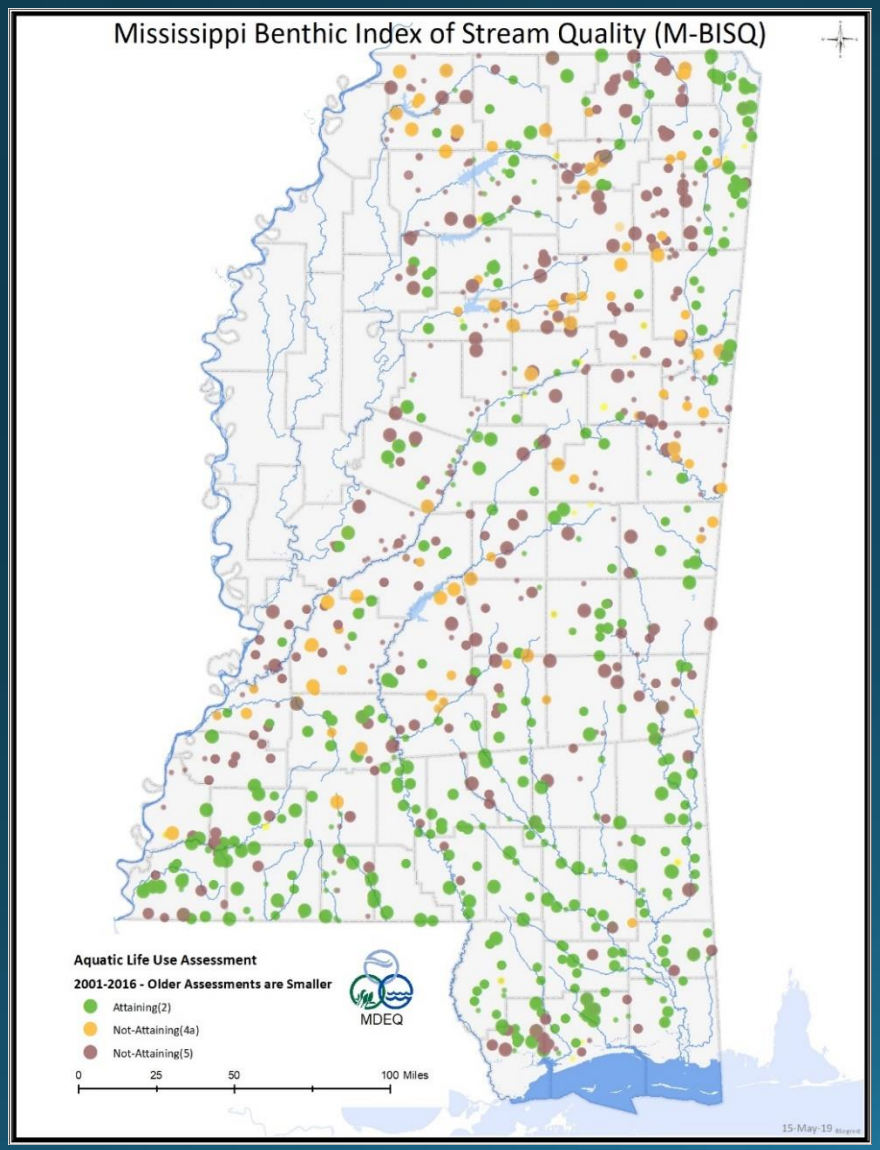
MDEQ Stressor Identification Program



- MDEQ uses M-BISQ to assess waters impaired for ALUS
- 1153 Sites have been sampled with 1686 scored samples
- Data provides high level of confidence in response to specific pollutants
- Interdisciplinary team of engineers and scientists insures consistency and reduces bias

Stressor Identification Process

- Step 1 – Define the impairment
- Step 2 – Compile a list of candidate causes and develop a conceptual model
- Step 3 – Compile all data relevant to the impaired reach according the conceptual model
- Step 4 - Evaluate the data
- Step 5 - Identify the probable causes of impairment using a Strength of Evidence (SOE) approach
- Step 6 - Generate a report of the results

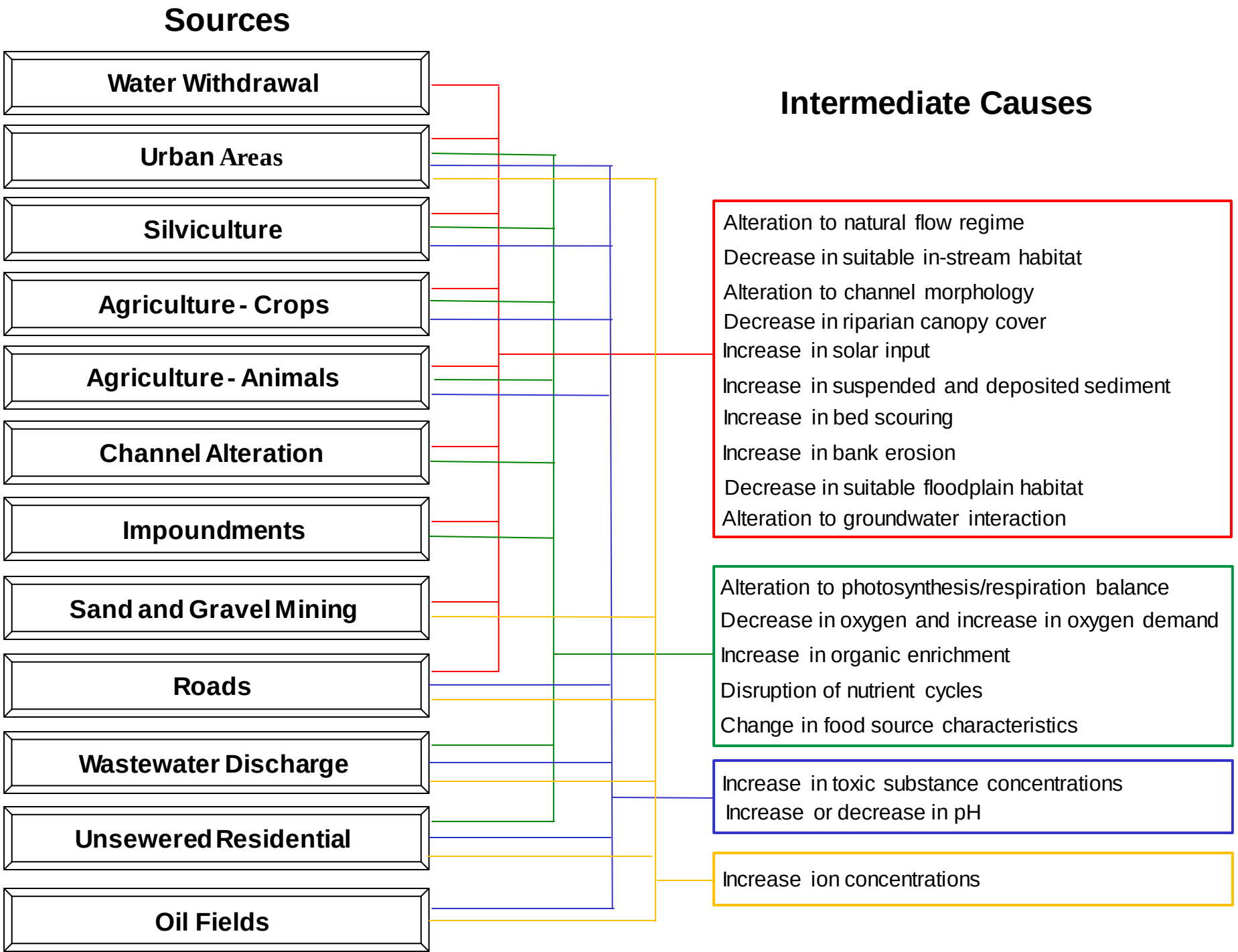
Step 1
Define the impairment

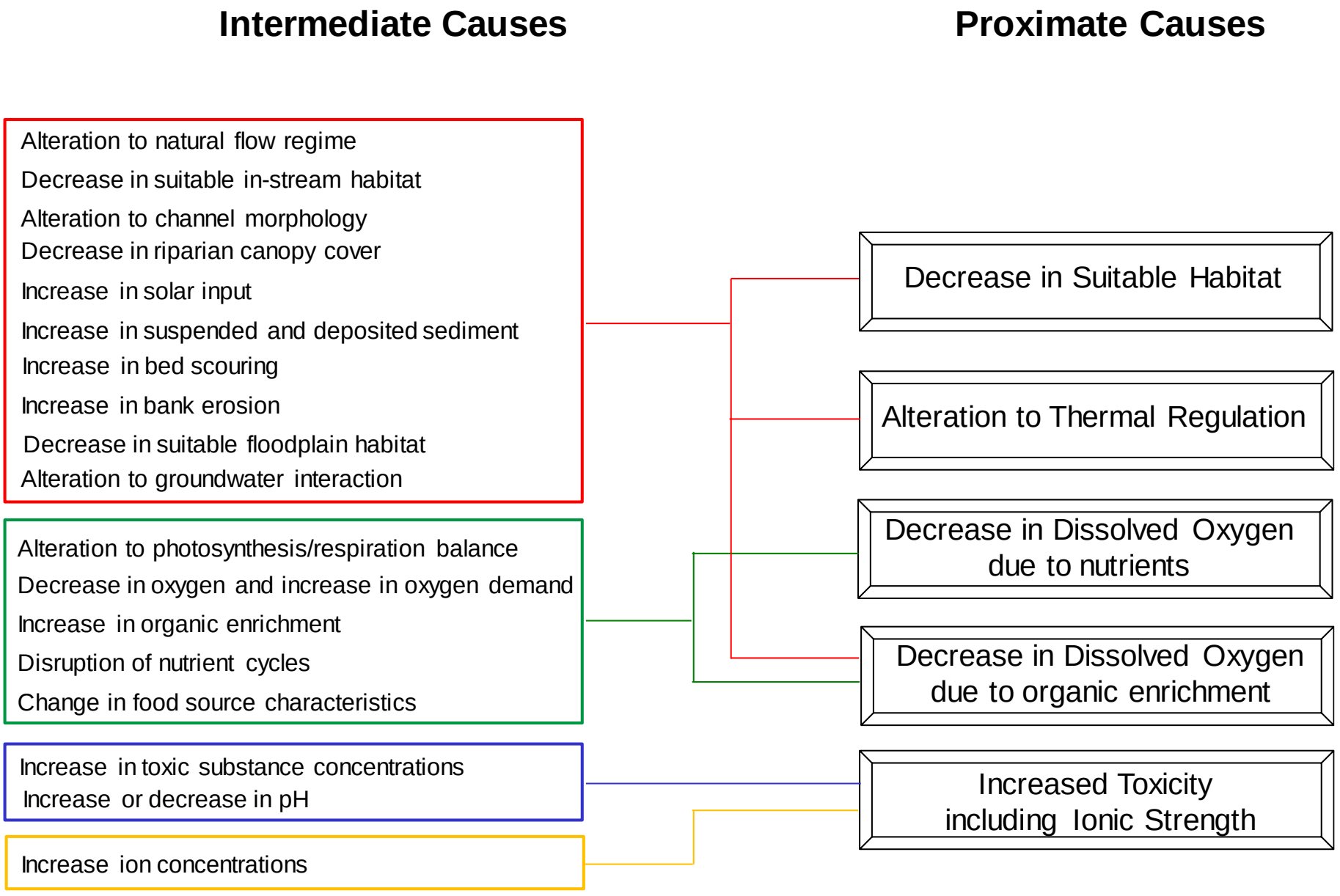
- Describes and lays out the geographic and temporal scope, Information includes:
  - Reach Name
  - Location description
  - Date of the sample used for listing
  - Geographic details; County, Basin, HUC, Ecoregion, Bioregion
  - Dates of other samplings not on date of listed sampling
  - Current LU/LC
  - Historical LU/LC that is different from current
  - Biological metrics used to list the site as impaired (M-BISQ metrics)

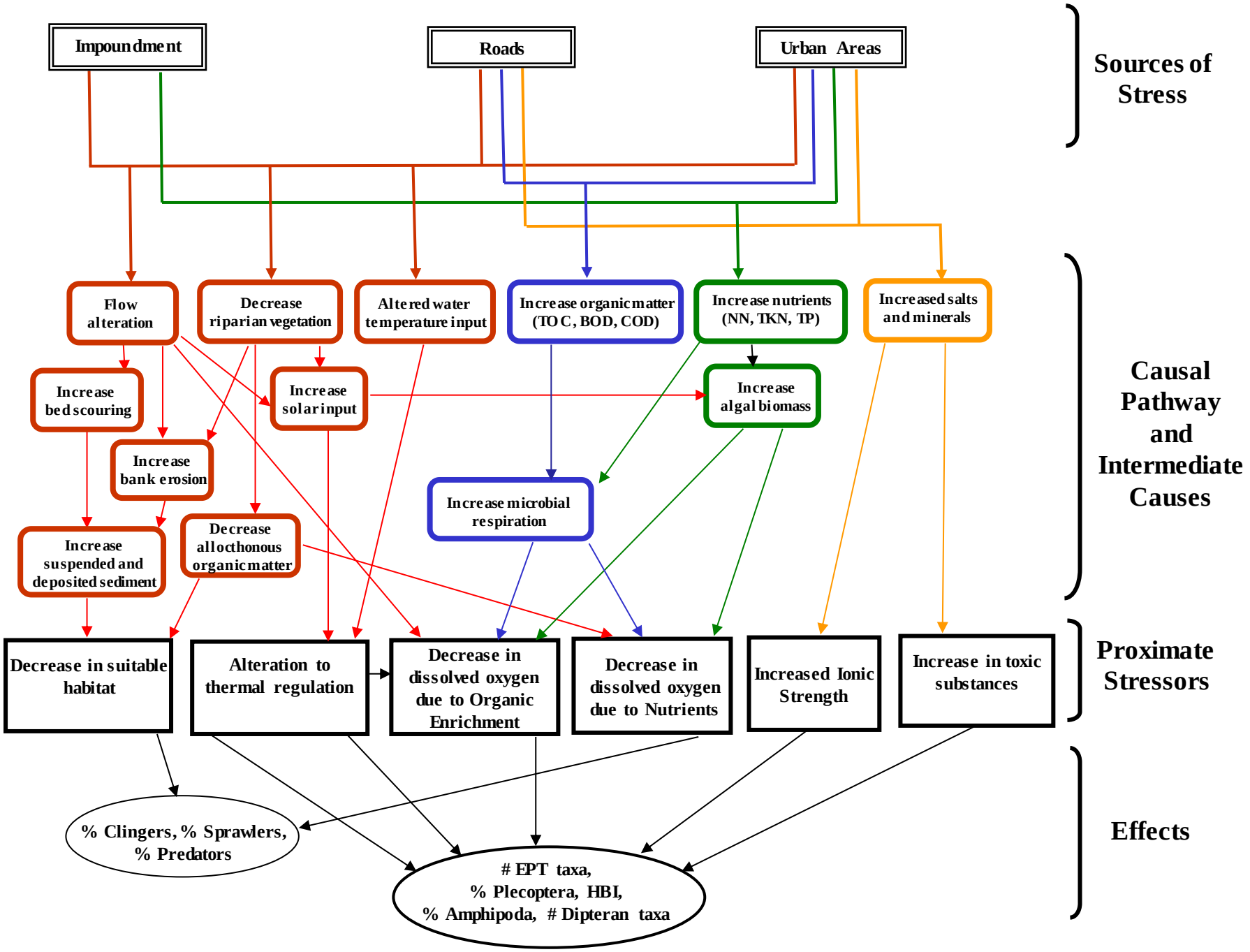
Step 2

Compile list of candidate causes and develop a conceptual model

- Causes
  - Intermediate
    - Part of the causal pathway but do not directly cause the impairment
  - Proximate Causes five major groups
    - Decrease in suitable habitat (includes sediment, physical structure, hydrologic, etc.)
    - Alteration to thermal regime
    - Decrease in dissolved oxygen
      - Due to nutrients
      - Due to organic enrichment
    - Toxicity (includes specific conductance, pH, metals, pesticides….)


Sources
Water Withdrawal
Urban Areas
Silviculture
Agriculture - Crops
Agriculture - Animals
Channel Alteration
Impoundments
Sand and Gravel Mining
Roads
Wastewater Discharge
Unsewered Residential
Oil Fields
Intermediate Causes
Alteration to natural flow regime
Decrease in suitable in-stream habitat
Alteration to channel morphology
Decrease in riparian canopy cover
Increase in solar input
Increase in suspended and deposited sediment
Increase in bed scouring
Increase in bank erosion
Decrease in suitable floodplain habitat
Alteration to groundwater interaction
Alteration to photosynthesis/respiration balance
Decrease in oxygen and increase in oxygen demand
Increase in organic enrichment
Disruption of nutrient cycles
Change in food source characteristics
Increase in toxic substance concentrations
Increase or decrease in pH
Increase ion concentrations


Intermediate Causes
Proximate Causes
Alteration to natural flow regime
Decrease in suitable in-stream habitat
Alteration to channel morphology
Decrease in riparian canopy cover
Increase in solar input
Increase in suspended and deposited sediment
Increase in bed scouring
Increase in bank erosion
Decrease in suitable floodplain habitat
Alteration to groundwater interaction
Alteration to photosynthesis/respiration balance
Decrease in oxygen and increase in oxygen demand
Increase in organic enrichment
Disruption of nutrient cycles
Change in food source characteristics
Increase in toxic substance concentrations
Increase or decrease in pH
Increase ion concentrations
Decrease in Suitable Habitat
Alteration to Thermal Regulation
Decrease in Dissolved Oxygen due to nutrients
Decrease in Dissolved Oxygen due to organic enrichment
Increased Toxicity including Ionic Strength


Impoundment
Roads
Urban Areas
Sources of Stress
Flow alteration
Decrease riparian vegetation
Altered water temperature input
Increase organic matter (TOC, BOD, COD)
Increase nutrients (NN, TKN, TP)
Increased salts and minerals
Increase bed scouring
Increase solar input
Increase algal biomass
Increase bank erosion
Increase microbial respiration
Increase suspended and deposited sediment
Decrease allocthonous organic matter
Causal Pathway and Intermediate Causes
Decrease in suitable habitat
Alteration to thermal regulation
Decrease in dissolved oxygen due to Organic Enrichment
Decrease in dissolved oxygen due to Nutrients
Increased Ionic Strength
Increase in toxic substances
Proximate Stressors
% Clingers, % Sprawlers, % Predators
# EPT taxa, % Plecoptera, HBI, % Amphipoda, # Dipteran taxa
Effects

Step 3
Compile all data relevant to the impairment

- Data sources
  - All data collected during initial site visit
  - MDEQ databases
  - Legacy STORET
  - USGS
  - Geospatial
  - Site reconnaissance

Biological Data

- Macroinvertebrate data
  - At least one sample, maybe more
  - Taxa list and number of each taxa found in sample
  - General pollution tolerance values for each taxa
  - Over 70 metrics calculated from community
    - Richness (i.e. taxa richness)
    - Community make up (i.e. percent EPT)
    - Feeding group metrics (i.e. shredders)
    - Habit metrics (i.e. burrowers)
    - Tolerance metrics (i.e. percent sensitive EPT, percent tolerant organisms)

Collect during Biological Sampling

- Water Quality
  - At least one sample from time of bio sample collection, maybe more
  - D.O. (point), pH, Temp., Specific Conductance
  - Nutrients (T and P)
  - COD, TOC, TSS, Turbidity
- Habitat Assessment
  - Qualitative, ten categories
    - 3 substrate/habitat availability and makeup
    - 4 geomorphic
    - 3 riparian
- Substrate particle size

Comparison Report

	Stressed Site	Difference from LD condition		Least Disturbed Condition				Difference from LD condition	
Chemical Parameters	Rambo Creek	East LD	East Non-impaired	East LD	East Non-impaired	percentile used for LD		East LD	East Non-impaired
Specific Conductance	35.00	**NA**	**NA**	61.68	61.25	75th		43.25	42.86
Dissolved Oxygen (% Sat)	94.40	**comparable**	**comparable**	93.00	92.85	25th		1.51	1.67
Ammonia	0.16	**comparable**	**comparable**	0.15	0.17	75th		6.67	5.88
Nitrate + Nitrite	0.03	**lower**	**lower**	0.17	0.25	75th		82.35	88.00
Total Kjeldehal Nitrogen	0.16	**lower**	**lower**	0.45	0.49	75th		64.44	67.35
Total Nitrogen	0.19	**lower**	**lower**	0.56	0.67	75th		66.07	71.75
pH	6.26	**lower**	**lower**	6.66	6.84	75th		6.01	8.41
Total Phosphorus	0.03	**lower**	**lower**	0.04	0.05	75th		25.00	40.00
Temperature	3.94	**lower**	**lower**	8.05	8.18	50th		51.06	51.80
Total Organic Carbon	4.00	**lower**	**lower**	5.00	5.00	75th		20.00	20.00
Chemical Oxygen Demand	10.00	**lower**	**lower**	12.50	14.00	75th		20.00	28.57
Total Chlorides	3.60	**higher**	**higher**	3.95	4.80	75th		8.86	25.00
Alkalinity	10.00	**higher**	**higher**	11.55	12.10	75th			
Turbidity	17.00	**higher**	**higher**	21.00	21.25	75th			
Physical Parameters									
Basin Area	4168.78	**larger**	**larger**	10772.66	14621.38	50th		61.30	71.49
Total Habitat Score	170.00	**lower**	**lower**	122.00	118.00	25th		39.34	44.07
Instream Cover Habitat Score	50.00	**comparable**	**comparable**	36.00	31.00	25th		38.89	61.29
Channel Habitat Score	66.00	**higher**	**higher**	50.00	49.25	25th		32.00	34.01
Bank Habitat Score	54.00	**lower**	**lower**	32.00	29.25	25th		68.75	84.62
% Silt/Clay	3.00	**lower**	**lower**	18.00	15.00	50th		83.33	80.00
% Sand	97.00	**lower**	**lower**	68.00	72.00	50th		42.65	34.72
% Gravel	0.00	NA	NA	0.00	0.00	50th		NA	NA
% Cobble	0.00	NA	NA	0.00	0.00	50th		NA	NA
% Boulder	0.00	NA	NA	0.00	0.00	50th		NA	NA
% Bedrock	0.00	NA	NA	0.00	0.00	50th		NA	NA
% Hardpan Clay	0.00	**higher**	**higher**	0.00	0.00	50th		NA	NA

Comparison Report

	Stressed Site	Site Specific Comparators				
Chemical Parameters	Rambo Creek	Wolf Creek	unnamed trib to Poplar Creek	Scoobachita Creek	Atwood Creek	percentile used for LD
Specific Conductance	35.00	40.00	20.80	35.90	35.90	75th
Dissolved Oxygen (% Sat)	94.40	99.82	91.80	96.40	96.40	25th
Ammonia	0.16	0.10	0.02	0.02	0.02	75th
Nitrate + Nitrite	0.03	0.14	0.01	0.02	0.02	75th
Total Kjeldehal Nitrogen	0.16	0.53	0.02	0.49	0.49	75th
Total Nitrogen	0.19	0.67	0.03	0.51	0.51	75th
pH	6.26	6.29	5.93	5.89	5.89	75th
Total Phosphorus	0.03	0.03	0.02	0.03	0.03	75th
Temperature	3.94	1.87	7.29	8.15	8.15	50th
Total Organic Carbon	4.00	2.00	5.00	5.00	5.00	75th
Chemical Oxygen Demand	10.00	12.00	5.00	5.00	5.00	75th
Total Chlorides	3.60	3.40	2.40	3.10	3.10	75th
Alkalinity	10.00	18.60	5.00	5.00	5.00	75th
Turbidity	17.00	21.00	12.00	18.00	18.00	75th

Comparison Report

		Stressed Site	Difference from LD		Least Disturbed			Difference from LD condition	
East Bioregional Metrics	**Response to Stress**	Rambo Creek	East LD	East Non-impaired	East LD	East Non-impaired	percentile used for LD	East LD	East Non-impaired
M-BISQ Score	decrease	62.34	**lower**	**lower**	65.55	68.30	25th	4.89	8.73
# of Diptera Taxa	decrease	15.00	**comparable**	**comparable**	16.00	16.00	25th	6.25	6.25
# of EPT Taxa	decrease	11.00	**comparable**	**lower**	7.00	9.00	25th	57.14	22.22
# of Filter Feeding Taxa	decrease	6.00	**lower**	**lower**	4.00	5.00	25th	50.00	20.00
# Predator Taxa	decrease	15.00	**comparable**	**lower**	7.00	7.00	25th	114.29	114.29
# of Shredder Taxa	decrease	3.00	**higher**	**higher**	4.00	4.00	25th	25.00	25.00
# of Gastropoda Taxa	increase	1.00	**lower**	**lower**	1.00	1.00	75th	0.00	0.00
# of Clinger Taxa	decrease	14.00	**lower**	**lower**	10.00	13.00	25th	40.00	7.69
# of Insect Taxa	decrease	34.00	**comparable**	**lower**	28.00	31.00	25th	21.43	9.68
# of Intolerant Taxa	decrease	10.00	**higher**	**lower**	7.00	8.25	25th	42.86	21.21
# of Non-Insect Taxa	increase	6.00	**comparable**	**comparable**	7.00	7.00	75th	14.29	14.29
# of Plecoptera Taxa	decrease	2.00	**higher**	**higher**	1.00	2.00	25th	100.00	0.00
# of Total Taxa	decrease	40.00	**higher**	**lower**	34.00	36.00	25th	17.65	11.11
Percent Amphipoda Individuals	increase	0.44	**higher**	**higher**	1.76	1.04	75th	75.13	57.92
Percent Caenidae Individuals	increase	0.44	**higher**	**higher**	3.88	2.74	75th	88.75	84.04
Percent Cricotopus, Orthocladius and Chironomus Individuals	increase	0.00	**higher**	**higher**	6.67	6.59	75th	100.00	100.00
Percent Crustacean Molluscan Individuals	increase	3.06	**higher**	**higher**	7.02	7.07	75th	56.46	56.78
Percent Dipteran Individuals	decrease	72.49	**lower**	**lower**	44.41	44.01	25th	63.24	64.71
Percent Ephemeroptera Individuals	decrease	11.35	**higher**	**higher**	4.74	6.47	25th	139.39	75.49
Percent EPT (No Caenidae) Individuals	decrease	16.59	**lower**	**lower**	11.74	15.28	25th	41.33	8.61
Percent Sensitive EPT Individuals	decrease	15.72	**lower**	**lower**	9.93	11.77	25th	58.32	33.54
Percent Gastropoda Individuals	increase	0.44	**higher**	**higher**	0.50	0.50	75th	12.66	12.12
Percent Sprawler Individuals	increase	19.65	**higher**	**higher**	32.38	28.68	75th	39.32	31.48
Percent Intolerant Individuals	decrease	9.61	**lower**	**lower**	8.40	9.52	25th	14.43	0.95
Percent Plecoptera Individuals	decrease	1.75	**higher**	**higher**	1.72	1.86	25th	1.73	5.90
Percent Tanytarsini Individuals	decrease	9.61	**lower**	**lower**	4.91	7.55	25th	95.64	27.28
Percent Tolerant Individuals	increase	3.93	**higher**	**higher**	10.01	6.24	75th	60.76	36.97
Percent Gastropoda Taxa	increase	2.50	**higher**	**higher**	2.33	2.26	75th	7.50	10.61
Percent Non-Insect Taxa	increase	15.00	**higher**	**higher**	18.43	17.86	75th	18.63	16.00
Percent Tolerant Taxa	increase	7.44	**higher**	**higher**	11.56	8.69	75th	35.58	14.36
Percent Intolerant Taxa	decrease	25.00	**lower**	**lower**	20.55	21.77	25th	21.65	14.82
Beck's Biotic Index	decrease	22.00	**lower**	**lower**	14.00	18.00	25th	57.14	22.22
Hilsenhoff's Biotic Index	increase	4.13	**higher**	**higher**	4.60	4.37	75th	10.10	5.38
North Carolina Biotic Index	increase	6.08	**higher**	**higher**	6.81	6.62	75th	10.62	8.12
Shannon Diversity Index	decrease	2.59	**higher**	**higher**	2.57	2.71	25th	0.87	4.47

Comparison Report

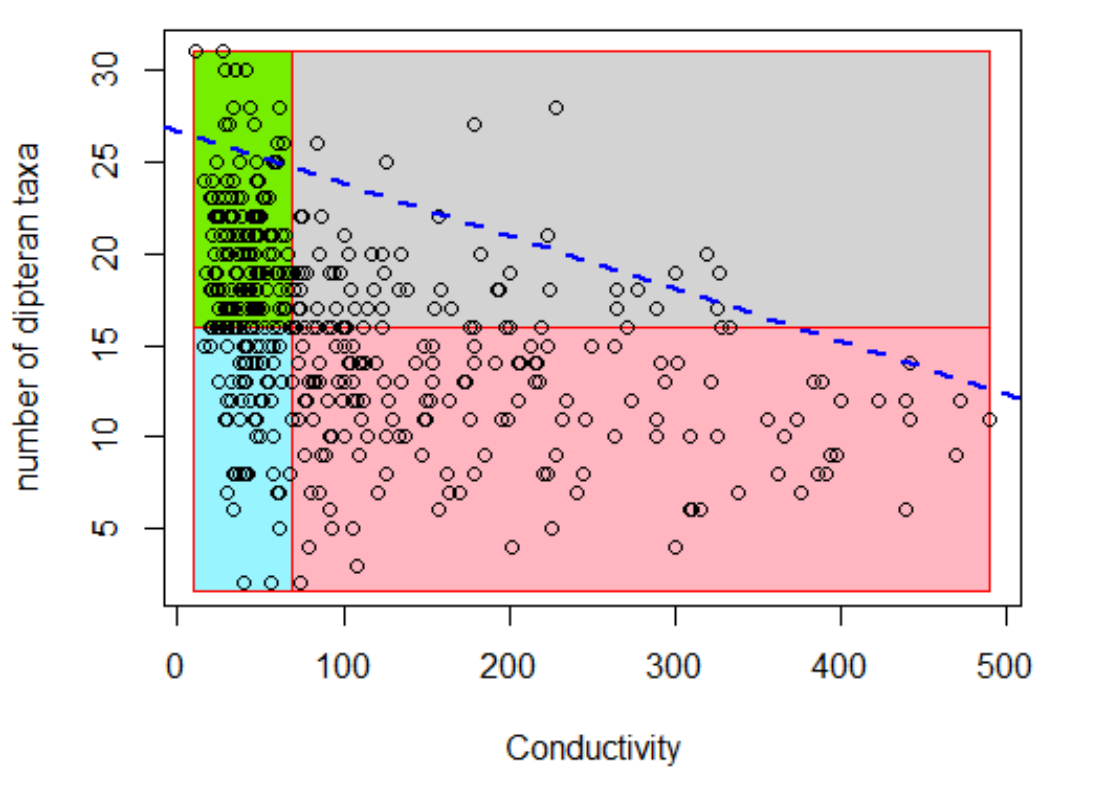
		Stressed Site	Site Specific Comparators				
East Bioregional Metrics	**Response to Stress**	Rambo Creek	Wolf Creek	unnamed trib to Poplar Creek	Scoobachita Creek	Atwood Creek	percentile used for LD
M-BISQ Score	decrease	62.34	68.34	72.40	77.74	68.68	25th
# of Diptera Taxa	decrease	15.00	15.00	21.00	21.00	23.00	25th
# of EPT Taxa	decrease	11.00	14.00	9.00	10.00	8.00	25th
# of Filter Feeding Taxa	decrease	6.00	5.00	5.00	5.00	5.00	25th
# Predator Taxa	decrease	15.00	15.00	8.00	12.00	11.00	25th
# of Shredder Taxa	decrease	3.00	7.00	5.00	6.00	4.00	25th
# of Gastropoda Taxa	increase	1.00	0.00	0.00	0.00	0.00	75th
# of Clinger Taxa	decrease	14.00	16.00	12.00	14.00	13.00	25th
# of Insect Taxa	decrease	34.00	40.00	34.00	38.00	34.00	25th
# of Intolerant Taxa	decrease	10.00	8.00	13.00	15.00	14.00	25th
# of Non-Insect Taxa	increase	6.00	4.00	0.00	5.00	6.00	75th
# of Plecoptera Taxa	decrease	2.00	6.00	3.00	2.00	0.00	25th
# of Total Taxa	decrease	40.00	44.00	34.00	43.00	40.00	25th
Percent Amphipoda Individuals	increase	0.44	2.49	0.00	0.53	0.00	75th
Percent Caenidae Individuals	increase	0.44	3.48	0.45	2.11	0.00	75th
Percent Cricotopus, Orthocladius and Chironomus Individuals	increase	0.00	8.51	0.87	0.00	1.74	75th
Percent Crustacean Molluscan Individuals	increase	3.06	9.45	0.00	0.53	2.90	75th
Percent Dipteran Individuals	decrease	72.49	47.76	83.26	65.79	86.96	25th
Percent Ephemeroptera Individuals	decrease	11.35	11.94	1.81	6.32	2.90	25th
Percent EPT (No Caenidae) Individuals	decrease	16.59	22.39	11.31	13.16	6.76	25th
Percent Sensitive EPT Individuals	decrease	15.72	18.91	10.41	11.58	5.80	25th
Percent Gastropoda Individuals	increase	0.44	0.00	0.00	0.00	0.00	75th
Percent Sprawler Individuals	increase	19.65	26.37	17.65	14.74	15.46	75th
Percent Intolerant Individuals	decrease	9.61	6.47	16.74	18.95	15.46	25th
Percent Plecoptera Individuals	decrease	1.75	7.46	3.62	5.26	0.00	25th
Percent Tanytarsini Individuals	decrease	9.61	4.48	12.22	15.26	52.66	25th
Percent Tolerant Individuals	increase	3.93	10.45	1.81	2.63	0.97	75th

Step 4

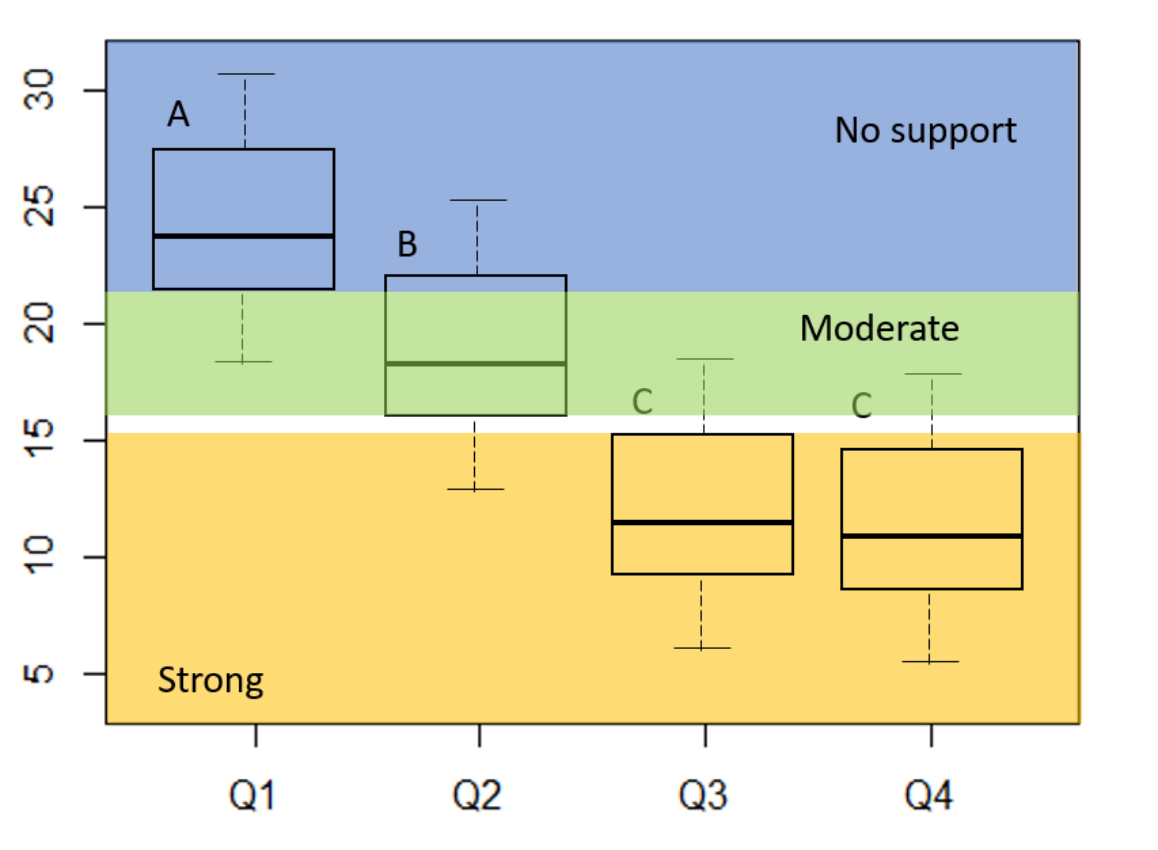
Evaluate the data

- Strength-of-evidence approach
- Use a SOE spreadsheet to document process
- Co-occurrence
  - Use Data collected from time the sample was collected that resulted in listing of impairment
    - Phys/Chem, Bio metrics
    - Compared to LD/NI condition and SSCs
    - Comparison report
- Complete causal pathway
  - Use data from other times
    - Recon
    - Watershed characteristics
    - Point sources
    - EnSpire
- Plausibility Stressor-response
  - Use Data collected from time the sample was collected that resulted in listing of impairment
    - Compare against Scatterplots and Box and Whisker Plots

Causal Consideration		Decrease in Suitable habitat		Alteration to Thermal Regulation		Decreased Dissolved Oxygen due to Nutrients		Decreased Dissolved Oxygen due to Organic Enrichment		Increased toxicity (toxic substances and/or ionic strength)	
		Evidence	Score	Evidence	Score		Score		Score	Evidence	Score
within-case	**Co-occurrence** This uses data from time of the biological sample collected - Comparison Spreadsheet	**Document the habitat scores here, and specific taxa that support**									
within-case	**Complete Causal Pathway** This uses other data from the site (not data from co-occurrence) compared to upstream/downstream, SSC, and/or LD ONLY for indirect indicators	**This is the total score for the below 5**									
	Recon (instream stations)										
	Watershed Characteristics (Recon watershed observations/LULC/MWCRT), SuperFunds/Brownfields, etc.										
	Point Source (EnSite, CTS)										
	Enspire										
	Other Data Sources: Facilities, IHL, Federal, Water Quality Portal										
at other places	**Plausibility- stressor - response:** Given the known relationship between the cause and the affect as stated above, would the effect be expected at the level of stressor seen at the site? Use correlations and scatter plots and any literature derived curves associations	**This is the total score for the below 5**									
	Scatter Plots:						-				
	Box Plots:						-				
multiple lines of evidence	**Consistency of evidence:** Given the above lines of evidence, does the evidence all support the candidate cause?	**This is the total score for the above 3 main**					--				
Probability of Cause Resulting in Effect:											



- **Upper left quadrat** : if site is in this quadrat of the regional distribution, the scatterplot contradicts the hypothesis, and is scored as ***incompatible (-)***. In this example, conductivity is lower than the regional median and number of dipteran taxa is greater than the regional median, suggesting that conductivity is not causing biological impairment at site A.
- **Lower left quadrat:** If site is in this quadrat, the scatterplot contradicts the hypothesis, and is scored as ***incompatible (-).*** In this example, the number of dipteran taxa is less than the regional median (suggesting biological impairment) but conductivity is less than the regional median. If site A falls in this quadrat, evidence from the scatterplot suggests that a physical or chemical variable *other than the one plotted* is causing the biological impairment.
- **Upper right quadrat**: If site is in this quadrat, the scatterplot neither supports or contradicts the hypothesis, and is scored as ***uncertain (0)***. In the example, conductivity is greater than the regional median suggesting it may be a stressor, but the number of dipteran taxa is greater than the regional median which does not support a conclusion of conductivity causing biological impairment.
- **Lower right quadrat**: If site A falls in this quadrat, the scatterplot supports the hypothesis, and is scored as ***support (+).*** In the example, conductivity is greater than the regional median and the number of dipteran taxa is less than the regional median, providing support to the idea that elevated conductivity is contributing to biological impairment. Examination of the location of site A within this quadrat may suggest a level of confidence in using the scatterplot as support for the hypothesis, with stronger support deriving from positioning of site A further toward the lower right of this quadrat. For example, if site A is positioned near the upper and/or leftward boundaries of this quadrat (the regional medians of both variables plotted) then the scatterplot analysis shows



<u>Rubric for interpretation:</u>

Site A in Q4 *and* Q4 is significantly lower than Q1 and Q2: ***strong support*** for hypothesis

Site A in Q2 *and* Q2 is significantly lower than Q1 ***moderate support*** for hypothesis

Site A not in Q2, Q3 or Q4: hypothesis ***not supported***

Site A in Q4 but Q4 not significantly different than Q1 and Q2: hypothesis ***not supported***

Site A in Q3 but Q3 not significantly different than Q1 and Q2: hypothesis ***not supported***

Step 5

Identify the probable causes of impairment using a SOE approach

- Integrates the assessments from Step 4 to draw an overall conclusion

Finding	Interpretation	Score
Strong evidence	All of the data support the case for the candidate cause	++
Some evidence	Some of the data support the case for the candidate cause; no data weakens the case for the candidate cause	+
Uncertain	The data neither supports nor weakens the case for the candidate cause; an equal amount of data supports and weakens the case, evidence is ambiguous	0
Less likely	Some of the data weakens the case for the candidate cause; no data supports the case	-
Not supported	All of the data weakens the case for the candidate cause	--
No data	Data do not exist to evaluate this case of the candidate cause	ND

Step 6

Generate a report of the results

1. Probable primary cause of biological impairment
2. Probable secondary cause of biological impairment
3. Less probable cause of biological impairment
4. Unlikely cause of biological impairment
5. Insufficient evidence to determine causality of biological impairment

THE END

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