MEASUREMENT OF WATER IN UNDERGROUND MINES

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The Plan

First ask the question:

- What is mine water management and why do we care?

Then take a look at:

- The need for data
- Types of inflow to an underground mine
- Challenges to measuring inflow
- Methods – application notes, pros and cons
- Trends in the industry

Mine Water Management

- Management in this context means:
  - Collecting and conveying inflow
  - Controlling inflow and discharge from sumps
  - Pumping to the surface

- Pumping can be a high overhead cost and varies by:
  - Lift
  - Horsepower
  - Staged interim storage
  - Pipe run lengths

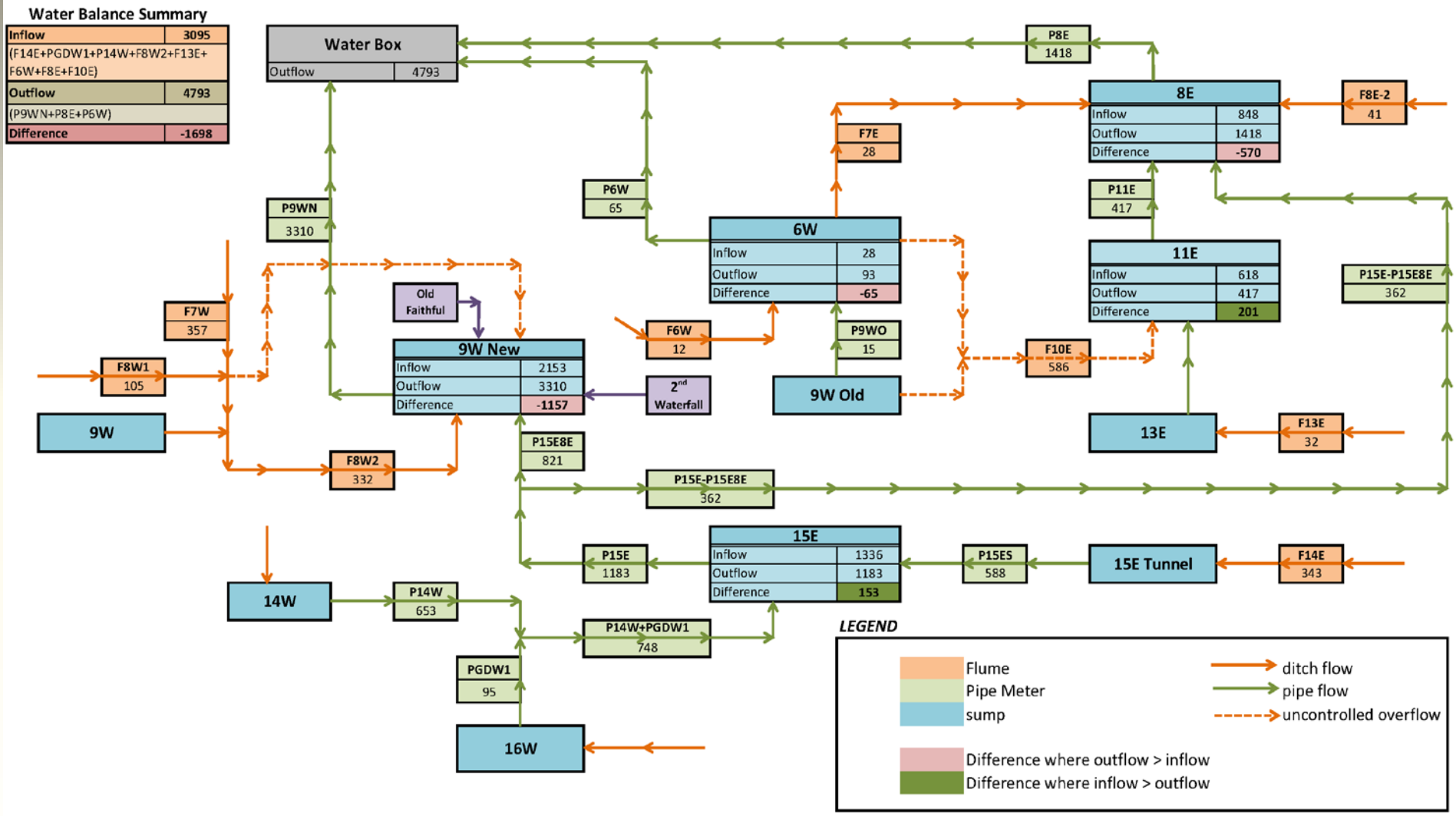
- Discharge requirements often driven by permits

Need for Comprehensive Data Collection

Measurement of flow and pressure is needed for:

- Operational efficiency and cost management
- Water balance
- Rock engineering
- Treatment and discharge requirements

Components of a Water Balance

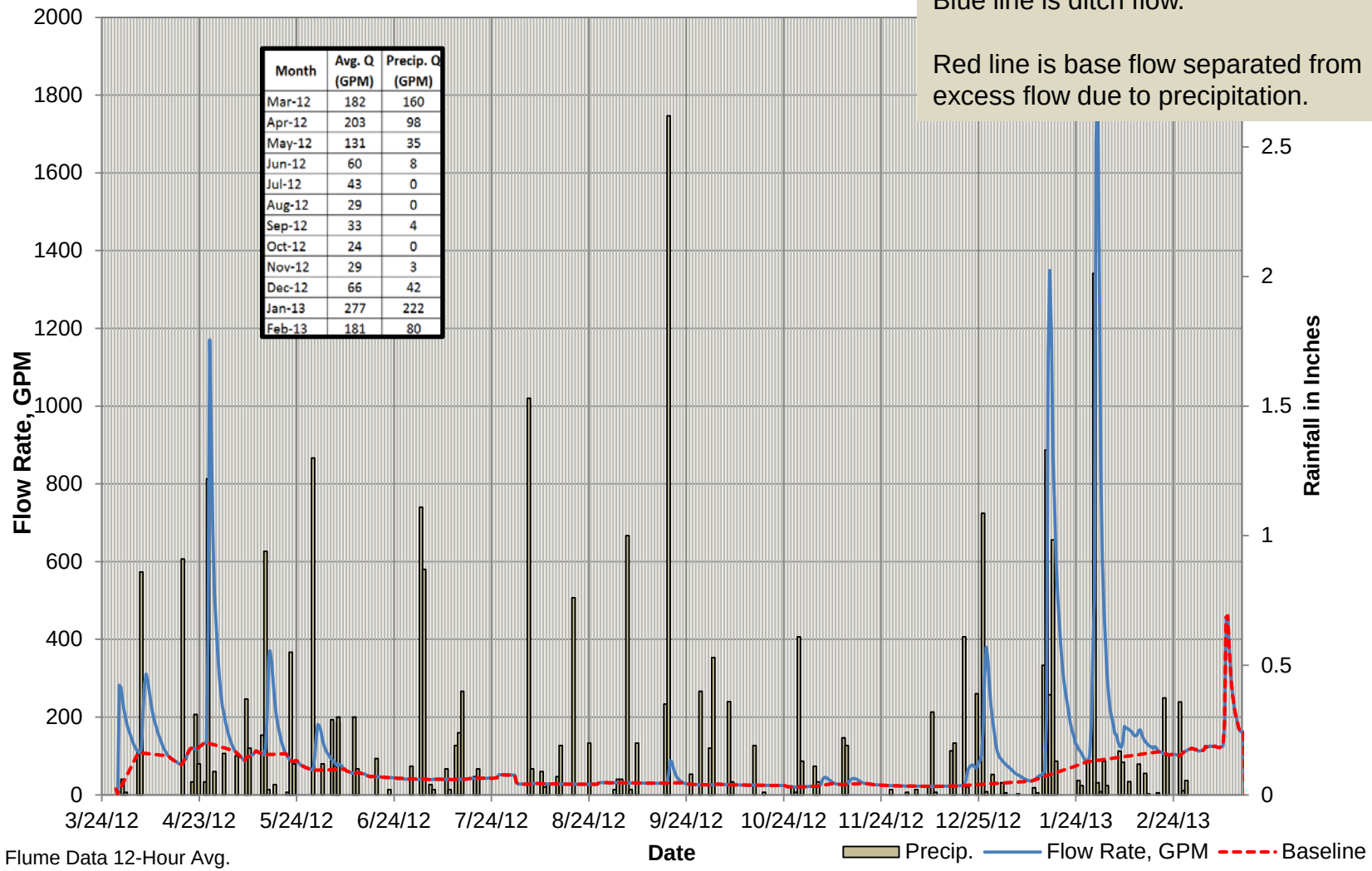


Information Content

Flow in mine ditch. Note influence from precipitation at surface.

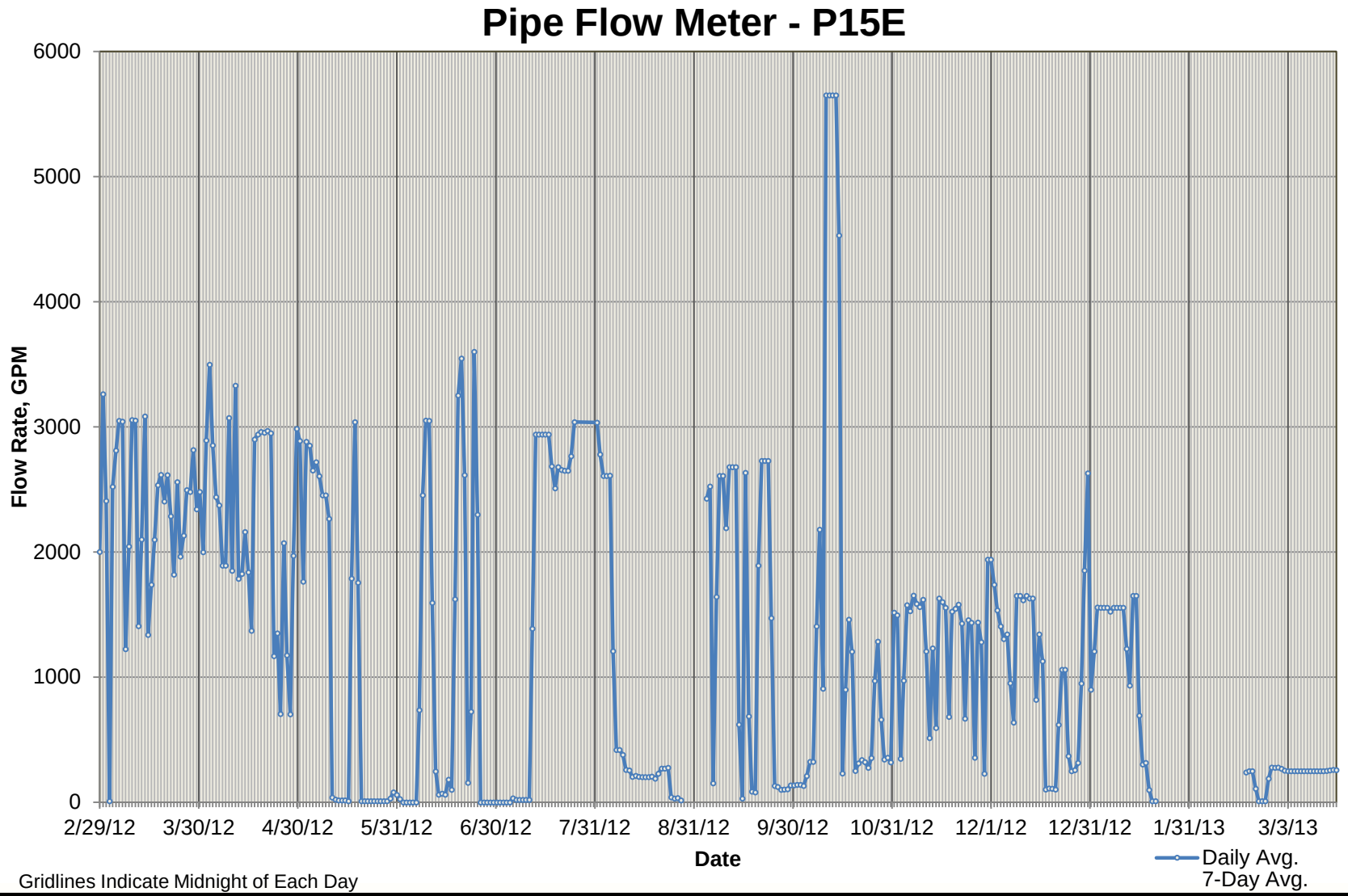
Blue line is ditch flow.

Red line is base flow separated from excess flow due to precipitation.



Flume Data 12-Hour Avg.

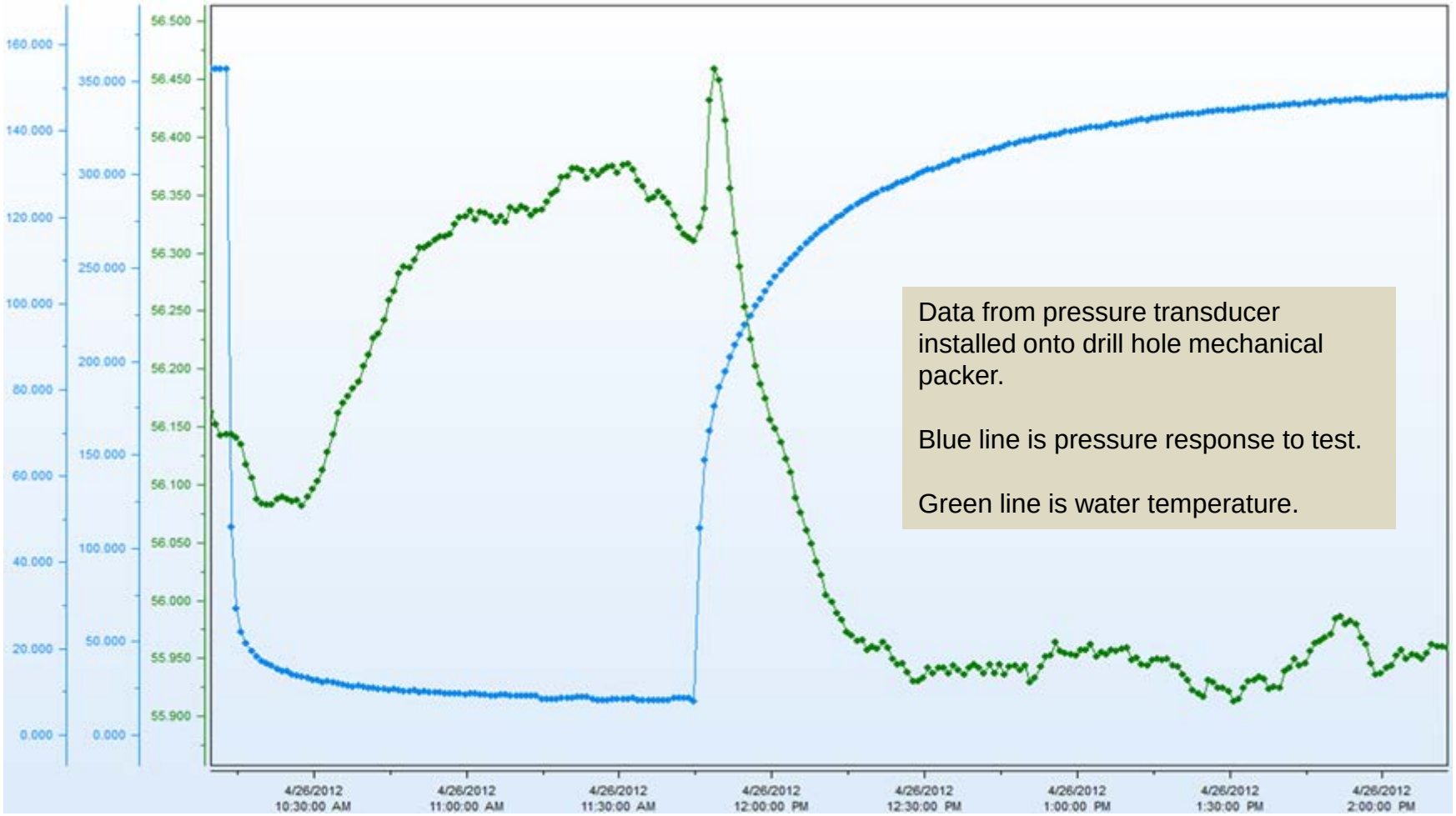
Information Content



Gridlines Indicate Midnight of Each Day

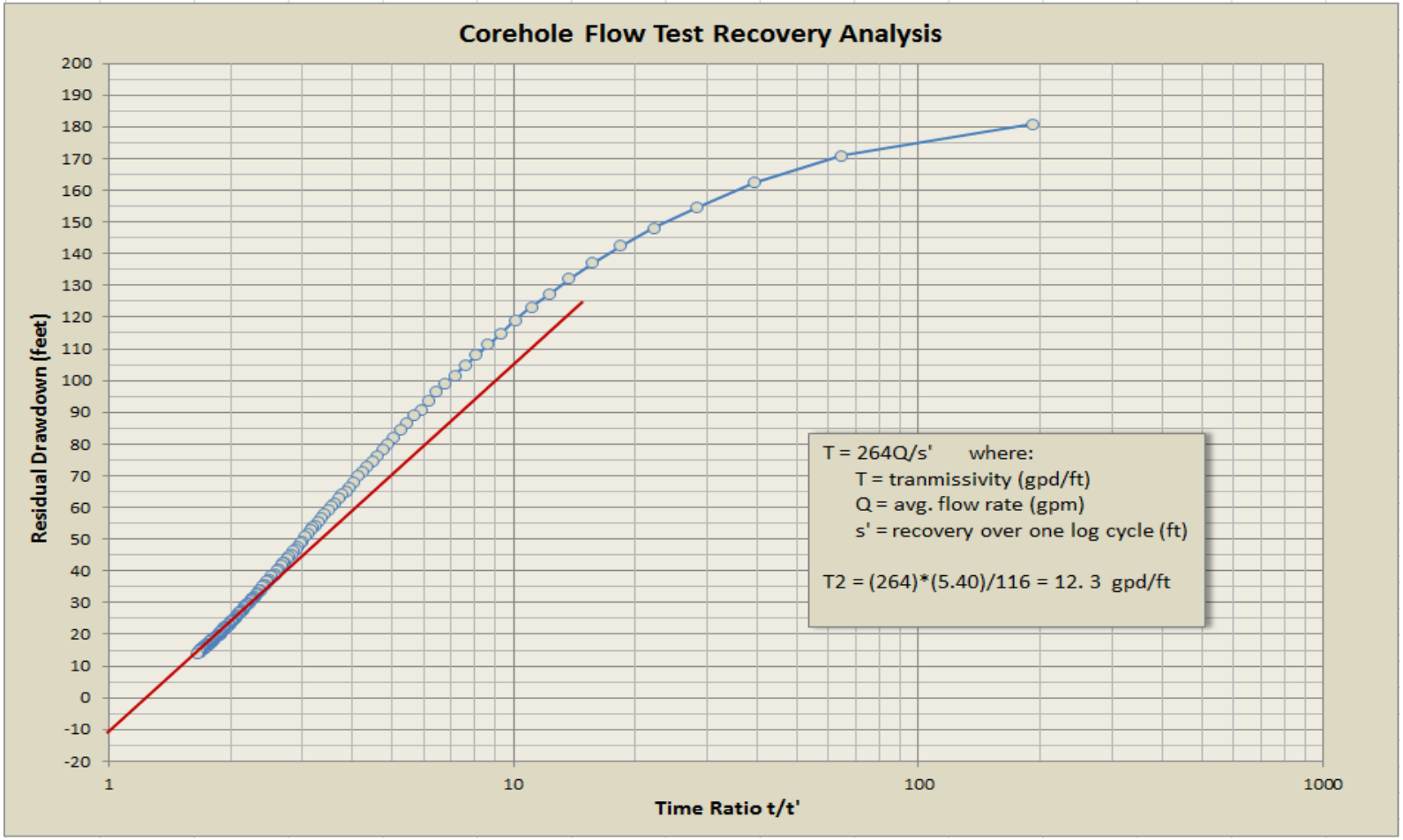
Data Analysis

Drill hole flow & recovery test data



Data Analysis

Drill hole flow test Theis recovery analysis



Mine Water Inflow

Sheet flow on rib

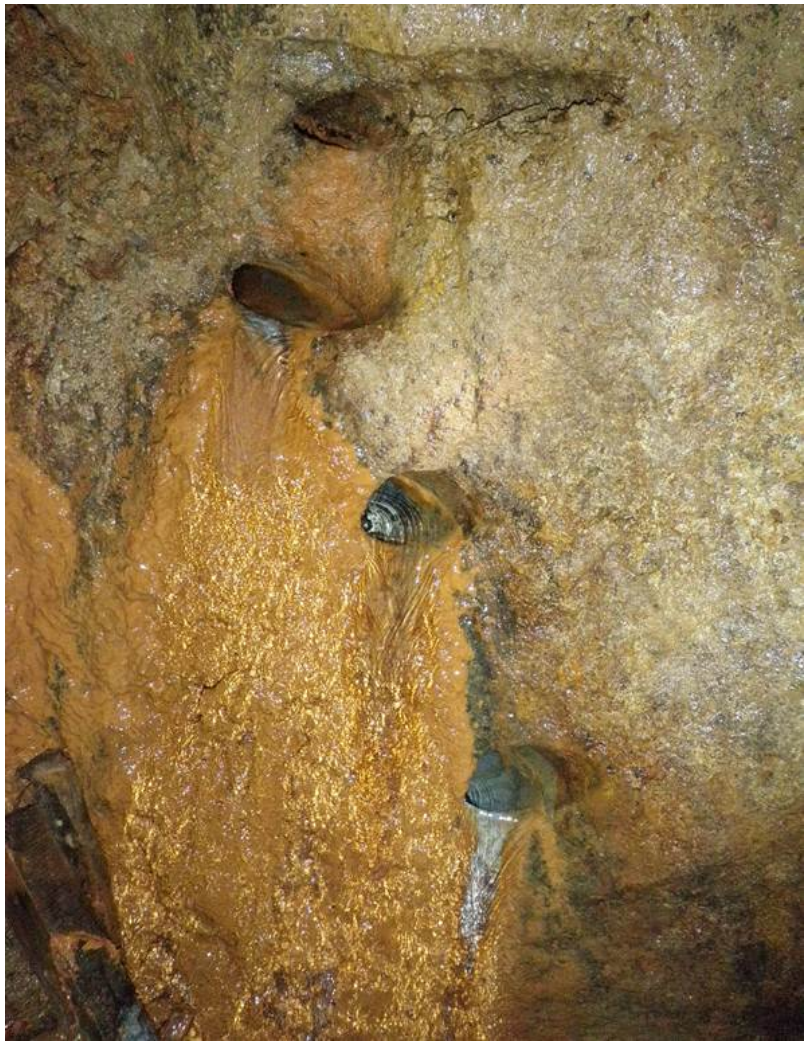
Mine Water Inflow

Diffuse Inflow –

Slow dripping or seeping

Mine Water Inflow

Flowing drill holes



Mine Water Inflow

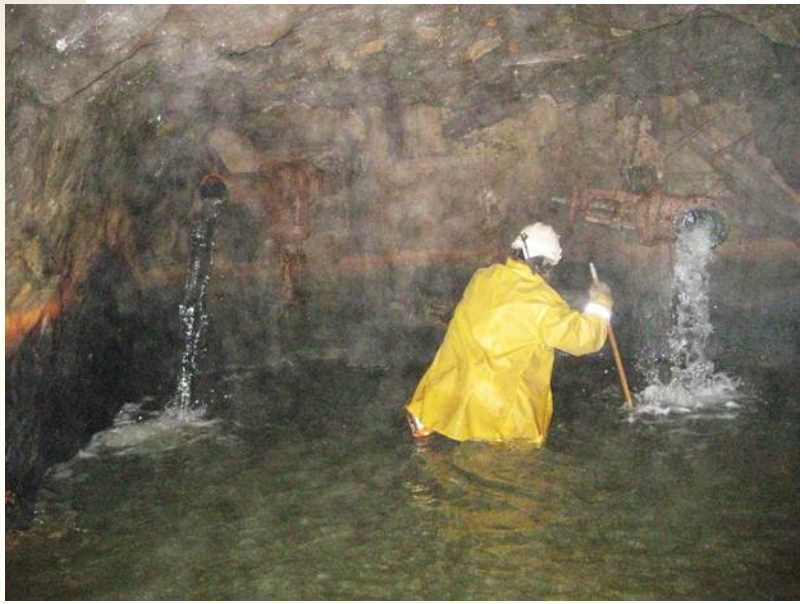
Karst and large voids

Mine Water Inflow

Seepage through seals or bulkheads

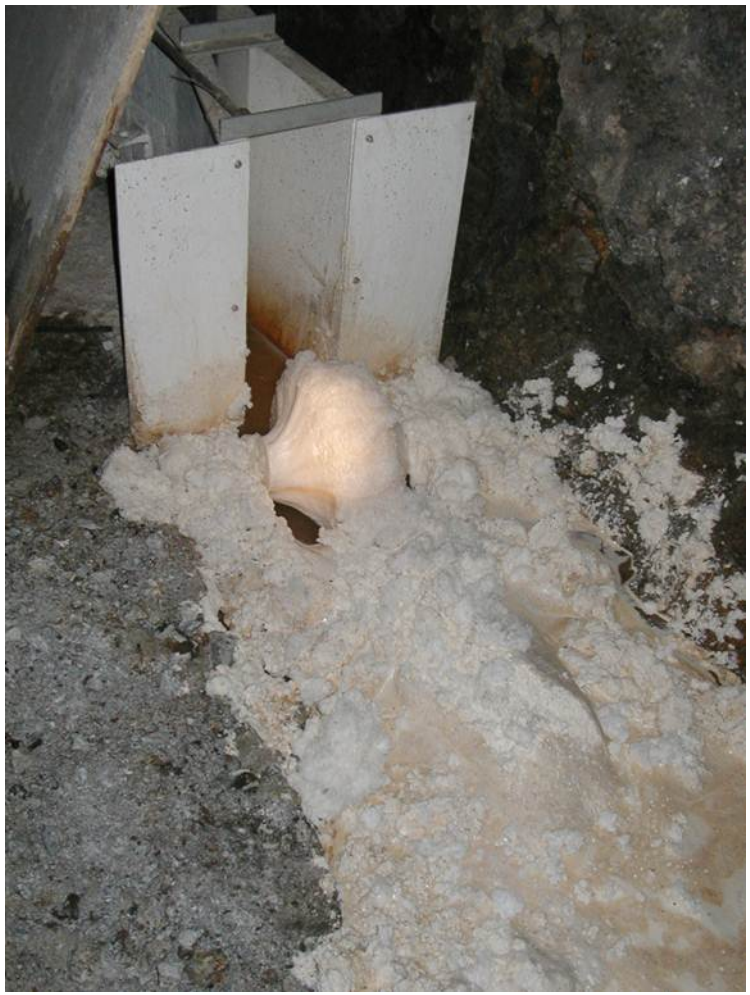
Measurement Challenges

Pipe flow discharges underground



Measurement Challenges

Precipitate and debris in ditch



Measurement Challenges

Full, flat gradient ditch

Measurement Challenges

Sediment in shut-in apparatus

Measurement Challenges

Destruction from flood

Methods of Measurement

Ad Hoc bag dam to collect diffuse flow.

Accumulation measured with sharp-crested weir.

Methods of Measurement

Weir in ditch to collect “casual” flows. In this case, drainage through railroad ballast.

Methods of Measurement

Parshall flume in ditch

Application Note:

Stepped base, narrow throat

Methods of Measurement

Palmer-Bowlus flume in ditch

Application Note:

Round base, large range, wide throat

Methods of Measurement

H-Flume at surface to measure seepage into a block cave subsidence zone

Application Note:

Requires free outfall, large range

Methods of Measurement

Ultrasonic Dual Transit Time Flow Meter

Application Note:

Non-invasive, any pipe material, any size

Methods of Measurement

Sump Level Measurement

Pressure datalogger

Sonic meter

Methods of Measurement

Rock hydrostatic pressure measurement

Application Note:

Flow/shut-in tests provides estimate of K,

Cost effective compared to packer testing from surface

	Applications	Cost
Ditch Flow		
Weir	Still water (Pool) Requires freeboard No debris, no precipitation	Low ($1,500 - $3,000)
Flume	Moving flow Minimal raise in head Self cleaning (handles debris) Some types handle submerged flow	Higher cost ($2,000 - $5,000)
Pipe Flow		
Ultrasonic	Non-invasive to pipe Doppler vs. Dual transit time	High cost ($2,500 - $4,000)
Magnetic	Invasive No moving parts	Most costly ($3,500 - $5,000)
Propeller	No debris, no precipitation Invasive to different degrees	Lowest cost ($500 – $1,500)
Sump Level		
Float Wheel	Still water, minimal air movement Low cost ($750 - $2,000)	Low cost ($750 – $2,000)
Pressure Transducer	Direct readings of depth of water Low cost ($500 - $1,500)	Low cost ($500 - $1,500)
Ultrasonic	Does not contact water	High cost ($2,000 - $4,000)

	Advantages	Disadvantages
Ditch Flow		
Weir	Simple Many installation options	Vulnerable measurement point Not self cleaning Requires still pool - raises head
Flume	Self cleaning No large raise in head - good for ditches New designs allow submerged conditions Tend to be more accurate than weirs Good option for unattended operation	More involved installation More expensive than weirs
Pipe Flow		
Ultrasonic	Non-invasive to pipe No moving parts, accuracy not degraded with time	Cost Complex meter programming
Magnetic Induction	No moving parts Long track record of use	Invasive installation (flanged insert)
Propeller/paddle wheel	Low cost Long track record of use Invasive to pipe, but often simpler than magnetic	Moving parts, accuracy degrades with time Affected by debris, encrustation, cavitation
Sump Level		
Float Wheel	Dependable, long track record of use Low cost	Moving parts Not set up for electronic datalogging
Pressure Transducer	Direct readings of depth of water Low cost	Can be affected by water chemistry
Ultrasonic	Does not contact water	Cost Can be affected by changes in air density

Trends in Mine Water Management

Mine water management will increase in importance if (when) commodity prices fall.

- Pumping, storing, and conveying water is often a high overhead cost.
- Environmental controls are becoming a more important driver at mine sites outside of the US.

Technology is an important driver

- Automated data collection continues to improve and drop in price.
- More mines are adopting SCADA controls and many operators expect a seamless integration into a comprehensive mine monitoring system.
- Pipe flows and sump levels are measured in most mines. Many still not automated, but most are moving that way.

The Take Away

- All inflow and conveyance conditions can be measured. Some collection may be needed.
- A water balance model is only as good as its data.
- Measurement devices should be carefully selected for the conditions to take advantage of the strengths of each.
- Minimize maintenance, maximize data content.

Thank You

Questions……?