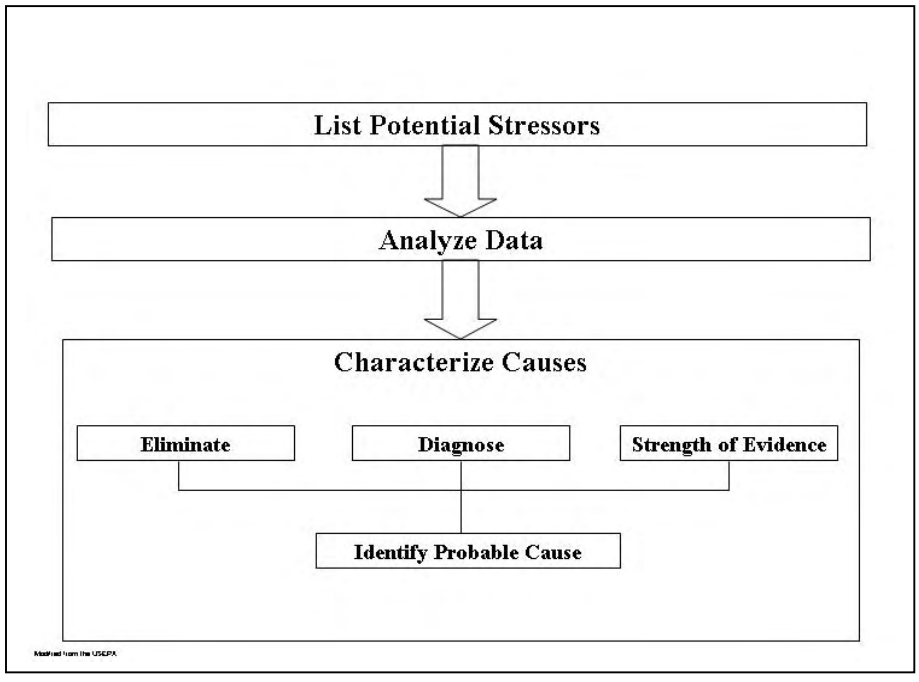
BROWN'S CREEK BIOLOGICAL TMDL – STRESSOR IDENTIFICATION

Project Approach

Brown's Creek is a DNR designated trout stream and is located in the Brown's Creek watershed. The headwaters of Brown's Creek has been listed as being biologically impaired for both fish and macroinvertebrates while the lower portion still maintains a viable trout population. Although biological assessments are useful for identifying biological impairments, they do not identify the cause of impairment. Linking biological effects with their causes is complex, particularly when multiple stressors impact a waterbody. Investigation procedures are needed that can successfully identify the stressor(s) and lead to appropriate corrective measures through habitat restoration and point/non-point source controls.

The Stressor Identification (SI) process developed by U.S. EPA is a formal method for analyzing available evidence such as biological, physical and chemical data, as well as land use and habitat data, and identifying the causes of biological impairment of aquatic systems through a step-by-step procedure (U.S. EPA 2000a, Figure 1). The SI process is aimed at balancing scientific rigor with best professional judgment in a cost efficient way. It begins with the current data or present understanding and uses the knowledge of the project team and project committees, plus a data gathering process in an iterative fashion to evaluate the adequacy of the best professional judgment being applied. For the Brown's Creek Biotic TMDL, the WCD proposes to utilize this process for determining the primary stressor(s) in Brown's Creek.

Figure 1. Steps that will be taken to identify stressors in Brown's Creek



Work Tasks

PHASE I: LIST CANDIDATE CAUSES

The first step of the Stressor Identification Process is to develop a list of candidate causes, or stressors that will be evaluated. This will be accomplished by carefully describing the impairment and gathering all available data on the impaired water and listing all of the potential causes of impairment.

Task 1: Existing Data Review and Summary

All existing data will be collected and reviewed. The purpose of this data collection will be to characterize the impairment and to identify the technical data already available for the SI process in efforts to list the potential causes of impairment to the extent possible with the available data.

Task 1a. Describe the impairment

A detailed description of the biological impairment will be written.

Task 1b. Gather and review available data

The following data sources from within the Brown's Creek watershed, where available, will be compiled and reviewed:

- Water quantity data (e.g. stage, discharge, velocity)
- Water quality data (e.g., turbidity, suspended solids, phosphorus, other nutrients, dissolved oxygen, biochemical oxygen demand,)
- Stream cross-sections
- Land use and land cover
- Watershed delineations
- Topography
- Soils
- Groundwater studies
- Point source permits and discharge records
- Feedlot inventories
- Septic system inventories
- Climate data
- MPCA and DNR documents related to the impairments

Task 1c. Develop list of candidate causes

- Visual inspection of data. Data will be plotted to determine when exceedences of water quality standards and criteria are occurring, under what conditions they are occurring, and what the magnitude of each exceedences is.
    - Water quality parameters will be plotted with respect to time and with respect to flow. This provides information regarding seasonal variation, annual variation, and variation relative to flow conditions,

which can all be used to identify the critical conditions of the creek with respect to the impairments.

- Where sufficient data are available, load duration curves will be created and used to evaluate under which flow conditions the standards may be being exceeded. This provides information regarding pollutant sources. For example, if the majority of the exceedences occur under high flow conditions, the source is likely from watershed runoff. If exceedences occur under low-flow conditions, the source is likely in-stream or a point source. More information about the use of flow duration curves can be found in *Assessment Tools Selection*.

- Data summaries. General descriptive statistics will be used to summarize the data, including, but not limited to, the following: sample size, mean, median, standard deviation, and percentiles. Conclusions from the visual inspection of the data will determine how the data will be grouped for these data summaries (e.g. by site, by year, by season) and what the potential candidate causes are.
- Data comparisons. Data from the various monitoring sites will be compared among the sites to describe the extent of the impairments across the watershed.

Task 1d. Develop a conceptual model

Based on the review of existing data, a conceptual model will be developed (Figure 2). The purpose of a conceptual model is to show the cause and effect relationship between potential stressors and the impairment.

Task 2: Project Meeting

One project meeting will be held with MPCA staff and a Technical Advisory Committee (TAC[1]) after the information has been gathered for Task 1 and a preliminary list of candidate causes has been identified. The purpose of the meeting will be to present conclusions and to discuss any potential data gaps. The desired outcome of the meeting is a list of candidate causes, a conceptual model, and a monitoring strategy agreed upon by the project team.

Phase I Work Products:

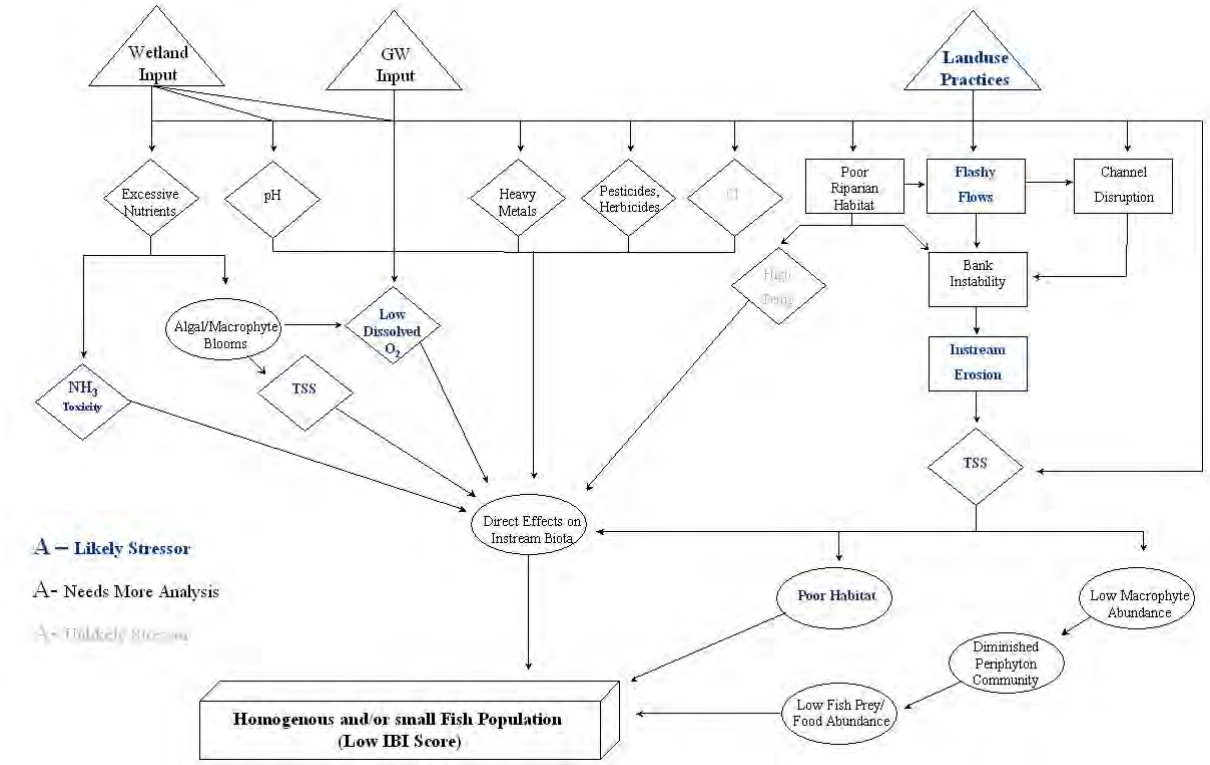
- A summary of the candidate causes
- A conceptual model that shows cause and effect relationships

PHASE II: ANALYZE EVIDENCE

This step of the Stressor Identification Process involves analyzing all of the data related to each of the potential causes. The WCD will utilize everything that is known about impaired aquatic ecosystems in this phase. All data will be organized in terms of associations that could support or refute proposed causal scenarios.

[1] The TAC will consist of members of the St. Croix Basin Team and potentially local watershed experts.

Figure 2. Example of a simplified conceptual model



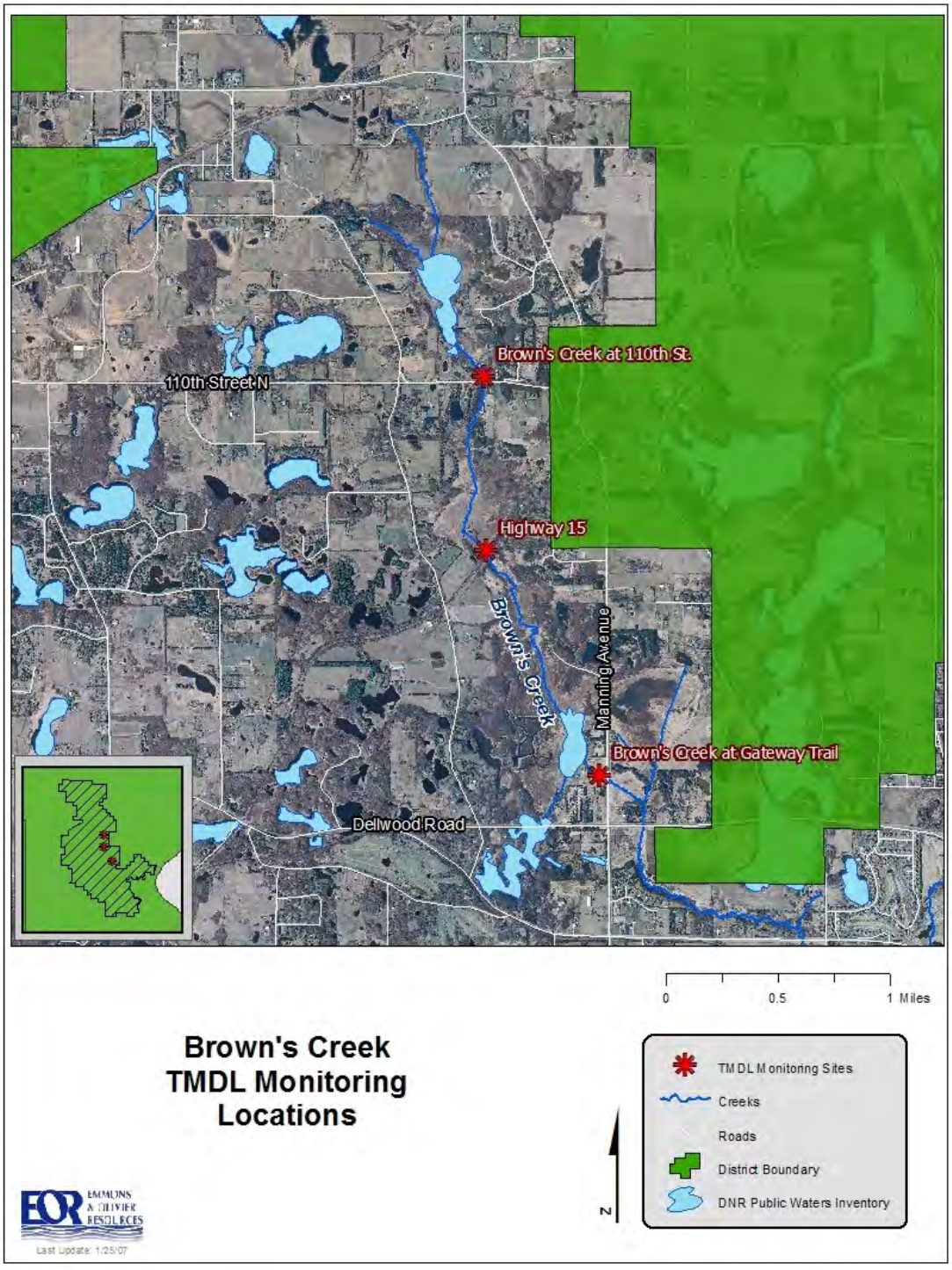
Task 1: Collection of Additional Monitoring Data

Based on the results of Phase I, all data gaps will be filled through the collection of additional monitoring data and field studies. Based on current knowledge of the Brown's Creek watershed and a cursory review of existing data, three monitoring sites are being proposed (Figure 3) for additional data gathering. The following tasks will be conducted to fill in data gaps currently known.

Task 1a. Stream Classification Assessment

An extremely important component of stream ecology is establishing relationships between habitat, flows and channel form and function. Stream classification of habitat, channel geomorphology, and sediment size will be conducted in Brown's Creek to better understand the physical characteristics of the creek. The methodology proposed will

Figure 3. Proposed Monitoring Sites



follow the Rosgen Classification system outlined in the 1996 Applied River Morphology book authored by David Rosgen. If conditions allow, the proposed level of stream classification will follow the Level II assessment at a minimum. This method will be used to classify the current condition of the stream. Stream condition is described in great detail using this method resulting in a description of stream condition as it relates to stream stability, potential, and function. Key components of the assessment will be tracked using the MPCA's Index of Physical Integrity (Magner, 2006).

A. Stream channel type and state (form and function features of the stable channel type)
    a. Flow
    b. Transported sediment
    c. Stream-side vegetation
B. Watershed activities affecting runoff volume, rates and timing
C. Best Management Practices – BMPs
    a. Watershed
    b. Stream corridor

While the Rosgen analysis can include a riparian assessment and stream habitat assessment (i.e., pebble count, in-stream organic debris, streambank erosion potential), this analysis would be complimented by using the MPCA standard operating procedure for stream habitat assessment. Significant areas such as bank failures and debris jams will be recorded using a GPS. Soil samples will be collected at various points along the banks of the creek for soil particle size distribution. These samples will be stored and no lab analysis will be done at this time. Field crews have been trained in Rosgen methodology through the MNDNR Fluvial Geomorphology and Stream Classification Workshops or through the Wildland Hydrology Fluvial Geomorphology and Stream Classification Workshops.

Task 1b. Inventory Biological Community in Brown's Creek

Biological assessments and criteria address the cumulative impacts of all stressors, especially habitat degradation and chemical contamination, which result in a loss of biological diversity. To assess the current status of the biological community in the impaired section of Brown's Creek, both fisheries data and macroinvertebrate data would be collected and analyzed under this proposed study. WCD would collaborate with Dr. Bruce Vondracek and Dr. Len Ferrington of the University of Minnesota on this task.

- Fisheries Data: WCD will work with either with the Minnesota Department of Natural Resources Fisheries Division, or contract with a State University to perform two fisheries surveys, one in the headwaters area and one in the trout stream portion. These monitoring sites would correspond to sampling sites were flow, water quality; macroinvertebrates and habitat would also be collected. Dr. Vondracek will provide technical oversight.
- Macroinvertebrate Data: Spring sampling will take place at a minimum of three sampling sites. These monitoring sites correspond to sampling sites were flow,

water quality, fish, and habitat would also be collected. Organisms will be identified to the genus level. These data would be processed and compared to earlier macroinvertebrate data in addition to chemical and physical data.

It is estimated that over 50% of the macroinvertebrate community found in the headwaters of Brown's Creek is comprised of the Family Chironomidae. Due to this fact, the WCD will also be working with Dr. Leonard Ferrington, Jr. from the University Of Minnesota Department Of Entomology. Dr. Ferrington currently has collected Chironomidae pupal exuviae data on Brown's Creek in the lower portion of the system and would supplement the macroinvertebrate data by collecting pupal exuviae of emerging chironomid in the headwaters reach as well. In this project, collections of surface floating pupal exuviae (SFPE) would be used to generate information about chironomid communities at an array of sites within Brown's Creek.

Task 1c. Groundwater Interaction

A critical component of a TMDL is to identify natural versus anthropogenic sources of pollutants. In the case of Brown's Creek, understanding the relationship between the creek, groundwater, and DO is critical to reviewing the DO standard for Brown's Creek and TMDL regulations in the headwaters area.

Groundwater typically has lower DO concentrations than surface water because of the reducing environment through which it flows. In the Brown's Creek headwater's area, groundwater DO concentrations are hypothesized to be low because groundwater flows through decaying peat in the surrounding wetlands before discharging to the creek. The effect of changing DO concentrations can be observed in the changing dissolved iron concentrations in groundwater along the flow path described above. Recharging water in an upland environment, like the St. Croix Moraine, would typically start out at DO surficial concentrations of 8 to 12 mg/l. As groundwater flows through the Superior Lobe sediments the DO is reduced organic carbon present in these glacial sediments. The initial DO concentrations may be reduced to 1 to 5 mg/l. Where this ground water encounters the relatively iron and organic rich Des Moines Lobe sediments the DO can be further reduced to levels below 1 mg/l

In order to fully understand the relationship between groundwater flow, aquifer materials, and DO along Brown's Creek, groundwater flow and chemistry must be investigated in other parts of the watershed and along other flow paths. DO levels must be measured to very low, sub-mg/l, levels in groundwater samples and at springs. Groundwater discharge must be measured relative to surface water flows.

- Determine groundwater flow in aquifers around Brown's Creek: Much of the information needed for Brown's Creek has been collected as part of the Northern Washington County Groundwater Study. The data will be compiled and reviewed as part of this task

- Groundwater Discharge to Brown's Creek: This task involves direct observations and measurements of groundwater discharge to Brown's Creek. The results will be used to determine the contribution of groundwater to the water budget of the creek. Specifically it includes:

    - Walking the length of Brown's Creek to identify groundwater discharge points (springs).
    - Locating the discharge points using GPS and creating a map.
    - Measuring groundwater discharge at each location via standard gauging tools and/or tracer dilution.

- Measurement of Controls on Dissolved Oxygen: This task involves measuring the dissolved oxygen in groundwater discharging to Brown's Creek to get a better understanding of the physical and chemical processes that influence dissolved oxygen levels in groundwater and the creek.
    - Collect and analyze samples from up to 10 wells and 5 springs for:
    - Major anions and cations, especially Fe and Mn
    - Redox and eH potential
    - Dissolved oxygen to 0.01 mg/l levels
    - Total Organic Carbon
    - Determine organic carbon loading to the creek from groundwater
    - Characterize sources of organic carbon by fluorometric and/or isotopic methods

Task 1d. Lake Discharge Assessment
Goggins and School Section Lakes are hydrologically associated with the headwaters of Brown's Creek. An assessment of previously collected data will be completed to determine if the discharge of these lakes has any potential impact on the biological impairment (i.e., temperature, dissolved oxygen, nutrients)

Task 2: Additional Monitoring Data Review, Analyses, and Summary

The data collected in Task 1 will be reviewed, evaluated, and compared and contrasted to the conclusions drawn in Phase I.

Task 3: Project Meeting

One project meeting will be held with MPCA staff and a Technical Advisory Committee (TAC) after the information has been gathered for Phase II. The purpose of the meeting will be to present conclusions. The desired outcome of the meeting is an agreement by the project team that all relevant data has been collected.

Phase II Work Products:

- Electronic files containing monitoring and field data
- Data and maps in Arc View format
- Technical Memorandum summarizing the current biological assessment of the headwater's area of Brown's Creek

- Technical Memorandum summarizing the geomorphic assessment of the headwater's area of Brown's Creek
- Technical Memorandum summarizing the estimated groundwater inputs into Brown's Creek

PHASE III: CHARACTERIZE CAUSES

In this step of the Stressor Identification Process, the analyzed data and other information regarding the impaired water is used as evidence to eliminate, to diagnose or to compare the strength of evidence in order to identify the probable cause of the impairment. The input information includes a description of the effects to be explained, the set of potential causes, and the evidence relevant to the characterization. Evidence is brought in and analyzed as needed until sufficient confidence in the causal characterization is reached.

Task 1: Develop Strength of Evidence Tables

Strength of Evidence tables will be developed that organize information so that evidence that supports or does not support each candidate cause can be easily communicated. Causal considerations that will be analyzed during this process are:

- Consistency of Association – The repeated observation of the effect and candidate cause in different places or times.
- Co-occurrence – The spatial co-location of the candidate cause and effect.
- Temporality – Evaluation of whether or not the cause preceded the effect.
- Biological Gradient – Evaluating if the effect increases with exposure.
- Complete Exposure Pathway – The physical course a stressor takes from source to the receptors of interest.
- Plausibility – What is the degree to which a cause and effect relationship would be expected given know facts.
- Analogy- Examines whether the hypothesized relationship between cause and effect is similar to any well-established cases.

Task 2: Project Meeting

One project meeting will be held with MPCA staff and a Technical Advisory Committee (TAC) after the strength of evidence tables have been completed. The purpose of the meeting will be to present the evidence to diagnose the primary stressor(s) impacting the biological communities within the headwaters area of Brown's Creek. The desired outcome of the meeting is a list of the primary stressor(s) agreed upon by the project team.

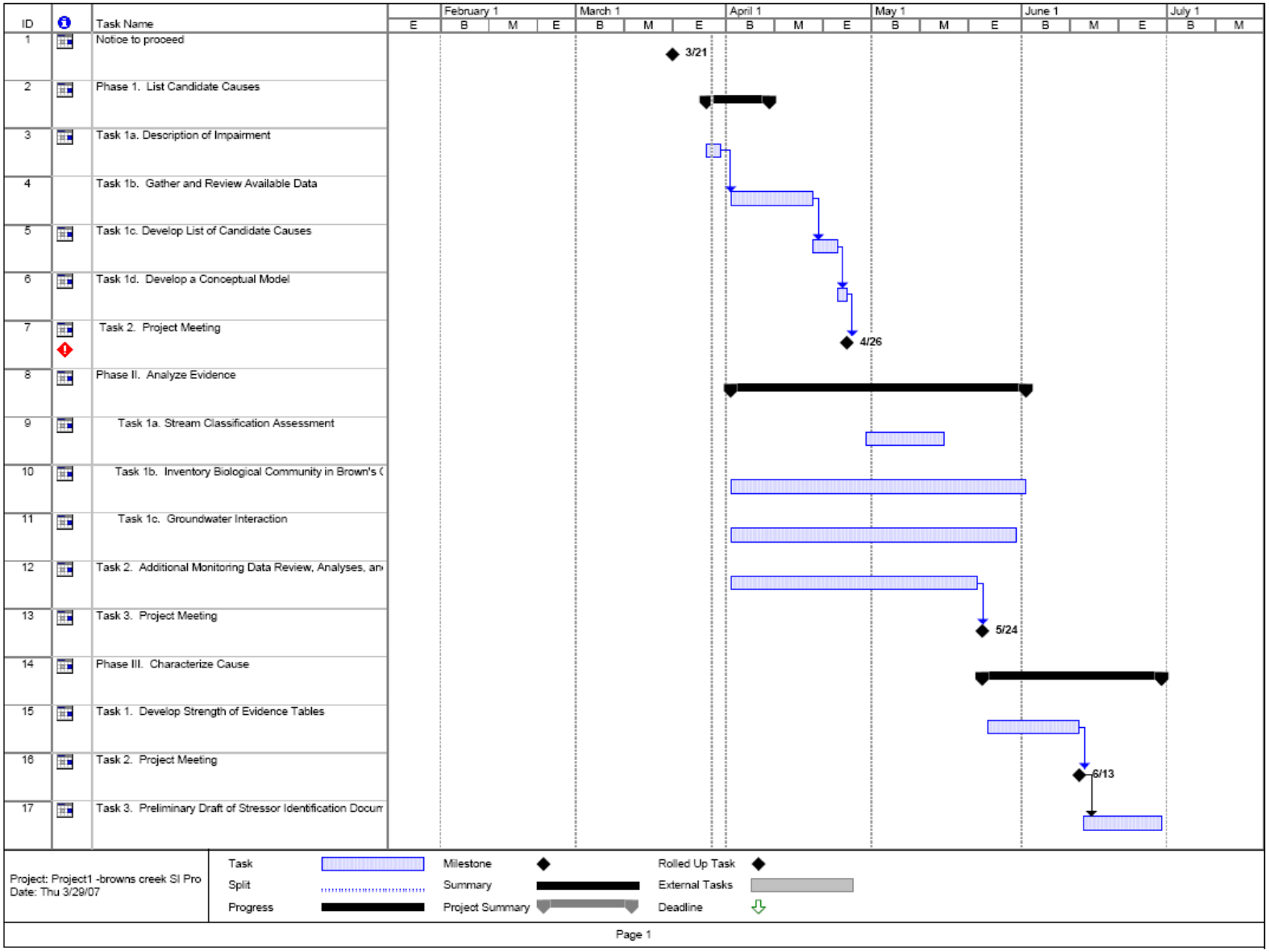
Task 3: Preliminary Draft of SI Document for Brown's Creek

After receiving comments on the strength of evidence tables from MPCA staff and the TAC, a preliminary draft of the SI documentation will be drafted detailing and summarizing all steps taken throughout the process to identify the primary stressor(s) in Brown's Creek.

Phase III Work Product

- Draft SI report (4 hard copies and 1 electronic copy)

Schedule


ID
Task Name
February 1
March 1
April 1
May 1
June 1
July 1
1 Notice to proceed
2 Phase 1. List Candidate Causes
3 Task 1a. Description of Impairment
4 Task 1b. Gather and Review Available Data
5 Task 1c. Develop List of Candidate Causes
6 Task 1d. Develop a Conceptual Model
7 Task 2. Project Meeting
8 Phase II. Analyze Evidence
9 Task 1a. Stream Classification Assessment
10 Task 1b. Inventory Biological Community in Brown's (
11 Task 1c. Groundwater Interaction
12 Task 2. Additional Monitoring Data Review, Analyses, an
13 Task 3. Project Meeting
14 Phase III. Characterize Cause
15 Task 1. Develop Strength of Evidence Tables
16 Task 2. Project Meeting
17 Task 3. Preliminary Draft of Stressor Identification Docum
3/21
4/26
5/24
6/13
Project: Project1 -browns creek SI Pro
Date: Thu 3/29/07
Task
Split
Progress
Milestone
Summary
Project Summary
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External Tasks
Deadline
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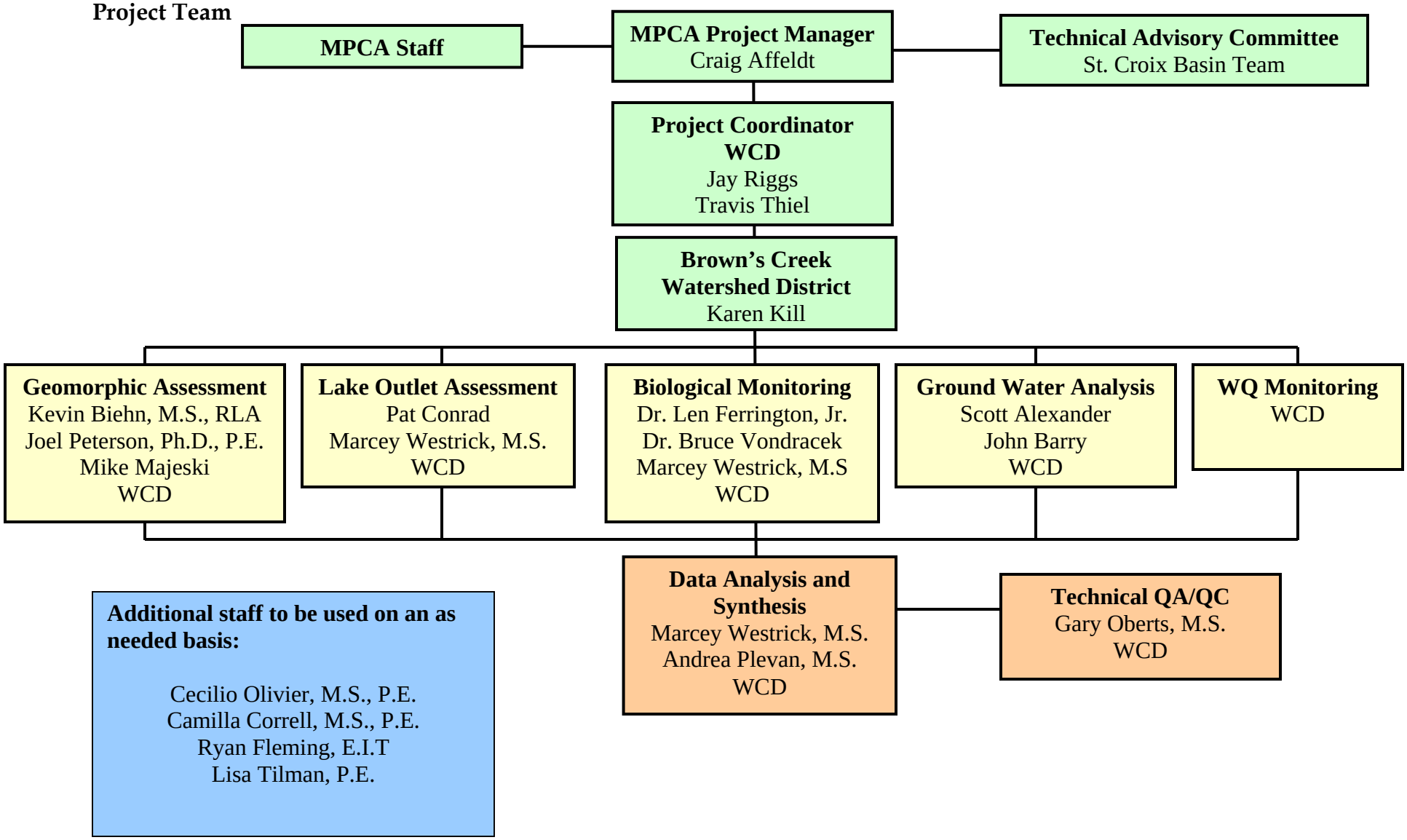
Project Team
MPCA Staff
MPCA Project Manager
Craig Affeldt
Technical Advisory Committee
St. Croix Basin Team
Project Coordinator
WCD
Jay Riggs
Travis Thiel
Brown's Creek
Watershed District
Karen Kill
Geomorphic Assessment
Kevin Biehn, M.S., RLA
Joel Peterson, Ph.D., P.E.
Mike Majeski
WCD
Lake Outlet Assessment
Pat Conrad
Marcey Westrick, M.S.
WCD
Biological Monitoring
Dr. Len Ferrington, Jr.
Dr. Bruce Vondracek
Marcey Westrick, M.S
WCD
Ground Water Analysis
Scott Alexander
John Barry
WCD
WQ Monitoring
WCD
Data Analysis and
Synthesis
Marcey Westrick, M.S.
Andrea Plevan, M.S.
WCD
Technical QA/QC
Gary Oberts, M.S.
WCD
Additional staff to be used on an as needed basis:
Cecilio Olivier, M.S., P.E.
Camilla Correll, M.S., P.E.
Ryan Fleming, E.I.T
Lisa Tilman, P.E.

Assessment Tools

Flow and Load Duration Curves

A flow duration curve plots the percentage of time that flow in a stream exceeds a certain value. These graphs provide a visual display of the range of flows in a stream and how frequently the different flows are observed.

Load duration curves (Figure 4) compare pollutant loading data to the pollutant load that the stream could assimilate, based on flow regime, and still maintain a water quality standard. Load duration curves are helpful in assessing a water quality impairment because they illustrate under which flow regimes the water quality standard is exceeded.

Figure 4. Load duration curve example