OTTER CREEK WATERSHED TMDL PROJECT

Stakeholder Meeting

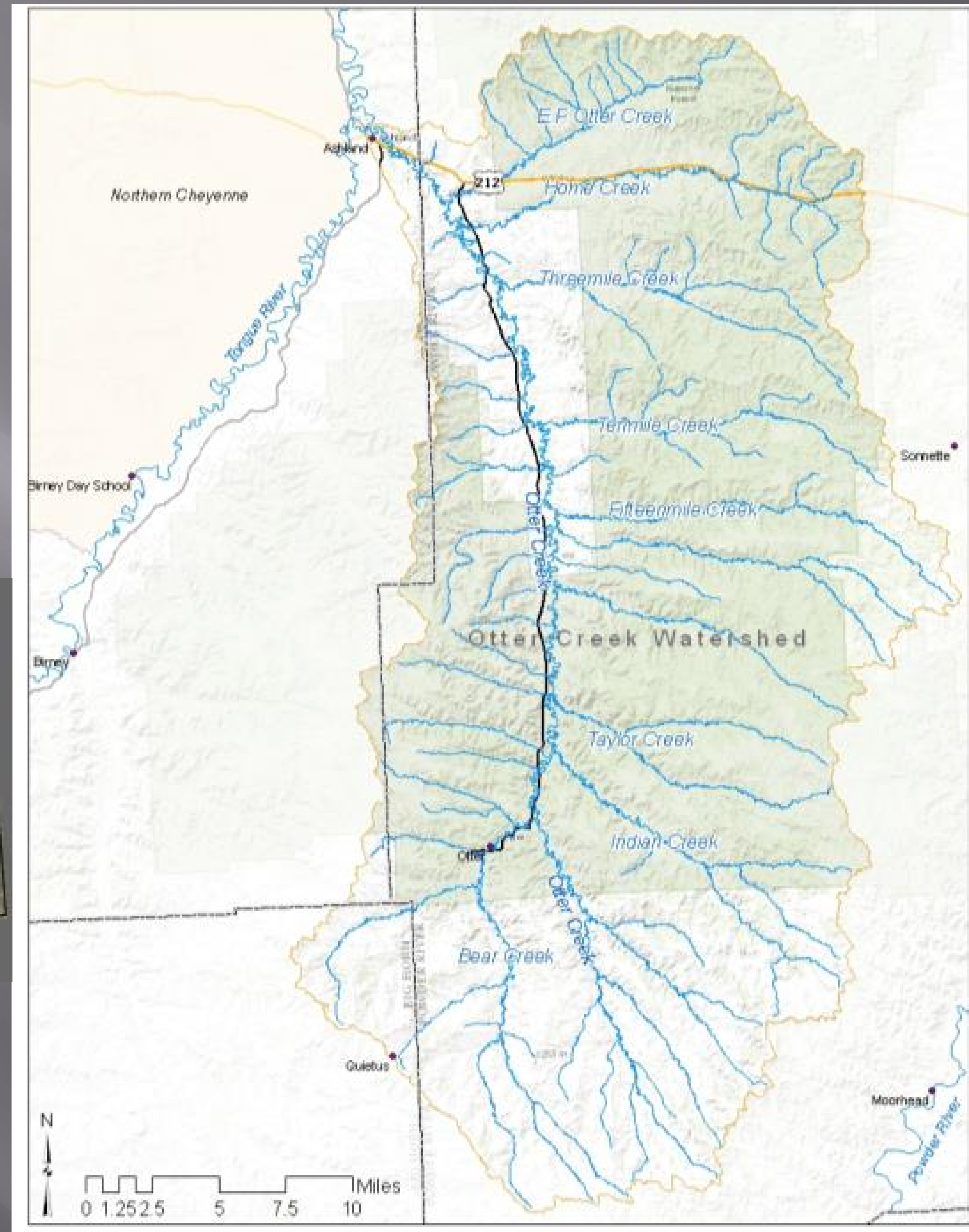
May 5, 2015

DEQ Montana Department of Environmental Quality

Presentation Outline

- Project Area & Water Quality Impairments (Christina Staten)
- Salinity Model Results (Erik Makus)
- Salinity TMDL (Amy Steinmetz)
- Iron TMDL Development (Dean Yashan)
- Tongue River Project Planning (Dean Yashan)

Project Location: Otter Creek Watershed



Water Quality Impairment Causes

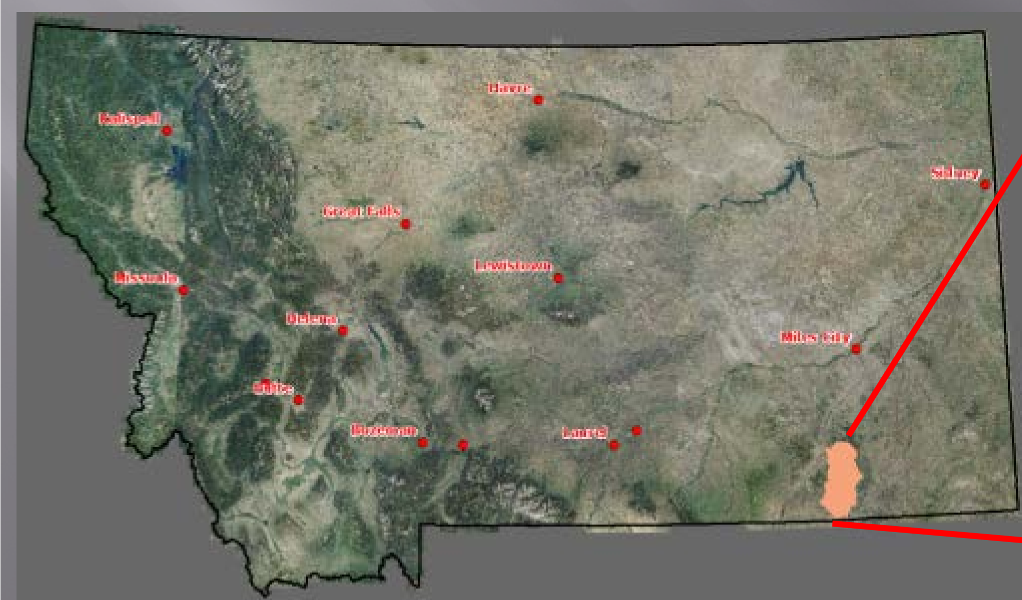
- Impairment Causes Requiring a TMDL (Pollutants)
  - Iron
  - Salinity
- Non-Pollutant Impairment Causes
  - Alteration of Streamside Vegetation
- Previous Impairment Causes
  - Sediment (Removed as a cause of impairment in 2014)

OTTER CREEK WATERSHED SALINITY MODEL

Erik Makus, P.H.
Hydrologist
May 5th, 2015

Presentation Overview

- Why are EC and SAR important?
- Summary of existing data
- Summary of modeling results
- Modeling Conclusions



Electrical Conductivity

- Electrical conductivity (EC) is a measure of the ability of water to conduct electricity.
  - The more cations (Na, Ca, Mg, etc.) and anions (HCO_3, SO_4, NO_3) that are in the water, the higher the EC.
  - Therefore, EC is a relative measure of salinity.
  - EC is temperature dependent
- Specific conductivity (SC) is EC corrected to 25^oC (77^oF).
- EC definition in MT rule matches SC so…

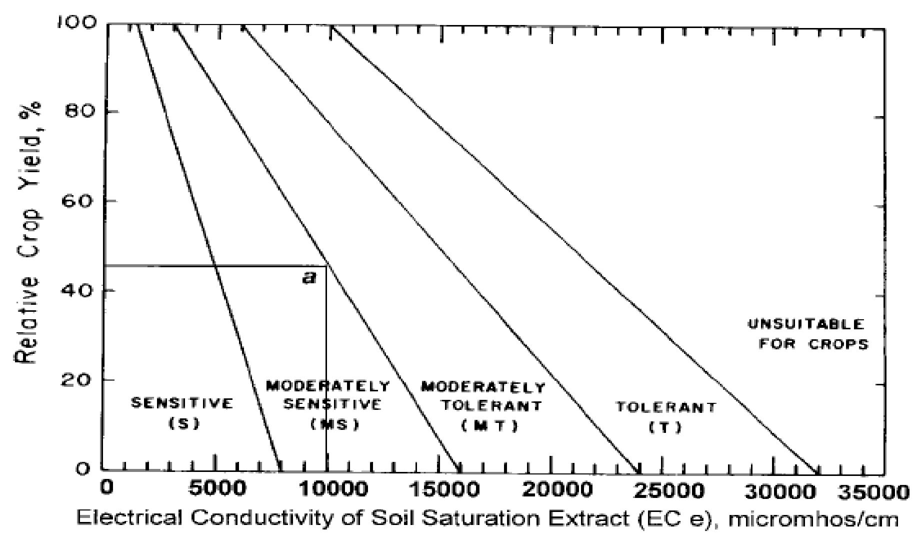
Electrical Conductivity

Conductivity = EC = SC = Salinity

Salinity and Agriculture

- Over time, high EC irrigation water equates to high EC (high salinity) in soils.
- High salinity soils make it harder for plants to absorb water and nutrients.
- When EC rises above a species-specific threshold, crop yields decrease.

Figure 1. Relative crop yield compared to the salinity of the soil solution.



Source: South Dakota Extension Office Fact Sheet 903

Sodium Adsorption Ratio

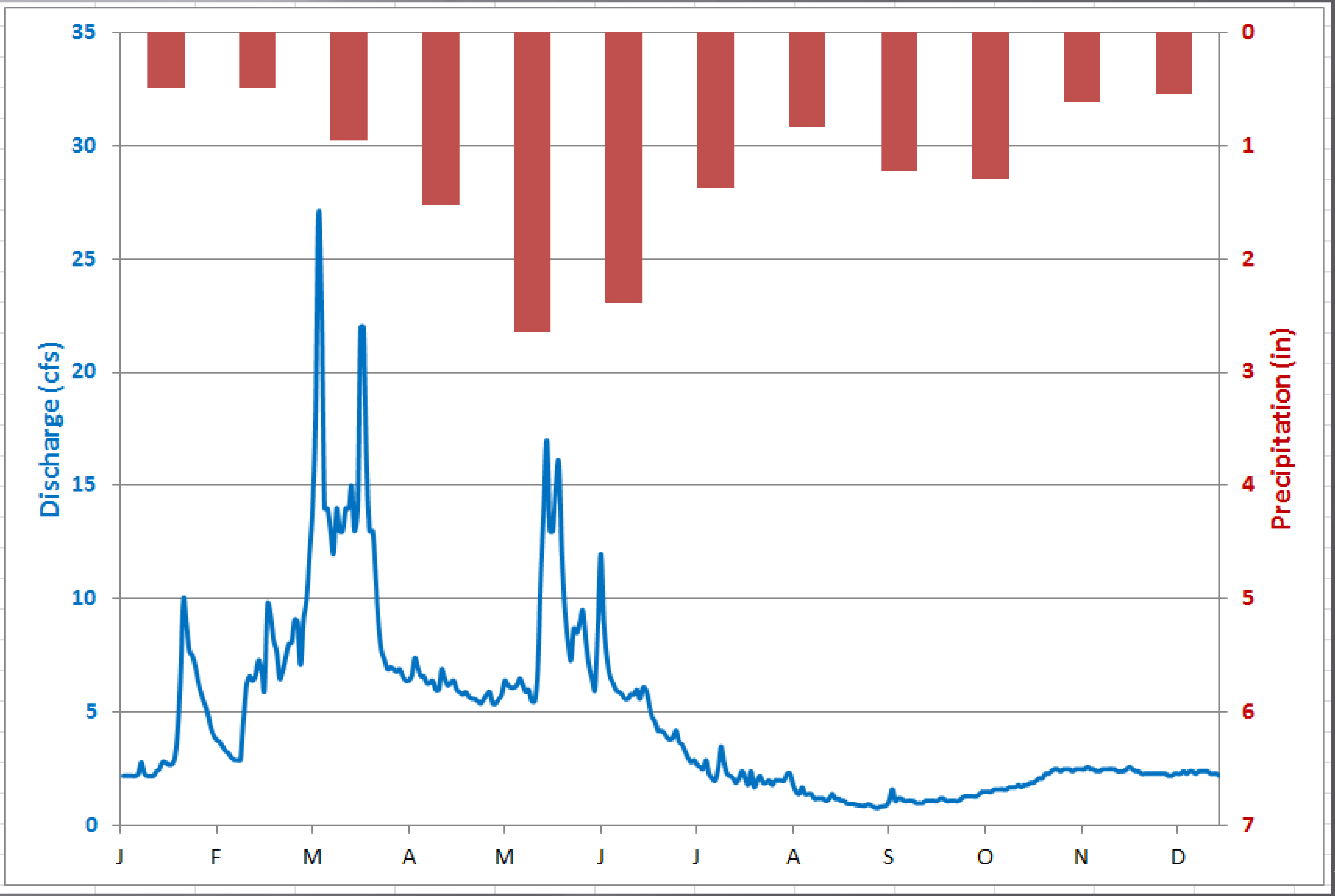
- Sodium adsorption ratio (SAR) is the ratio of sodium to calcium and magnesium.
- High SAR means high sodium compared to Ca and Mg, and vice versa.
- Unitless
- Concentrations used in calculation are in milliequivalents per liter (meq/L)

$$SAR = \frac{[Na]}{\sqrt{([Ca] + [Mg])/2}}$$

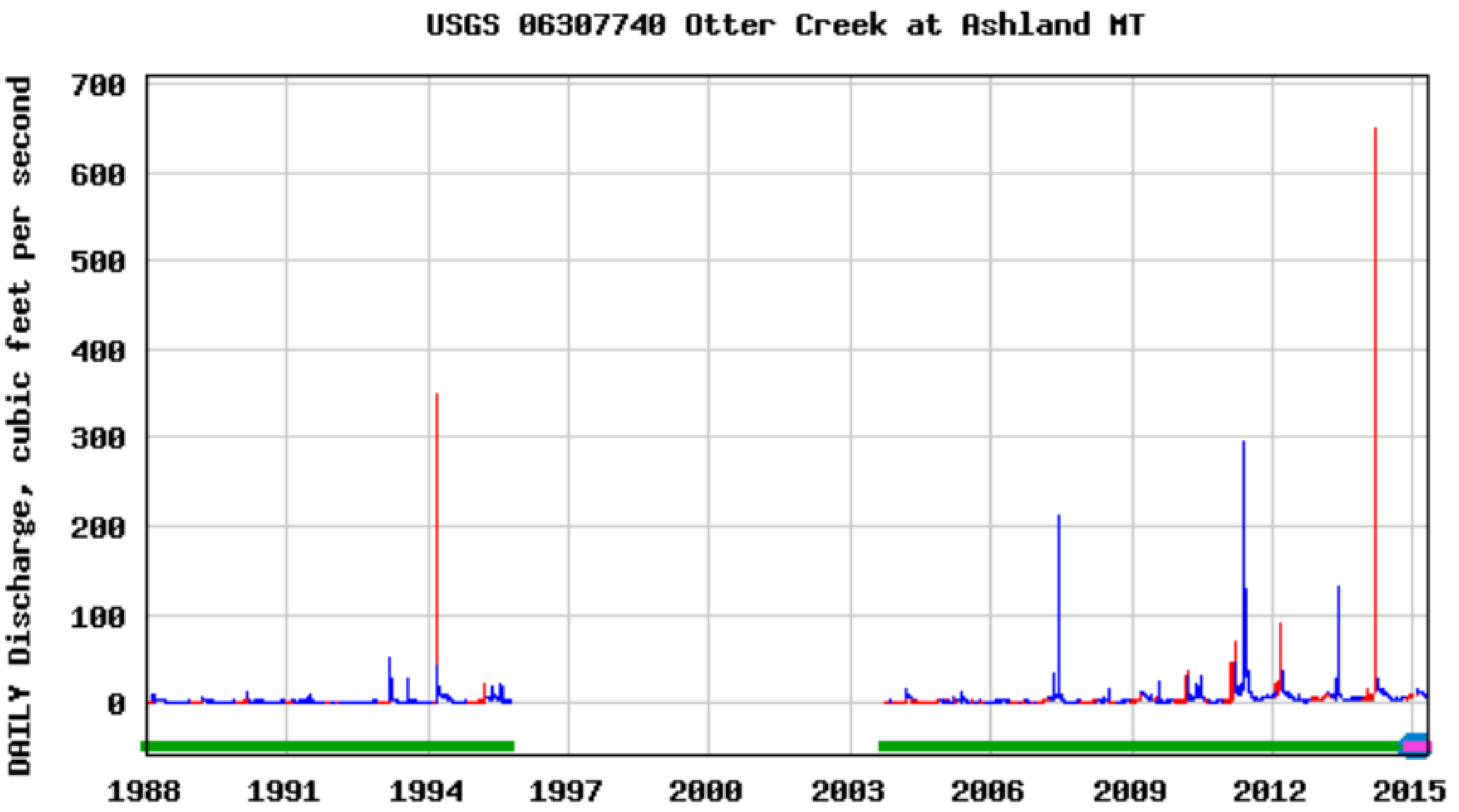
SAR and Agriculture

- Irrigation water with high SAR causes loss of soil structure.
- Soil forms a crust that water can't penetrate.
- Ruins soil for most agricultural uses.

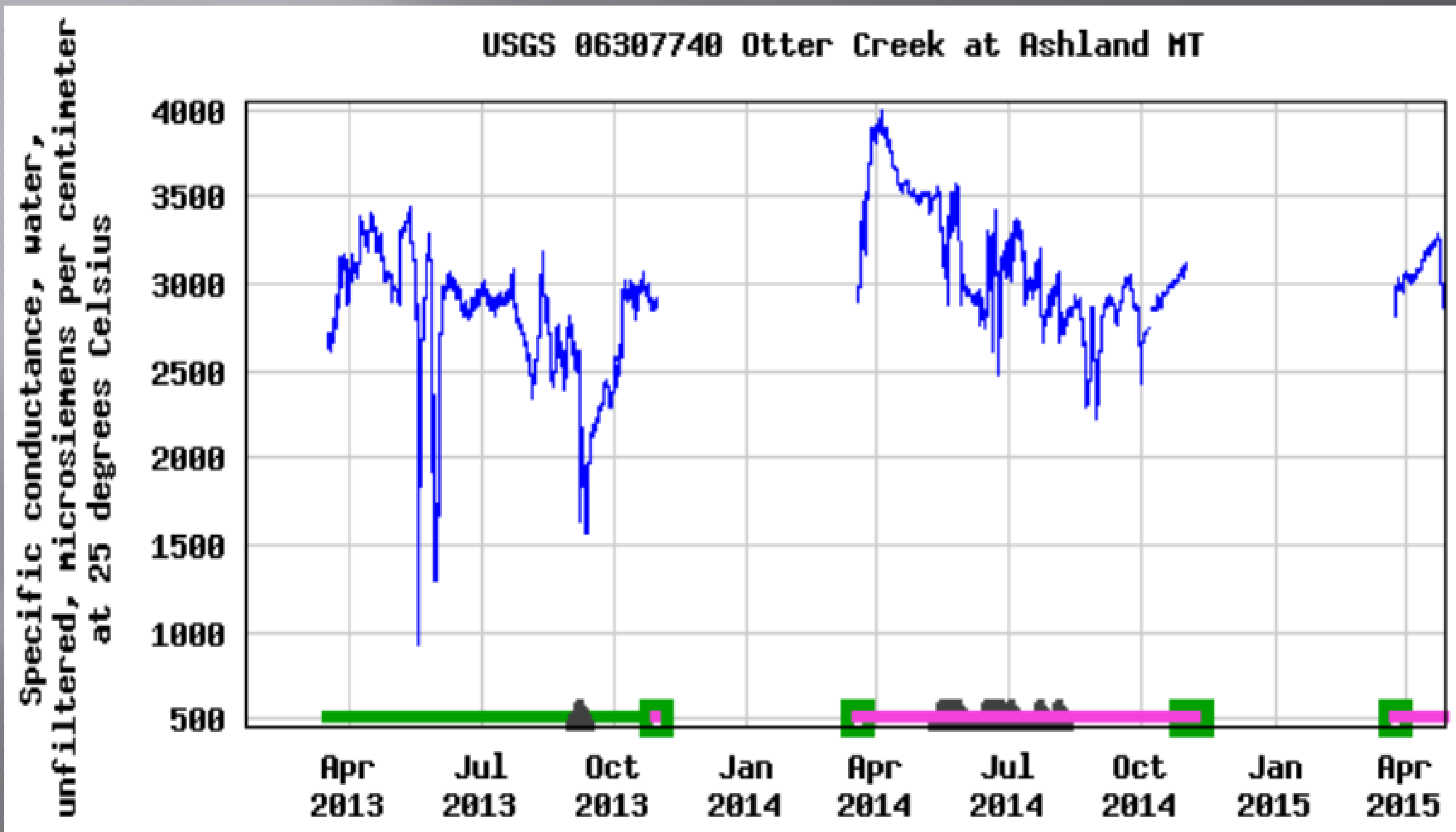
Average Annual Hydrograph (1974-2014)



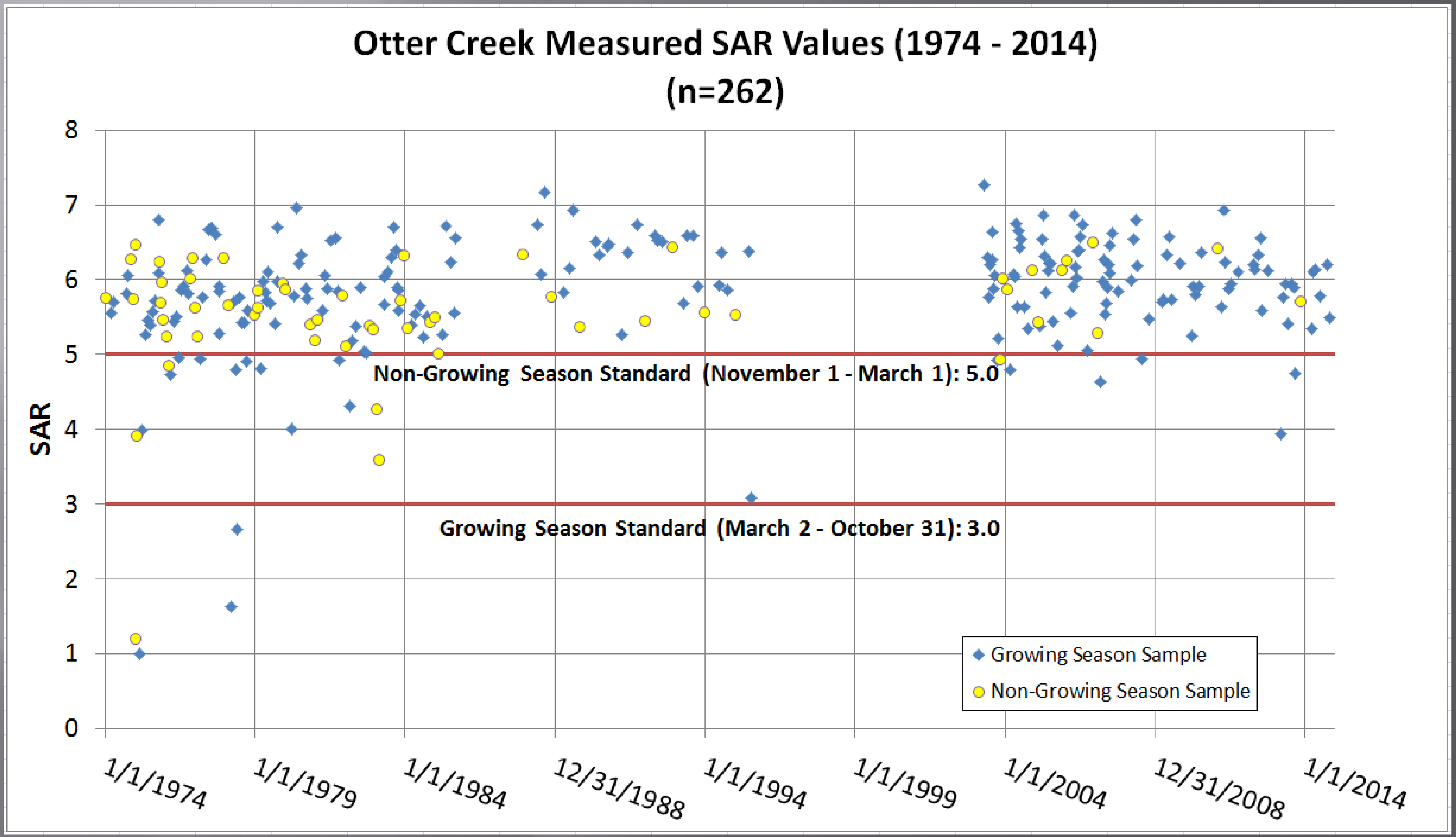
Flow Data


USGS 06307740 Otter Creek at Ashland MT
DAILY Discharge, cubic feet per second
700
600
500
400
300
200
100
0
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015

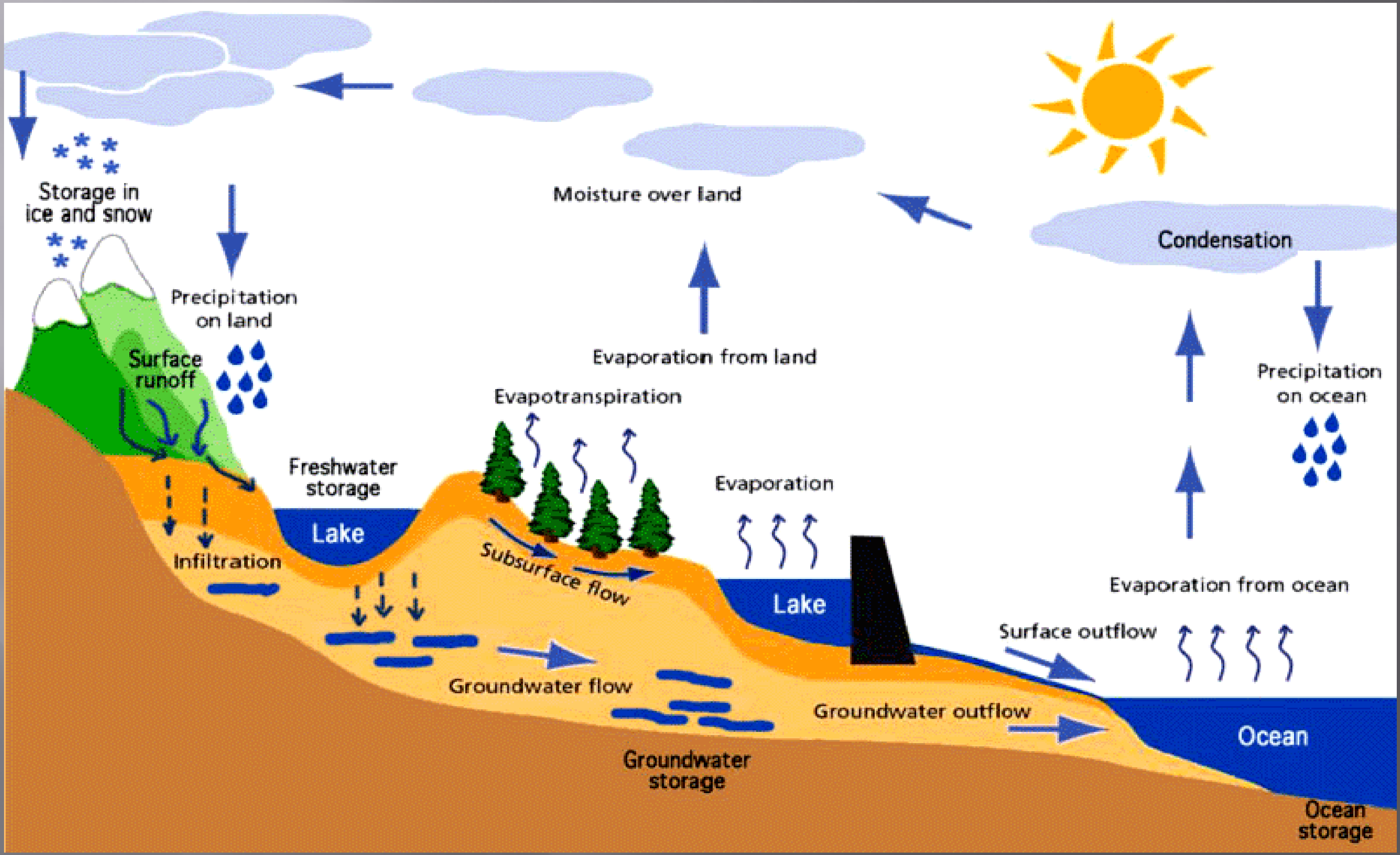
Specific Conductance (SC)



Sodium Adsorption Ratio (SAR)

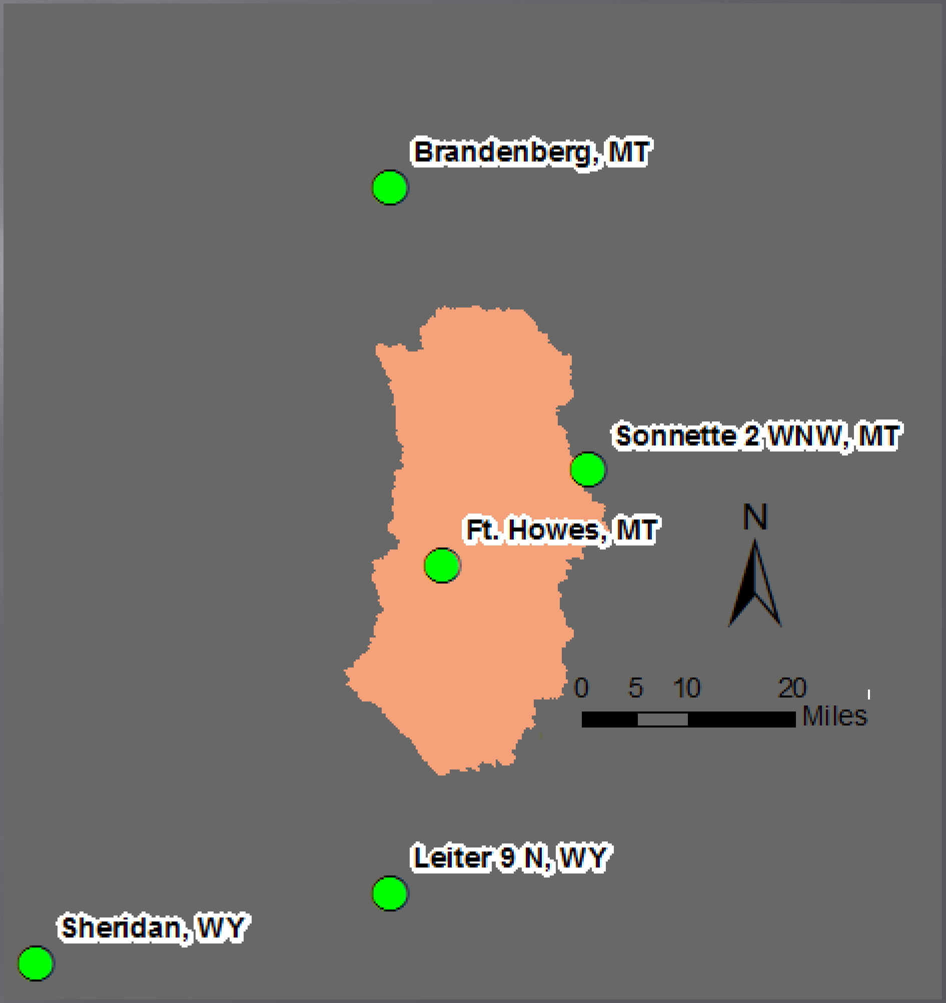


LSPC: Hydrologic/Water Quality Model



Climate Data

- LSPC requires six climate inputs on an hourly time step.
- Leiter and Sonnette were used for temperature and precipitation.
- Fort Howes was used for temperature, wind speed, and relative humidity.
- Sheridan, WY was used for solar radiation and PET.

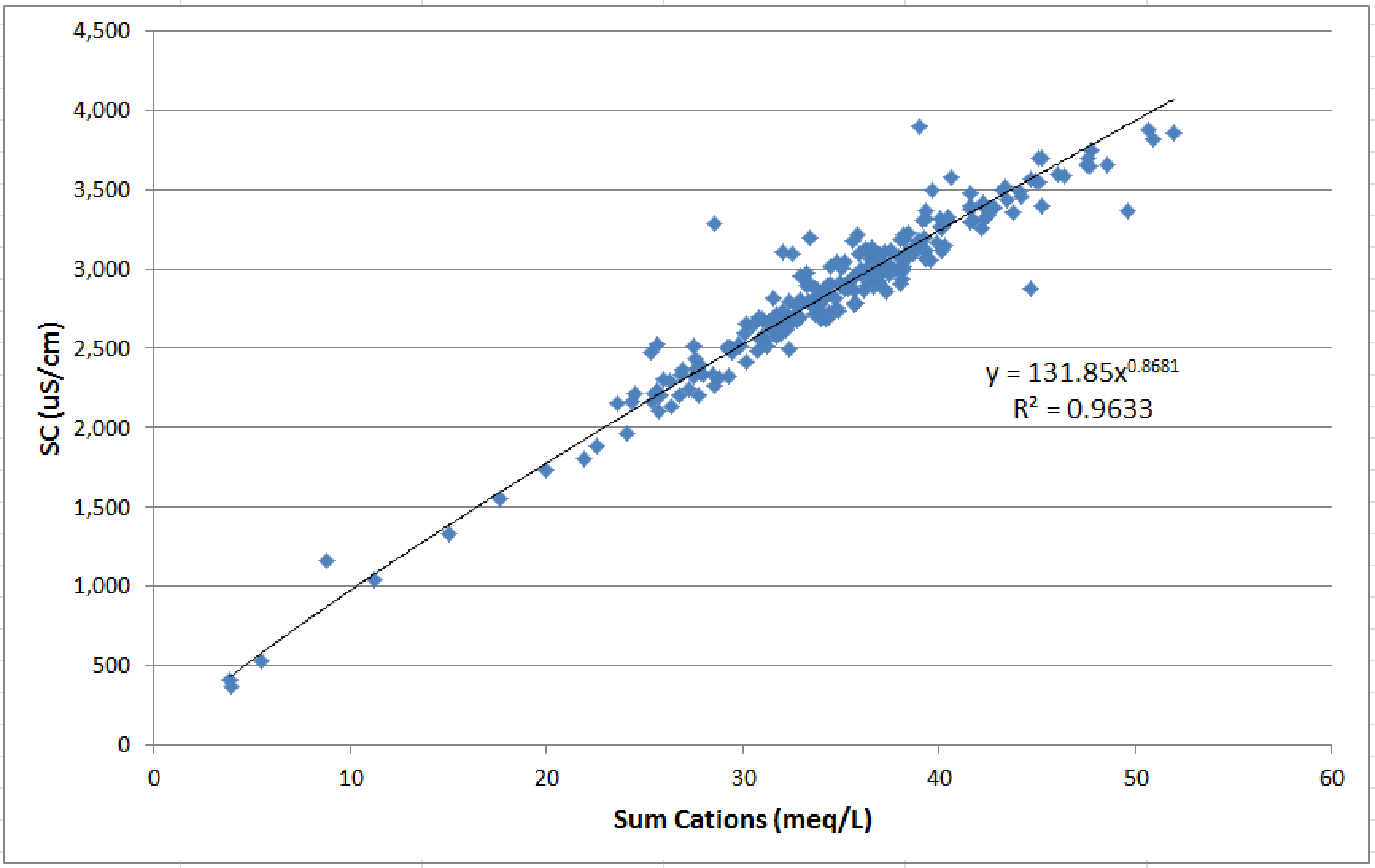


SAR Modeling in LSPC

- LSPC models cations as conservative constituents (transport only; no chemical reactions or uptake)
- Calcium (Ca^{2+}), magnesium (Mg^{2+}), and sodium (Na^{+}) are modelled.
- Can then calculate SAR.

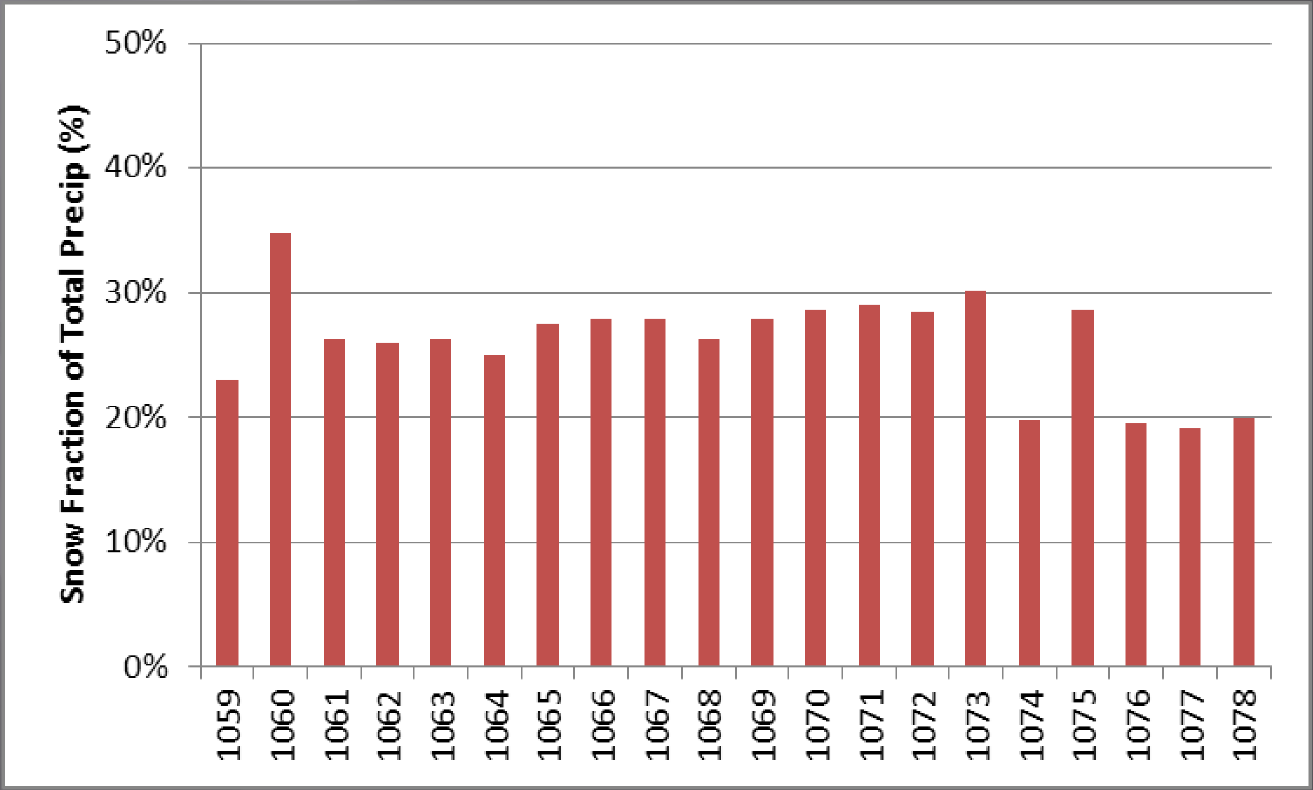
$$SAR = \frac{[Na]}{\sqrt{([Ca] + [Mg])/2}}$$

Salinity Modeling in LSPC

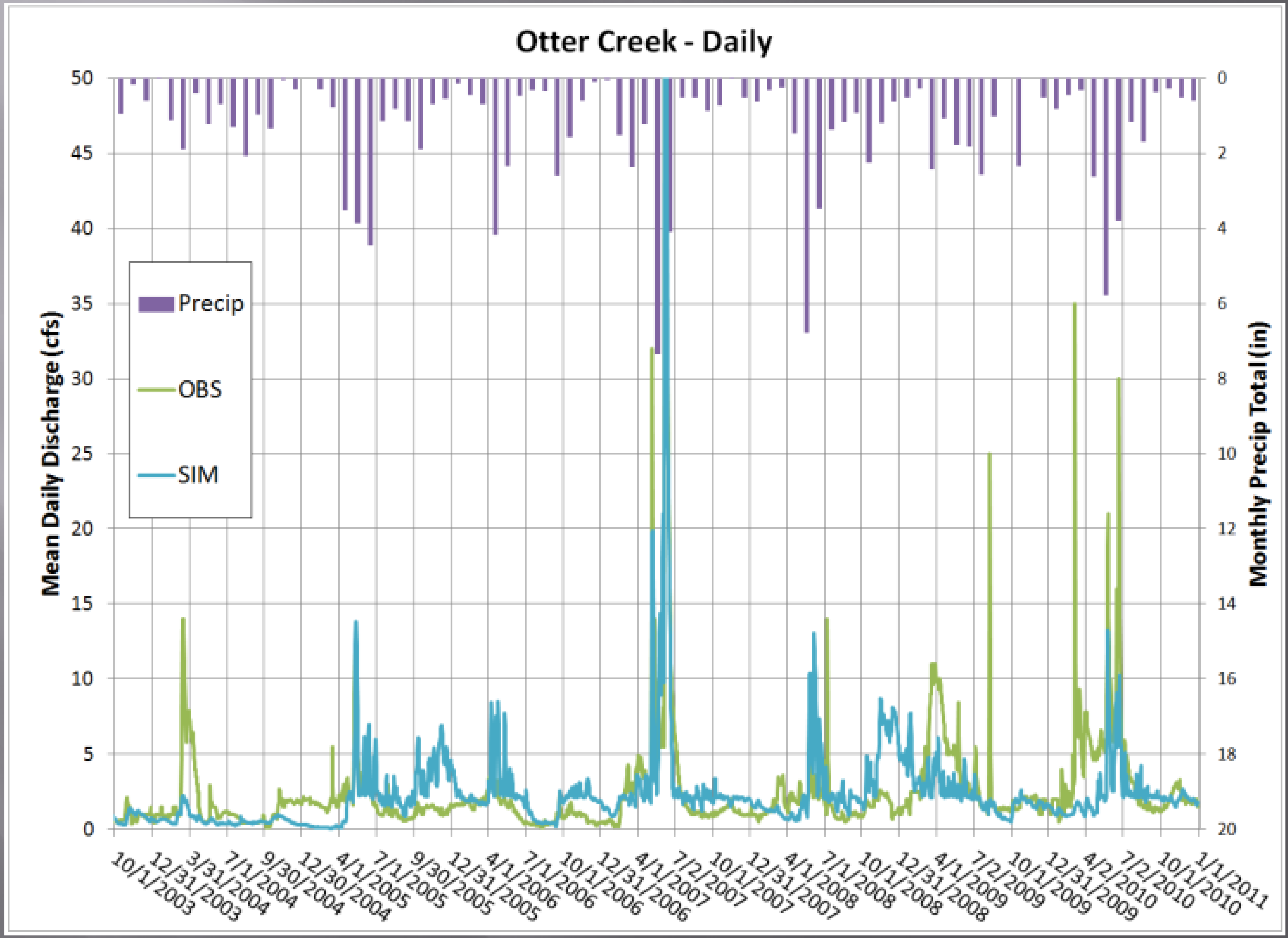


Rain/Snow Balance

- No snow gages located in the watershed
- Miles City long term records show about 20% of total precipitation falls as snow.
- Sheridan:
  30%



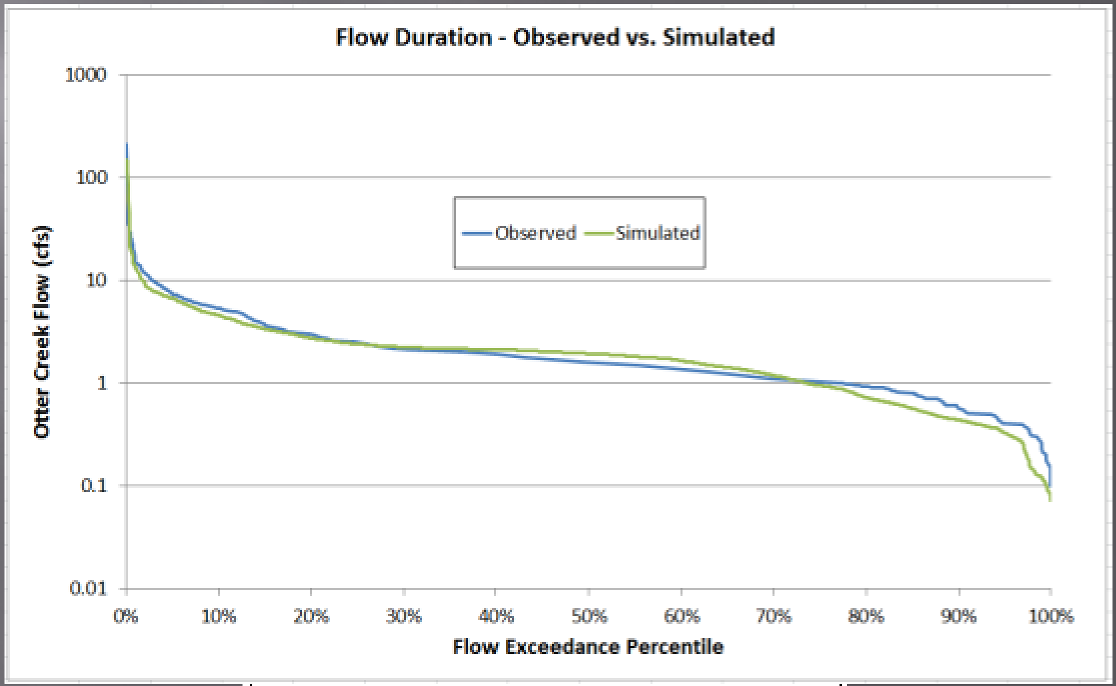
Time Series



Otter Creek - Daily
Mean Daily Discharge (cfs)
Monthly Precip Total (in)
Precip
OBS
SIM
50
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
20
10/1/2003
12/31/2003
3/31/2004
7/1/2004
9/30/2004
12/30/2004
4/1/2005
7/1/2005
9/30/2005
12/31/2005
4/1/2006
7/1/2006
10/1/2006
12/31/2006
4/1/2007
7/2/2007
10/1/2007
12/31/2007
4/1/2008
7/1/2008
10/1/2008
12/31/2008
4/1/2009
7/2/2009
10/1/2009
12/31/2009
4/2/2010
7/2/2010
10/1/2010
1/1/2011

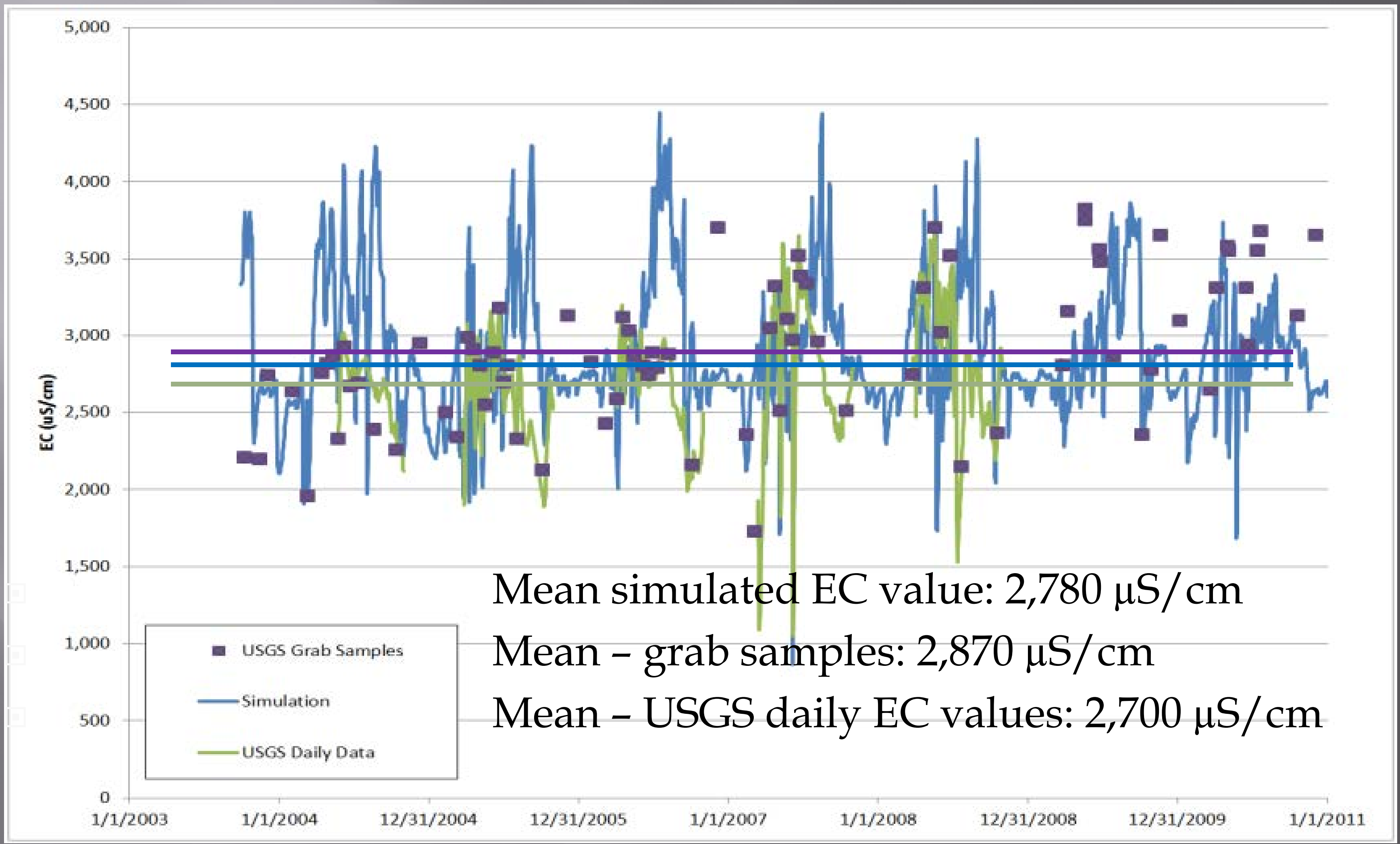
Modeling Metrics - Hydrology

- Model is fair at reproducing low flows.
  - Very low flows - around 0.5 cfs range
  - Very small part of overall water balance
  - Mostly during drought of 2004.
- Model is good at reproducing overall water balance, high flows, and range/variability.

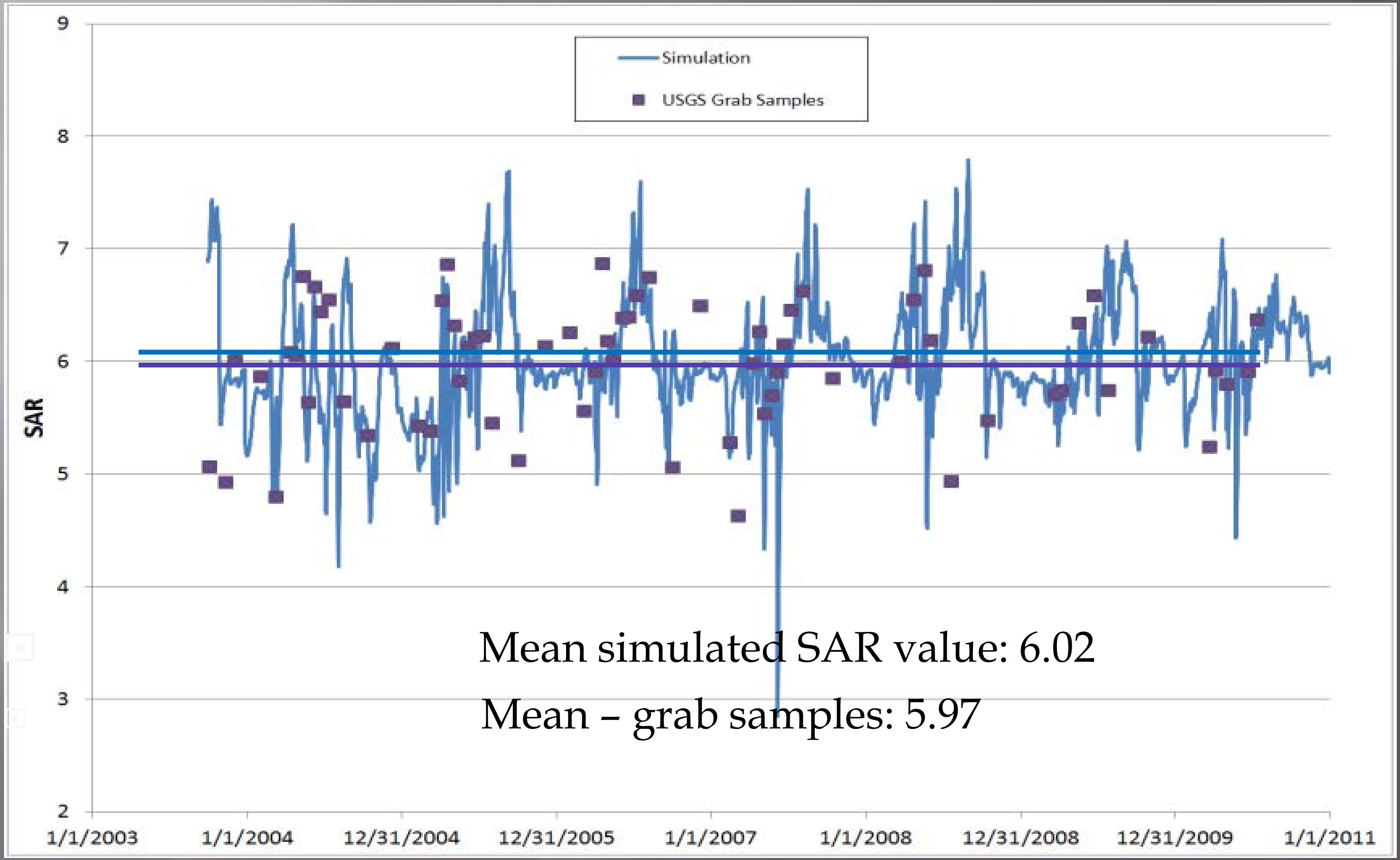


KEY
Good
Fair
Poor

Simulated EC Results



Simulated SAR Results

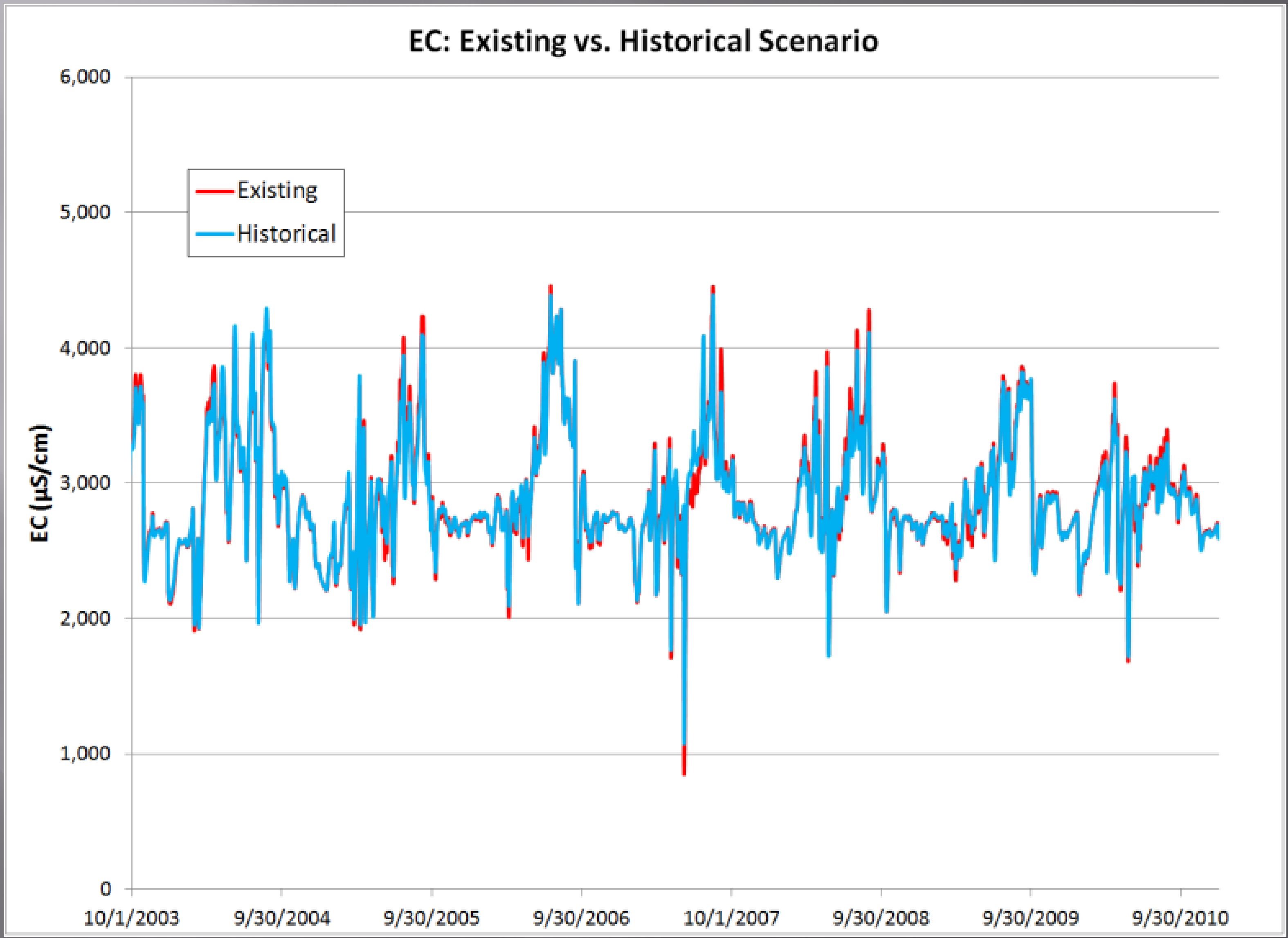


Historical Scenario

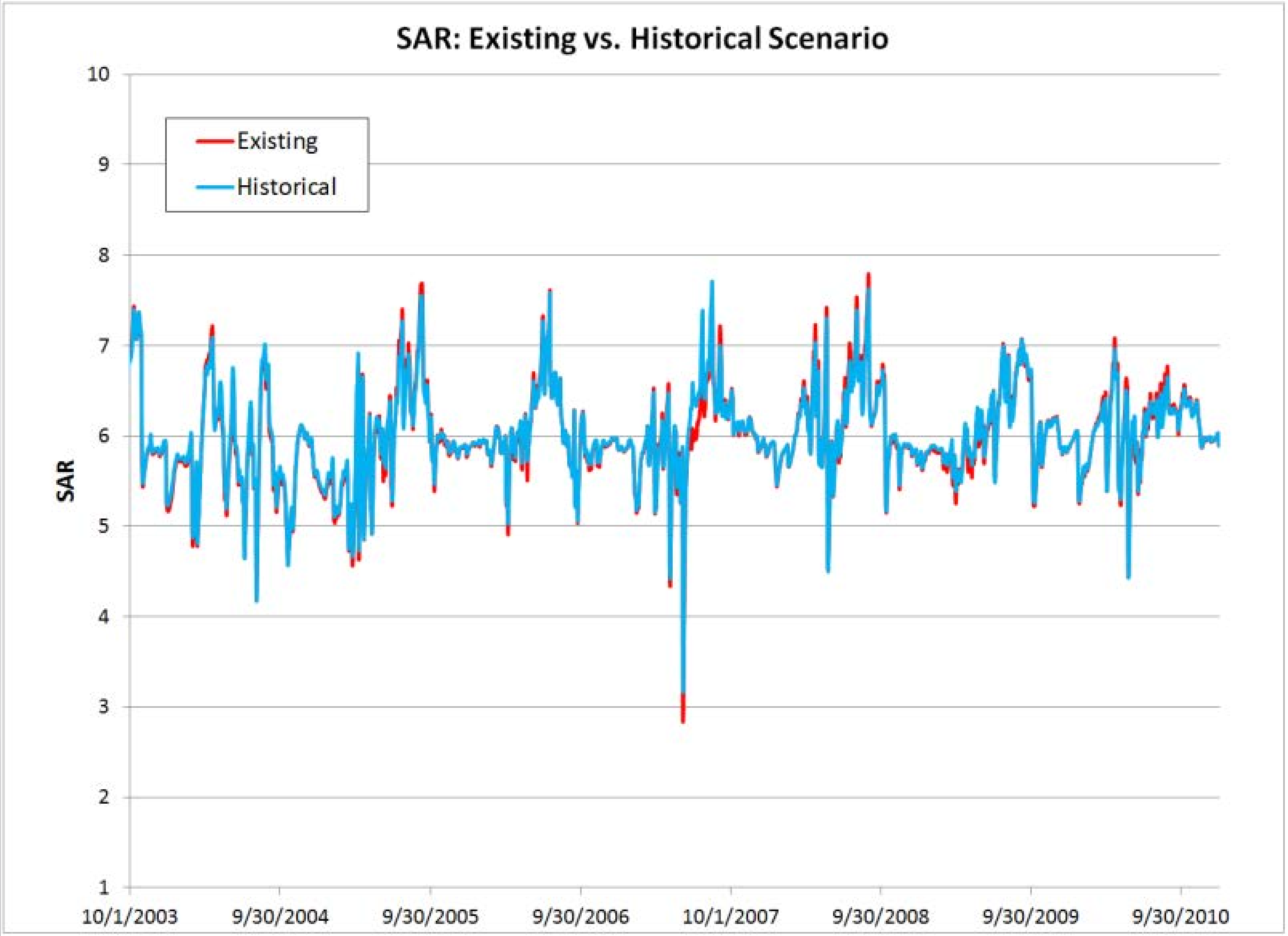
- Remove stock ponds/check dams
- Remove urban footprint (0.5% of watershed)
- Remove irrigated land (0.4% of watershed)
- No industrial point sources to remove

Land Use	Area (ac)	Area (%)
Barren/Mining	398	0.1%
Forest	~~110,693~~	24.4%
Pasture	~~184,187~~	40.6%
Shrubland	~~144,225~~	31.8%
Urban	~~2,150~~ 0	0.5%
Wetlands	~~9,643~~	2.1%
Irrigated Land	~~1,892~~ 0	0.4%
Total	**453,189**	**100.0%**

Historical Simulation - EC



Historical Simulation - SAR



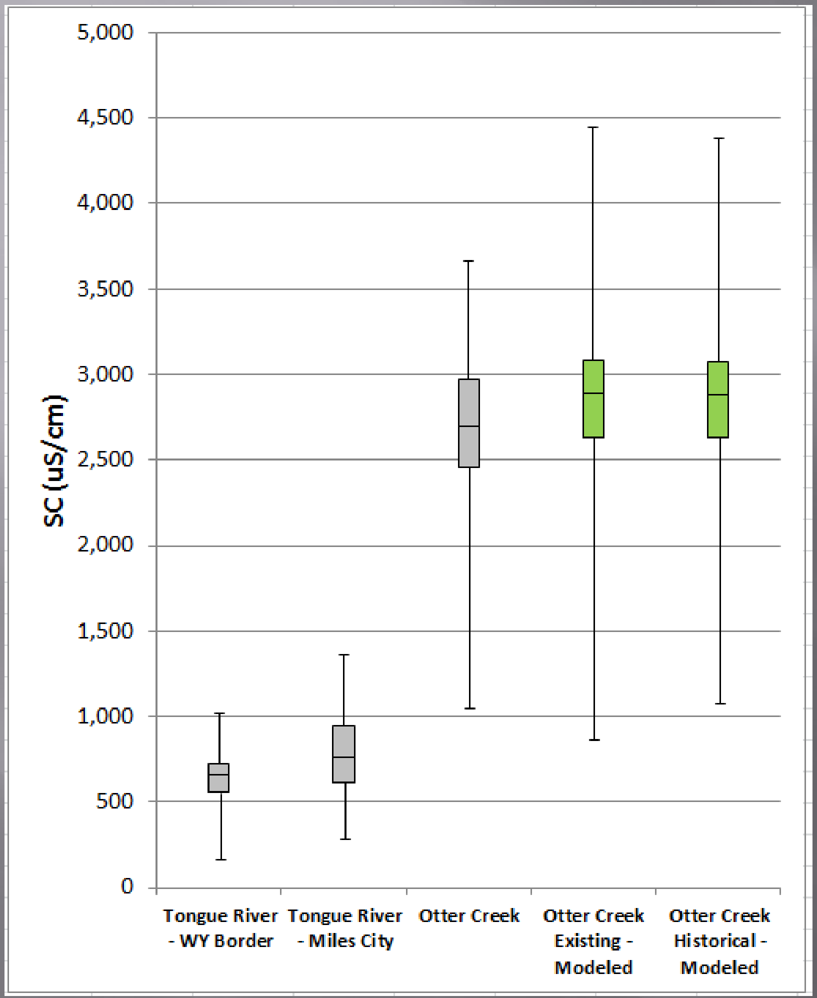
Historical Simulation - Statistics

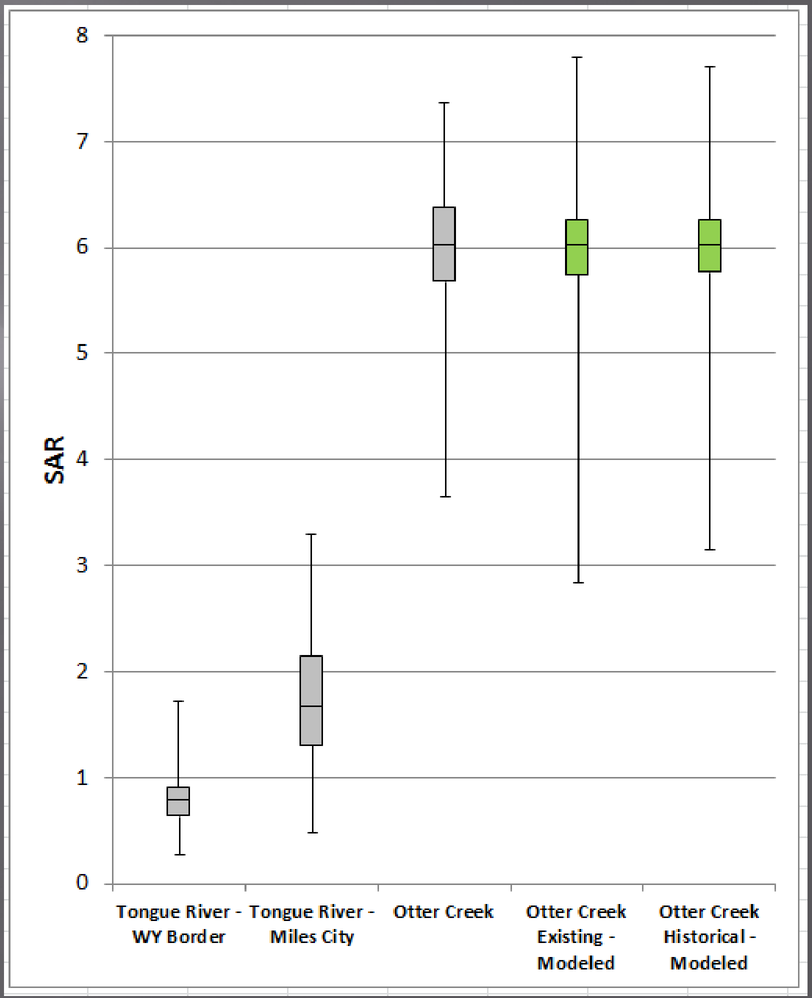
- Most numbers stay very similar, 1% change or less
- No practical difference

EC (uS/cm)		
	Existing	Historical
mean	2890	2881
median	2780	2781
min	867	1083
max	4448	4381
p05	2287	2296
p95	3763	3699

SAR		
	Existing	Historical
mean	6.02	6.03
median	5.94	5.95
min	2.85	3.16
max	7.79	7.7
p05	5.21	5.25
p95	6.91	6.87

Historical Simulation Comparison





Modeling Summary

- DEQ created a water quality model for the Otter Creek watershed that adequately represents existing conditions in the watershed.
- Used this tool and knowledge of historical practices to build a historical scenario.
- Result: Historical water quality is similar to existing water quality.
- ***Can use existing water quality data to determine appropriate standards in Otter Creek.***

Salinity Modeling Questions?

SALINITY TMDL

Amy Steinmetz
Water Quality Standards Section

Overview

- Impairment Status
- Water Quality Standards
- Implementation of the Standards

Impairment Status

- Currently
  - "Impaired"

- Water quality standards based on natural
  - Supports beneficial uses

Water Quality Standards (WQS)

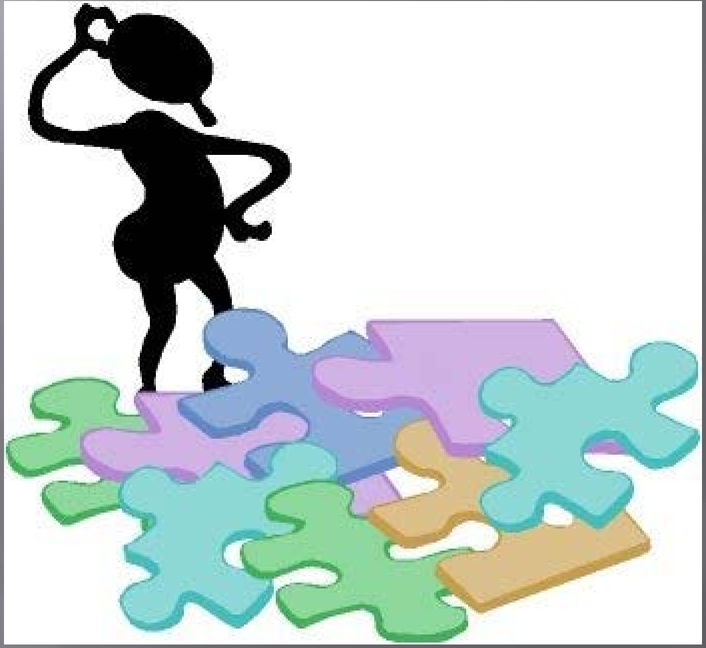
- WQS include uses and criteria to protect uses
- Current criteria are well below natural
- Criteria should be protective of uses but not so far below natural that they cannot be met

Site Specific Criteria

Site specific criteria based on natural

- Reflect the natural condition of the stream
- Protect uses
- Don’t require anyone to “improve” natural

How's This All Going to Work??



Implementation of the Standards

- Assessment
- Nondegradation
- Permits

Salinity Standards Questions?

OTTER CREEK IRON TMDL DEVELOPMENT

Dean Yashan

Watershed Section Supervisor (DEQ)

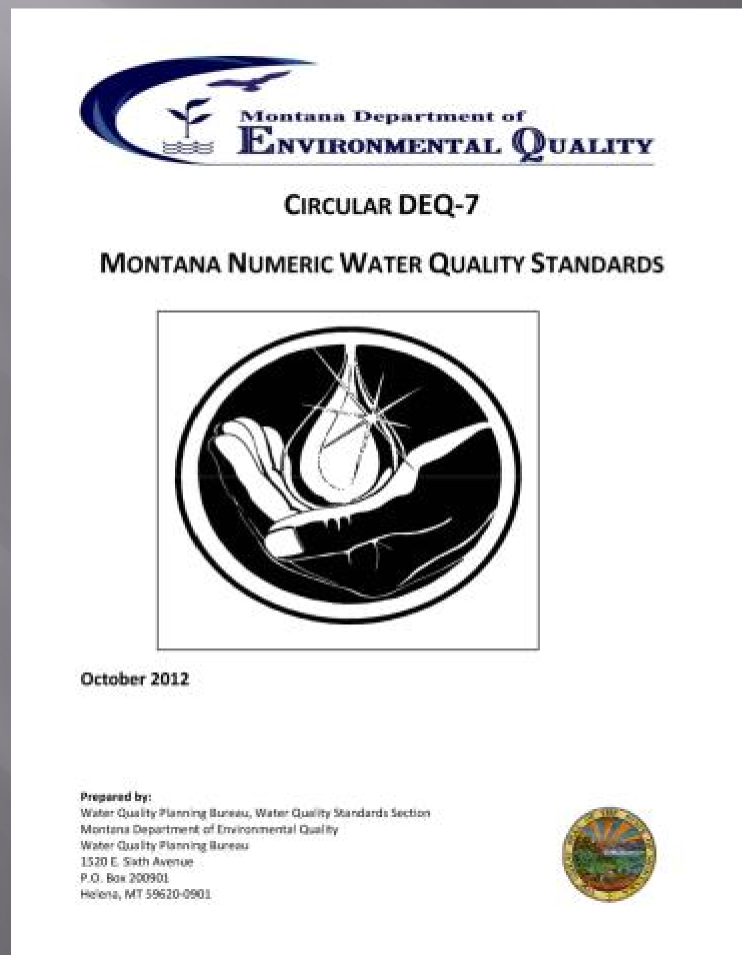
Kristy Fortman

Senior TMDL Planner (DEQ)

Outline - Iron (Fe) TMDL Components

- TMDL Target & Comparison to Target
- Defining the Allowable Load or TMDL
- Source Assessment
- TMDL Allocation Approaches

TMDL Target & Comparison to Target



Montana Department of Environmental Quality

CIRCULAR DEQ-7

MONTANA NUMERIC WATER QUALITY STANDARDS

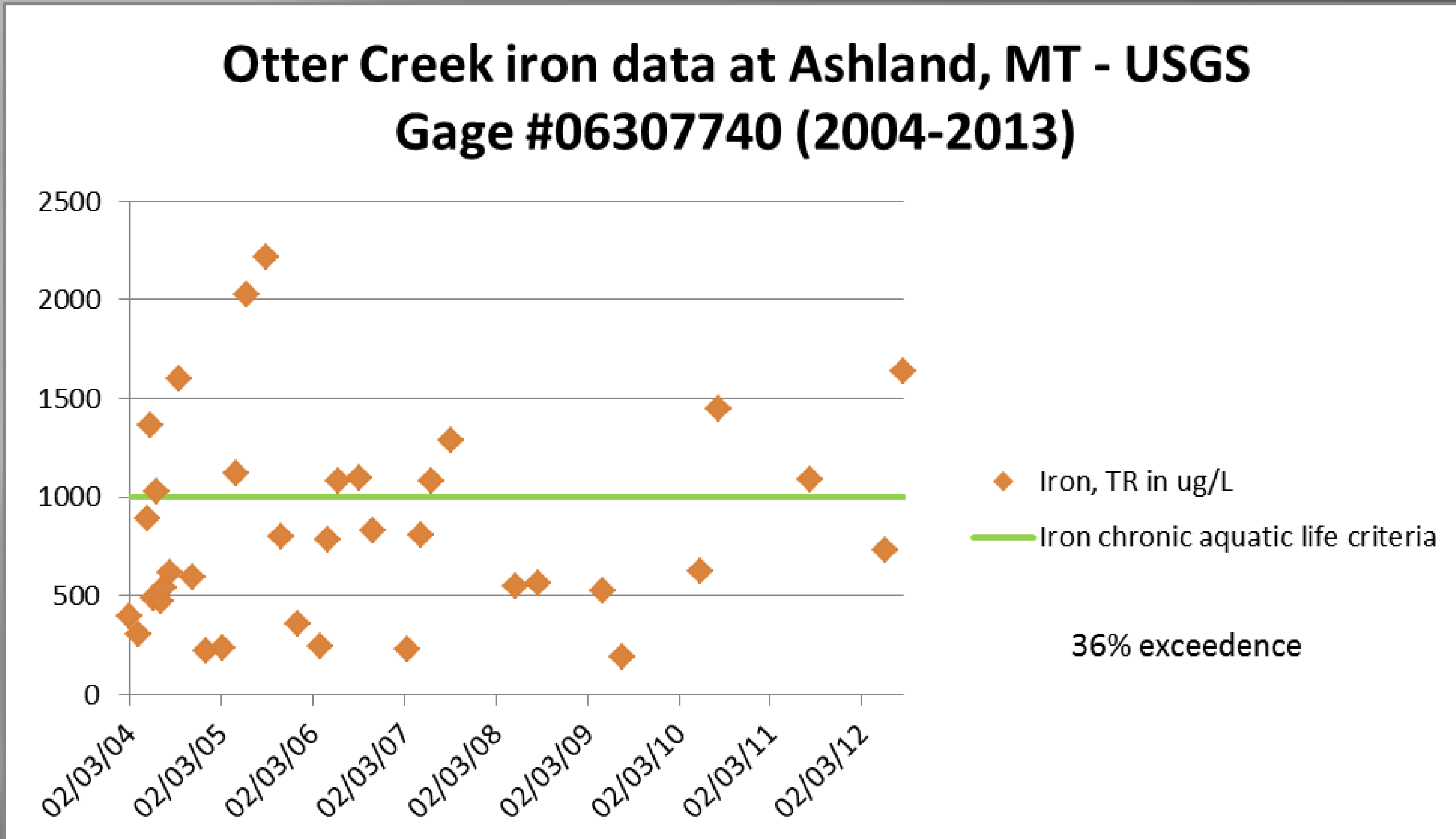
October 2012

Prepared by:
Water Quality Planning Bureau, Water Quality Standards Section
Montana Department of Environmental Quality
Water Quality Planning Bureau
1520 E. Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901

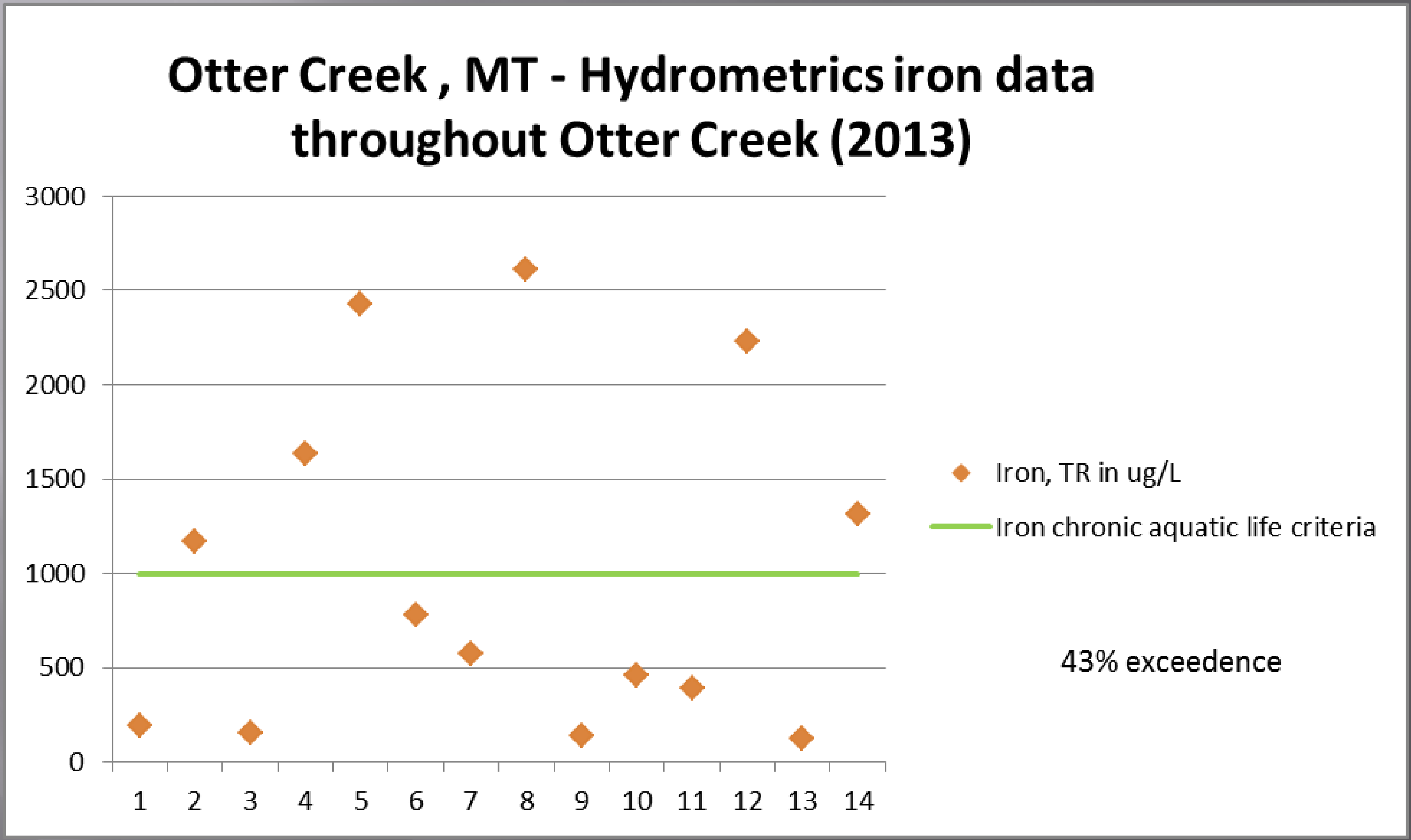
TMDL Target

- Based on numeric water quality standard for iron
- Chronic aquatic life standard for total recoverable (TR) iron = 1000 µg/l (1 mg/l); applies all seasons
- 10% allowable exceedance rate using mix of high and low flow sample conditions
- Therefore, the TMDL target = 1000 µg/l (with a 10% allowable exceedance rate)

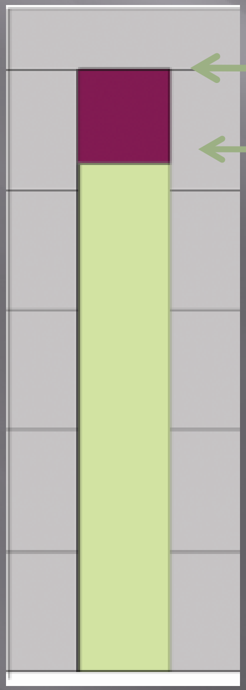
Iron Data – Target Comparison



Iron Data – Target Comparison



Defining the Allowable Load or TMDL



Total Current Load

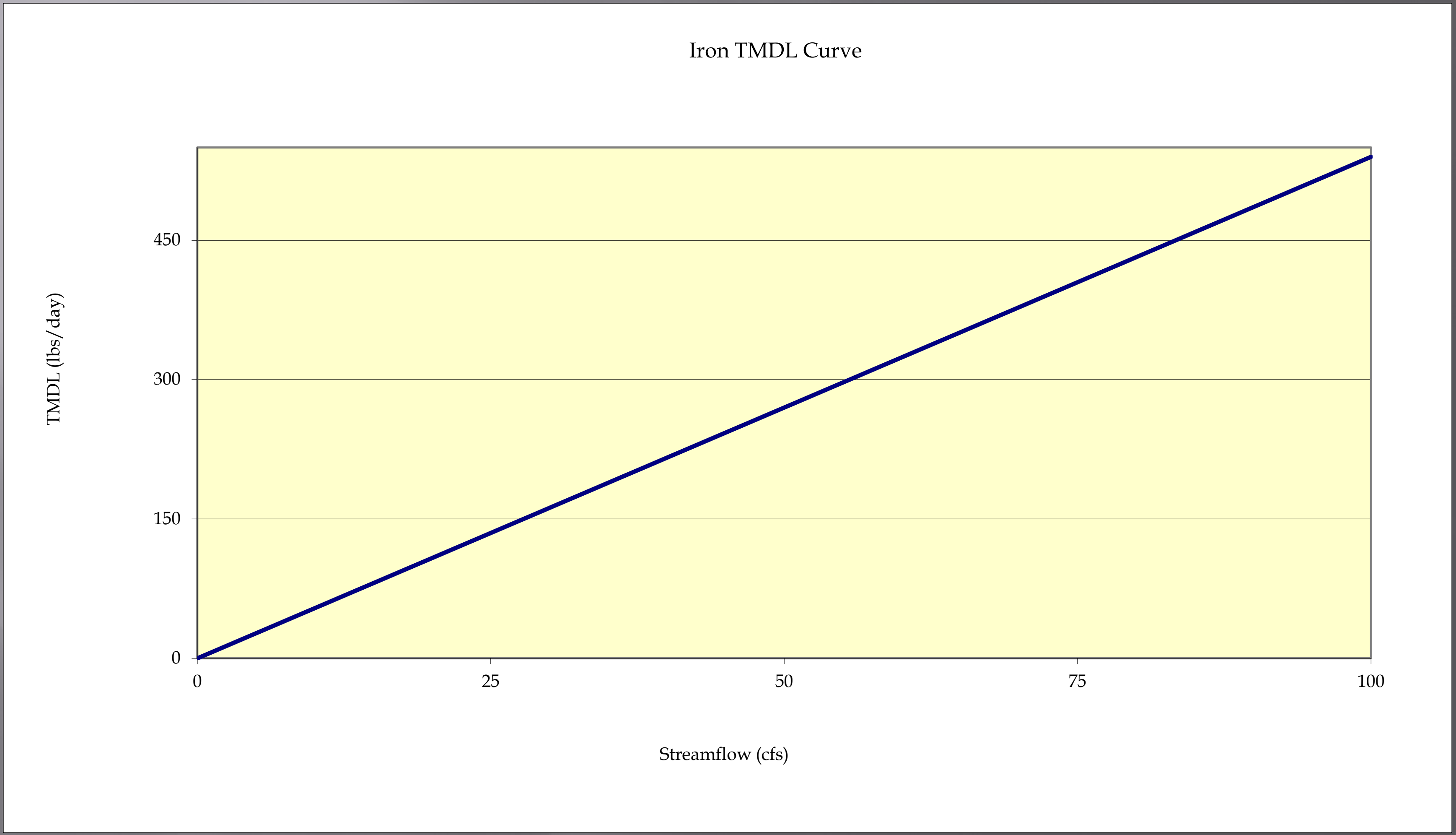
TMDL (Allowable Load)

Iron TMDL

- TMDL = Allowable Loading Rate
- Iron TMDL (lb/day) = [flow (cfs)] X [1000 μg/l] X 0.00539 (conversion factor)

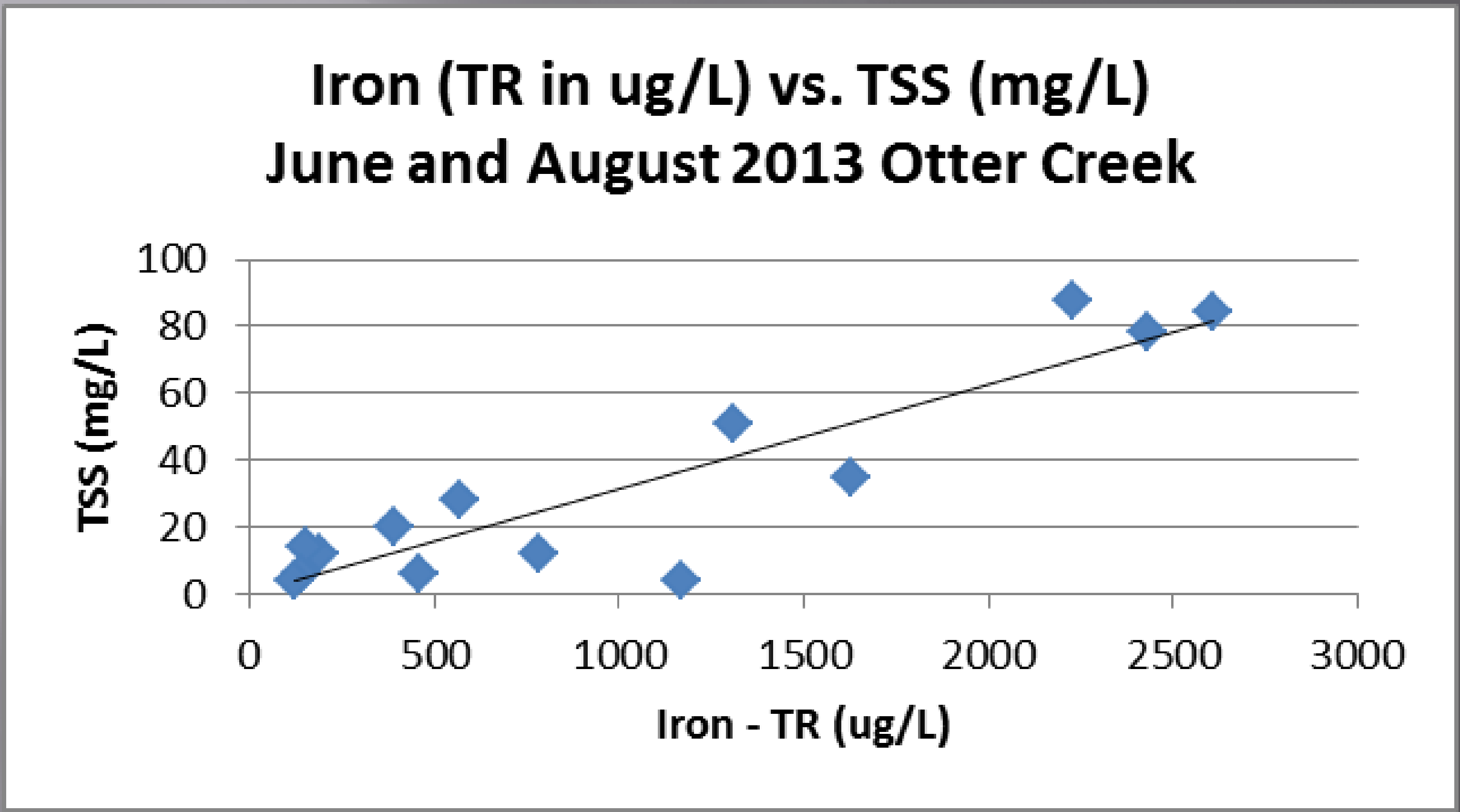
Note: If the target is exceeded, then the TMDL will be exceeded (36% target exceedance rate equals 36% TMDL exceedance rate)

Iron TMDL Curve

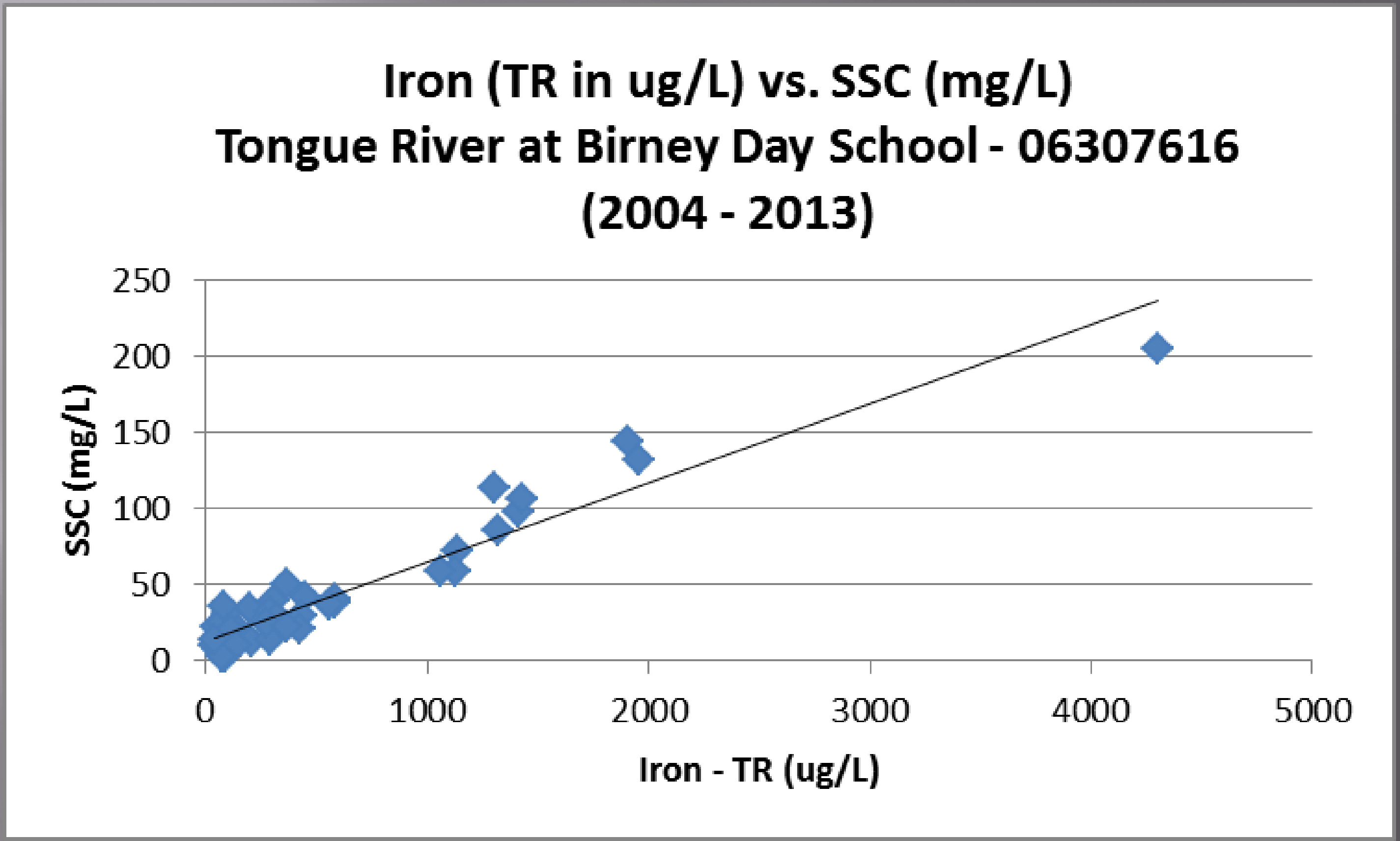


Source Assessment

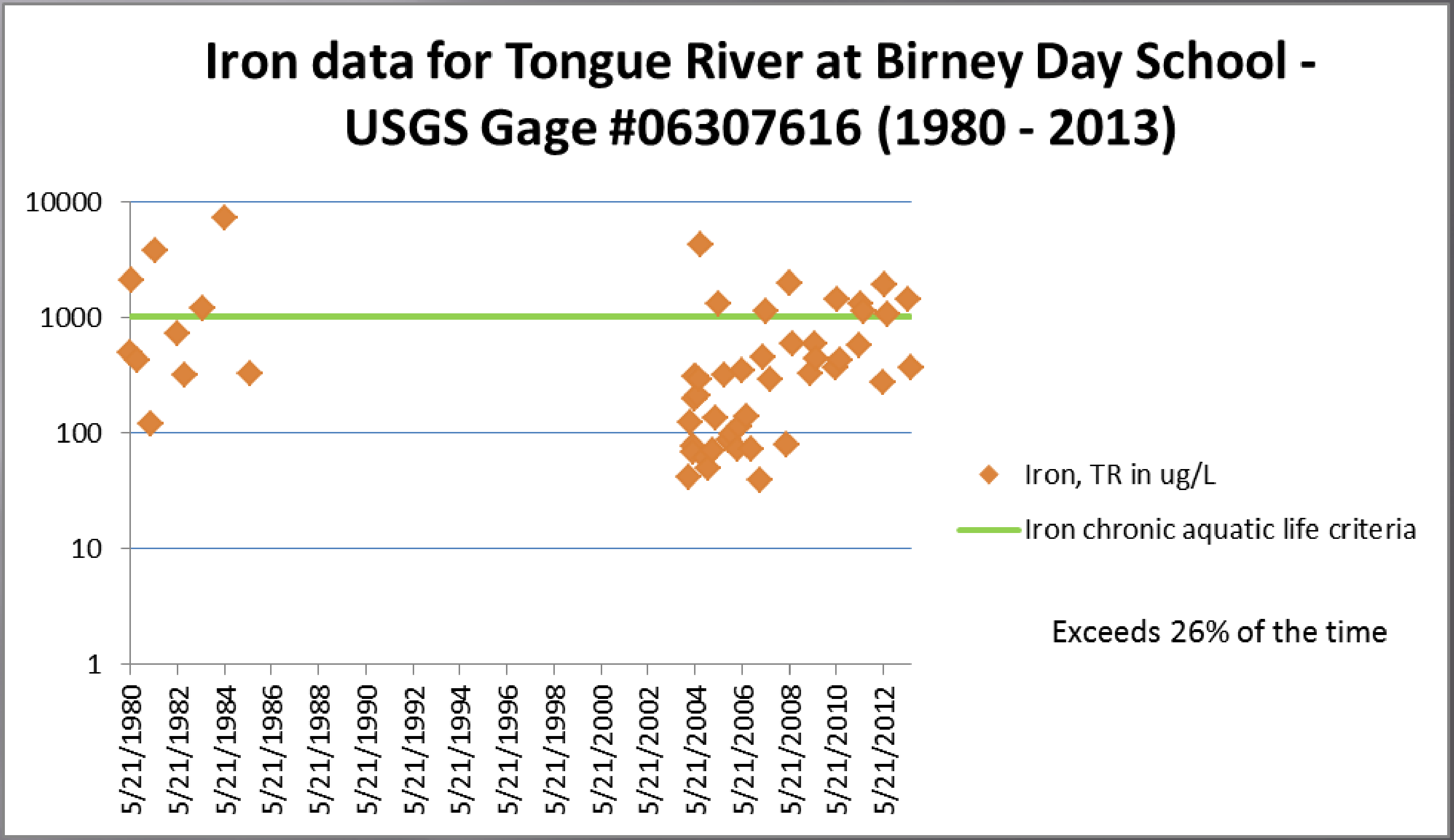
TR Iron – Total Suspended Solids (TSS) Relationship



TR Iron – Suspended Solids Concentration (SSC) Relationship



Other Areas of Elevated TR Iron Concentrations: Comparison to 1000 µg/L target



Other Areas of Elevated TR Iron Concentrations: Comparison to 1000 μg/L target

- Tenmile Cr. (recent): approx 12% exceed
- Home Cr. (recent): < 10% exceed
- Threemile Cr. (recent): 100% (5/5 samples)
- Pumpkin Cr. (USGS 2004 – 2014): 60% exceed
- Tongue R. at Miles City (USGS 2004 – 2014): 56%

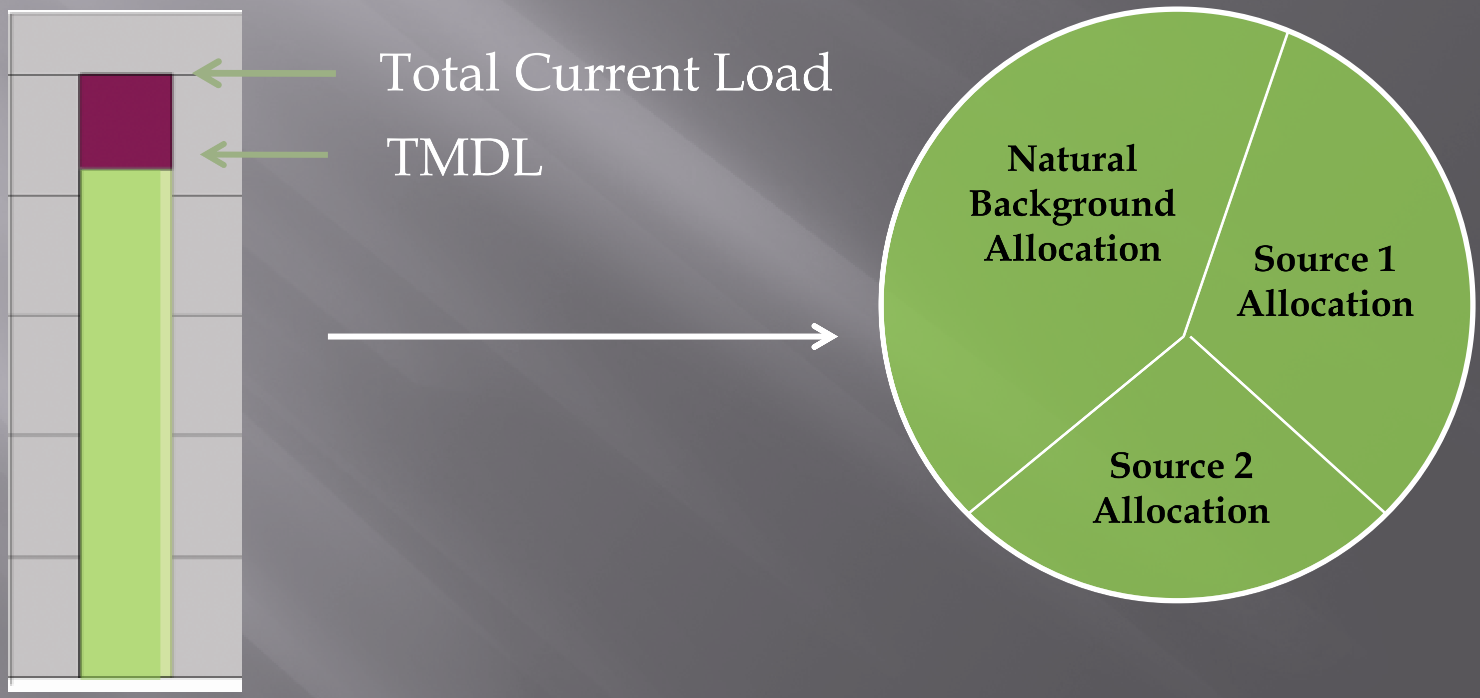
Source Assessment Summary

- Iron in Otter Creek is predominately total recoverable (TR), normally very little dissolved
- Elevated TR iron found throughout Tongue watershed
- Strong linkage between TR iron and TSS/SSC (likely from soil erosion)

Source Assessment Summary

- High iron concentrations often seen at high flow conditions (higher soil erosion potential)
- Predominately natural; not uncommon in many eastern Montana streams

Iron TMDL Allocation



Typical Simple Approaches for Iron & Other Metals Allocations

- TMDL = Natural Background Allocation + Abandoned Mine Allocation
  - All reductions via mine remediation

- TMDL = Composite Allocation to All Sources (Human & Natural Background)
  - Normally there are mining or other human sources where iron reductions can be achieved; but ability to meet standard might be uncertain and/or natural background not well defined

Possible Approach for Otter Creek Iron Allocations

- TMDL = Otter Creek Coal Mine Allocation + Composite Allocation to All Other Sources (Human & Natural Background)

Considerations for the Otter Creek Coal Mine Allocation

- Discharges with TR iron concentrations $\leq$ 1000 ug/l would likely not cause or contribute to water quality impairment (in both Otter Cr & Tongue R)
- Alternatively could require no changes in magnitude and frequency of iron target exceedances below new mining activities
- Need to protect Tongue River water quality
- Need to work with DEQ mine permit personnel to ensure consistent approaches/outcomes

Iron TMDL Questions?

TONGUE RIVER TMDL DEVELOPMENT PROJECT

General Approach

- Primary focus on salinity impairments (Tongue River, Hanging Woman & Pumpkin Creeks)
- Salinity modeling will provide source assessment and other relevant TMDL information
- Salinity modeling results anticipated in 2016

Tongue River Watershed Salinity Sources in Montana

- Existing & future coal mines
- Irrigated agriculture
- Natural background
- Coal bed methane
- Other minor sources (grazing stock ponds, etc.)

Note: Salinity loading from Wyoming will also be addressed; probably as a composite load

Tongue River Watershed TMDL Schedule & Outreach

- Watershed Advisory Group (WAG) formation
- Additional schedule and project planning details yet to be developed


Questions & Discussion