Accuracy of U.S. Geological Survey Streamflow Data

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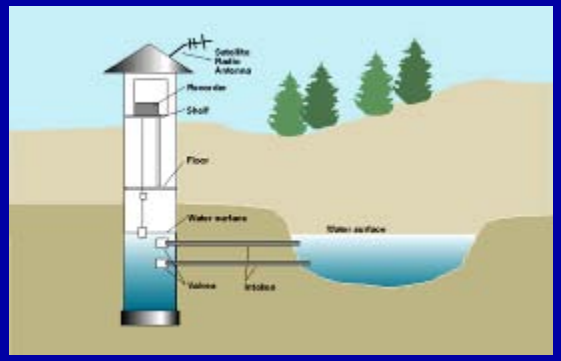
USGS

The USGS measures stream stage and produces a continuous record of discharge by making period discharge measurements



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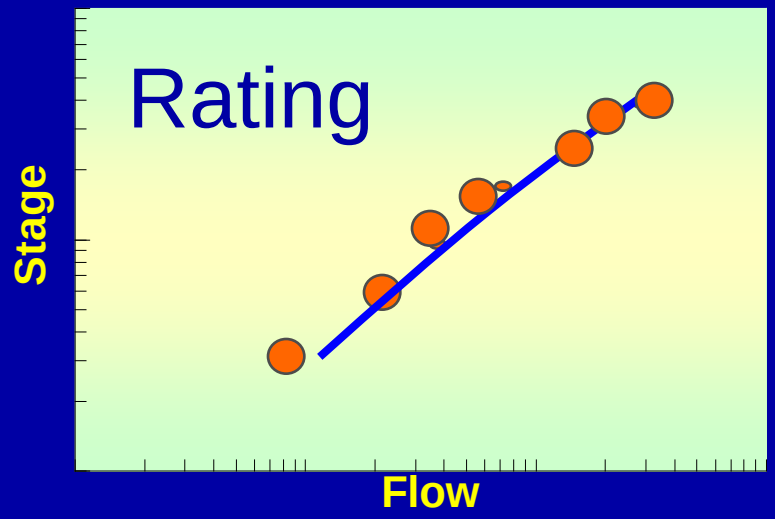

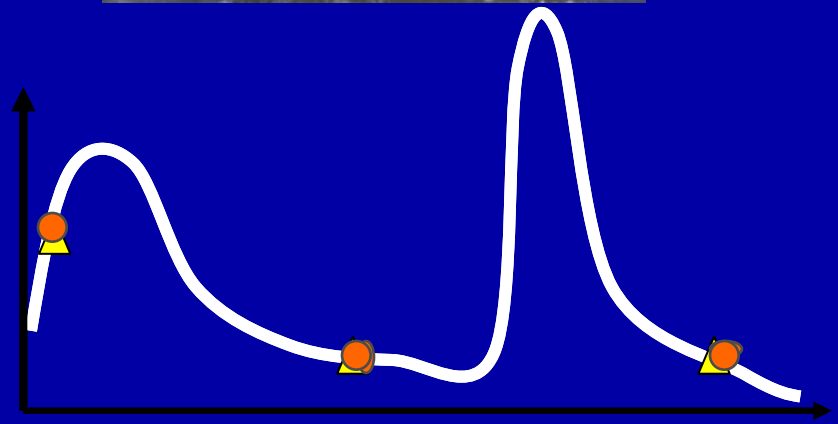

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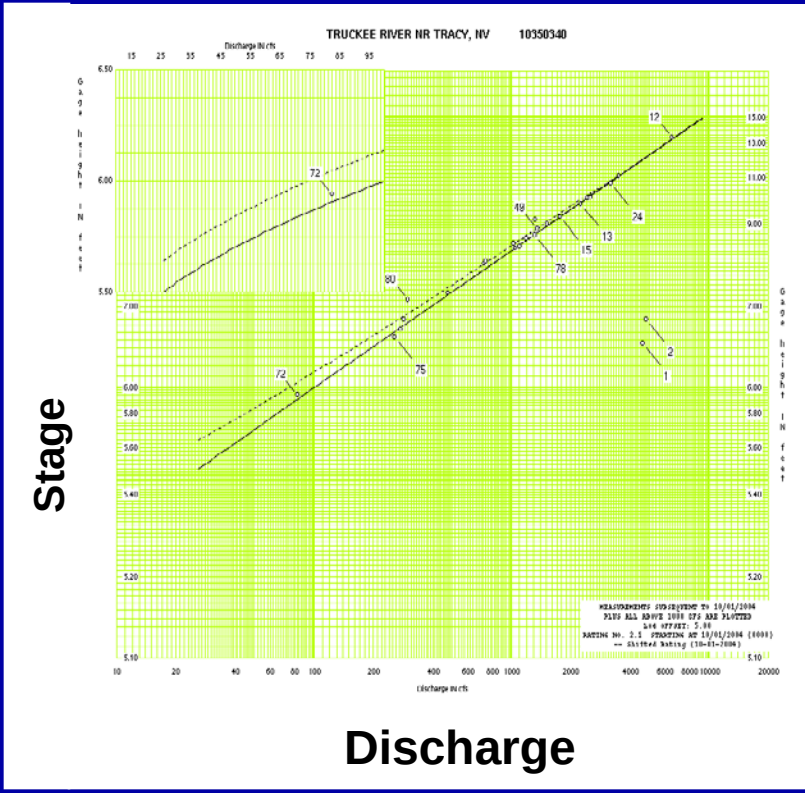
Published Accuracy of Streamflow Records are categorized according to the following ranks:

- **Excellent – 95% of daily discharges within 5% of true value**
- **Good – 95% of daily discharges within 10% of true value**
- **Fair – 95% of daily discharges within 15% of true value**
- **Poor – Daily discharges have less than "fair" accuracy**



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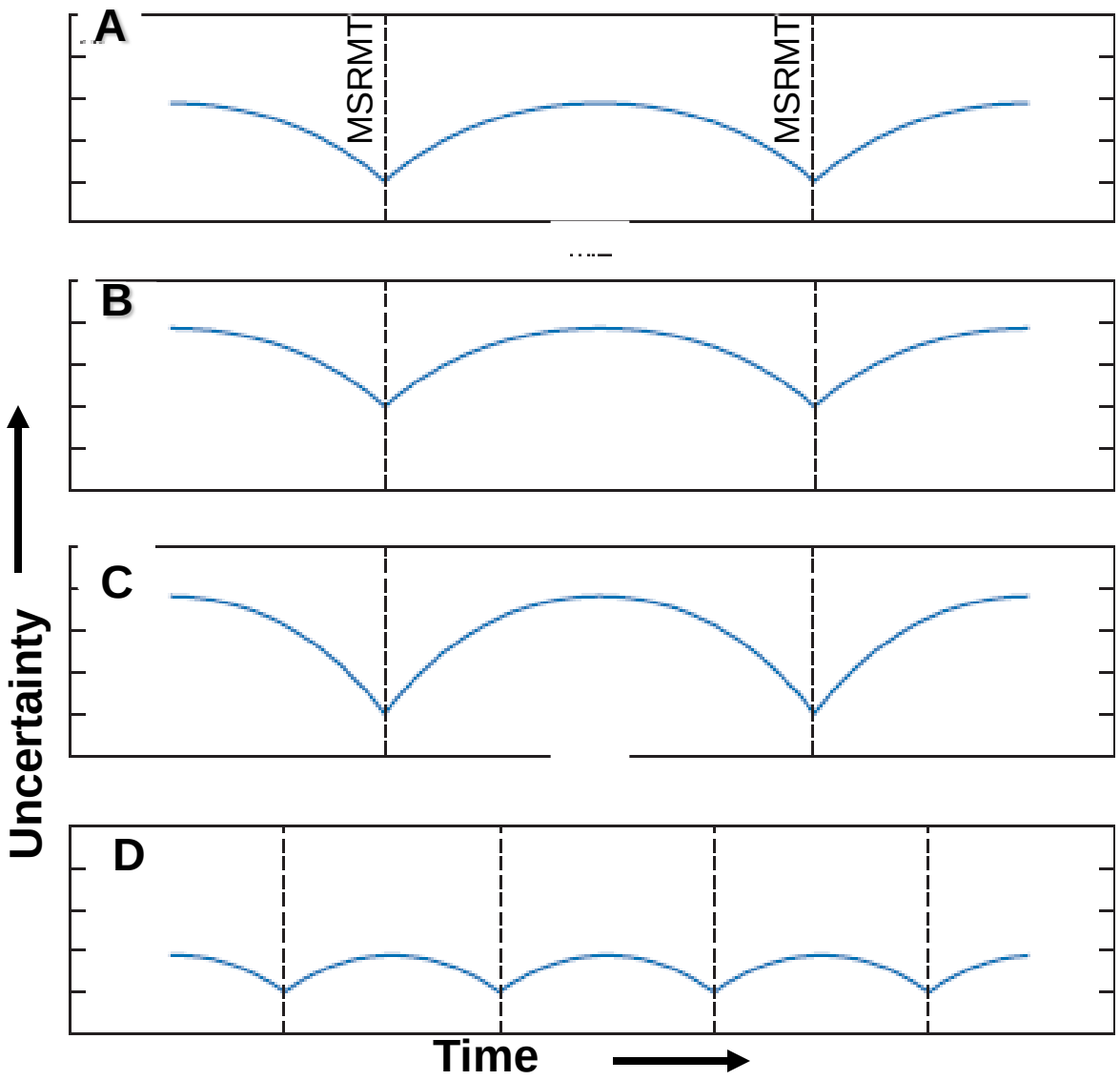
Here is a conceptual model how uncertainty varies in a discharge record:



Base Condition

Larger Measurement Uncertainty:

- Verify instrument performance!

- Make check msrmts!

Larger Process Uncertainty

More frequent Visits/Measurements

-Visit/measure more often!

USGS

Accuracy of Streamflow Records

- Accuracy corresponds to the quality of the collected data and the computed record
- **Collected Gage-Height Data**
  - Quality of gage-height data / application of corrections to gage-height record
- **Computed Flow Record**
  - Measurement accuracy
  - Stability of control / application of shifts
  - Measurement frequency and timeliness

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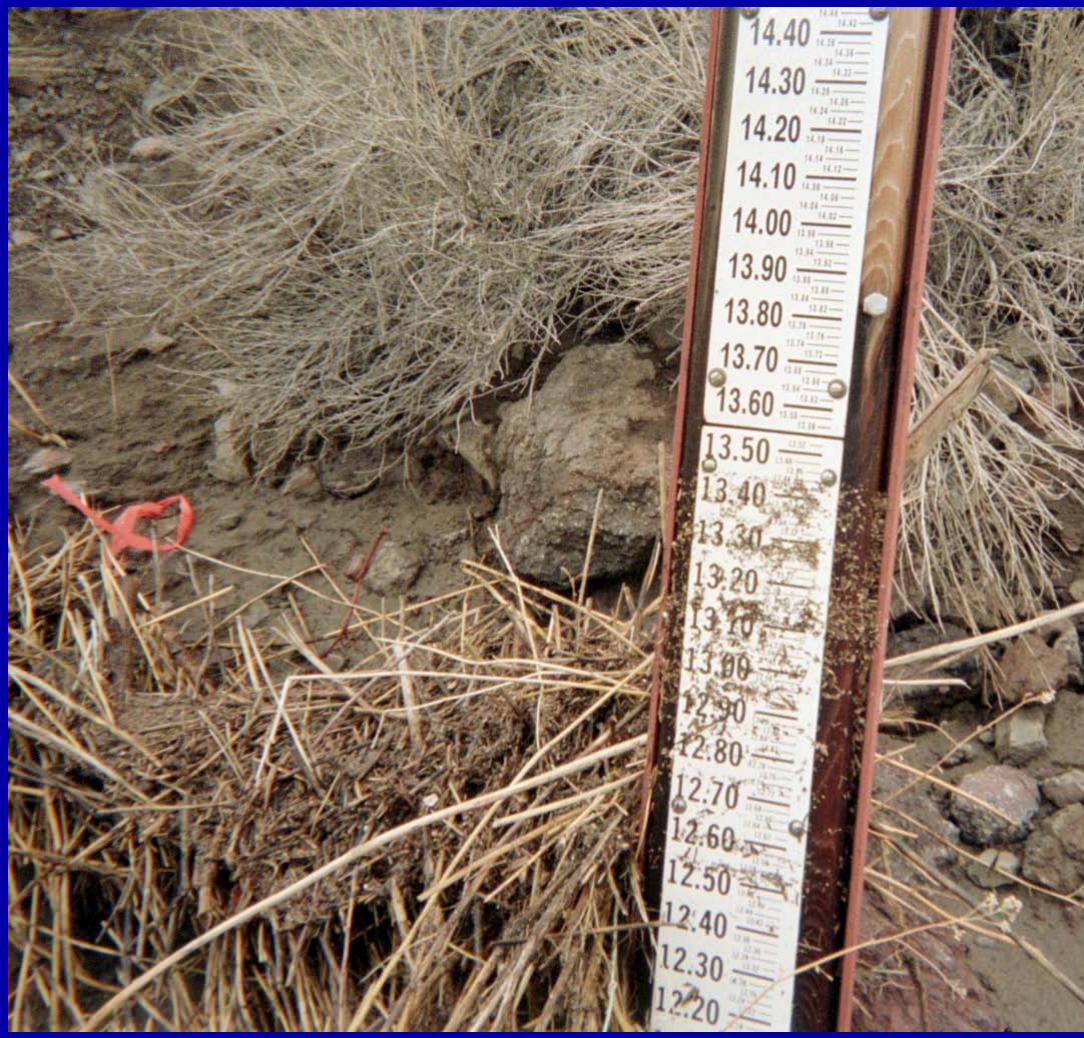
USGS has strict accuracy standards for collected stage data

- **Reference Gage Accuracy = +/- .01 ft or 0.2 % of effective range.**
- **Collected gage-height data compared with outside reference gage**



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Datum at gages is regularly verified using guidelines established at USGS Headquarters.

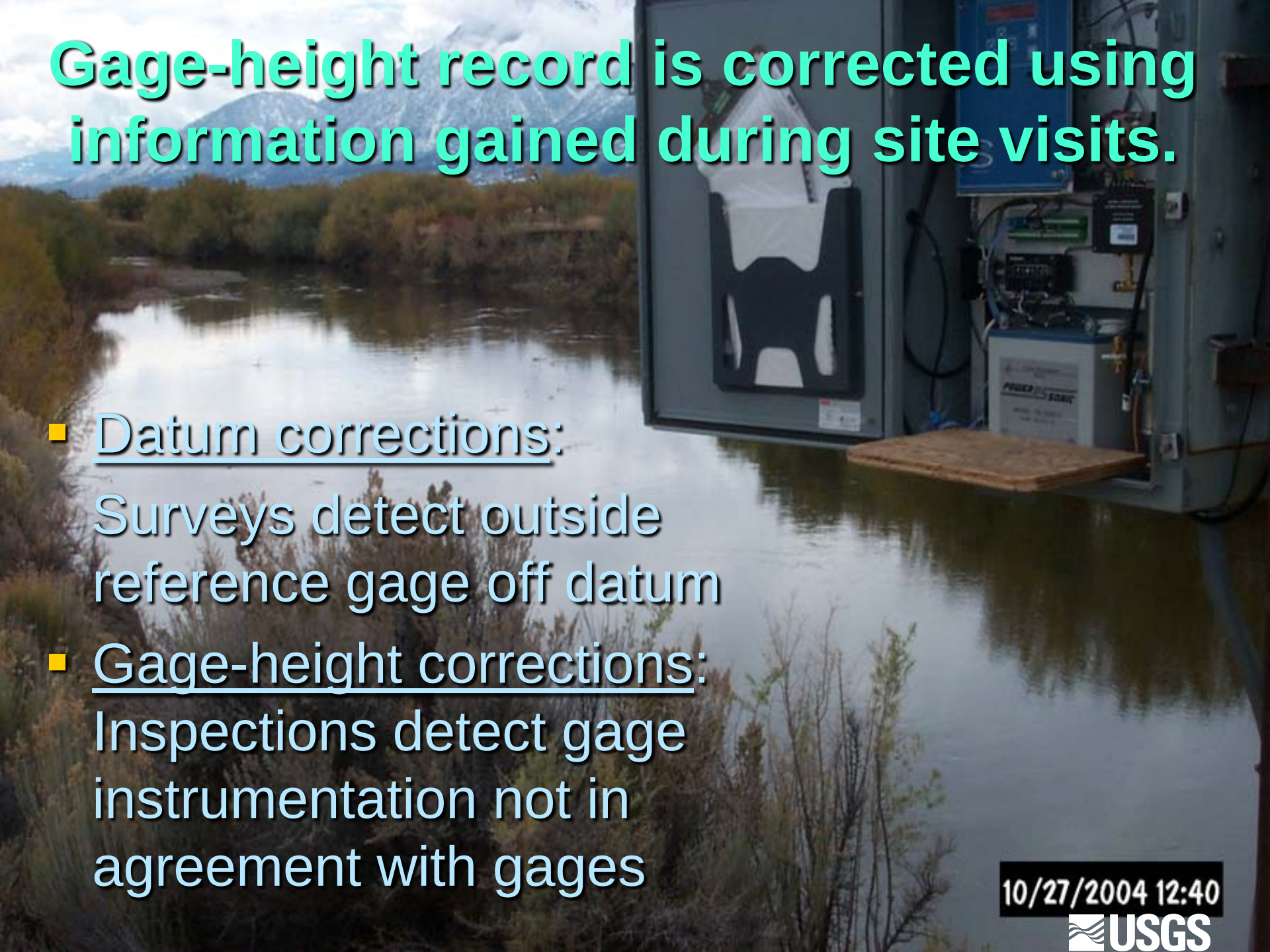
Datum controlled to nearest 0.015 ft

Every 1 to 3 years, we run levels to verify gages have not moved from established datum

USGS

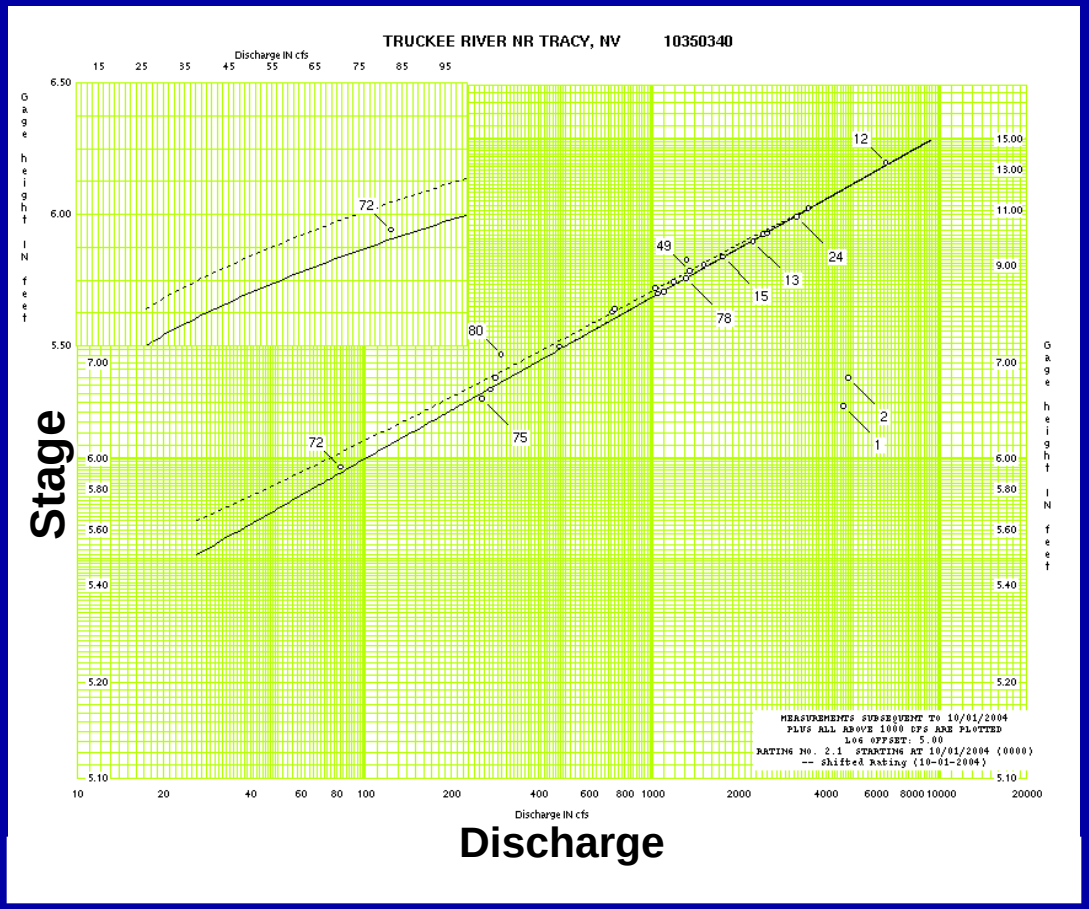
Gage-height record is corrected using information gained during site visits.

- Datum corrections: Surveys detect outside reference gage off datum
- Gage-height corrections: Inspections detect gage instrumentation not in agreement with gages



Flow Record: The relation between stage and discharge is regularly refined using periodic discharge measurements and other information noted during site visits.

- Development
  - Requires wide range of flow measurements
  - Reviewed and approved by Office Chief
- Calibration
  - Measurements define subtle changes in channel control features that affect stage-discharge relation
  - Shifts defined by the measurements to correct stage-discharge relation



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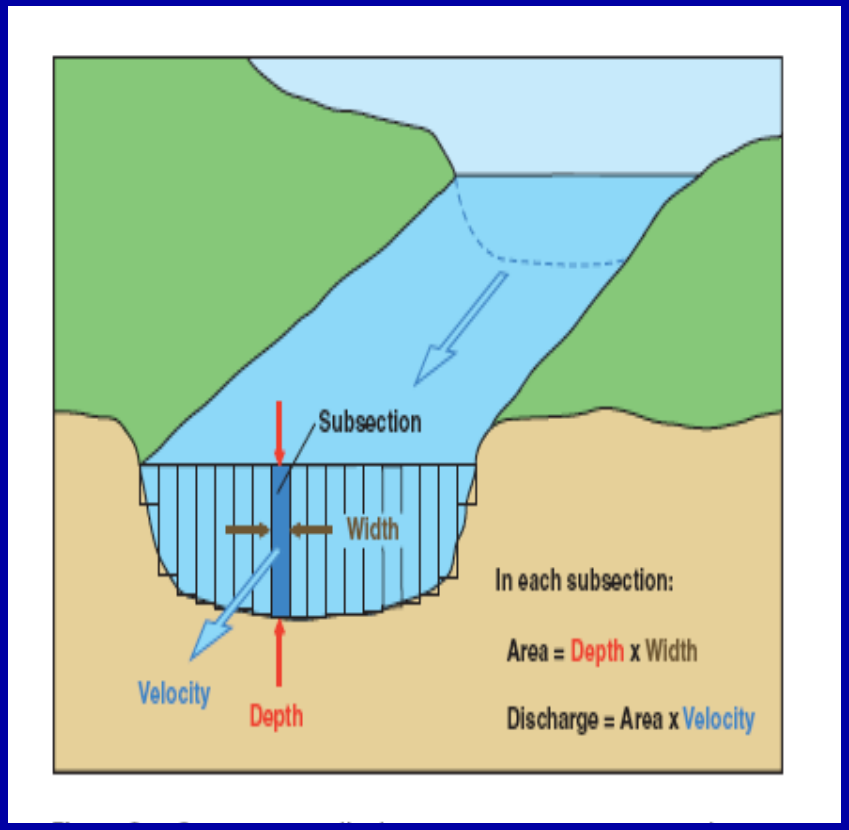
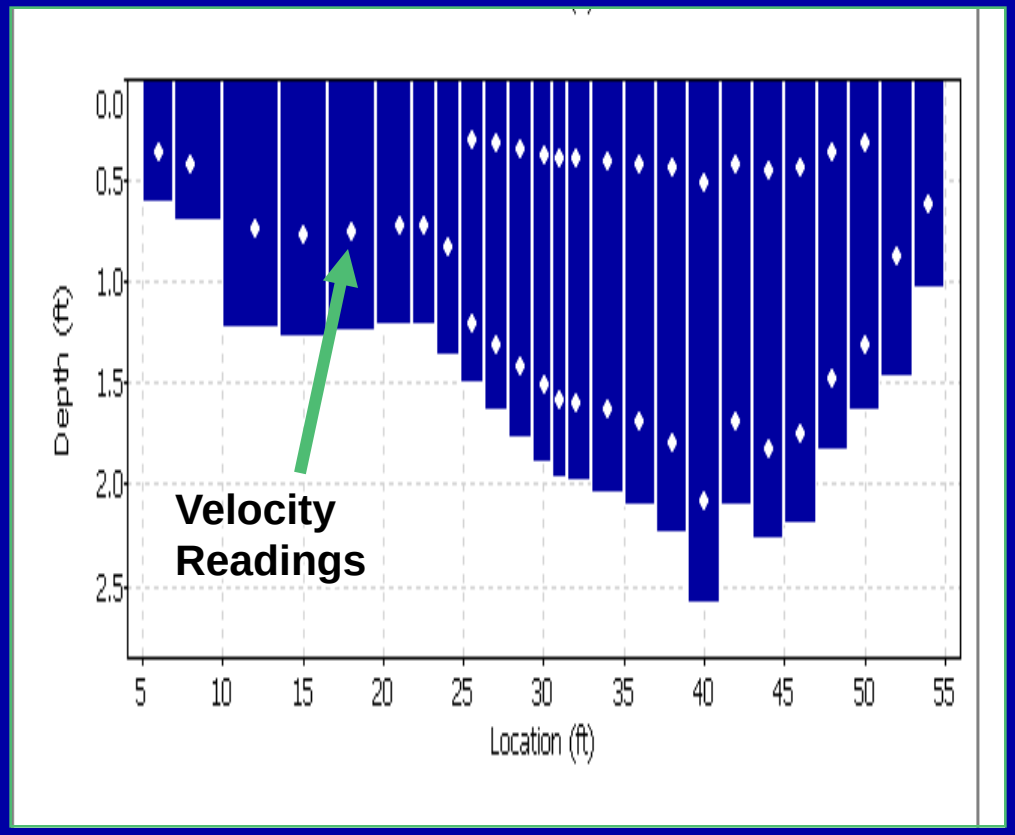
Flow Record: Discharge measurements are made using guidelines by USGS Headquarters.





USGS

The uncertainty of discharge measurements is determined using ISO and USGS standards.

- **<u>ISO uncertainty</u> – International Standard (published)**
  - **Accuracy of instrument**
  - **Number of verticals**
  - **Uncertainty in widths and depths**
  - **Number of velocity msrmts in verticals**

- **<u>Statistical Calculation</u> – USGS (unpublished)**
  - **Accuracy of instrument**
  - **Uncertainty of depth and changes in depths between verticals**
  - **Variations of velocity and changes in velocity between verticals**
  - **Uncertainty in widths**

USGS

Here is an example of uncertainty assigned to a measurement using a acoustic Doppler velocity meter (ADV).

Discharge Measurement Summary

Date Generated: Mon Aug 20 2007

File Information

File Name	1033610.2.WAD
Start Date and Time	2007/06/01 11:15:07

Site Details

Site Name	
Operator(s)	

System Information

Sensor Type	FlowTracker
Serial #	P461
CPU Firmware Version	3.2
Software Ver	2.11

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

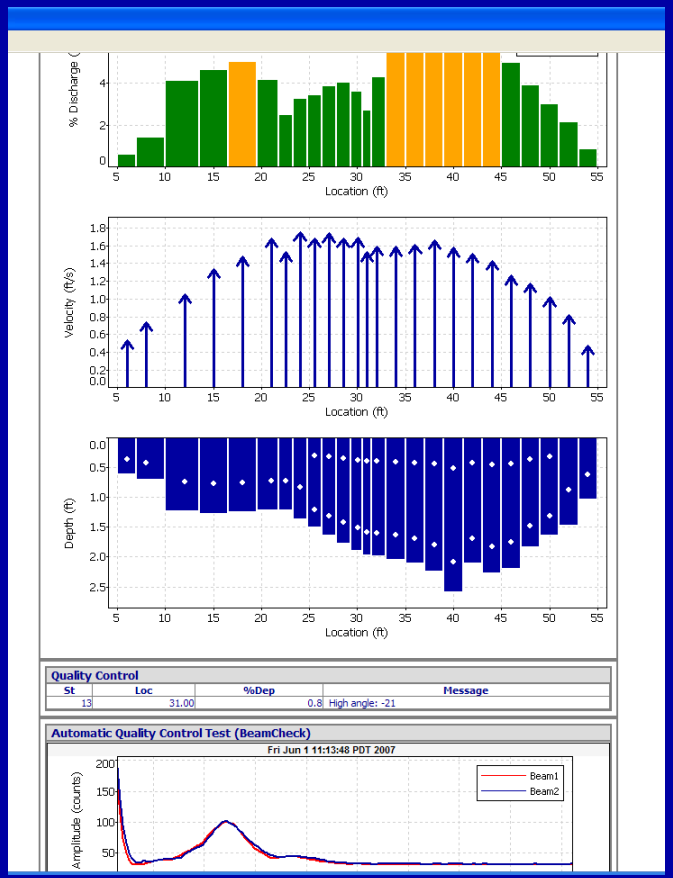
Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	1.4%
Velocity	0.2%	1.0%
Width	0.1%	0.1%
Method	1.0%	-
# Stations	1.9%	-
Overall	**2.4%**	**2.0%**

Summary

Averaging Int.	40	# Stations	27
Start Edge	LEW	Total Width	52.00
Mean SNR	26.9 dB	Total Area	80.020
Mean Temp	52.51 °F	Mean Depth	1.539
Disch. Equation	Mid-Section	Mean Velocity	1.3923
		Total Discharge	**111.4094**

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	11:15	4.00	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	11:15	6.00	0.6	0.620	0.6	0.248	0.5358	1.00	0.5358	1.240	0.6644	0.6
2	11:16	8.00	0.6	0.710	0.6	0.284	0.7385	1.00	0.7385	2.130	1.5730	1.4
3	11:18	12.00	0.6	1.240	0.6	0.496	1.0512	1.00	1.0512	4.341	4.5627	4.1
4	11:19	15.00	0.6	1.280	0.6	0.512	1.3353	1.00	1.3353	3.840	5.1270	4.6
5	11:21	18.00	0.6	1.260	0.6	0.504	1.4747	1.00	1.4747	3.780	5.5738	5.0
6	11:22	21.00	0.6	1.220	0.6	0.488	1.6795	1.00	1.6795	2.745	4.6107	4.1
7	11:23	22.50	0.6	1.220	0.6	0.488	1.5240	1.00	1.5240	1.830	2.7892	2.5
8	11:25	24.00	0.6	1.380	0.6	0.552	1.7510	1.00	1.7510	2.070	3.6243	3.3
9	11:27	25.50	0.2/0.8	1.510	0.2	1.208	1.8438	1.00	1.6798	2.265	3.8043	3.4
9	11:28	25.50	0.2/0.8	1.510	0.8	0.302	1.5157					
10	11:30	27.00	0.8/0.2	1.650	0.2	1.320	1.8901	1.00	1.7382	2.475	4.3018	3.9
10	11:29	27.00	0.8/0.2	1.650	0.8	0.330	1.5863					
11	11:32	28.50	0.2/0.8	1.780	0.2	1.424	1.8629	1.00	1.6780	2.670	4.4799	4.0
11	11:33	28.50	0.2/0.8	1.780	0.8	0.356	1.4931					
12	11:35	30.00	0.8/0.2	1.900	0.2	1.520	1.7953	1.00	1.6850	2.375	4.0018	3.6
12	11:34	30.00	0.8/0.2	1.900	0.8	0.380	1.5748					
13	11:37	31.00	0.2/0.8	1.980	0.2	1.584	1.7530	1.00	1.5223	1.980	3.0142	2.7



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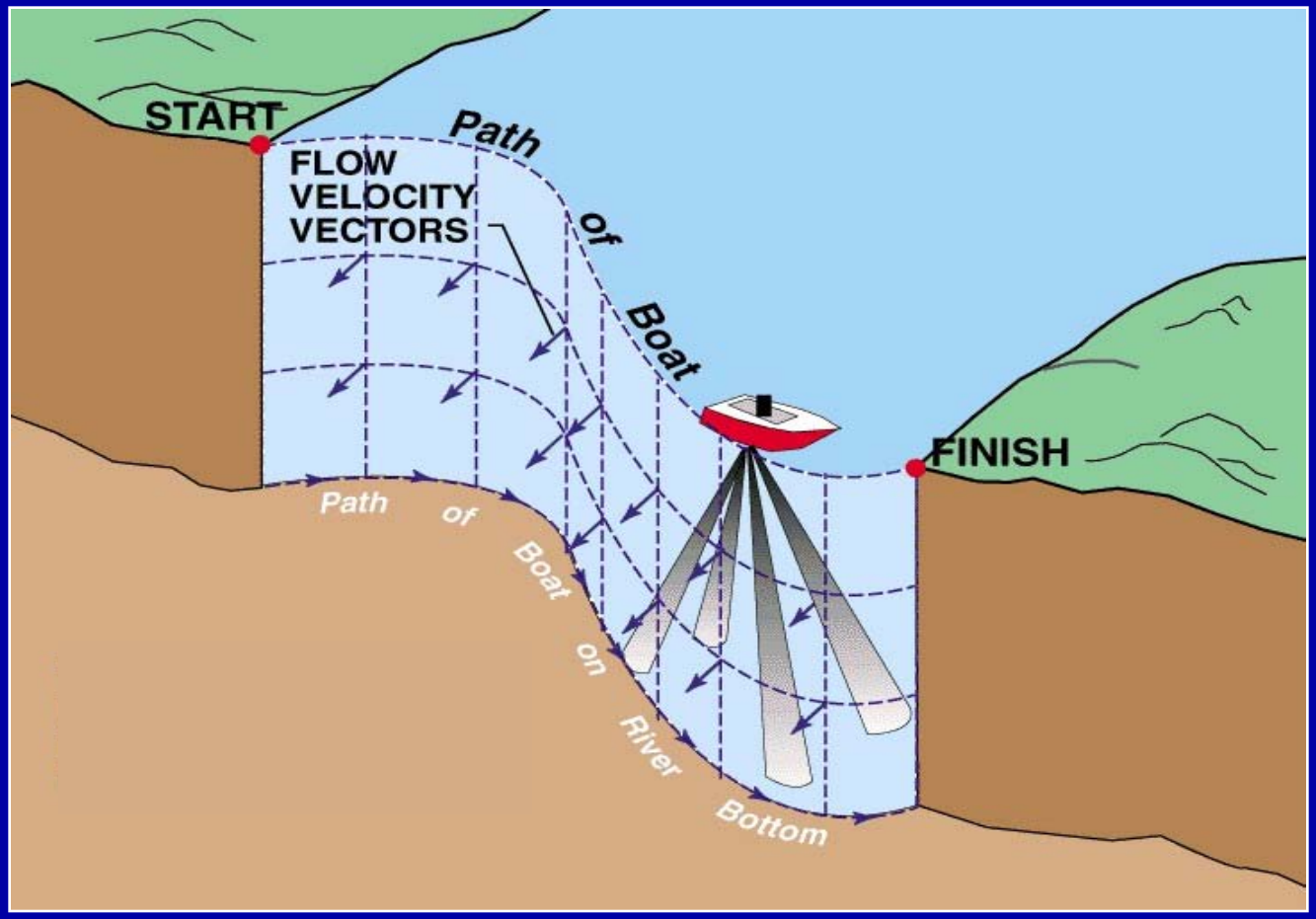
The USGS is making more measurements using hydroacoustic instruments.



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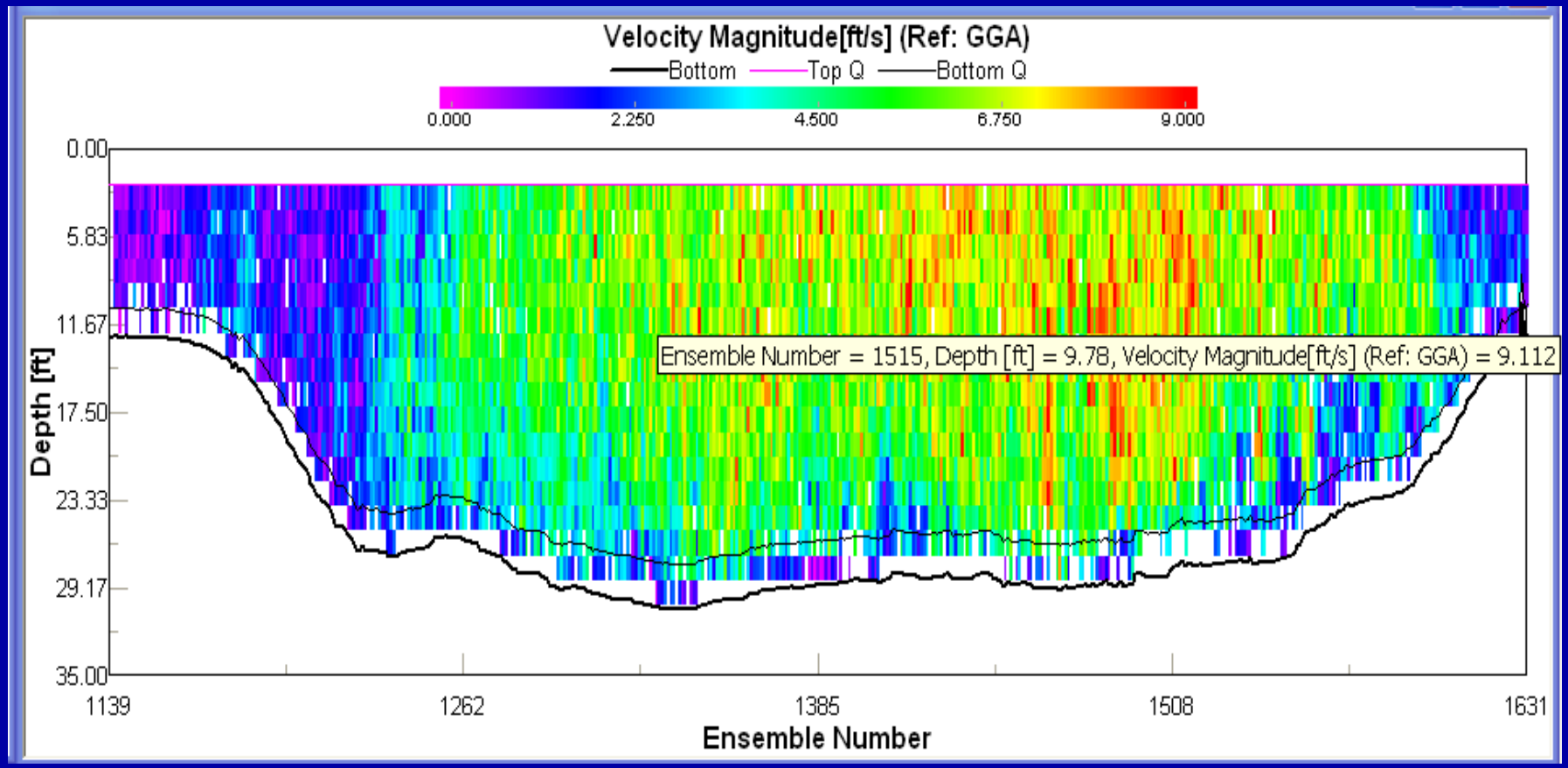
Using hydroacoustic current meters has allowed us to make more accurate and frequent measurements at some gages.

- Streamflow measurements are made quicker
- Measurements are more accurate during rapidly varying flow conditions
- No moving parts
- Safer measuring conditions
- **Measure much higher number of velocities in the stream cross-section**

USGS

Here is an example of the type and quantity of information available using hydroacoustic measurements.



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We regularly make check measurements to ensure accurate discharge values.

- Check measurements routinely made for verification of instrument and measurement accuracy

USGS

Flow Record:

Shifting Controls on Stage-Discharge Relations

- The “Control” controls the stage of water in a gage pool for a given flow
- Ideally, but rarely stable so that for any given flow, the gage height is the same.

USGS

Here is another example of how the control can change the stage-discharge relationship.

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Flow Record

Shifting controls on Stage-Discharge Relations

- Shifting controls due to:
  1. channel scour and fill
  2. growth/removal of vegetation or algae
  3. accumulation/removal of debris
- Shift applied to gage-height record to adjust temporary stage/discharge relation to the base rating
- "Shifts" used until evidence of permanent change in rating is documented

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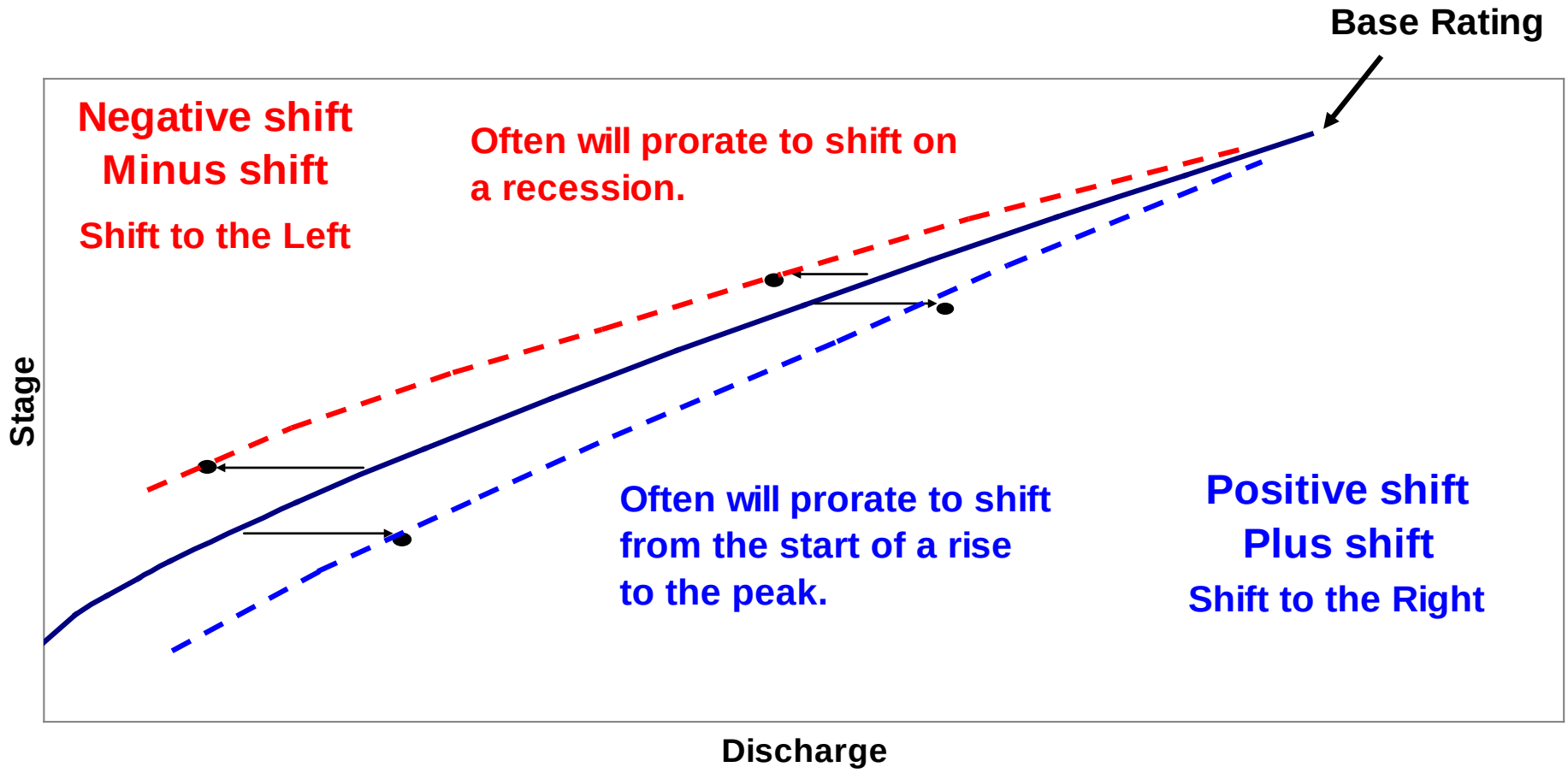
Again, frequent discharge measurements are required to refine the stage-discharge record to provide accurate discharge values.



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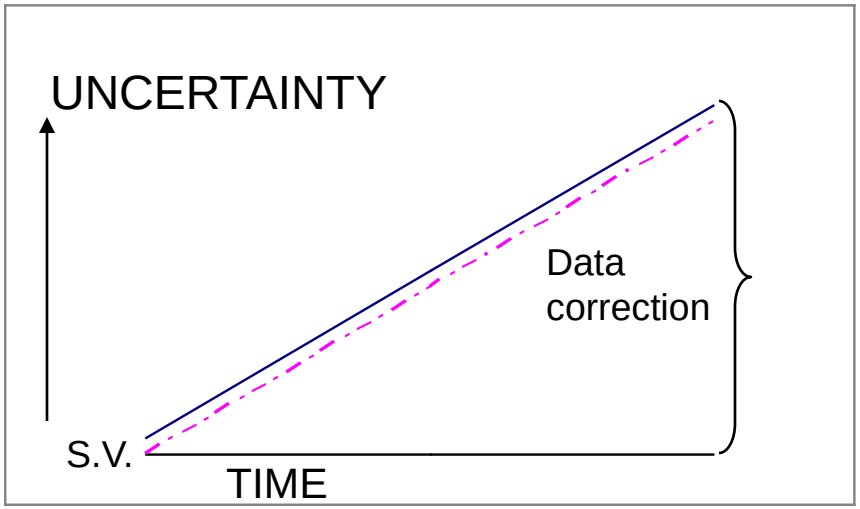
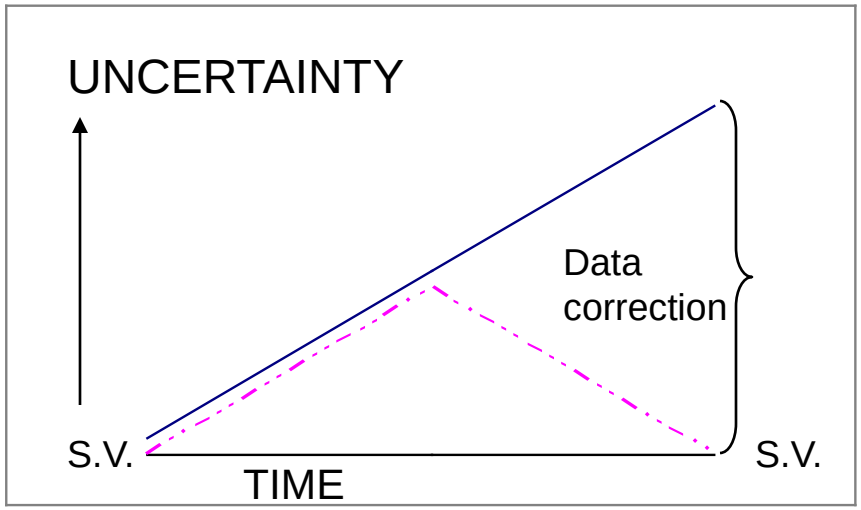
Shorter periods between discharge measurements can increase accuracy of the streamflow record.

Current Model of Data Uncertainty



Future Model of Data Uncertainty



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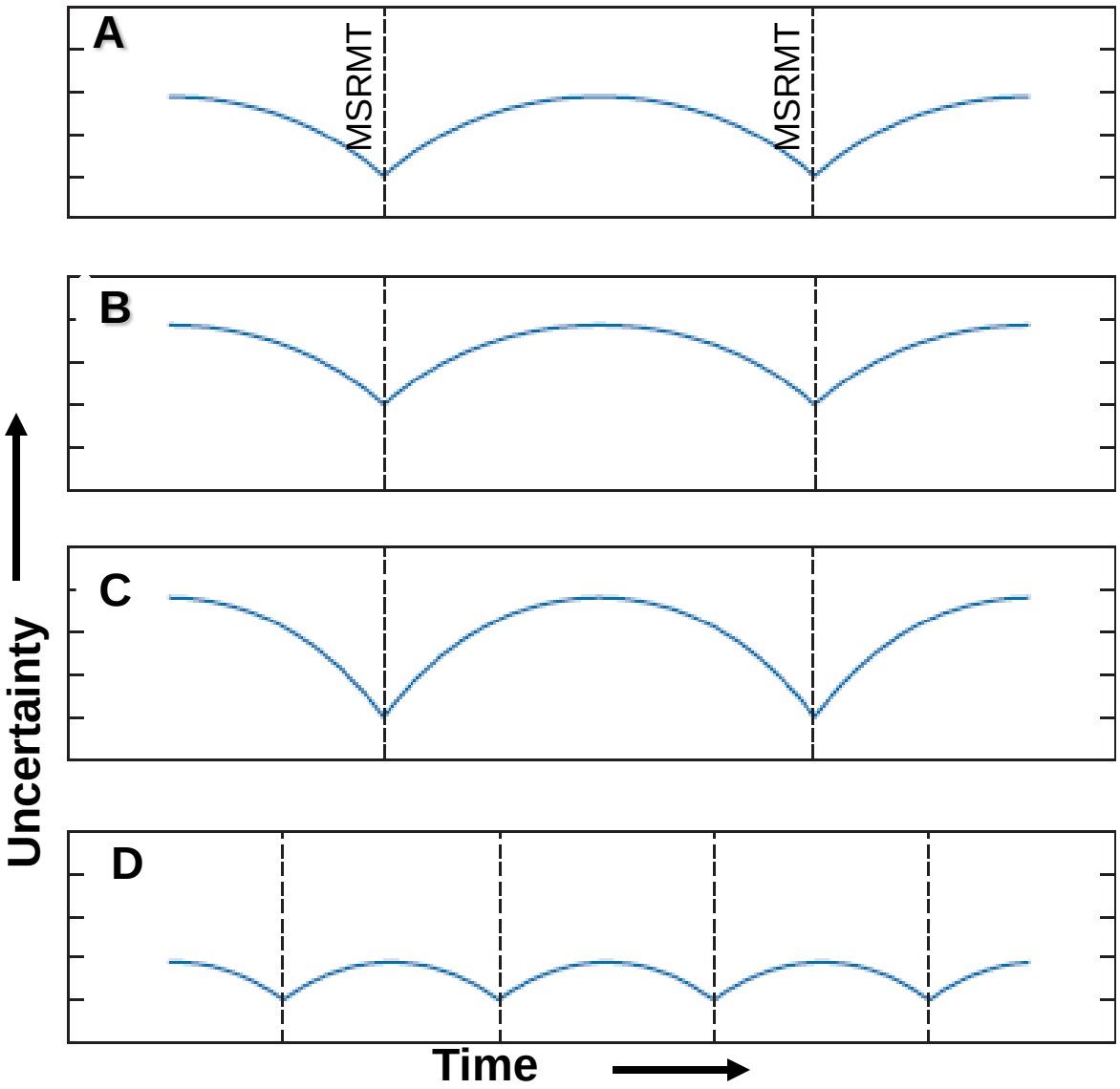
So using the conceptual model for uncertainty, here's what we do to produce accurate records.



Base Condition

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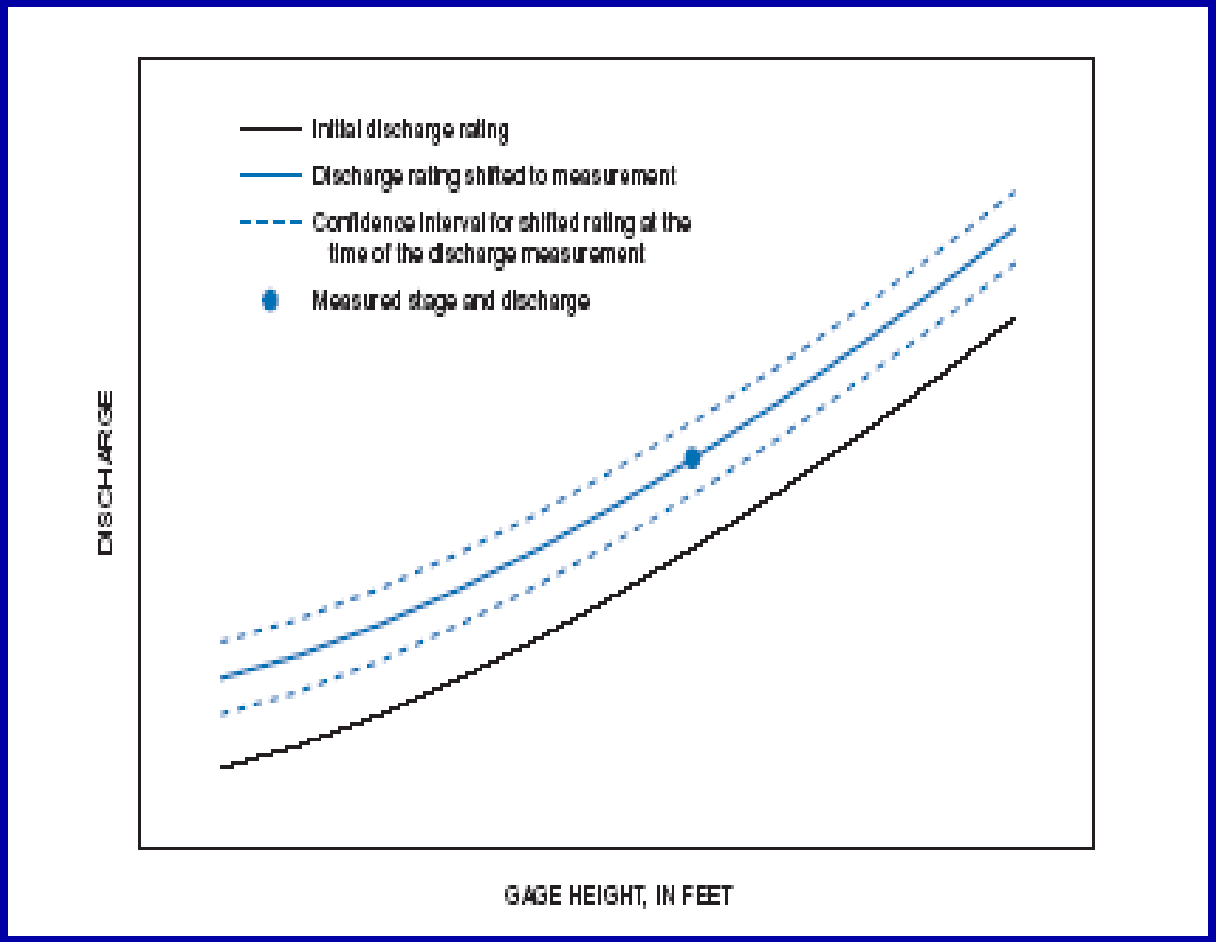
Flow Records: Uncertainty



- With uncertainty, published data has error bands, but with standard tested practices, little bias occurs over time
- USGS project to develop methods to evaluate and publish uncertainty of every data value

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