

**Preliminary Results:  
Demonstration of Nonanthropogenic  
Arsenic and  
Nonanthropogenic Standard Selection  
Yellowstone River**

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# Outline

- History
- Demonstration of Nonanthropogenic (DON)
- Nonanthropogenic Standard Selection (NAS)
- Conclusions



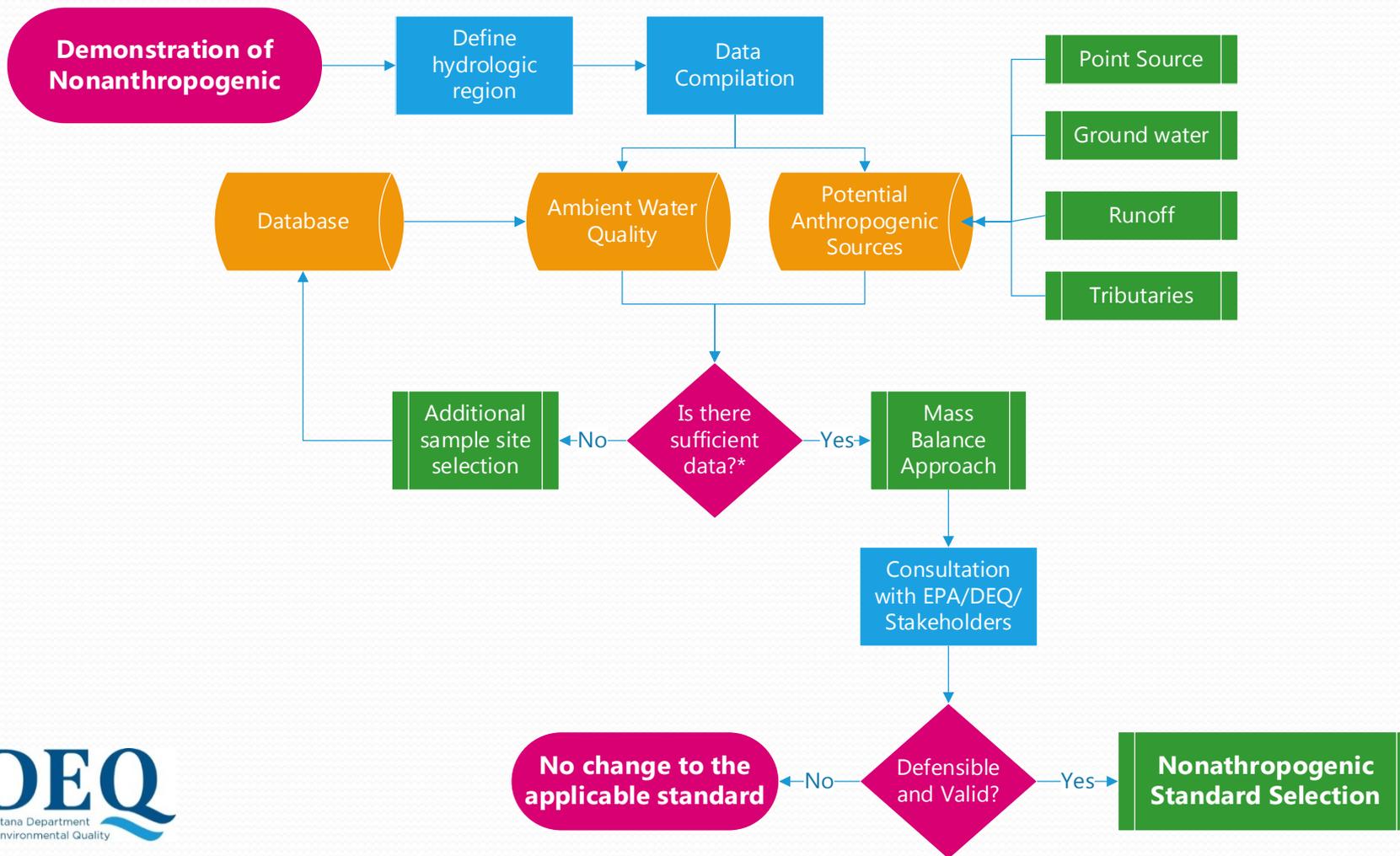
# History

- A spinoff of SB325 legislation – resulting in nonanthropogenic arsenic site specific standards
- Madison River DON/NAS Draft Documentation Complete
  - [Demonstration of Nonanthropogenic Arsenic: Madison River, Madison County, Montana](#)
  - [Nonanthropogenic Standard Selection: Madison River, Madison County, Montana](#)
- DON and NAS processes have been reviewed by the SB325 workgroup and EPA
- These same processes were used to develop the Yellowstone River Arsenic DON/NAS
- Preliminary Results for Yellowstone River Arsenic DON/NAS complete

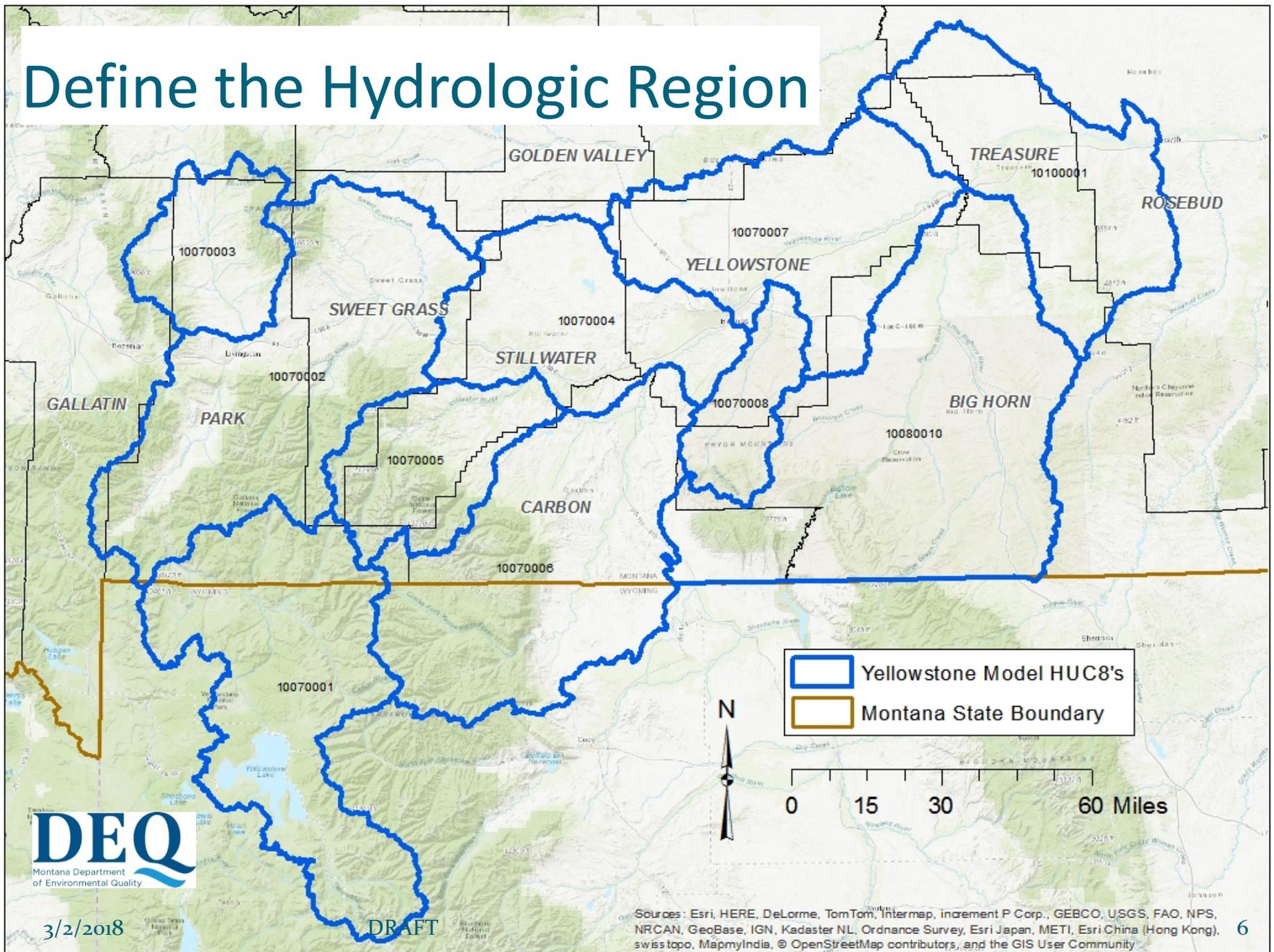
# Demonstration of Nonanthropogenic (DON)

Yellowstone River

# Demonstration of Nonanthropogenic Process



# Define the Hydrologic Region



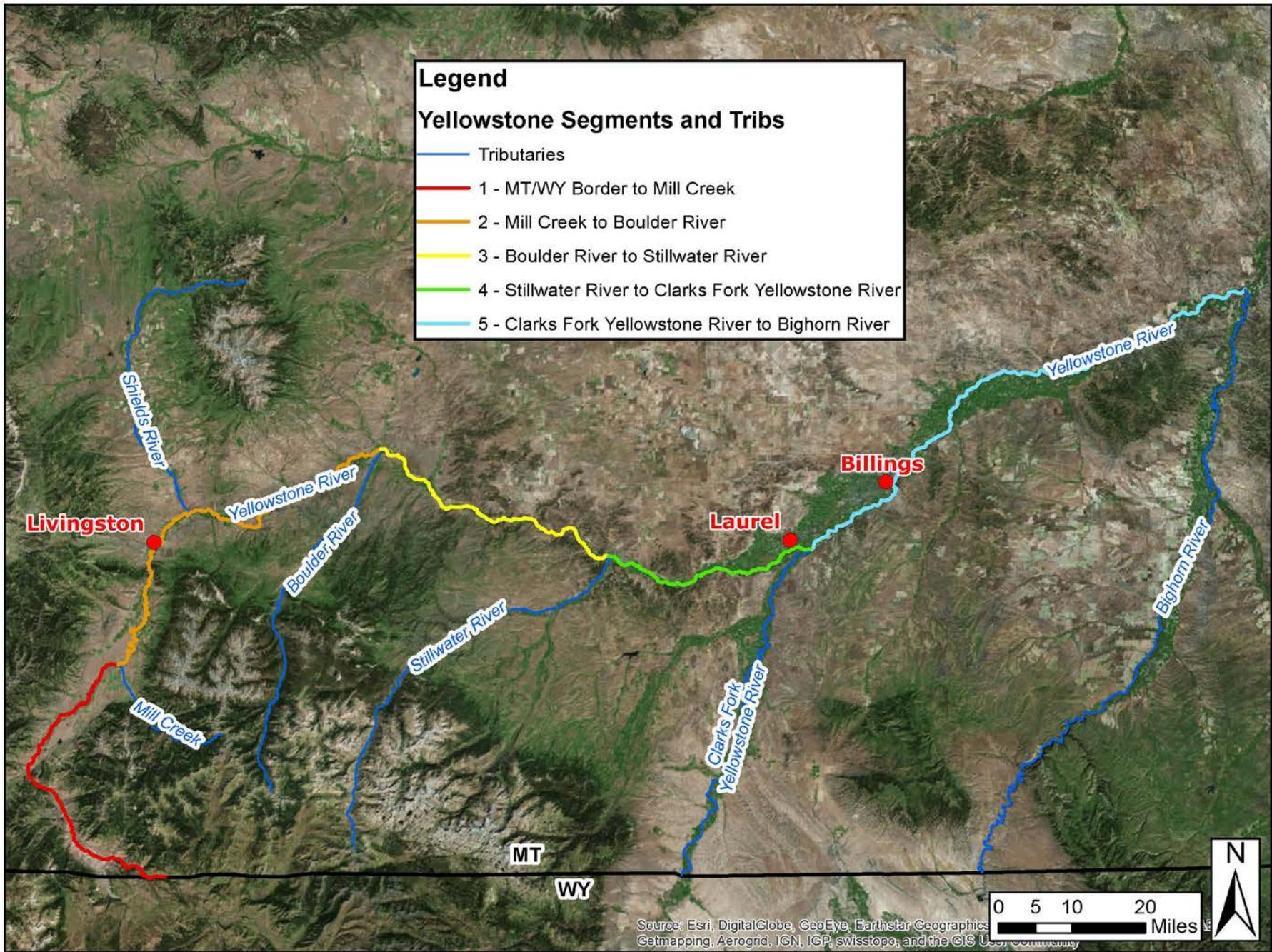
# Hydrologic Segments

Segment	Beginning	End	Length (miles)	Median Ambient Concentration ug/L
1	Montana/Wyoming Border	Mill Creek near Pray	45	23
2	Mill Creek near Pray	Boulder River at Big Timber	54	18
3	Boulder River at Big Timber	Stillwater River near Columbus	37	14
4	Stillwater River near Columbus	Clark Forks of the Yellowstone River at Laurel	27	12
5	Clarks Fork of the Yellowstone River at Laurel	Bighorn River at Bighorn	73	9.5

### Legend

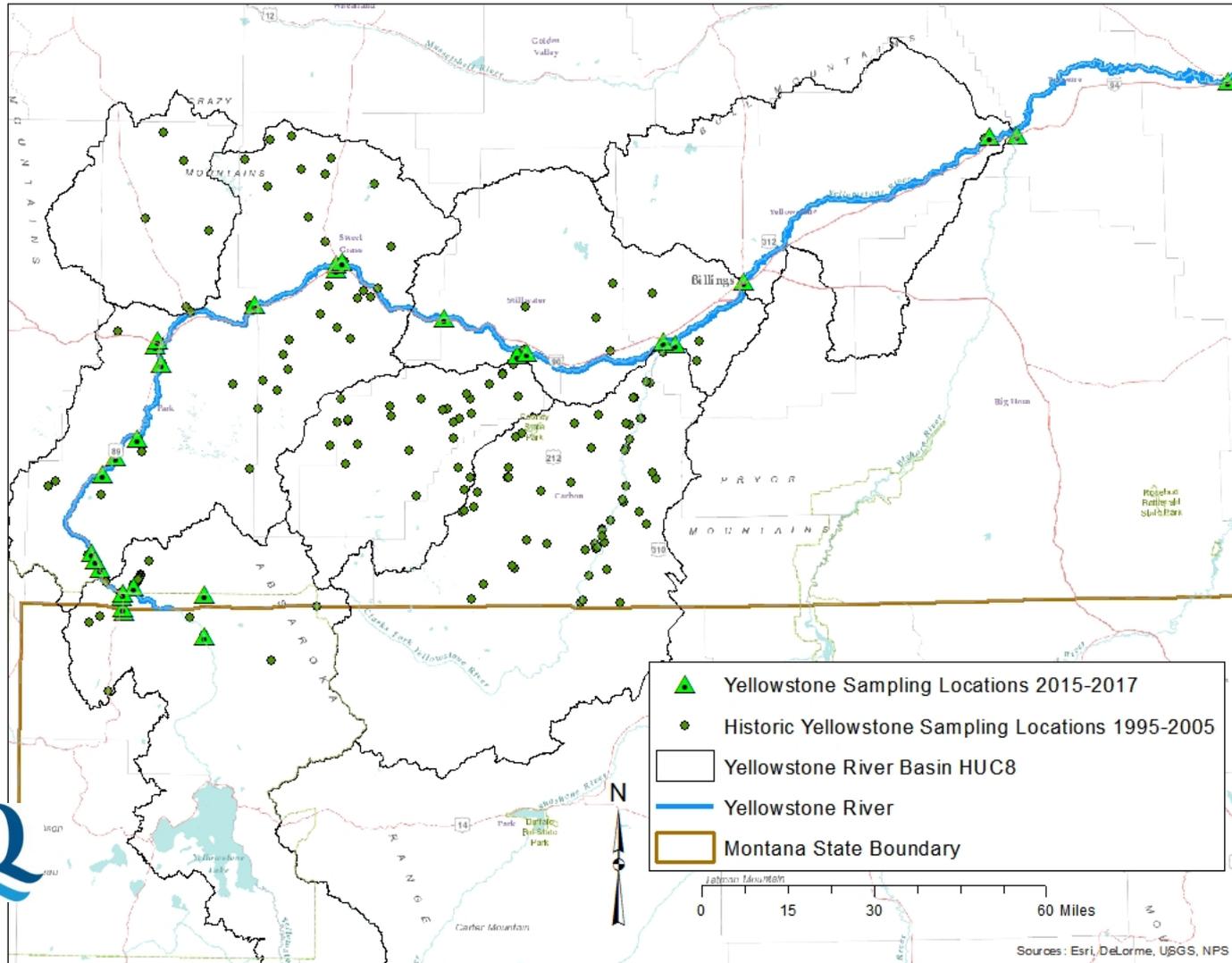
#### Yellowstone Segments and Tribs

-  Tributaries
-  1 - MT/WY Border to Mill Creek
-  2 - Mill Creek to Boulder River
-  3 - Boulder River to Stillwater River
-  4 - Stillwater River to Clarks Fork Yellowstone River
-  5 - Clarks Fork Yellowstone River to Bighorn River



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, Getmapping, Aerogrid, IGN, ICP, swisstopo, and the GIS User Community

# Data Compilation – Ambient Water Quality

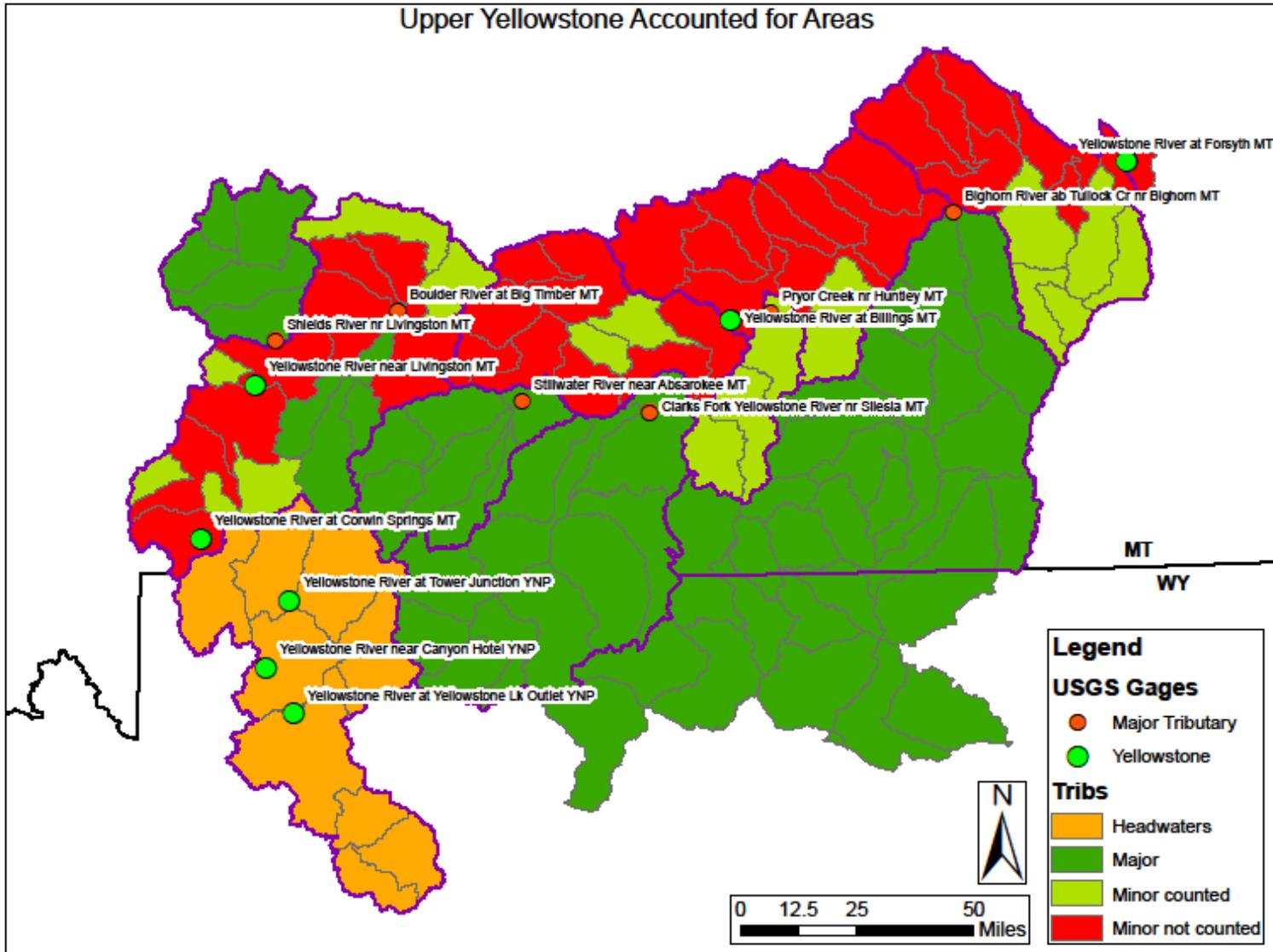




# Permitted Point Sources with Arsenic

MPDES No.	Facility	Receiving Body	Facility Load (Kg/ Month)	River Load at Facility (Kg/ Month)	% of River Load	Facility Load (Kg/month)	River Load at Facility (Kg/ Month)	% of River Load
			<i>June</i>			<i>December</i>		
MT003025 2	TVX MINERAL HILL INC -TVX MINERAL HILL MINE	BEAR CREEK	0.19	6,109	0.003%	0.39	2,417	0.016%
MT002270 5	GARDINER WWTF	YELLOWSTONE RIVER	4.44	6,109	0.073%	2.25	2,417	0.093%
MT002043 5	CITY OF LIVINGSTON WWTP	YELLOWSTONE RIVER	0.50	7,037	0.007%	0.50	2,463	0.020%
MT000026 4	CENEX HARVEST STATES COOP.	YELLOWSTONE RIVER	3.64	11,983	0.030%	5.37	2,382	0.226%
MT000028 1	WESTERN SUGAR COOPERATIVE	YEGEN DRAIN	0.95	12,943	0.007%	0.74	2,307	0.032%
MT000025 6	PHILLIPS 66 - BILLINGS REFINERY	YEGEN DRAIN	0.31	12,943	0.002%	0.45	2,307	0.019%
MT000047 7	EXXONMOBIL REFINING & SUPPLY	YELLOWSTONE RIVER	1.67	12,943	0.013%	2.54	2,307	0.110%
MT002258 6	CITY OF BILLINGS WWTP	YELLOWSTONE RIVER	6.81	12,943	0.053%	6.81	2,307	0.295%
<b>Total From All Permittees at Billings</b>			<b>18.52</b>	<b>12,943</b>	<b>0.143%</b>	<b>19.04</b>	<b>2,307</b>	<b>0.826%</b>

# Tributary Contribution



# Mass Balance Approach

- The Mass Balance Approach involves calculation of Mass Loads of Arsenic from various sources defined in the Mass Load Equation (next Slide). Mass load is defined as:

$$ML = C \times Q \times t \times cf$$

**ML** – Mass Load – pounds/day, kilograms/month

**C** – Concentration (ug/L or mg/L)

**Q** – Volume of water at a point (cubic feet per second, cfs)

**T** – A period of time (season, month, or year)

**cf** – conversion factor for mass load calculation

# Mass Load Equation – The total of Arsenic Mass Loads

$$\Sigma \text{TAL} = \text{YNP} + \text{PSL} + \text{GW} + \text{Trib} + \text{RO}$$

$\Sigma \text{TAL}$  - Total Arsenic Load of a sampling location, based on flow rate and concentration at a specific time

**YNP** - Geothermal arsenic load from the Yellowstone Caldera, @ the park boundary,  $\Sigma \text{TAL} = \text{YNP}$

**PSL** – Point source arsenic load, permitted discharge operations

**GW** – Groundwater arsenic load contribution

**Trib** – Surface water discharge into the main stems from the major tributaries

**RO** – Surface water runoff

# Yearly Mass Balance

Station	Median Total Arsenic Load (TAL)	Source Loads (PSL + GWA)	Anthropogenic Runoff Load (ROA)	Running Total Anthropogenic Loads (PSL + ROA + GWA)	Median Non-Anthropogenic Loads (NAL)
<b>kg/year</b>					
MT/WY Border to Mill Creek	41587.0	41.4	25.3	357.6	41229.5
Mill Creek to Boulder River	44664.2	6.0	133.7	497.3	44167.0
Boulder River to Stillwater River	44364.3	0.0	24.8	522.1	43842.2
Stillwater River to Clarks Fork Yellowstone River	50763.8	62.1	117.9	702.1	50061.7
Clarks Fork Yellowstone River to Bighorn River	51551.9	225.0	364.5	1291.6	50260.4

# Mass Load Summary

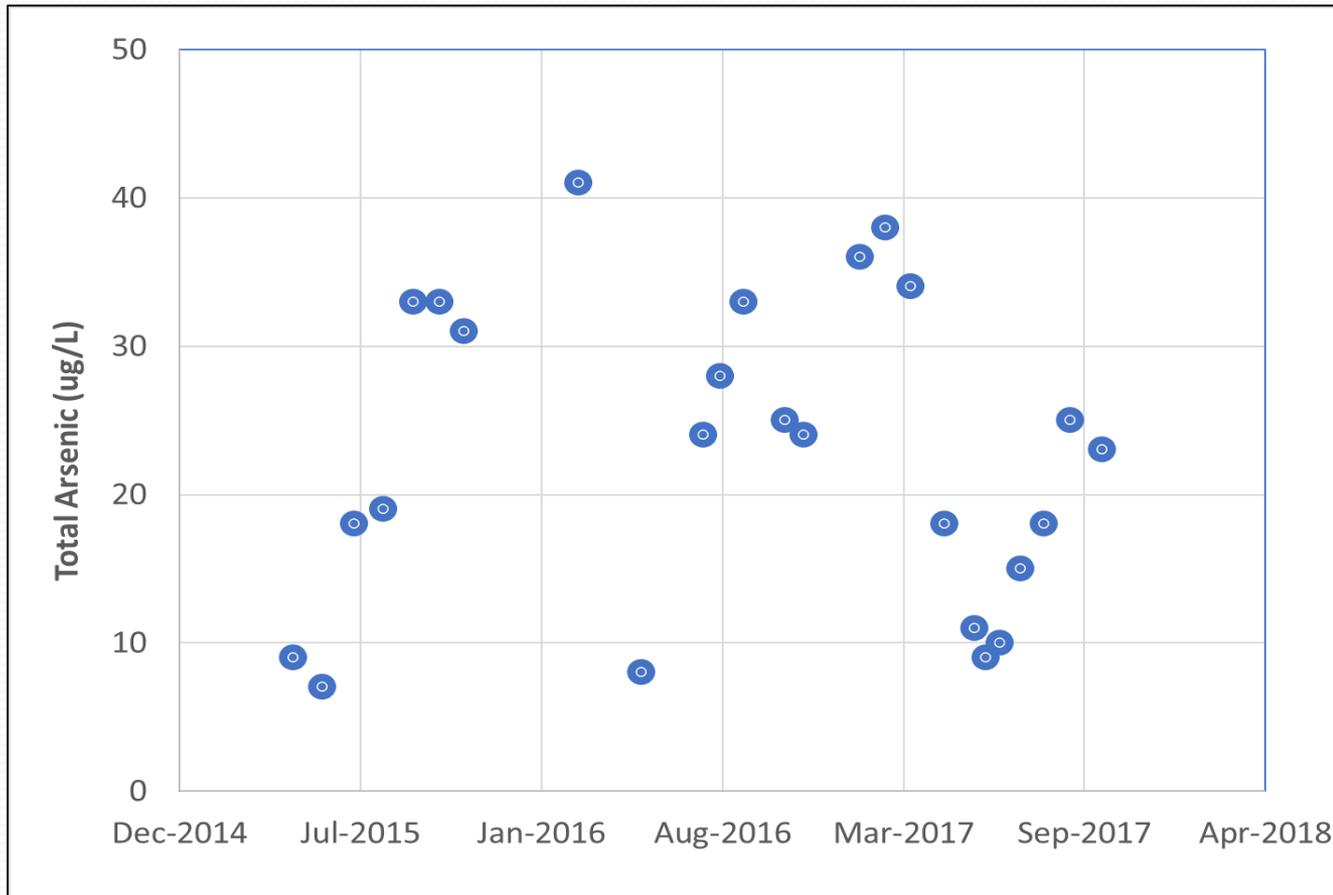
<b>Mass Balance</b>	<b>Load at Bighorn (kg/year)</b>	<b>% of TAL at Bighorn</b>
Start: MT/WY Border	41,229	80%
Anthropogenic Arsenic Load	1292	2.5%
Non-Anthropogenic Tributary Load	7,908	15.3%
Unaccounted for Mass Load/Error	1,123	2.2%
End: Mouth of the Big Horn River (kg/year)	51,552	100.0%
Total Nonanthropogenic Arsenic from MT/WY Border to the Confluence of the Bighorn River	49,137	95.3%



# Nonanthropogenic Standard Selection (NAS)

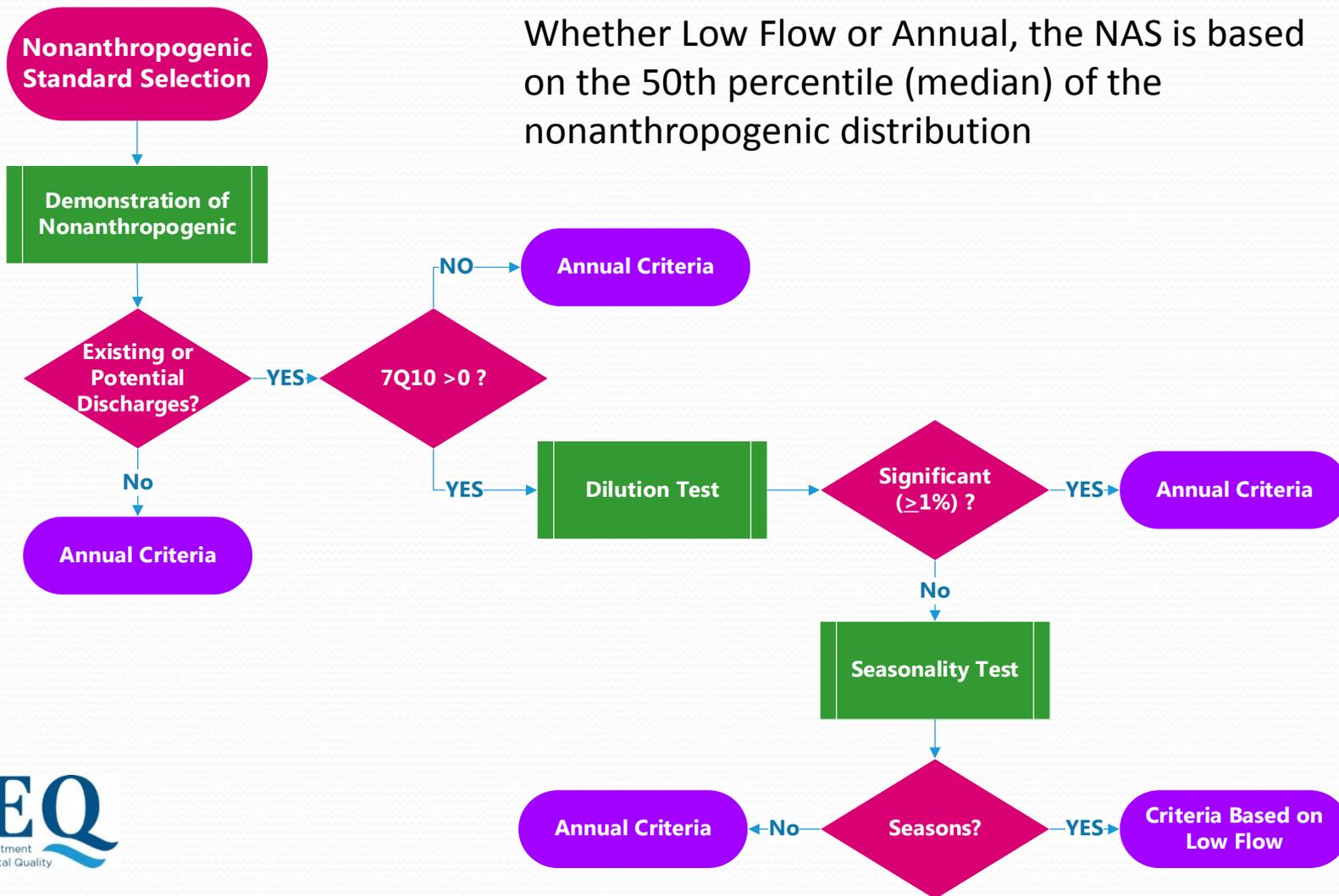
Yellowstone River

# Picking a NAS Is Not Simple – Example: Concentration Patterns at Corwin Springs



# Nonanthropogenic Standard (NAS) Selection Process

Whether Low Flow or Annual, the NAS is based on the 50th percentile (median) of the nonanthropogenic distribution



# Dilution Test – Permitted Discharges

MPDES No.	Facility	Hydrologic Segment Discharge	Maximum Flow (cfs)	Max Conc.(ug/L)
MT0030252	TVX MINERAL HILL INC -TVX MINERAL HILL MINE	1	0.42	14
MT0022705	GARDINER WWTF	1	0.65	10
MT0020435	CITY OF LIVINGSTON WWTP	2	1.7	4
MT0000264	CENEX HARVEST STATES COOP.	4	2.2	8
MT0000281	WESTERN SUGAR COOPERATIVE	5	3.2	4
MT0000256	PHILLIPS 66 - BILLINGS REFINERY	5	1	6
MT0000477	EXXONMOBIL REFINING & SUPPLY	5	3.9	12
MT0022586	CITY OF BILLINGS WWTP	5	23	4

# Dilution Test - Results

Station	USGS Station Number	7Q10 (cfs)	Discharger Max Flow (cfs)	Dilution Test (MAX/7Q10)	Conclusions
MT/WY Border to Mill Creek	6191500	504	1.07	0.2%	Use Seasonal Determination
Mill Creek to Boulder River	6192500	766	1.7	0.2%	Use Seasonal Determination
Boulder River to Stillwater River	N/A	907	0	0	Annual Criteria
Stillwater River to Clarks Fork Yellowstone	N/A	1047	2.2	0.2%	Use Seasonal Determination
Clarks Fork of the Yellowstone River to Bighorn River	6214500	1197	31.1	2.6%	Annual Criteria



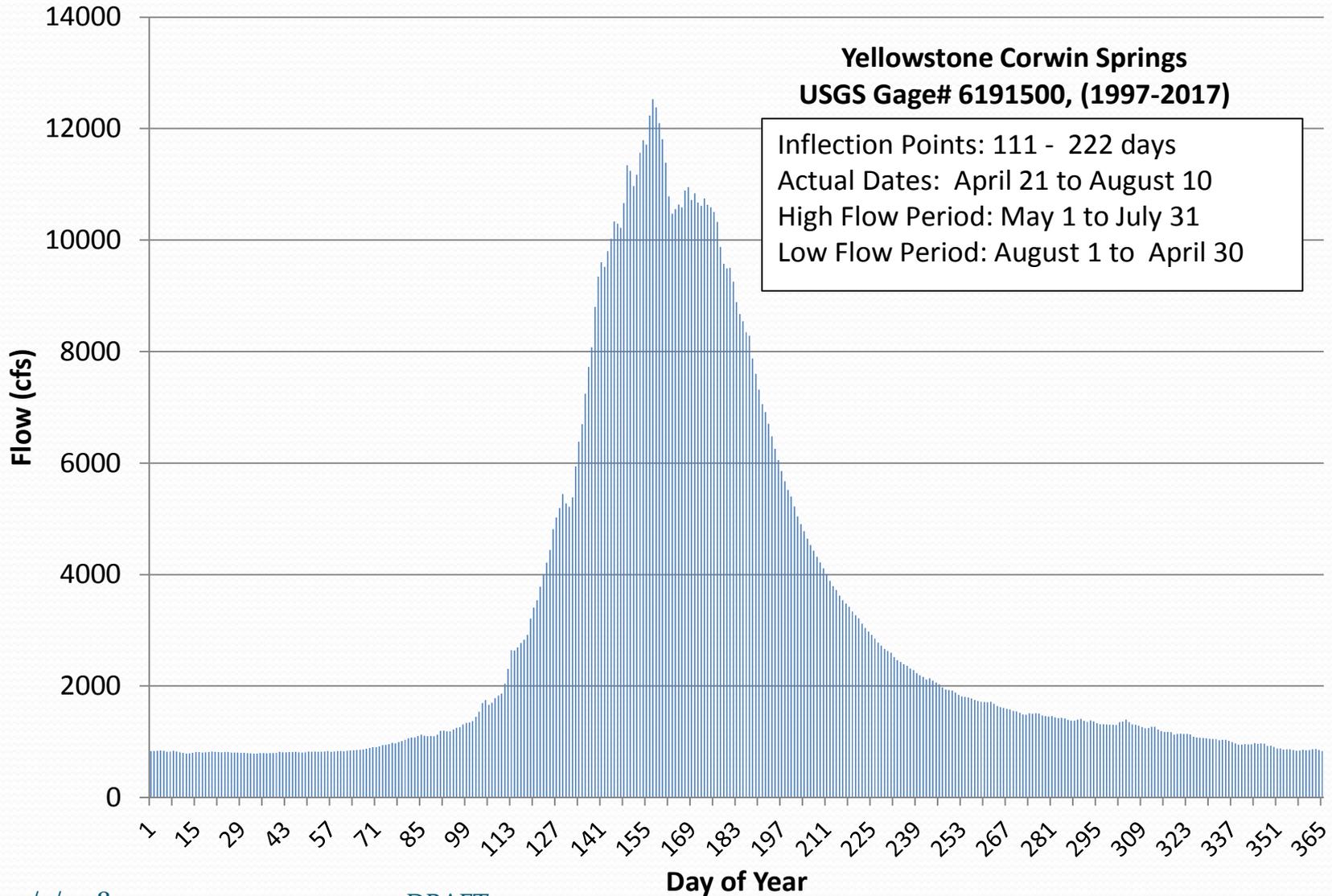
# Seasonal Determination

- Flow Duration Hydrograph
  - Minimum of 5 years of daily flow data
  - Recorded flows for each day of year for period of record averaged and plotted
  - Points of Greatest Inflection – High and Low flow periods
- Mann Whitney Test

Test arsenic concentrations from high and low flow periods for significant differences

  - Significant – one annual standard from low flow months
  - Not Significant - one annual standard from all months

# Seasonal Determination-Hydrograph



# Seasonal Determination Results

## Results for: Worksheet 2

### Mann-Whitney Test and CI: C1, C2

	N	Median
C1	9	10.000
C2	16	29.500

Point estimate for  $\eta_1 - \eta_2$  is -16.000  
95.6 Percent CI for  $\eta_1 - \eta_2$  is (-24.003,-10.003)  
W = 50.5  
Test of  $\eta_1 = \eta_2$  vs  $\eta_1 \neq \eta_2$  is significant at 0.0002  
The test is significant at 0.0002 (adjusted for ties)

alpha = .05

p-value = .0002  
p < alpha; therefore, the data does support the hypothesis that there is a difference between the population medians.  
Significant  
Seasonality

- Mann-Whitney Test using Minitab
- Concentrations determined significantly different between high and low flow periods
- Seasonality
- NAS selected is an annual standard based on low flow months

## Seasonality – YES

### 1. MT/WY Border to Mill Creek: Model Derived Median Monthly Nonanthropogenic Arsenic Loads, Flow Rates, and Concentrations

Month	Median Nonanthropogenic Arsenic Load (kg/month)	Median Flow Rate (cfs)	Median Nonanthropogenic Concentration (ug/L)
October	3111	1360	31
November	2259	1460	21
December	2414	903	36
January	2190	878	34
February	2196	903	33
March	2595	1070	33
April	3486	2535	18
May	5694	7340	10
June	6105	9120	9
July	4692	3860	16
August	3708	2060	24
September	3090	1305	32
<b>Annual Standard Based on Low Flow Months</b>			<b>32</b>

*\*High Flow Period in Blue and the Low Flow Period in Red, derived from Histogram*

# Summary: NAS Yellowstone River

Segment	Seasonality Results	Type of Standard Selected	Numeric Criteria	Frequency and Duration
1. MT/WY Border to Mill Creek	Seasonality	Annual Based on Low Flow Months	32	Average Annual Concentration Not to Exceed Criteria
2. Mill Creek to Boulder River	Seasonality	Annual Based on Low Flow Months	24	Average Annual Concentration Not to Exceed Criteria
3. Boulder River to Stillwater River	N/A	Annual Based on All Months	16	Average Annual Concentration Not to Exceed Criteria
4. Stillwater River to Clarks Fork of the Yellowstone River	Seasonality	Annual Based on Low Flow Months	14	Average Annual Concentration Not to Exceed Criteria
5. Clarks Fork of the Yellowstone River to Bighorn River	N/A	Annual Based on All Months	10	Average Annual Concentration Not to Exceed Criteria



# Frequency and Duration of Arsenic

- Current DEQ 7 (2010)
  - (16) Surface or groundwater **concentrations** may not exceed these values*
- Reasoning for change
  - Arsenic is a carcinogenic MCL-based criterion that factors cost and technology into the recommendation - less stringent than a health-based recommendation
  - Since the MCL is not derived directly from toxicity, a “may not” exceed is not necessary.
- Proposed Frequency and Duration for Arsenic
  - Average annual concentrations may not exceed the standard*

# Conclusions

- 95% of the Arsenic in the Yellowstone River at the confluence of the Bighorn River is Nonanthropogenic
- Preliminary DON and NAS complete for Yellowstone River – MT/WY Border to confluence of Bighorn River
- Results subject to change - still undergoing internal review and finalization
- Frequency and duration for arsenic will be changed for all of Montana
- DON and NAS documentation will be completed and released for external review by June 2018



# Questions?

Water Quality Standards

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# Timeline for Rulemaking

## Tasks

- Draft DON and NAS for External Review
- Draft Arsenic Rule Language
- Briefing to BER
- Present to WPCAC
- Request from BER adoption of proposed rule
- BER adoption of proposed rule

## Target Dates

June 2018

June 2018

June 8, 2018

July 13, 2018

August 10, 2018

December 7, 2018