Managing Mine Pool Discharges in the Monongahela Basin

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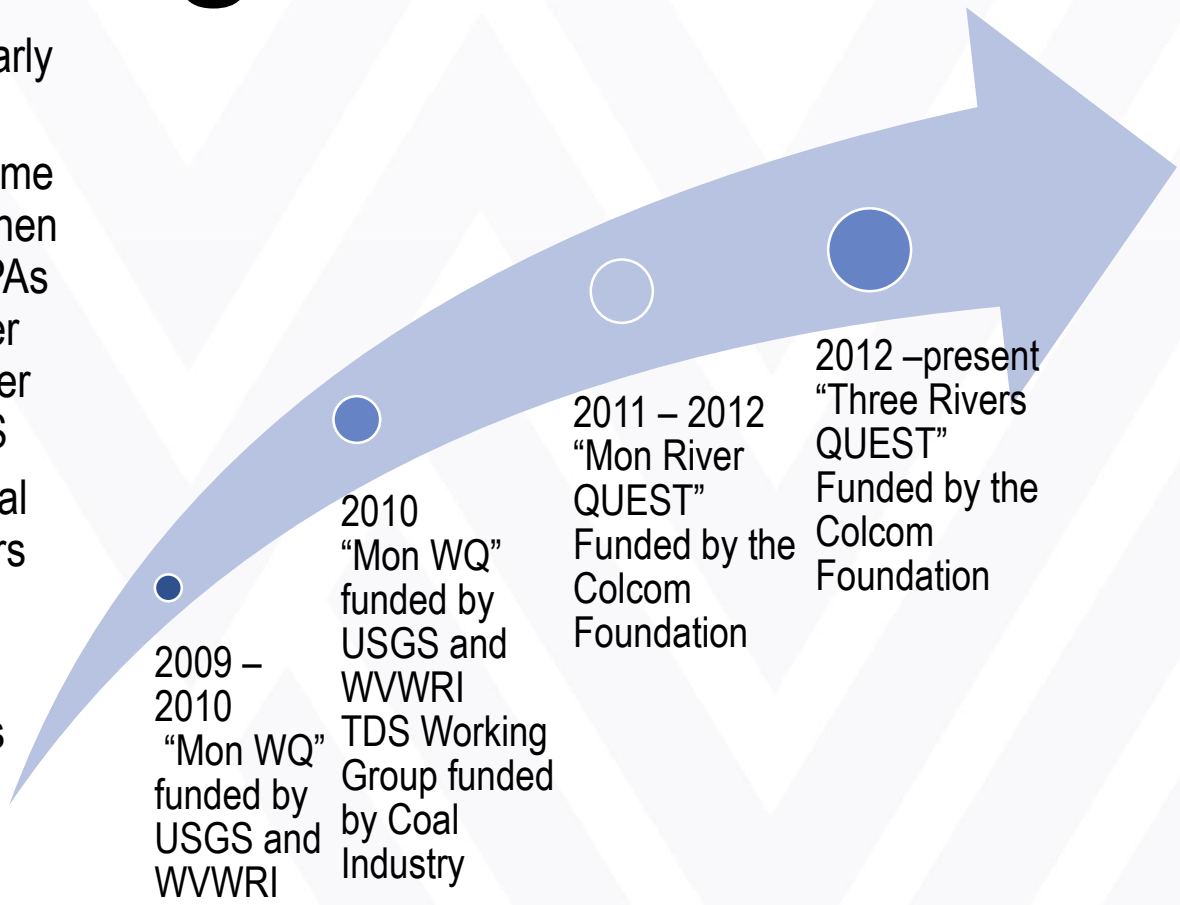
Background

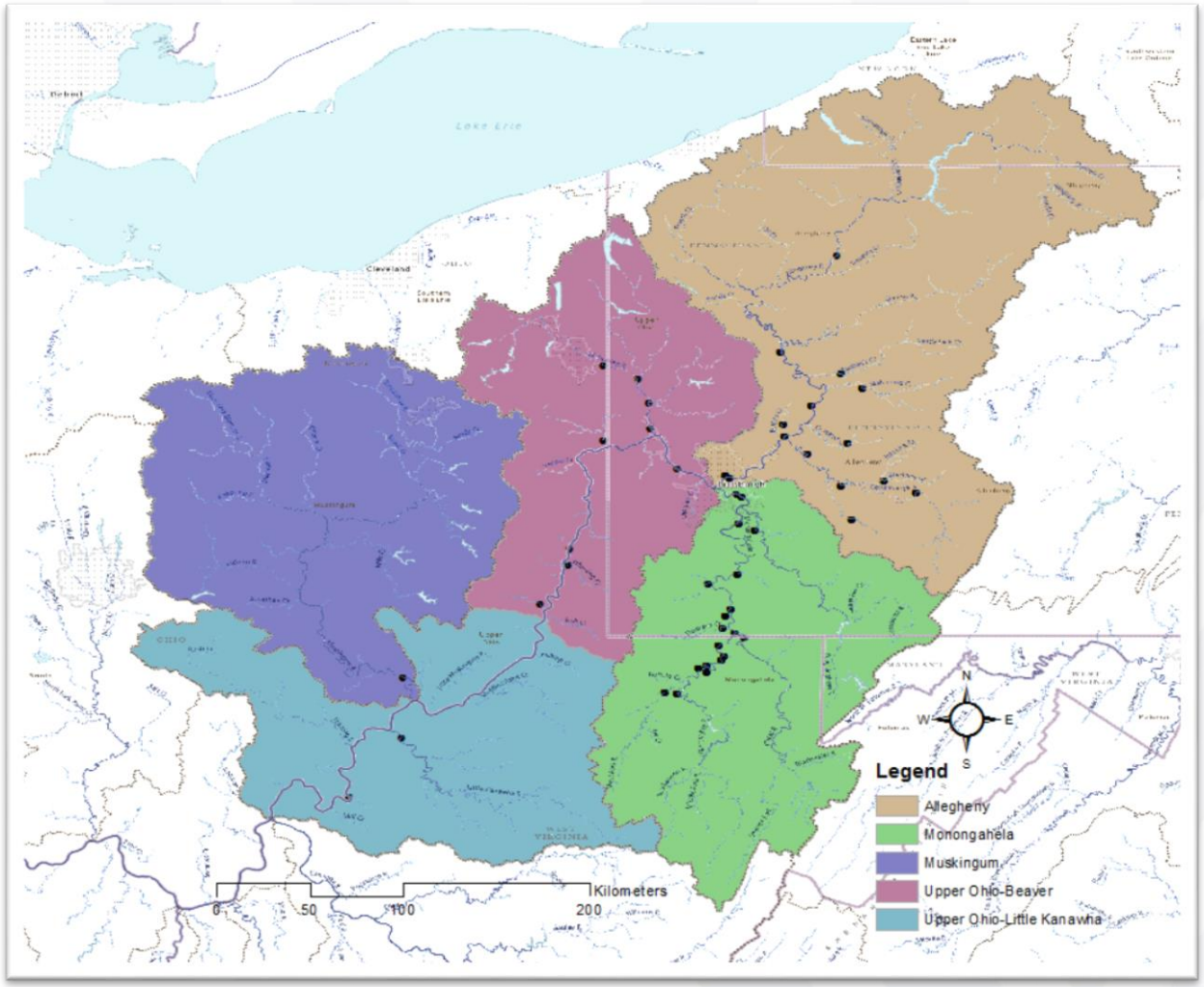
High TDS events in late summer/early fall 2008

- Lead to a shut down of some municipal water intakes when the river exceeded the EPAs secondary drinking water standards of 500 parts per million (or mg/L) of TDS
- Complaints from industrial and residential river users
- Dunkard Creek fish kill September 2009
- Evidence that TDS was increasing



- Allegheny
  - Duquesne and Trout Unlimited
  - Volunteers
- Monongahela
  - WV Water Research Institute
  - Volunteers
- Ohio
  - Wheeling Jesuit University
  - Volunteers

Monthly chemical monitoring stations



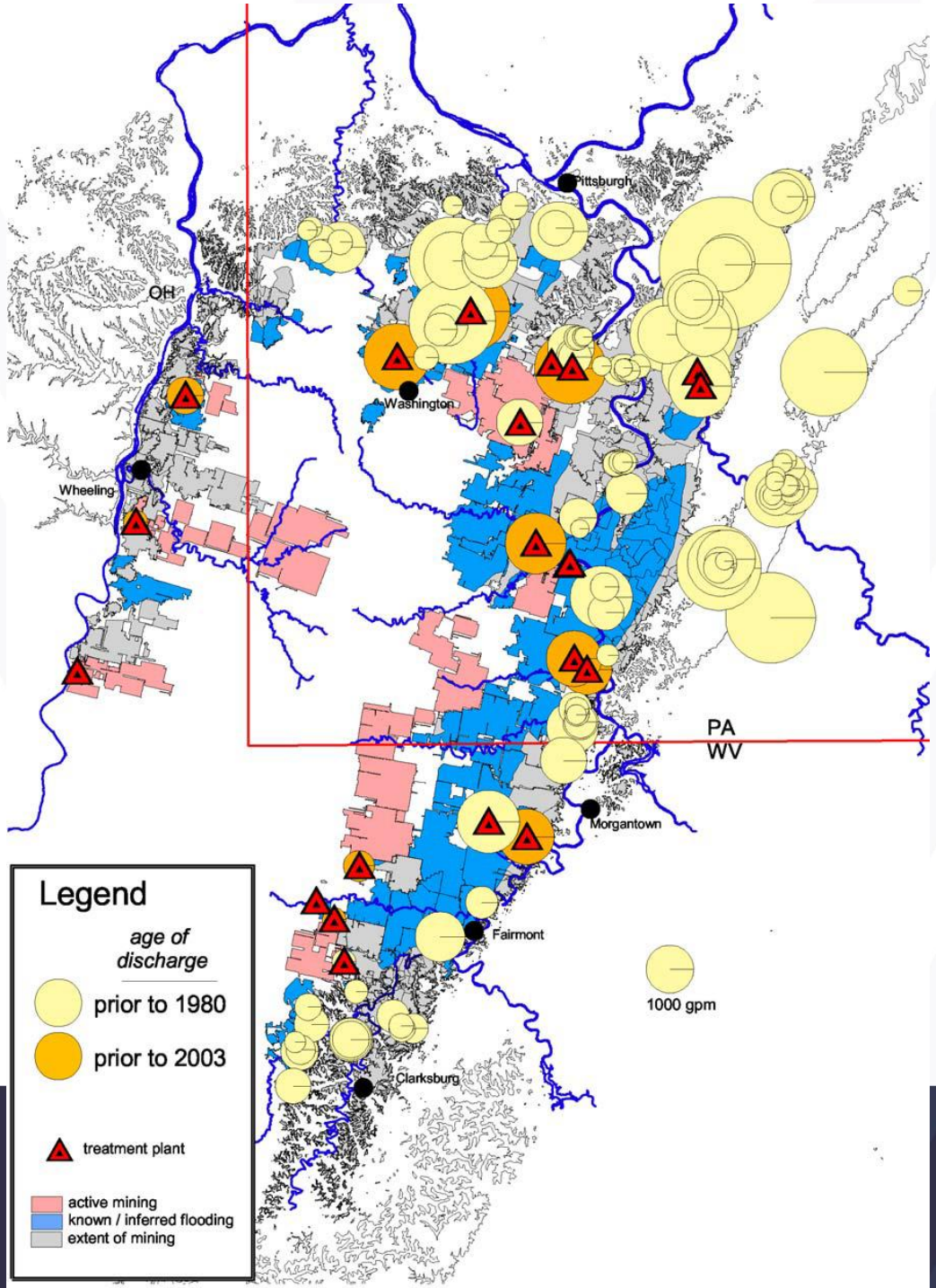
Mine pools of the Northern Appalachian Coal Basin (2003)

Pittsburgh Coal Seam mines only:

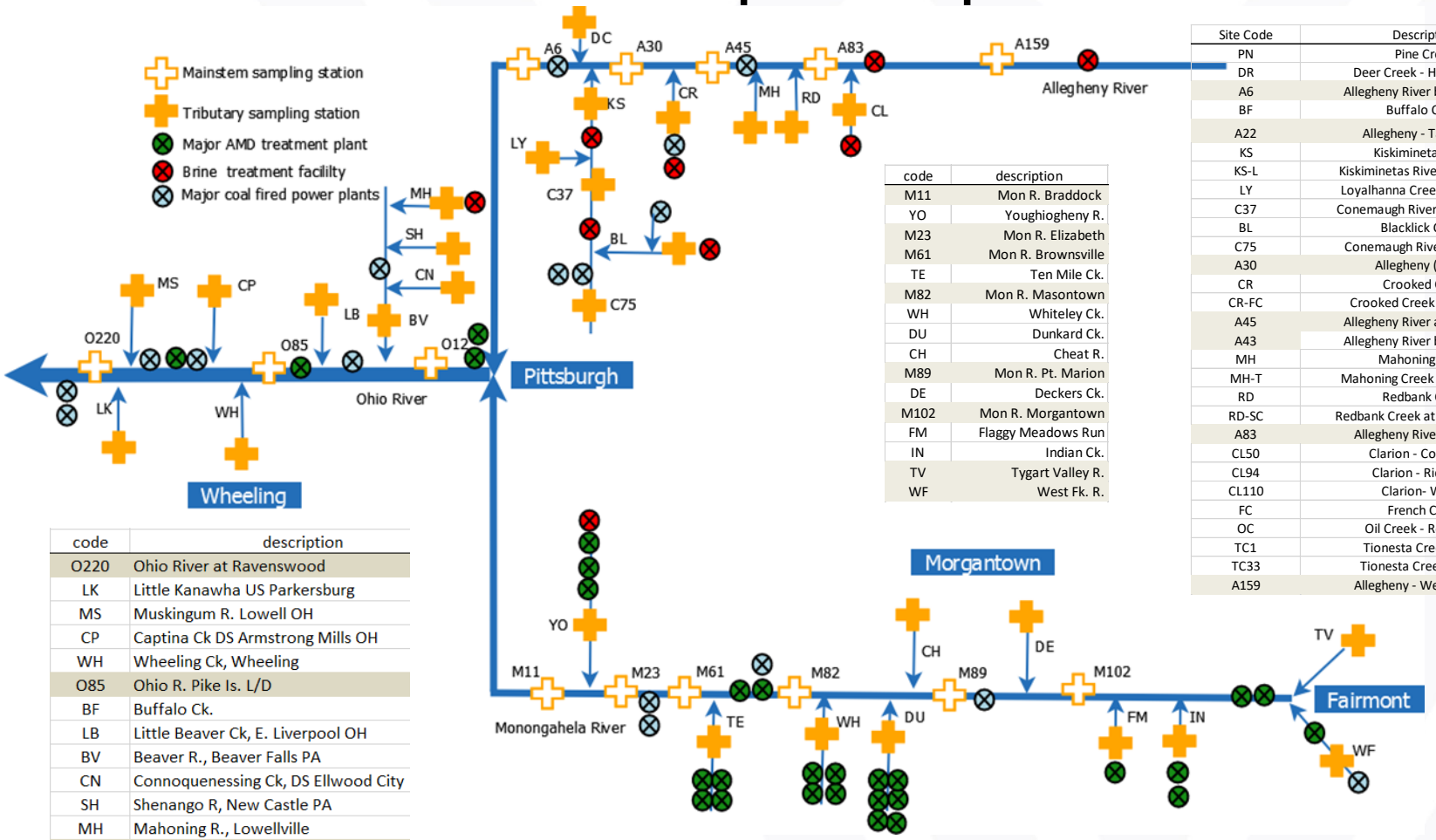
Output: 115,000 gpm

Treated: 38,000 gpm

AML: 77,000 gpm



Sites in Relation to AMD discharges, brine treatment and power plants

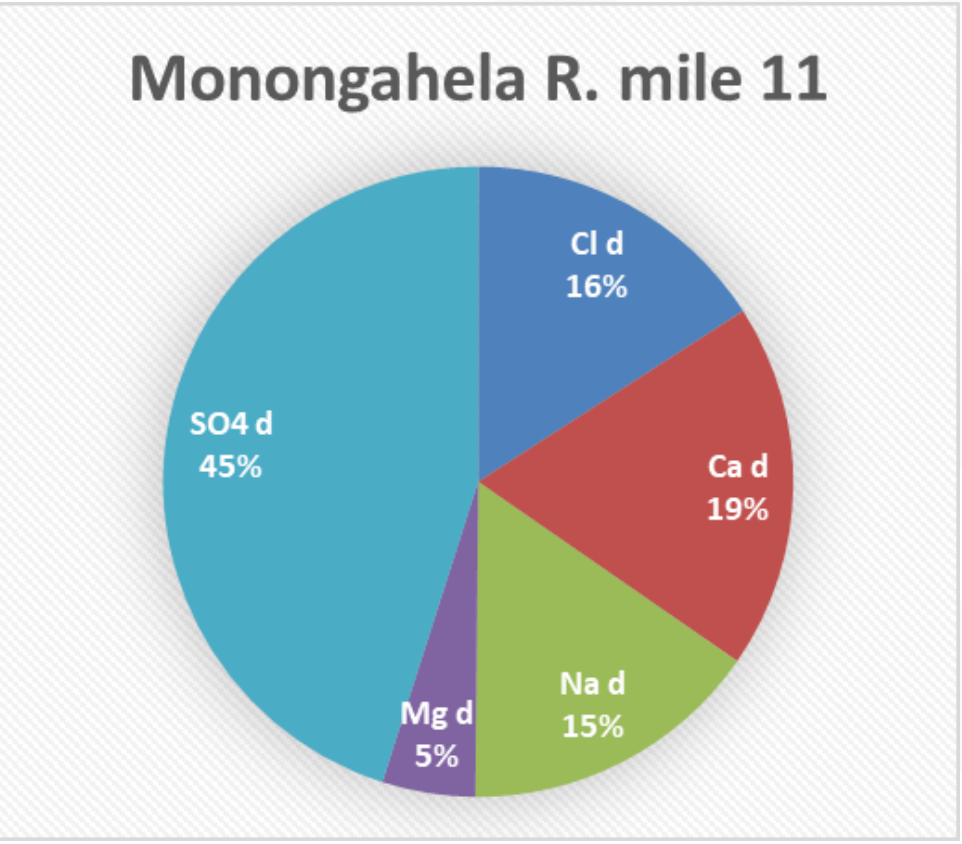


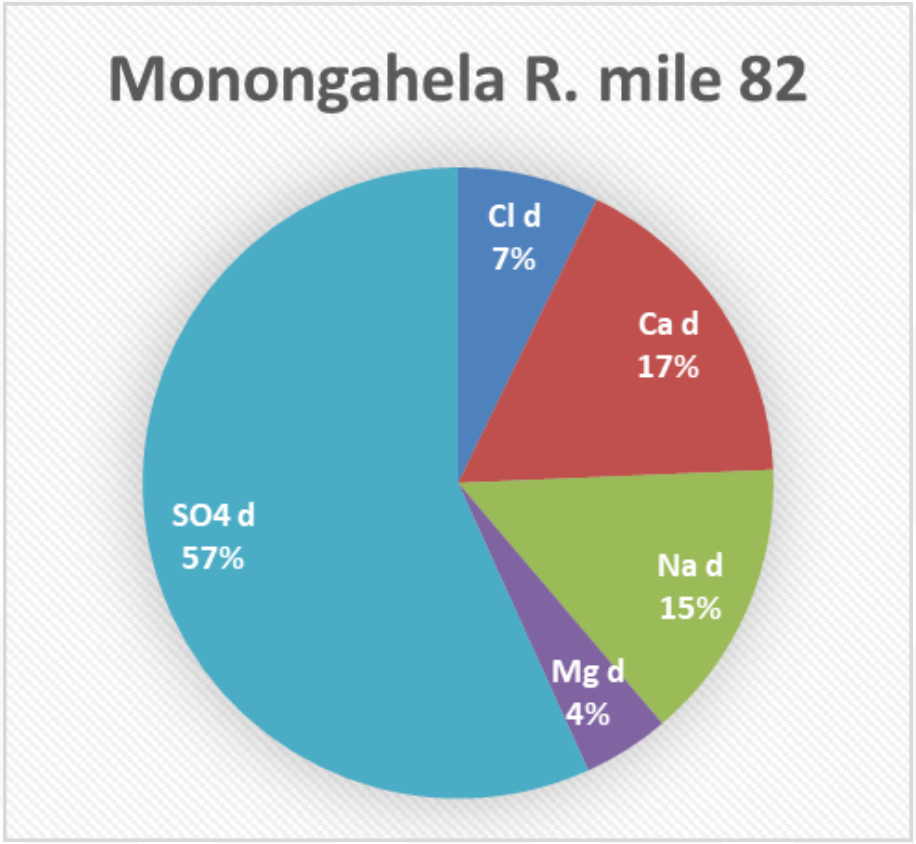
code	description
O220	Ohio River at Ravenswood
LK	Little Kanawha US Parkersburg
MS	Muskingum R. Lowell OH
CP	Captina Ck DS Armstrong Mills OH
WH	Wheeling Ck, Wheeling
O85	Ohio R. Pike Is. L/D
BF	Buffalo Ck.
LB	Little Beaver Ck, E. Liverpool OH
BV	Beaver R., Beaver Falls PA
CN	Connoquenessing Ck, DS Ellwood City
SH	Shenango R, New Castle PA
MH	Mahoning R., Lowellville
O12	Ohio R., Sewickley PA

code	description
M11	Mon R. Braddock
YO	Youghiogheny R.
M23	Mon R. Elizabeth
M61	Mon R. Brownsville
TE	Ten Mile Ck.
M82	Mon R. Masontown
WH	Whiteley Ck.
DU	Dunkard Ck.
CH	Cheat R.
M89	Mon R. Pt. Marion
DE	Deckers Ck.
M102	Mon R. Morgantown
FM	Flaggy Meadows Run
IN	Indian Ck.
TV	Tygart Valley R.
WF	West Fk. R.

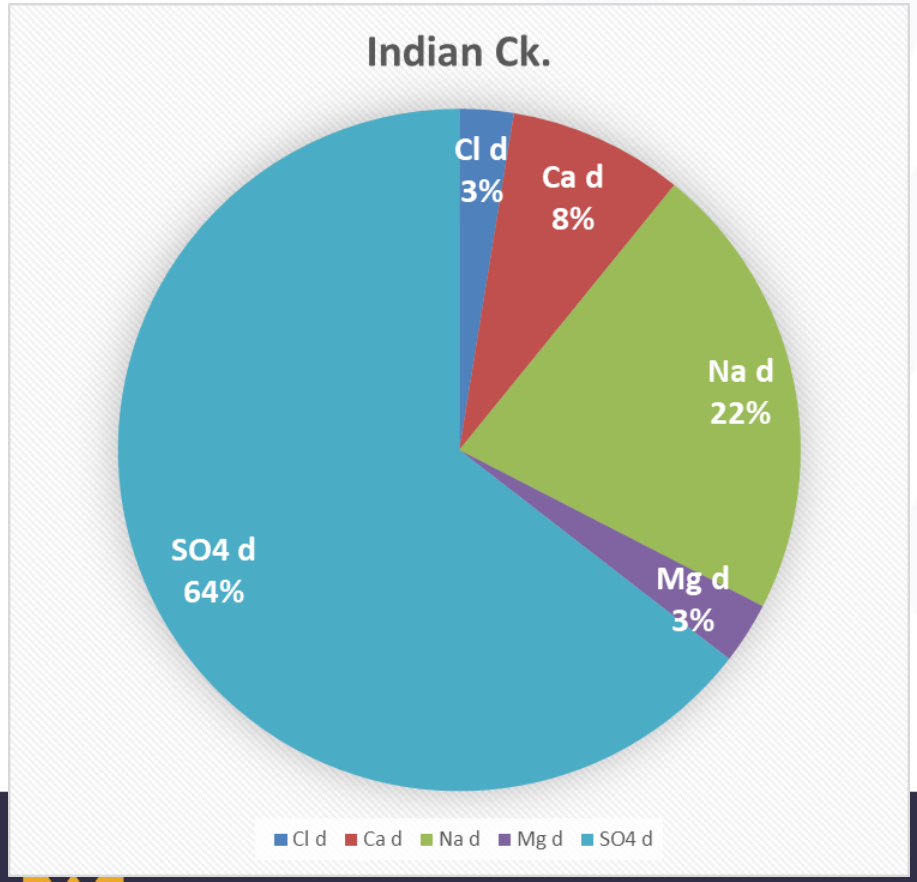
Site Code	Description
PN	Pine Creek
DR	Deer Creek - Harmarville
A6	Allegheny River below L&D 2
BF	Buffalo Creek
A22	Allegheny - Tarentum
KS	Kiskiminetas River
KS-L	Kiskiminetas River - Leechburg
LY	Loyalhanna Creek at Kingston
C37	Conemaugh River at Tunnelton
BL	Blacklick Creek
C75	Conemaugh River at Seward
A30	Allegheny (L&D 5)
CR	Crooked Creek
CR-FC	Crooked Creek - Ford City
A45	Allegheny River above L&D 7
A43	Allegheny River below L&D 7
MH	Mahoning Creek
MH-T	Mahoning Creek - Templeton
RD	Redbank Creek
RD-SC	Redbank Creek at Saint Charles
A83	Allegheny River at Parker
CL50	Clarion - Cooksburg
CL94	Clarion - Ridgeway
CL110	Clarion- Wilcox
FC	French Creek
OC	Oil Creek - Rouseville
TC1	Tionesta Creek - Dam
TC33	Tionesta Creek - Lynch
A159	Allegheny - West Hickory

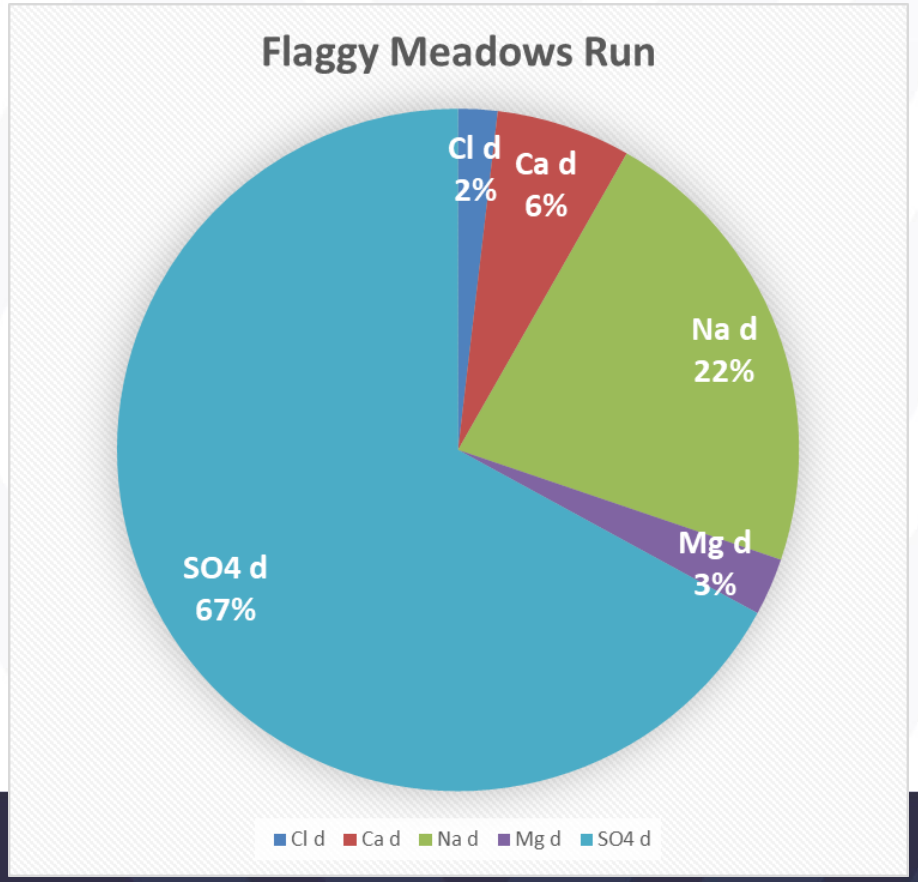
Mainstem major ion profiles: nearly identical but Cl increases toward Pittsburgh





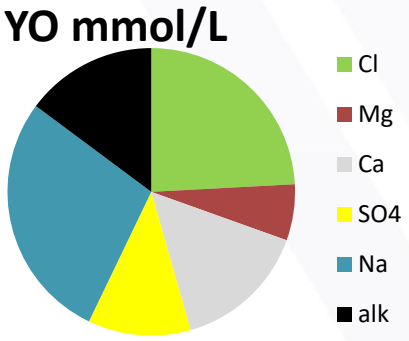
Both streams receive major inputs from AMD treatment plants, nearly identical ionic profiles

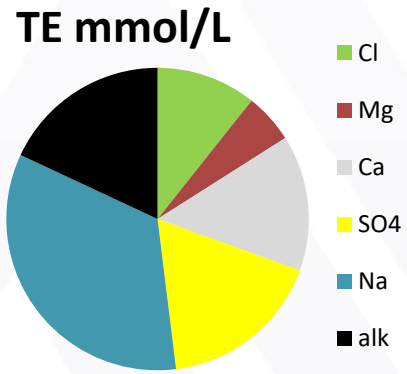




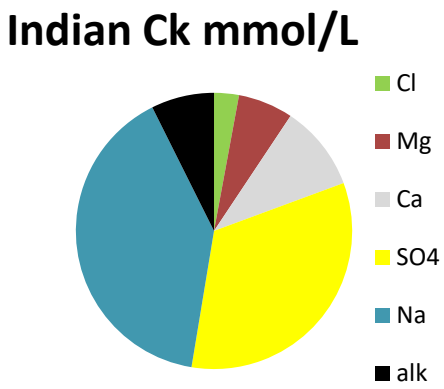
Brine and Mine Water have different chemical signatures

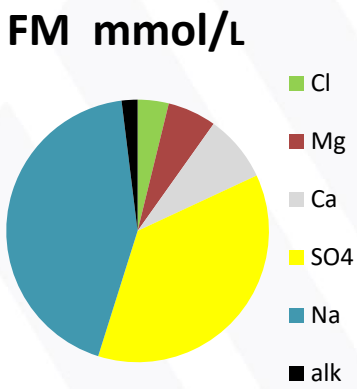
Brine

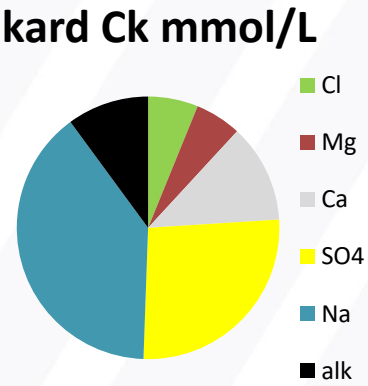




Mine water



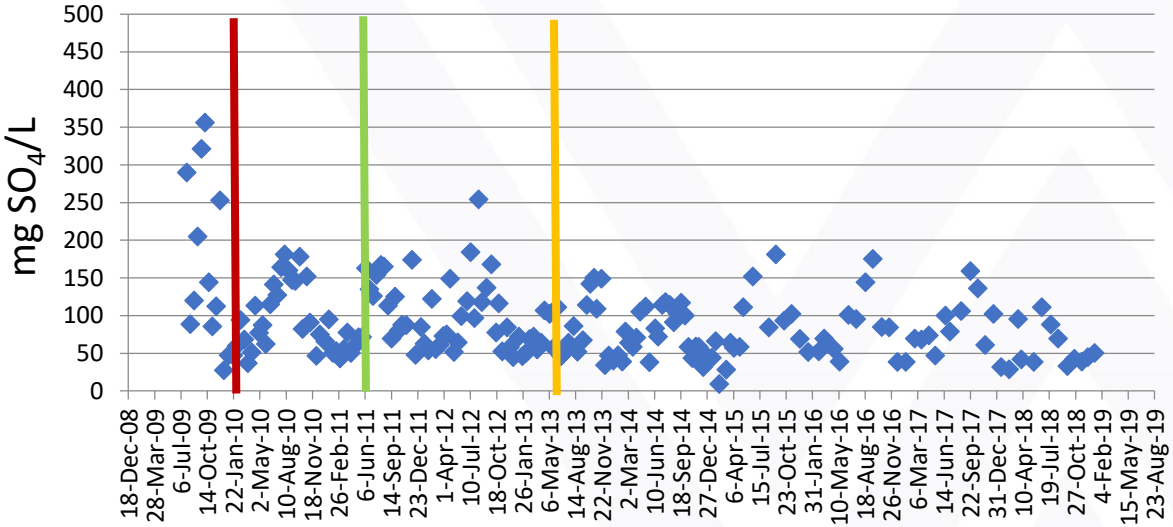


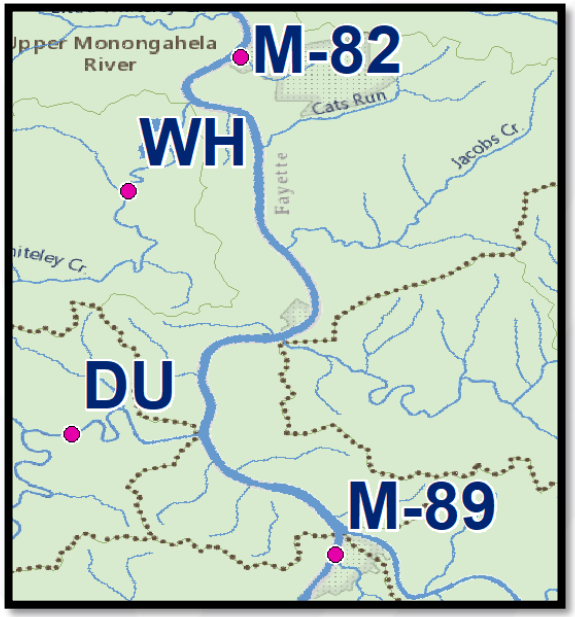


Strategy for controlling TDS/Sulfate

- Determine flow variations in the Monongahela River using USGS data from 1945 to 2009
- Use seasonal TDS/Sulfate loads from 3RQ data
- Determine the critical river flow by mass balance
- Characterize TDS/Sulfate loads from the AMD treatment plants
- Determine the amount of TDS/Sulfate that can be added via the AMD treatment plants
- Using a safety factor of 2x, apportion load allowances needed to maintain TDS<500 and Sulfate<250 at daily river flows
- Distribute model to industry

M82



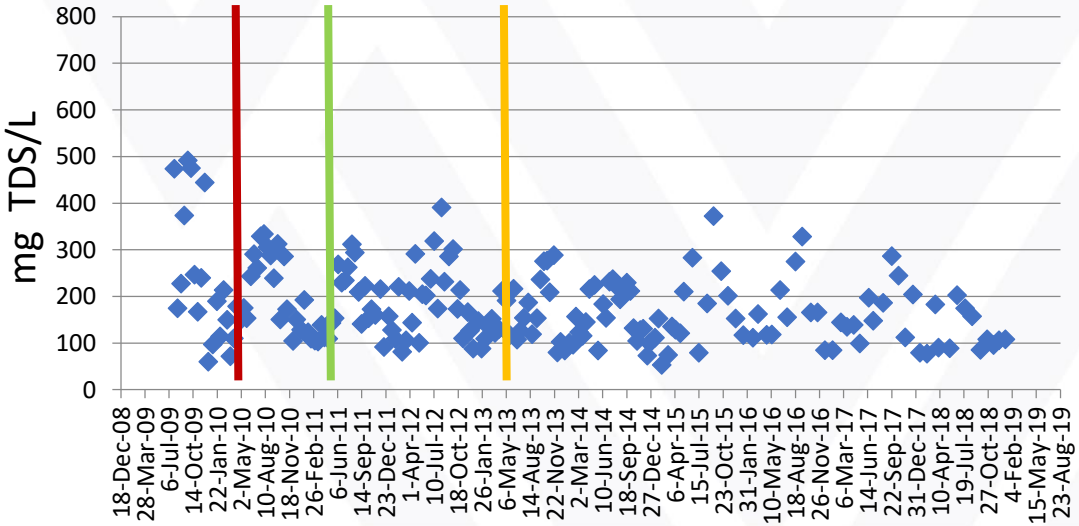


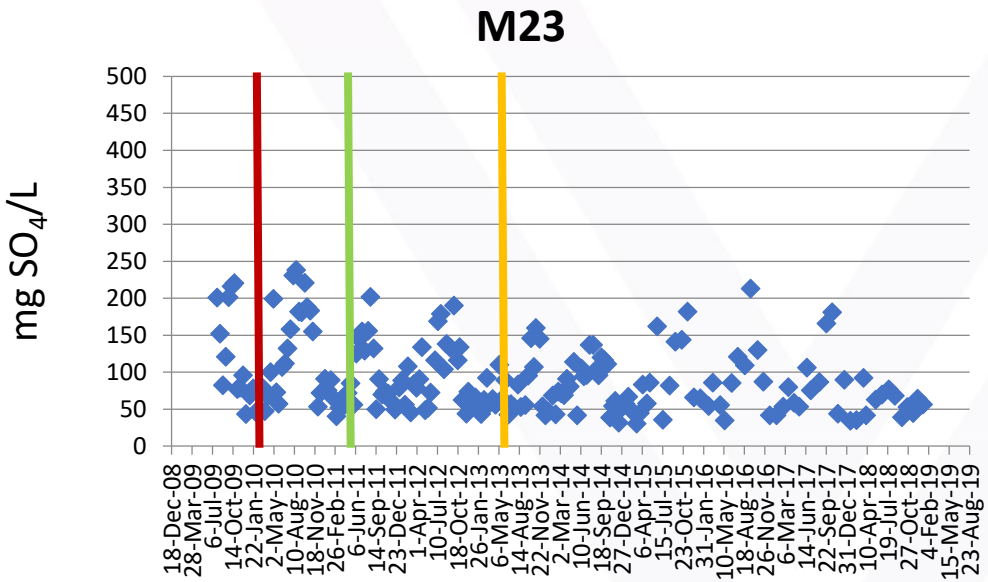
Red = January 2010 Managed Discharge Initiation

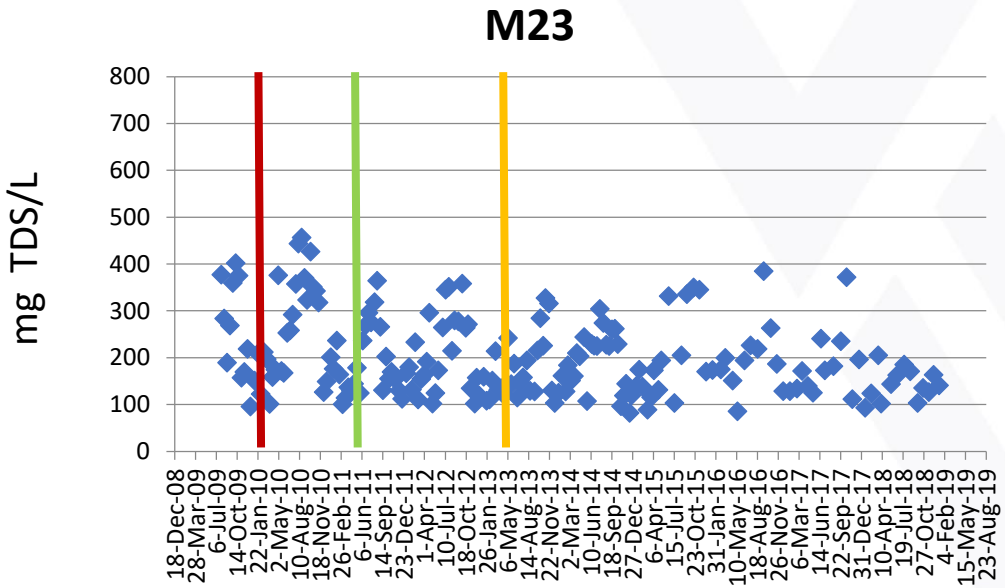
Green = May 2011 PA restricts produced water in POTWs

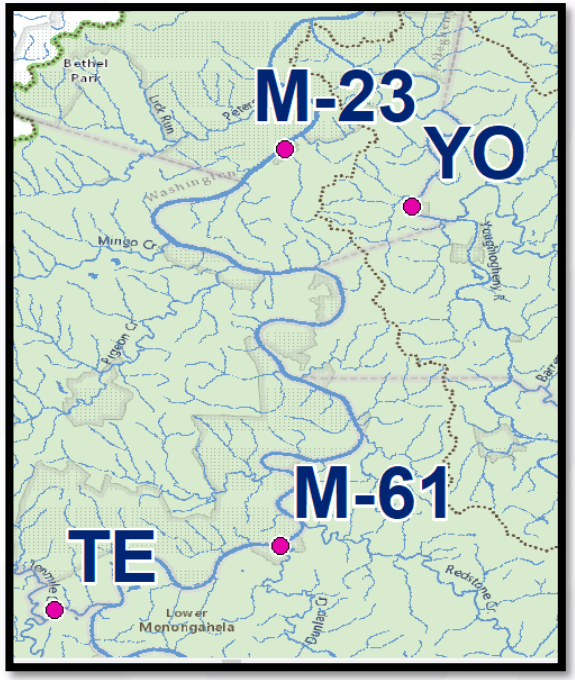
Yellow = May 2013 Reverse Osmosis plant at Mannington WV

M82









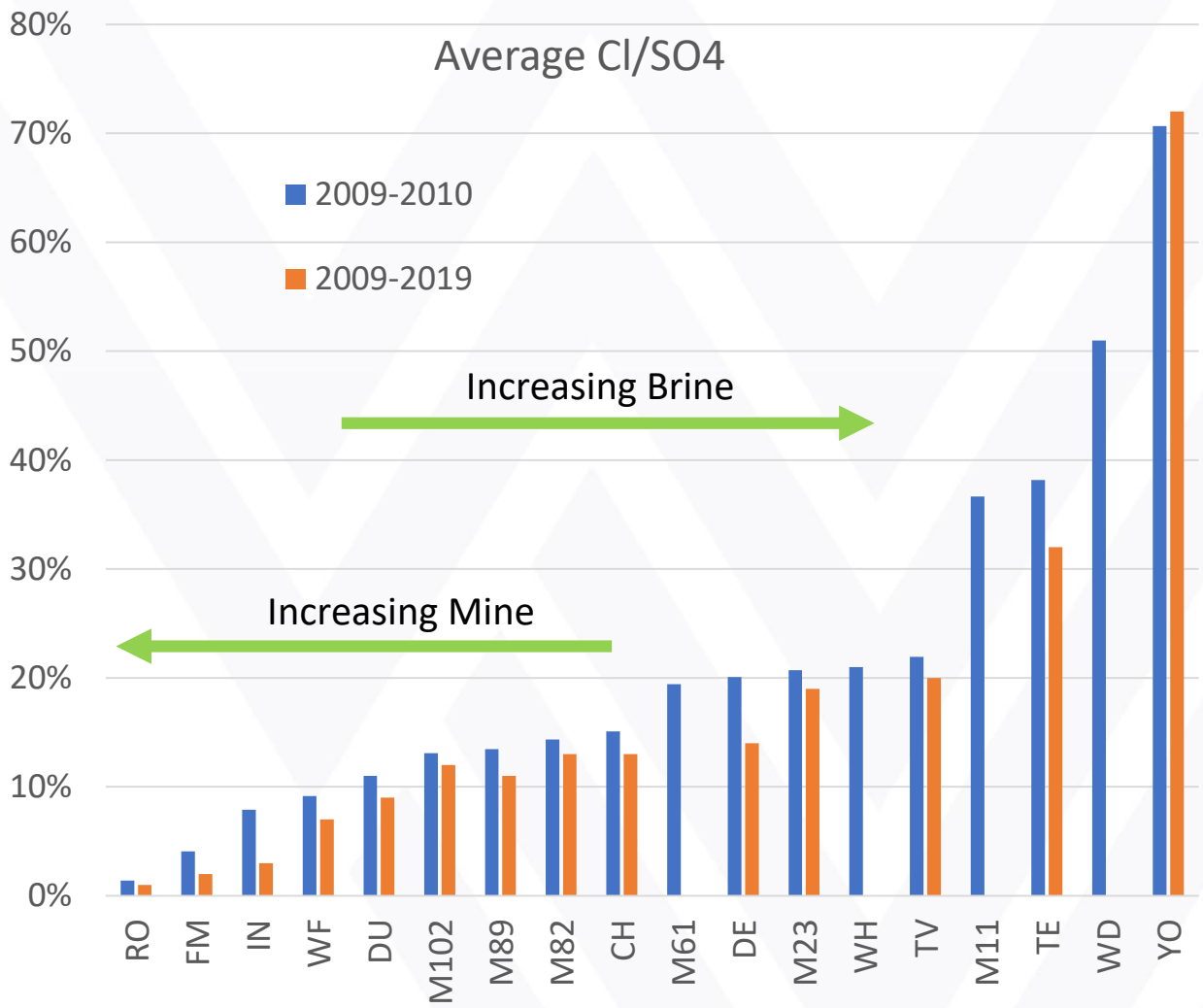
Red = January 2010 Managed Discharge Initiation

Green = May 2011 PA restricts flowback in POTWs

Yellow = May 2013 Osmosis Plant begins operations on Dunkard Creek

Stream effects

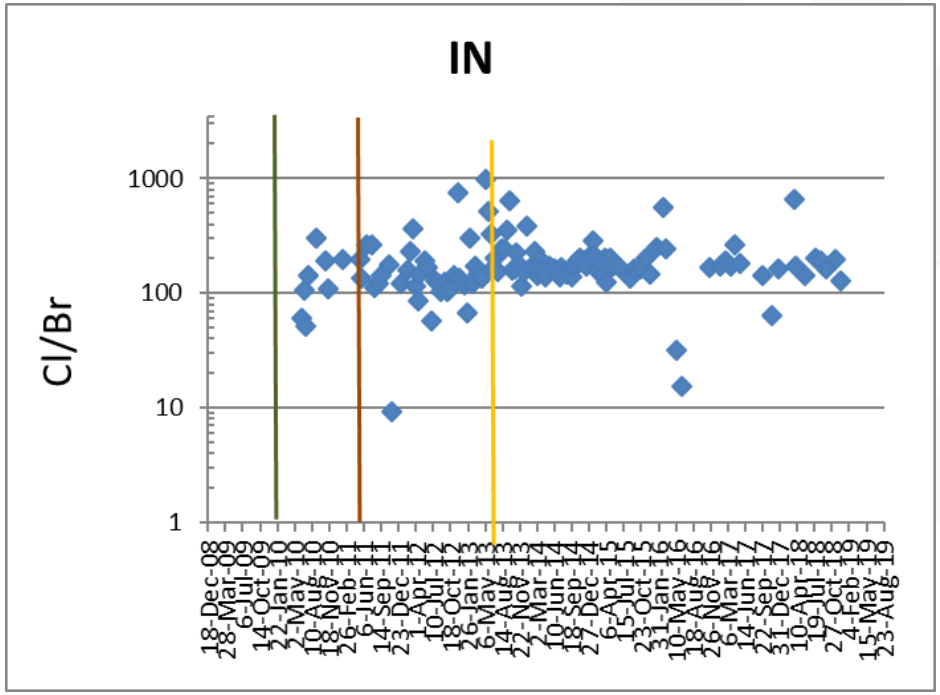
- The ratio to chloride to sulfate ions looks like a good way to distinguish water from coal mines from frac water.
- Coal mining influence increases to the left
- Frac water influence increases to the right

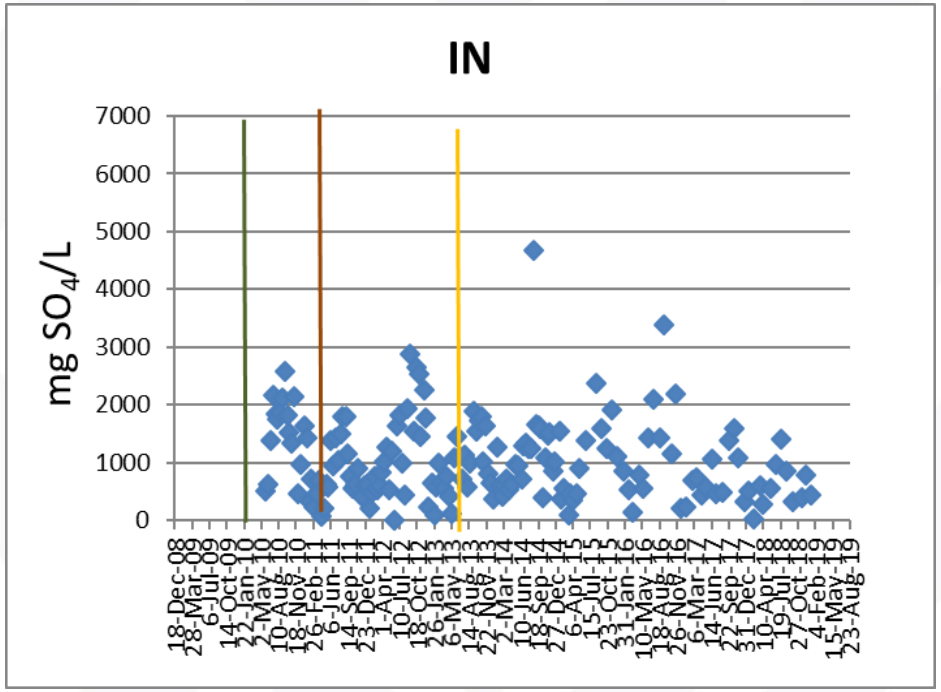


Indian Creek

Cl/Br typical of mine drainage, with a few excursions

Sulfate is controlled largely by gypsum saturation

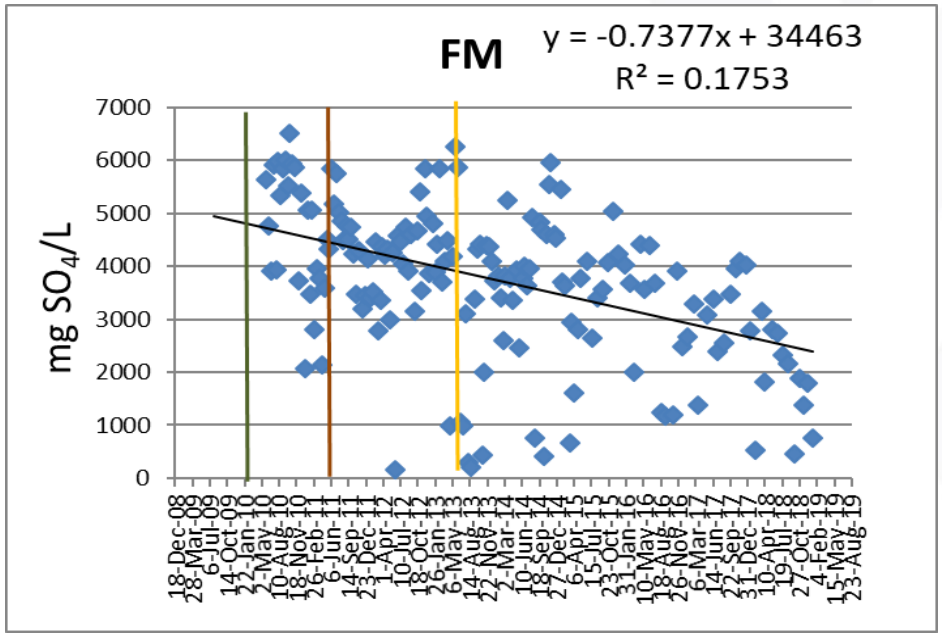




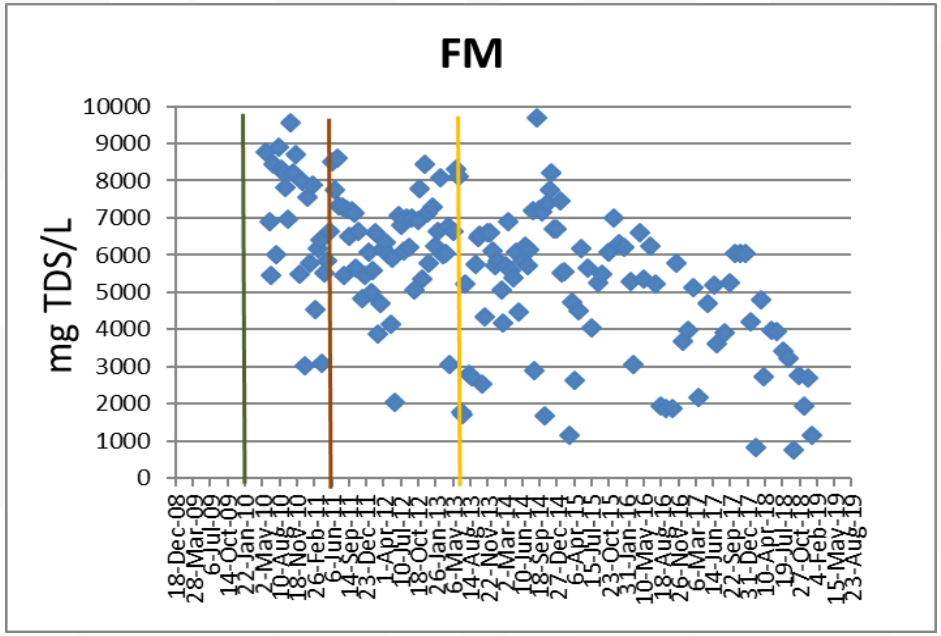
Trends at Flaggy Meadows Run 2009 to 2019

Sulfate:

moving from Na to Ca as dominant cation?



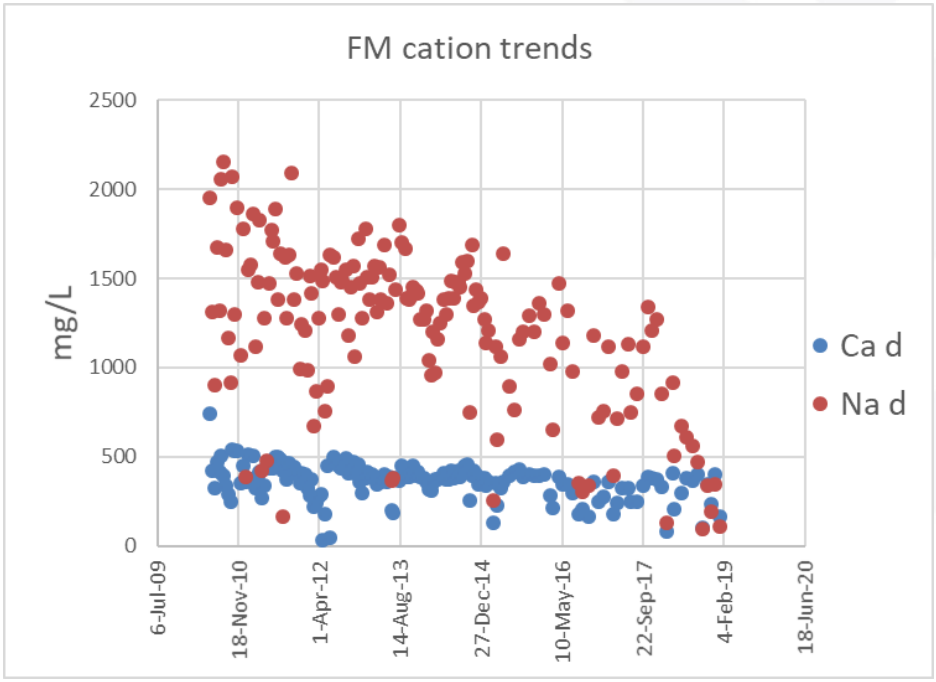
TDS



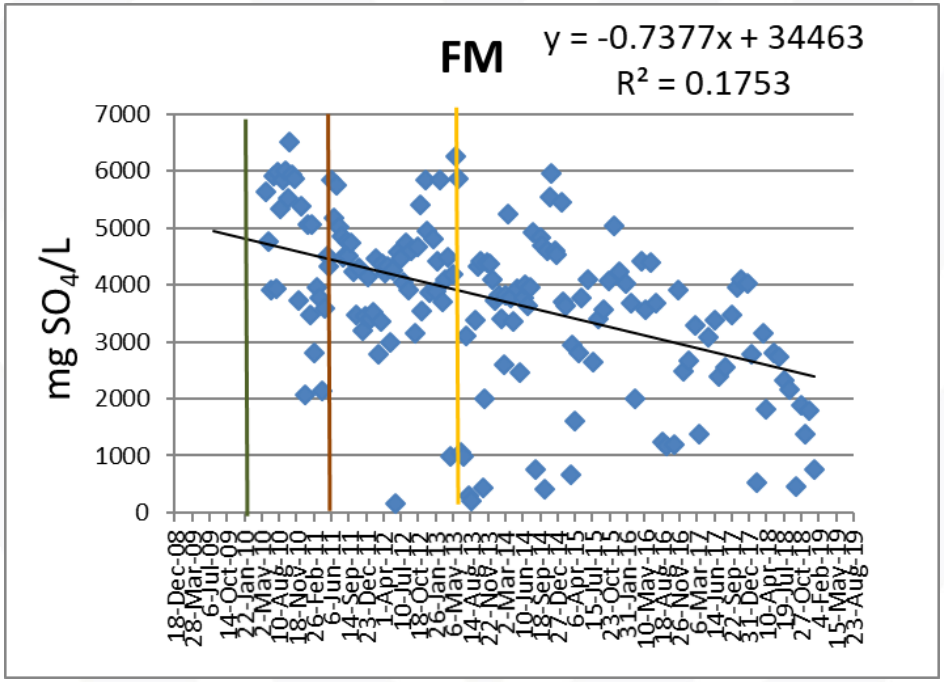
Flaggy Meadows Run trends 2010 to 2019

Declining Na, steady Ca

big change in 2017

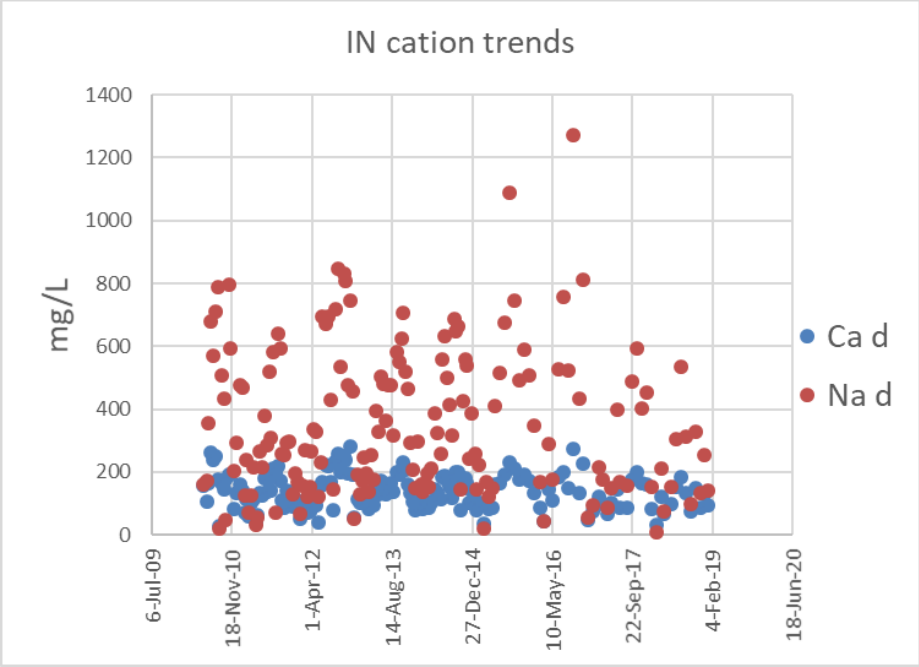


Sulfate moves toward gypsum saturation

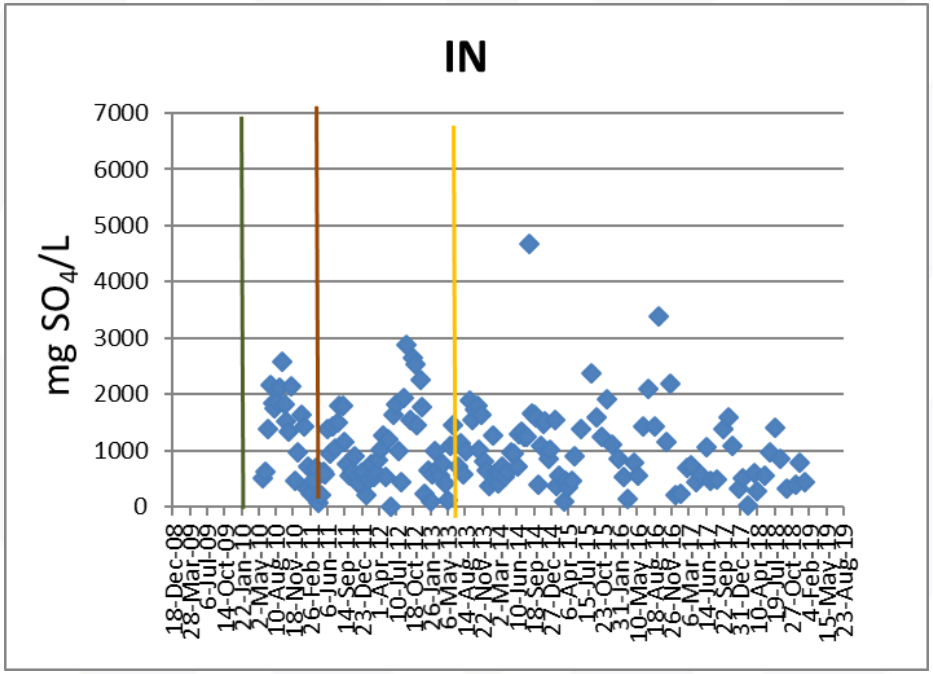


Indian Creek trends 2009 to 2019

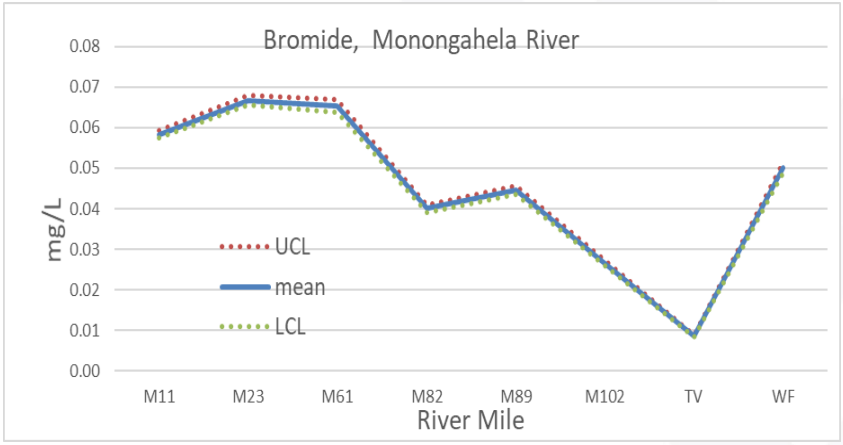
Both Na and Ca flat, much less Na than Flaggy Meadows Run

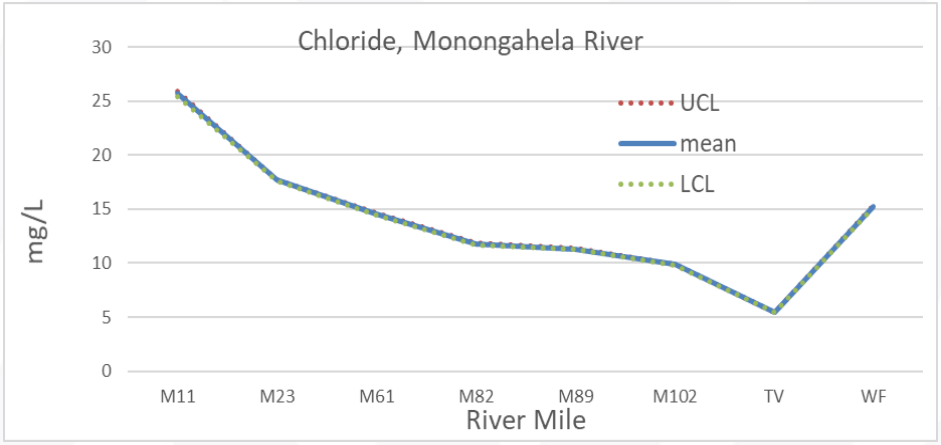


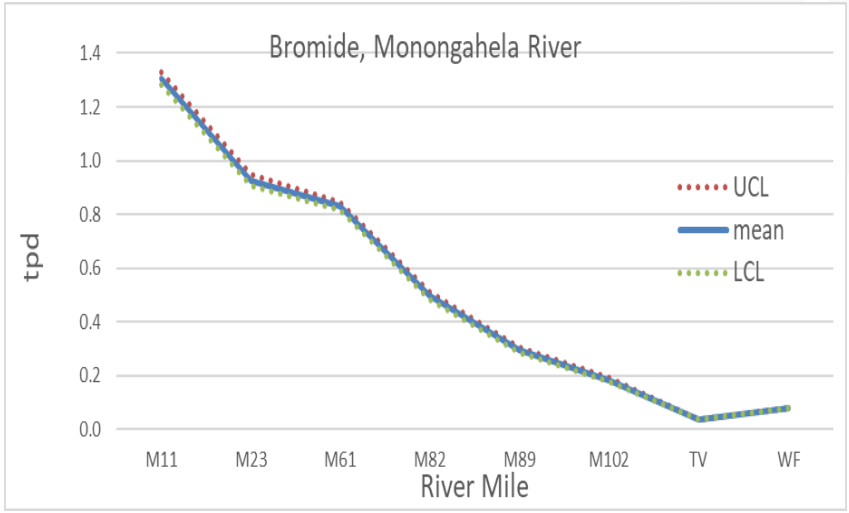
Little if any change in sulfate

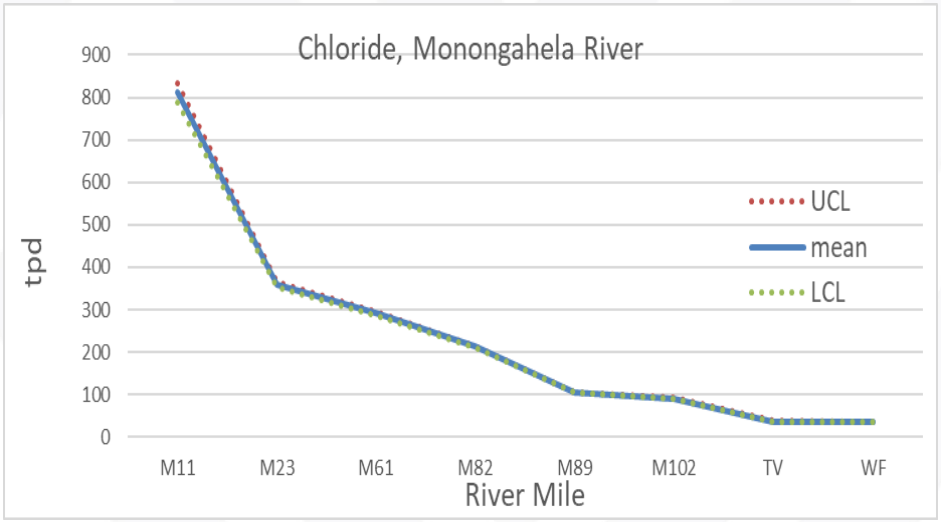


Mainstem Monongahela River Concentration vs. Load

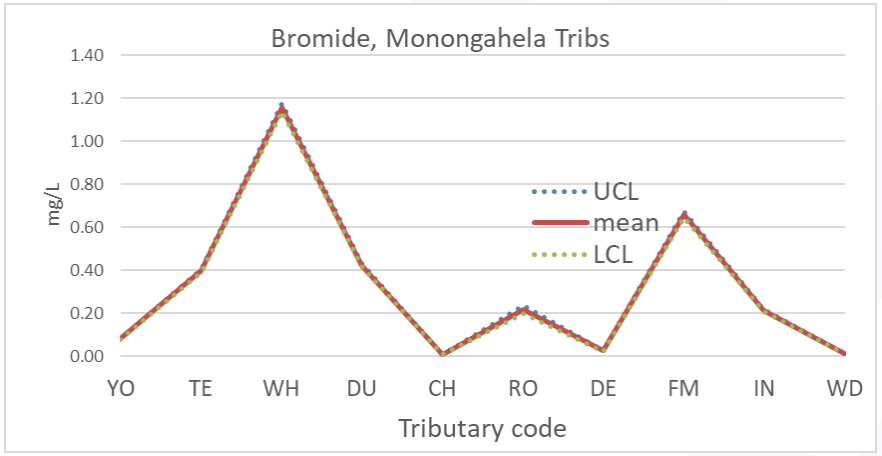


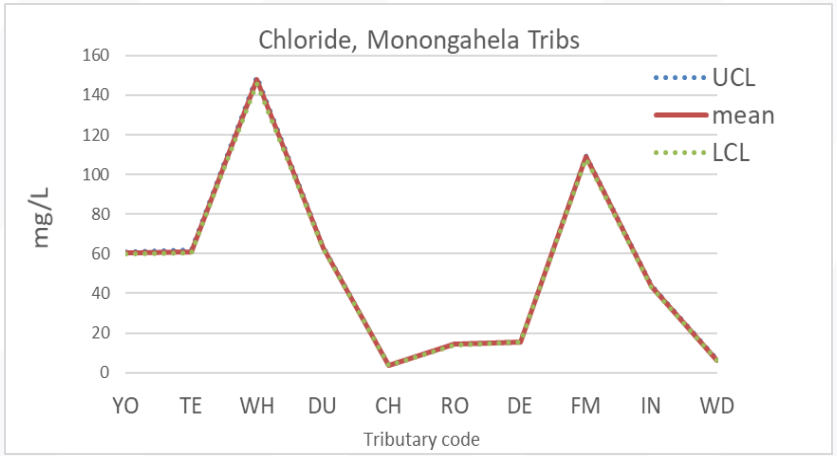


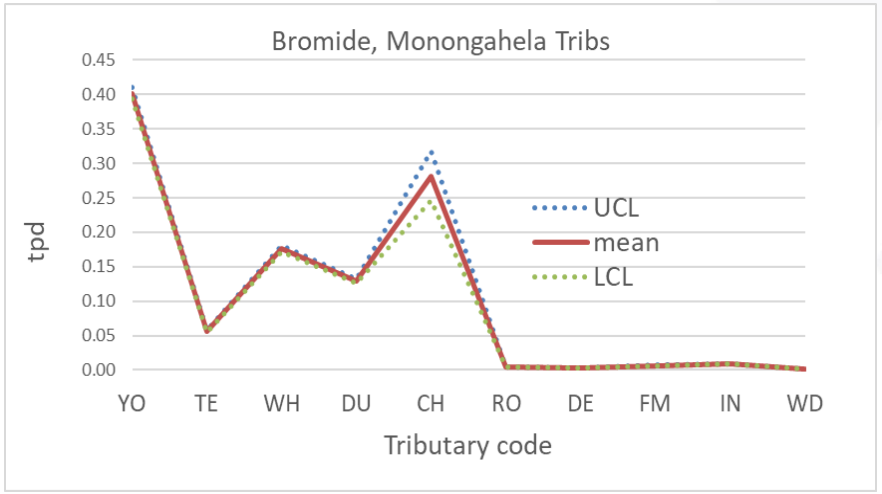


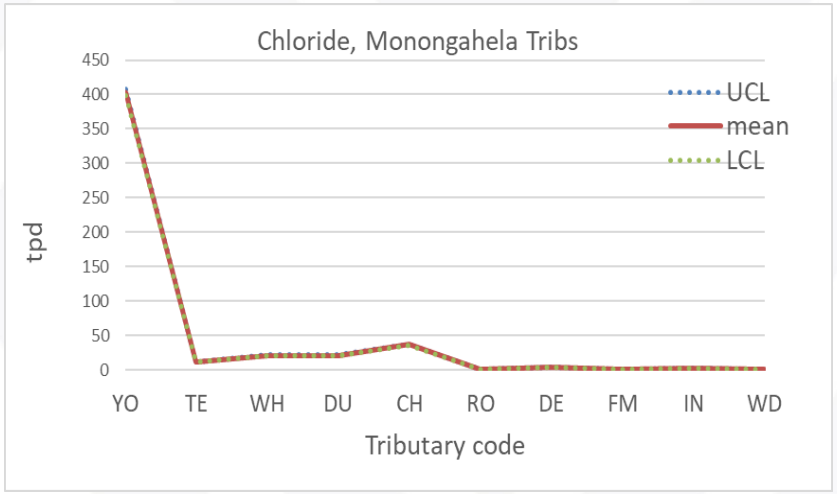


Sources


Bromide, Monongahela Tribs
mg/L
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
YO TE WH DU CH RO DE FM IN WD
Tributary code
UCL
mean
LCL


Chloride, Monongahela Tribs
mg/L
160
140
120
100
80
60
40
20
0
YO TE WH DU CH RO DE FM IN WD
Tributary code
UCL
mean
LCL


Bromide, Monongahela Tribs
tpd
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
YO TE WH DU CH RO DE FM IN WD
Tributary code
UCL
mean
LCL


Chloride, Monongahela Tribs
tpd
450
400
350
300
250
200
150
100
50
0
YO TE WH DU CH RO DE FM IN WD
Tributary code
UCL
mean
LCL

TDS management: the old school approach

- Point source pollutant control of TDS: sulfate, sodium, calcium…
- Reverse osmosis units downstream of every AMD treatment plant
  - ~$100MM capX
  - ~$2MM/year opX
- Outcomes:
  - More coal industry bankruptcies
  - Massive liability transfers to PA and WV
  - Would not address AML discharges
  - High cost/low performance

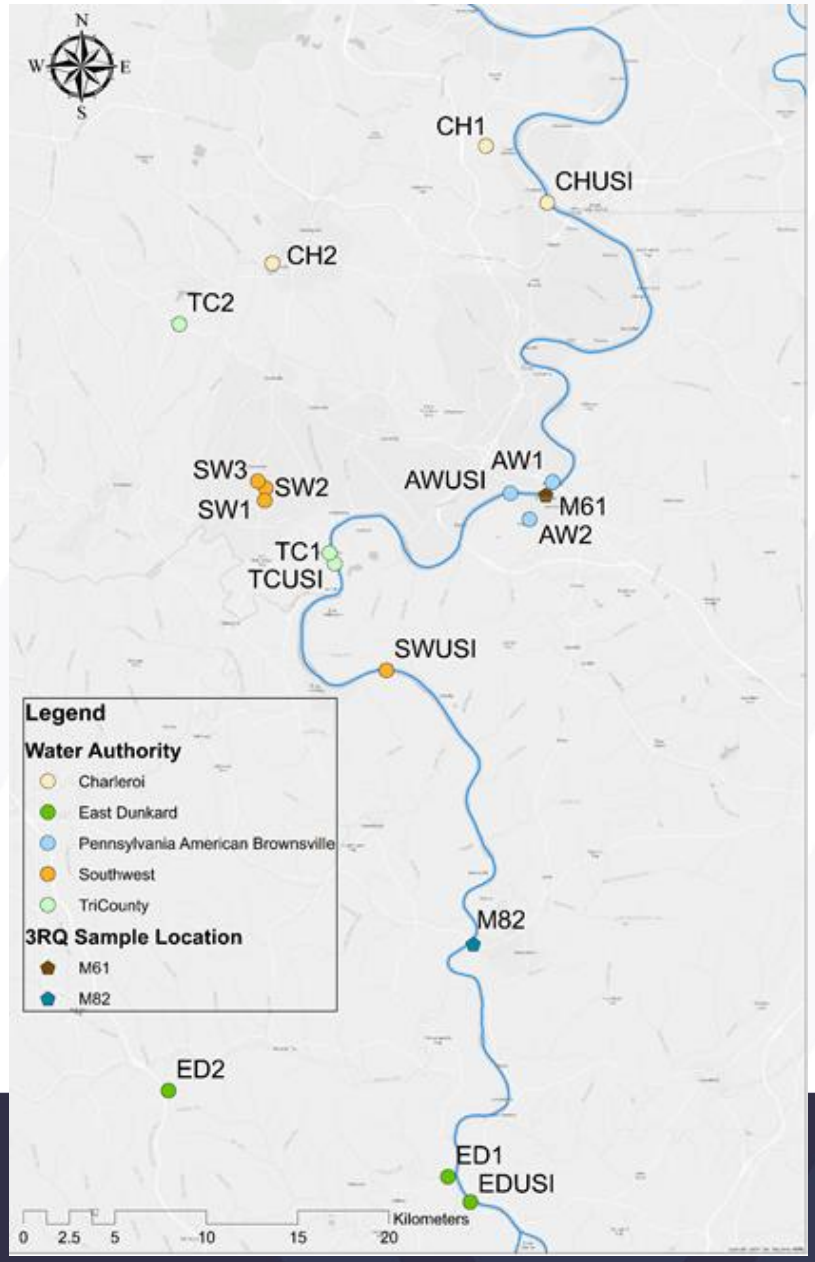
Voluntary discharge management: A better way to manage pollutants

- The TDS problem has been resolved
- Implementation was, essentially, immediate
  - January 2010
- After five years of performance monitoring, USEPA and PADEP both lifted the impaired designation for sulfate on the Monongahela River
- Removal from the CWA 303d list
  - December 2014
- Implementation was inexpensive and non-disruptive
- The treatment strategy is robust
  - Effective over wide ranges in river flow

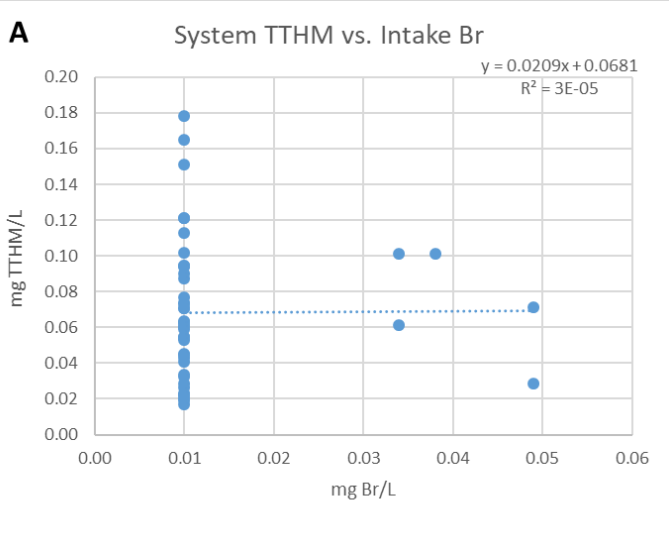
But are Bromide and Chloride present in sufficient concentrations to generate Trihalomethanes (THMs)?

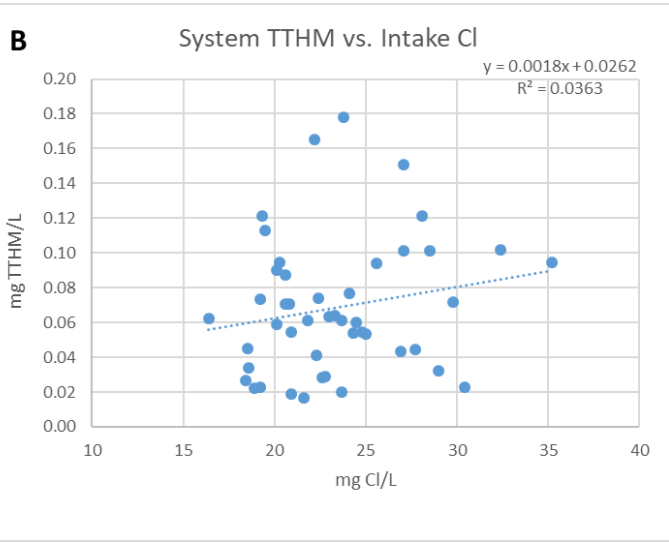
We worked with Public water suppliers
-Sampled US intakes
-Distribution network

2016 Targeted study: TTHM

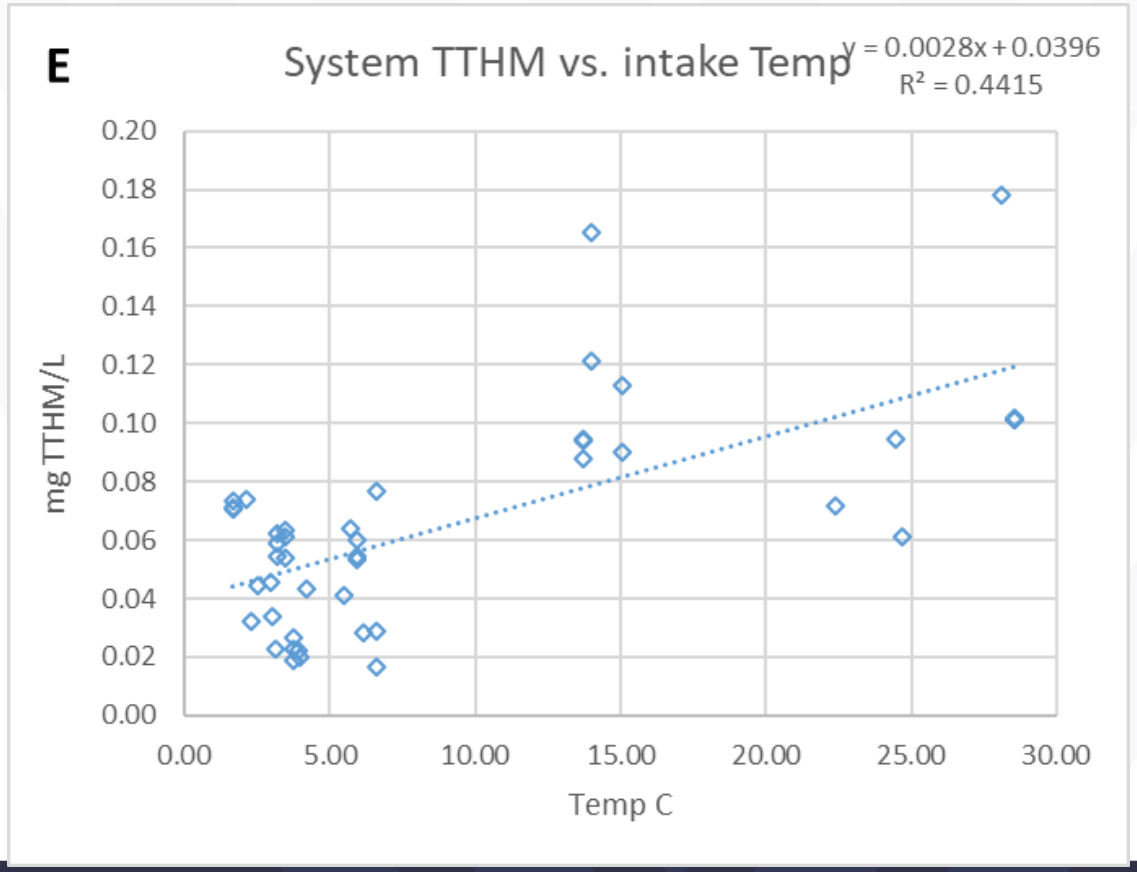


No correlation between TTHM and intake Br or Cl





The strongest correlation was with river temperature:
Treatment systems chlorinate more heavily during late summer: pathogen control



Questions?

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Additional information:

WV Water Research Institute: http://wvwri.org/
3 River QUEST: http://3riversquest.org/