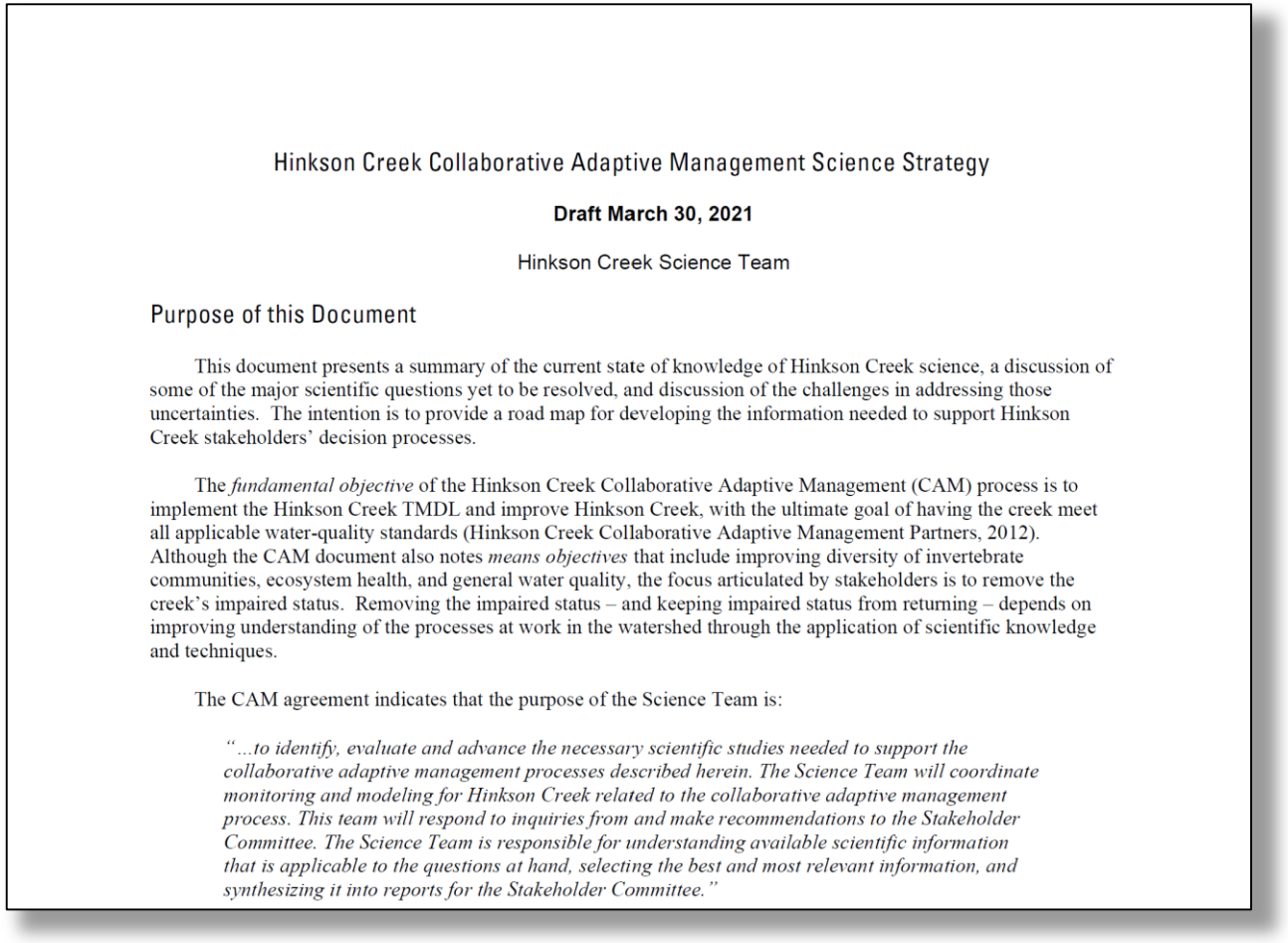
Hinkson Creek Science Strategy

Tim Rielly

Department of Natural Resources

Robert Jacobson, Ph.D.

US Geological Survey



Hinkson Creek Collaborative Adaptive Management Science Strategy

Draft March 30, 2021

Hinkson Creek Science Team

Purpose of this Document

This document presents a summary of the current state of knowledge of Hinkson Creek science, a discussion of some of the major scientific questions yet to be resolved, and discussion of the challenges in addressing those uncertainties. The intention is to provide a road map for developing the information needed to support Hinkson Creek stakeholders' decision processes.

The *fundamental objective* of the Hinkson Creek Collaborative Adaptive Management (CAM) process is to implement the Hinkson Creek TMDL and improve Hinkson Creek, with the ultimate goal of having the creek meet all applicable water-quality standards (Hinkson Creek Collaborative Adaptive Management Partners, 2012). Although the CAM document also notes *means objectives* that include improving diversity of invertebrate communities, ecosystem health, and general water quality, the focus articulated by stakeholders is to remove the creek's impaired status. Removing the impaired status – and keeping impaired status from returning – depends on improving understanding of the processes at work in the watershed through the application of scientific knowledge and techniques.

The CAM agreement indicates that the purpose of the Science Team is:

> *"…to identify, evaluate and advance the necessary scientific studies needed to support the collaborative adaptive management processes described herein. The Science Team will coordinate monitoring and modeling for Hinkson Creek related to the collaborative adaptive management process. This team will respond to inquiries from and make recommendations to the Stakeholder Committee. The Science Team is responsible for understanding available scientific information that is applicable to the questions at hand, selecting the best and most relevant information, and synthesizing it into reports for the Stakeholder Committee."*

Outline

Tim Rielly:
- Collaborative Adaptive Management (CAM) context
- Role of the Science Team
- Status of Hinkson Creek

Robb Jacobson:
- The Conceptual Ecological Model
- State of the Science
- Mitigation projects – types, monitoring, assessment
- Current view of science priorities
- Notes on decision-relevant science and CAM

Hinkson CAM

- Hinkson Creek was listed as impaired on the 303d list of impaired waters due to unknown pollutants.

- The Collaborative Adaptive Management (CAM) process is the result of a legal agreement, whose aim is to resolve the impairment of Hinkson Creek.

- This process is a collaborative approach that identifies Stakeholder, Action and Science teams to shape and determine the needs for Hinkson Creek and improve water quality. The process makes and recommends changes and determines the effects of those changes.

Collaborative Adaptive Management (CAM) Process

- The Total Maximum Daily Load (TMDL) is a “phased and adaptive plan to restore water quality conditions in the Hinkson Creek watershed.”

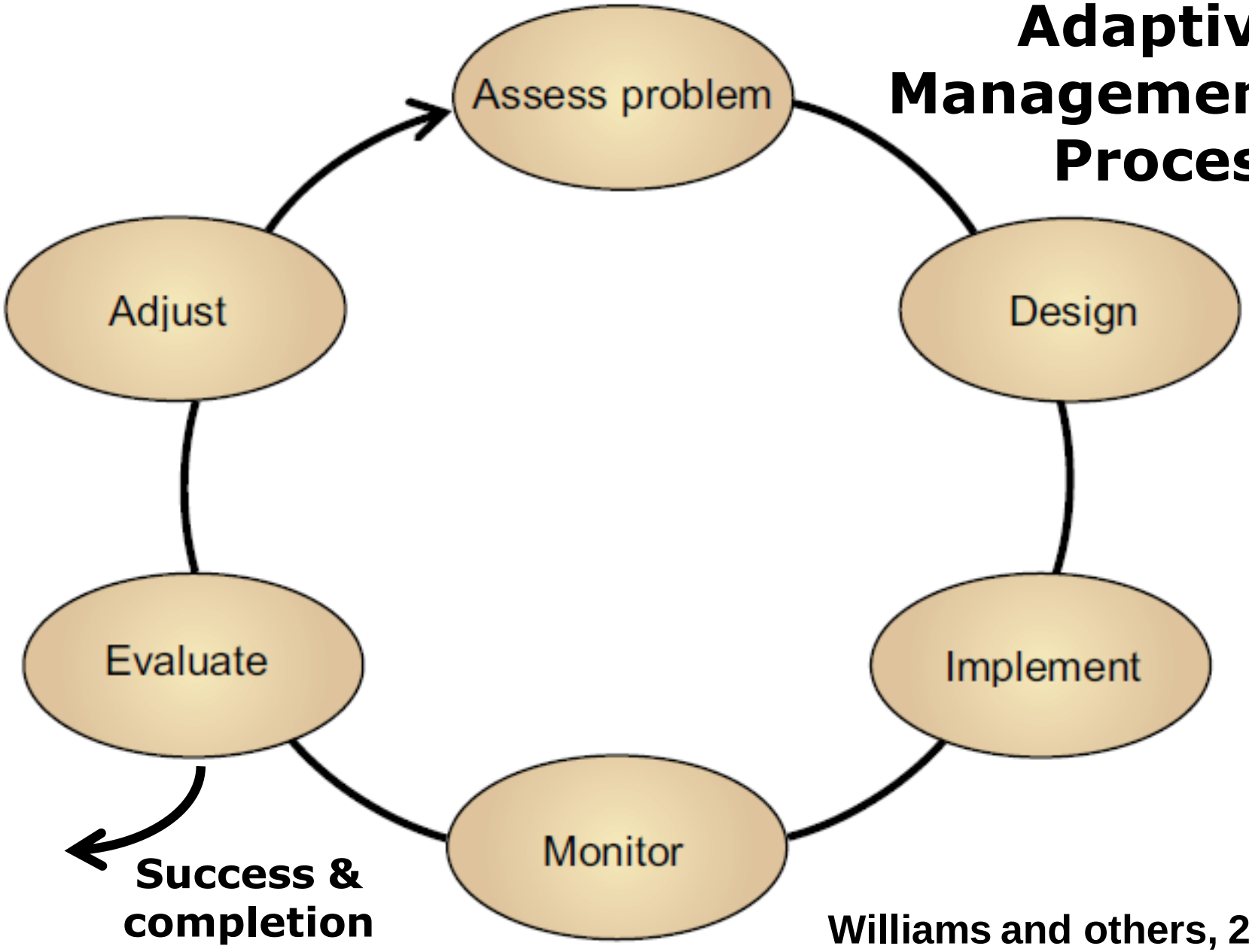
- The goal of the TMDL CAM process is to restore the Protection of Warm Water Aquatic Life designated beneficial use of Hinkson Creek by actions from the CAM process.

CAM Process Cont.

- A 303(d) listed stream is “de-listed” once a TMDL is approved and the water body placed in Category 4a of the Integrated Report. The stream is still impaired and continued monitoring is required until the stream attains use.

- For Hinkson Creek, the CAM process requires monitoring to reduce uncertainty as to the type and sources of pollutants, and also to measure improvements from actions.

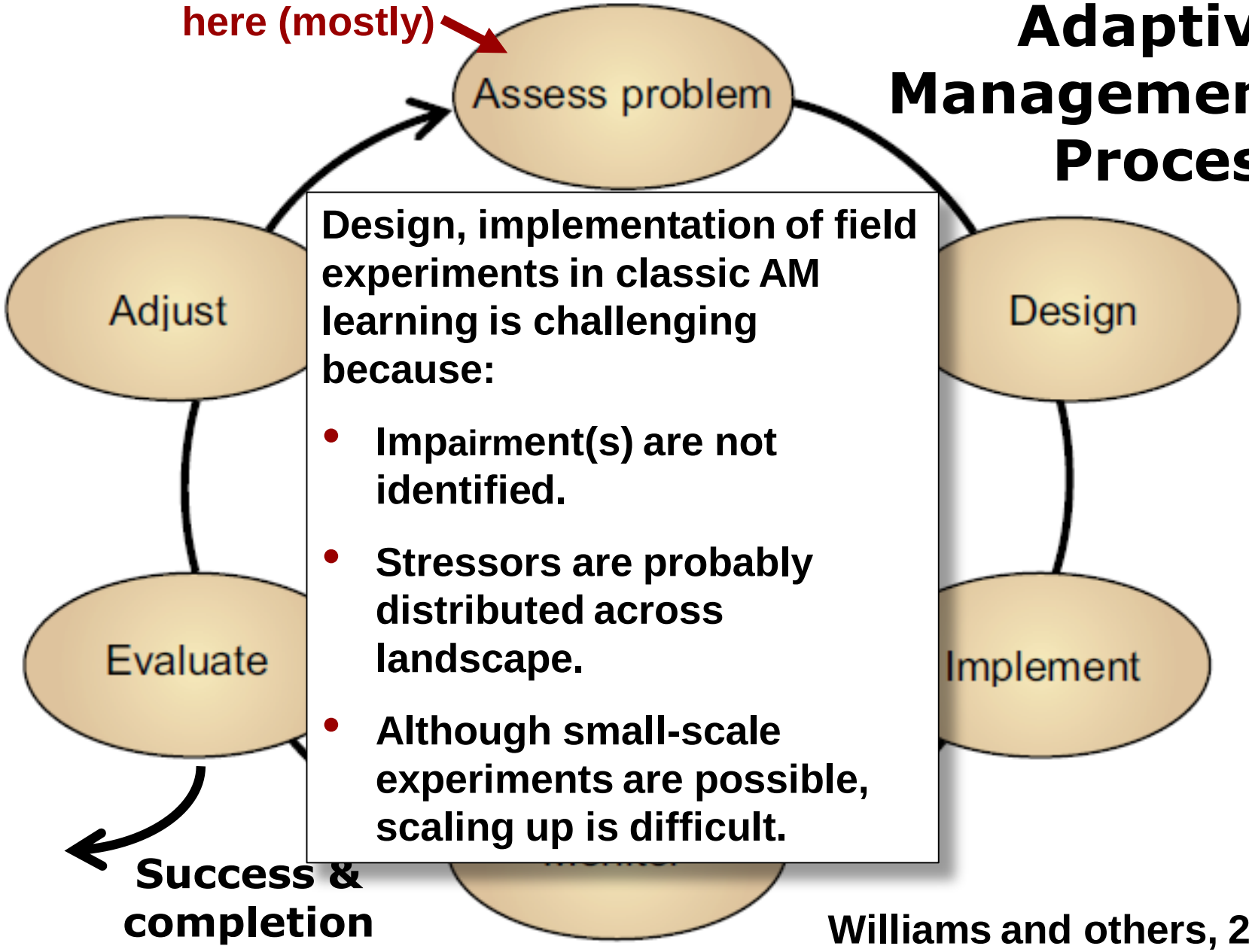
Science and Adaptive Management Process



Williams and others, 2007

Science and Adaptive Management Process

We are still here (mostly)



Design, implementation of field experiments in classic AM learning is challenging because:

- **Impairment(s) are not identified.**
- **Stressors are probably distributed across landscape.**
- **Although small-scale experiments are possible, scaling up is difficult.**

Williams and others, 2007

Science Team's Role for CAM

- Evaluate potential factors contributing to the impairment of Hinkson Creek.

- Evaluate the optimum application of science to resolve uncertainties, determining the efficacy of actions that would improve water quality conditions, and advising Stakeholders and the Action Team on science strategies.

- Make recommendations to provide the Stakeholders with the information needed to make informed decisions about investment in science, based on what is known, what is not known, and what needs to be known with consideration of risk tolerance.

"Creation of a Science Team. A Science Team has been appointed consisting of not more than nine (9) persons, not holding public office…This team is to be populated by individuals with scientific backgrounds and credentials relating to the areas of biology, hydrology, ecology, chemistry, botany, geomorphology and other physical science disciplines to evaluate characteristics of Hinkson Creek." - *CAM agreement*

Name	Organization
Paul Blanchard, Hydrologist	Missouri Department of Conservation
John Holmes, Stormwater Expert/Civil Engineer	Allstate Consultants
Robert Jacobson, Research Hydrologist	U.S. Geological Survey, Columbia Environmental Research Center
Dave Michaelson, Stream Ecologist	Missouri Department of Natural Resources
Dan Obrecht, Water Quality Specialist	University of Missouri
Barry Poulton, Research Ecologist	U.S. Geological Survey, Columbia Environmental Research Center
Tim Rielly, Water Quality Specialist	Missouri Department of Natural Resources
Robert Voss, Environmental Supervisor	Missouri Department of Natural Resources
Catherine Wooster-Brown	U.S. Environmental Protection Agency

Science team operations

- Monthly meetings
- Ground rules:
  - Focus on providing independent, decision-relevant advice.
  - Focus on science, eschew advocacy.
  - Necessary at times for members to recuse themselves for some decisions.
- Products
  - Advice to action and stakeholder teams.
  - Science strategy plan.
  - Limited data analysis; some review.

Status of Hinkson Creek

Macroinvertebrate Stream Condition Index (MSCI)

- The Missouri Department of Natural Resources (DNR) conducted invertebrate monitoring at 11 sites from 2012 to 2017 to track progress in mitigating impairment. The final metric for the invertebrate monitoring is the Macroinvertebrate Stream Condition Index (MSCI) score.

- The MSCI is a multi-metric score calculated based on macroinvertebrate community attributes, and it is used to assess whether a stream is fully supporting of the beneficial use designation of aquatic life protection as defined in Missouri's Water Quality Standards.

MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

MSCI Scores overview

- MSCI scores range from 4 to 20
- MSCI Scores greater than or equal to 16 indicate “fully supporting” status
- “Fully supporting” of the designated use as defined in Missouri’s Water Quality Standards
- Designated use = protection of aquatic life

MISSOURI DEPARTMENT OF NATURAL RESOURCES

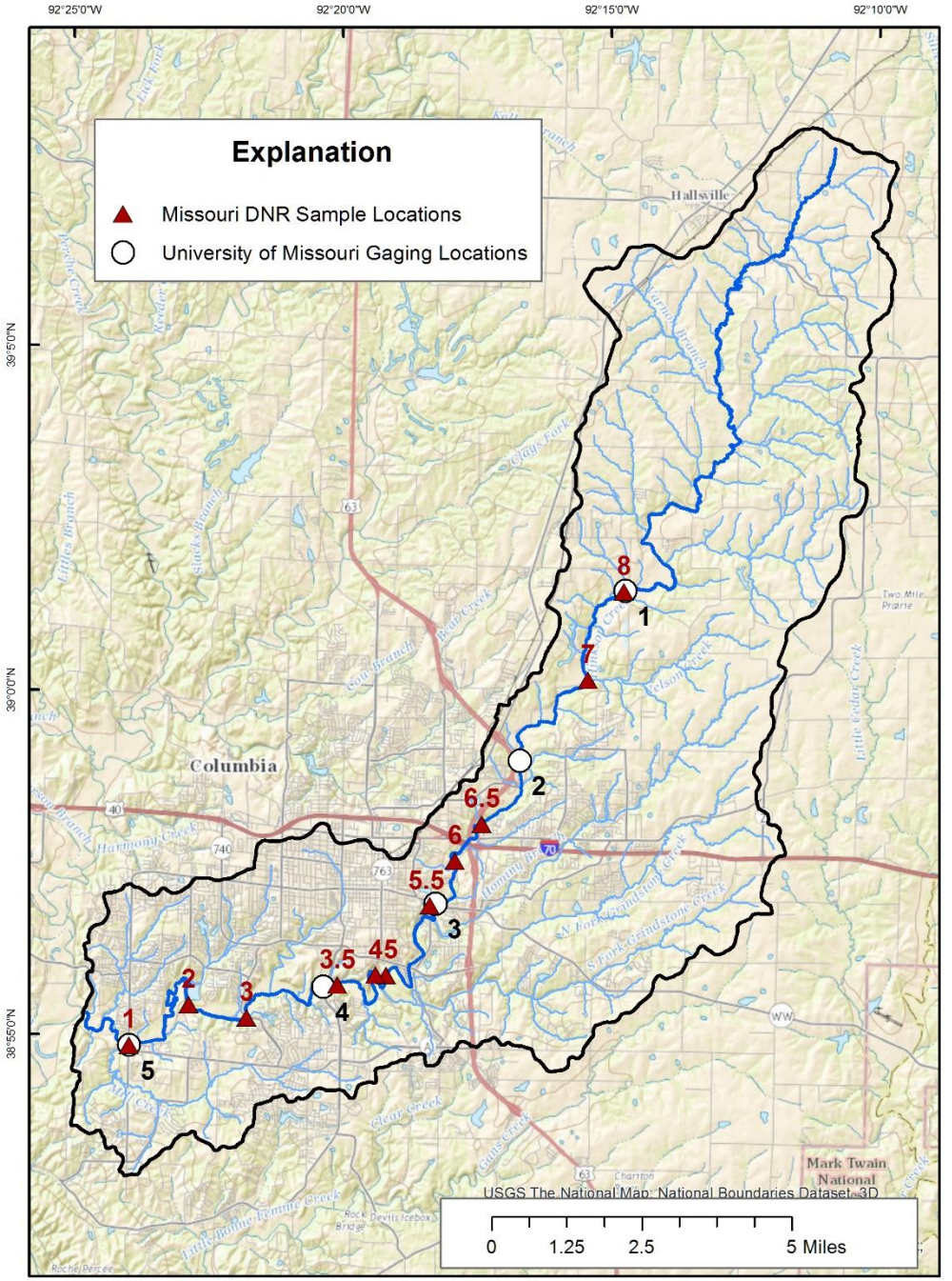
2012 CAM Agreement

- MoDNR agreed to conduct biological assessments for 3 years (2012-2015)
- Drought conditions resulted in “non-representative” conditions in fall 2012 and fall 2013
- Due to drought conditions, MoDNR sampling concluded with the fall 2017 sample season

Hinkson Creek sampling sites

11 DNR sampling locations

University of Missouri gaging stations (Hubbart studies)



MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

Hinkson Creek 2012-2017

Total Samples = 101*

Fully Supporting = 55

Partially Supporting = 46

% Fully Supporting = 54.5

*samples affected by drought or insufficient habitat were excluded from this total.

MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

Ozark/Moreau/Loutre Ecological Drainage Unit Reference Streams

Total Samples = 23
Fully Supporting = 19
Partially Supporting = 4
% Fully Supporting = 82.6

MSCI Scores

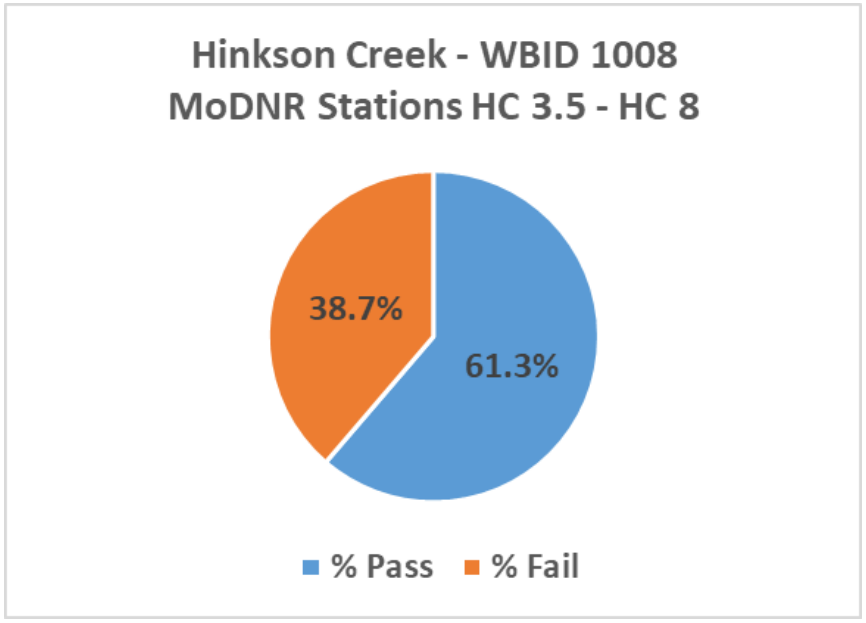
Table 1. Macroinvertebrate Stream Condition Index (MSCI) scores by sampling location and date, 2001 - 2017. Fall 2017 was the most recent sample. Cells are colored from red to green, low to high scores. Cells with values greater than or equal to 16 are fully supporting. Gray cells indicate insufficient samples collected. The delineation between WBID 1007 (downstream) and WBID 1008 (upstream) is at Providence Road, near location 3.5. WBID 1007 is desgnated Class P (permanent flow) whereas WBID 1008 is designated Class C (potential to dry to isolated pools during drought).

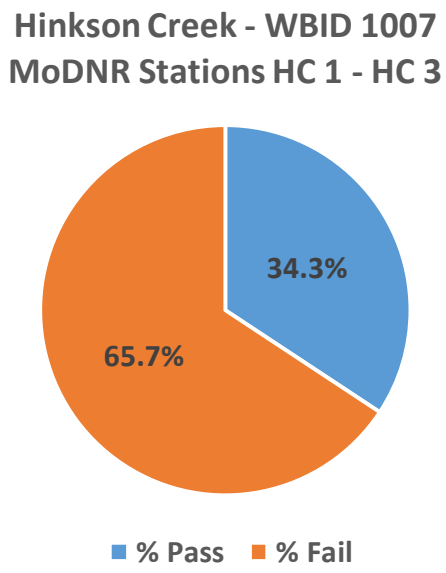
	Date of Sample																		Averages			Calculated Probabilities*					
Sample Location	Fall 2001	Spring 2002	Fall 2003	Spring 2004	Spring 2005	Fall 2005	Spring 2006	Spring 2012	Fall 2012	Spring 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017	2001-2017	2012-2017	2001-2006	Passing scores	Failing Scores	% Passing	% Failing	Reference %	Binomial Probability*
1008																						**57**	**36**	**61%**	**39%**	77.6%	**0.000**
HC 8		16.0						18.0		14.0	16.0	18.0	16.0		12.0	14.0	14.0		15.3	15.3	16.0	5	4	56%	44%	77.6%	0.121
HC 7		16.0	18.0	16.0	16.0	18.0		16.0		16.0	14.0	20.0	16.0		14.0	20.0	16.0		16.6	16.5	16.8	11	2	85%	15%	77.6%	0.824
HC 6.5				16.0				16.0		16.0	14.0	18.0	16.0	16.0	16.0	16.0	14.0		15.8	15.8	16.0	8	2	80%	20%	77.6%	0.692
HC 6	12.0		16.0	14.0	18.0	16.0		14.0		16.0	14.0	20.0	16.0	18.0	12.0	12.0	16.0	12.0	15.1	15.0	15.2	8	7	53%	47%	77.6%	0.033
HC 5.5			14.0	16.0	16.0			16.0		16.0	16.0	18.0	12.0	16.0	16.0	14.0	14.0	16.0	15.4	15.4	15.3	9	4	69%	31%	77.6%	0.329
HC 5								16.0		16.0	12.0	20.0	12.0	14.0	16.0	14.0	14.0	14.0	14.8	14.8		4	6	40%	60%	77.6%	0.011
HC 4		12.0						16.0		16.0	16.0	18.0	14.0	14.0	16.0	14.0	16.0	14.0	15.1	15.4	12.0	6	5	55%	45%	77.6%	0.077
HC 3.5					12.0	12.0		14.0		16.0	16.0	14.0	12.0	16.0	16.0	16.0	12.0	16.0	14.3	14.8	12.0	6	6	50%	50%	77.6%	0.033
1007																						**12**	**23**	**34%**	**66%**	77.6%	**0.000**
HC 3	16.0	12.0					16.0			10.0	12.0	14.0	12.0	16.0	16.0	16.0	16.0	14.0	14.2	14.0	14.7	6	6	50%	50%	77.6%	0.033
HC 2	14.0	12.0					12.0			14.0	12.0	16.0	12.0	16.0	16.0	14.0	14.0	14.0	13.8	14.2	12.7	3	9	25%	75%	77.6%	0.000
HC 1	14.0	14.0					14.0			12.0		14.0	12.0	20.0	16.0	16.0	12.0	14.0	14.4	14.5	14.0	3	8	27%	73%	77.6%	0.001

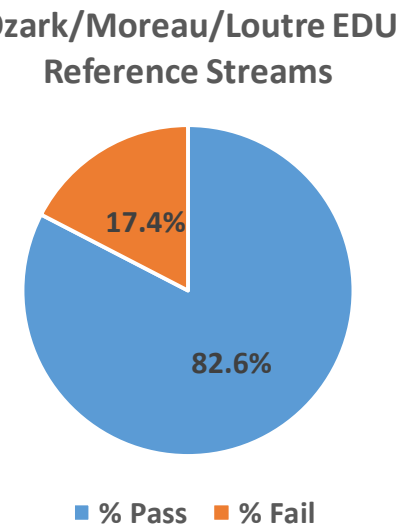
*The binomial calculations for assessing Hinkson Creek's compliance with Missouri's Water Quality Standards were made using Microsoft Excel's BINOMDIST function given the following set of conditions.

1)	To determine whether results are statistically similar/dissimilar, a binomial probability with an appropriate level of significance (α=alpha) is calculated based on the null hypothesis that the test stream (Hinkson Creek) would have a similar percentage of MSCI scores that are 16 or greater as Ozark/Moreau/Loutre EDU biocriteria reference streams (2022 Listing Methodology Document).
2)	Excel BINOMDIST Variables: Number_s=number of successes; Trials=number of independent trials; Probability_s=probability of success on each trial; Cumulative=TRUE.
3)	The percentage of fully supporting scores in the Ozark/Moreau/Loutre EDU BIOREF streams) is 0.826.
4)	From the 2022 Listing Methodology Document: "...rate a stream as impaired if biological criteria reference stream frequency of fully supporting scores is greater than five percent more than the test stream...." Based on that language, Probability_s =0.826-0.05.
5)	Probability_s=0.776
6)	Test level significance is α=0.1.
7)	Null hypothesis: "The test stream has the same percent of fully biologically supporting scores as the BIOREF streams."
8)	Conclusion: if the Cumulative Probability is greater than α=0.1, the null hypothesis is accepted, and the conclusion is "unimpaired."

Comparison of All Hinkson Scores







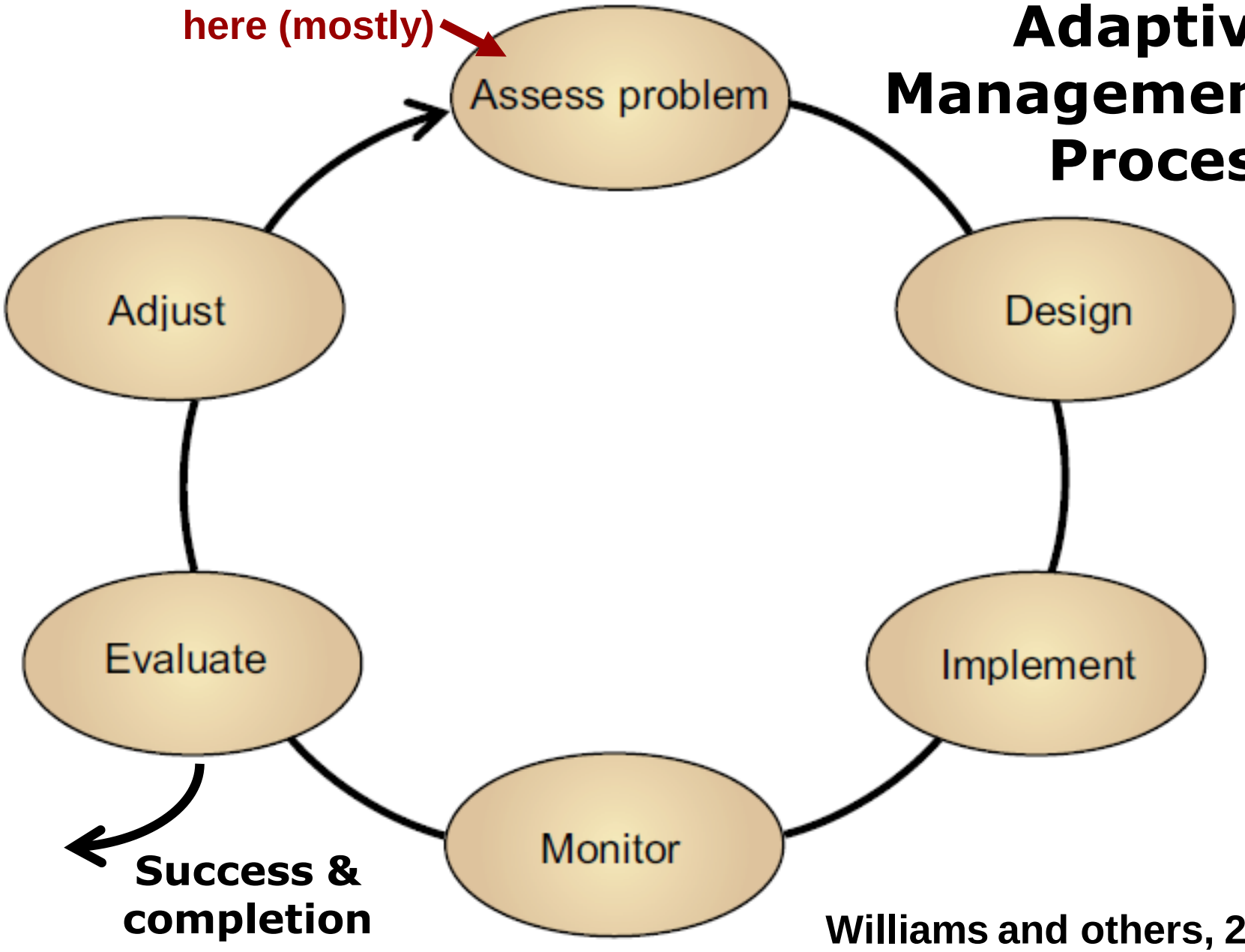
- Invertebrate data shows the Class C portion of the stream is closer to attainment than the Class P segment.

- Continued monitoring will need to determine the effectives of improvements to Hinkson recommended by the Action and Stakeholders Team.

- Delisting would require multiple years of data attaining use and watershed improvements to justify a break point in the data.

"The Mission of the Committee requires any project it considers must clearly and specifically relate to removing Hinkson Creek from its impaired status."

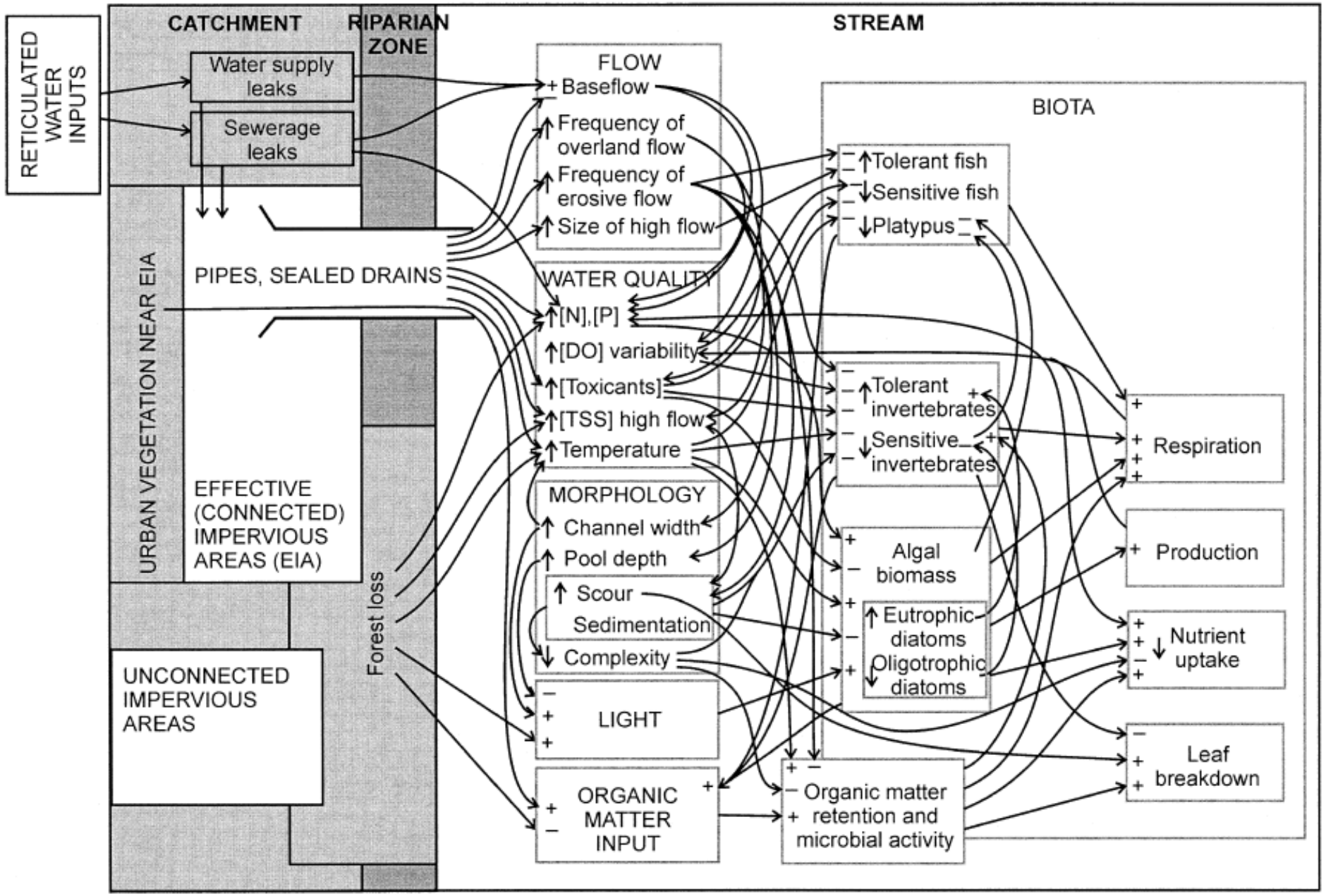
Science and Adaptive Management Process



Williams and others, 2007

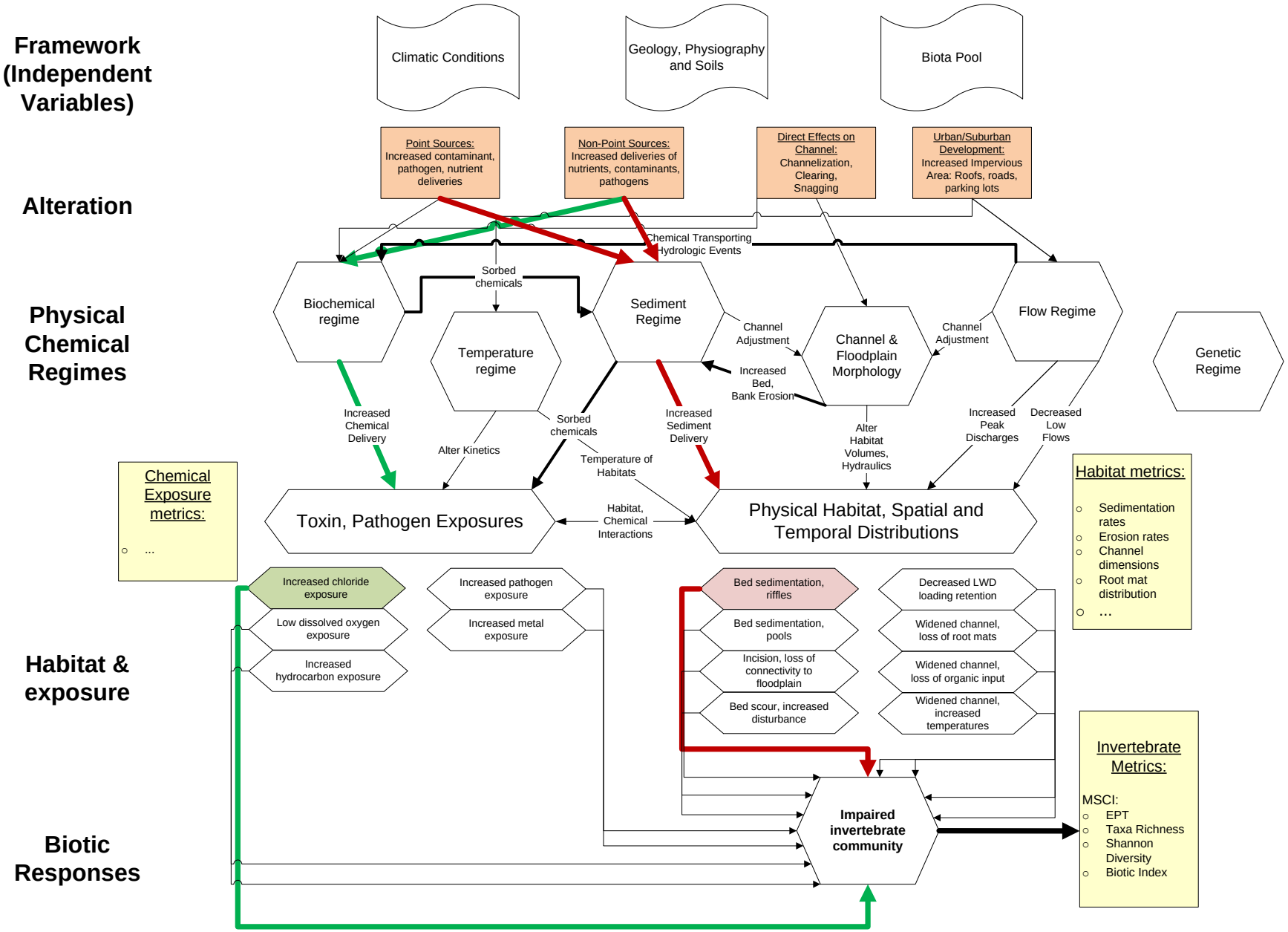
"The term "urban stream syndrome" describes the consistently observed ecological degradation of streams draining urban land... ascribed to... primarily urban stormwater runoff delivered to streams by hydraulically efficient drainage systems"

(Walsh and others, 2005).

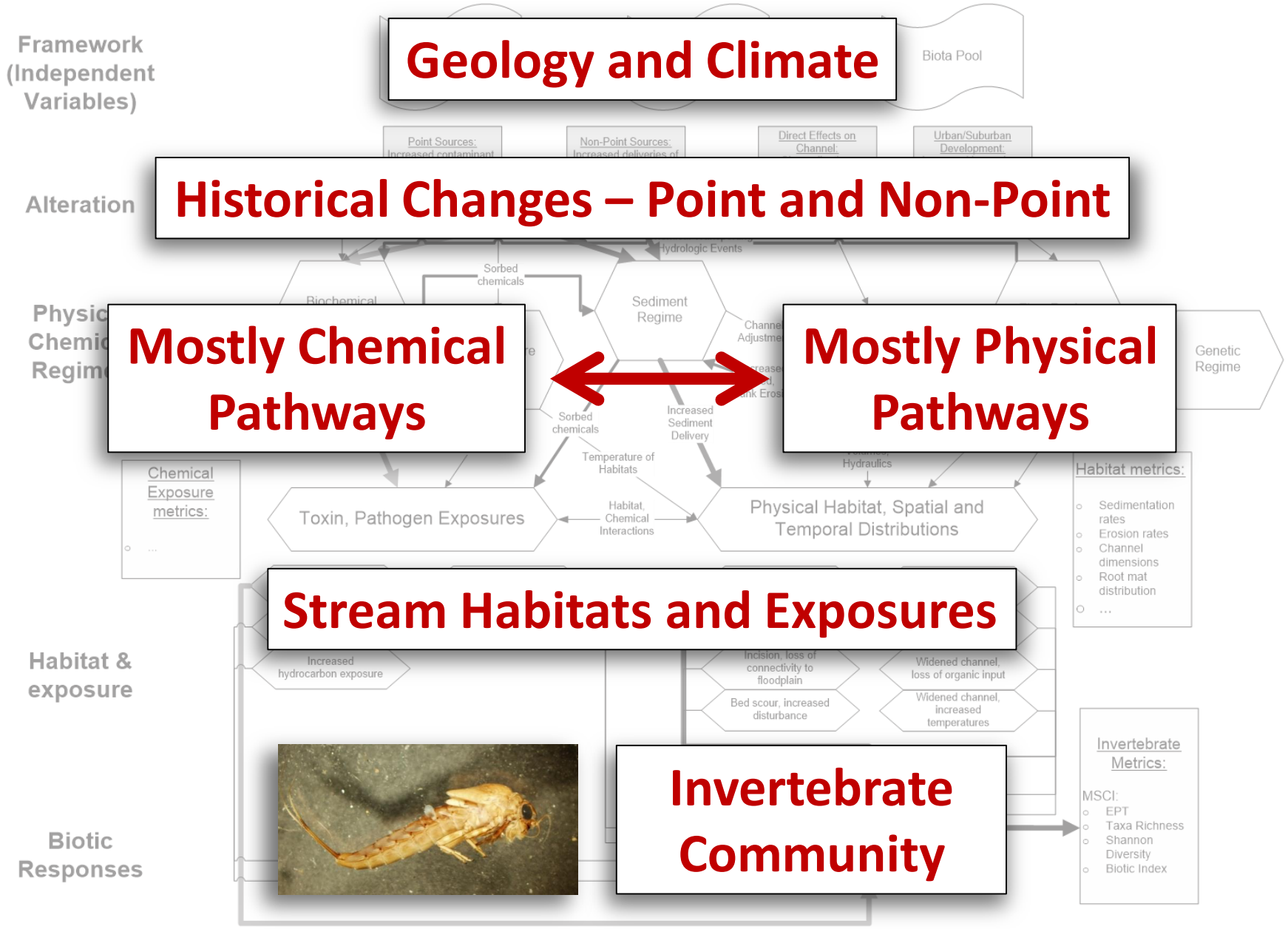


Urban Stream Syndrome (Walsh and others, 2005).

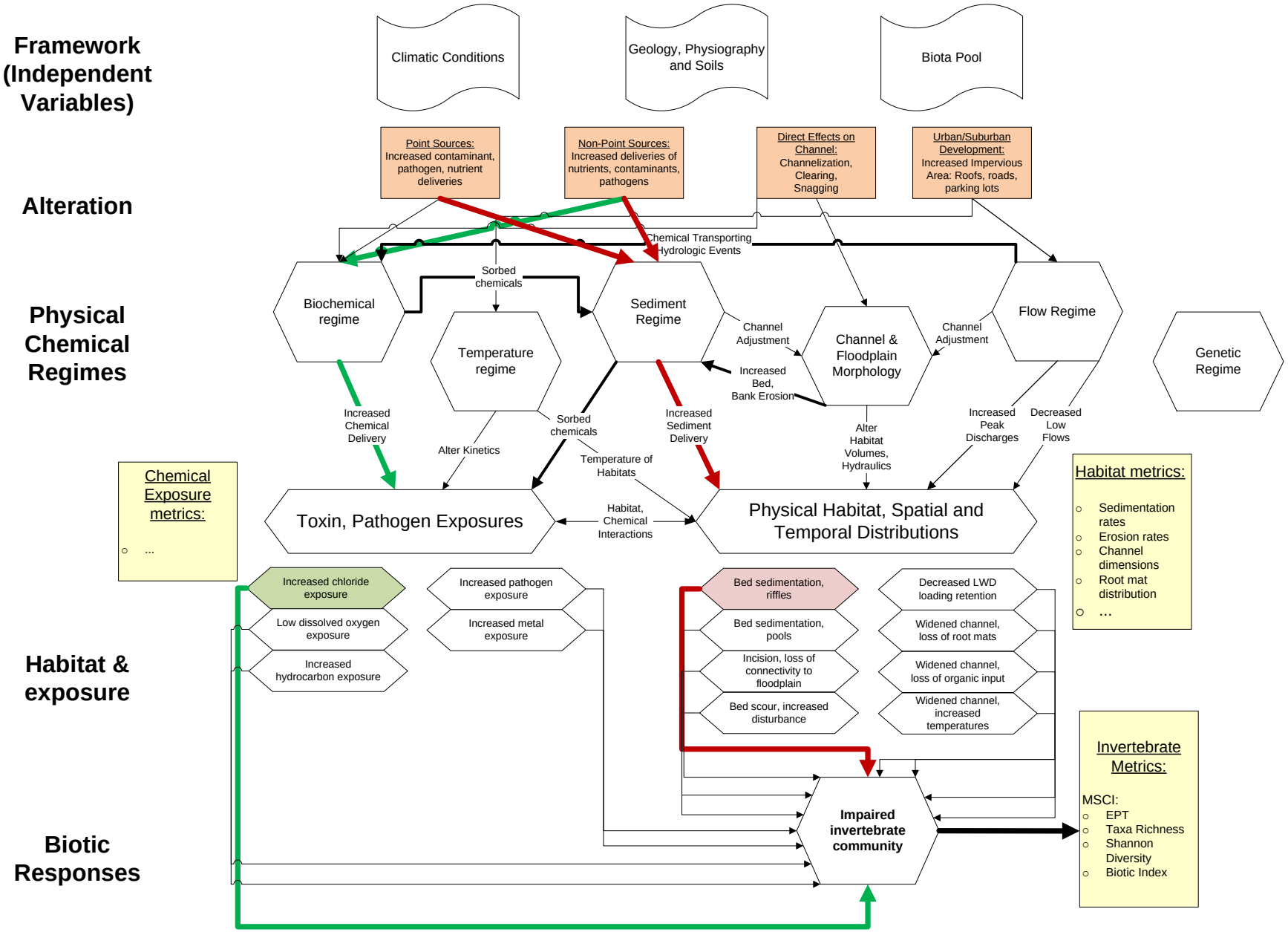
What's wrong with Hinkson Creek?



What's wrong with Hinkson Creek?



What's wrong with Hinkson Creek?



Hinkson Creek Land Use

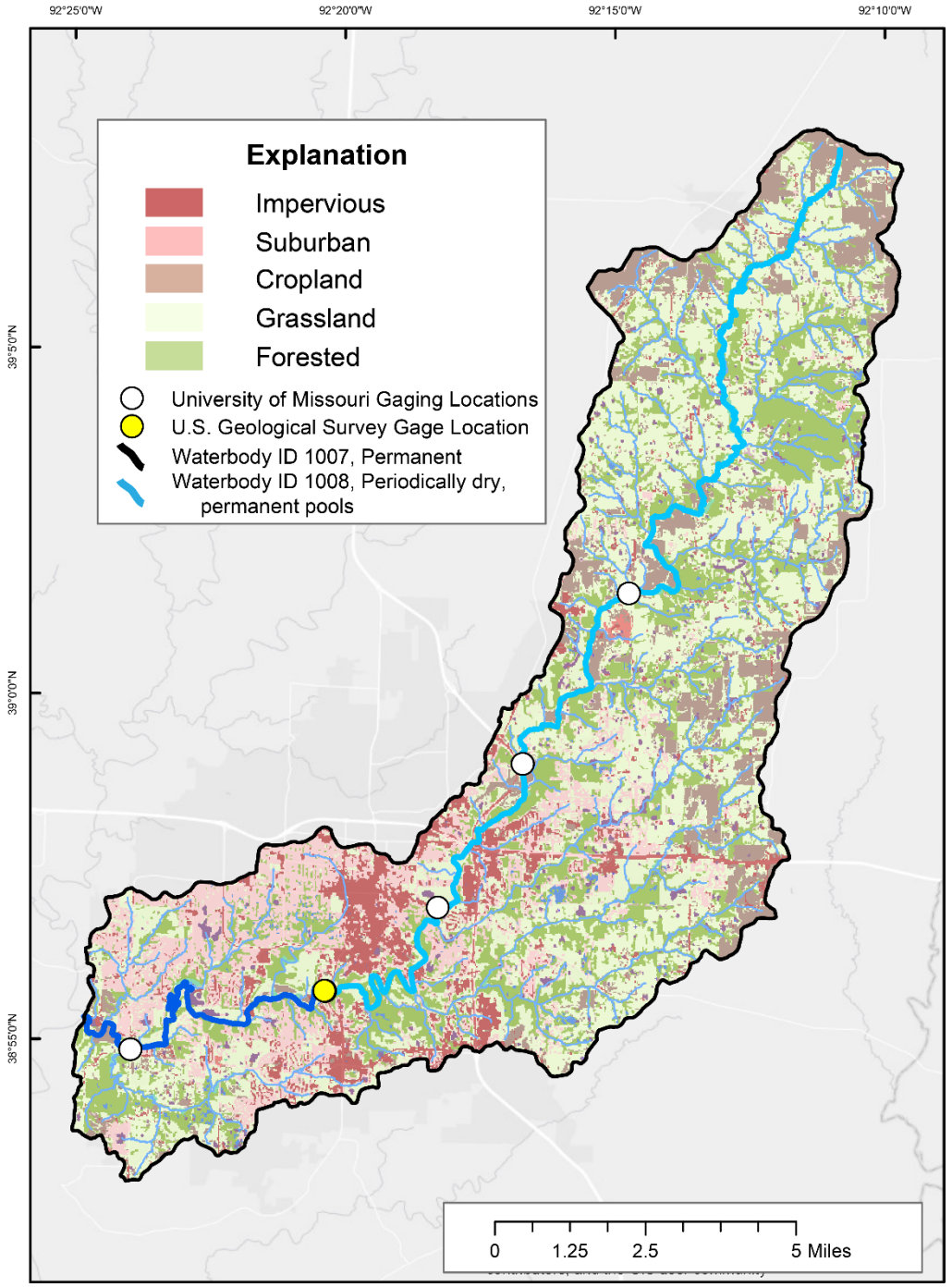
89.8 square miles

Mixed land use

Urban stream syndrome starts about 10% impervious

Columbia is 15%

Hinkson watershed 7%



Hinkson Creek: State of the Science

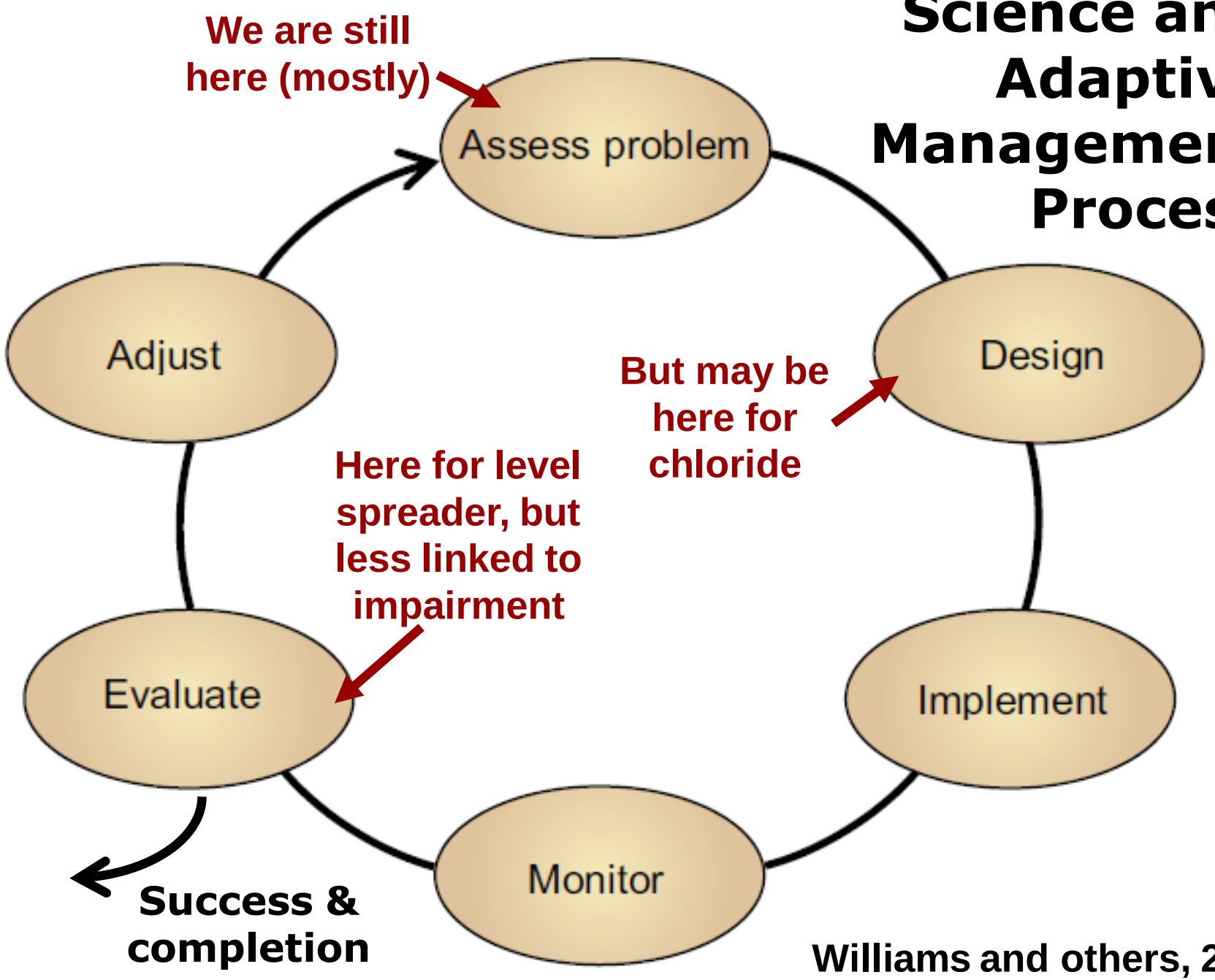
"The purpose of the Science Team is to identify, evaluate and advance the necessary scientific studies needed to support the collaborative adaptive management processes described herein." – CAM agreement

- After nearly 10 years of science investment, there is a *lot* available.
  - Synthesized briefly in the science strategy plan.
- Many strong building blocks; no smoking guns.
- Science has become more focused through time, with learning.

- The state of the science is strong, as shown by the last three webinars.
  - A robust assessment of a level spreader performance.
  - The synthesis of macroinvertebrate data, potential stressors.
  - The synthesis of chemical data: role of chloride in impairment.

"The Mission of the Committee requires any project it considers must clearly and specifically relate to removing Hinkson Creek from its impaired status."

Science and Adaptive Management Process



Williams and others, 2007

Mitigation Projects

"The Science Team will coordinate monitoring and modeling for Hinkson Creek related to the collaborative adaptive management process."

Science Team doesn't really "coordinate" but does discuss, advise.
Science plan presents three questions, three levels of monitoring and assessment:

1. Does the project work as designed?
2. Does the project measurably mitigate impairment to Hinkson Creek?
3. Can the project be scaled up to make a difference, remove Hinkson Creek from impaired status?

Science Priorities

"The Science Team is responsible for understanding available scientific information that is applicable to the questions at hand, selecting the best and most relevant information, and synthesizing it into reports for the Stakeholder Committee." --- *CAM agreement*

Priority section of report presents an organization and discussion about science components relevant to hypotheses about impairment.

- Biological metrics – macroinvertebrate and fish communities
- Chemical stressors – including common chemicals like chloride, sulfate, nutrients… and emerging, exotic chemicals. Links to biota.
- Physical stressors – including suspended sediment, deposited sediment, channel disturbance. Links to biota.
- Special topics – socio-economics, outreach, operational efficiencies.

Science Priorities

Table 4. Listing of science components and Science Team benefit, cost, and benefit:cost scores, March 2021.

				2021 Results			
Category	Serial Number	Component description	Status, March 2021	Average benefit responses	Average cost responses	Average benefit:cost	Notes on sequencing, mechanisms
Physical stressors	11	Lidar analysis of bank retreat and sediment delivery.	Some planning with County GIS.	7.0	4.0	1.8	This component is being discussed by County GIS personnel and could happen any time. It could be completed within 1 year.
Physical stressors	12	Transect based survey of bank erosion.	No progress	6.7	6.0	1.1	This is a long-term project, requiring 3+ years of sampling and would logically follow after the longitudinal sediment phase 2, component 6.1.
Chemical stressors	13	Comprehensive chemical sampling of major water quality parameters or suspected contaminants, high temporal frequency, fixed stations.	Different approach from conductivity, nutrients, or passive samplers. No progress	7.5	7.1	1.1	This is a long-term project requiring 3+ years of sampling to cover hydroclimatic variability. This investment may be more justified after targeted water quality investigations.
Chemical stressors	14.1	Targeted chemical sampling	Deployment of continous conductivity and temperature monitoring stations. Recommended by data-mining report. Will be accompanied with periodic water sampling and lab analysis for calibration, QA/QC, and	7.9	5.8	1.4	This is a logical follow on to the Geosyntec data-mining report. 3+ years would be required to cover hydroclimatic variability.

Table 4 is the fourth iteration of a semi-quantitative prioritization process, table 4.

- Benefit to decision making 1-10. Cost: 1-10. Benefit:cost ratio.
- Most previous science components maintained – progress indicated where progress was substantial.
- Subdivided and added some topics as new ideas were introduced
- Big shift in 2021 compared to earlier. The macroinvertebrate data-mining study and the chloride studies present compelling and actionable information*.

Science Priorities

*Only chloride? Unlikely.

- Macroinvertebrate data-mining study noted lack of deposited sediment data – essential habitat metric.
- Data on sediment erosion, transport, deposition are limited.
- Chloride and conductivity are relatively easy and inexpensive to measure, lending them greater potential influence in decision making.
- As noted by others, impairments to Hinkson are probably multi-faceted.
- How much mitigation of which factors would be sufficient to lead to removal of impaired status?

Science Priorities

Rank	Number	Type	Component	Benefit	Cost	Ratio
Rankings based on benefits						
1	21	Operations, efficiency	Increase collaboration with academia	8.2	4.4	1.9
1	16	Chemical stressor	Road treatment (salt) adaptive management experiment	8.2	6.5	1.3
3	14.1	Chemical stressor	Targeted chemical sampling – conductivity	7.9	5.8	1.4
4	13	Chemical stressor	Comprehensive chemical sampling – major parameters	7.5	7.1	1.1
5	14.2	Chemical stressor	Nutrients – MU study	7.4	4.1	1.8
Rankings based on benefit:cost						
1	15	Chemical stressor	Reanalysis, synthesis of Hubbart data	7.2	2.8	2.5
2	18	Physical stressor	Modeling study of stream disturbance	5.8	2.5	2.3
3	21	Operations, efficiency	Increase collaboration with academia	8.2	4.4	1.9

An Adaptive Management Experiment

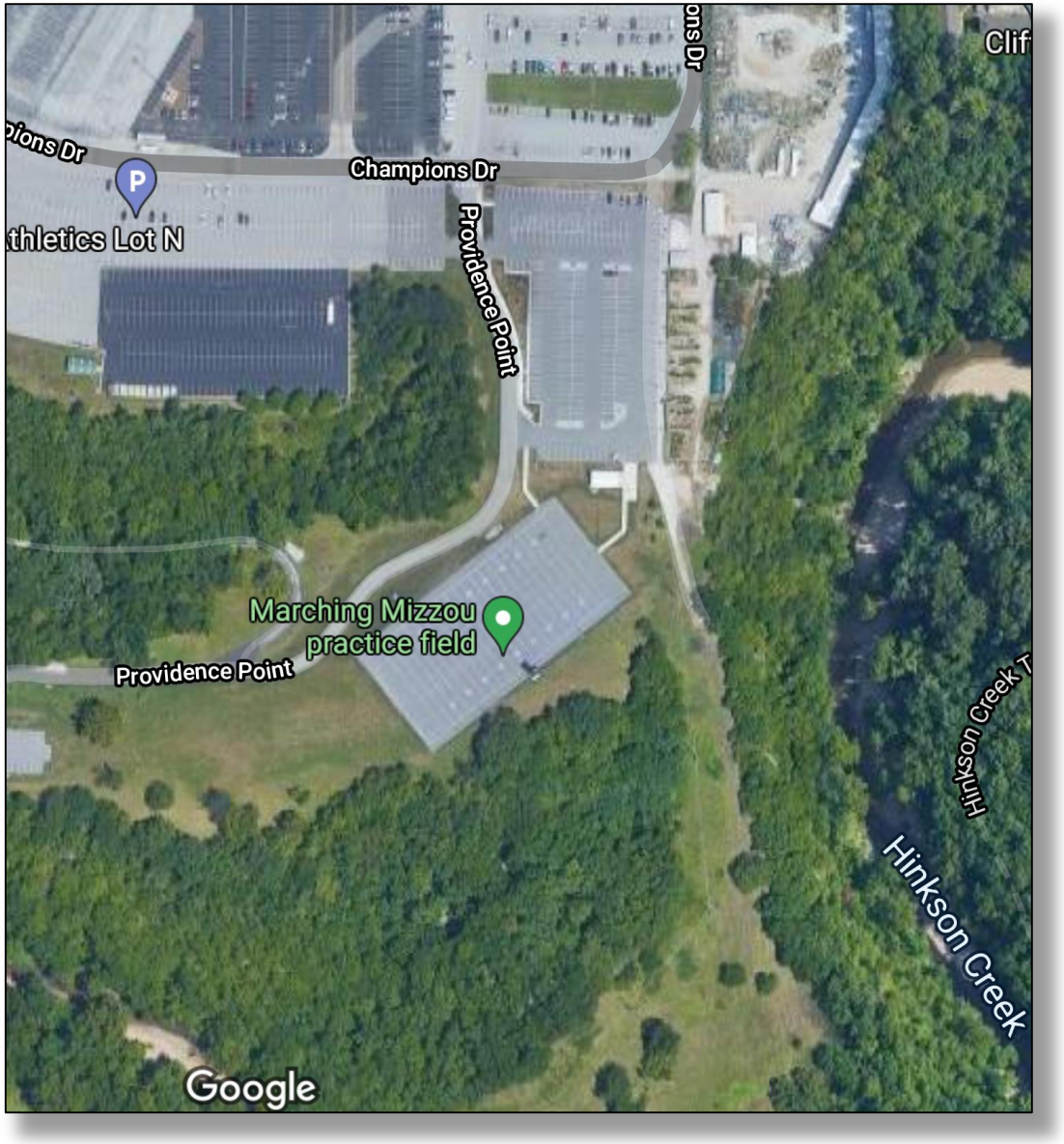
Context:

- Chlorides may reach chronic exposure levels at some times, some places in Hinkson Creek.
- Roads and parking lot treatments are implicated for much, if not all.
- Proposed experiment will address the hypothesis that best-management treatment practices can be applied to minimize chloride loading to Hinkson Creek while maintaining public safety.

An Adaptive Management Experiment

Approach:
Instrumented parking lots with range of treatment levels. Treatments compared to controls. Replicate over storms, treatment levels. Science value and demo value.

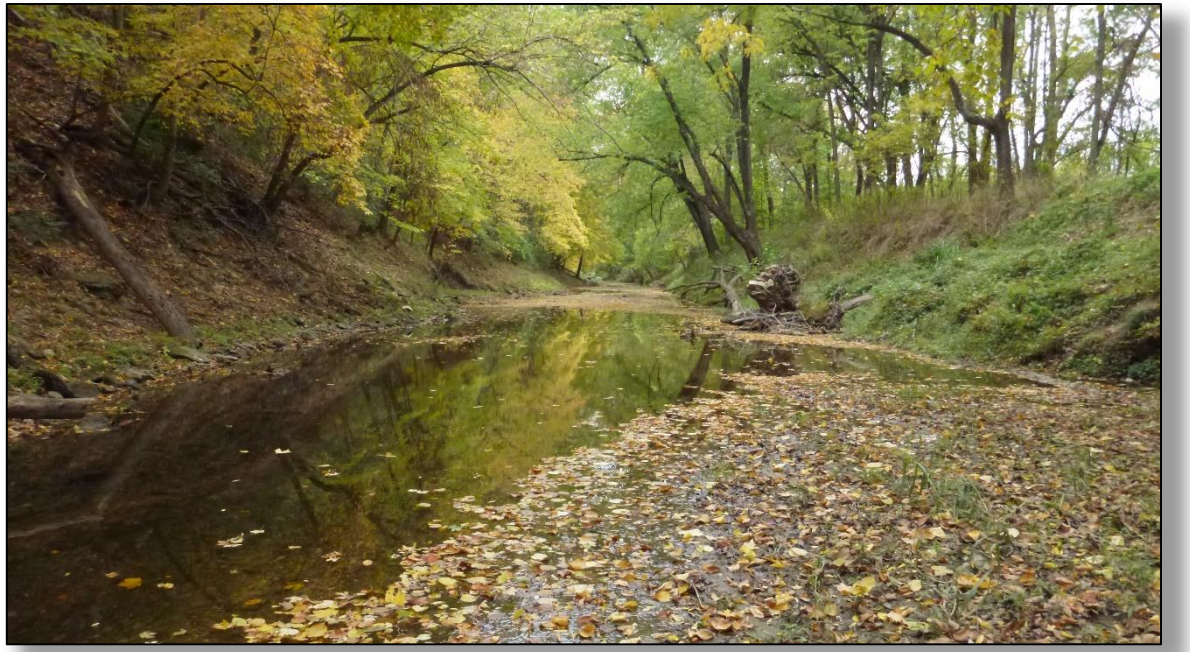
1. Evaluate effectiveness – if it works as designed, lowers chloride, maintains safety.
2. Evaluate whether treatment has a measurable positive effect on impairment.
3. Evaluate whether scaling up treatment BMPs could have effect to remove impairment of Hinkson Creek. Follow-on modeling study.



Science Processes and CAM

The science strategy plan also provides recommendations on how to optimize science in the practice of collaborative adaptive management, accelerate towards delisting.

- It would be beneficial to increase frequency and quality of communication among science, action, and stakeholder teams.
- It would accelerate decision-relevant science if there were a systematic, periodic RFP funding process for Hinkson Creek science projects.
- CAM partners should require quarterly reviews and annual reports from CAM-funded projects.
- CAM should require data collected through CAM-funded projects be distributed into the public domain after a reasonable embargo for publication and quality control.
- CAM partners should consider a peer-review process for Hinkson Creek science.
  - Journal peer review frequently does not address quality and scope needed for local decision making.
  - Science team may be able to do this; ability to commit is unclear.
- CAM partners should fund a data-management + analysis position to support Hinkson Creek science.



Hinkson Creek in perspective

Although impaired, it retains a lot of ecological, aesthetic, and recreational value.