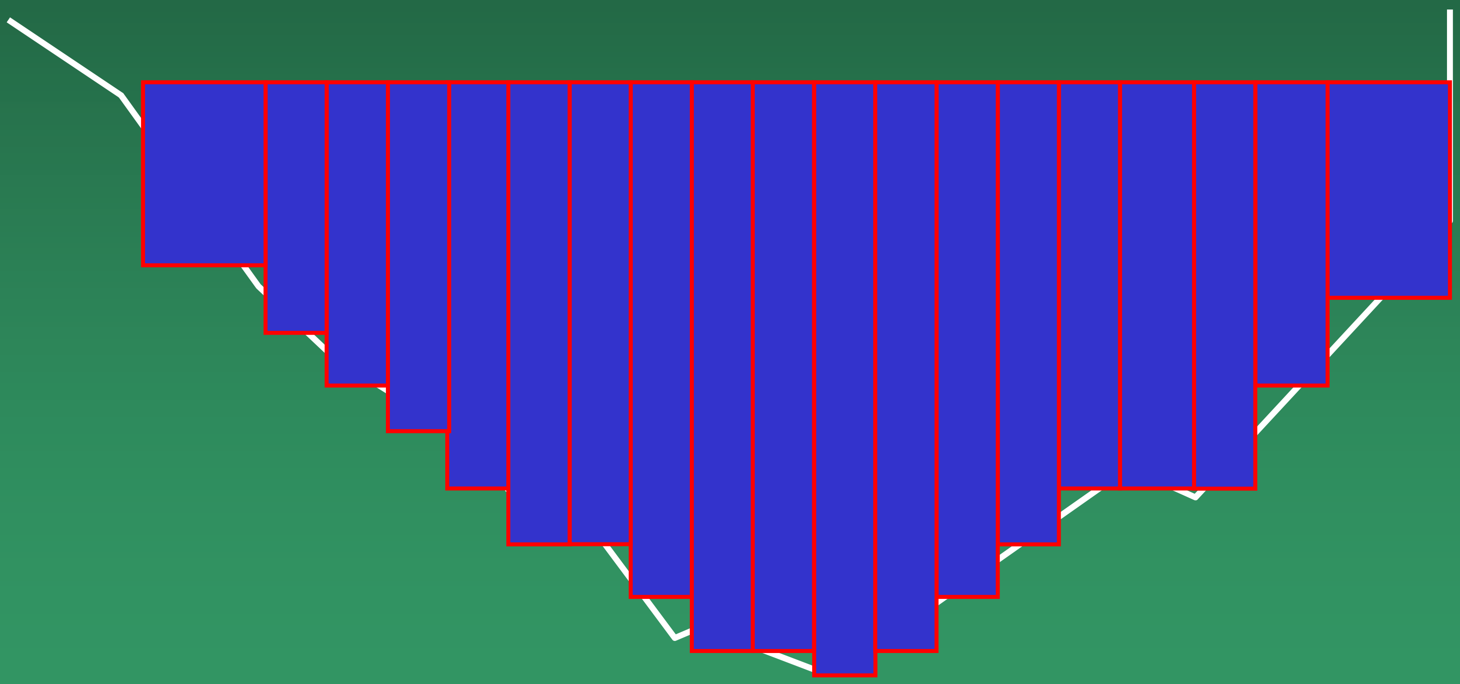


Water velocity in each sub-section estimated using a current meter to measure water velocity at selected locations



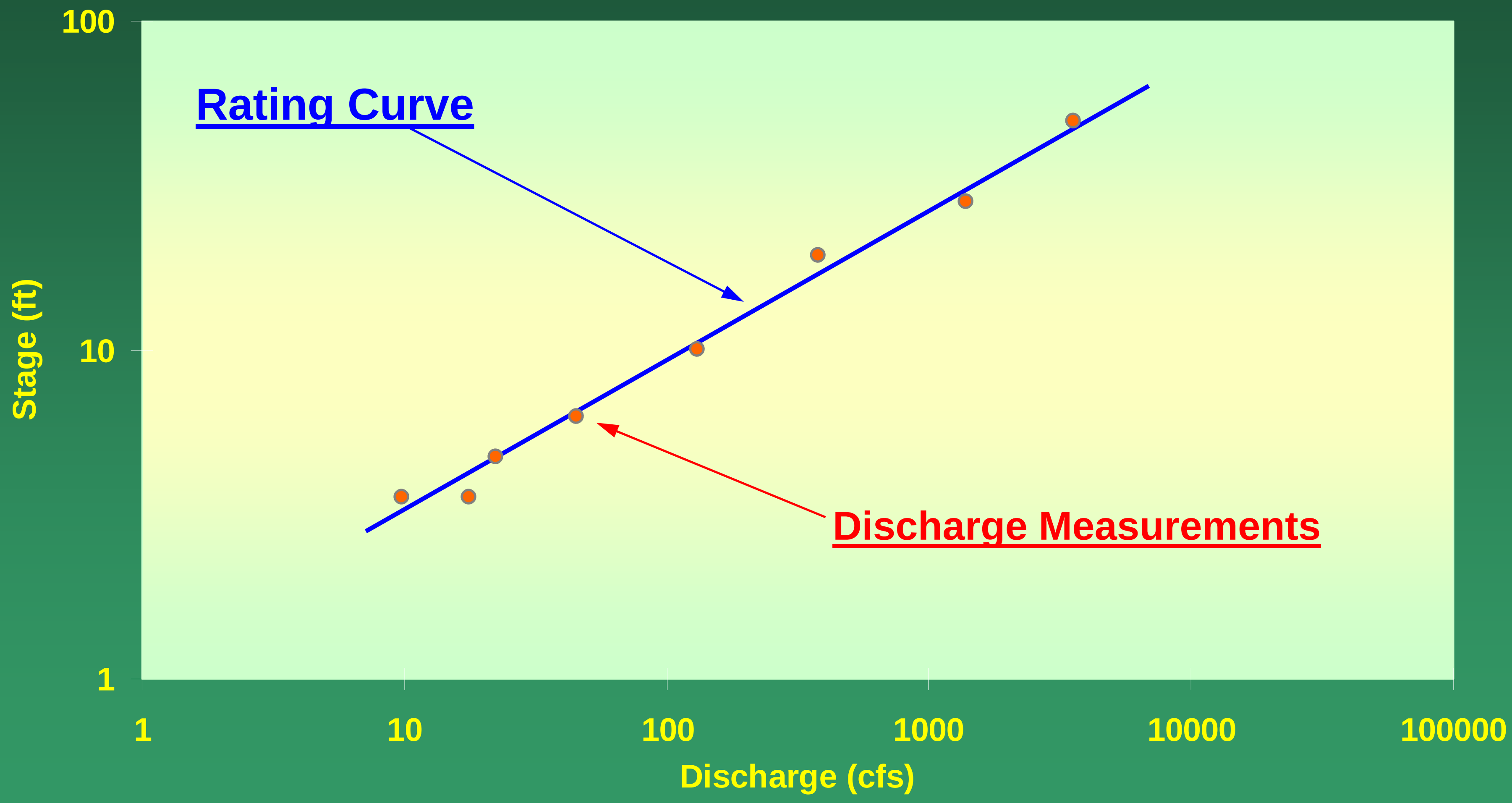
Stream discharge is sum of discharges in all sub-sections

Total Discharge = ((Area$_1$ x Velocity $_1$) + (Area$_2$ x Velocity$_2$) + ….. (Area$_n$ x Velocity$_n$))



science for a changing world

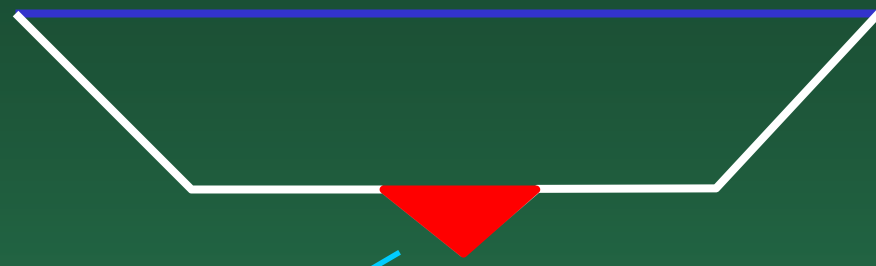
Discharge measurements are used to develop rating curves

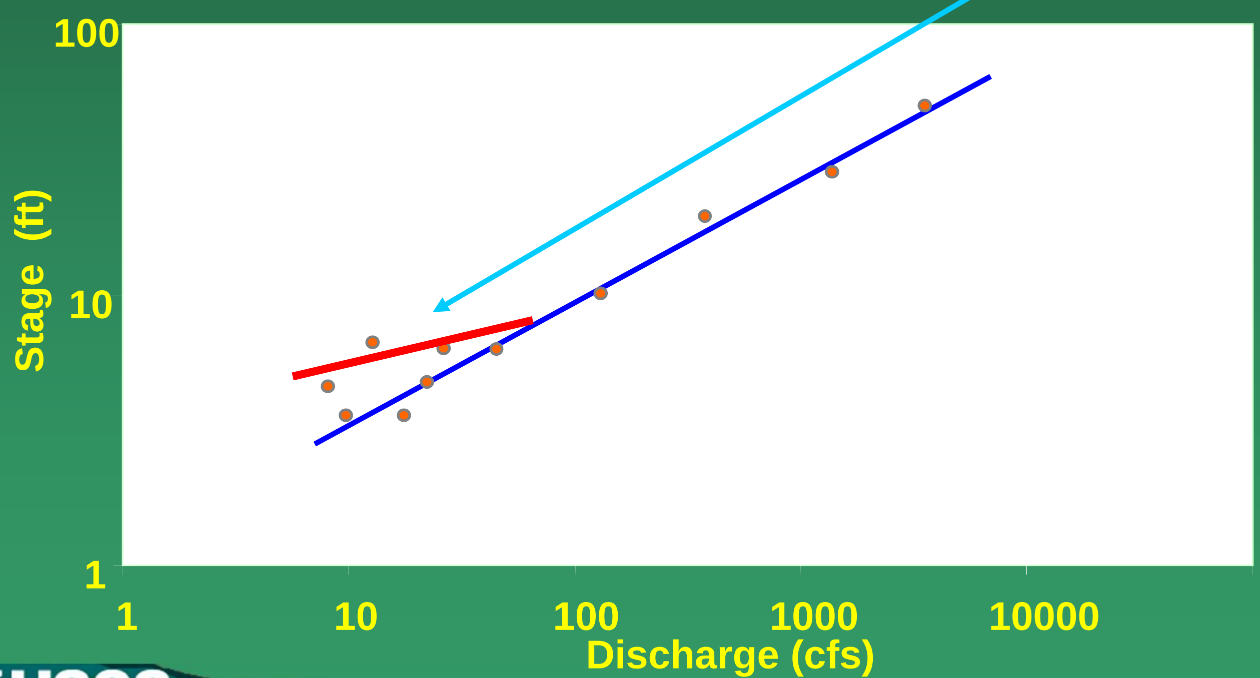


Discharge must be measured at all stages

Discharge measurements during high stages are particularly important

To maintain ratings, discharge must be measured regularly

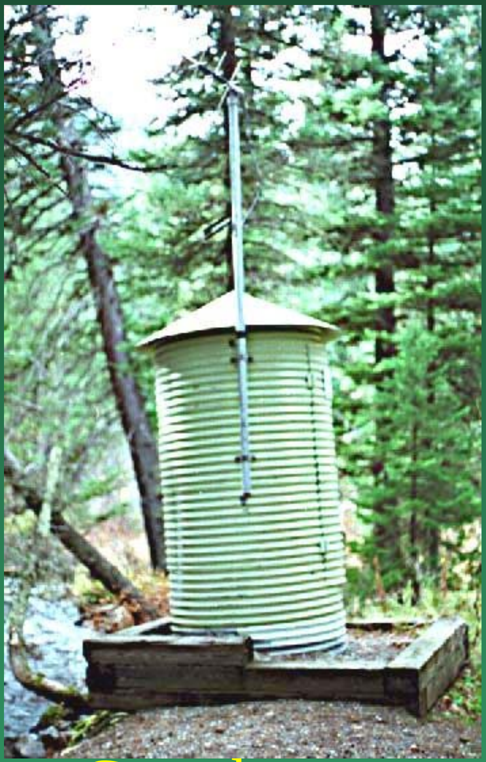




For example: rating changes as channel fills.

Datum must be checked regularly

Surveying crew from
Utah District



Gage houses
settle

Benchmark

All gaging station data are checked and reviewed

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

In Refer Reply To:
Mail Stop 415

MEMORANDUM

March 11, 1998

To: T.J. Conomos
Regional Hydrologist, Western Region

From: Thomas H. Yorke
Chief, Office of Surface Water

Subject: Technical review of Surface-Water Activities of the Utah District, 1997

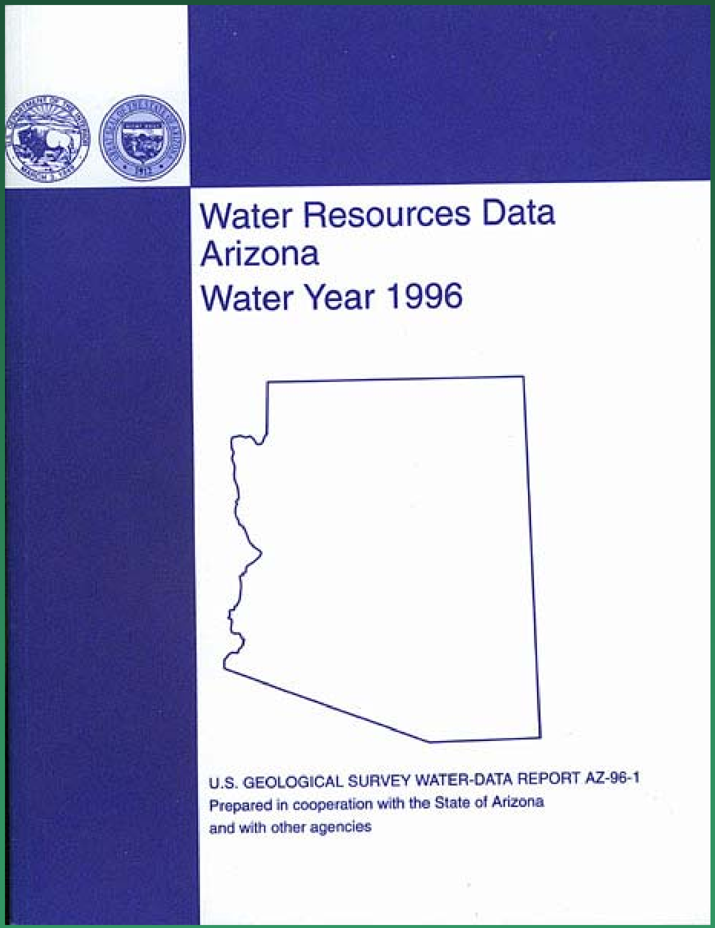
A technical review of surface-water activities in the Utah District was conducted during the period September 14-19, 1997. The review team consisted of Dan Hitch (Nebraska), Jeanne Robbins (North Carolina), Mike Nolan (Western Region surface-water specialist), and Bill Kirby (Office of Surface Water, team leader). A copy of the review report is attached.

And by national review teams

Data Dissemination-- Historical Data

Verde River near Scottsdale, Arizona

Paper Copy →



Daily discharge and peak-flow data

USGS
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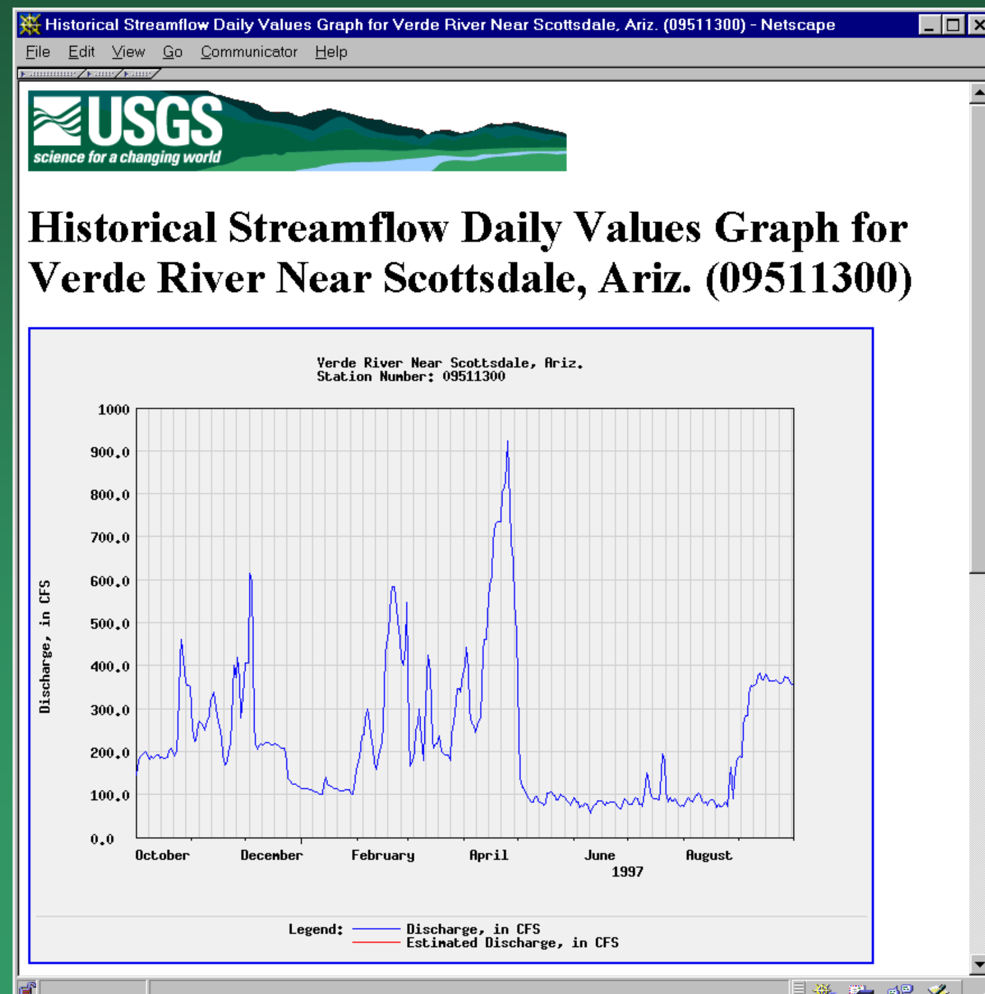
Electronic Data Dissemination--
Historical Daily-Mean Discharge

Verde River near Scottsdale, AZ

http://water.usgs.gov →

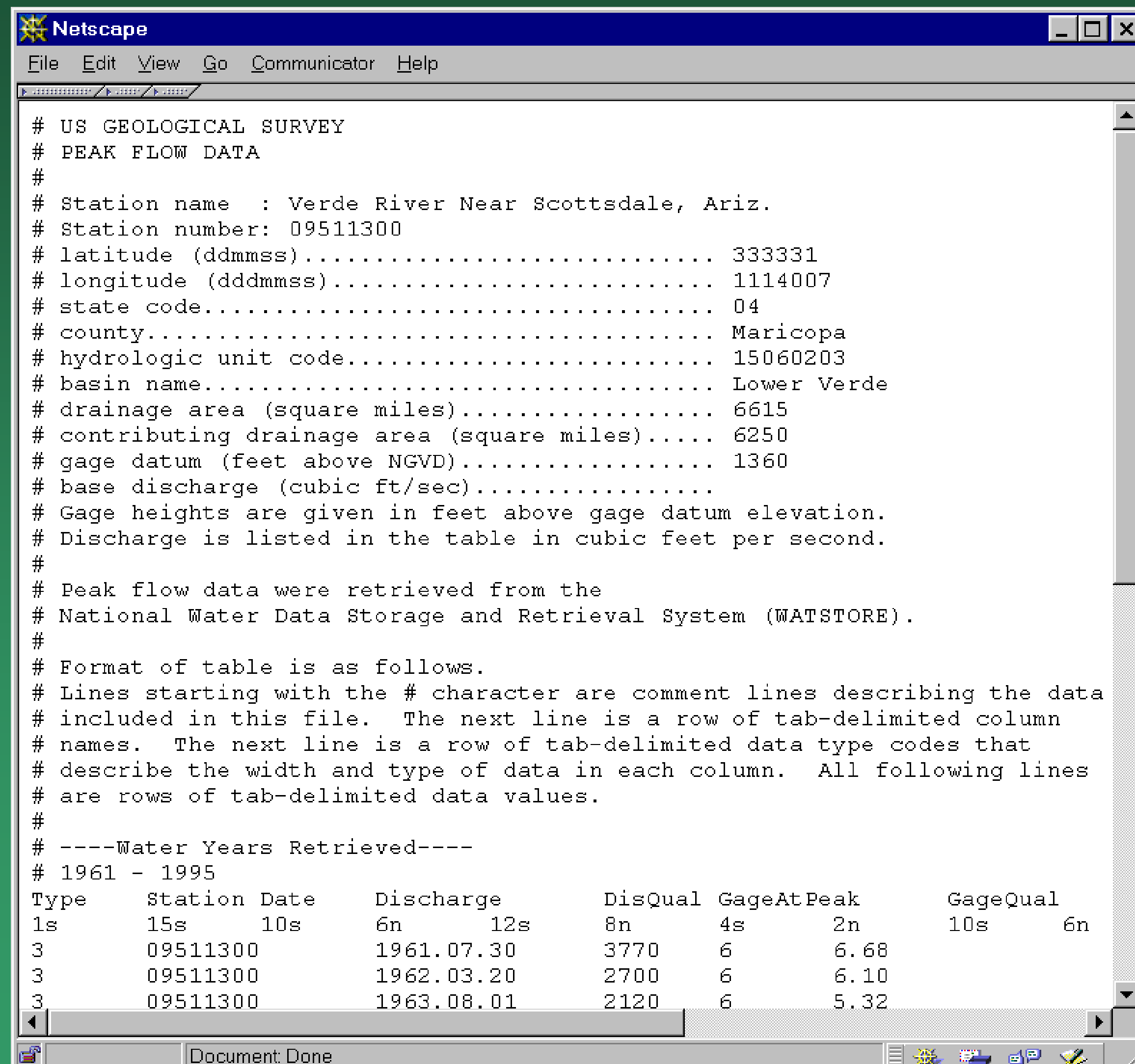
Graphs



Electronic Data Dissemination--Historic Peak-Flow Data

Verde River near Scottsdale, AZ

http://water.usgs.gov →




```
# US GEOLOGICAL SURVEY
# PEAK FLOW DATA
#
# Station name  : Verde River Near Scottsdale, Ariz.
# Station number: 09511300
# latitude (ddmmss)........................... 333331
# longitude (dddmmss).......................... 1114007
# state code................................... 04
# county....................................... Maricopa
# hydrologic unit code......................... 15060203
# basin name................................... Lower Verde
# drainage area (square miles)................. 6615
# contributing drainage area (square miles)..... 6250
# gage datum (feet above NGVD)................. 1360
# base discharge (cubic ft/sec)................
# Gage heights are given in feet above gage datum elevation.
# Discharge is listed in the table in cubic feet per second.
#
# Peak flow data were retrieved from the
# National Water Data Storage and Retrieval System (WATSTORE).
#
# Format of table is as follows.
# Lines starting with the # character are comment lines describing the data
# included in this file.  The next line is a row of tab-delimited column
# names.  The next line is a row of tab-delimited data type codes that
# describe the width and type of data in each column.  All following lines
# are rows of tab-delimited data values.
#
# ----Water Years Retrieved----
# 1961 - 1995
Type    Station Date    Discharge       DisQual GageAtPeak      GageQual
1s      15s     10s     6n      12s     8n      4s      2n      10s     6n
3       09511300        1961.07.30      3770    6       6.68
3       09511300        1962.03.20      2700    6       6.10
3       09511300        1963.08.01      2120    6       5.32
```

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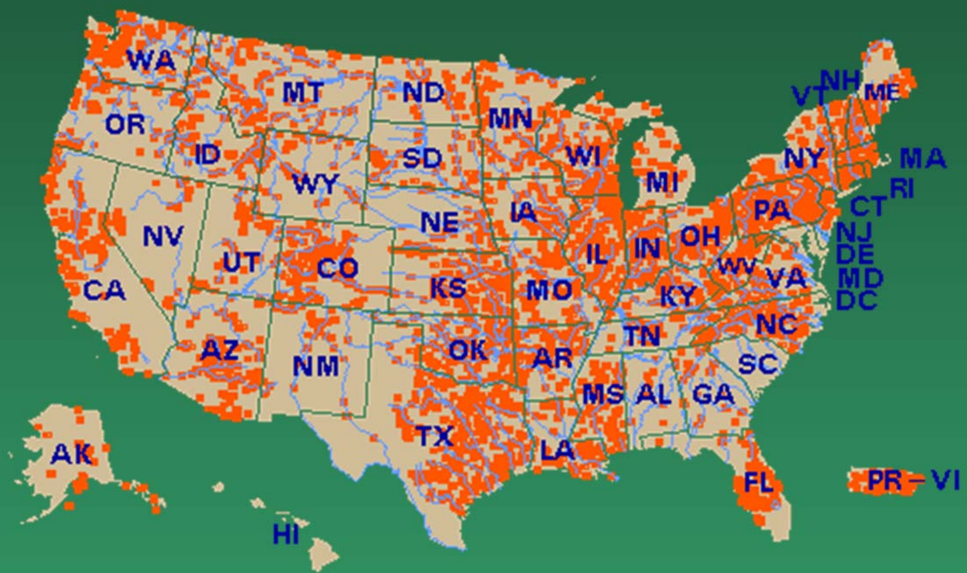
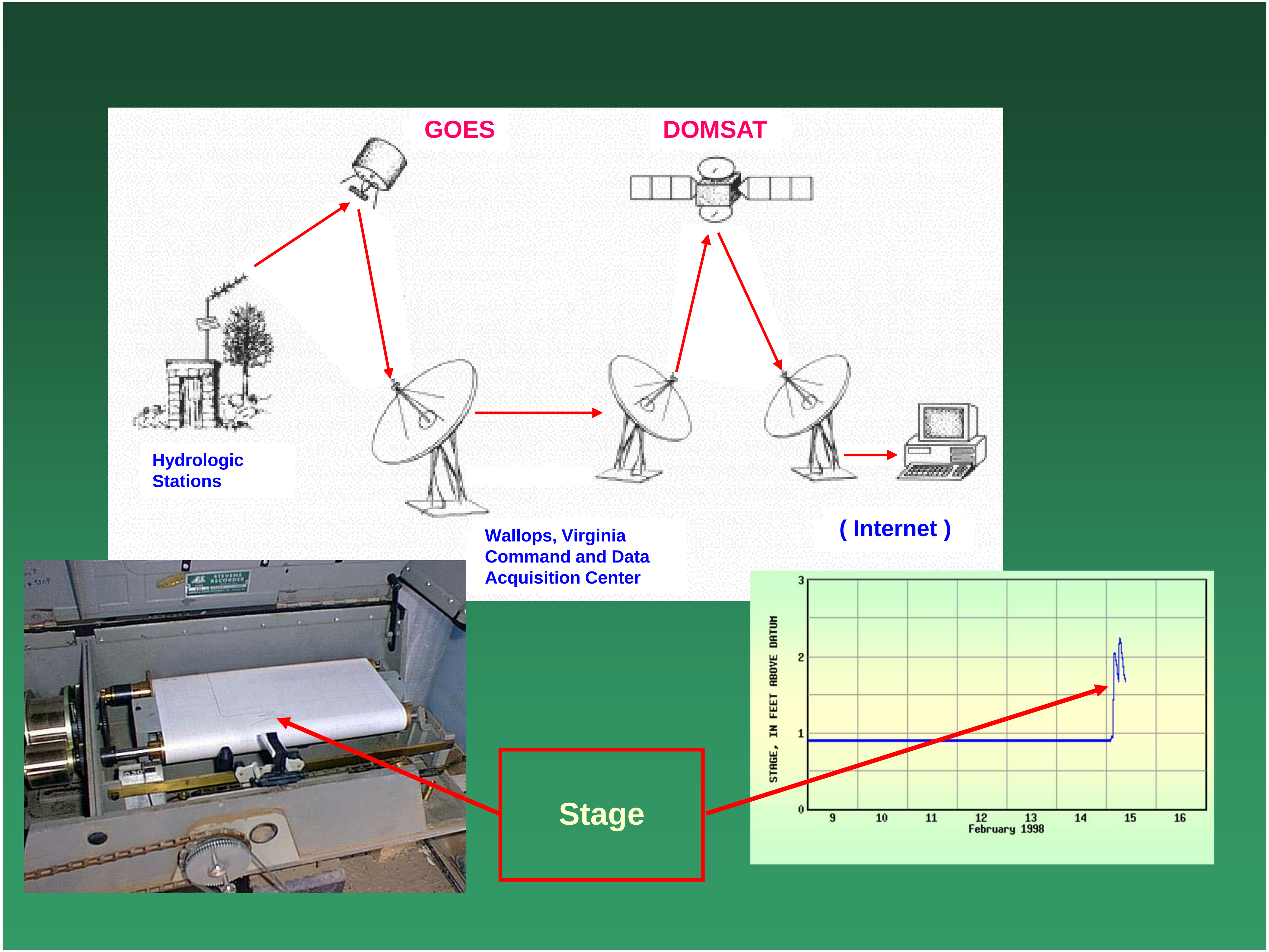
Data Dissemination-- Real-Time



http://water.usgs.gov



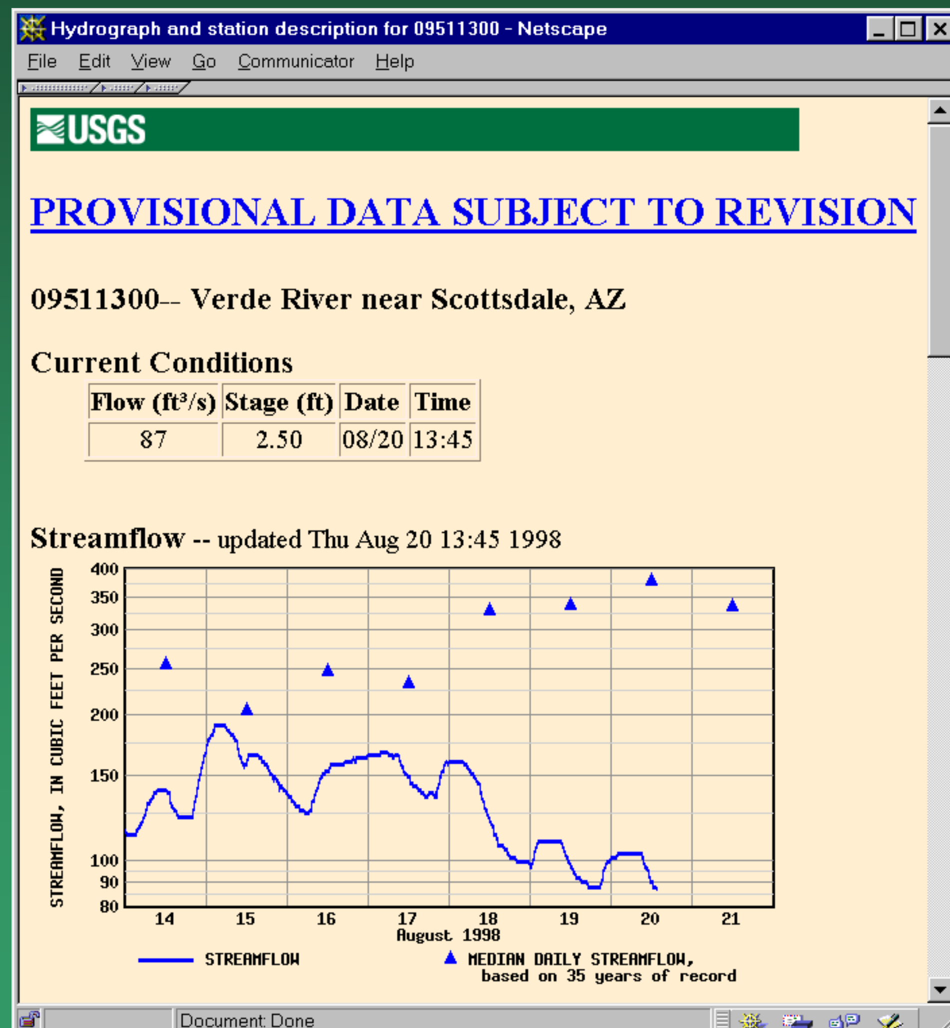
GOES
DOMSAT
Hydrologic Stations
Wallops, Virginia Command and Data Acquisition Center
(Internet)
Stage
STAGE, IN FEET ABOVE DATUM
0
1
2
3
9
10
11
12
13
14
15
16
February 1998

Data dissemination-- Real Time

http://water.usgs.gov

Verde River near Scottsdale, AZ

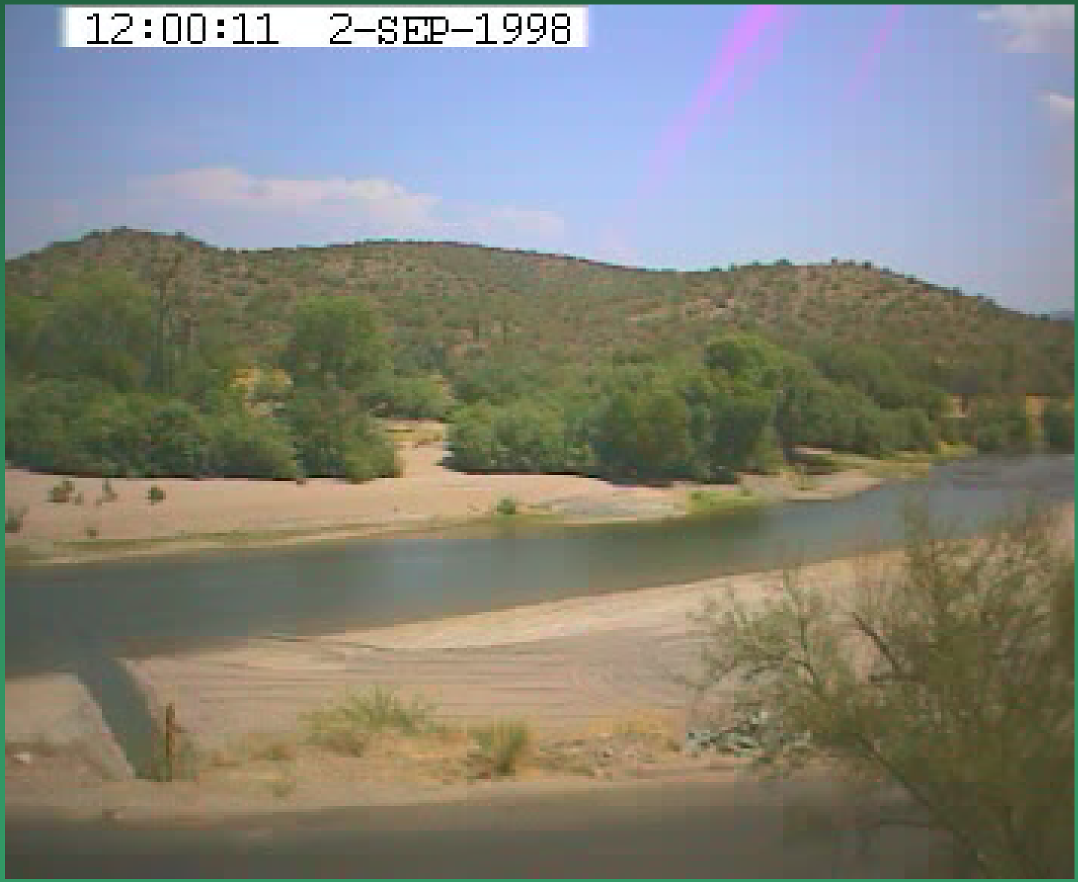
Graphs



Data Dissemination--
Live Pictures of Gaged Channels

http://wwwdaztcn.wr.usgs.gov

Verde River near
Scottsdale, AZ



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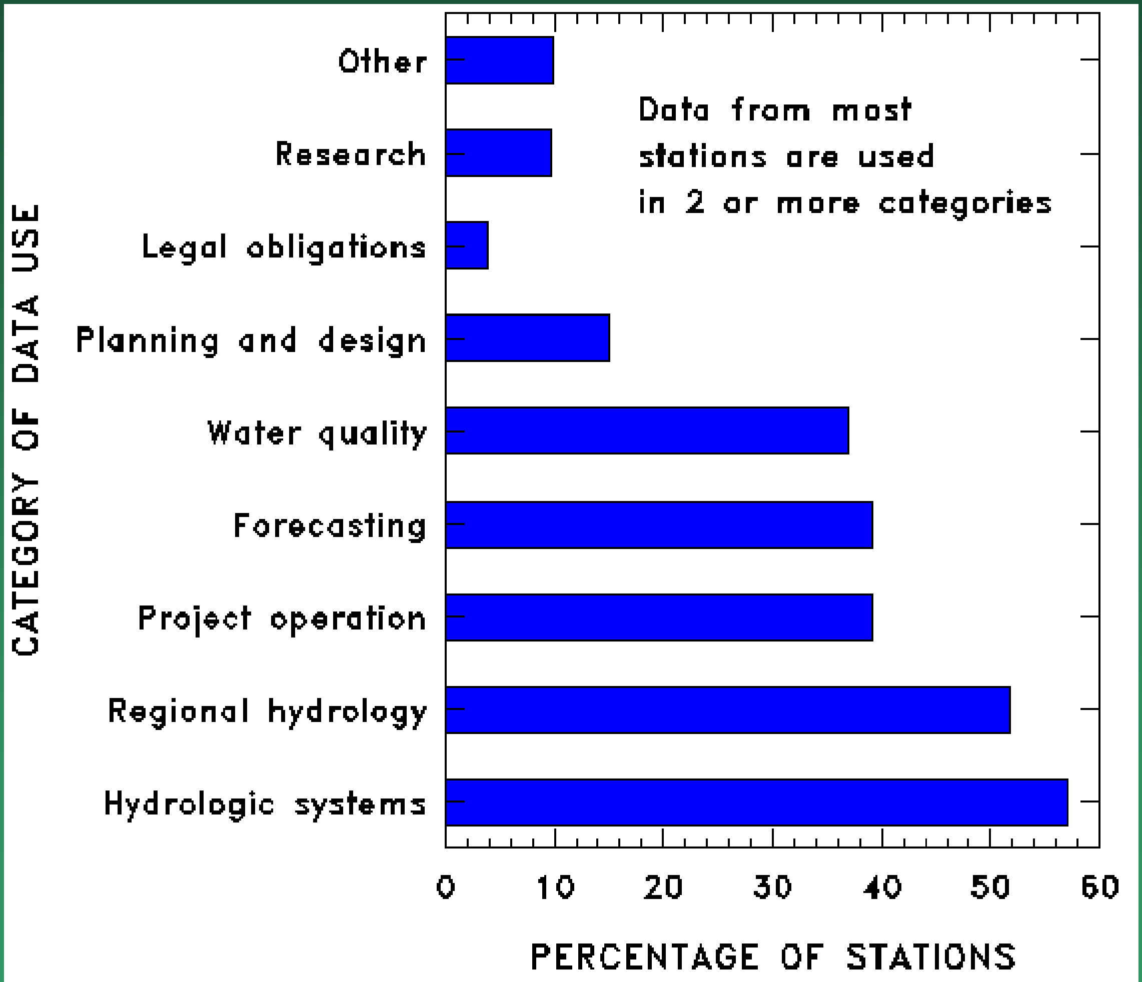
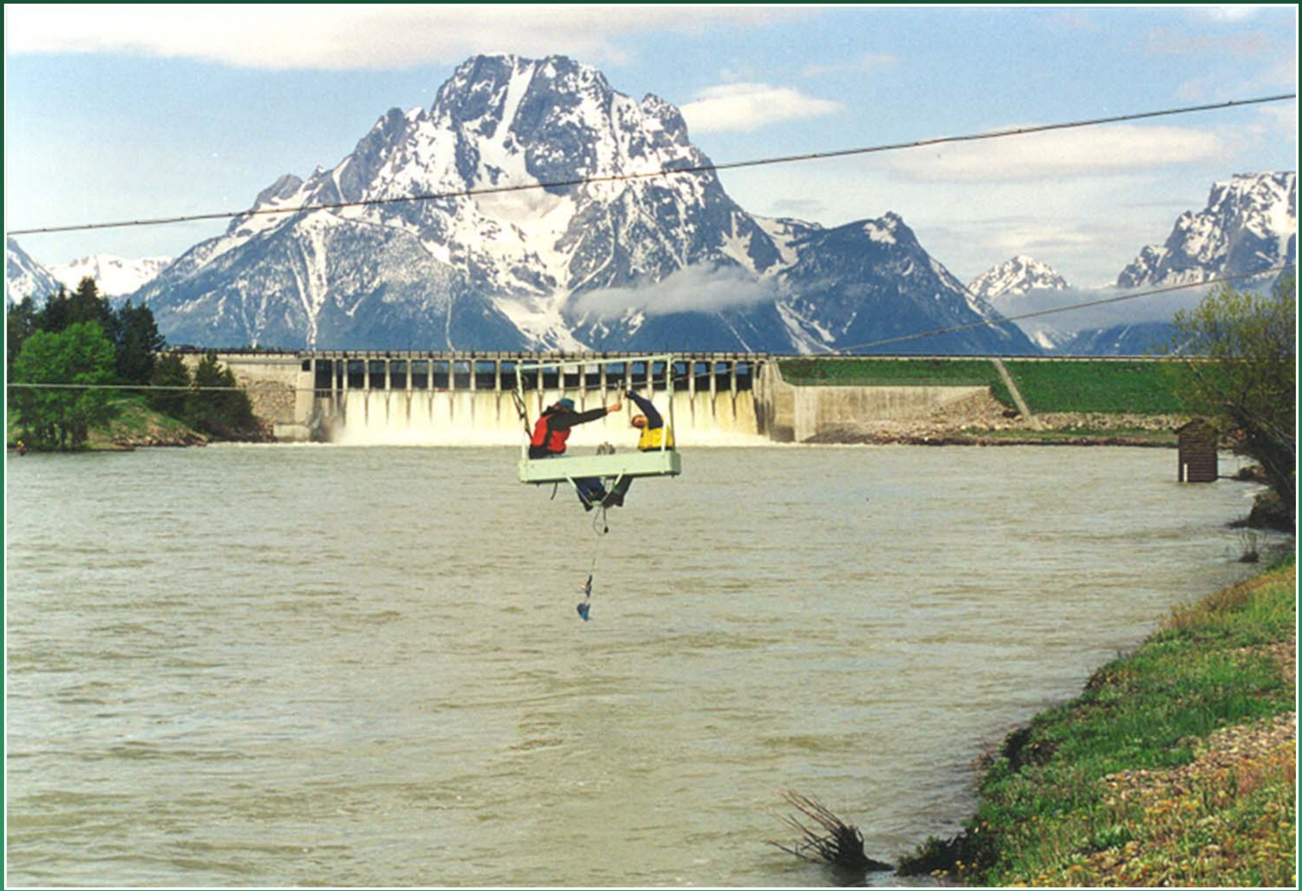
Data from USGS gaging stations can be used to meet a variety of needs



Data from Thomas and Wahl, 1993

Current needs



Reservoir releases

Current needs--
Flood Forecasting

Stream Gaging and Flood Forecasting

A Partnership of the U.S. Geological Survey and the National Weather Service
U. S. Geological Survey Fact Sheet FS-066-95

Ninety-eight percent of stations used for real-time river forecasting are operated by the U.S.G.S.

Figure 1. Flooding of Neosho River near Parsons, Kansas, spring 1994.

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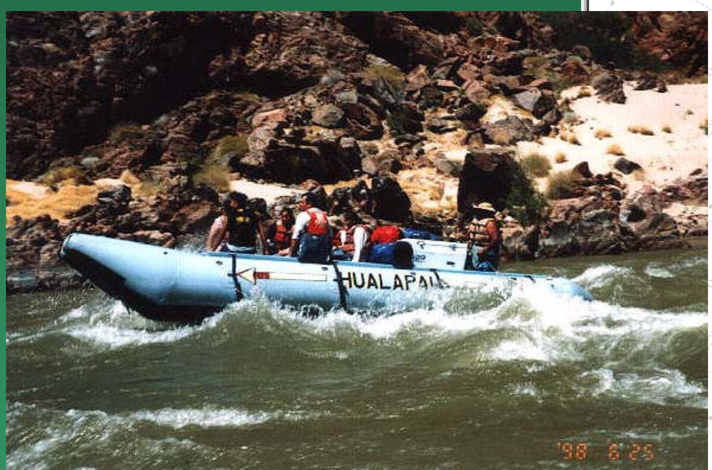
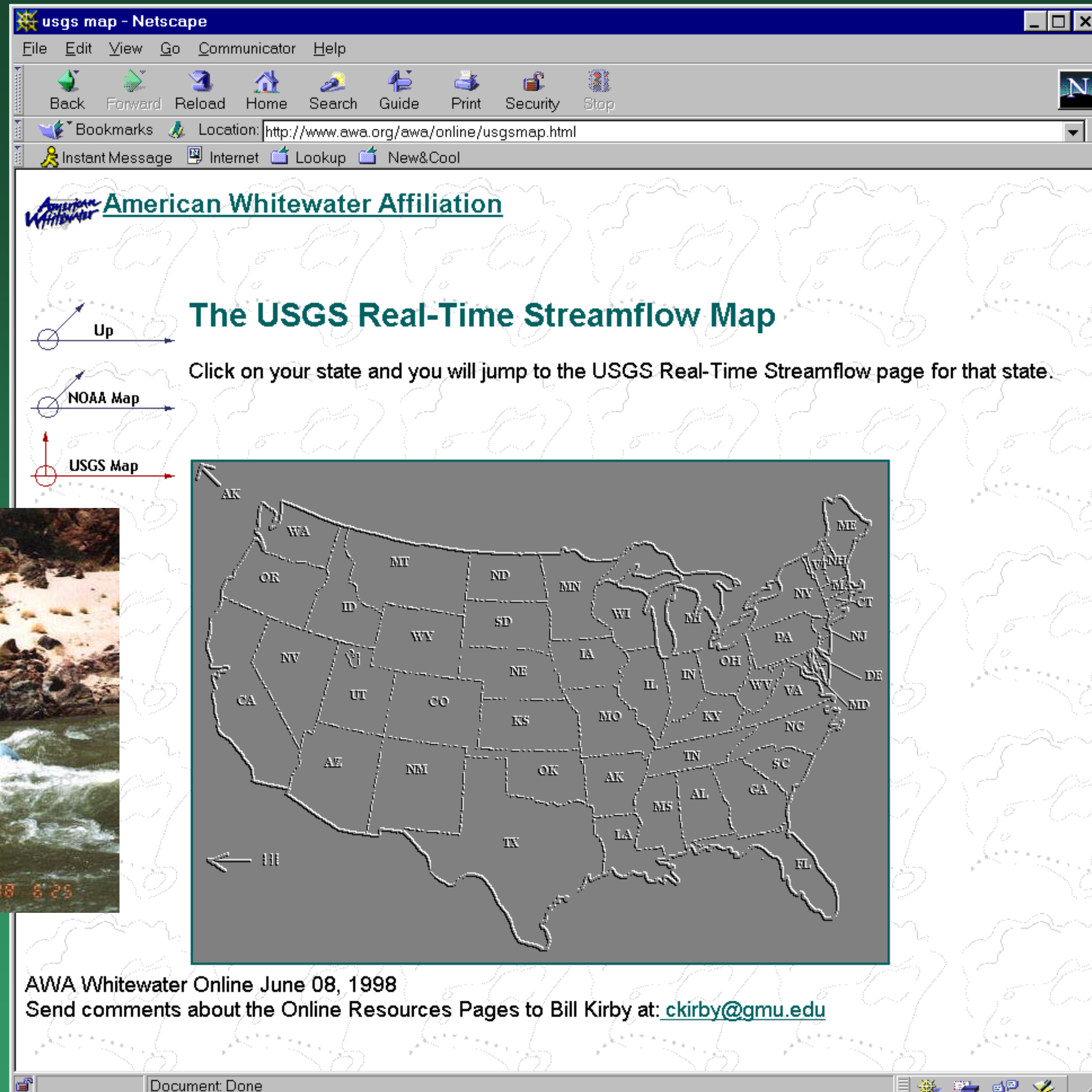
Current needs--Recreation

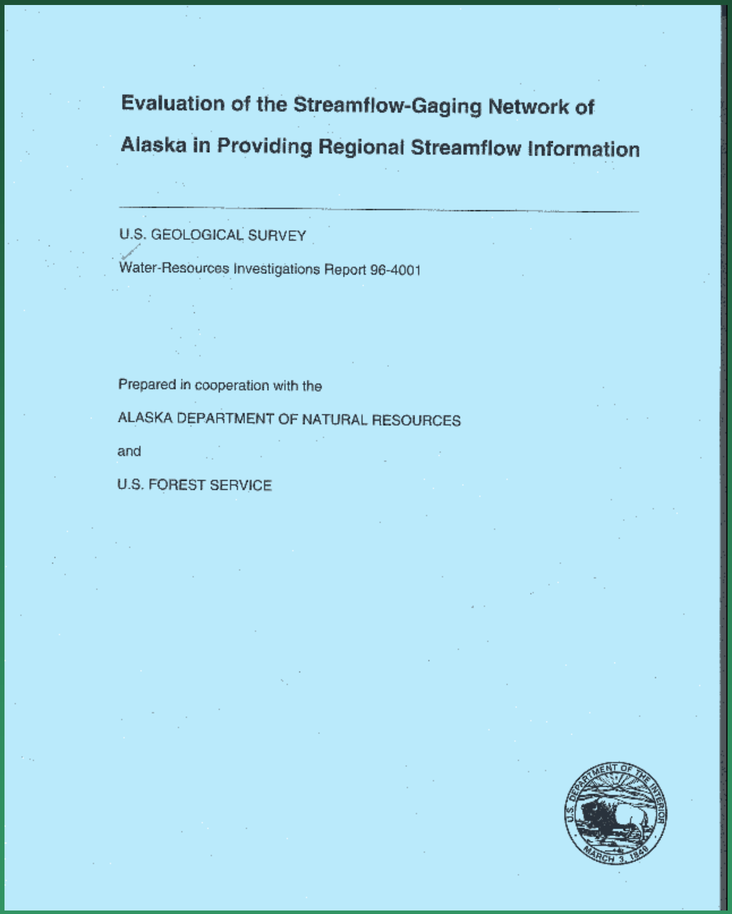
Whitewater Rafting





USGS
science for a changing world

Long-term needs



Evaluation of the Streamflow-Gaging Network of Alaska in Providing Regional Streamflow Information

U.S. GEOLOGICAL SURVEY

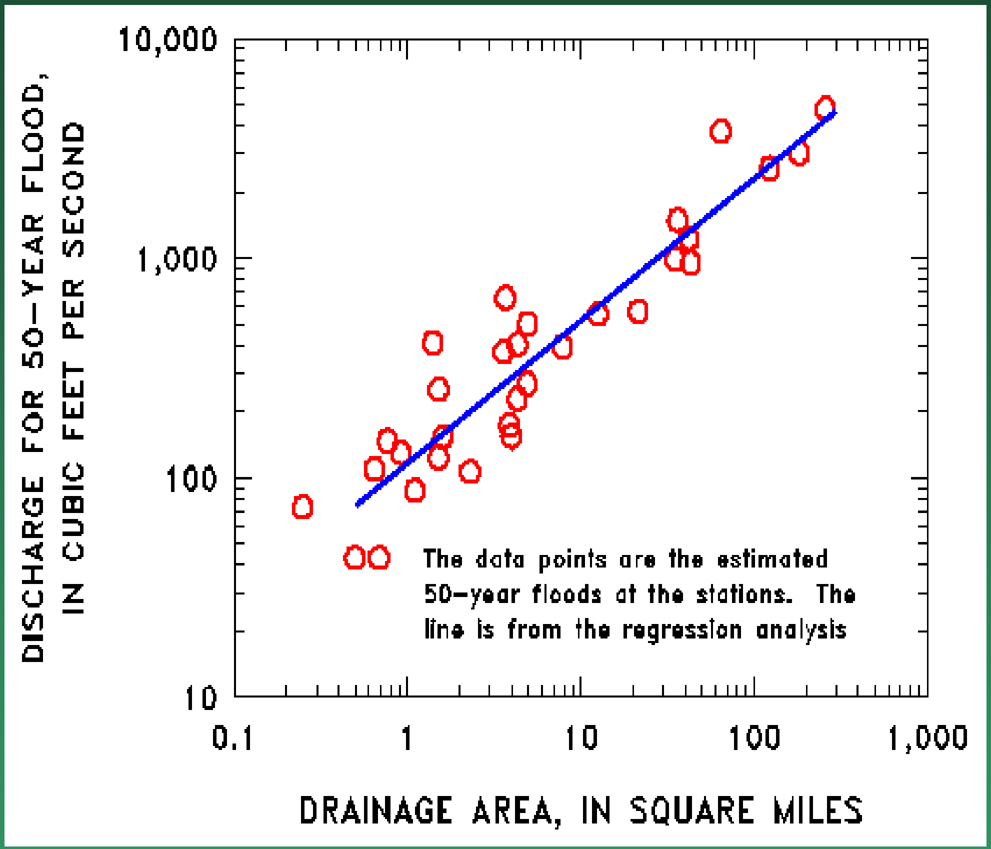
Water-Resources Investigations Report 96-4001

Prepared in cooperation with the

ALASKA DEPARTMENT OF NATURAL RESOURCES

and

U.S. FOREST SERVICE



Regional relations

USGS
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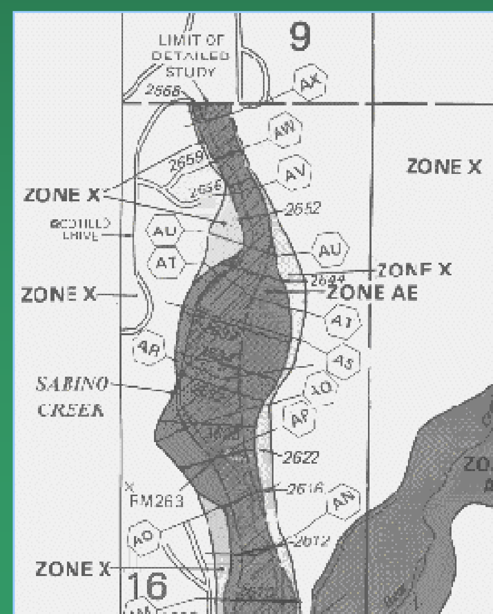
Uses of Streamflow Information:
<u>Flood Frequency Analysis</u>

Flood channel construction



FEMA Flood
Hazard Map


U. S. GEOLOGICAL SURVEY
RIO GRANDE GAGING STATION
ESTABLISHED 1889
FIRST GAGING STATION ESTABLISHED BY
U. S. GEOLOGICAL SURVEY

The End

See Selected References

or

Quit

Data Collection at U.S. Geological Survey Streamgages

By: K. Michael Nolan
and
Jeff V. Phillips
Narrated by: Ron James

USGS
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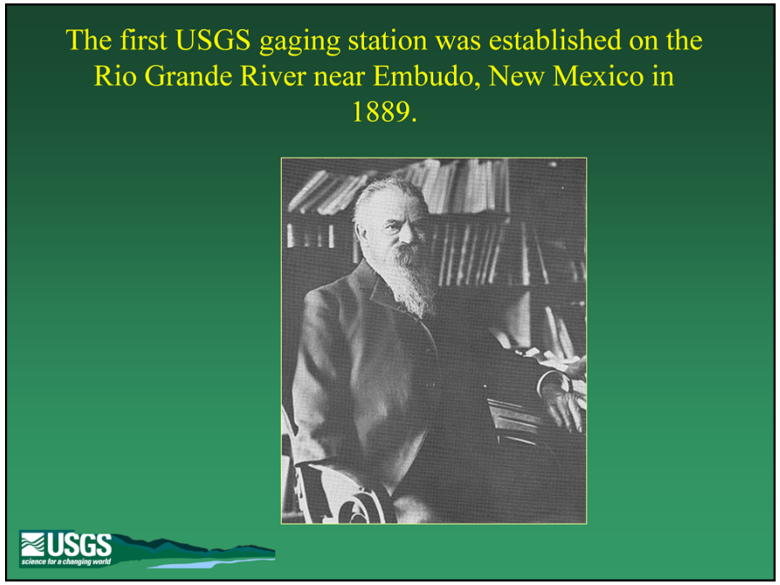
Selected References

- Frazier, A.H. and Heckler, W., 1972, Embudo, New Mexico, birthplace of systematic stream gaging, USGS: Prof. Paper 779, 23p.
- Mason, R.M. and B.A. Weiger, 1995, Stream gaging and flood forecasting - A partnership of the U.S. Geological Survey and the National Weather Service: U.S. Geological Survey Fact Sheet 209-95, 4p.
- Thomas, W.O., Jr., and Wahl, K.L, 1993, Summary of the nationwide analysis of the cost effectiveness of the U.S. Geological Survey stream-gaging program (1983--88): U.S. Geological Survey Water Resources Investigations Report 93--4168, 27 p

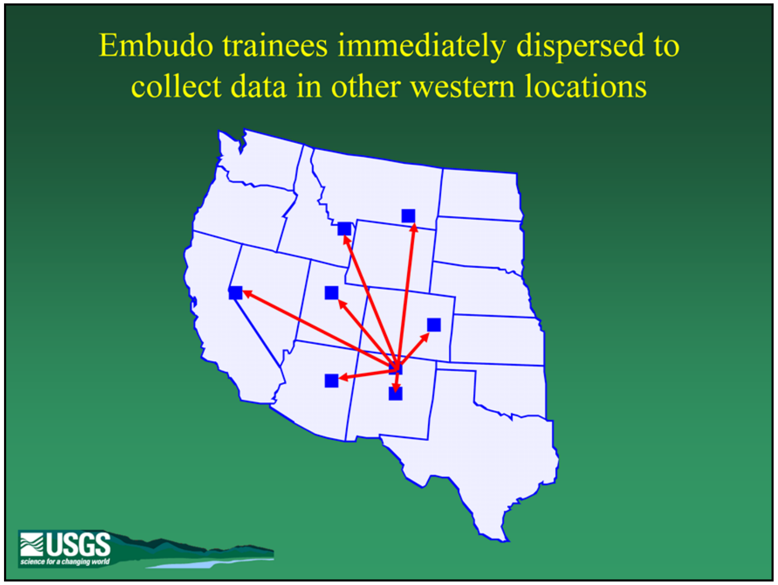
Quit

U.S. Geological Survey streamgages provide hydrologic information needed to define, use and manage the Nation’s water resources. The following presentation U describes methods used to collect data at USGS gaging stations. These methods, along with the underlying philosophy of the streamgaging program have allowed the USGS to collect relevant streamflow data for over 100 years.

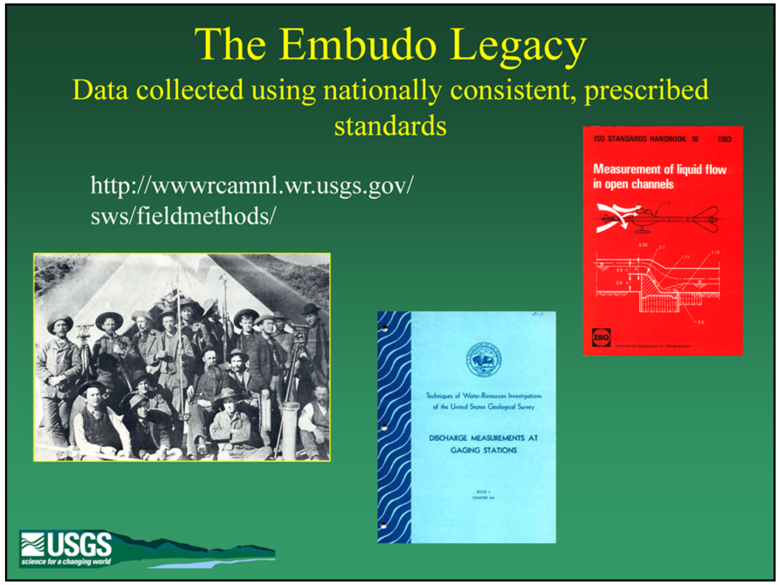


The U.S. Geological Survey began collecting streamflow information in 1889, when the first stream-gaging station was established on the Rio Grande River near Embudo New Mexico.

Personnel from the Irrigation Survey, which was then a branch of the U.S. Geological Survey, were directed by John Wesley Powell to develop procedures that could be used to produce reliable streamflow estimates. Powell felt that it was important to inventory the flow of streams in the arid west prior to settlement.



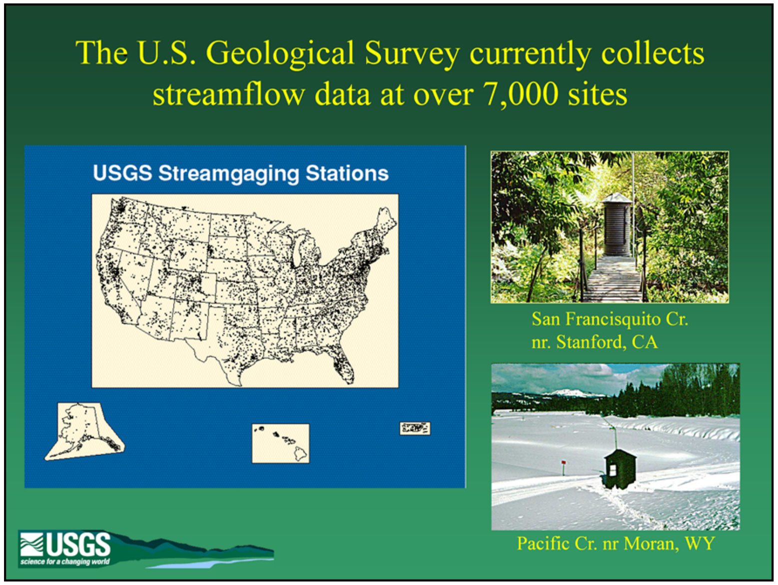
As soon as methods were developed at Embudo personnel were dispersed throughout the west to collect streamflow data on the Truckee-Carson River, the Arkansas River, the Upper Rio Grande, the Gila River, the Snake River, the Upper Missouri River and in the Utah Territory.



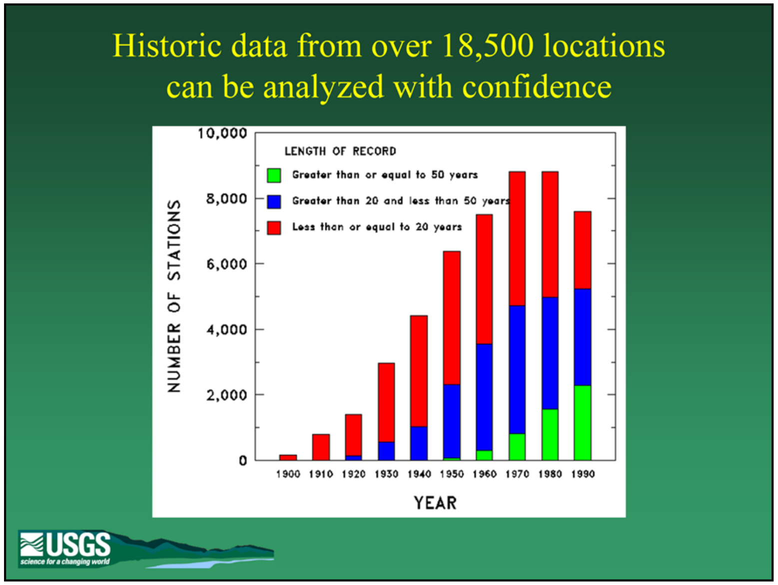
Ever since hydrographers left Embudo, the USGS has collected streamflow data using nationally consistent methods. These methods have allowed the USGS to collect data to the highest practical standards.

All methods used to collect streamflow data are documented in USGS publications, such as the Techniques in Water Resources Investigations series. Many USGS procedures form the basis for handbooks issued by the International Standards Organization.

A newly developed WEB-based training class allows all USGS employees to readily study basic methods used to collect streamflow data.

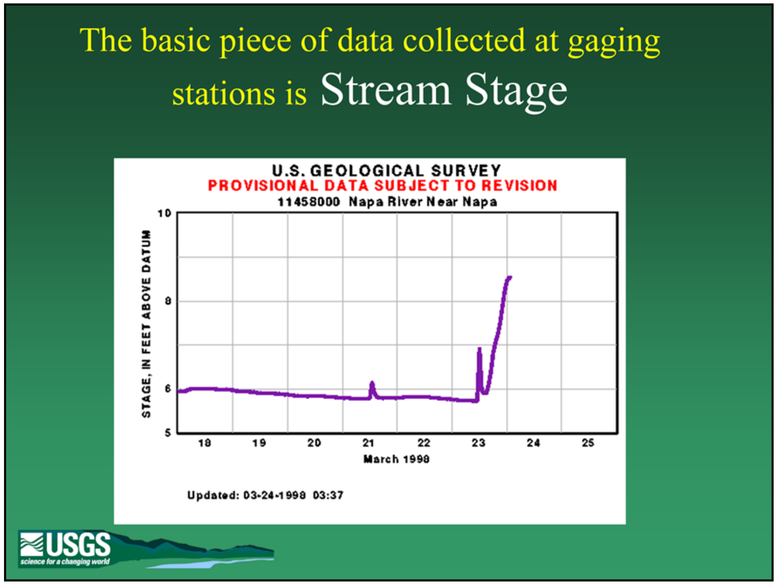


The USGS currently operates over 7000 gaging stations.

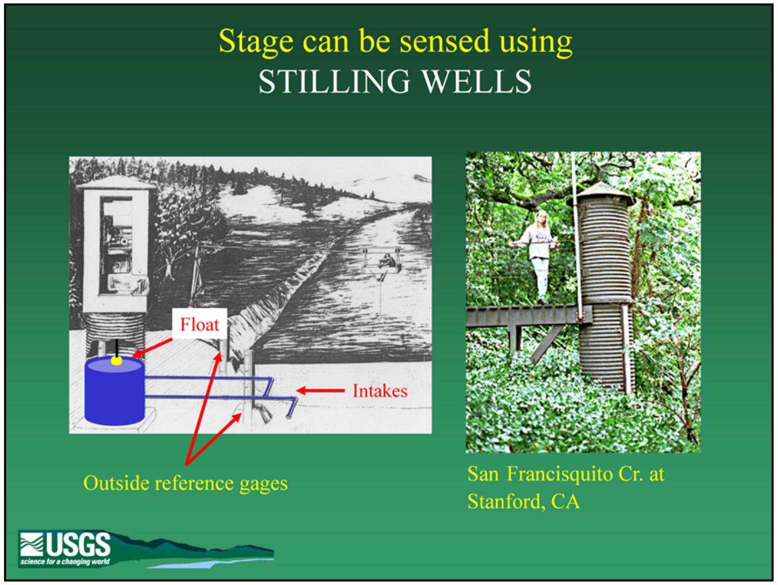


In addition to data from current stations, USGS data bases contain mean daily-discharge data for over 18,500 locations. Because data have always been collected to nationally consistent standards all data in USGS data bases can be used and analyzed with confidence to meet both current and long-term needs.

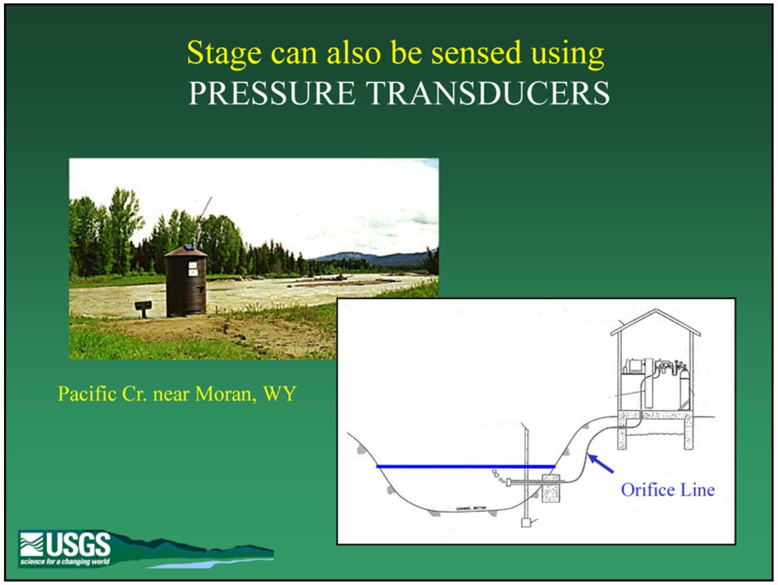
Because it is so important for data to be collected and processed using prescribed standards it is worth describing how data are collected at USGS gaging stations.



The basic piece of data collected at gaging stations is stream stage, which is the height of the water surface above some reference surface, or datum.

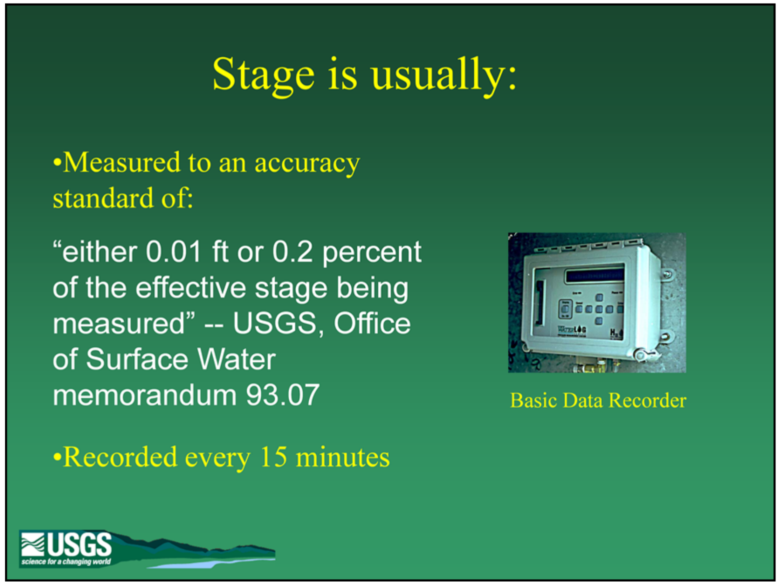


Stage can be sensed inside stilling wells, which are used to dampen momentary fluctuations in the water surface. The wells are connected to the stream by intakes, which allow water in the well to stand at the same stage as water in the stream. The water surface, or stage, is sensed and recorded using floats in the stilling well. Outside reference gages are used to verify that the water level in the well is the same as the water level in the stream.



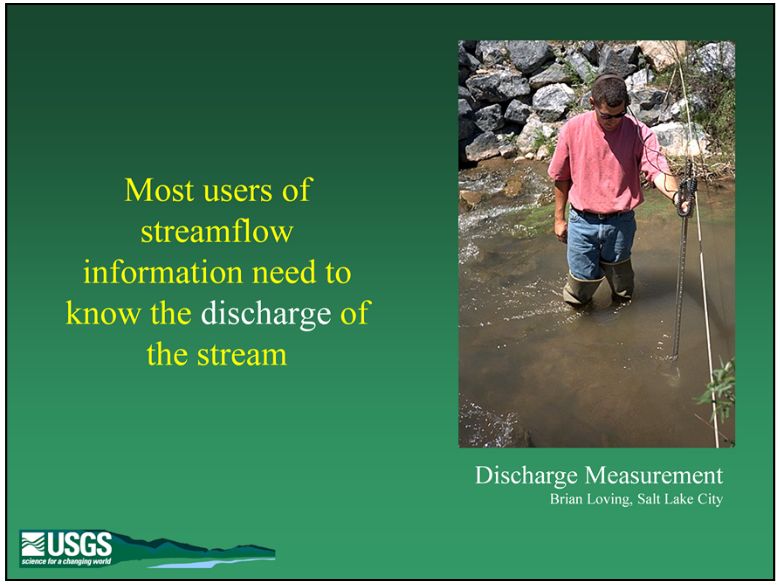
Stage can also be sensed using pressure transducers. The pressure exerted by water at any point in the water column is a function of water depth. This pressure can be transmitted through an gas- or liquid-filled orifice line to a pressure transducer.

The USGS usually uses orifice lines filled with nitrogen gas and pressure transducers that meet USGS specification to sense pressure. Such installations are used when stilling wells are difficult or impractical to install.

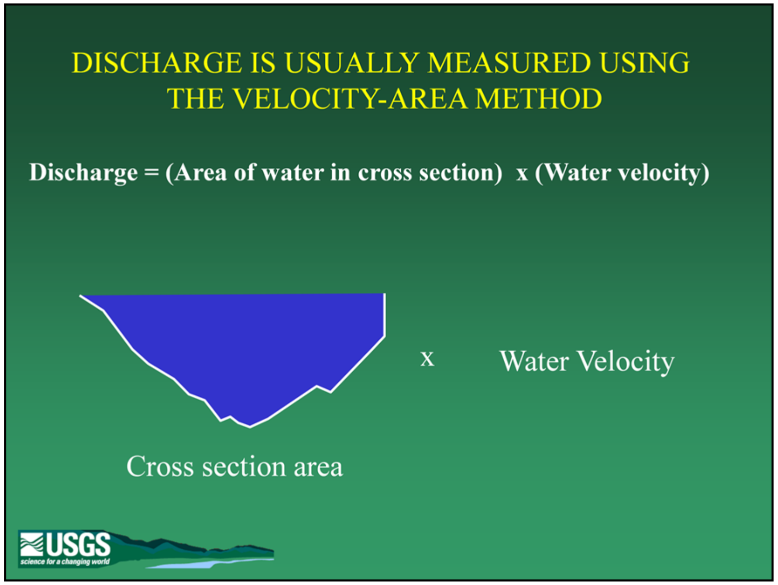


According to USGS policy, installations and equipment should be capable of measuring stage to plus or minus one one-hundredth of a foot, or 0.2 percent of the effective stage being measured.

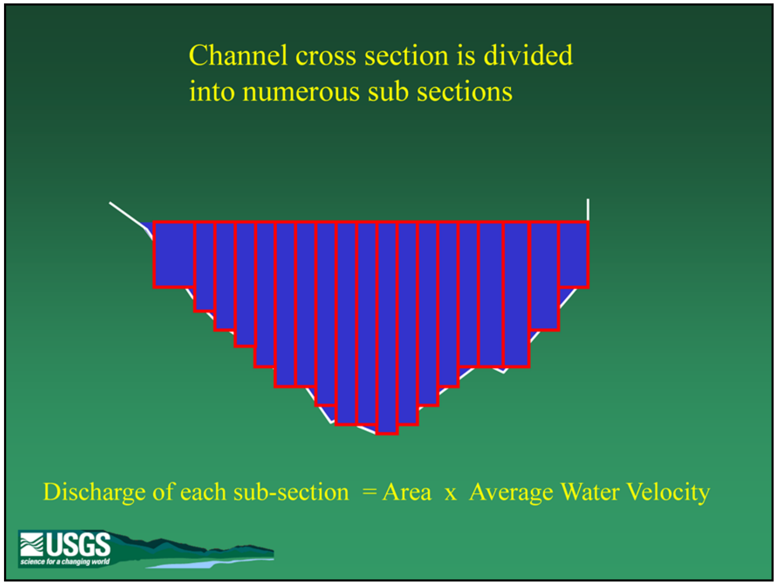
Stage is recorded every 15 minutes at most gaging stations. These data are commonly referred to as “unit values”.



Although stream stage is directly useful for some purposes, such as floodplain mapping, most users of streamflow information need to know the discharge of the stream. Discharge is the volume of flow passing a specific point in a given amount of time.

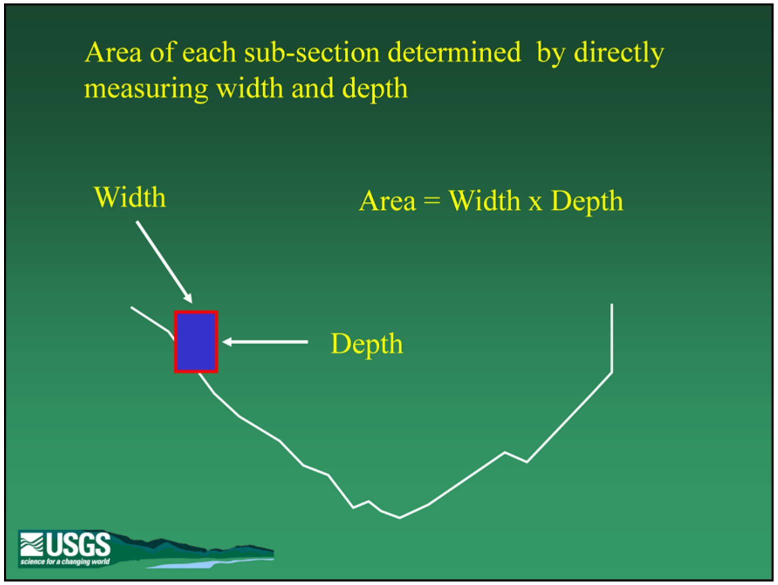


The most practical method of measuring stream discharge is through the velocity-area method. Discharge is determined as the product of the area of the water and the water velocity..

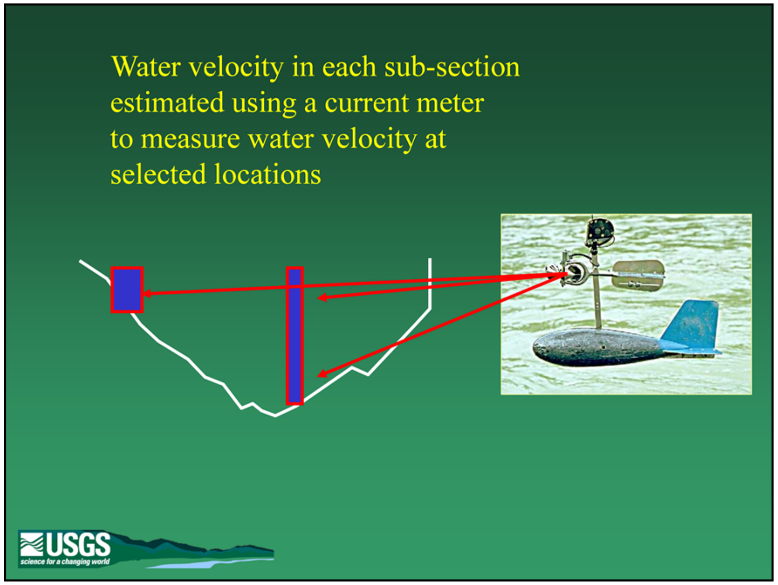


Measuring the average velocity of an entire cross section is impractical, so the USGS uses what's called the mid-section velocity area method. Using this method the channel cross section is divided into a number of sub-sections.

Most natural channels must be broken down into 25 or 30 sub-sections to adequately characterize their irregular geometry. The discharge of each sub-section is determined by measuring it's area and water velocity.

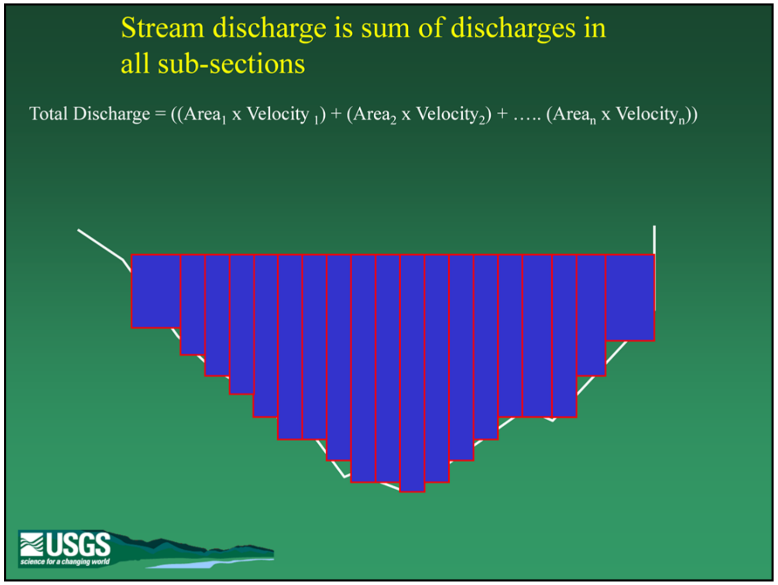


The area of each subsection is determined by directly measuring width and depth

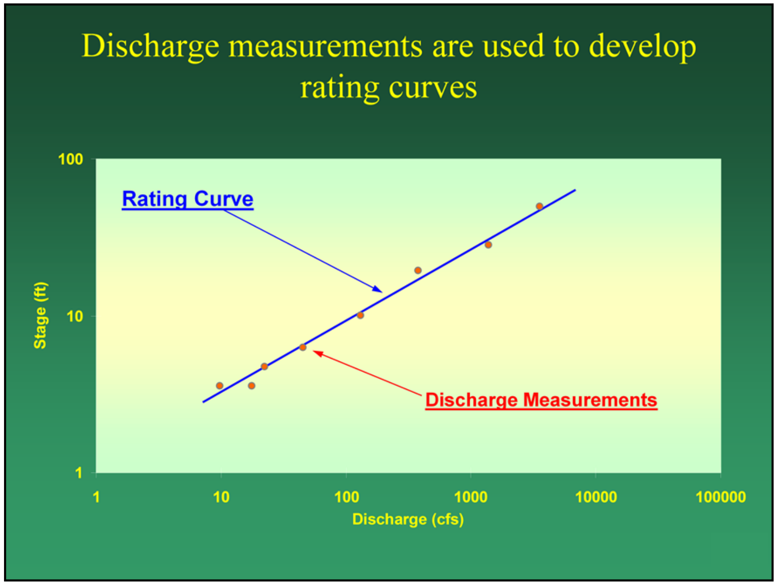


Average water velocity in each sub-section is estimated using current meters to measure water velocity at selected locations..

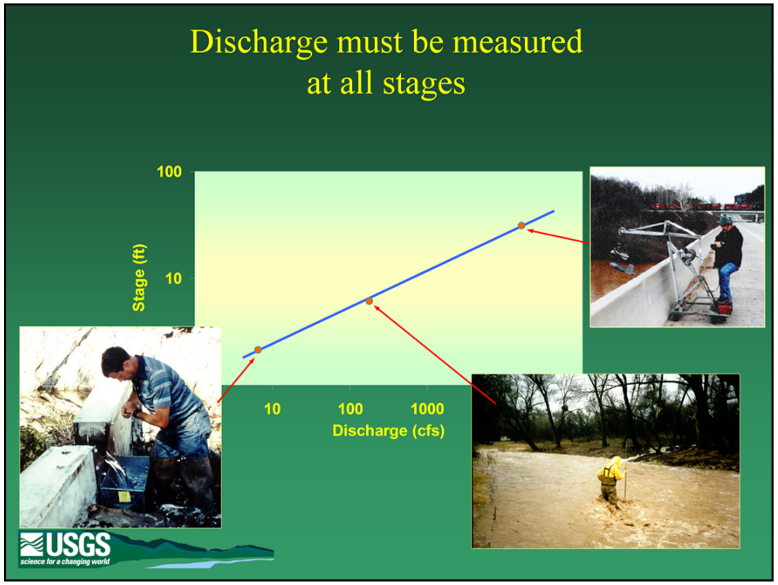
For shallow sections average velocity is estimated by measuring the velocity at 0.6 of the distance from the water surface to the streambed. When depths are large, the average velocity is best estimated by averaging velocities measured at 0.2 and 0.8 the distance from the water surface to the streambed.



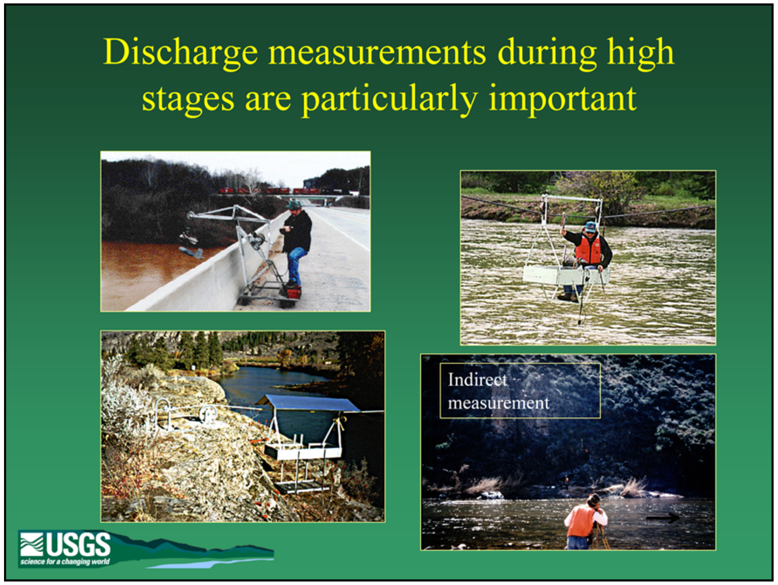
The sum of the incremental discharges in each sub-section is the discharge of the stream!



A continuous record of discharge is determined by developing a relationship between stage, which is measured continuously, and discharge. This “rating” is developed using data from individual discharge measurements.

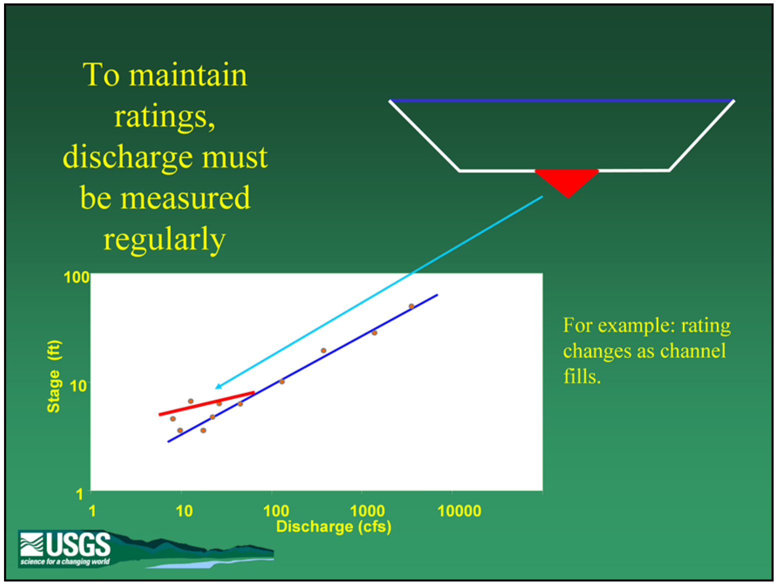


To properly develop ratings, discharge must be measured at all stages. Otherwise the relation between stage and discharge will be uncertain for some ranges in stage. USGS personnel visit gaging stations regularly, making discharge measurements when needed to define ratings.



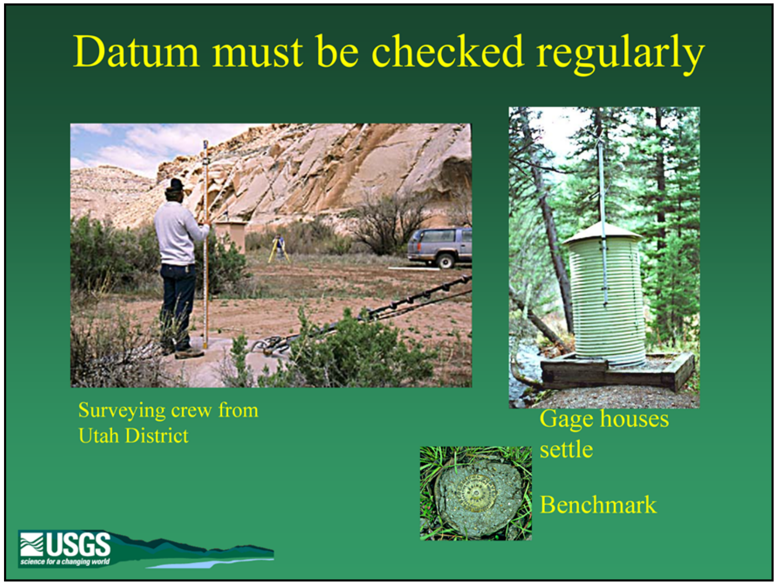
It is particularly important to make discharge measurements when stream stages are high. Such measurements define the upper ends of ratings. As such they form the basis for flood warning, flood forecasting and estimates of annual flow volumes. The means of making current-meter measurements are provided at most USGS gaging stations. Measurements during high stages are often made from bridges or cableways.

Sometimes, it is impossible to make current-meter measurements during large floods. When direct current-meter measurements cannot be made, discharge is measured indirectly by surveying the high-water marks left by the flood and using hydraulic formulas to calculate discharge associated with the peak stage



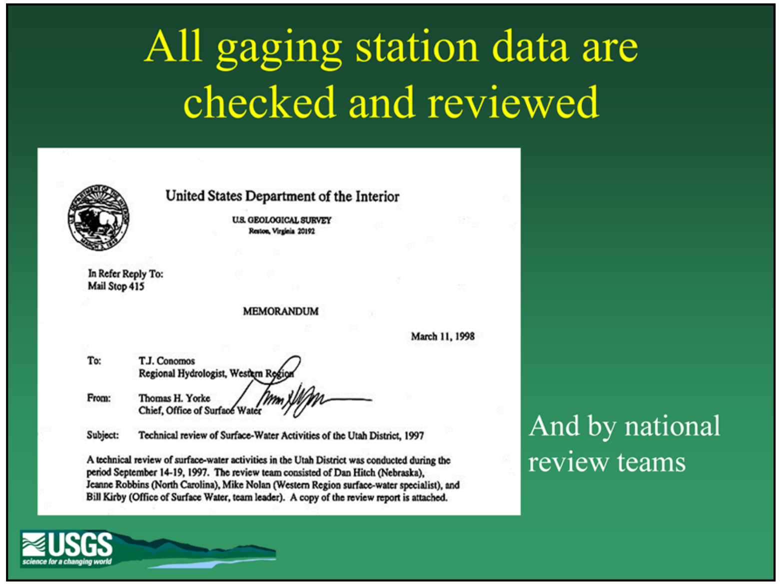
Use of ratings to convert stage to discharge would be rather straight forward except for the fact that the stream channels change as they scour and fill. For example, if sediment is deposited in the channel bottom, as indicated here in red, discharge will be less than it was previously for the same stage.

Because most channels erode or fill naturally, discharge must be measured regularly. These measurements document any changes, or lack of changes, to ratings. Discharge is measured at most gaging stations every 6 or 8 weeks. Measurements are made more frequently at sites where the streambed is particularly unstable.



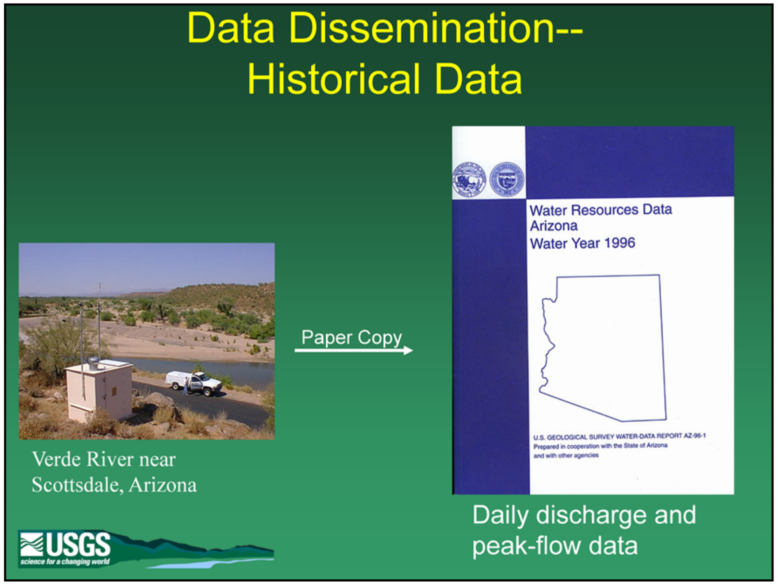
Stage is the level of the stream above some datum. It is, therefore, important that the datum does not change. It is not uncommon, however, for gage structures and staff gages to be damaged by high flows and/or settle over time. If datum changes go unrecognized, incorrect estimates of discharge will result.

Three or more benchmarks or reference marks are maintained at all USGS gaging stations to provide checks on the datum. Level surveys are run between benchmarks, reference marks, staff gages and gage structures every few years. Level surveys are run more regularly at sites known to be unstable.

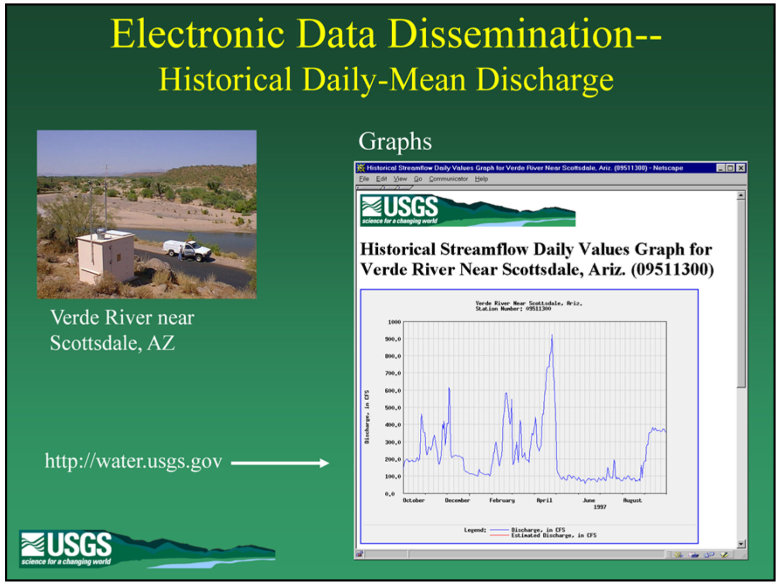


All data collected at USGS Gaging Stations are checked and reviewed to ensure that data have been collected and analyzed according to standards documented in USGS reports and technical memorandums.

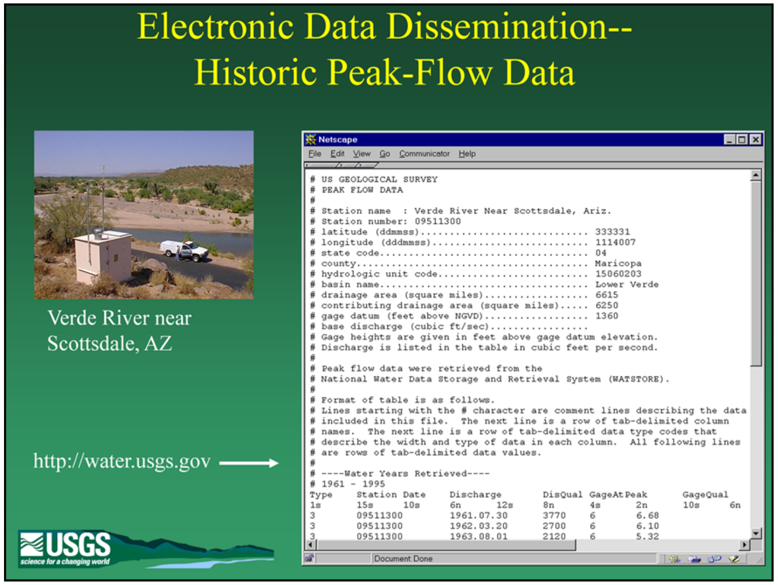
National consistency is assured by tri-annual review by teams sent from USGS headquarters. The review process ensures that all data published and entered into USGS data bases are collected and analyzed using prescribed national standards.



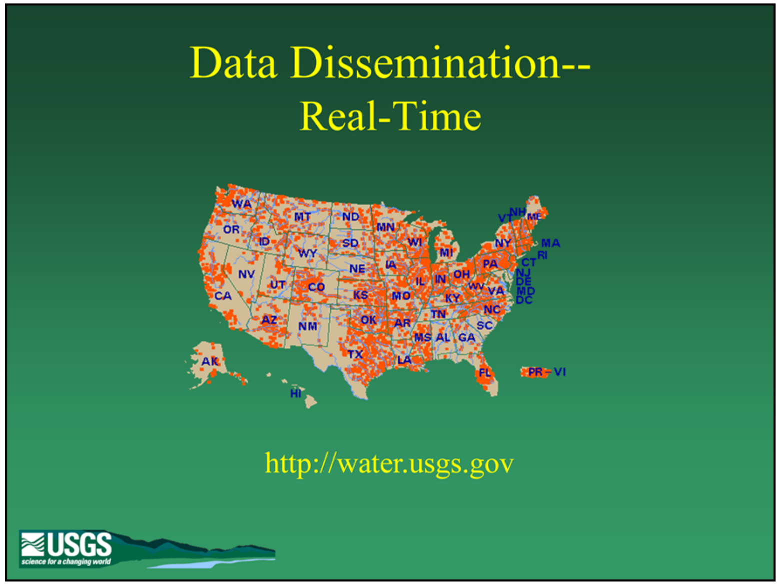
Data from gaging stations are disseminated through a variety of outlets to make data available to as many users as possible. For example, daily-discharge and peak-flow data are published in paper reports on a water-year basis.



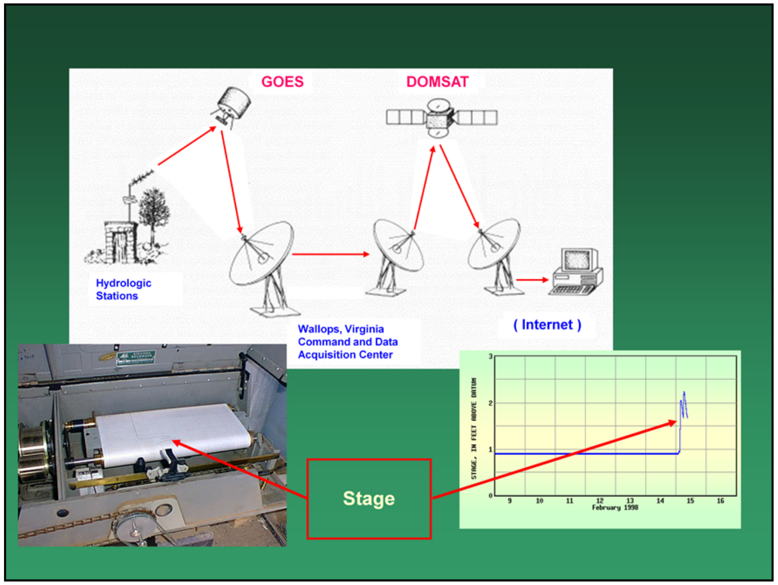
Historic data are also served on the world wide web. Daily-mean discharge data can be downloaded in tabular form for use in user-defined applications. These same data can be viewed in graphs that portray stage or discharge.



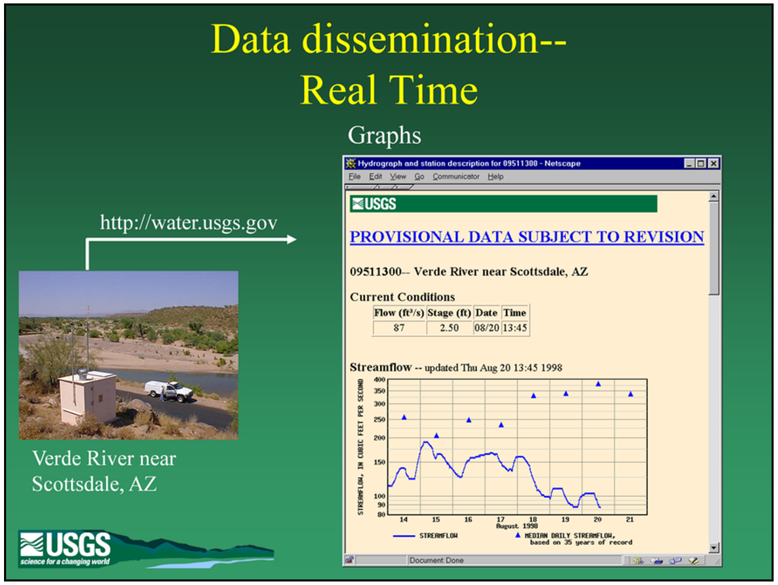
Historic peak-flow data are also available on the world wide web. These data are presented in electronic data tables. Users can download a listing of annual peaks recorded during the period of gage operation or a listing of peaks that occurred above a base discharge.



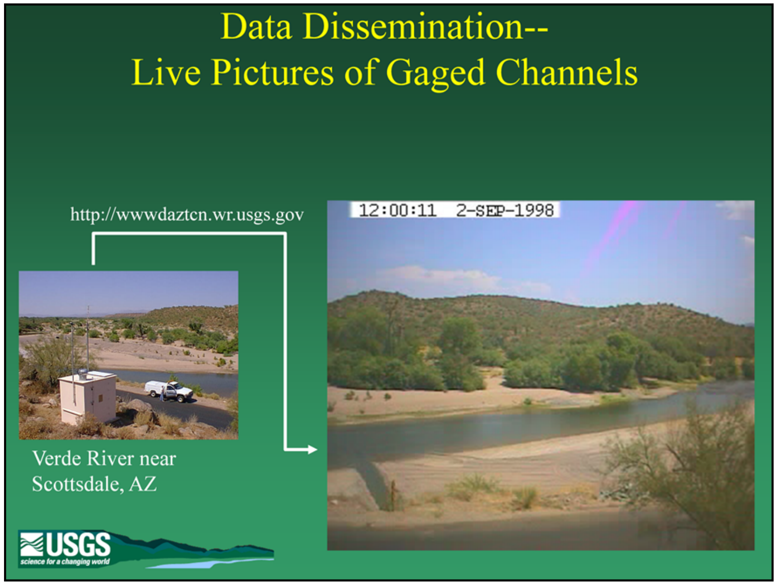
In addition to historic data, data from many USGS streamgaging stations are available on a real-time basis. Data are currently telemetered from over 4000 USGS streamgages. Sites from which data are telemetered are shown here in red. Most telemetered data are available via the World Wide Web.



USGS streamflow data are generally telemetered using the GOES satellite system, as displayed here. Data from some sites are telemetered using FM radios or cellular phones

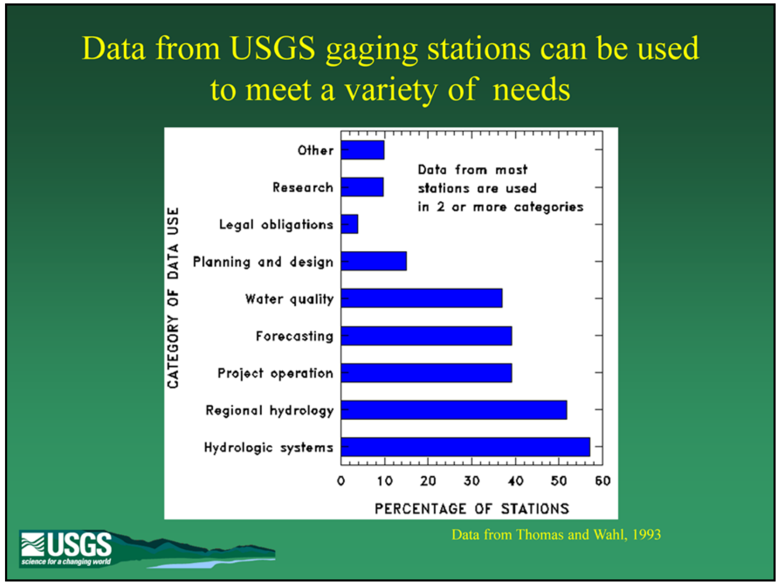


Real time information on stream stage and discharge are available as electronic data table and graphs from the world-wide web.



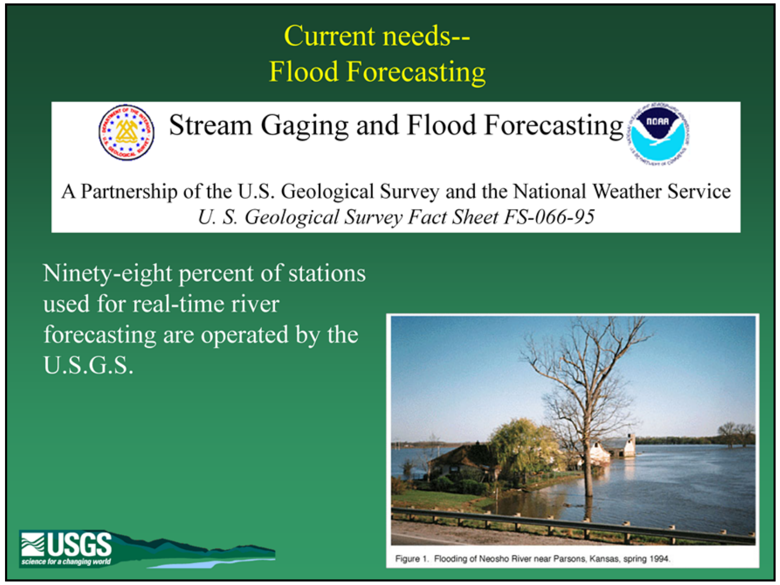
The USGS is experimenting with making live pictures of gage sites available via the world wide web. Pictures of the stream channel of the Verde River near Scottsdale, Arizona, are updated hourly on the Arizona District's Home Page.

These photos will be used to verify gage operation. They will also provide visual assessment of flow to scientists, public safety officials and the general public.

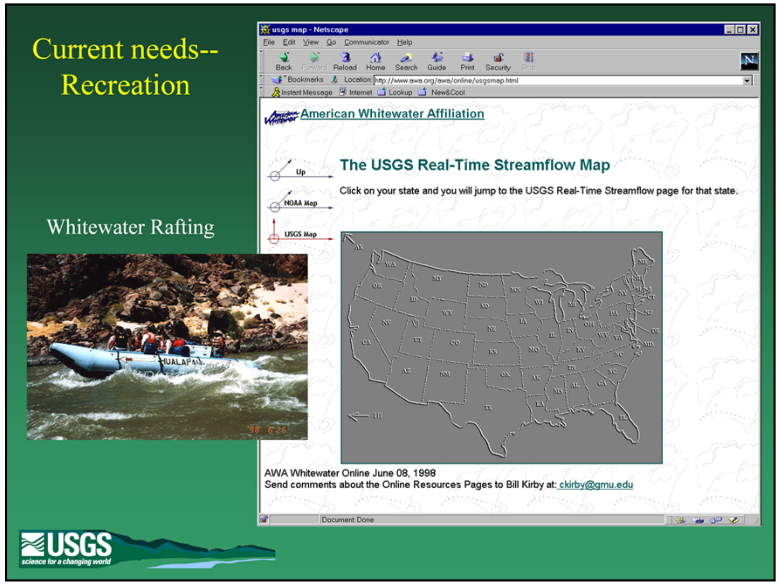


Streamflow information can be used to meet a variety of needs. The USGS locates and operates gages to maximize the usefulness of data collected at gaging stations.

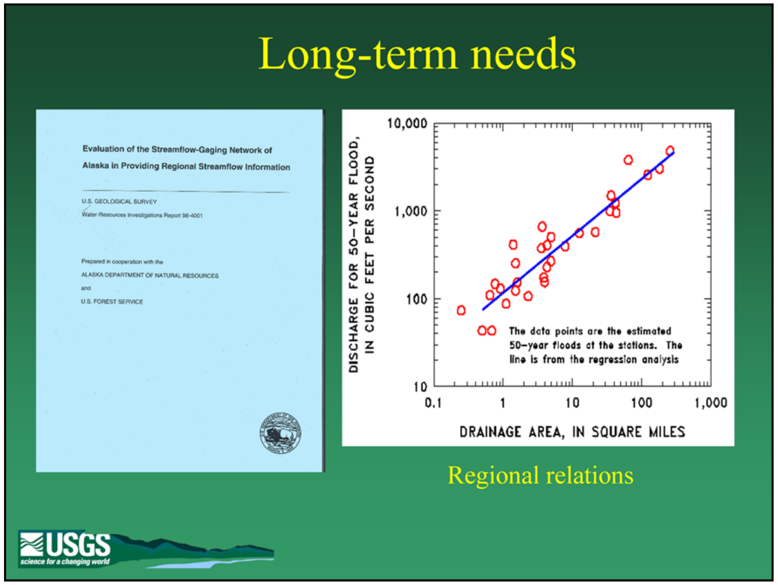
Data collected at gaging stations are used to meet both current and long-term needs. For example, gages below major reservoirs provide current information on reservoir releases.



Likewise, gages located along major streams and rivers are often used for input to flood-warning models. Approximately 98% of the stations used for real-time river forecasting are operated by the U.S.G.S.



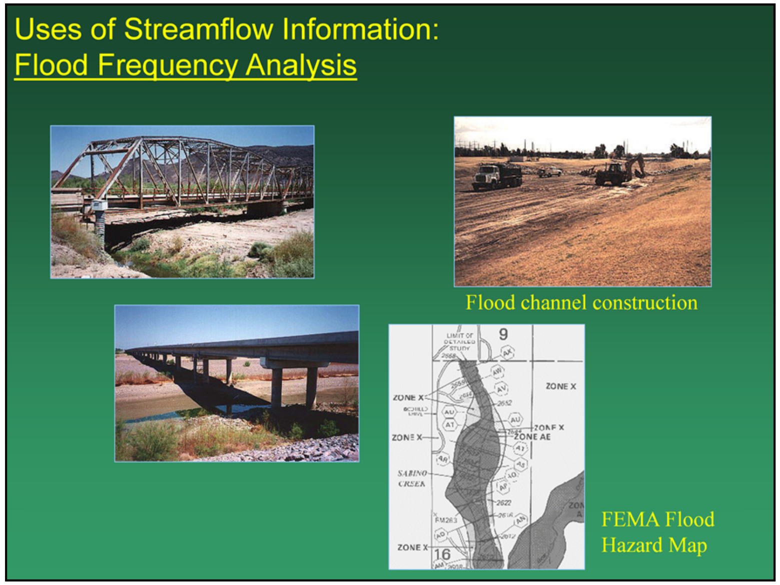
Real-time streamflow data telemetered from USGS gages are also being used to meet a variety of recreational needs. For example, whitewater rafters use data telemetered from USGS gages to assess rafting conditions on many rivers across the country.



Deciding where to locate gages to collect data to meet long-term needs is more difficult than deciding where to locate gages to meet current needs.

Long-term needs, such as future, but currently unplanned, bridges and flood-control projects, require that gages be located at sites from which data can be transferred with confidence throughout a hydrographic region. Such transfer of information can result in regional relations, such as shown here.

Gaging station programs are often evaluated to see how well they are meeting both long-term and short-term needs. A well designed program is capable of providing a great deal of regional information



One of the major long-term needs met using streamflow data is flood frequency analysis. Annual peaks discharges recorded at gaging stations are used in statistical procedures to estimate design discharges, such as the 100-year flood. This discharge is more appropriately referred to as the 1-percent discharge because it has a 1-percent chance of occurring during any given year.

The 1-percent flood is commonly used as the design discharge for construction of bridges, flood channels, and delineation of flood-prone areas, such as on FEMA or flood insurance maps.

The USGS continues to look for new technology that will improve streamflow data collection. For example, hand-held laser distance meters are now being used to rapidly measure channel widths when discharge measurements are made from boats. Acoustic doppler technology allows rapid measurement of flow in large rivers. Newly developed instrumentation automates data collection and discharge computations during current-meter discharge measurements.

We will continue to build upon the legacy started with the Embudo station. We hope to find even more ways to collect and disseminate better data more efficiently without jeopardizing the broad-based impartial data currently found in USGS data bases.

The End

See Selected References

or

Quit

Data Collection at U.S. Geological Survey Streamgages

By: K. Michael Nolan
and
Jeff V. Phillips
Narrated by: Ron James

Selected References

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- Mason, R.M. and B.A. Weiger, 1995, Stream gaging and flood forecasting - A partnership of the U.S. Geological Survey and the National Weather Service: U.S. Geological Survey Fact Sheet 209-95, 4p.
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