Illinois
Environmental
Protection Agency

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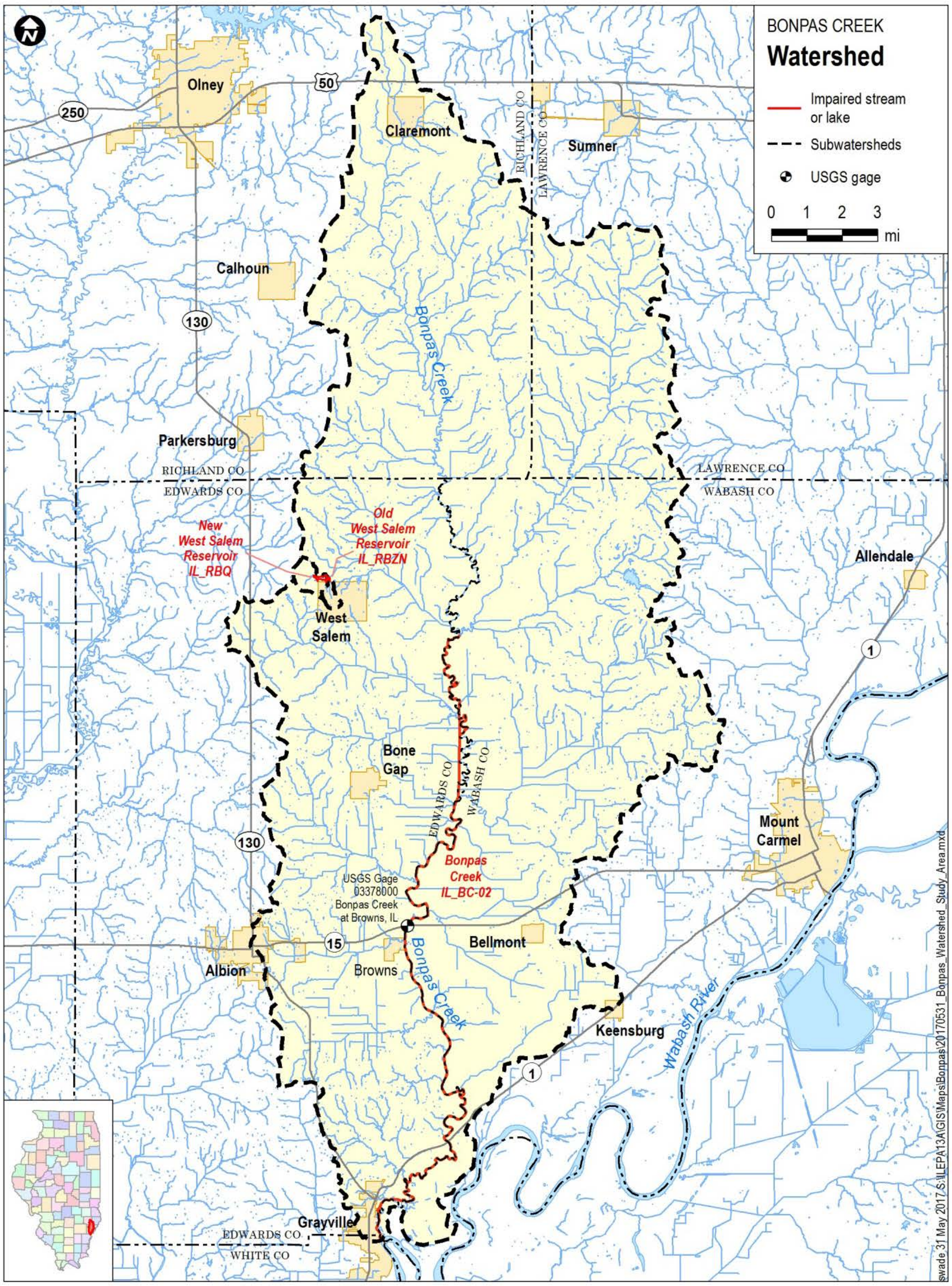
March 2019

IEPA/BOW/IL-2019-001

Bonpas Creek Watershed TMDL Report



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MAR 1 3 2019

REPLY TO THE ATTENTION OF:

WW-16J

Sanjay Sofat, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Mr. Sofat:

The U.S. Environmental Protection Agency has conducted a complete review of the final Total Maximum Daily Loads (TMDLs) for fecal coliform, atrazine, and phosphorus for the Bonpas Creek watershed, including supporting documentation and follow up information. The waterbody is located in southeastern Illinois. The TMDLs submitted by the Illinois Environmental Protection Agency address the impaired Aquatic Life, Aesthetic Quality, and Primary Contact Uses for the waterbodies.

The TMDLs meet the requirements of Section 303(d) of the Clean Water Act and EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, EPA hereby approves Illinois's three TMDLs for fecal coliform, atrazine, and phosphorus as noted in the enclosed decision document. The statutory and regulatory requirements, and EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois's effort in submitting these TMDLs and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Peter Swenson, Chief of the Watersheds and Wetlands Branch, at 312-886-0236.

Sincerely,

Joan M. Tanaka

Joan M. Tanaka
Acting Director, Water Division

Enclosure

cc: Abel Haile, IEPA

TMDL: Bonpas Creek Watershed, Lawrence, Wabash, Richland and Edwards Counties, Illinois
Date:

DECISION DOCUMENT FOR THE APPROVAL OF THE BONPAS CREEK WATERSHED, IL TMDL

Section 303(d) of the Clean Water Act (CWA) and EPA's implementing regulations at 40 C.F.R. Part 130 describe the statutory and regulatory requirements for approvable TMDLs. Additional information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable. These TMDL review guidelines are not themselves regulations. They are an attempt to summarize and provide guidance regarding currently effective statutory and regulatory requirements relating to TMDLs. Any differences between these guidelines and EPA's TMDL regulations should be resolved in favor of the regulations themselves.

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking

The TMDL submittal should identify the waterbody as it appears on the State's/Tribe's 303(d) list. The waterbody should be identified/georeferenced using the National Hydrography Dataset (NHD), and the TMDL should clearly identify the pollutant for which the TMDL is being established. In addition, the TMDL should identify the priority ranking of the waterbody and specify the link between the pollutant of concern and the water quality standard (see Section 2 below).

The TMDL submittal should include an identification of the point and nonpoint sources of the pollutant of concern, including location of the source(s) and the quantity of the loading, e.g., lbs/per day. The TMDL should provide the identification numbers of the NPDES permits within the waterbody. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of the natural background. This information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as:

(1) the spatial extent of the watershed in which the impaired waterbody is located;
(2) the assumed distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources;
(4) present and future growth trends, if taken into consideration in preparing the TMDL (e.g., the TMDL could include the design capacity of a wastewater treatment facility); and

(5) an explanation and analytical basis for expressing the TMDL through *surrogate measures*, if applicable. *Surrogate measures* are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

Comment:
Location Description: The Illinois Environmental Protection Agency (IEPA) developed TMDLs for fecal coliform, atrazine, and phosphorus for impaired waters in the Bonpas Creek watershed in southeastern Illinois (Table 1 of this Decision Document). The Bonpas Creek watershed begins in Richland County near Olney, Illinois, and flows south into the Wabash River near Grayville, Illinois (Figure 3-1 of the TMDL). Table 1 of this Decision Document is from Table 1-1 in the TMDL and lists the waterbodies addressed by this TMDL. Illinois also has Load Reduction Strategies (LRS) included in this TMDL submittal to address pollutants that do not have a numeric criterion. EPA is not reviewing the LRSs.

Table 1: TMDLs and LRS in the Bonpas Creek watershed

Segment Name	Segment ID	Designated use	Pollutant Addressed
TMDLs			
Bonpas Creek	**IL_BC-02**	**Recreation**	**Fecal coliform**
		Aquatic Life	**Atrazine**
New West Salem Reservoir	**IL_RBQ**	**Aesthetic Quality**	**Phosphorus**
LRS			
Bonpas Creek	IL_BC-02	Aquatic Life	Sediment
Old West Salem Reservoir	IL_RBZN	Aquatic Life	Phosphorus

* - Spring Branch was initially listed as impaired for ammonia

The Bonpas Creek watershed is approximately 178,000 acres in size. The upstream portion of Bonpas Creek (IL_BC-04), is listed as impaired for low dissolved oxygen (DO), as is BC-02, but analysis by IEPA determined that the low DO is not due to a pollutant, and therefore no TMDL is required. IEPA will be revising the status of these two segments during the next Section 303(d) listing cycle (Section 5 of the TMDL). Segment BC-02 is also listed as impaired due to sedimentation/siltation, and IEPA has developed a LRS to address the impairment. Old West Salem Reservoir (IL_RBZN) is listed as impaired for phosphorus, but the reservoir is 2 acres in size, well below the IEPA definition of a lake (20 acres), and therefore no TMDL was developed.

Distribution of land use: The land use for Bonpas Creek watershed is mainly agricultural and pasture in nature, with most of the agricultural land use in row crop (corn/soybean). Urban and open space makes up a very small portion of the watershed (Section 2.3 and Table 10 of Stage 1 of the TMDL). Several small villages are located within the watershed. Table 2 of this Decision Document contains a summary of the land use for the Bonpas Creek watershed.

Table 2: Land use in the Bonpas Creek Watershed

Land Use	Bonpas Creek	
	%	acres
Cultivated crops (corn and soybeans)	65.5	116350
Pasture/Hay	12	21651
Developed*	6.5	11792
Forest	15	27209
Other	0.5	732
Total	100	177734

* - includes 9763 acres of developed open land

Problem Identification:
The impaired waterbodies in the Bonpas Creek watershed were added to the Section 303(d) list for impairments due to high levels of fecal coliform, atrazine, and phosphorus. Bonpas Creek exceeded the bacteria standards numerous times, and to varying degrees. Atrazine exceeded the criteria once in five samples. New West Salem Reservoir exceeded the lake phosphorus standard for every sample in the last ten years (Table 13 of Stage 1 of the TMDL).

Pollutants of Concern:
The pollutants of concern are fecal coliform, atrazine, and phosphorus (Table 1 of this Decision Document).

Pollutant:
Fecal coliform: Bacteria exceedances can negatively impact recreational uses (fishing, swimming, wading, boating, etc.) and public health. At elevated levels, bacteria may cause illness within humans who have contact with or ingest bacteria-laden water. Recreation-based contact can lead to ear, nose, and throat infections, and stomach illness.

Atrazine: Atrazine is a widely used herbicide, used on corn to control broadleaf and grassy weeds. It is sprayed on crops during the spring and summer months, where it is absorbed into weeds and stops photosynthesis. It generally breaks down in soil, but moisture delays the degradation. The half-life of atrazine in soils is about 146 days. In water, atrazine has a half-life of 742 days. Although there are strict requirements for usage, atrazine can still wash off the plants and soil during rain events and enter local waterbodies. This runoff can be exacerbated by agricultural drainage tiles. Research into the health effects of atrazine is ongoing, but atrazine is a regulated contaminant under the Safe Drinking Water Act. IEPA determined that the source of atrazine for Bonpas Creek is nonpoint runoff from agricultural fields, and that none of the point sources in the watersheds are a source of atrazine.

Total phosphorus: While TP is an essential nutrient for aquatic life, elevated concentrations of TP can lead to nuisance algal blooms that negatively impact aquatic life and recreation (swimming, boating, fishing, etc.). Algal decomposition depletes oxygen levels which stresses benthic macroinvertebrates and fish. Excess algae can shade the water column which limits the distribution of aquatic vegetation. Aquatic vegetation stabilizes bottom sediments, and also is an important habitat for macroinvertebrates and fish. Furthermore, depletion of oxygen can cause phosphorus release from bottom sediments (i.e. internal loading).

Degradations in aquatic habitats or water quality (ex. low dissolved oxygen) can negatively impact aquatic life use. Increased algal growth, brought on by elevated levels of nutrients within the water column, can reduce dissolved oxygen in the water column, and cause large shifts in dissolved oxygen and pH throughout the day. Shifting chemical conditions within the water column may stress aquatic biota (fish and macroinvertebrate species). In some instances, degradations in aquatic habitats or water quality have reduced fish populations or altered fish communities from those communities supporting sport fish species to communities which support more tolerant rough fish species.

Priority Ranking:
The watershed was given priority for TMDL development due to the impairment impacts on the public value of the impaired water resource, and the timing as part of the Illinois basin monitoring process.

Source Identification (point and nonpoint sources):
Point Source Identification:
Fecal coliform: IEPA identified three individual point sources located in the Bonpas Creek watershed (Table 6-3 of the TMDL). Three Concentrated Animal Feeding Operations (CAFOs) were identified in the watershed.

Phosphorus and Atrazine: No point source dischargers were identified in the Bonpas Creek watershed that could discharge atrazine, and no point sources were identified that could discharge phosphorus in the New West Salem Reservoir (Section 6 of the TMDL).

Nonpoint Source Identification: The potential nonpoint sources for the Bonpas Creek watershed TMDLs are described below.

Fecal coliform
Stormwater runoff from agricultural land use practices: Non-regulated stormwater runoff can add fecal coliform to the impaired waters. The sources of bacteria in stormwater include animal/pet wastes, and wildlife. Manure spread onto fields is a source of bacteria, and can be exacerbated by tile drainage lines, which channelize the stormwater. Tile lined fields and channelized ditches enable particles to move more efficiently into surface waters.

Animal Operations: Runoff from agricultural/animal lands may contain significant amounts of bacteria which may lead to impairments in the Bonpas Creek watershed. Manure spread onto fields is often a source of bacteria, and can be exacerbated by tile drainage lines, which channelize the stormwater. Tile lined fields and channelized ditches enable bacteria to move more efficiently into surface waters. Furthermore, livestock with direct access to a waterway can directly deposit nutrients via animal wastes into a waterbody, which may result in very high localized bacteria concentrations.

Failing septic systems: IEPA noted that failing septic systems, where waste material can pond at the surface and eventually flow into surface waters or be washed in during precipitation events, are potential sources of bacteria. IEPA noted that much of the watershed is serviced by septic systems, but that the newer systems are usually aerated systems, which include a disinfection tank to reduce bacteria.

Phosphorus
Stormwater runoff from agricultural land use practices: Runoff from agricultural lands may contain significant amounts of nutrients, organic material and organic-rich sediment which may lead to impairments in the lake watershed. Manure spread onto fields is often a source of phosphorus, and can be exacerbated by tile drainage lines, which channelize the stormwater. Tile lined fields and channelized ditches enable particles to move more efficiently into surface waters. Phosphorus, organic material and organic-rich sediment may be added via surface runoff from upland areas, grasslands, and agricultural lands used for growing hay or other crops. Stormwater runoff may contribute nutrients and organic-rich sediment to surface waters from livestock manure, fertilizers, vegetation and erodible soils.

Failing septic systems: IEPA noted that failing septic systems, where waste material can pond at the surface and eventually flow into the waterbodies or be washed in during precipitation events, are potential sources of phosphorus.

Internal loading: The release of phosphorus from lake sediments via physical disturbance from benthic fish (rough fish, ex. carp) and from wind mixing the water column may all contribute internal phosphorus loading to the lake. Phosphorus may build up in the bottom waters of the lake and may be resuspended or mixed into the water column when the thermocline decreases and the lake water mixes.

Atrazine:
Agricultural runoff: As noted above, atrazine is used as an herbicide on cultivated crops. IEPA determined that the source of atrazine for Bonpas Creek is nonpoint runoff from agricultural fields.

Population and future growth trends
The population in the watershed is fairly small. IEPA did not account for any future growth in the watershed.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this first element.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy. (40 C.F.R. §130.7(c)(1)). EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

The TMDL submittal must identify a numeric water quality target(s) - a quantitative value used to measure whether or not the applicable water quality standard is attained. Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. The TMDL expresses the relationship between any necessary reduction of the pollutant of concern and the attainment of the numeric water quality target. Occasionally, the pollutant of concern is different from the pollutant that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as Dissolved Oxygen (DO) criteria). In such cases, the TMDL submittal should explain the linkage between the pollutant of concern and the chosen numeric water quality target.

Comment:
Designated Use/Standards: Section 4.1 of the TMDL states that the Bonpas Creek is not meeting the General Use designation. The applicable water quality standards (WQS) for these waterbodies are established in Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards, Subpart B for General Use Water Quality Standards. The portions of the WQS that apply to Bonpas Creek is General Use, specifically the Aesthetic Quality Use and Primary Contact Use (Section 4.1.1 of the TMDL).

For atrazine, the criteria are derived pursuant to 35 IAC 302.210, which allows criteria to be derived to protect human health and or wildlife. Atrazine has an acute and a chronic criterion for wildlife. The chronic criterion is 82 μg/L, as a "not to exceed" value, while the acute criterion of 9 μg/L is not to be exceeded by the arithmetic average of at least four consecutive samples collected over a period of at least four days.

Criteria: The applicable criteria are found in Table 3 of this Decision Document.

Table 3: WQSs for the Bonpas Creek TMDLs

Pollutant	Units	Criteria
Phosphorus	mg/L	0.05
Atrazine	μg/L	9***
Fecal coliform	Count/100 mL	200*, 400** May through October

* - geometric mean based upon a minimum of 5 samples in a 30-day period
** - not to be exceed by more than 10% of the samples in a 30-day period
*** - acute criteria are not to be exceeded by the arithmetic average of at least four consecutive samples collected over a period of at least four days.

Target: The water quality targets for these TMDLs are the WQSs for the waters. For fecal coliform, IEPA used the 200 counts per 100 mL monthly geometric mean portion of the standard to calculate loads in the Bonpas Creek. IEPA stated that while the TMDL will focus on the geometric mean portion of the water quality standard, both parts of the water quality standard must be met. For phosphorus, the water quality target is the criterion of 0.05 mg/L. For atrazine, the water quality target is the acute criterion of 9 μg/L (Section 6.2 of the TMDL).

Other pollutants: As noted previously, IEPA has developed LRSs to address pollutants that do not have a numeric criterion (Table 1 of this Decision Document). While these are not TMDLs, the LRSs will likely reduce other pollutants in the watershed. For these LRSs, IEPA developed water quality targets as goals to reduce TSS and TP impacts (Table 4 of this Decision Document). For these waters, the targets are:

Table 4: LRS Targets for the Bonpas Creek watershed

Pollutant	Target
TP	0.05 mg/L
TSS	27.75 mg/L

IEPA applied the phosphorus lake criterion of 0.05 mg/L to Old West Salem Reservoir as part of the LRS. During the TMDL development process, IEPA determined the lake to be too small (2 acres) to be properly classified as a "lake" under IEPA rules. Therefore, the LRS value is considered a "target" rather than a criterion.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this second element.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

The pollutant loadings may be expressed as either mass-per-time, toxicity or other appropriate measure (40 C.F.R. §130.2(i)). If the TMDL is expressed in terms other than a daily load, e.g., an annual load, the submittal should explain why it is appropriate to express the TMDL in the unit of measurement chosen. The TMDL submittal should describe the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

The TMDL submittal should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling. EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

TMDLs must take into account *critical conditions* for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable *critical conditions* and describe their approach to estimating both point and nonpoint source loadings under such *critical conditions*. In particular, the TMDL should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

Comment:
The approach utilized by the IEPA to calculate the loading capacity for the fecal coliform, atrazine, and phosphorus TMDLs is described in Section 5.2 of the TMDL.

Fecal coliform: For the bacteria TMDL, a geometric mean of 200 cfu/100 ml fecal coliform for five samples equally spaced over a 30-day period was used to calculate the loading capacity of the TMDLs. IEPA determined that the geometric mean portion of the WQS provides the best overall characterization of the status of the watershed. The EPA agrees with this assertion, as stated in the preamble of *The Water Quality Standards for Coastal and Great Lakes Recreation*

Waters Final Rule (69 FR 67218-67243, November 16, 2004) on page 67224, "...the geometric mean is the more relevant value for ensuring that appropriate actions are taken to protect and improve water quality because it is a more reliable measure, being less subject to random variation, and more directly linked to the underlying studies on which the 1986 bacteria criteria were based."

IEPA stated that while the bacteria TMDL will focus on the geometric mean portion of the water quality standard (i.e., the chronic WQS of 200 cfu/100mL), attainment of the WQS involves the water body meeting both the chronic (200 cfu/100 mL) and acute (400 cfu/100 mL) portions of the water quality standard. EPA finds these assumptions to be reasonable.

Typically loading capacities are expressed as a mass per time (e.g. pounds per day). However, for bacteria loading capacity calculations, mass is not always an appropriate measure because bacteria are expressed in terms of organism counts. This approach is consistent with the EPA's regulations which define "load" as "an amount of matter that is introduced into a receiving water" (40 CFR §130.2). To establish the loading capacities for the Bonpas Creek bacteria TMDL, IEPA used Illinois's water quality standards for fecal coliform (200 cfu/100 mL). A loading capacity is, "the greatest amount of loading that a water can receive without violating water quality standards." (40 CFR §130.2). Therefore, a loading capacity set at the WQS will assure that the water does not violate WQS. IEPA's fecal coliform TMDL approach is based upon the premise that all discharges (point and nonpoint) must meet the WQS when entering the water body. If all sources meet the WQS at discharge, then the water body should meet the WQS and the designated use.

Flow data from a USGS gage on Bonpas Creek (Figure 3-1 of the TMDL) were used to develop the Load Duration Curve (LDC). The watershed flow data were available from several decades (Section 7.2.1.1 of the TMDL). Daily stream flows are necessary to implement the LDC approach.

The LDCs were created by multiplying individual flow values by the WQS and then multiplying that value by a conversion factor. The resulting points are plotted onto a load duration curve graph. The LDC graph for Bonpas Creek has flow duration interval (percentage of time flow exceeded) on the X-axis and pollutant loads (number of bacteria or pollutant mass per unit time) on the Y-axis. The fecal coliform LDC used fecal coliform measurements in millions of bacteria per day. The curved line on an LDC graph represents the TMDL for the respective flow conditions observed at that location.

Pollutant values from the monitoring sites were converted to individual sampling loads by multiplying the sample concentration by the instantaneous flow measurement observed/estimated at the time of sample collection. The individual sampling loads were plotted on the same figure with the LDC (Figure 5-4 of the TMDL).

IEPA followed a slightly different process in developing the atrazine and fecal coliform TMDLs. IEPA developed the Loading Capacity based upon representative flows in the segments (Tables 6-4 of the TMDL). The tables are divided into the load capacity "allowable load", load allocation and wasteload allocation (Table 5 of this Decision Document). The reductions required to attain the fecal coliform WQS range from 56%-99%.

Table 5: Fecal coliform TMDL Summary for Bonpas Creek IL_BC-02

Bonpas Creek Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)	Load Allocation (LA) (cfu/day)
5	2.45E+10	1.19E+09	2.33E+10
100	4.89E+11	1.19E+09	4.88E+11
500	2.45E+12	1.19E+09	2.45E+12
1000	4.89E+12	1.19E+09	4.89E+12
2000	9.79E+12	1.19E+09	9.79E+12
3000	1.47E+13	1.19E+09	1.47E+13
4000	1.96E+13	1.19E+09	1.96E+13
5000	2.45E+13	1.19E+09	2.45E+13
6000	2.94E+13	1.19E+09	2.94E+13
7000	3.44E+13	1.19E+09	3.44E+13

The strengths of using the LDC method are that critical conditions and seasonal variation are considered in the creation of the LDC by plotting hydrologic conditions over the flows measured during the recreation season. Additionally, the LDC methodology is relatively easy to use and cost-effective. The weaknesses of the LDC method are that nonpoint source allocations cannot be assigned to specific sources, and specific source reductions are not quantified. Overall, IEPA believes, and EPA concurs, that the strengths outweigh the weaknesses for the LDC method.

Implementing the results shown by the LDC requires watershed managers to understand the sources contributing to the water quality impairment and which Best Management Practices (BMPs) may be the most effective for reducing pollutant loads based on flow magnitudes. Different sources will contribute pollutant loads under varying flow conditions. For example, if exceedances are significant during high flow events this would suggest storm events are the cause, and implementation efforts can target BMPs that will reduce stormwater runoff and consequently pollutant loading into surface waters. This allows for a more efficient implementation effort.

The bacteria TMDL for the Bonpas Creek was calculated as appropriate. Allocations were determined for regulated permittees discharging fecal coliform (Table 8 of this Decision Document). The load allocation was calculated after the determination of the Margin of Safety. Other load allocations (ex. non-regulated stormwater runoff, wildlife inputs, etc.) were not divided amongst individual nonpoint contributors. Instead, load allocations were combined into a generalized loading. The LDC for fecal coliform show exceedences under all flow conditions, however, the exceedences are greater during higher flows, indicating the sources are precipitation-related.

Table 5 of this Decision Document calculates loads based upon several representative flows based upon the loading capacity curve. However, it should be understood that the components of the TMDL equation could be illustrated for any point on the entire loading capacity curve. The load duration curve method can be used to display collected pollutant monitoring data and allows for the estimation of load reductions necessary for attainment of the appropriate water quality standards. Using this method, daily loads were developed based upon the flow in the water body. Loading capacities were determined for the segment for multiple flow regimes. This allows the TMDL to be represented by an allowable daily load across all flow conditions. Although there are numeric loads for each flow regime, the LDC is being approved for these TMDLs.

Atrazine: A similar process as described above was used to develop the atrazine TMDL (Section 5.2 of the TMDL). The same flow calculations were used, except that the flows were multiplied by the atrazine target of 9 µg/L. Although the data are limited, the exceedence of the LDC occurs at a high flow, suggesting that runoff due to precipitation events are the source of atrazine (Figure 5-4 and Table 6-7 of the TMDL). Approximately a 9% reduction in atrazine loads are required to attain WQSs.

Table 6: Atrazine TMDL Summary for Bonpas Creek IL_BC-02

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
5	0.2	0.02	0*	0.22
100	4.9	0.49	0*	4.37
500	24.3	2.43	0*	21.84
1000	48.5	4.85	0*	43.69
2000	97.1	9.71	0*	87.38
3000	145.6	14.56	0*	131.07
4000	194.2	19.42	0*	174.75
5000	242.7	24.27	0*	218.44
6000	291.3	29.13	0*	262.13

Total Phosphorus:
IEPA used the U.S. Army Corps of Engineers BATHTUB model to calculate the loading capacity for New West Salem Reservoir (Section 5.3 of the TMDL). BATHTUB is a model for lakes and reservoirs to determine steady-state water and nutrient mass balances in a spatially segmented hydraulic network. BATHTUB uses empirical relationships to determine "eutrophication-related water quality conditions".[1] This TMDL uses the BATHTUB model to link observed phosphorus water quality conditions and modeled phosphorus loading to in-lake water quality estimates. BATHTUB can be a steady-state annual or seasonal model that predicts a lake's water quality. BATHTUB utilizes annual or seasonal time-scales, which are appropriate because watershed TP loads are normally impacted by seasonal conditions.

The model estimates in-lake phosphorus concentration by calculating net phosphorus loss (phosphorus sedimentation) from annual phosphorus loads as functions of inflows to the lake, lake depth, and hydraulic flushing rate. To estimate loading capacity, the model is rerun, reducing current loading to the lake until the modeled result shows that in-lake total phosphorus would meet the applicable WQS.[2] The BATHTUB model also allows IEPA to assess impacts of changes in nutrient loading from the various sources.

The BATHTUB modeling effort was used to calculate the loading capacity for New West Salem

[1] BATHTUB Manual - http://www.wwwalker.net/bathtub/help/bathtubWebMain.html
[2] Ibid. BATHTUB Manual

Reservoir. The loading capacity is the maximum phosphorus load which the waterbody can receive over an annual period and still meet the lake nutrient WQS. The loading capacity was calculated to meet the WQS during the growing season (June 1 through September 30). This time period contains the months that the general public typically uses the lake for aquatic recreation. This time of the year also corresponds to the growing season when water quality is likely to be impaired by excessive nutrient loading. Table 7 of this Decision Document shows the TMDL summary for the lake.

Table 7: Phosphorus TMDL Summary for New West Salem Reservoir

	TP Load (kg/day)
LA	0.18
WLA	0
MOS	0.02
Loading Capacity	**0.2**
Existing Load	4
Load Reduction	95%

To attain the TMDL, IEPA determined that the internal loading of phosphorus has to be reduced by almost 100%, and approximately a 50% reduction in tributary loading is required.

Other Impairments:
IEPA reviewed the other impairments in the watershed, as listed in Table 1-1 of the TMDL. Both segments of Bonpas Creek (BC-02 and BC-04) are listed as impaired for low dissolved oxygen (DO). IEPA used the QUAL2E model to analyze the impairment, and the results indicated that even with biological oxygen demand (BOD) and other oxygen-scavenging substances reduced to 0, the DO criteria will not be met. IEPA determined that the cause of the low DO is low flow, where the waterbody does not have sufficient flow/volume to maintain the DO levels (Section 6.1.1 and Attachment 2of the TMDL). As IEPA determined that no pollutant was the cause of the impairment, no TMDL was developed for the low DO impairment.

Bonpas Creek (BC-02) was also identified as impaired for sedimentation/siltation. IEPA has a policy of deferring TMDLs for pollutants that do not have numeric criteria, and IEPA does not have a numeric criterion for sediment (Section 1 of the TMDL). However, IEPA did develop a Load Reduction Strategy for Bonpas Creek (BC-02), designed to identify reductions needed to address the impairment. The LRS is not part of this TMDL decision process.

The Old West Salem Reservoir (IL_RBZN) was identified as impaired due to exceedences of the lake phosphorus criteria (Table 1-1 of the TMDL). The lake was initially identified as 32 acres in size, above the 20 acre minimum size to be defined as a lake under the IEPA phosphorus criteria. During TMDL development, IEPA determined the lake size is 2 acres, not the originally recorded 32 acres, and therefore is not subject to the lake phosphorus criterion. No TMDL was developed.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this third element.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity attributed to existing and future nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Where possible, load allocations should be described separately for natural background and nonpoint sources.

Comment:
The LAs for the waterbodies are found Tables 5-7 of this Decision Document. The nonpoint sources of fecal coliform, atrazine, and phosphorus in the watershed are nonpoint source runoff from row crop agricultural fields, failing septics, and animal operations. As discussed in Sections 8 and 10 of this Decision Document, IEPA provided further analysis of how reductions from the various pollutant sources could be attained.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fourth element.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit.

The individual WLAs may take the form of uniform percentage reductions or individual mass based limitations for dischargers where it can be shown that this solution meets WQSs and does not result in localized impairments. These individual WLAs may be adjusted during the NPDES permitting process. If the WLAs are adjusted, the individual effluent limits for each permit issued to a discharger on the impaired water must be consistent with the assumptions and requirements of the adjusted WLAs in the TMDL. If the WLAs are not adjusted, effluent limits contained in the permit must be consistent with the individual WLAs specified in the TMDL. If a draft permit provides for a higher load for a discharger than the corresponding individual WLA in the TMDL, the State/Tribe must demonstrate that the total WLA in the TMDL will be achieved through reductions in the remaining individual WLAs and that localized impairments will not result. All permittees should be notified of any deviations from the initial individual WLAs contained in the TMDL. EPA does not require the establishment of a new TMDL to reflect these revised allocations as long as the total WLA, as expressed in the TMDL, remains the same or decreases, and there is no reallocation between the total WLA and the total LA.

Comment:
Fecal coliform: IEPA determined loads for fecal coliform for the three dischargers in the Bonpas Creek watershed (Table 8 of this Decision Document). The WLAs are based upon the design average flow of the facilities (Section 6.2.2 of the TMDL). The appropriate flow was multiplied by the WQS of 200 cfu/100 mL for the facilities. All three of the facilities have been granted disinfection exemptions by IEPA; the WLA is applicable at the downstream point where the disinfection exemption ends.

IEPA identified three CAFOs in the watershed (Section 2.9 and Figure 9 of Attachment 5 of the TMDL). The CAFOs were not given an allocation (WLA = 0). IEPA did not identify any other point sources for fecal coliform.

Table 8: Fecal coliform WLAs in the Bonpas Creek TMDL

Permit Number	Facility Name	Design Average Flow (MGD)	WLA (cfu)
ILG580164	Village of West Salem-South WWTP	0.0425	3.2E+08
ILG580206	Village of Bellmont WWTP	0.065	4.9E+08
IL0071111	Village of Browns STP	0.05	3.8E+08

Atrazine: No point sources discharging atrazine were identified in the Bonpas Creek watershed. The WLA = 0.

Phosphorus: No point sources discharging phosphorus were identified in the New West Salem Reservoir watershed. The WLA = 0.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fifth element.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

Comment:
Fecal coliform: The Bonpas Creek TMDL incorporates an implicit MOS in the TMDL (Section 6.2.5 of the TMDL). The WLA is based upon the 200 cfu/100 mL as a 30-day geometric mean portion of the WQS to determine the daily load. This essentially sets the monthly geometric mean portion of the WQS as a daily not-to-exceed value (i.e., no averaging), significantly overestimating the bacteria reductions needed to attain WQSs in the Bonpas Creek watershed.

An additional conservative assumption is that IEPA did not use a rate of decay, or die-off rate of pathogen species, in the TMDL calculations or in the creation of the load duration curve for fecal coliform. Bacteria have a limited capability of surviving outside their hosts, and normally a rate of decay would be incorporated. IEPA determined that it was more conservative to use the WQS (200 cfu/100 mL) and not to apply a rate of decay, which could result in a discharge limit greater than the WQS.

As stated in *EPA's Protocol for Developing Pathogen TMDLs* (EPA 841-R-00-002), many different factors affect the survival of pathogens, including the physical condition of the water. These factors include, but are not limited to sunlight, temperature, salinity, and nutrient deficiencies. These factors vary depending on the environmental condition/circumstances of the water, and therefore it would be difficult to assert that the rate of decay caused by any given combination of these environmental variables was sufficient to meet the WQS of 200 cfu/100 mL. Thus, it is more conservative to apply the State's WQS as the MOS, because this standard must be met at all times under all environmental conditions.

Atrazine: The Bonpas Creek TMDL incorporates an explicit MOS in the TMDL (Section 6.3.4 of the TMDL; Table 6 of this Decision Document). IEPA reserved 10% of the loading capacity and allocated the remaining load to nonpoint sources, as there are no point sources.

Phosphorus: The New West Salem Reservoir phosphorus TMDL incorporates an explicit MOS of 10% of the total loading capacity. The MOS reserved 10% of the loading capacity and allocated the remaining loads to point and nonpoint sources (Table 7 of this Decision Document). IEPA noted that the MOS is reasonable due to the generally good calibration of the BATHTUB model for hydrology and pollutant loading (Attachment 3 of the TMDL). The calibration results indicate the model adequately characterize the lake, and therefore additional MOS is not needed.

EPA finds that the TMDL document submitted by IEPA has an appropriate MOS satisfying all requirements concerning this sixth element.

7. Seasonal Variation

The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variations. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Comment:

The LDC process accounts for seasonal variation by utilizing streamflows over a wide range. For fecal coliform and atrazine, runoff carries the pollutants into the streams. The LDC graphs can be used to determine under which conditions exceedences are occurring, and any seasonal component (i.e., spring melt).

Bacterial loads vary by season, typically reaching higher values in the dry summer months when low flows and warm water contribute to bacteria abundance, and reaching relatively lower values in colder months when bacterial growth rates attenuate. Bacterial WQS need to be met between May 1st to October 31st, regardless of the flow condition. The development of the LDC utilized flow measurements from local flow gages. These flow measurements were collected over a variety of flow conditions observed during the recreation season. The LDC developed from these flow records represents a range of flow conditions within the impaired watersheds and thereby accounted for seasonal variability over the recreation season.

For atrazine, herbicide application is typically in the spring and early summer when weeds are sprouting. The limited data set appears to indicate that higher flows (expected during higher rainfall events) are the source of atrazine entering the waterbody.

For phosphorus, use of the BATHTUB model addresses seasonal variation by accounting for run-off during the year. Precipitation data are considered in developing the loads of phosphorus from run-off events.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this seventh element.

8. Reasonable Assurances

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES) permit(s) provides the reasonable assurance that the wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

EPA's August 1997 TMDL Guidance also directs Regions to work with States to achieve TMDL load allocations in waters impaired only by nonpoint sources. However, EPA cannot disapprove a TMDL for nonpoint source-only impaired waters, which do not have a demonstration of reasonable assurance that LAs will be achieved, because such a showing is not required by current regulations.

Comment:
IEPA developed a Watershed Implementation Plan (WIP) as part of the TMDL for Bonpas Creek. IEPA provided information on controls of fecal coliform, atrazine, and phosphorus, and will be targeted in the watershed.

Reasonable assurances that the WLAs will be implemented are through the NPDES program. IEPA listed three WWTPs that discharge fecal coliform in the Bonpas Creek watershed. Section 6.4 of the TMDL addresses the discharges of fecal coliform from permitted facilities. No point sources of phosphorus or atrazine were identified in the TMDL.

The WIP discusses various BMPs that, when implemented, will significantly reduce pollutant loadings to attain WQS. For most of these BMPs, IEPA provided some watershed analysis on the impacts these BMPs may have on pollutant loads. This discussion included the impacts of waterbody buffers, conservation tillage, and nutrient managment plans on the transport of pollutants into the waterbodies. For atrazine, IEPA also noted the impacts of changing application practices for atrazine (such as applying post-emergent to reduce volume) as well as mixing atrazine with other herbicides could reduce the volume of atrazine use while maintaining weed control.

IEPA also identified critical areas for fecal coliform and phosphorus (and sediment) reductions, as noted in Section 4.5 of the WIP. The WIP is also meant to be consistent with Section 319 of the Clean Water Act. The EPA notes that this TMDL approval does not opine on the adequacy of this WIP to meet the Section 319 requirements.

As part of the WIP, IEPA identified a schedule and milestones for implementing various control measures (Section 6.1 and Tables 6-1 to 6-5 of the WIP). This schedule is for a 25-year time period, and focuses on high-priority efforts in the short-term, as well as long-term controls needed.

IEPA identified a local watershed group that will be participating in the implementation efforts in the watershed (Section 5 of the WIP). The Bonpas River Conservancy District have helped implement projects and BMPs in the watershed to reduce flooding and enhance conservation in the watershed. The local Soil and Water Conservation Districts have also been involved in activities in the watershed to improve water quality,

EPA finds that this criterion has been adequately addressed.

9. Monitoring Plan to Track TMDL Effectiveness

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan to track the effectiveness of a TMDL, particularly when a TMDL involves both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur. Such a TMDL should provide assurances that nonpoint source controls will achieve expected load reductions and, such TMDL should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.

Comment:

The TMDL contains discussion on future monitoring and milestones (Section 7 of the WIP). There were several monitoring sites used to gather data for the Bonpas Creek. The Bonpas Creek sites are part of the Illinois Ambient Water Quality Monitoring System, and will continue to be monitored quarterly. IEPA also performs intensive basin surveys every five years using a rotating basins process. Detailed monitoring of the Bonpas Creek and associated tributaries will be performed during these surveys. In order to demonstrate attainment of the milestones and benchmarks noted in the TMDL, future monitoring will be critical. IEPA identified several locations recommended for future monitoring in the watershed (Figure 7-1 of the WIP).

EPA finds that this criterion has been adequately addressed.

10. Implementation

EPA policy encourages Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired by nonpoint sources. Regions may assist States/Tribes in developing implementation plans that include reasonable assurances that nonpoint source LAs established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. In addition, EPA policy recognizes that other relevant watershed management processes may be used in the TMDL process. EPA is not required to and does not approve TMDL implementation plans.

Comment:
Numerous implementation options are discussed in the WIP. These options are directed for reductions in fecal coliform, atrazine, total phosphorus, as well as sediment.

The potential BMPs are:

- Cover crops
- No-till/strip till
- Grassed waterways
- Filter strip, grass conversion, and field borders
- Streambank stabilization
- Shoreline stabilization
- Detention basin/pond
- Septic Systems
- Nutrient management

For most of these BMPs, IEPA provided some watershed analysis on the impacts these BMPs may have on the pollutants addressed in these TMDLs as well as TP and TSS loads that are discussed under LRSs.

EPA reviews, but does not approve, implementation plans. EPA finds that this criterion has been adequately addressed.

11. Public Participation

EPA policy is that there should be full and meaningful public participation in the TMDL development process. The TMDL regulations require that each State/Tribe must subject calculations to establish TMDLs to public review consistent with its own continuing planning process (40 C.F.R. §130.7(c)(1)(ii)). In guidance, EPA has explained that final TMDLs submitted to EPA for review and approval should describe the State's/Tribe's public participation process, including a summary of significant comments and the State's/Tribe's responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 C.F.R. §130.7(d)(2)).

Provision of inadequate public participation may be a basis for disapproving a TMDL. If EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

Comment:
An initial public meeting was held on May 1, 2014, to describe the watershed plan and TMDL process. The public comment period for the draft TMDL opened on November 7, 2018 and closed on December 15, 2018. A public meeting was held on November 7, 2018, in Albion, Illinois.

The public notices were published in the local newspaper and interested individuals and organizations received copies of the public notice. A hard copy of the TMDL was made available at the Edwards County Soil and Water Conservation District office and the West Salem Village Hall. The draft TMDL was also made available at the website https://www2.illinois.gov/epa/public-notices/Pages/default.aspx . No public comments were received.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this eleventh element.

12. Submittal Letter

A submittal letter should be included with the TMDL submittal, and should specify whether the TMDL is being submitted for a *technical review* or *final review and approval*. Each final TMDL submitted to EPA should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter, whether for technical review or final review and approval, should contain such identifying information as the name and location of the waterbody, and the pollutant(s) of concern.

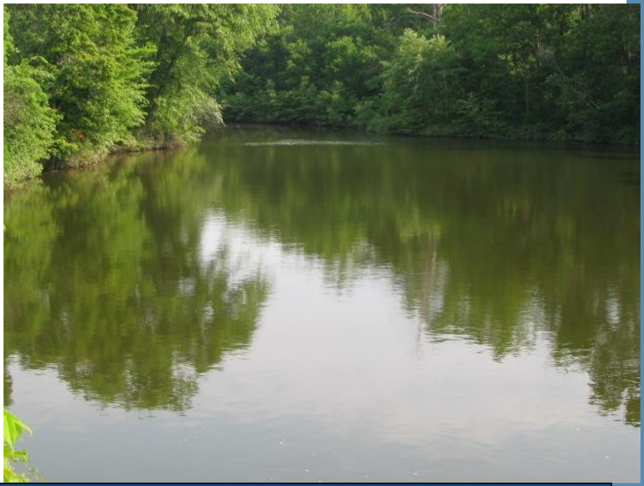
Comment:
On January 31, 2019, EPA received the Bonpas Creek watershed TMDL, and a submittal letter from Sanjay Sofat, IEPA, to Linda Holst, EPA. In the submittal letter, IEPA stated it was submitting the TMDL report for EPA's final approval. The submittal letter included the name and location of the waterbodies and the pollutants of concern.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this twelfth element.

Conclusion
After a full and complete review, EPA finds that the TMDLs for the Bonpas Creek watershed satisfy all of the elements of an approvable TMDL. This approval is for three TMDLs; one for fecal coliform, one for atrazine, and one for phosphorus, as noted in Table 1 of this Decision Document.

EPA's approval of this TMDL does not extend to those waters that are within Indian Country, as defined in 18 U.S.C. Section 1151. EPA is taking no action to approve or disapprove TMDLs for those waters at this time. EPA, or eligible Indian Tribes, as appropriate, will retain responsibilities under the CWA Section 303(d) for those waters.



TMDLs and Load Reduction Strategies, and Watershed Implementation Plan for the Bonpas Creek Watershed

Prepared for:
Illinois EPA

March 2019

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TMDLs and Load Reduction Strategies and Watershed Implementation Plan for the Bonpas Creek Watershed

Prepared for:
Illinois EPA

March 2019

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Executive Summary

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois 303(d) lists are published every two years and are available at:
https://www2.illinois.gov/epa/topics/water-quality/watershed-management/tmdls/Pages/303d-list.aspx.
This report focuses on assessments based on the 2012 303(d) list (IEPA, 2012), in addition to the upstream Bonpas Creek segment, which was subsequently assessed as impaired. Section 303(d) of the Clean Water Act and USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Load Reduction Strategies (LRSs) are being completed for causes that do not have numeric standards. LRSs for causes of impairment with target criteria will consist of loading capacity and the percent reduction needed to meet the target criteria.

Four (4) waterbodies in the Bonpas Creek watershed are listed on the 2012 Illinois Section 303(d) List of Impaired Waters (IEPA, 2012) as not meeting their designated uses. IEPA conducted additional sampling in 2015 to support the modeling presented in this report. This document presents TMDLs for Bonpas Creek (segments IL_BC-02 and IL_BC-04) and New West Salem Reservoir (IL_RBQ) to allow these segments to fully support their designated uses. The LRSs for Bonpas Creek (IL_BC-02) and Old West Salem Reservoir (IL_RBZN) are also presented. The report builds on the Stage 1 report, covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Stage 2 Sampling
- Development of Numeric Targets
- Development of Water Quality Models
- TMDL Development
- LRS Development
- Public Participation and Involvement
- Adaptive Implementation Process
- Clean Water Act Section 319

Illinois EPA conducts TMDLs following a three-stage process. Stage 1 includes watershed characterization, data analysis and model selection. Stage 2 involves data collection, and is conducted if necessary. Stage 3 includes model calibration and application, and TMDL and implementation plan development. Bonpas Creek Stage 1 work began in September, 2013. A public meeting to present the Stage 1 findings and the draft Stage 1 report was held in May 2014. The final Stage 1 report was completed in May, 2014, and recommended additional monitoring for dissolved oxygen modeling, and the delisting of manganese as an impairment. Stage 2 low flow sampling was conducted in 2015 by Illinois EPA to support dissolved oxygen modeling of Bonpas Creek. IEPA has confirmed that a manganese TMDL is not needed for IL_BC-02. This segment is scheduled to be monitored as part of the 2016 Intensive Basin Survey and manganese data will be collected to verify the recommendation for delisting, provided the new data meet the current water quality standards.

1
Problem Identification

The impaired waterbodies addressed in this Stage 3 report are listed below (Table 1-1), with the parameters (causes) they are listed for, and the impairment status of each designated use. TMDLs are currently only being developed for pollutants that have numerical water quality standards. Load Reduction Strategies (LRSs) are being developed for pollutants that do not have numerical water quality standards.

Based on a comparison of Bonpas Creek Segment IL_BC-04 TSS data to the LRS target concentration developed by IEPA, it was determined that TSS reduction is not needed, and it is not included in this Stage 3 report. Between the completion of the Stage 1 report, and the initiation of Stage 3 work, IEPA determined that the upstream segment of Bonpas Creek (segment IL_BC-04) is impaired due to low dissolved oxygen, and it is included in this Stage 3 TMDL report. Based on a review of all available data, **dissolved oxygen** violations of the water quality standard were observed to occur only during low flow conditions in segments IL_BC-02 and IL_BC-04. QUAL2E water quality model simulations for low flow conditions (see section 6.1), showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Model runs that keep all external loads at currently specified values and increase base stream flow result in the attainment of DO standards. Because this assessment indicates that low stream flows preclude attainment of dissolved oxygen standards, even in the complete absence of external pollutant loads, a TMDL is not being developed for dissolved oxygen.

Table 1-1. Impaired Waterbody Summary

Waterbody/Segment Name	Impaired Designated Use	Size (mile/acre)	Impairment Cause	TMDL or LRS?
Bonpas Cr. / IL_BC-02	Aquatic life	28.95	Atrazine	TMDL
	Aquatic life		Dissolved oxygen	No TMDL
	Primary contact recreation		Fecal coliform	TMDL
	Aquatic life		Sedimentation/siltation	LRS
Bonpas Cr. / IL_BC-04	Aquatic life	26.2	Dissolved oxygen	No TMDL
New West Salem Reservoir / IL_RBQ	Aesthetic quality	23[a]	Phosphorus (Total)	TMDL
Old West Salem Reservoir / IL_RBZN	Aesthetic quality	2[b]	Phosphorus (Total)	LRS

[a] The area of this reservoir, initially reported by IEPA to be 32 acres, was updated for this report based on a GIS analysis conducted to support lake modeling.
[b] A Load Reduction Strategy is being conducted for this waterbody because its surface area is less than the threshold area (20 acres) IEPA uses to define lakes.

2 Required TMDL Elements

USEPA Region 5 guidance for TMDL development requires TMDLs to contain specific components. Each of those components is summarized here for the Bonpas Creek segment IL_BC-02 and New West Salem Reservoir segment IL_RBQ TMDLs.

Bonpas Creek (IL_BC-02)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Bonpas Creek, HUC 0512011304. The pollutants of concern addressed in this TMDL are **atrazine and fecal coliform**. Potential sources contributing to the atrazine impairment include crop production (crop land or dry land). Potential sources contributing to the fecal coliform impairment include onsite treatment systems, animal feeding operations (nonpoint source), and wastewater treatment plants.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**

   Illinois currently has an acute **atrazine** water quality criterion of 82 ug/L and a chronic atrazine criterion of 9 ug/L. The TMDL target for atrazine is conservatively set at the chronic atrazine criterion of 9 ug/L.

   The **fecal coliform** TMDL target is conservatively set at the geometric mean of 200/100 mL. The IEPA (2006) guidelines for identifying dissolved oxygen as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:**

   A load capacity calculation was completed to determine the maximum **atrazine** loads that will maintain compliance with the atrazine target under a range of flow conditions:

Bonpas Creek Flow (cfs)	Allowable Atrazine Load (lbs/day)
5	0.24
100	4.9
500	24.3
1000	48.5
2000	97.1
3000	145.6
4000	194.2
5000	242.7
6000	291.3

   A load capacity calculation was completed to determine the maximum **fecal coliform** loads that will maintain compliance with the fecal coliform target for May through October under a range of flow conditions:

Bonpas Creek Flow (cfs)	Allowable Fecal Coliform Load (cfu/day)
5	2.45E+10
100	4.89E+11
500	2.45E+12
1000	4.89E+12
2000	9.79E+12
3000	1.47E+13
4000	1.96E+13
5000	2.45E+13
6000	2.94E+13
7000	3.44E+13

4. **Load Allocations (LA):** The load allocation given to non-point source loads from watershed sources is shown below for atrazine and fecal coliform.

Atrazine

Bonpas Creek Flow (cfs)	Load Allocation (LA) (lbs/day)
5	0.22
100	4.37
500	21.84
1000	43.69
2000	87.38
3000	131.07
4000	174.75
5000	218.44
6000	262.13

Fecal coliform

Bonpas Creek Flow (cfs)	Load Allocation (LA) (cfu/day)
5	2.33E+10
100	4.88E+11
500	2.45E+12
1000	4.89E+12
2000	9.79E+12
3000	1.47E+13
4000	1.96E+13
5000	2.45E+13
6000	2.94E+13
7000	3.44E+13

5. **Wasteload Allocations (WLA):**

All of the point sources in this watershed are considered *de minimis*[1] contributors to the **atrazine** impairment, so a WLA is not assigned for these facilities. This report has concluded that the current NPDES permit effluent limits are appropriate, and no reductions in atrazine are needed at this time. However, future plant expansions and new facilities may be subject to applicable Water Quality Standards (WQS) or technologically achievable Water Quality Based Effluent Limits (WQBEL).

The WLA for the 3 permitted sewage treatment plant discharges in the Bonpas Creek segment IL_BC-02 watershed was calculated based on the permitted design average flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100mL). All three of these NPDES-permitted dischargers have disinfection exemptions; therefore, the WLA is based on the dischargers meeting 200 cfu/100 mL at the downstream end of their exempted reach. The WLA for **fecal coliform** is shown below.

Bonpas Creek Flow (cfs)	Wasteload Allocation (WLA) (cfu/day)
5	1.19E+09
100	1.19E+09
500	1.19E+09
1000	1.19E+09
2000	1.19E+09
3000	1.19E+09
4000	1.19E+09
5000	1.19E+09
6000	1.19E+09
7000	1.19E+09

6. **Margin of Safety:**

The **atrazine** TMDL contains an explicit margin of safety of 10% (see below). This 10% margin of safety was included to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

[1] USEPA considers "*de minimis*" as 0.

Bonpas Creek Flow (cfs)	MOS (10%) (lbs/day)
5	0.02
100	0.49
500	2.43
1000	4.85
2000	9.71
3000	14.56
4000	19.42
5000	24.27
6000	29.13

The **fecal coliform** TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 mL at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 mL for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

7. **Seasonal Variation:**

This **atrazine** TMDL was conducted with an explicit consideration of seasonal variation. The atrazine standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

The **fecal coliform** TMDL was conducted with an explicit consideration of seasonal variation. The load capacity calculation approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

8. **Reasonable Assurances**: WLAs will be implemented through the NPDES permit process. According to 40 CFR ' 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has the authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL.

Nonpoint source controls to achieve LAs will be implemented in an iterative process that places priority on those sources having the largest impact on water quality, with consideration given to ease of implementation and cost.

9. **Monitoring Plan to Track TMDL Effectiveness**: The implementation plan includes a monitoring plan to track effectiveness.
10. **Transmittal Letter**: A transmittal letter will accompany this TMDL document.
11. **Public Participation:** A public meeting to present the findings of this Stage 3 report will be held at a location in the watershed, once this report is complete.

New West Salem Reservoir (IL_RBQ)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** New West Salem Reservoir, HUC 0512011304. The pollutant of concern addressed in this TMDL is total phosphorus. Potential sources contributing to this impairment include nonpoint source runoff (cropland). New West Salem Reservoir is ranked low priority on the 2014 Illinois EPA 303(d) list (IEPA, 2014).
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The General Use water quality criteria for phosphorus in Illinois lakes is 0.05 mg/l. For this TMDL, the numeric water quality target was set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is an average load of 0.2 kg/day (0.44 lbs/day). This allowable load corresponds to an approximately 50% reduction from existing tributary loads.
4. **Load Allocations (LA):** The load allocation given to non-point source loads from watershed sources is 0.18 kg/day (0.40 lbs/day).
5. **Wasteload Allocations (WLA):** There are no point sources that discharge in the watershed. No WLA was set for this watershed.
6. **Margin of Safety**: The TMDL contains an explicit margin of safety corresponding to 10% of the loading capacity, or 0.02 kg/day (0.04 lbs/day).
7. **Seasonal Variation:** This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate because 1) the analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release; and 2) there is a long response time between phosphorus loading and sediment response, typically on the order of several years.
8. **Reasonable Assurances:** Reasonable assurances for point sources are not included because there are no permitted point sources in the watershed.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Details regarding past studies of the lake are provided in the Stage 1 report.

9. **Monitoring Plan to Track TMDL Effectiveness:** The implementation plan includes a monitoring plan to track effectiveness.
10. **Transmittal Letter**: A transmittal letter will accompany this TMDL document.
11. **Public Participation**: A public meeting to present the findings of this Stage 3 report will be held at a location in the watershed, once this report is complete.

3
Stage 2 Sampling

The Stage 1 report recommended additional sampling be conducted during low flow conditions to support dissolved oxygen modeling. In 2015, IEPA conducted Stage 2 sampling to support dissolved oxygen modeling. Samples were collected in August, September and October, 2015, and data were reported for CBOD5, BOD5, nitrite-nitrate nitrogen, ammonia, total Kjeldahl nitrogen (TKN), total phosphorus, dissolved phosphorus, chlorophyll a, total suspended solids and volatile suspended solids. Flow, velocity and channel morphometry were also recorded during sampling.

Figure 3-1 shows the locations sampled in 2015. The data collected at these locations were used in the dissolved oxygen modeling described in this report. TMDLs and LRSs for other parameters were based on existing data, previously collected by IEPA and described in the Stage 1 report.

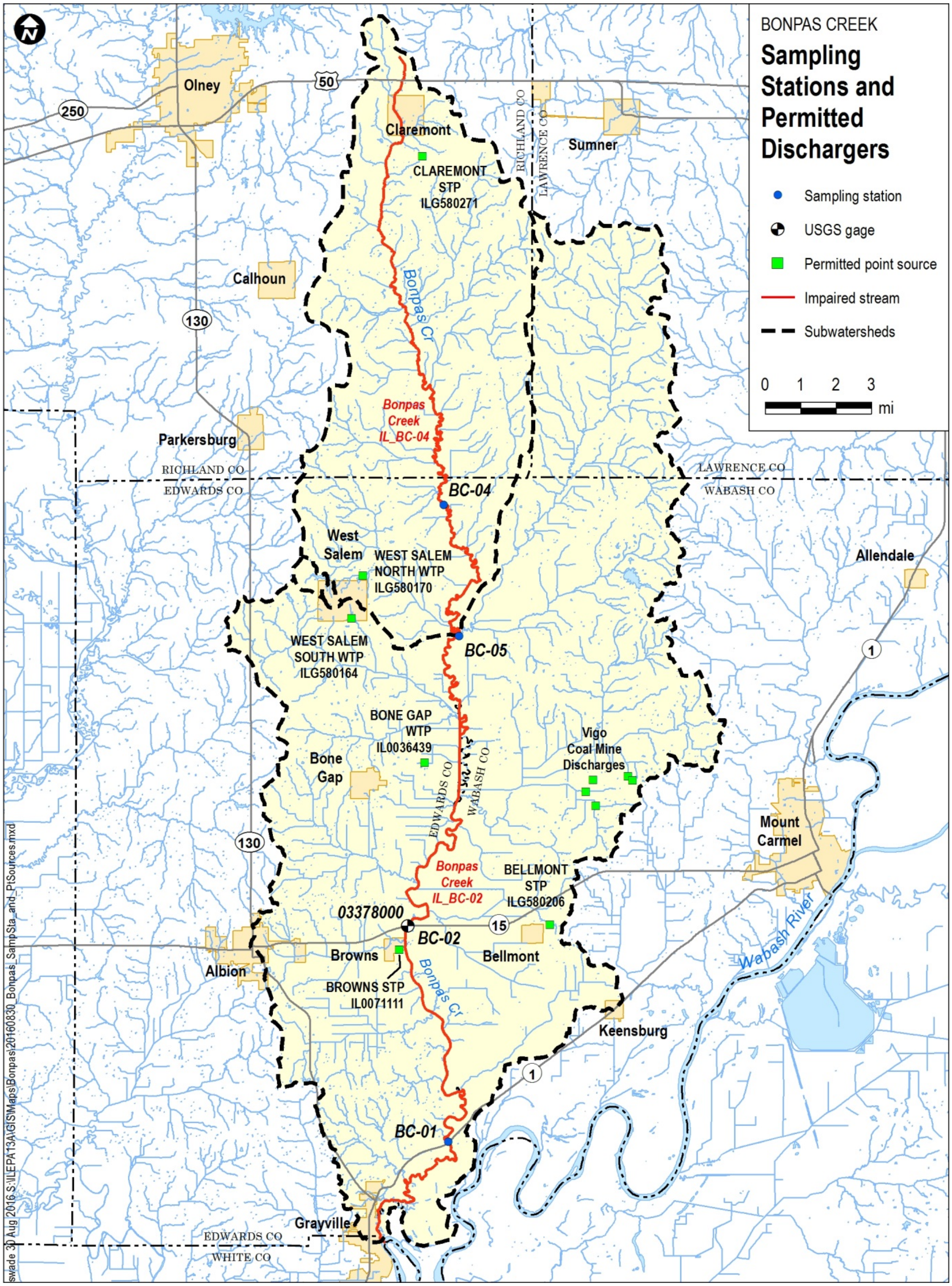

Figure 3-1. 2015 Sampling Locations in the Bonpas Creek Watershed

4 Development of Numeric Targets

Designated use, use support and water quality criteria for waterbodies in the Bonpas Creek watershed have been previously described in Sections 3 (Designated Use and Criteria) and Section 4 (Use Support) of the Stage 1 Report (Attachment 5). This section describes the development of numeric TMDL and LRS targets. Although the DO target is described for two Bonpas Creek segments, it is noted that following a modeling assessment, no TMDL was developed for DO due to the fact that low DO is caused by low flow.

4.1 Development of TMDL and LRS Targets

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint.

4.1.1 Bonpas Creek Segment IL_BC-02

For the Bonpas Creek (IL_BC-02) dissolved oxygen assessment, the target is set at the water quality criterion for daily minimum dissolved oxygen of 5.0 mg/L recognizing that this is the more conservative of the seasonal minimal dissolved oxygen criteria (recall that between August and February, the minimum equals 3.5 mg/L). The QUAL2E model predicts a daily average dissolved oxygen concentration and does not directly predict daily minimum values. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output. Based upon data analysis described in Section 6, a maximum diurnal variation of 1.3 mg/l was used to ensure that the 5.0 mg/l water quality standard is met.

Illinois has an acute atrazine water quality criterion of 82 ug/L and a chronic atrazine criterion of 9 ug/L. (http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria-list.pdf). For the Bonpas Creek (IL_BC-02) atrazine TMDL, the target is conservatively set at the water quality criterion of 9 ug/L (General Use standard, chronic criterion for aquatic life).

The General Use standards for fecal coliform bacteria are in Section 302.209 of Title 35. During the months May through October (swimming season), based on a minimum of five samples taken over not more than a 30 day period, fecal coliform bacteria shall not exceed a geometric mean of 200 per 100 mL, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 mL. For the Bonpas Creek (IL_BC-02) fecal coliform TMDL, the target is conservatively set at the water quality criterion of 200 colony forming units (cfu)/100 mL.

When appropriate numeric standards do not exist, surrogate parameters must be selected to represent protection of the designated use. For Bonpas Creek IL_BC-02, IEPA has developed a LRS target of 27.75 mg/L TSS (IEPA, 2016). This target is based on an average of validated, real-world data (1999-2013) for the nearby Upper Kaskaskia watershed, which contains several streams that are in full support of aquatic life.

4.1.2 Bonpas Creek Segment IL_BC-04

For the Bonpas Creek (IL_BC-04) dissolved oxygen assessment, the target is set at the water quality criterion for daily minimum dissolved oxygen of 5.0 mg/L recognizing that this is the more conservative of the seasonal minimal dissolved oxygen criteria (recall that between August and February, the minimum equals 3.5 mg/L). The QUAL2E model predicts a daily average dissolved oxygen concentration and does not directly predict daily minimum values. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output. Based upon data analysis described in Section 6, a maximum diurnal variation of 2.2 mg/l was used to ensure that the 5.0 mg/l water quality standard is met.

4.1.3 New West Salem Reservoir IL_RBQ

For the New West Salem Reservoir phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/L.

4.1.4 Old West Salem Reservoir IL_RBZN

For the Old West Salem Reservoir phosphorus LRS, the LRS target is set at the water quality criterion for total phosphorus of 0.05 mg-P/L.

5 Development of Water Quality Models

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. This section describes the modeling to support TMDL and LRS development, and is divided into the following sections:

- QUAL2E modeling for dissolved oxygen. As discussed previously, this modeling showed that the low DO was due to low flow and TMDLs were not developed
- Load Duration Curve approach for fecal coliform and atrazine TMDLs
- BATHTUB modeling for total phosphorus TMDL and LRS

The remainder of this section describes the TSS modeling to support the TSS LRS.

5.1 QUAL2E Model for the Dissolved Oxygen

The QUAL2E water quality model was used to define the relationship between external oxygen-demanding loads and the resulting concentrations of dissolved oxygen in Bonpas Creek. QUAL2E is a one-dimensional stream water quality model applicable to dendritic, well-mixed streams. It assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the main direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows.

5.1.1 Model Selection

A discussion of the model selection process for the Bonpas Creek watershed is provided in the Stage 1 report.

The QUAL2E model (Brown and Barnwell, 1987) was selected to address dissolved oxygen impairments in Bonpas Creek. QUAL2E is the most commonly used water quality model for addressing low flow conditions. An empirical approach was selected for determining watershed loads, recognizing a more detailed analysis of specific sources is conducted during the implementation phase.

5.1.2 Modeling Approach

The modeling approach selected for dissolved oxygen consists of using data collected during 2015 dry weather surveys to define the current water quality of the river, and using the QUAL2E model to define the extent to which loads must be reduced to meet water quality standards. This is the recommended approach presented in the Stage 1 report.

5.1.3 QUAL2E Model Inputs

This section gives an overview of the model inputs required for QUAL2E application, and how they were derived. The following categories of inputs are required for QUAL2E:

- Model options (title data)
- Model segmentation
- Hydraulic characteristics
- Reach kinetic coefficients

- Initial conditions
- Incremental inflow conditions
- Headwater characteristics
- Point source flows and loads

5.1.3.a Model Options

This portion of the model input parameters defines the specific water quality constituents to be simulated. QUAL2E was set up to simulate temperature, biochemical oxygen demand, the nitrogen series, phosphorus, algae and dissolved oxygen.

5.1.3.b Model Segmentation

The QUAL2E model divides the river being simulated into discrete segments (called "reaches") that are considered to have constant channel geometry and hydraulic characteristics. Reaches are further divided into "computational elements", which define the interval at which results are provided. The Bonpas Creek QUAL2E model consists of five reaches, which are comprised of a varying number of computational elements. Computational elements were specified to have a fixed length of 0.5 miles. Reaches are defined with respect to water quality monitoring stations and tributaries. Model segmentation is presented below in Table 5-1 and Figure 5-1.

Table 5-1. QUAL2E Segmentation

Reach	River miles	Number of computational elements	Other features
1	38 - 47.5	19	Claremont WWTP
2	28 - 38	20	
3	18 - 28	20	West Salem North STP
4	8 - 18	20	West Salem South WWTP, Vigo Coal Friendsville Mine, Bellmont WWTP
5	0 - 8	16	Browns STP

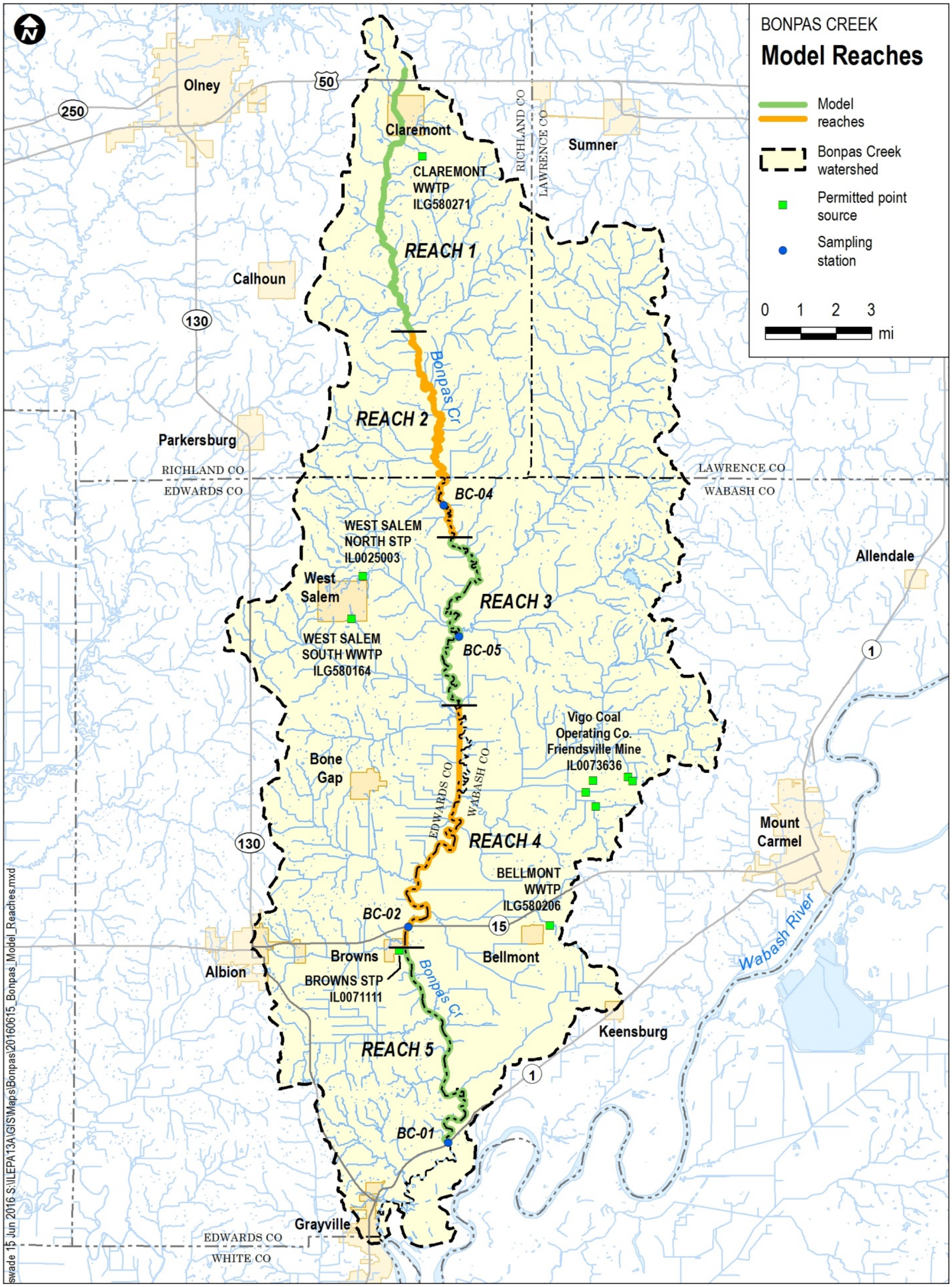

Figure 5-1. Bonpas Creek QUAL2E Segmentation

5.1.3.c Hydraulic characteristics

A functional representation was used to describe the hydraulic characteristics of the system. For each reach, velocity and depth were specified, based on measurements taken during the August, September and October 2015 field surveys.

5.1.3.d Reach Kinetic Coefficients

Kinetic coefficients were initially set at values commonly used in past QUAL2E applications from Illinois. The appropriateness of these initial values were assessed during the model calibration process, where these coefficients were refined as necessary (within accepted ranges taken from the scientific literature) to allow model results to best describe observed water quality data.

5.1.3.e Initial Conditions

Initial model conditions were based on field observations taken during 2015 and USGS flow measurements. Specifically, observed concentrations of ammonia, phosphorus, organic nitrogen, nitrate and chlorophyll a were used to specify initial conditions.

5.1.3.f Incremental Inflow Conditions

Incremental inflows were calculated using a drainage area ratio and measured USGS flows. Increases in flows were added to each reach incrementally to represent non-monitored tributaries (flows were increasing from upstream to downstream). Concentrations for these incremental inflows were considered to have concentrations at typical background levels, and temperatures consistent with the mainstem. Other flows came from the headwater and point sources.

5.1.3.g Headwater Characteristics

Headwater characteristics were based on the flow/water quality measurements collected at the more upstream IEPA station (BC-04).

5.1.3.h Point Source Flows and Loads

There are seven permitted NPDES discharges in the Bonpas Creek watershed. Five of these are sewage treatment plants, one is a water treatment plant and one is a coal mine. The NPDES permits are for: West Salem North STP (ILG580170), Claremont STP (ILG580271), Browns STP (IL0071111), Bellmont STP (ILG580206), Bone Gap WTP (ILG640152), West Salem South STP (ILG580164) and Vigo Coal operating Co, Friendsville Mine (IL0073636) (Stage 1 Report, Section 2.9).

The model considers six permitted point sources that discharge to Bonpas Creek via six tributaries. All of these discharges are assumed to contribute no load or small loads (based on discharge monitoring report (DMR) data and some assumptions where data were not available). The Bone Gap Water Treatment Plant discharges filter backwash and was excluded from the model based on a determination that it was not contributing to low dissolved oxygen. See Table 5-2 for details of when data were used, and when assumptions were made.

Table 5-2. Concentrations of QUAL2e model inputs (range of inputs used for model calibration runs)

Model input point	Flow (cfs)	Temp. (Deg F)	DO (mg/L)	CBOD5 (mg/L)	Ammonia (mg/L)	Source
Headwater	0.03 - 0.08	63.5 - 68	4.8 - 6.85	1	.05	Data collected at BC-04
Claremont STP discharge to Reach 1	0	N/A	N/A	N/A	N/A	No DMR data for this general permit.*
West Salem North STP discharge to Reach 2	0.05 - 0.07	70	7.4 - 7.9	4	0	DMR data (flow, CBOD5, DO)
Incremental inflow to Reach 2	0.03 - 0.08	63.5 - 68	6	1	0.05	Calculated from flow balance. Water quality specified based on typical background levels.
West Salem South WWTP discharge to Reach 3	0.037	70	7.4 -7.9	4	0	DMR data (flow) + estimated from available data for West Salem North.
Incremental inflow to Reach 3	0.02 - 0.07	63.5 - 68	6	1	0.05	Calculated from flow balance. Water quality specified based on typical background levels.
Vigo Coal Friendsville Mine discharge to Reach 4	0	N/A	N/A	N/A	N/A	DMR data and flow balance calculation
Bellmont WWTP discharge to Reach 4	0	N/A	N/A	N/A	N/A	No data*
Incremental inflow to Reach 4	0.04 – 0.29	63.5 - 68	6	1	0.05	Calculated from flow balance. Water quality specified based on typical background levels.
Browns STP discharge to Reach 5	0	N/A	N/A	N/A	N/A	"No discharge" or "insufficient flow" reported on DMR
Incremental inflow to Reach 5	0.01	63.5 - 68	6	1	0.05	Calculated from flow balance. Water quality specified based typical background levels.

*If no data were available, it was assumed these facilities were not discharging.

N/A = Not applicable.

5.1.4 QUAL2E Calibration

QUAL2E model calibration consisted of:

- Applying the model with all inputs specified as above
- Comparing model results to observed dissolved oxygen, BOD, ammonia, and chlorophyll data
- Adjusting model coefficients to provide the best comparison between model predictions and observed dissolved oxygen data.

The QUAL2E dissolved oxygen calibration for Bonpas Creek (IL_BC-02 and IL_BC-04) is discussed below. The model was initially applied with the model inputs as specified above. Observed data for the three low flow surveys conducted in 2015 were used for calibration purposes.

QUAL2E was calibrated to match the observed average dissolved oxygen concentrations measured at three locations (BC-04, BC-05 and BC-02) on the mainstem of the creek. Data collected at station BC-01 were not used because it was determined these were likely influenced by backwater effects from the Wabash River. The initial BOD and ammonia calibration was deemed successful, albeit not totally conclusive, as the majority of observed data (as well as model predictions) for both parameters were below laboratory detection limits. Similarly, the initial coefficients used to describe chlorophyll a correctly replicated observed low observed field concentrations and confirmed that algal productivity was not an important component of the dissolved oxygen budget.

Model results initially over-predicted observed dissolved oxygen data. Model calibration was attained by adjusting reach-specific sediment oxygen demand, with calibration values ranging from 0.017 to 0.040 mg/sq ft/day. The resulting dissolved oxygen predictions compared well to the measured concentrations for all three surveys, as shown in Figure 5-2. The QUAL2E model output files from the calibration runs are included in Attachment 2.

It is noted that DMR data for West Salem South WWTP indicate that an extremely high CBOD5 concentration (120 mg/l) occurred in October, although it uncertain whether these discharge concentrations were occurring during the time of the survey. To assess the impact of this on the instream DO concentrations, a model run was conducted assuming the violation occurred on the date of sampling (10/6/15). The exact date, however, is unknown. Model results with the high CBOD5 effluent concentration are shown as a red line in the bottom graph. Results indicate that, regardless of assumption made for this discharge concentration, model results fall within the range of the observed data.

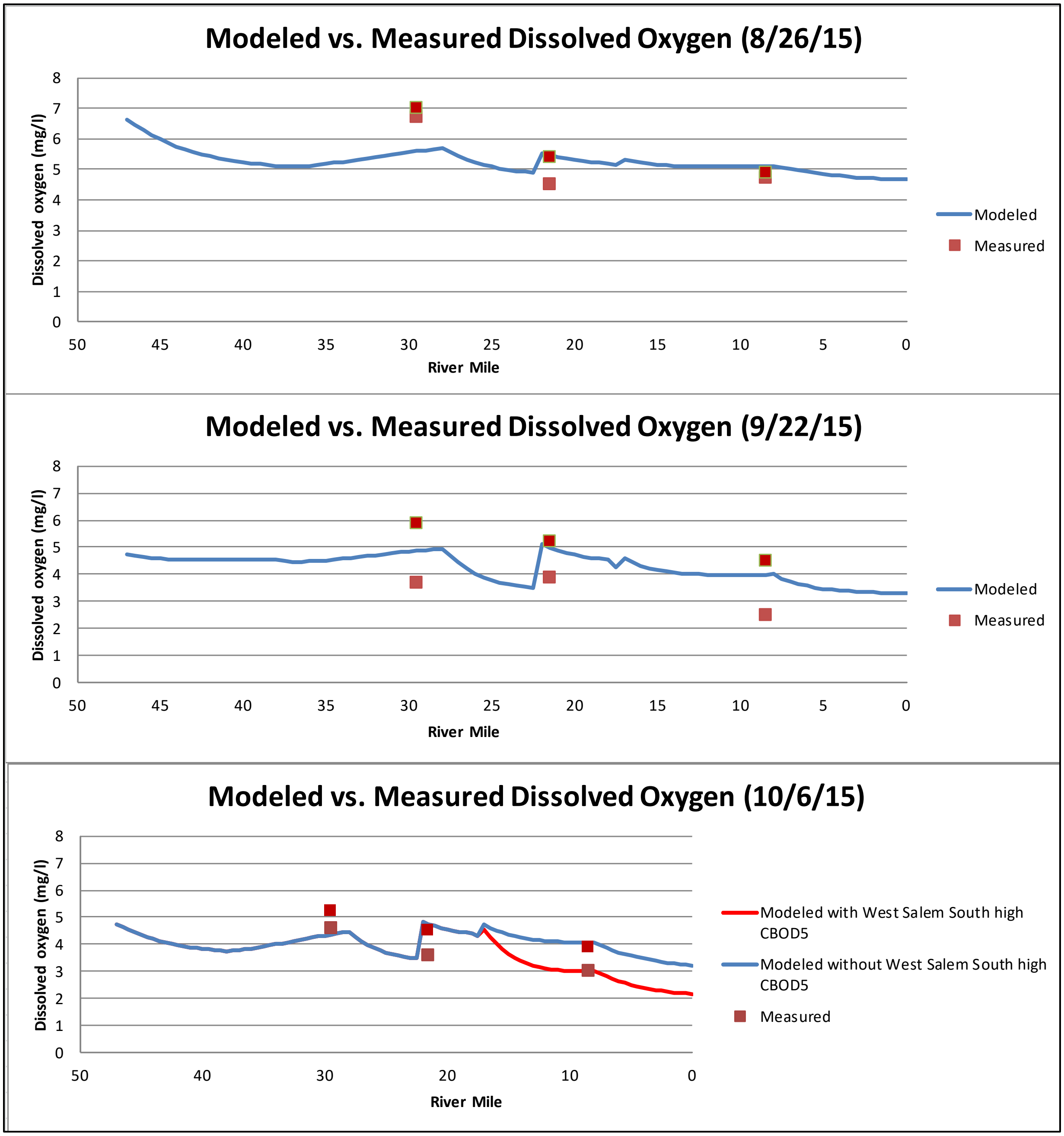

Figure 5-2. QUAL2E DO Calibration for Bonpas Creek for Three Sampling Surveys

5.2 Load Duration Curve Approach

A load duration curve approach was used in the atrazine and fecal coliform analysis for Bonpas Creek (IL_BC-02). This LDC covers the Bonpas Creek watershed from station BC-05 to the mouth of the creek, excluding the segment BC_04 watershed (See Figure 3-1 map of the watershed with subwatersheds shown for the two Bonpas Creek segments described here). A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.2.1 Model Selection

A detailed discussion of the model selection process for Bonpas Creek is provided in the Stage 1 Report. The load-duration curve approach was selected because it is a simpler approach that can be supported with the available data and still support the selected level of TMDL implementation for this TMDL. The load-duration curve approach identifies broad categories of atrazine and fecal coliform sources and the extent of control required from these source categories to attain water quality standards.

5.2.2 Approach

The load duration curve approach uses stream flows for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results; 2) translating the flow duration curve (produced in step 1) into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature.

5.2.3 Data inputs

This section describes the flow and water quality data used to support development of the load duration curve for atrazine and fecal coliform bacteria.

5.2.3.a Flow

Daily flow measurements are available for the USGS gage on Bonpas Creek (USGS gage number 03378000 at Browns, IL) for the period from 1999 through present. A drainage area ratio (277.7 mi^2 at mouth/228 mi^2 at gage) was applied to the flows to calculate flows at the mouth of Bonpas Creek for use in this analysis. All of the atrazine and fecal coliform data were collected at IEPA station BC-02, which is at the same location as the USGS gage.

5.2.3.b Atrazine

All atrazine data collected by IEPA between 1999 and 2006 were used in the analysis.

5.2.3.c Fecal coliform

Fecal coliform data collected by IEPA between 1999 and 2006 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies only during this period.

5.2.4 Analysis

A flow duration curve was generated by ranking daily flows at the Bonpas mouth from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. Load duration curves for atrazine and fecal coliform were generated by multiplying the flows in the duration curve by the water quality standard of 9 µg/L for atrazine, and 200 cfu/100 mL for fecal coliform bacteria. The load duration curves are shown with a solid line in Figure 5-3 and 5-4, for atrazine and fecal coliform, respectively. Observed pollutant loads of atrazine were calculated using available concentration data paired with corresponding flows, and were plotted on the same graph. For fecal coliform, observed pollutant loads were calculated in the same manner, using only measurements collected between May and October. The worksheets for these analyses are provided in Attachment 4.

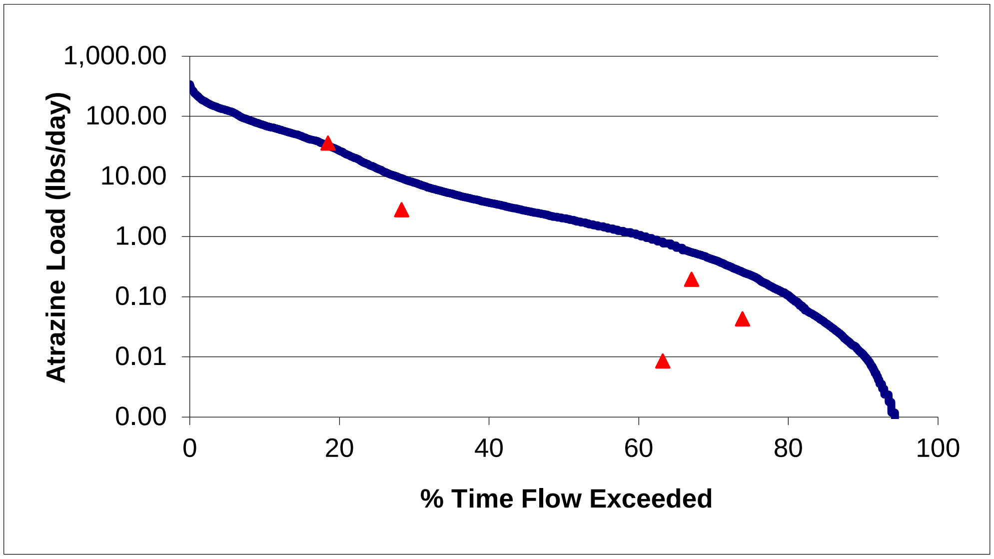

Figure 5-3. Atrazine Load Duration Curve for Bonpas Creek (IL_BC-02) with Observed Loads (triangles)

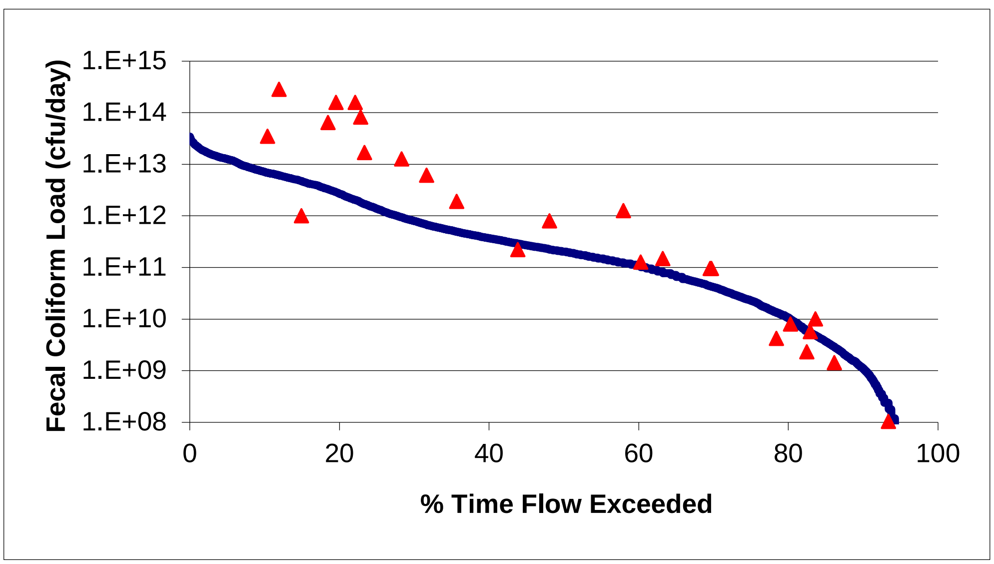

Figure 5-4. Fecal Coliform Load Duration Curve for Bonpas Creek (IL_BC-02) with Observed Loads (triangles)

In Figure 5-3, the data show that the single exceedance of the atrazine target occurs at the highest sampled flow in Bonpas Creek segment IL_BC-02. This indicates that wet weather sources contribute to the observed violation of the water quality standard. In Figure 5-4, the data show exceedances of the fecal coliform target occur in the higher range of flows. This similarly indicates that wet weather sources contribute to the observed violations of the water quality standard.

5.3 BATHTUB Model

5.3.1 Model Selection

The BATHTUB model (Walker, 1986) was selected as the tool to define load reduction necessary to attain phosphorus targets in Old West Salem Reservoir and New West Salem Reservoir. A detailed discussion of the model selection process is provided in the Stage 1 report. BATHTUB can predict the relationship between phosphorus load and resulting in-lake phosphorus. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

BATHTUB is a software program for predicting the lake/reservoir response to nutrient loading. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of empirical regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, chlorophyll concentrations, and Secchi depth (transparency). Both tabular and graphical displays are available from the program.

5.3.2 Modeling Approach

The approach taken for the total phosphorus TMDL and the total phosphorus LRS consisted of using existing empirical data to define current loads to each of the lakes, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach was taken because phosphorus concentrations exceed the water quality standard by up to a factor of five (New West Salem Reservoir, 2012 data) and by up to a factor of twenty (Old West Salem Reservoir, 2000 data). In addition, sediment phosphorus concentrations in both reservoirs exceed 1,000 mg/kg in at least one sample. These sediment phosphorus concentration data were not used specifically in the BATHTUB modeling, but do confirm that internal phosphorus loading is a potentially significant source. Phosphorus loads will need to be reduced to a small fraction of existing load in order to attain water quality standards.

5.3.3 BATHTUB Model Inputs

This section gives an overview of the model inputs required for BATHTUB application, and how they were derived for application to Old West Salem Reservoir and New West Salem Reservoir. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

5.3.3.a Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 2, and the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The Canfield and Bachman phosphorus option was selected for phosphorus, as this is a commonly used formulation for Midwestern phosphorus TMDLs (e.g. MPCA, 2007; https://www.pca.state.mn.us/sites/default/files/wq-iw8-03e.pdf). Nitrogen was not simulated because phosphorus is the nutrient of concern.

Chlorophyll a and transparency were not simulated because the water quality target is specified as total phosphorus. The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. No nitrogen calibration was required. The use of availability factors was not required and estimated concentrations were used to generate mass balance tables.

Table 5-3. BATHTUB Model Options

Model	Model Option
Conservative substance	Not computed
Total phosphorus	Canfield and Bachman
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Model and Data
Availability factors	Ignored
Mass-balance tables	Use estimated concentrations

5.3.3.b Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. One decision in the application of BATHTUB is the selection of length of time over which inputs and outputs should be modeled. An annual averaging period was used for both lakes, consistent with the fact that tributary loading estimates represented annual average conditions.

Precipitation inputs were taken from the observed long term annual average precipitation data at Olney, IL and scaled for the April-July simulation period. This resulted in a precipitation value of 42.5 inches for Old West Salem reservoir and 42.5 inches for New West Salem Reservoir. Evaporation was set equal to values suggested by NOAA Technical Reports 33 and 34 (NOAA, 1982; NOAA, 1982a), which is 0.99 inches for the averaging period. There was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

5.3.3.c Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of each segment. The segmentation scheme selected for Old West Salem Reservoir and New West Salem Reservoir was designed to provide one segment for each of the primary lake sampling stations. Old West Salem Reservoir was represented as a single segment, and New West Salem Reservoir was divided into with two segments, as shown in Figure 5-7. The areas of the segments and the watersheds for the segments were determined by Geographic Information System (GIS).

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths (total, thermocline and mixed layer) were calculated from the lake monitoring data, while segment lengths and surface areas were calculated via GIS. A complete listing of all segment-specific inputs is provided in Attachment 3.

Figure 5-5. Old and New West Salem Lake Segmentation Used in BATHTUB

5.3.3.d Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at Bonpas Creek at Browns, Illinois (03378000), adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage * Segment-specific drainage area ratio

Drainage area ratio = Drainage area of watershed contributing to model segment

Drainage area of watershed contributing to USGS gage

Segment-specific drainage area ratios were calculated via GIS information.

Total phosphorus concentrations for each tributary and direct drainage inflow were estimated by dividing the watershed phosphorus load (calculated based on land use and literature phosphorus loading rates from Harmel et al., 2006 (for pasture and corn) and USEPA , 1999 (for all other land uses) by the tributary flow.

Because New West Salem Reservoir flows into Old West Salem Reservoir, the loads from that outflow were also included as an input to Old West Salem Reservoir. The outflow from New West Salem Reservoir was calculated as the inflow (calculated using a drainage area ratio as described above) minus lake evaporation. The phosphorus concentration of the outflow was set equal to the average surface concentration measured near the dam (station RBQ-1), as the outflow from this reservoir overtops the dam.

A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 3.

5.3.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

5.3.4.a Old West Salem Reservoir

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2000 were used for calibration purposes. The May - October observed lake data were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus, i.e. model predictions were lower than observed concentrations. Phosphorus loss rates in BATHTUB reflect a typical "net settling rate" (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 25 $mg/m^2/day$. The resulting modeled and observed total phosphorus concentrations are shown in Table 5-4. BATHTUB output files are provided in Attachment 3.

5.3.4.b New West Salem Reservoir

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2000 were used for calibration purposes. The May - October observed lake data were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model. Data for 2012 were also available, but because 2000 was a more typical year in terms of climate, it was selected for calibration.

BATHTUB was first calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus data in both lake segments. Phosphorus loss rates in BATHTUB reflect a typical “net settling rate” (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 45 $mg/m^2/day$ in the near-dam segment (Segment 1). The presence of an internal phosphorus load is consistent with the observed elevated sediment phosphorus concentrations described previously. No additional internal phosphorus load was required for the more upstream segment (Segment 2). The resulting modeled and observed total phosphorus concentrations are shown in Table 5-5. BATHTUB output files are provided in Attachment 3.

Table 5-4. Segment Modeled vs. Observed Total Phosphorus Concentration: Old West Salem

Segment	Modeled Concentration (ug/L)	Observed Concentration (ug/L)
1	179	174

Table 5-5. Segment Modeled vs. Observed Total Phosphorus Concentration: New West Salem

Segment	Modeled Concentration (ug/L)	Observed Concentration (ug/L)
1 (near dam)	223	216
2 (upstream)	136	140
Lake-wide average	177	176

5.4 Total Suspended Solids Model for Load Reduction Strategy Development

This section describes the model selection and modeling approach for the total suspended solids load reduction strategy for Bonpas Creek stream segment IL_BC-02, identified by IEPA as being impaired due to elevated total suspended solids concentrations.

5.4.1 Model Selection

The total suspended solids load reduction strategy is based on a simple empirical model using all available instream TSS data. For segment IL_BC-02, a total of 29 samples were available for three stations for the period 2004 through 2015.

5.4.2 Modeling Approach

Total suspended solids measurements collected in the Bonpas Creek segments were compared to the target total suspended solids concentration of 27.75 mg/L (Section 4.1) to determine the percent reduction needed for the LRS.

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6
TMDL Development for the Bonpas Creek Watershed

This section presents the development of the fecal coliform and atrazine TMDLs for Bonpas Creek (IL_BC-02), and the total phosphorus TMDL for New West Salem Reservoir (IL_RBQ). Section 6.1 also describes a dissolved oxygen assessment for IL_BC-02 and IL_BC-04, and the determination that no dissolved oxygen TMDLs would be developed for these segments.

6.1 Dissolved Oxygen

A dissolved oxygen assessment was conducted for Bonpas Creek segment IL_BC-02 and IL_BC-04. The result of this assessment indicates that low stream flows preclude attainment of dissolved oxygen standards, even in the complete absence of external pollutant loads. For this reason, a TMDL is not being developed for dissolved oxygen. Details of the assessments are discussed below.

Two lines of assessment were used to make the determination that it is low stream flows, rather than external pollutant loads that precludes attainment of dissolved oxygen standards:

1. Sediment oxygen demand is the dominant component of the dissolved oxygen mass balance provided by QUAL2E.
2. Setting all external loading sources to zero in the QUAL2E model does not result in attainment in dissolved oxygen standards.
3. Leaving all external loads at currently specified values, but increasing base stream flow, does result in attainment with dissolved oxygen standards.

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The first step in determining the loading capacity was to reduce external sources of oxygen-demanding substances to determine whether these reductions would result in the river attaining the dissolved oxygen target.2.

QUAL2E simulations showed that, even with incremental inflow and permitted BOD loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results showed that sediment oxygen demand was the dominant source of the oxygen deficit, and that DO standards could only be attained during critical periods via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Model runs that keep all external loads at currently specified values and increase base stream flow result in the attainment of DO standards. Because this assessment indicates that low stream flows preclude attainment of dissolved oxygen standards, even in the complete absence of external pollutant loads, a TMDL is not being developed for dissolved oxygen.

[2] This modeling target considers observed diurnal variation and ensures that the 5.0 mg/L water quality standard is met.

6.2 Fecal Coliform TMDL

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for Bonpas Creek segment Il_BC-02. The approach described below is consistent with past EPA-approved Illinois TMDLs, by showing load capacity over a wide range of flows instead of the five flow regimes described in USEPA guidance.

6.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The loading capacity for Bonpas Creek segment IL_BC-02 was defined as shown previously in Figure 5.4, over the full range of specified flows based on expected Bonpas Creek flows at the mouth of the creek. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 mL). The fecal coliform loading capacity for IL_BC-02 is represented for select flows in Table 6-1.

Table 6-1. Fecal Coliform Load Capacity (IL_BC-02)

Bonpas Creek Flow (cfs)	Allowable Load (cfu/day)
5	2.45E+10
100	4.89E+11
500	2.45E+12
1000	4.89E+12
2000	9.79E+12
3000	1.47E+13
4000	1.96E+13
5000	2.45E+13
6000	2.94E+13
7000	3.44E+13

The maximum fecal coliform concentrations recorded between May and October were examined for each flow duration interval, as shown in Table 6-2, in order to estimate the percent reduction in existing loads required to meet the 200 cfu/100 mL target. As shown in Table 6-2, a greater reduction is needed at higher river flows to meet the target. During these higher flow periods, fecal coliform measurements were observed to exceed 200 cfu/100 mL more frequently.

Table 6-2. Required Reductions in Existing Loads under Different Flow Conditions (IL_BC-02)

Flow Percentile Interval	Bonpas Creek Flow (cfs)	# samples > 200/ # samples (May-Oct)	Maximum fecal coliform concentration (cfu/100 ml)	Percent Reduction to Meet Target
0-30	162 – 7,015	8/9	15,400	99%
30-60	22 - 162	4/5	2,100	90%
60-100	0 - 22	7/15	450	56%

6.2.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

The WLA for the 3 permitted sewage treatment plant discharges in the Bonpas Creek segment IL_BC-02 watershed was calculated based on the permitted design average flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100mL). All three of these NPDES-permitted dischargers have disinfection exemptions; therefore, the WLA is based on the dischargers meeting 200 cfu/100 mL at the downstream end of their exempted reach. WLAs are presented in Table 6-3.

Table 6-3. Segment IL_BC-02 Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption?	Design average flow (MGD)	Permit expiration date	WLA (cfu/day)
ILG580164	Village of West Salem - South WWTP	Yes, year-round	0.0425	6/30/18	3.2E+08
ILG580206	Village of Bellmont WWTP	Yes, year-round	0.065	6/30/18	4.9E+08
IL0071111	Village of Browns STP	Yes, year-round	0.05	4/30/18	3.8E+08

The total WLA for the three (3) point source dischargers in the IL_BC-02 watershed is 1.19E+09 cfu/day.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as an implicit MOS was used in this TMDL (Table 6-4). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 6-4. Fecal Coliform TMDL for Segment IL_BC-02 Bonpas Creek[1]

Bonpas Creek Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)	Load Allocation (LA) (cfu/day)
5	2.45E+10	1.19E+09	2.33E+10
100	4.89E+11	1.19E+09	4.88E+11
500	2.45E+12	1.19E+09	2.45E+12
1000	4.89E+12	1.19E+09	4.89E+12
2000	9.79E+12	1.19E+09	9.79E+12
3000	1.47E+13	1.19E+09	1.47E+13
4000	1.96E+13	1.19E+09	1.96E+13
5000	2.45E+13	1.19E+09	2.45E+13
6000	2.94E+13	1.19E+09	2.94E+13
7000	3.44E+13	1.19E+09	3.44E+13

[1]This TMDL has an implicit Margin of Safety, so MOS is not included in this table.

6.2.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 5-6 provides a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.2.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The load capacity calculation approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 mL at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 mL for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

6.3 Atrazine TMDL

A load capacity calculation approach was applied to support development of an atrazine TMDL for Bonpas Creek segment IL_BC-02. The approach described below is consistent with past EPA-approved Illinois TMDLs, by showing load capacity over a wide range of flows instead of the five flow regimes described in USEPA guidance.

6.3.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined as shown previously in Figure 5.3, over the full range of specified flows based on expected Bonpas Creek flows at the mouth of the creek. The allowable loading capacity was computed by multiplying Bonpas Creek flow by the TMDL target concentration of 9 ug/l. The atrazine loading capacity for IL_BC-02 is represented for select flows in Table 6-5.

Table 6-5. Atrazine Load Capacity (IL_BC-02)

Bonpas Creek Flow (cfs)	Allowable Load (lbs/day)
5	0.24
100	4.9
500	24.3
1000	48.5
2000	97.1
3000	145.6
4000	194.2
5000	242.7
6000	291.3
7000	339.8

The maximum atrazine concentrations were examined for each flow duration interval, as shown in Table 11, in order to estimate the percent reduction in existing loads required to meet the 9 µg/L target. Reductions of up to 9% in current loads are needed at higher river flows to meet the target. No reductions are needed at lower flows.

Table 6-6. Required Reductions in Existing Loads under Different Flow Conditions (IL_BC-02)

Flow Percentile Interval	Bonpas Creek Flow (cfs)	# samples > 1,000/# samples	Maximum atrazine concentration (µg/L)	Percent Reduction to Meet Target
0-20	549 – 7,015	1 / 1	9.9	9%
20-40	75 – 549	0 / 1	2.7	0%
40 - 100	0 – 75	0 / 3	3.2	0%

6.3.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There are no permitted dischargers of atrazine in the Bonpas Creek segment IL_BC-02 watershed, and per USEPA guidance the wasteload allocation was set to zero.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 6-7). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 6-7. Atrazine TMDL for Bonpas Creek (Segment IL_BC-02)

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
5	0.2	0.02	0*	0.22
100	4.9	0.49	0*	4.37
500	24.3	2.43	0*	21.84
1000	48.5	4.85	0*	43.69
2000	97.1	9.71	0*	87.38
3000	145.6	14.56	0*	131.07
4000	194.2	19.42	0*	174.75
5000	242.7	24.27	0*	218.44
6000	291.3	29.13	0*	262.13

*The atrazine point source contribution from the NPDES permitted facilities in the watershed to the impaired segment is considered *de minimis* (zero) as discussed above; therefore, this report has concluded that the current permits are appropriate, and no reductions in atrazine are needed at this time. However, future plant expansions and new facilities may be subject to applicable Water Quality Standards (WQS) or technologically achievable Water Quality Based Effluent Limits (WQBEL).

6.3.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 5-5 provides a graphical depiction of the data compared to the load capacity, showing that the TMDL target is exceeded during higher flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions, including high flows; therefore critical conditions were addressed during TMDL development.

6.3.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The atrazine standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

6.3.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The atrazine TMDL contains an explicit margin of safety of 10%. This 10% margin of safety was included to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

6.4 Total Phosphorus TMDL

6.4.1 Calculation of the Loading Capacity

The loading capacity for New West Salem Reservoir was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that New West Salem Reservoir phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux, which currently represents the excess above natural flux, is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios (i.e., TMDL assumes 100% reduction of internal phosphorus load). As such, reasonable assurance provided elsewhere (Section 2), that nonpoint source loads will be reduced also provides reasonable assurance that excess sediment flux will be eliminated. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 0.4 kg/day (0.88 lbs/day) and a concentration of 0.07 mg/L. This exceeds the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are necessary. The loading capacity was an average of 0.2 kg/day (0.44 lbs/day). This allowable load corresponds to an approximately 50% reduction from existing tributary loads, estimated as 0.4 kg/day (0.88 lbs/day).

6.4.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

There are no point sources in the watershed, and therefore there is no wasteload allocation given for New West Salem Reservoir. The entire loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 0.2 kg/day (0.44 lbs/day), and an explicit margin of safety of 10% (discussed below in Section 6.5), the load allocation for New West Salem Reservoir of 0.18 kg/day (0.40 lbs/day).

6.4.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon an annual period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

6.4.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate due to the facts that:

1. The analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release.
2. There is a long response time between phosphorus loading and sediment response, typically on the order of several years (e.g. Chapra and Canale, 1991).

6.4.5 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.02 kg/day (0.04 lbs/day) for New West Salem Reservoir.

6.4.6 Reserve Capacity

This watershed is located in Edwards County, the population of which has decreased by 3.6% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2000, Edwards County had a population of 31,334 and in 2010, 29,718 people were counted by the U.S. Census Bureau.

The Department of Commerce and Economic Opportunity (DCEO) for Illinois released county population projections that extend to 2030. They estimate that the population in Edwards County will grow slightly through 2030 (Stage 1 Report Section 2.6). A reserve capacity is not needed, due to the slight projected increase in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

6.4.7 TMDL Summary

The total phosphorus TMDL for New West Salem Reservoir, segment IL_RBQ, is presented in Table 6-8.

Table 6-8. New West Salem IL_RBQ TMDL Summary

Allocation	Total Phosphorus Load kg/day (lbs/day)
Current Load	4 kg/day (0.88 lbs/day)
Load Capacity (LC)	0.2 kg/day (0.44 lbs/day)
Percent reduction	50% reduction in tributary loads; 100% reduction in excess sediment phosphorus flux
Wasteload Allocation (WLA)	Not applicable. There are no permitted dischargers in this watershed
Load Allocation (LA)	0.18 (0.4)
Margin of safety (10% of LC)	0.02 (0.04)

7
LRS Development

This section presents the development of the total suspended solids Load Reduction Strategy for Bonpas Creek IL_BC-02 and the total phosphorus Load Reduction Strategy for Old West Salem Reservoir (IL_RBZN). IEPA requires a LRS to identify the load capacity, and the percentage reduction needed.

7.1 TSS Load Reduction Strategy (Bonpas Creek IL_BC-02)

The load capacity was calculated by multiplying the total suspended solids concentration of 27.75 mg/L by the average annual 2015 Bonpas Creek flows estimated using a drainage area ratio approach and USGS measured flows for Bonpas Creek at Browns, IL (Gage 03378000). The percent reduction was calculated by comparing the average TSS concentration of 79.55 mg/l, calculated from the full record of measured total suspended solids concentrations (See Stage 1 Report) to the LRS target concentration.

Table 7-1 presents the TSS LRS.

Table 7-1. Total Suspended Solids LRS

Stream (Segment)	Monitoring Station(s)	Target (mg/L)	Average Concentration (mg/L)	Current load (lbs/day)	Load capacity (lbs/day)	Percent Reduction
Bonpas Creek (IL_BC-02)	BC-02	27.75	79.55	155,867	54,371	65%

7.2 Total Phosphorus Load Reduction Strategy (Old West Salem Reservoir IL_RBZN)

The required load reduction for phosphorus was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. For these model runs, phosphorus concentrations from New West Salem Reservoir, which flows into Old West Salem Reservoir, were set equal to 0.05 mg/l, assuming New West Salem Reservoir will be in compliance with water quality standards as a result of the TMDL described above. The maximum tributary concentration that results in compliance with water quality standards in Old West Salem Reservoir was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that Old West Salem phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 0.14 kg/day (0.31 lbs/day) and an average in-lake concentration of 0.06 mg/L. This concentration exceeds the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are necessary. The loading capacity was an average of 0.11 kg/day (0.24 lbs/day) over the year-long period, with the total load across all sources over this period not to exceed 40 kg (87.6 lbs). This allowable load corresponds to an approximately 33% reduction from existing tributary loads, estimated as 59.6 kg (131.4 lbs) over the annual period.

8
Public Participation and Involvement

This section summarizes the November 15, 2018 public meeting at which Illinois EPA Planning Unit TMDL staff, along with their consultant, presented the results of the Stage 3 Draft report for the Bonpas Creek watershed.

Illinois EPA provided public notice for this meeting by placing a display-ad, The Navigator Journal Register (the local newspaper in Albion, Illinois). In addition, a direct mailing was sent to several stakeholders/Permittees in the watershed. The notice gave the date, time, location, and purpose of the meeting. The notice also provided references on how to obtain additional information about the draft TMDL report, the TMDL program, and other related information. A hard copy of the draft TMDL report was available for viewing at the Edwards County SWCD Office, West Salem Village Hall during business, and electronically on the Agency's webpage: https://www2.illinois.gov/epa/publicnotices/Documents/Bonpas%20Creek%20Watershed%20Stage%203%20Public%20Notice.pdf.

The draft Stage 3 public meeting was held on November 15, 2018, at 8:00 am, at the Edwards County Fairgrounds Exhibition Building (Across from Edwards County SWCD) in Albion, Illinois. Approximately 20 people participated in the public meeting and the public comment period ended at midnight on December 15, 2018. Illinois EPA did not receive any public comments.

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Attachment 1: Stage 1 Report

Stage 1 Report

Bonpas Creek Watershed

Prepared for:
Illinois Environmental
Protection Agency

June 19, 2014

LimnoTech

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Bonpas Creek Watershed
Total Maximum Daily Load
Stage One Report

Prepared for:
Illinois EPA

June 19, 2014

Prepared by:
LimnoTech, Inc.

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ACRONYMS

ALMP	Ambient Lake Monitoring Program
AQI	Aquatic Quality Index
AWQMN	Ambient Water Quality Monitoring Network
BMP	Best Management Practices
CDL	Cropland Data Layer
CFR	Code of Federal Regulations
DCEO	Department of Commerce and Economic Opportunity
DO	Dissolved Oxygen
GIS	Geographic Information System
IAC	Illinois Administrative Code
IDOA	Illinois Department of Agriculture
IEPA	Illinois Environmental Protection Agency
LRS	Load Reduction Strategy
NASS	National Agricultural Statistics Service
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
SOD	Sediment Oxygen Demand
SSURGO	Soil Survey Geographic Database
TMDL	Total Maximum Daily Load
TSI	Trophic State Index
TSS	Total Suspended Solids
UAL	Unit Area Load
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation

Executive Summary

This Stage 1 report was developed for the impaired waterbody segments located within the Bonpas Creek watershed. It provides a characterization of watershed conditions, an analysis of available data to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the 2012 303(d) list, and a review and recommendation of approaches for developing TMDLs and LRSs. This report also provides a plan for collecting additional field data, and summarizes public participation in this Stage 1 process.

Confirmation of Impairments

The Bonpas Creek watershed was indicated in the 2012 303(d) list as having 4 waterbodies with impaired use support. For impaired waterbodies caused by pollutants that have numeric water quality standards, TMDLs are to be developed; other causes of impairment are to be addressed in LRSs. At the time the 303(d) list was prepared, this would suggest 6 TMDLs and 2 LRSs. Since development of the 2012 (and prior biennial 303(d) lists), some numeric water quality standards have been revised that affect whether or not a TMDL is prepared.

This review of available water quality data and current state water quality standards recommends that a TMDL not be prepared for manganese in Bonpas Creek (BC-02). Four (4) TMDLs and three (3) LRSs are recommended as shown below.

Waterbody	Pollutant	Recommendation
Bonpas Cr. / IL_BC-02	Atrazine	Prepare TMDL
	Manganese	Delist
	Dissolved oxygen	Prepare TMDL
	Fecal coliform	Prepare TMDL
	Sedimentation/siltation	Prepare LRS
Bonpas Cr. / IL_BC-04	Sedimentation/siltation	Prepare LRS
New West Salem Reservoir / IL_RBQ	Phosphorus (Total)	Prepare TMDL
Old West Salem Reservoir / IL_RBZN	Phosphorus (Total)	Prepare LRS

Recommendations for TMDL Development

A simple approach is recommended for the TMDL and LRS. The total phosphorus TMDL for New West Salem Reservoir and the total phosphorus LRS for Old West Salem Reservoir will be developed using the BATHTUB model, and measured or modeled tributary phosphorus loads. This approach has been used for previous lake phosphorus TMDLs and approved by EPA Region 5. The TSS load reduction strategies for Bonpas Creek segments IL_BC-02 and IL_BC-04 will be prepared using USLE-based methods, or, alternatively, a combination of the Simple Method and unit area loading rates. The atrazine and fecal coliform TMDLs for Bonpas Creek

IL_BC-02 will be prepared using a load duration approach. Finally, the dissolved oxygen TMDL for IL_BC-02 will be developed using QUAL2E/QUAL2K.

Recommendations for Field Data Collection

The available data are sufficient to support the recommended methods and development of the Bonpas Creek (IL_BC-02) atrazine and fecal coliform TMDLs, and the Bonpas Creek (IL_BC-02 and IL_BC-04) sedimentation/siltation LRSs. Furthermore, the available data are sufficient to support the phosphorus TMDL and LRS for New West Salem Reservoir and Old West Salem Reservoir, respectively. Additional data collection is recommended to support dissolved oxygen modeling and TMDL development for Bonpas Creek (IL_BC-02).

1 Introduction

Illinois EPA has developed a three-stage approach to TMDL development. This Stage 1 report describes initial activities related to the development of TMDLs for the Bonpas Creek watershed, including: watershed characterization, data analysis to confirm the causes and sources of impairment, and methodology selection. Subsequent stages will include Stage 2 data collection (as needed) and Stage 3 model calibration, TMDL development and implementation plan development.

This section provides background information on the TMDL process, and Illinois assessment and listing procedures. The specific impairments in the Bonpas Creek watershed are also described.

1.1 TMDL Process

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois recently issued the 2012 303(d) list (IEPA 2012), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Load Reduction Strategies (LRSs) are being completed for causes that do not have numeric standards. LRSs for causes of impairment with target criteria will consist of loading capacity, percentage reduction for nonpoint sources, margin of safety and reserve capacity, if applicable.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and a consultant team have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. Additionally, this report recommends TMDL and LRS approaches, including an assessment of whether additional data are needed to develop a defensible TMDL.

In a subsequent stage of work the TMDLs and LRSs will be developed and IEPA will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

1.2 Illinois Assessment and Listing Procedures

Surface water assessments in the 2012 Integrated Report are based primarily on biological, chemical, physical habitat, and fish-tissue information collected through 2010 from various monitoring programs

(Illinois EPA 2007). These programs include: the Ambient Water Quality Monitoring Network, Intensive Basin Surveys, Facility-Related Stream Surveys, the Fish Contaminant Monitoring Program, the Ambient Lake Monitoring Program (ALMP), the Illinois Clean Lakes Monitoring Program, the Volunteer Lake Monitoring Program, the Lake Michigan Monitoring Program, TMDL monitoring and other outside sources (IEPA, 2012).

Illinois EPA conducts its assessment of water bodies using seven designated use categories: public and food processing water supplies, aquatic life, fish consumption, primary contact, secondary contact, indigenous aquatic life, and aesthetic quality (IEPA, 2012). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully supporting (the water body attains the designated use); or
- Not supporting (the water body does not attain the designated use).

When sufficient data are available, each applicable designated use in each segment is assessed as Fully Supporting (good), Not Supporting (fair), or Not Supporting (poor). Waters in which at least one applicable use is not fully supported are called "impaired." Waters identified as impaired based on biological, physicochemical, physical habitat, and toxicity data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters.

1.3 Identified Waterbody Impairments

The impaired waterbody segments included in the project watershed are listed in Table 1, along with the parameters they are listed for, and the use impairments as identified in the 2012 303(d) list (IEPA, 2012). TMDLs are currently only being developed for pollutants that have numerical water quality criteria. Load Reduction Strategies (LRSs) are being developed for those pollutants that do not have numerical water quality criteria. The pollutants that are the focus of this study are indicated in Table 1 in boldface type. Table 1 provides information on the impaired waterbodies, including size, causes of impairment, and use support. Those impairments that are the focus of this report are shown in bold font.

The remaining sections of this report include:

- Watershed characterization: description of watershed features
- Water quality standards and summary of impairment: discussion of relevant water quality standards, database development and summary of data for impaired segments
- Confirmation of causes and sources of impairment: assessment of sufficiency of data to support the listing and identification of potential sources contributing to the impairment
- Methodology: identification and selection of watershed and water quality models
- Data collection to support modeling: a general description of data needed to support modeling
- Public participation: description of the public meeting related to this project
- References

Table 1. Impaired Waterbodies in the Project Watershed

Waterbody/Segment Name	Size (mile/acre)	Use Support[2]	Impairment Cause	Potential Sources
Bonpas Creek / IL_BC-02	28.95	Aquatic Life (N) Primary Contact (N)	**Atrazine; Manganese; Dissolved oxygen; Sedimentation/siltation;** **Fecal coliform**	Crop production (Crop land or dry land); Animal feeding operations (nonpoint source); Source unknown
Bonpas Creek / IL_BC-04	26.2	Aquatic Life (N)	**Sedimentation/siltation**	Crop production (Crop land or dry land)
West Salem New Reservoir / IL_RBQ	32	Aesthetic Quality (N) Aquatic Life (F)	**Total phosphorus;** Aquatic algae	Crop production (Crop land or dry land)
West Salem Old Reservoir / IL_RBZN	2	Aesthetic Quality (N) Aquatic Life (F)	**Total phosphorus**; Aquatic algae	Crop production (Crop land or dry land)

[1] Bold font indicates cause will be addressed in this report by a TMDL or LRS. Other potential causes of impairment listed for these waterbodies are not subject to TMDL or LRS development at this time.

[2]F = Fully supporting, N = Not supporting, Other uses were not assessed

2 Watershed Characterization

2.1 Methods

The project watershed was characterized by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, local agencies have been contacted to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed.

After the watershed boundaries for the impaired waterbodies in the project watershed were delineated from topographic and stream network (hydrography) information, other relevant information was obtained. This included land use and land cover, soils, point source dischargers, state, county and municipal boundaries, oil and gas wells, mines, livestock operations, data collection locations and the location of 303(d) waterbodies.

2.2 Watershed Location

The four impaired waterbodies addressed in this report are all in the Bonpas Creek watershed, which is located in Lawrence, Wabash, Richland and Edwards Counties in southeastern Illinois. The watershed study area is approximately 177,734 acres (277 mi^2) in size. Figure 1 shows a map of the target watershed and includes some key features such as waterways, impaired waterbodies, and subwatersheds

The sections that follow provide a broad overview of the characteristics of the Bonpas watershed.

2.3 Climate and Hydrology

The drainage in Bonpas Creek is generally north-to-south, with a classic dendritic pattern modified somewhat by channelization. The creek is a tributary to the Wabash River.

The Bonpas Creek watershed lies in a temperate climate zone with cold, snowy winters and hot, wet summers. The National Weather Service (NWS) maintains a weather station near the Bonpas watershed in Olney, Illinois. The station has been active since 1901. Olney lies in Richland County and is on the north end of the watershed, approximately 5 miles west of Claremont and the Bonpas Creek headwaters. Precipitation information from this station should fairly accurately represent climate conditions observed in the Bonpas Creek watershed.

Precipitation data from 1901 up to present are summarized in Table 2. The 112 years of historical precipitation data for Station 116446 in Olney average 42.5 inches of precipitation each year. The highest monthly average occurs in May, when about 4.7 inches can be expected. The lowest monthly average occurs in February (2.5 inches). The most intense storms, based upon the daily maximum precipitation, generally come in spring and fall. Winter exhibits the most mild storm events.

Table 2. Long-term Precipitation Statistics for Olney, Illinois

Month/Season	Precipitation (in)	Days of Rain	Max Daily Precipitation (in)
January	3.2	9	3.2
February	2.5	8	2.5
March	4.1	10	6.3
April	4.1	11	3.8
May	4.7	11	5.4
June	4.0	9	4.4
July	3.7	8	4.6
August	3.5	8	4.1
September	3.3	7	6.4
October	3.2	7	4.6
November	3.7	9	5.3
December	3.3	9	4.0
Fall	10.1	24	6.4
Spring	12.9	32	6.3
Summer	11.2	25	4.6
Winter	8.9	26	4.0
Annual	42.5	106	6.4

Source: Downloaded from http://www.isws.illinois.edu/data/climatedb/choose.asp?stn=116446

There is an active United States Geological Survey (USGS) streamflow gage in the watershed, located on Bonpas Creek near Browns, at the county road 15 bridge (gage 03378000, Figure 1). The gage is about 14 miles upstream from the confluence with the Wabash River. The drainage area at this gage is 228 square miles and daily discharge measurements are available from 1941 to present.

Flow duration curves represent the percentage of time that a specified streamflow is equaled or exceeded during a given period. Figure 2 is a flow duration curve for USGS gaging station 03378000. Such analyses are a summary of the past hydrologic events (in this case, daily discharge). Figure 2 illustrates the frequency that certain volumes of flow occurred in Bonpas Creek over the available flow record (1941-present). Flows of zero cfs are observed throughout the flow record, although most (79%) occur between August and November. Based on input received from the public, flooding has been identified as an issue near the mouth of Bonpas Creek.

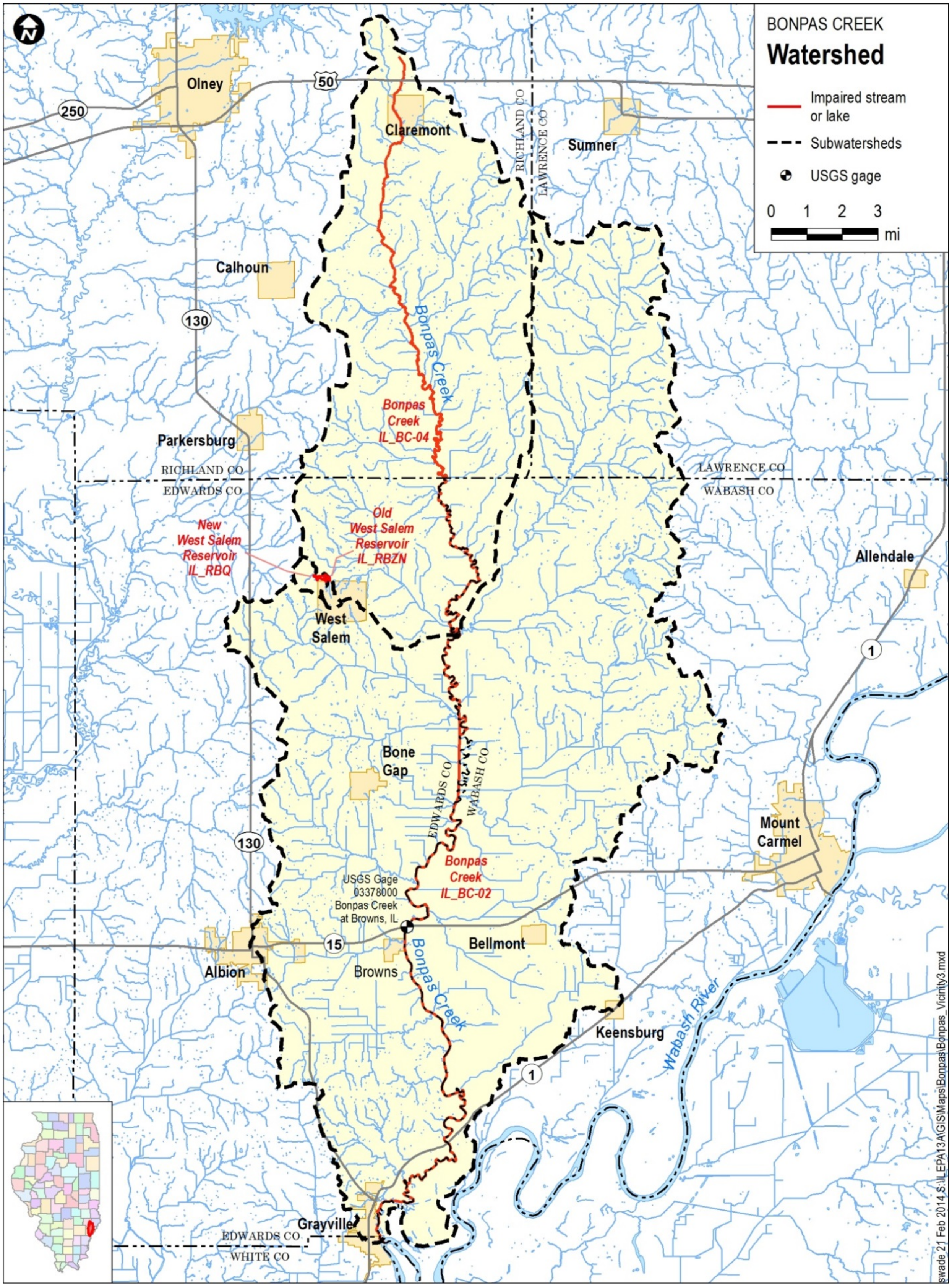

Figure 1. Study Area Map

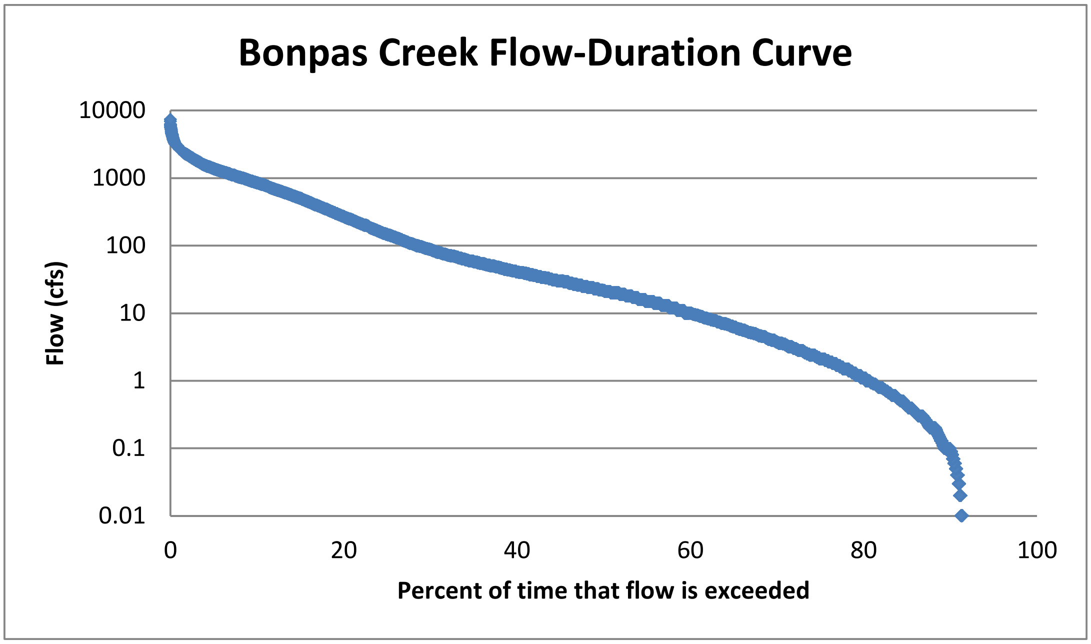

Figure 2. Flow Duration Curve, USGS Station 03378000, Bonpas Creek near Browns, IL 10/1/1941 through 9/30/2012.

2.4 Topography

The highest elevations (approximately 604 feet) in the Bonpas Creek watershed are at the far northern end of the watershed. The lowest elevation (359 feet) is where Bonpas Creek drains into the Wabash River, at the far southern end of the watershed.

2.5 Soils

Together with topography, the nature of soils in a watershed play an important role in the amount of runoff generated and soil erosion. The Natural Resources Conservation Service's (NRCS) Soil Survey Geographic (SSURGO) database was reviewed to characterize study area soils. The target watershed has rich silt loam soils, lying predominately on slopes less than 2%. The most common soil types in the watershed are silt loam (76%) and silty clay loam (9%). The remaining soil types occur in much smaller percentages in the watershed. The most predominant hydrologic soil group is C (63%), followed by D (15%). 9% of the watershed soils are hydrologic soil group B/D and 8% are C/D.

The NRCS places soils into erodibility classes based upon slope and other factors. The erodibility potential of soils in the study area was assessed by classifying the numeric Kw factors for the surface soil horizon (SSURGO soil data) into erodibility categories.

The erodibility potential of soils in the study area is summarized for each subwatershed by area (Table 3) and percentage (Table 4). Land covered by water is excluded from this tally. Figure 3 maps the variability in erodible soils within the watershed.

Table 3. Soil Erodibility in Target Watersheds, in acres

Waterbody	Subwatershed	High erodibility	Moderate erodibility	Low erodibility	Total
Bonpas Creek	IL_BC-02	89,746	86,019	1,187	176,952
Bonpas Creek	IL_BC-04	32,060	19,821	-	51,882
New West Salem Reservoir	IL_RBQ	128	36	-	165
Old West Salem Reservoir	IL_RBZN	237	170	-	406

*The acreage shown is the sum of all land draining to the impaired segment, including watersheds of upstream segments and tributaries.

Table 4. Soil Erodibility in Target Watersheds, by percentage

Waterbody	Subwatershed	High erodibility	Moderate erodibility	Low erodibility
Bonpas Creek	IL_BC-02	50.7%	48.6%	0.7%
Bonpas Creek	IL_BC-04	61.8%	38.2%	-
New West Salem Reservoir	IL_RBQ	78%	22%	-
Old West Salem Reservoir	IL_RBZN	58.3%	41.7%	-

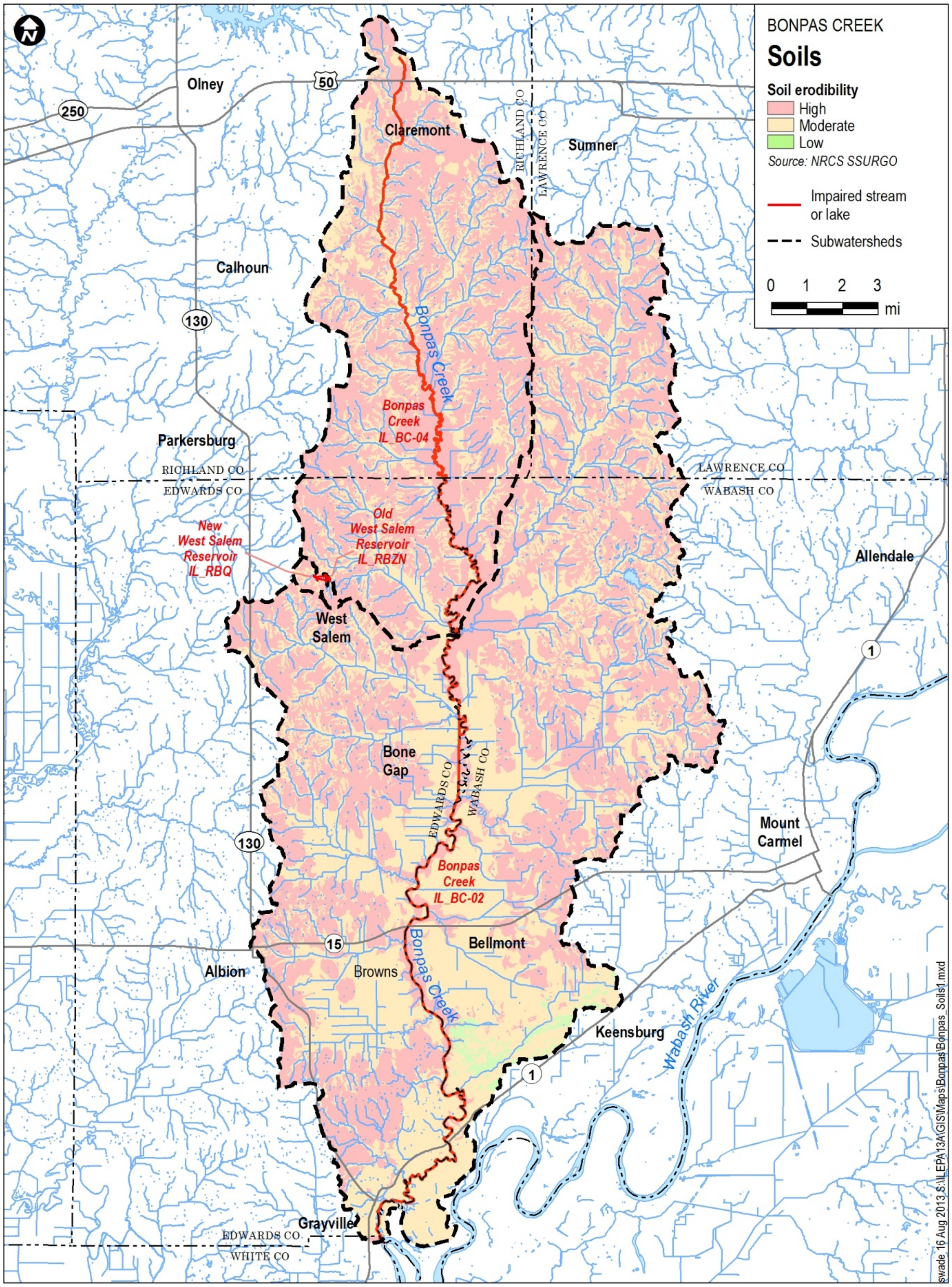

Figure 3. Bonpas Watershed Soil Erodibility

The Illinois Soil Conservation Transect Survey program provides a general overview of the current status of soil conservation efforts on agriculture land in the state. Survey results provide data on the presence of conservation practices in each county (IDOA, 2013). The 2013 survey provides information on tillage systems used in planting corn and soybean crops in the spring and small grain crops in the fall. The surveyors also collect data on ephemeral or gully erosion in surveyed fields, and the most recent information available was used (IDOA, 2013). Data are available by county rather than by watershed (Tables 5 through 8). As described in Section 2.8, corn and soybeans are the predominant crops in this watershed.

Table 5. Percent of Corn Fields in Each Tillage System in Illinois and in Target Watershed Counties

County	Conventional	Reduced	Mulch-Till	No-Till
Illinois	49.1%	23.9%	16.2%	10.8%
Edwards County	10%	15%	5%	71%
Lawrence County	57%	26%	9%	8%
Richland County	78%	0%	12%	11%
Wabash County	84%	11%	4%	1%

Note: Numbers may not sum to 100%, but reflect data from IDOA, 2013.

Table 6. Percent of Soybean Fields in Each Tillage System in Illinois and in Target Watershed Counties

County	Conventional	Reduced	Mulch-Till	No-Till
Illinois	21.5%	20.2%	19.7%	38.6%
Edwards County	6%	9%	9%	76%
Lawrence County	21%	23%	20%	36%
Richland County	31%	0%	33%	36%
Wabash County	45%	23%	18%	14%

Note: Numbers may not sum to 100%, but reflect data from IDOA, 2013.

Table 7. Percent of Small Grain Fields in Each Tillage System in Illinois and in Target Watershed Counties

County	Conventional	Reduced	Mulch-Till	No-Till
Illinois	22%	13.8%	22.6%	41.6%
Edwards County	3%	0%	0%	97%
Lawrence County	18%	13%	45%	24%
Richland County	0%	0%	98%	2%
Wabash County	100%	0%	0%	0%

Note: Numbers may not sum to 100%, but reflect data from IDOA, 2013.

Table 8. Percent of Fields Indicating Ephemeral Erosion in Illinois and in Target Watershed Counties

County	Yes	No
Illinois	19.6%	80.4%
Edwards County	27%	73%
Lawrence County	12%	88%
Richland County	2%	98%
Wabash County	12%	88%

2.6 Urbanization and Growth

Urbanization in the watershed is centered in the towns of Claremont, West Salem, Bone Gap, Browns, Albion and Bellmont. The land cover data (see Section 2.8) indicates that the watershed is approximately 7% urbanized, most of which is considered open developed land. Very little land is considered heavily developed.

Population statistics and projections are available on a county basis. A majority of the watershed lies in Edwards and Wabash Counties. Populations in these counties have decreased by 3.6% and 7.7% respectively (Table 9). The counties of Richland and Lawrence account for the remaining watershed and have seen population increases of 0.5% and 8.9% respectively. The state as a whole has experienced a 3.3% increase in overall population.

Table 9. Population in Illinois and Target Watershed Counties

County	2000 Census 1 Total Population	2010 Census Total Population	2000-2010 Change	2000-2010 % Change
Illinois	12,419,293	12,830,632	411,339	3.3
Edwards County	6,971	6,721	-250	-3.6
Lawrence County	15,452	16,833	1,381	8.9
Richland County	16,149	16,233	84	0.5
Wabash County	12,937	11,947	-990	-7.7

Source: Downloaded from http://www2.illinois.gov/census/Pages/Census2010Data.aspx on September 30, 2013

The Illinois Department of Commerce and Economic Opportunity (DCEO) developed population projections to estimate populations through 2030. The projections estimated that populations in all four of the target counties would increase slightly through 2030, with the most growth being seen in Richland and Wabash counties.

2.7 Mining, Oil and Gas Activities

Activities related to mining and oil and gas drilling have the potential to influence the quality of surface waters. Oil and gas have been extracted throughout this watershed and some surface and underground coal mining is also evident. Figure 4 shows the prevalence of active or former oil and gas wells and Figure 5 shows coal mine locations in the watershed. One active surface mine was identified (see Section 2.9), which discharges to the Bonpas Creek watershed. The underground mine does not drain to the Bonpas Creek watershed and should not have any impacts.

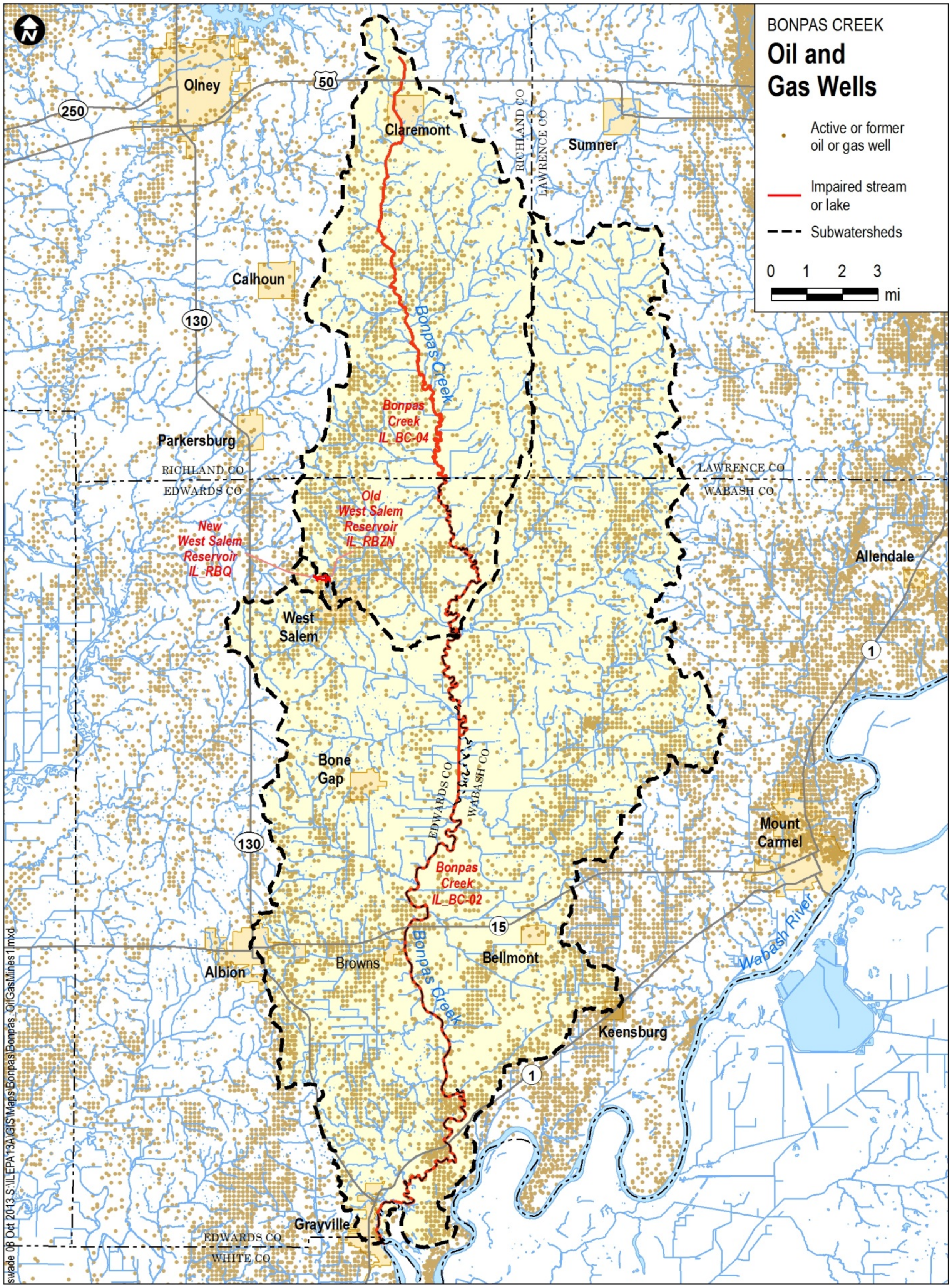

Figure 4. Oil and gas wells (active or former)

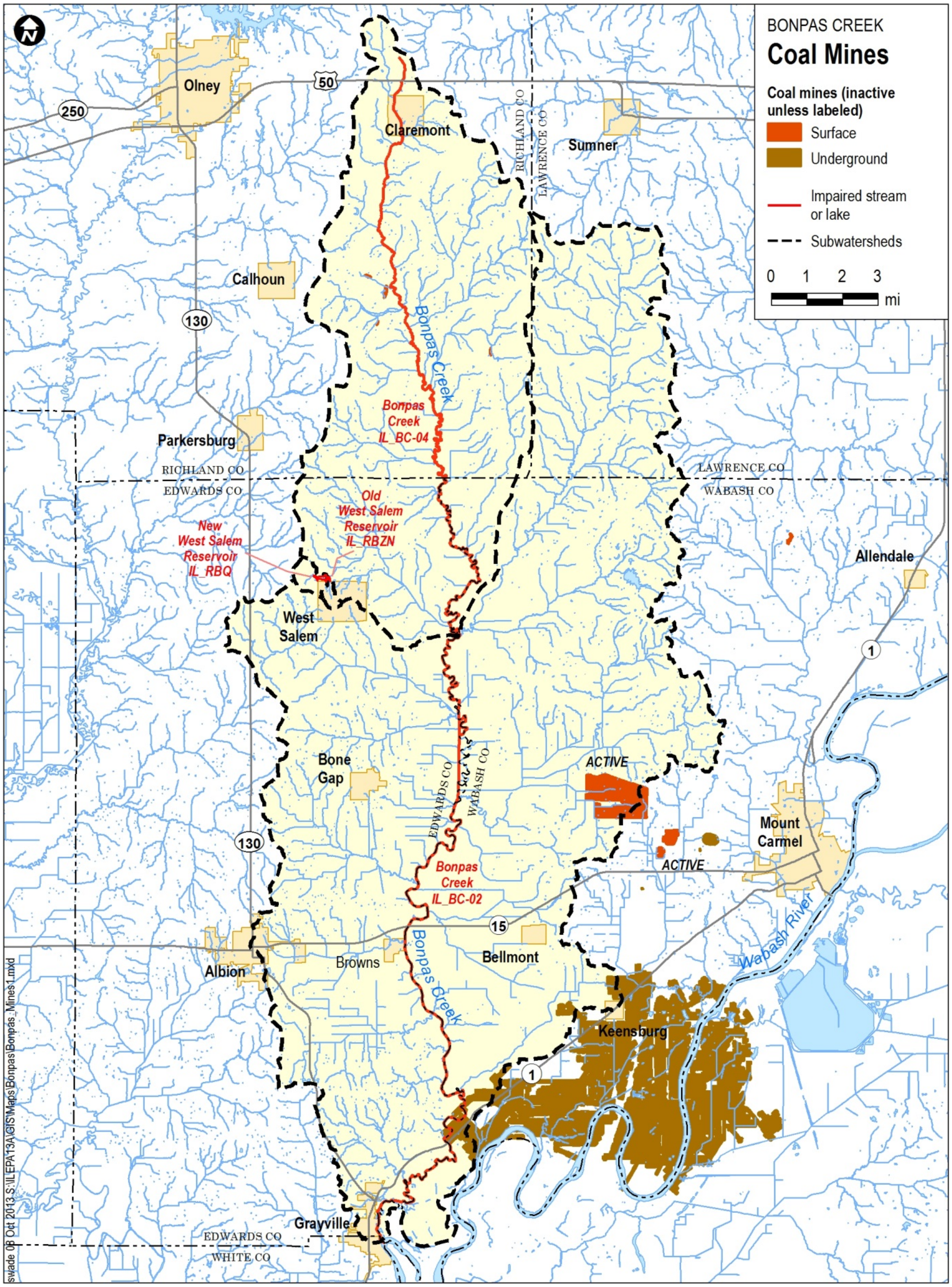

Figure 5. Coal Mines

2.8 Land Cover

Land cover in the study area is tabulated by subwatershed in Table 10 and mapped in Figure 6. These data are derived from 2011 Cropland Data Layer (CDL) for Illinois from the Natural Resources Conservation Service (NRCS). CDL is a variation on the National Land Cover Database (NLCD).

From these data it is apparent that the Bonpas Creek watershed is predominantly agricultural with 68% being cultivated crops and around 12% being pasture and hay. Forest covers approximately 15% of the watershed with the remainder consisting primarily of developed open area. Of the cultivated crops, nearly all of them are corn and soybeans. Corn accounts for 49% while soybeans account for 45%. Most of the remainder is a double crop of winter wheat/soybeans.

Table 10. Land Use Land Cover of Subwatersheds for the 4 Impaired Waterbodies in the Project Watershed, in acres

Land Cover Type	Bonpas Creek (IL_BC-02)*	Bonpas Creek (IL_BC-04)**	New West Salem Reservoir (IL_RBQ)	Old West Salem Reservoir (IL_RBZN)
Barren	1.8	0	0.0	0.0
Cultivated crop	116,350	31,349	255.1	18.0
Developed, high intensity	31	7	0.0	4.7
Developed, low intensity	1,841	381	3.6	51.2
Developed, medium intensity	157	35	0.0	9.3
Developed, open	9,763	2,873	25.8	59.4
Forest	27,209	10,580	60.0	13.3
Grassland/pasture/hay	21,651	6,717	66.1	12.5
Water	440	119	20.2	1.8
Wetlands	290	73	0.4	0.2
Total	**177,734**	**52,136**	**431**	**170**

*IL_BC-02 includes the watersheds for IL_BC-04, IL_RBQ, IL_RBZN
**IL_BC-04 includes the watersheds for IL_RBQ and IL_RBZN

Through the National Water Quality Initiative, the Natural Resources Conservation Service is working with farmers and ranchers in watersheds located throughout the Nation to improve water quality where this is a critical concern. The Bonpas Creek watershed is one of the target watersheds. As part of this initiative, NRCS conservation professionals will provide technical assistance and planning tools to help farmers and ranchers determine which conservation actions will provide the best results to improve water quality on their land. Nutrient management systems, erosion control, conservation tillage, pest management, and buffers systems are just some of the practices being offered as part of the National Water Quality Initiative. To help install these conservation practices, NRCS will provide financial assistance payments to eligible producers through the Environmental Quality Incentives Program (EQIP). http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelprdb1047761 In addition, it is notable that the Bonpas Conservancy has been active in this watershed in the past and is interested in improving water quality in the watershed.

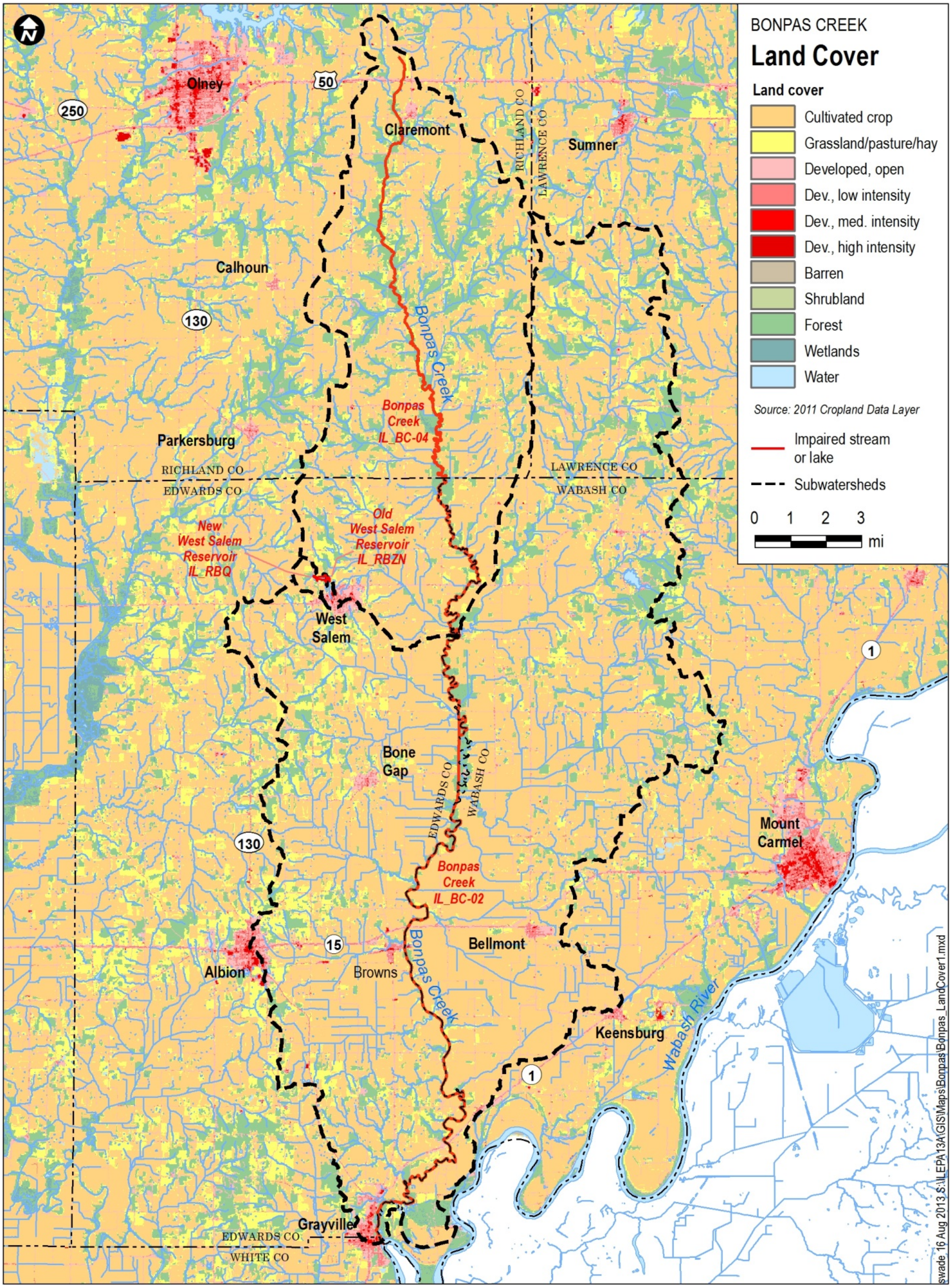

Figure 6. Land Cover in the Project Watershed

2.9 Point sources and septic systems

Six entities were identified that are permitted to discharge treated wastewater in the target watershed. Five of the facilities discharge treated sanitary wastewater and one is a water treatment plant (Table 11, Figure 7). All of these facilities have active permits and their general permits are in the process of being reissued. Five of the Vigo Coal mine outfalls are located in the project watershed (Bonpas Creek (IL_BC-02 subwatershed)), and permit information is summarized in Table 11 and outfalls shown on Figure 7.

In addition, there are three permitted confined animal feeding operations (CAFOs) in the watershed which are dairy (medium), swine (large) and pasture beef (small) facilities (Figure 7). The size differentiation is based on the number of animals, among other factors outlined by IEPA.

The rural areas of this region utilize a mix of septic tanks and aeration units to treat private wastewater. In the aeration systems, water is aerated, treated with chlorine, and then discharged to the surface. This is a common practice due to poor drainage that results from the clay soils in the region. A large majority of newly installed treatment systems are being installed as aeration systems (Wabash County Health Department, 2013).

Table 11. NPDES Discharges in the Target Watershed

NPID	Facility Name	TYPE	Description	Permit Expiration[1]	Subwatershed
ILG580170	West Salem North STP	Municipal	STP outfall	12/31/2007	Bonpas Cr. (IL_BC-04)
ILG580271	Claremont STP	Municipal	STP outfall	12/31/2007	Bonpas Cr. (IL_BC-04)
IL0071111	Browns STP	Municipal	STP outfall	4/30/2018	Bonpas Cr. (IL_BC-02)
ILG580206	Bellmont STP	Municipal	STP outfall	12/31/2007	Bonpas Cr. (IL_BC-02)
ILG640152	Bone Gap WTP	Municipal	Iron filter backwash	4/30/2017	Bonpas Cr. (IL_BC-02)
ILG580164	West Salem South STP	Municipal	STP outfall	12/31/2007	Bonpas Cr. (IL_BC-02)
IL0073636	Vigo Coal Operating Co., Friendsville Mine		Alkaline mine drainage	12/31/2018	Bonpas Cr. (IL_BC-02)

Note: At the time of this report, the General NPDES Permits (ILG580) are on public notice for reissuance: http://www.epa.state.il.us/water/permits/lagoons/index.html

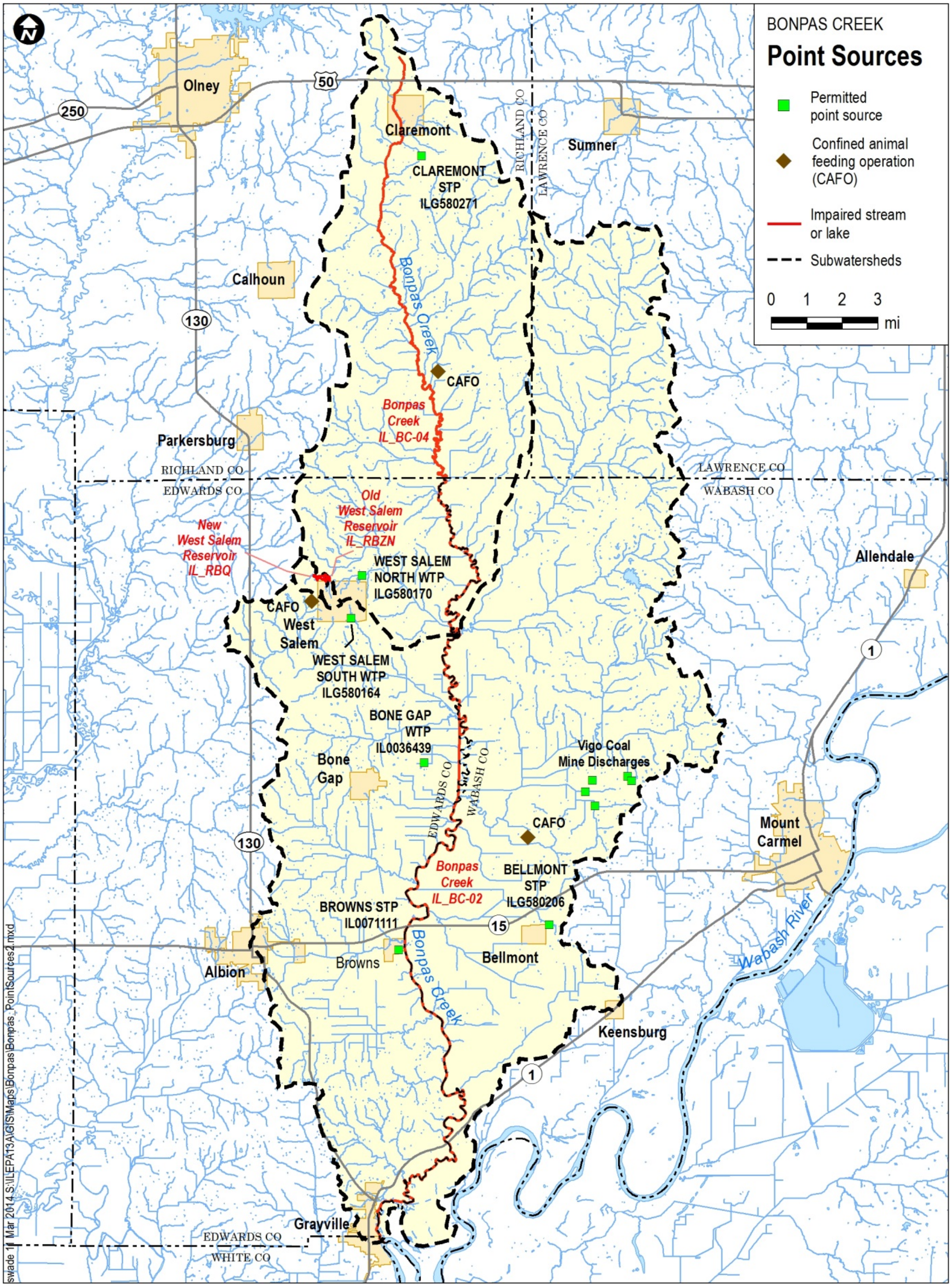

Figure 7. NPDES-permitted Dischargers

2.10 Livestock and poultry

The National Agricultural Statistics Service (NASS) performs a census of livestock and poultry production every five years. The most recent census is from 2007. The data are not collected on a watershed basis, but are available by county. Tables from the census are relevant as these operations are a potential source of bacteria and nutrients to area waterbodies.

In the four-county area, cattle farms are the most common type of livestock farm in the region. They make up a majority of the farms in the region. However, on a per animal basis, hogs greatly outnumber the other types of livestock in the region. This suggests that the hogs are far more concentrated on their farmlands. The less common livestock farms in the region include sheep and poultry. Livestock and poultry census data are provided in Table 12. Information regarding CAFOs is found in Section 2.9

Table 12. Livestock and Poultry Census Data

County	Census Item	# of Farms	# of Animals
Edwards County	Cattle, including calves - inventory	86	3,727
	Hogs – inventory	11	13,112
	Sheep, including lambs - inventory	9	443
	Poultry totals - hatched, measured in head	13	-
Lawrence County	Cattle, including calves - inventory	66	2,266
	Hogs - inventory	18	38,766
	Sheep, including lambs - inventory	2	(D)
	Poultry totals - hatched, measured in head	12	-
Richland County	Cattle, including calves - inventory	123	4,974
	Hogs – inventory	16	54,670
	Sheep, including lambs - inventory	6	93
	Poultry totals - hatched, measured in head	23	-
Wabash County	Cattle, including calves - inventory	43	2,141
	Hogs – inventory	1	(D)
	Sheep, including lambs - inventory	7	40
	Poultry totals - hatched, measured in head	8	-

(D) Withheld to avoid disclosing data for individual operations.

3 Water Quality Standards

Water quality standards are intended to protect the designated uses of water. In Illinois, the Illinois Pollution Control Board (IPCB) is authorized to establish designated uses and quality standards for water. The state's water quality standards are promulgated as the Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards. These standards are updated every three years in accordance with federal regulations.

Water in the state is classified according to its designated uses. These are: General Use, Public and Food Processing Water Supplies, Lake Michigan, and Secondary Contact and Indigenous Aquatic Life Use. The General Use classification is designed to protect aquatic life, wildlife, agricultural use, most industrial uses, aesthetic quality and primary contact use for those waters whose physical configuration permits such use.

The designated use that is not being supported in the Bonpas Creek watershed which is requiring TMDLs is General Use. The specific impaired uses in this watershed are aquatic life, primary contact and aesthetic quality. The water quality standards that are not being met in one or more waterbodies that are designated for General Use in this watershed are summarized below.

3.1 Offensive Conditions

Water quality standards for offensive conditions are defined in a narrative form, rather than numeric, in Section 302.203 of Title 35 of the Illinois Administrative Code. That section states that waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin

3.2 Atrazine

Atrazine is a white, crystalline solid organic compound. It is a widely used herbicide for control of broadleaf and grassy weeds. Atrazine was estimated to be the most heavily used herbicide in the United States in 1987/89, with its most extensive use for corn and soybeans in Illinois, Indiana, Iowa, Kansas, Missouri, Nebraska, Ohio, Texas, and Wisconsin. Effective in 1993, its uses were greatly restricted. Illinois currently has an acute atrazine water quality criterion of 82 ug/L and a chronic atrazine criterion of 9 ug/L. (http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria-list.pdf).

3.3 Dissolved Oxygen

The General Use standards for dissolved oxygen (DO) are in Section 302.207 of Title 35. General Use waters must maintain sufficient DO concentrations to prevent offensive conditions as required in Section 302.203. Quiescent and isolated areas of General Use waters including but not limited to wetlands, sloughs, backwaters and waters below the thermocline in lakes and reservoirs must be maintained at sufficient dissolved oxygen concentrations to support their natural ecological functions and resident aquatic communities. With some exceptions identified by the state for enhanced dissolved oxygen protection, and not located in this watershed, the DO concentration in the main body of all streams, in the water above the thermocline of thermally stratified lakes and reservoirs, and in the entire water column of unstratified lakes and reservoirs must not be less than:

1. During the period of March through July, 5.0 mg/L at any time, and, 6.0 mg/L as a daily mean averaged over 7 days.
2. During the period of August through February, 3.5 mg/L at any time, 4.0 mg/L as a daily minimum averaged over 7 days, and, 5.5 mg/L as a daily mean averaged over 30 days.

3.4 Fecal coliform

The General Use standards for fecal coliform bacteria are in Section 302.209 of Title 35. During the months May through October (swimming season), based on a minimum of five samples taken over not more than a 30 day period, fecal coliform bacteria shall not exceed a geometric mean of 200 per 100 mL, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 mL.

3.5 Manganese

The General Use standards for aquatic life use support are in Section 302.208 of Title 35. Manganese (dissolved) has acute and chronic standards, and both are hardness based. The acute standard is:

$$\exp(4.9187 + 0.7467 * ln(H)) * \ 0.9812$$

where H is hardness (in mg/L as $CaCO_3$). The chronic standard is:

$$\exp(4.0635 + 0.7467 * ln(H)) * \ 0.9812$$

Units for both the acute and chronic standards are ug/l.

The manganese standard was revised in 2012 through Illinois Pollution Control Board Rulemaking R2011-018 (In the Matter of: Triennial Review of Water Quality Standards for Boron, Fluoride and Manganese: Amendments to 35 Ill. Adm. Code 301.106, 302.Subparts B, C, E, F and 303.312).

3.6 Phosphorus

The General Use standard for phosphorus is in Section 302.206 of Title 35. Phosphorus shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 20 acres or more, or in any stream at the point where it enters any such reservoir or lake.

Figure 8 below shows the location of all of the monitoring stations within the Bonpas Creek watershed.

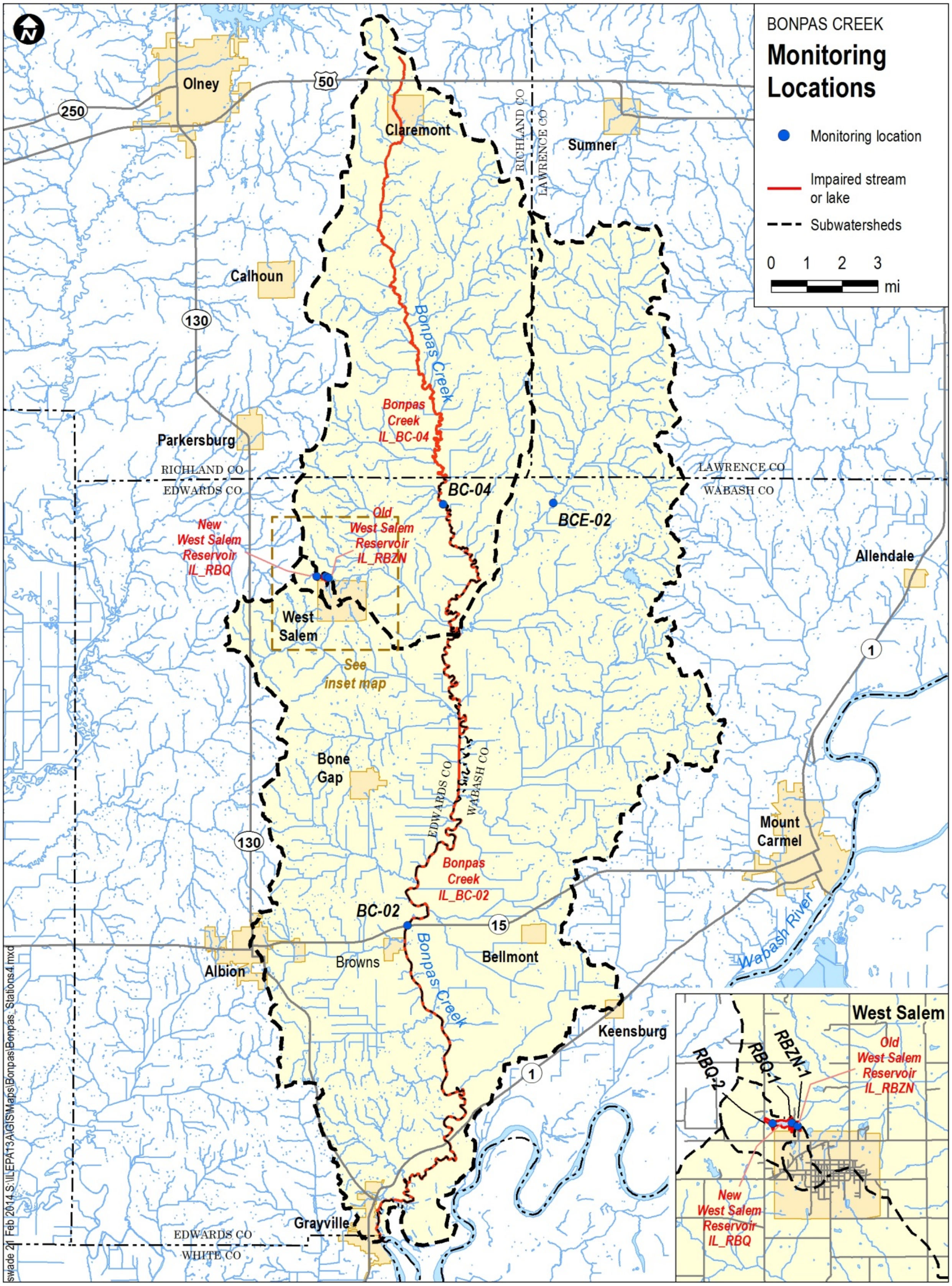

Figure 8. Monitoring stations within the Bonpas Creek watershed

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4 Confirmation of Causes and Sources of Impairment

This section provides an analysis of available water quality data to verify the impairments identified in the State's 2012 Integrated Water Quality Report and Section 303(d) List (IEPA, 2012). Only pollutants with numeric water quality standards are subjected to this analysis. Following that, potential pollutant sources in the subwatersheds are likewise verified.

4.1 Sufficiency of data to support listing

Four waterbodies in the Bonpas Creek watershed appear on the 2012 303(d) list due to nonsupport of designated uses. The available data have been reviewed to determine if they are suitable for use support assessments and whether the data are sufficient to confirm the use impairments and the causes of impairment.

4.1.1 Suitability of data to support use support assessments

The aesthetic quality use is identified as not-supporting in West Salem New and West Salem Old reservoirs. The physical and chemical data used for aesthetic quality use assessments in lakes include: Secchi disk transparency, chlorophyll a, total phosphorus (epilimnetic samples only), nonvolatile suspended solids (NVSS, epilimnetic samples only), and percent surface area macrophyte coverage. Data are collected a minimum of five times per year (April through October) from one or more established lake sites. IEPA (2012) considers data to be usable for use support assessments if they meet the following minimum requirements: 1) At least four out of seven months (April through October) of data are available, 2) At least two of these months occurs during the peak growing season of June through August (this requirement does not apply to non-volatile suspended solids (NVSS) and 3) Usable data are available from at least half of all lakes sites within any given lake each month. Additionally, there are minimum parameter requirements (2 out of 3 parameters required for aesthetic use support assessment). The parameters are total phosphorus, secchi depth and chlorophyll a. Although the percent surface area macrophyte coverage data were not available for the two lakes, the remaining data were sufficient to calculate the aesthetic quality index.

Two stream segments are not supporting of the aquatic life use. For assessing aquatic life use support in streams, the most recent consecutive three years of data are used, and it is not necessary that observations be available for every parameter of each type; the assessment is made based on available data. As defined in IEPA (2012), sufficient water chemistry data means that a dataset at least as representative of water-chemistry conditions as the three year dataset that is typically available from an Ambient Water Quality Monitoring Network station. Based on the Table 13 summaries, sufficient data are available to assess use support.

Table 13 summarizes relevant water quality data identified in IEPA databases. These data are presented in Appendix C.

Table 13. Data Summary for Impairments

Water body segment	Parameter	Monitoring station	Period of record (# samples)	Minimum	Maximum	Average
Bonpas Cr. / IL_BC-02	Atrazine (ug/l)	BC-02	6/21/1999 - 6/28/2006 (N=5)	ND	9.9	3.46
	Manganese, Dissolved (ug/l)	BC-02	2/4/1999 - 1/10/2007 (N=59)	21	8,600	531.7
	Manganese, Total (ug/l)	BC-02	2/4/1999 - 1/10/2007 (N=58)	60	10,000	656
	Dissolved oxygen (mg/l)	BC-02	2/4/1999 - 12/6/2005 (N=48)	1.1	14.3	6.8
	Fecal coliform (counts/100 ml)	BC-02	5/24/1999 - 10/16/2006 (N=36)	20	15,400	1,911
	TSS (mg/l)	BC-02	3/9/2004 - 1/10/2007 (N=20)	8	471	67.7
Bonpas Cr. / IL_BC-04	TSS (mg/l)	BC-04	6/1/2011 - 8/29/2011 (N=4)	7	18	11.75
New West Salem Reservoir / IL_RBQ	Phosphorus, Total (mg/l)	RBQ-1	5/10/2000 – 10/19/2000 (N=15)	0.077	0.633	0.216
		RBQ-2	5/10/2000 – 10/19/2000 (N=5)	0.067	0.172	0.140
	Phosphorus as P in sediment (mg/kg)	RBQ-1	8/20/2000 (N=1)	1250	1250	1250
	Chlorophyll a, corrected for pheophytin (ug/l)	RBQ-1	5/10/2000 – 10/19/2000 (N=5)	56.2	196	124.4
		RBQ-2	5/10/2000 – 10/19/2000 (N=5)	47.4	120	85
	NVSS (calculated, mg/l)	RBQ-1	5/10/2000 – 10/19/2000 (N=15)	2	18	8.4
		RBQ-2	5/10/2000 – 10/19/2000 (N=5)	5	9	7.4
	Secchi depth (meters)	RBQ-1	5/10/2000 – 10/19/2000 (N=9)	0.33	0.48	0.45
		RBQ-2	5/10/2000 – 10/19/2000 (N=5)	0.41	0.46	0.43
Old West Salem Reservoir / IL_RBZN	Phosphorus (Total)	RBZN-1	5/10/2000 – 10/19/2000 (N=15)	0.041	1.030	0.173
	Phosphorus as P in sediment (mg/kg)	RBZN-1	8/20/2000 (N=1)	1010	1010	1010
	Chlorophyll a, corrected for pheophytin (ug/l)	RBZN-1	5/10/2000 – 10/19/2000 (N=5)	44.5	142	91.14
	NVSS (calculated, mg/l)	RBZN-1	5/10/2000 – 10/19/2000 (N=15)	1	10	4.8
	Secchi depth (meters)	RBZN-1	5/10/2000 – 10/19/2000 (N=7)	0.51	0.61	0.56

ND = Non-detect

Averages calculated setting non-detects to zero.

4.1.2 Assessment of Impairment

Water quality data were compared to applicable numeric standards, following IEPA (2012) listing guidance, to confirm the impairment. Table 14 provides additional detail regarding the impairment confirmation.

Table 14. Confirmation of Use Impairment and Waterbody Listing

Waterbody/ Cause of Impairment	Applicable Water Use Designation	Water Quality Criteria	Basis of Impairment	Notes
Bonpas Cr. / IL_BC-02				
Atrazine	General Use (Aquatic Life)	Acute criteria of 82 ug/L. Chronic criteria of 9 ug/L.	1 of 5 samples > chronic criterion	Assessed using all data. Exceedance observed in most recent year.
Manganese, dissolved	General Use (Aquatic Life)	Calculated. Hardness dependent.	0 of 19 samples > criterion; Recommend delisting	Assessed using three most recent years of data.
Dissolved oxygen	General Use (Aquatic Life)	5.0 mg/l March-July 3.5 mg/l other months	4 of 25 samples < criterion	Assessed using three most recent years of data. Two of the measurements < criterion were observed in most recent year of data.
Fecal coliform	Primary contact recreation	Geomean of ≥ 5 samples in 30 days >200/100 ml or fewer than 10% of samples >400/100 ml	Geomean (=1032) >200/100ml 60% of samples were > 400/100 ml	Assessed using 2006 data (5 samples).
New West Salem Reservoir / IL_RBQ				
Phosphorus (Total)	Aesthetic quality	0.05 mg/l	20 of 20 samples > criterion	The total phosphorus standard applies to all lakes of 20 acres or larger.
Old West Salem Reservoir / IL_RBZN				
Phosphorus (Total)	Aesthetic quality	0.05 mg/*	11 of 15 samples > criterion	
		2179 mg/kg	0 of 1 sample > criterion	The 2006 integrated report states that lakes < 20 acres could be listed if phosphorus >2179 in the sediment

*Old West Salem Reservoir is 2 acres in size. In lakes < 20 acres, total phosphorus is listed when the narrative standard in 35 Ill. Adm. Code 302.203 is not attained due to aquatic plant or algal growth (IEPA, 2012)

The 2012 integrated report (IEPA, 2012) provides the methodology for identifying causes of impairment, with the criteria varying based on the number of samples. The most recent consecutive years of data are used.

For atrazine, data are available for two non-consecutive years, 1999 and 2006. Based on Table C-3 in IEPA, 2012, impairment of the aquatic life use is indicated if one observation exceeds an applicable standard for either the chronic or acute standard. All data were assessed, and one sample from 2006 was found to be in exceedance of the criteria. There appears to be a correlation between flow and atrazine concentration, with concentrations increasing with increasing Bonpas Creek flow. The listing is confirmed and a TMDL is recommended.

For dissolved manganese, there are 8 years of data. Although there was one violation of the current manganese standard identified in 1999, the listing does not appear warranted based on the recommended method for identifying impairment. When the most recent 3 consecutive years of data are analyzed (2005, 2006, 2007), there are no exceedances of the manganese standard in those 19 samples, and segment IL_BC-02 is recommended for delisting for manganese. Based on a review of all available data, it is noted that dissolved manganese is inversely correlated with Bonpas Creek flow at the USGS gage, with the highest dissolved manganese concentrations observed at the lowest flows.

For dissolved oxygen, there are 6 years of data. The most recent three years of data (2002, 2004 and 2005) were analyzed for confirming impairment, although it is noted that these sampling years are not consecutive. Of these 25 samples, four were below the criteria. Three of the four violations occurred in the August and September, when flow in Bonpas Creek (03378000 Bonpas Creek at Browns, IL) was less than 0.5 cfs (See Figure 9 showing dissolved oxygen at BC-02 plotted vs. the log of flow). Because there were more than 2 observations below the standard, this listing is confirmed and a TMDL is recommended. It is noted that two violations were observed in just the most recent year (2005).

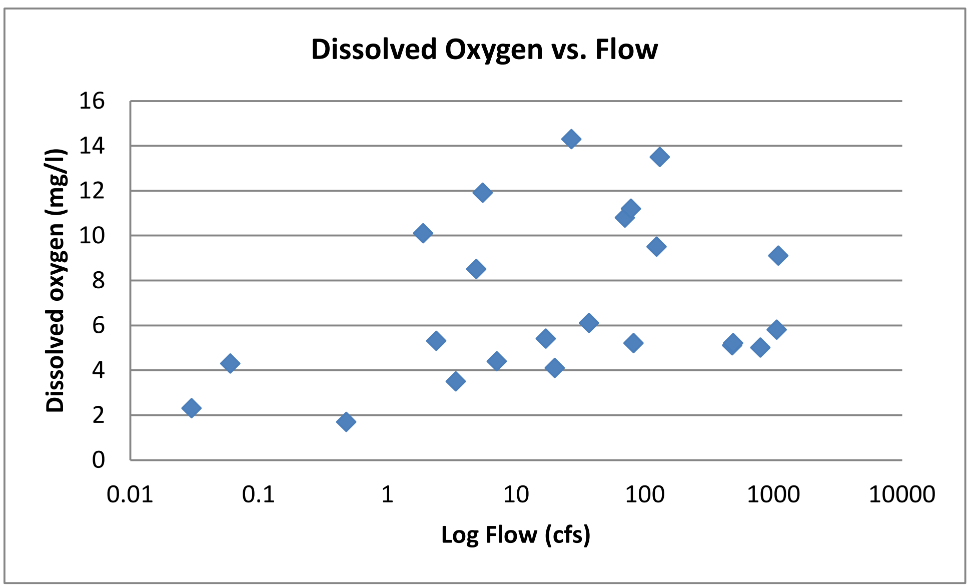

Figure 9. Dissolved oxygen (BC-02) vs. Bonpas Creek Flow (03378000)

Fecal coliform was analyzed using 5 samples collected in 2006 at station BC-02, following the guidance in the 2012 integrated report. The geometric mean of these samples (1032) was greater than 200/100ml and 60% of the samples were > 400/100 ml, confirming the listing. A TMDL is recommended. A strong correlation between Bonpas Creek flow (gage 03378000) and fecal coliform was observed (Figure 10).

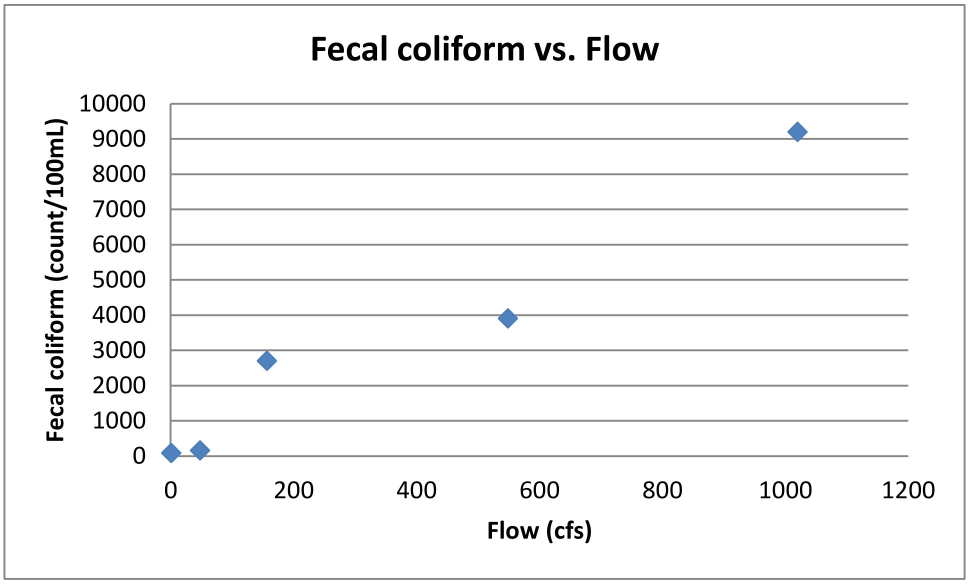

Figure 10. Fecal coliform (station BC-02) vs. Bonpas Creek flow (03378000)

For the two segments impaired due to sedimentation/siltation (segments IL_BC-02 and IL_BC-04), data were not identified to confirm the impairment. LRS are recommended for these segments based on visual observations during the site visit (See Appendix B, Photos).

Assessment of the aesthetic use support for the two lakes was conducted by calculating the aesthetic quality index (IEPA, 2012).

4.1.2.a Assessment of Aesthetic Use Impairment

The State of Illinois uses the Aesthetic Quality Index (AQI) to assess if a lake is supporting the aesthetic quality use. The AQI is the sum of the median Trophic State Index (TSI) (Carlson, 1977), and scores based on percent macrophyte coverage and NVSS concentration.

West Salem New Reservoir and West Salem Old Reservoir were both confirmed to be not supporting (fair) based on the AQI (Tables 15 and 16). The total phosphorus cause is confirmed for both reservoirs, although it is noted that West Salem Old Reservoir is much smaller than the IEPA cutoff of 20 acres, and does not meet the size standard for lakes in Illinois. A LRS will be developed for West Salem Old Reservoir instead of a TMDL.

Table 15. Aesthetic Quality Index (AQI) calculations

Evaluation Factor	Parameter	Weighting Criteria	Points	West Salem New Reservoir	West Salem Old Reservoir
1. Median Trophic State Index (TSI)	For data collected May-October: Median lake TSI value calculated from total phosphorus (samples collected at one foot depth), chlorophyll a and Secchi disk transparency.	Actual Median TSI Value		64.16	62.15
2. Macrophyte Coverage	Average percentage of lake surface area covered by macrophytes during peak growing season (June through August). Determined by: a. Macrophyte survey conducted during same water year as the chemical data used in the assessment; or b. Average value reported on the VLMP Secchi Monitoring Data form.	a. <5 b. >5<15 c. >15<25 d. >25	a. 0 b. 5 c. 10 d. 15	0 (no data)	0 (no data)
3. Nonvolatile Suspended Solids (NVSS) Concentration	Median lake surface NVSS concentration for samples collected at one foot depth (reported in mg/l)	a. <3 b. >3<7 c. >7<15 d. >15	a. 0 b. 5 c. 10 d. 15	(NVSS=7.5) 10	(NVSS=6.0) 5
Total AQI Score >>				**74.16**	**67.15**

The degree of use support is evaluated based on the guidelines in Table 16 and is assessed as 'not supporting (fair)' for both lakes, consistent with IEPA's 'not supporting' use assessment.

Table 16. Guidelines for assessing aesthetic quality use support in Illinois inland lakes

Degree of Use Support	Guidelines
Fully Supporting (Good)	Total AQI points are < 60
Not Supporting (Fair)	Total AQI points are $\geq$ 60 <90
Not Supporting (Poor)	Total AQI points are $\geq$ 90

Source: IEPA, 2012

4.1.3 TMDL recommendations

The review of available water quality data and current state water quality standards recommends that a TMDL not be prepared for manganese for Segment IL_BC-02, due to a change in the manganese standard. The manganese standard was revised through Illinois Pollution Control Board Rulemaking R2001-018 (In the Matter of: Triennial Review of Water Quality Standards for Boron, Fluoride and Manganese: Amendments to 35 Ill. Adm. Code 301.106, 302. Subparts B, C, E, F and 303.312). TMDLs are recommended for the other impaired waterbodies in this watershed that have numeric standards for the identified impairments.

4.1.4 LRS recommendations

Based on a review of available data, it is recommended that 2 LRS's be developed for sedimentation/siltation for Bonpas Creek segments IL_BC-02 and IL_BC-04, and that 1 LRS be developed for total phosphorus for West Salem Old Reservoir. Sedimentation/siltation does not have numeric water quality standards. Prior to 2008, IEPA used the guideline of >34% silt/mud for sedimentation/siltation. A reevaluation resulted in IEPA changing this to >75% silt/mud. Data were not identified to confirm the sedimentation/siltation listing; however both segments were observed to be very muddy during the site visit.

4.2 Source Assessment

This section discusses potential sources of pollutants for the Bonpas Creek watershed water use impairments. Potential sources are known or suspected activities, facilities, or conditions that may be contributing to impairment of a designated use. The potential sources identified by Illinois EPA in the 2012 Integrated Report are reprinted in Table 17. Additional potential sources identified through Stage 1 work are shown in Table 17 in bold font.

Table 17. Waterbody Impairment Causes and Sources (from IEPA, 2012)

Waterbody/Cause of Impairment	Potential Sources
Bonpas Creek / IL_BC-02	
Atrazine	Crop production (crop land or dry land)
Manganese	Source unknown
Dissolved oxygen	Animal Feeding Operations (nonpoint source) **Low streamflow**
Sedimentation/siltation	Crop production (crop land or dry land) **Streambank erosion**
Fecal coliform	Source unknown **Onsite treatment systems** **Animal Feeding Operations (NPS)** **Wastewater treatment plants**
Bonpas Creek / IL_BC-04	
Sedimentation/siltation	Crop production (crop land or dry land); **Streambank erosion**
West Salem New Reservoir / IL_RBQ	
Total phosphorus	Crop production (crop land or dry land); **Shoreline erosion**
Aquatic algae	Crop production (crop land or dry land)
West Salem Old Reservoir / IL_RBZN	
Total phosphorus	Crop production (crop land or dry land); **Shoreline erosion**
Aquatic algae	Crop production (crop land or dry land)

5 Methodology

This section identifies potentially applicable methodologies to be used in TMDL development, describes the model selection process, and finally, provides specific recommendations for TMDL and LRS for the project watershed.

5.1 Identification of potentially applicable models and procedures to be used in TMDL and LRS development

Development of TMDLs and LRSs requires: 1) a method to estimate the amount of pollutant load being delivered to the water body of interest from all contributing sources, and 2) a method to convert these pollutant loads into an in-stream or in-lake concentration for comparison to water quality targets. Both of these steps can be accomplished using a wide range of methodologies, ranging from simple calculations to complex computer models. This section describes the approach for identifying methodologies that are potentially applicable for waterbodies in the Bonpas Creek watershed. It is divided into separate discussions of:

- Identifying candidate watershed model frameworks
- Identifying candidate water quality model frameworks

5.1.1 Identify Candidate Watershed Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize watershed loads for TMDL and LRS development. Table 18 summarizes some important characteristics of each of the models relative to TMDL and LRS application, and Appendix D describes each of these modeling frameworks in more detail.

Table 18. Summary of potentially applicable models for estimating watershed loads

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL or LRS
Empirical Approach	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Simple Method/Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
USLE	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
AVGWLF/ MapShed	Moderate	Monthly average	Moderate	Requires data describing flow and concentration	Good for mixed use watersheds; compromise between simple and more complex models
L-THIA	Moderate	Annual Average	Low	None	Good for screening-level assessments. Model focuses on the

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL or LRS
					average impact, rather than an extreme year or storm.
STEPL	Moderate	Annual Total	Moderate	none	Suited for urban and rural watersheds. A simple model designed for TMDL support.
SWMM	Moderate	Continuous	Moderate	Requires data describing flow and concentration	Primarily suited for urban watersheds
AnnAGNPS	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available
HSPF	High	Continuous	High	Requires data describing flow and concentration	Good for mixed use watersheds; highly applicable if sufficient resources are available
SWAT	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available

5.1.2 Identify Candidate Water Quality Methodologies and Modeling Frameworks

Once pollutant loads are predicted by a watershed methodology or model, this information will be used by a water quality methodology or model to predict the system response to loading. Numerous methodologies exist to characterize the relationship between watershed loads and water quality for TMDL or LRS development. These are presented in Table 19, along with some important characteristics of each of the models relative to TMDL and LRS application. Additional information regarding these methodologies and their suitability for defining water quality for TMDL or LRS development is presented in Appendix E.

Table 19. Summary of potentially applicable models for estimating water quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL or LRS
Spreadsheet approaches/ Load duration curve	Steady State	River or lake	0- or 1-D	Low	DO, nutrients, algae, metals	Good for screening-level assessments
EUTROMOD	Steady State	Lake	0-D	Low	DO, nutrients, algae	Good for screening-level assessments
BATHTUB	Steady State	Lake	1-D	Moderate	DO, nutrients, algae	Good for screening-level assessments; can provide more refined assessments if supporting data exist
QUAL2E/ QUAL2K	Steady State	River	1-D	Moderate/ High	DO, nutrients, algae, bacteria	Good for low-flow assessments of conventional pollutants in rivers
WASP7	Dynamic	River or lake	1-D to 3-D	High	DO, nutrients, metals, organics	Excellent water quality capability; simple hydraulics

Table 19 (continued). Summary of potentially applicable models for estimating water quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL or LRS
CE-QUAL-RIV1	Dynamic	River	1-D	High	DO, nutrients, algae	Good for conventional pollutants in hydraulically complex rivers
HSPF	Dynamic	River or lake	1-D	High	DO, nutrients, metals, organics, bacteria	Wide range of water quality capabilities, directly linked to watershed model
CE-QUAL-W2	Dynamic	Lake	2-D vertical	High	DO, nutrients, algae, some metals	Good for conventional pollutants in stratified lakes or impoundments
EFDC	Dynamic	River or lake	3-D	High	DO, nutrients, metals, organics, bacteria	Potentially applicable to all sites, if sufficient data exist

5.2 Model Selection

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop the total phosphorus TMDL and total suspended solids LRS. This section describes the general guidelines that were applied to make specific model recommendations.

The following factors were considered when selecting an appropriate model for TMDL and LRS development:

- Management objectives: Management objectives define the specific purpose of the model, including the pollutant of concern, the water quality objective, the space and time scales of interest, and required level or precision/accuracy.
- Available resources: The resources available to support the modeling effort include data, time, and level of modeling effort.
- Site-specific characteristics: Site-specific characteristics include the land use activity in the watershed, type of water body (e.g. lake vs. river), important transport and transformation processes, and environmental conditions.

Model selection must be balanced between competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained.

The required level of reliability for this modeling effort is one able to “support development of a credible TMDL” and “support development of a reasonably assurable LRS.” The selected methods must be acceptable by IEPA and USEPA Region V. The amount of reliability required to develop a credible TMDL depends also on the degree of implementation to be included in the TMDL, which for this watershed, will be focused on point and nonpoint sources. The approach to be taken here regarding model selection will also consider the models’ ability to provide recommendations which correspond to the level of detail required to be eligible for 319 funding.

Available resources and site-specific characteristics are also considered when selecting an appropriate model or method for TMDL and LRS development. These considerations are discussed in the following section for each waterbody.

5.3 Model Recommendations

Model recommendations for development of a credible TMDL and LRS are described below for each impaired waterbody segment and summarized in Table 20. The recommended models are on the simpler end of the complexity scale, but have been demonstrated to be capable of satisfying management objectives at a much lower level of resources than required by the other candidate models. Final model selection will occur with input from Illinois EPA.

5.3.1 Bonpas Creek / IL_BC-02

This downstream segment of Bonpas Creek is 28.95 miles long, and receives flow from Bonpas Creek segment IL_BC-04 and some small tributaries. There are several permitted point source dischargers in this watershed. A USGS gage (03378000) is located on the mainstem of Bonpas Creek at Browns, Illinois, at the same location as monitoring station BC-02. Water quality data are available from several years and all of the data are over five years old.

This stream segment requires TMDLs for atrazine, dissolved oxygen and fecal coliform, and a LRS for sedimentation/siltation. A load-duration curve approach is recommended for atrazine and fecal coliform. QUAL2E/QUAL2K is recommended for dissolved oxygen modeling and development of the dissolved oxygen TMDL. It is recommended that the TSS load reduction strategy be prepared using USLE-based methods, or, alternatively, a combination of the Simple Method and unit areal loading rates. The Simple Method/UAL techniques may be met with diminished stakeholder acceptance.

5.3.2 Bonpas Creek / IL_BC-04

This headwater segment of Bonpas Creek is 26.2 miles long and receives discharge from two permitted point source dischargers, and is upstream of Bonpas Creek segment IL_BC-02. This stream segment requires an LRS for sedimentation/siltation.

It is recommended that the TSS load reduction strategy be prepared using USLE-based methods, or, alternatively, a combination of the Simple Method and unit areal loading rates. The Simple Method/UAL techniques may be met with diminished stakeholder acceptance.

5.3.3 New West Salem Reservoir / IL_RBQ

The 32-acre New West Salem reservoir requires a TMDL for total phosphorus, and has been sampled in 2000 and 2012 at two locations. The 2012 data are not presented in this report because they were preliminary at the time of this analysis.

Empirical estimates of watershed loads linked to the BATHTUB model are recommended for total phosphorus modeling. This approach has been successfully applied to support total phosphorus TMDLs for numerous similar lakes and impoundments throughout Illinois. An alternate approach would be to use a Unit Area Load approach to calculate watershed phosphorus loads to the lake.

5.3.4 Old West Salem Reservoir / IL_RBZN

The 2-acre Old West Salem reservoir requires a LRS for total phosphorus, and was last sampled in 2000 at one location.

Empirical estimates of watershed loads linked to the BATHTUB model are recommended for total phosphorus modeling. This approach has been successfully applied to support total phosphorus TMDLs for numerous similar lakes and impoundments throughout Illinois. An alternate approach would be to use a Unit Area Load approach to calculate watershed phosphorus loads to the lake.

Table 20. Summary of Recommendations for Developing TMDLs and LRSs in the Bonpas Creek Watershed.

Water body / Segment	Cause of impairment	Approach
Bonpas Creek IL_BC-02	Atrazine	Load duration curve
	Manganese	Not applicable – recommend delisting
	Dissolved oxygen	QUAL2E/QUAL2K
	Fecal coliform	Load duration curve
	Sedimentation/siltation	Universal Soil Loss Equation or Simple Method/UAL
Bonpas Creek IL_BC-04	Sedimentation/siltation	Universal Soil Loss Equation or Simple Method/UAL
New West Salem Reservoir / IL_RBQ	Total phosphorus	Empirical Approach with BATHTUB
Old West Salem Reservoir / IL_RBZN	Total phosphorus	Empirical Approach with BATHTUB

6 Data Collection to Support Modeling

Additional data are required to support development of the TMDLs in the Bonpas Creek watershed. Physical and chemical data are required to support modeling.

6.1 Water Quality Data Collection

The recommended approach for the 28.95 mile long Bonpas Creek segment IL_BC-02 consists of using the water quality model QUAL2E/QUAL2K to address dissolved oxygen problems. Watershed loads for this segment will be defined using an empirical approach. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen-demanding substances at three locations located within this impaired Bonpas Creek segment. It is recommended that the measurements shown in Table 21 be collected on the same day, under low flow conditions. In addition, it is recommended that depth and velocity be measured at the same time as the water quality sampling, to support flow calculation, with USGS flows being used at location BC-02. Either continuous dissolved oxygen measurements or dissolved oxygen measurements collected in the morning and afternoon should be collected at three locations. The purpose of these dissolved oxygen measurements is to assess the effect of algae on instream dissolved oxygen concentrations. All three locations should be visually inspected for attached algae. Finally, at a station determined to be representative of this segment, based on a field survey, it is recommended that sediment oxygen demand (SOD) be measured.

Sufficient data exist to support development of the remaining TMDLs and LRSs for impaired waterbodies in this watershed. Table 21 summarizes Stage 2 recommendations.

Table 21. Stage 2 recommendations

Impaired segments	Measurement	Number of low flow surveys	Suggested locations
Bonpas Creek / IL_BC-02	Dissolved oxygen	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Water temperature	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Biochemical oxygen demand	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Total ammonia	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Nitrate	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Total phosphorus	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Ortho-phosphorus	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Channel morphometry	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Chlorophyll a	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Depth and velocity	2	BC-01 and a location near the upstream end of IL_BC-02
	Sediment oxygen demand	1	BC-02
	Continuous DO or DO measurements in the morning and afternoon	2	BC-01, BC-02 and a location near the upstream end of IL_BC-02
	Atrazine	None	None
	Dissolved manganese	None	None
	Fecal coliform	None	None
	Sedimentation/siltation	None	None
Bonpas Creek / IL_BC-04	Sedimentation/siltation	None	None
New West Salem Reservoir / IL_RBQ	Total phosphorus	None	None
Old West Salem Reservoir / IL_RBZN	Total phosphorus	None	None

7 Public Participation

TMDLs contain a public participation component to provide the public with an opportunity to provide comments and suggestions during the TMDL process. IEPA published a public notice for the meeting (Appendix F) and a hard copy of the draft report was available for viewing prior to the meeting, at the Edwards County SWCD office, West Salem Village Hall and on-line at www.epa.state.il.us/public-notices. A public meeting was held at the completion of Stage 1 work at the Edwards County Fairgrounds Exhibition Building in Albion Illinois on May 1, 2014 at 8:00 am. Approximately 60 people attended the meeting, in addition to the meeting organizers.

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8 References

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Appendix A. Data Sources and Local Contacts

Table A-1. Data sources

Data description	Agency	Source
Climate summaries	Illinois State Water Survey	http://www.sws.uiuc.edu/atmos/statecli/index.htm
Daily hydrology data	US Geological Survey	http://waterdata.usgs.gov/nwis/
Cropland Data Layer (CDL)	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
NPDES Dischargers	Illinois EPA	Jennifer Clarke
Soils	USDA Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
Sample stations -- statewide	Illinois Environmental Protection Agency	Email from staff
Impaired segments	Illinois Environmental Protection Agency	Email from staff
Livestock census	National Agricultural Statistics Service, US Department of Agriculture	http://www.nass.usda.gov/Data_and_Statistics/index.asp
Populated places	U.S. Census Bureau	Esri ArcGIS Online
Watershed Boundary Dataset	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
Elevation	National Elevation Dataset via the U.S. Geological Survey's The National Map	http://nationalmap.gov/viewer.html
MS4 status list	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/permits/storm-water/urbanized-area-list.html

Table A-2. State and Local Contacts

Contact	Agency/Organization	Phone/e-mail	Subject
Marina Sample	Wabash County Public Health Department	618-263-3873	Private sewage disposal units in Wabash county
Dave Muir	Illinois EPA	618-993-7098	Source identification
Margaret Fertaly	Illinois EPA	618-993-7099	Mining, facility inspection reports, CAFOs, sampling, watershed groups

Appendix B. Photos


Bonpas Creek (IL_BC-02) at Station BC-01 looking downstream (left) and upstream (right)

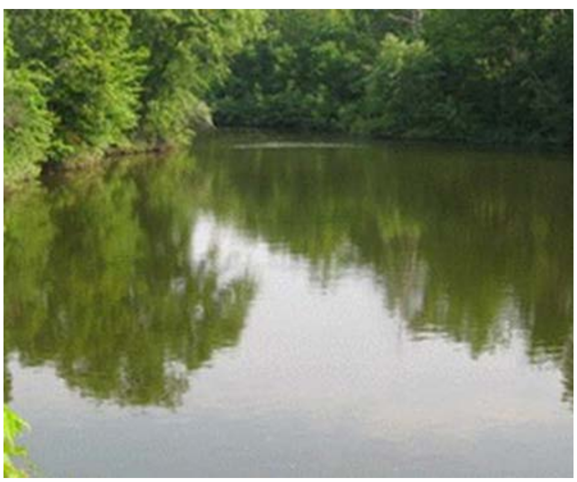

Bonpas Creek (IL_BC-02) at Station BC-03 looking downstream (left) and looking at upstream bank (right)

Bonpas Creek (IL_BC-04) at Station BC-04 looking downstream (left) and at downstream bank (right)

Bonpas Creek tributary at Station BCE-01 and Station BCE-02

New West Salem Reservoir (IL_RBQ)

Old West Salem Reservoir (IL_RBZN)

Oil wells in the Bonpas Creek watershed

Unnamed tributary to Bonpas Creek at 270 East

Agricultural land in the Bonpas Creek watershed

Appendix C. Historical Sampling Data

Bonpas Creek water samples

Station Code	Collection Date	Analyte	Result ORIG	Result Units	Qualifier	Reporting Limit
BC-02	06-Mar-06	Atrazine, Total	0	ug/l	ND	0.1
BC-02	17-May-06	Atrazine, Total	9.9	ug/l		0.1
BC-02	28-Jun-06	Atrazine, Total	2.7	ug/l		0.1
BC-02	21-Jun-99	Atrazine	3.2	ug/l		
BC-02	28-Jul-99	Atrazine	1.5	ug/l		
BC-02	09-Mar-04	Manganese, Dissolved	120	ug/l		
BC-02	20-Apr-04	Manganese, Dissolved	300	ug/l		
BC-02	25-May-04	Manganese, Dissolved	280	ug/l		
BC-02	22-Jun-04	Manganese, Dissolved	90	ug/l		
BC-02	03-Aug-04	Manganese, Dissolved	230	ug/l		
BC-02	14-Sep-04	Manganese, Dissolved	350	ug/l		
BC-02	15-Nov-04	Manganese, Dissolved	30	ug/l		
BC-02	02-Dec-04	Manganese, Dissolved	27	ug/l		
BC-02	26-Jan-05	Manganese, Dissolved	240	ug/l		
BC-02	15-Mar-05	Manganese, Dissolved	180	ug/l		
BC-02	19-Apr-05	Manganese, Dissolved	280	ug/l		
BC-02	09-May-05	Manganese, Dissolved	310	ug/l		
BC-02	23-Jun-05	Manganese, Dissolved	300	ug/l		
BC-02	23-Aug-05	Manganese, Dissolved	1100	ug/l		
BC-02	29-Sep-05	Manganese, Dissolved	1600	ug/l		
BC-02	26-Oct-05	Manganese, Dissolved	2700	ug/l		
BC-02	06-Dec-05	Manganese, Dissolved	110	ug/l		
BC-02	30-Jan-06	Manganese, Dissolved	110	ug/l		
BC-02	06-Mar-06	Manganese, Dissolved	150	ug/l		
BC-02	18-Apr-06	Manganese, Dissolved	480	ug/l		
BC-02	17-May-06	Manganese, Dissolved	62	ug/l		
BC-02	28-Jun-06	Manganese, Dissolved	170	ug/l		
BC-02	09-Aug-06	Manganese, Dissolved	28	ug/l		
BC-02	11-Sep-06	Manganese, Dissolved	1200	ug/l		
BC-02	16-Oct-06	Manganese, Dissolved	160	ug/l		
BC-02	15-Nov-06	Manganese, Dissolved	120	ug/l		
BC-02	10-Jan-07	Manganese, Dissolved	110	ug/l		

Station Code	Collection Date	Analyte	Result ORIG	Result Units	Qualifier	Reporting Limit
BC-02	04-Feb-99	Manganese, Dissolved	42	ug/l		
BC-02	08-Mar-99	Manganese, Dissolved	44	ug/l		
BC-02	22-Apr-99	Manganese, Dissolved	240	ug/l		
BC-02	24-May-99	Manganese, Dissolved	340	ug/l		
BC-02	21-Jun-99	Manganese, Dissolved	220	ug/l		
BC-02	29-Sep-99	Manganese, Dissolved	2000	ug/l		
BC-02	09-Nov-99	Manganese, Dissolved	8600	ug/l		
BC-02	09-Dec-99	Manganese, Dissolved	2700	ug/l		
BC-02	11-Jan-00	Manganese, Dissolved	90	ug/l		
BC-02	18-Apr-00	Manganese, Dissolved	250	ug/l		
BC-02	25-May-00	Manganese, Dissolved	150	ug/l		
BC-02	28-Jun-00	Manganese, Dissolved	80	ug/l		
BC-02	01-Aug-00	Manganese, Dissolved	21	ug/l		
BC-02	28-Sep-00	Manganese, Dissolved	120	ug/l		
BC-02	21-Nov-00	Manganese, Dissolved	140	ug/l		
BC-02	25-Jan-01	Manganese, Dissolved	130	ug/l		
BC-02	13-Mar-01	Manganese, Dissolved	240	ug/l		
BC-02	02-Apr-01	Manganese, Dissolved	240	ug/l		
BC-02	16-May-01	Manganese, Dissolved	380	ug/l		
BC-02	05-Jun-01	Manganese, Dissolved	310	ug/l		
BC-02	15-Aug-01	Manganese, Dissolved	670	ug/l		
BC-02	24-Oct-01	Manganese, Dissolved	140	ug/l		
BC-02	19-Nov-01	Manganese, Dissolved	250	ug/l		
BC-02	29-Jan-02	Manganese, Dissolved	120	ug/l		
BC-02	05-Mar-02	Manganese, Dissolved	86	ug/l		
BC-02	17-Apr-02	Manganese, Dissolved	130	ug/l		
BC-02	22-May-02	Manganese, Dissolved	310	ug/l		
BC-02	12-Jun-02	Manganese, Dissolved	290	ug/l		
BC-02	08-Aug-02	Manganese, Dissolved	720	ug/l		
BC-02	05-Sep-02	Manganese, Dissolved	1300	ug/l		
BC-02	04-Nov-02	Manganese, Dissolved	99	ug/l		
BC-02	04-Dec-02	Manganese, Dissolved	84	ug/l		
BC-02	04-Feb-99	Manganese, Total	120	ug/l		
BC-02	08-Mar-99	Manganese, Total	160	ug/l		
BC-02	22-Apr-99	Manganese, Total	330	ug/l		
BC-02	24-May-99	Manganese, Total	500	ug/l		
BC-02	21-Jun-99	Manganese, Total	300	ug/l		
BC-02	29-Sep-99	Manganese, Total	2200	ug/l		
BC-02	09-Nov-99	Manganese, Total	10000	ug/l		
BC-02	09-Dec-99	Manganese, Total	2800	ug/l		

Station Code	Collection Date	Analyte	Result ORIG	Result Units	Qualifier	Reporting Limit
BC-02	11-Jan-00	Manganese, Total	130	ug/l		
BC-02	18-Apr-00	Manganese, Total	290	ug/l		
BC-02	25-May-00	Manganese, Total	240	ug/l		
BC-02	28-Jun-00	Manganese, Total	140	ug/l		
BC-02	01-Aug-00	Manganese, Total	250	ug/l		
BC-02	28-Sep-00	Manganese, Total	160	ug/l		
BC-02	21-Nov-00	Manganese, Total	150	ug/l		
BC-02	25-Jan-01	Manganese, Total	140	ug/l		
BC-02	13-Mar-01	Manganese, Total	280	ug/l		
BC-02	02-Apr-01	Manganese, Total	290	ug/l		
BC-02	16-May-01	Manganese, Total	480	ug/l		
BC-02	05-Jun-01	Manganese, Total	710	ug/l		
BC-02	15-Aug-01	Manganese, Total	810	ug/l		
BC-02	24-Oct-01	Manganese, Total	290	ug/l		
BC-02	19-Nov-01	Manganese, Total	290	ug/l		
BC-02	29-Jan-02	Manganese, Total	170	ug/l		
BC-02	05-Mar-02	Manganese, Total	130	ug/l		
BC-02	17-Apr-02	Manganese, Total	250	ug/l		
BC-02	22-May-02	Manganese, Total	340	ug/l		
BC-02	12-Jun-02	Manganese, Total	420	ug/l		
BC-02	08-Aug-02	Manganese, Total	760	ug/l		
BC-02	05-Sep-02	Manganese, Total	1500	ug/l		
BC-02	04-Nov-02	Manganese, Total	130	ug/l		
BC-02	04-Dec-02	Manganese, Total	90	ug/l		
BC-02	09-Mar-04	Manganese, Total	160	ug/l		
BC-02	20-Apr-04	Manganese, Total	400	ug/l		
BC-02	25-May-04	Manganese, Total	410	ug/l		
BC-02	22-Jun-04	Manganese, Total	540	ug/l		
BC-02	14-Sep-04	Manganese, Total	400	ug/l		
BC-02	15-Nov-04	Manganese, Total	60	ug/l		
BC-02	02-Dec-04	Manganese, Total	69	ug/l		
BC-02	26-Jan-05	Manganese, Total	260	ug/l		
BC-02	15-Mar-05	Manganese, Total	190	ug/l		
BC-02	19-Apr-05	Manganese, Total	390	ug/l		
BC-02	09-May-05	Manganese, Total	420	ug/l		
BC-02	23-Jun-05	Manganese, Total	420	ug/l		
BC-02	23-Aug-05	Manganese, Total	1100	ug/l		
BC-02	29-Sep-05	Manganese, Total	1600	ug/l		
BC-02	26-Oct-05	Manganese, Total	2900	ug/l		
BC-02	06-Dec-05	Manganese, Total	130	ug/l		

Station Code	Collection Date	Analyte	Result ORIG	Result Units	Qualifier	Reporting Limit
BC-02	30-Jan-06	Manganese, Total	250	ug/l		
BC-02	06-Mar-06	Manganese, Total	160	ug/l		
BC-02	18-Apr-06	Manganese, Total	640	ug/l		
BC-02	17-May-06	Manganese, Total	230	ug/l		
BC-02	28-Jun-06	Manganese, Total	350	ug/l		
BC-02	09-Aug-06	Manganese, Total	350	ug/l		
BC-02	11-Sep-06	Manganese, Total	1300	ug/l		
BC-02	16-Oct-06	Manganese, Total	180	ug/l		
BC-02	15-Nov-06	Manganese, Total	150	ug/l		
BC-02	10-Jan-07	Manganese, Total	140	ug/l		
BC-02	09-Mar-04	Dissolved oxygen	9.5	mg/l		
BC-02	25-May-04	Dissolved oxygen	5.2	mg/l		
BC-02	22-Jun-04	Dissolved oxygen	5.1	mg/l		
BC-02	03-Aug-04	Dissolved oxygen	4.1	mg/l		
BC-02	14-Sep-04	Dissolved oxygen	4.4	mg/l		
BC-02	15-Nov-04	Dissolved oxygen	5.8	mg/l		
BC-02	02-Dec-04	Dissolved oxygen	9.1	mg/l		
BC-02	26-Jan-05	Dissolved oxygen	10.8	mg/l		
BC-02	15-Mar-05	Dissolved oxygen	14.3	mg/l		
BC-02	19-Apr-05	Dissolved oxygen	6.1	mg/l		
BC-02	09-May-05	Dissolved oxygen	5.4	mg/l		
BC-02	23-Jun-05	Dissolved oxygen	5.3	mg/l		
BC-02	23-Aug-05	Dissolved oxygen	1.7	mg/l		
BC-02	29-Sep-05	Dissolved oxygen	2.3	mg/l		
BC-02	26-Oct-05	Dissolved oxygen	3.6	mg/l		
BC-02	06-Dec-05	Dissolved oxygen	11.9	mg/l		
BC-02	04-Feb-99	Dissolved oxygen	9.8	mg/l		
BC-02	08-Mar-99	Dissolved oxygen	10.8	mg/l		
BC-02	22-Apr-99	Dissolved oxygen	7.3	mg/l		
BC-02	24-May-99	Dissolved oxygen	5.9	mg/l		
BC-02	21-Jun-99	Dissolved oxygen	5.7	mg/l		
BC-02	29-Sep-99	Dissolved oxygen	3.9	mg/l		
BC-02	09-Nov-99	Dissolved oxygen	1.1	mg/l		
BC-02	09-Dec-99	Dissolved oxygen	1.6	mg/l		
BC-02	11-Jan-00	Dissolved oxygen	9.3	mg/l		
BC-02	18-Apr-00	Dissolved oxygen	7.2	mg/l		
BC-02	25-May-00	Dissolved oxygen	5.5	mg/l		
BC-02	28-Jun-00	Dissolved oxygen	3.8	mg/l		
BC-02	01-Aug-00	Dissolved oxygen	5.4	mg/l		
BC-02	28-Sep-00	Dissolved oxygen	6.9	mg/l		

Station Code	Collection Date	Analyte	Result ORIG	Result Units	Qualifier	Reporting Limit
BC-02	21-Nov-00	Dissolved oxygen	10.5	mg/l		
BC-02	25-Jan-01	Dissolved oxygen	13	mg/l		
BC-02	13-Mar-01	Dissolved oxygen	10.2	mg/l		
BC-02	02-Apr-01	Dissolved oxygen	10.7	mg/l		
BC-02	16-May-01	Dissolved oxygen	5.2	mg/l		
BC-02	05-Jun-01	Dissolved oxygen	6.8	mg/l		
BC-02	15-Aug-01	Dissolved oxygen	3.1	mg/l		
BC-02	24-Oct-01	Dissolved oxygen	5.9	mg/l		
BC-02	19-Nov-01	Dissolved oxygen	7.3	mg/l		
BC-02	29-Jan-02	Dissolved oxygen	11.2	mg/l		
BC-02	05-Mar-02	Dissolved oxygen	13.5	mg/l		
BC-02	17-Apr-02	Dissolved oxygen	5.2	mg/l		
BC-02	22-May-02	Dissolved oxygen	5	mg/l		
BC-02	12-Jun-02	Dissolved oxygen	3.5	mg/l		
BC-02	08-Aug-02	Dissolved oxygen	4.3	mg/l		
BC-02	05-Sep-02	Dissolved oxygen	2.7	mg/l		
BC-02	04-Nov-02	Dissolved oxygen	8.5	mg/l		
BC-02	04-Dec-02	Dissolved oxygen	10.1	mg/l		
BC-02	5/24/1999	Fecal coliform	720	FCB Count/100mL		
BC-02	6/22/1999	Fecal coliform	440	FCB Count/100mL		
BC-02	9/30/1999	Fecal coliform	360	FCB Count/100mL		
BC-02	5/25/2000	Fecal coliform	380	FCB Count/100mL		
BC-02	6/28/2000	Fecal coliform	1020	FCB Count/100mL	B	
BC-02	8/1/2000	Fecal coliform	15400	FCB Count/100mL	B	
BC-02	9/28/2000	Fecal coliform	1820	FCB Count/100mL	B	
BC-02	10/30/2000	Fecal coliform	166	FCB Count/100mL	B	
BC-02	5/16/2001	Fecal coliform	64	FCB Count/100mL		
BC-02	6/5/2001	Fecal coliform	9000	FCB Count/100mL	B	
BC-02	8/15/2001	Fecal coliform	420	FCB Count/100mL		
BC-02	9/12/2001	Fecal coliform	210	FCB Count/100mL		
BC-02	10/24/2001	Fecal coliform	2000	FCB Count/100mL	L	
BC-02	5/22/2002	Fecal coliform	42	FCB Count/100mL		
BC-02	8/8/2002	Fecal coliform	20	FCB Count/100mL	B	
BC-02	9/5/2002	Fecal coliform	30	FCB Count/100mL	B	
BC-02	11/4/2003	Fecal coliform	63	FCB Count/100mL	B	
BC-02	12/9/2003	Fecal coliform	80	FCB Count/100mL		
BC-02	1/27/2004	Fecal coliform	64	FCB Count/100mL		
BC-02	3/9/2004	Fecal coliform	92	FCB Count/100mL		
BC-02	4/20/2004	Fecal coliform	3500	FCB Count/100mL		
BC-02	5/25/2004	Fecal coliform	780	FCB Count/100mL		

Station Code	Collection Date	Analyte	Result ORIG	Result Units	Qualifier	Reporting Limit
BC-02	6/22/2004	Fecal coliform	11000	FCB Count/100mL	B	
BC-02	8/3/2004	Fecal coliform	2100	FCB Count/100mL		
BC-02	9/14/2004	Fecal coliform	450	FCB Count/100mL		
BC-02	11/15/2004	Fecal coliform	420	FCB Count/100mL		
BC-02	12/2/2004	Fecal coliform	1600	FCB Count/100mL		
BC-02	5/9/2005	Fecal coliform	250	FCB Count/100mL		
BC-02	8/23/2005	Fecal coliform	100	FCB Count/100mL	B	
BC-02	9/29/2005	Fecal coliform	115	FCB Count/100mL		
BC-02	10/26/2005	Fecal coliform	64	FCB Count/100mL		
BC-02	5/17/2006	Fecal coliform	3900	FCB Count/100mL		
BC-02	6/28/2006	Fecal coliform	2700	FCB Count/100mL		
BC-02	8/9/2006	Fecal coliform	9200	FCB Count/100mL		
BC-02	9/11/2006	Fecal coliform	78	FCB Count/100mL		
BC-02	10/16/2006	Fecal coliform	155	FCB Count/100mL		
BC-04	01-Jun-11	Solids, Total Suspended	7	mg/l		
BC-04	07-Jun-11	Solids, Total Suspended	14	mg/l		
BC-04	14-Jun-11	Solids, Total Suspended	18	mg/l		
BC-04	29-Aug-11	Solids, Total Suspended	8	mg/l		
BC-02	09-Aug-06	Solids, Total Suspended	25	mg/l		
BC-02	11-Sep-06	Solids, Total Suspended	13	mg/l		
BC-02	16-Oct-06	Solids, Total Suspended	27	mg/l		
BC-02	15-Nov-06	Solids, Total Suspended	47	mg/l		
BC-02	10-Jan-07	Solids, Total Suspended	27	mg/l		
BC-02	09-Mar-04	Solids, Total Suspended	63	mg/l		4
BC-02	20-Apr-04	Solids, Total Suspended	116	mg/l		1
BC-02	25-May-04	Solids, Total Suspended	120	mg/l		1
BC-02	22-Jun-04	Solids, Total Suspended	471	mg/l		1
BC-02	03-Aug-04	Solids, Total Suspended	79	mg/l		1
BC-02	14-Sep-04	Solids, Total Suspended	39	mg/l		1
BC-02	15-Nov-04	Solids, Total Suspended	38	mg/l		8
BC-02	02-Dec-04	Solids, Total Suspended	54	mg/l		8
BC-02	26-Jan-05	Solids, Total Suspended	12	mg/l		8
BC-02	15-Mar-05	Solids, Total Suspended	10	mg/l		8
BC-02	19-Apr-05	Solids, Total Suspended	74	mg/l		8
BC-02	09-May-05	Solids, Total Suspended	108	mg/l		8
BC-02	23-Jun-05	Solids, Total Suspended	8	mg/l		8
BC-02	29-Sep-05	Solids, Total Suspended	10	mg/l		6
BC-02	26-Oct-05	Solids, Total Suspended	13	mg/l		6

B Results based upon colony counts outside the acceptable range.
L Actual value is known to be greater than value given.
ND Non-detect

New West Salem and Old West Salem Reservoir water and sediment samples

Station Code	Collection Date	Medium	Parameter Name	Result	Qualifier	Units
RBQ-1	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.135		mg/l
RBQ-1	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	19		mg/l
RBQ-1	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	7		mg/l
RBQ-1	5/10/2000	Water	DEPTH, SECCHI DISK DEPTH in	19		in
RBQ-1	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.345		mg/l
RBQ-1	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	23		mg/l
RBQ-1	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	5		mg/l
RBQ-1	5/10/2000	Water	DEPTH, SECCHI DISK DEPTH in	19		in
RBQ-1	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.329		mg/l
RBQ-1	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	24		mg/l
RBQ-1	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	7		mg/l
RBQ-1	5/10/2000	Water	DEPTH, SECCHI DISK DEPTH in	19		in
RBQ-1	5/10/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	56.2		ug/l
RBQ-1	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	0.192		mg/l
RBQ-1	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	17		mg/l
RBQ-1	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	11		mg/l
RBQ-1	6/21/2000	Water	DEPTH, SECCHI DISK DEPTH in	13		in
RBQ-1	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	0.192		mg/l
RBQ-1	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	16		mg/l
RBQ-1	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	10		mg/l
RBQ-1	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	0.228		mg/l
RBQ-1	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	15		mg/l
RBQ-1	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	7		mg/l
RBQ-1	6/21/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	196		ug/l
RBQ-1	7/12/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	192		ug/l
RBQ-1	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.633		mg/l
RBQ-1	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	14		mg/l
RBQ-1	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	10		mg/l
RBQ-1	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.188		mg/l
RBQ-1	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	15		mg/l
RBQ-1	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	13		mg/l
RBQ-1	7/12/2000	Water	DEPTH, SECCHI DISK DEPTH in	18		in
RBQ-1	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.186		mg/l
RBQ-1	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	16		mg/l
RBQ-1	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	11		mg/l
RBQ-1	7/12/2000	Water	DEPTH, SECCHI DISK DEPTH in	18		in
RBQ-1	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.174		mg/l
RBQ-1	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	21		mg/l

Station Code	Collection Date	Medium	Parameter Name	Result	Qualifier	Units
RBQ-1	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	12		mg/l
RBQ-1	8/28/2000	Water	DEPTH, SECCHI DISK DEPTH in	19		in
RBQ-1	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.17		mg/l
RBQ-1	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	17		mg/l
RBQ-1	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	9		mg/l
RBQ-1	8/28/2000	Water	DEPTH, SECCHI DISK DEPTH in	19		in
RBQ-1	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.198		mg/l
RBQ-1	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	21		mg/l
RBQ-1	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	9		mg/l
RBQ-1	8/28/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	101		ug/l
RBQ-1	8/28/2000	Sediment	PHOSPHORUS AS P	1250		mg/kg
RBQ-1	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.095		mg/l
RBQ-1	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	15		mg/l
RBQ-1	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	11		mg/l
RBQ-1	10/19/2000	Water	DEPTH, SECCHI DISK DEPTH in	16		in
RBQ-1	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.077		mg/l
RBQ-1	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	14		mg/l
RBQ-1	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	8		mg/l
RBQ-1	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.094		mg/l
RBQ-1	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	17		mg/l
RBQ-1	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	8		mg/l
RBQ-1	10/19/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	77		ug/l
RBQ-2	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.153		mg/l
RBQ-2	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	15		mg/l
RBQ-2	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	7		mg/l
RBQ-2	5/10/2000	Water	DEPTH, SECCHI DISK DEPTH in	18		in
RBQ-2	5/10/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	52.5		ug/l
RBQ-2	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	0.172		mg/l
RBQ-2	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	18		mg/l
RBQ-2	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	9		mg/l
RBQ-2	6/21/2000	Water	DEPTH, SECCHI DISK DEPTH in	17		in
RBQ-2	6/21/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	120		ug/l
RBQ-2	7/12/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	107		ug/l
RBQ-2	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.168		mg/l
RBQ-2	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	16		mg/l
RBQ-2	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	11		mg/l
RBQ-2	7/12/2000	Water	DEPTH, SECCHI DISK DEPTH in	16		in
RBQ-2	8/28/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	98.4		ug/l
RBQ-2	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.142		mg/l

Station Code	Collection Date	Medium	Parameter Name	Result	Qualifier	Units
RBQ-2	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	20		mg/l
RBQ-2	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	12		mg/l
RBQ-2	8/28/2000	Water	DEPTH, SECCHI DISK DEPTH in	18		in
RBQ-2	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.067		mg/l
RBQ-2	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	17		mg/l
RBQ-2	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	10		mg/l
RBQ-2	10/19/2000	Water	DEPTH, SECCHI DISK DEPTH in	16		in
RBQ-2	10/19/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	47.4		ug/l
RBZN-1	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.054		mg/l
RBZN-1	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	17		mg/l
RBZN-1	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	9		mg/l
RBZN-1	5/10/2000	Water	DEPTH, SECCHI DISK DEPTH in	22		in
RBZN-1	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.05		mg/l
RBZN-1	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	12		mg/l
RBZN-1	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	6		mg/l
RBZN-1	5/10/2000	Water	PHOSPHORUS AS P,Total mg/l	0.075		mg/l
RBZN-1	5/10/2000	Water	SOLIDS, FIXED,Total mg/l	11		mg/l
RBZN-1	5/10/2000	Water	SOLIDS, FIXED,Volatile mg/l	1		mg/l
RBZN-1	5/10/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	64.2		ug/l
RBZN-1	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	0.057		mg/l
RBZN-1	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	13		mg/l
RBZN-1	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	10		mg/l
RBZN-1	6/21/2000	Water	DEPTH, SECCHI DISK DEPTH in	20		in
RBZN-1	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	0.044		mg/l
RBZN-1	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	6		mg/l
RBZN-1	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	4		mg/l
RBZN-1	6/21/2000	Water	PHOSPHORUS AS P,Total mg/l	1.03		mg/l
RBZN-1	6/21/2000	Water	SOLIDS, FIXED,Total mg/l	20		mg/l
RBZN-1	6/21/2000	Water	SOLIDS, FIXED,Volatile mg/l	10		mg/l
RBZN-1	6/21/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	142		ug/l
RBZN-1	7/12/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	44.5		ug/l
RBZN-1	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.401		mg/l
RBZN-1	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	13		mg/l
RBZN-1	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	8		mg/l
RBZN-1	7/12/2000	Water	DEPTH, SECCHI DISK DEPTH in	22		in
RBZN-1	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.045		mg/l
RBZN-1	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	10		mg/l
RBZN-1	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	7		mg/l
RBZN-1	7/12/2000	Water	DEPTH, SECCHI DISK DEPTH in	22		in

Station Code	Collection Date	Medium	Parameter Name	Result	Qualifier	Units
RBZN-1	7/12/2000	Water	PHOSPHORUS AS P,Total mg/l	0.041		mg/l
RBZN-1	7/12/2000	Water	SOLIDS, FIXED,Total mg/l	10		mg/l
RBZN-1	7/12/2000	Water	SOLIDS, FIXED,Volatile mg/l	7		mg/l
RBZN-1	8/28/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	91		ug/l
RBZN-1	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.356		mg/l
RBZN-1	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	16		mg/l
RBZN-1	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	8		mg/l
RBZN-1	8/28/2000	Water	DEPTH, SECCHI DISK DEPTH in	22		in
RBZN-1	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.079		mg/l
RBZN-1	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	14		mg/l
RBZN-1	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	11		mg/l
RBZN-1	8/28/2000	Water	DEPTH, SECCHI DISK DEPTH in	22		in
RBZN-1	8/28/2000	Water	PHOSPHORUS AS P,Total mg/l	0.09		mg/l
RBZN-1	8/28/2000	Water	SOLIDS, FIXED,Total mg/l	10		mg/l
RBZN-1	8/28/2000	Water	SOLIDS, FIXED,Volatile mg/l	5		mg/l
RBZN-1	8/28/2000	Sediment	PHOSPHORUS AS P	1010		mg/kg
RBZN-1	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.075		mg/l
RBZN-1	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	6		mg/l
RBZN-1	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	4		mg/l
RBZN-1	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.098		mg/l
RBZN-1	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	13		mg/l
RBZN-1	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	10		mg/l
RBZN-1	10/19/2000	Water	DEPTH, SECCHI DISK DEPTH in	24		in
RBZN-1	10/19/2000	Water	PHOSPHORUS AS P,Total mg/l	0.107		mg/l
RBZN-1	10/19/2000	Water	SOLIDS, FIXED,Total mg/l	4		mg/l
RBZN-1	10/19/2000	Water	SOLIDS, FIXED,Volatile mg/l	3		mg/l
RBZN-1	10/19/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	114		ug/l

Appendix D. Candidate Watershed Methodologies and Modeling Frameworks

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Candidate watershed methodologies and modeling frameworks are described below.

Empirical Approaches:

Empirical approaches estimate pollutant loading rates based upon site-specific measurements, without the use of a model to describe specific cause-effect relationships. Time series information is required for both stream flow and pollutant concentration.

One advantage of empirical approaches is that direct measurement of pollutant loading will generally be far more accurate than any model-based estimate. The approach, however, has several disadvantages. The empirical approach provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. To address this limitation, statistical methods (e.g., Preston et al., 1989) can be used to integrate discrete measurements of suspended solids concentrations with continuous flow records to provide estimates of solids loads over a range of conditions.

The primary limitation of empirical techniques is their inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries serving single land uses, but most tributary monitoring stations reflect multiple land uses. As a complement to empirical estimates of watershed loads, the EUTROMOD and BATHTUB water quality models described below contain routines that apply the empirical approach to estimate watershed loads.

Simple Method/Unit Area Loads/Export Coefficients:

The Simple Method, also known as unit area loads or export coefficients, is routinely used to develop estimates of pollutant loads in a watershed. A unit area load or export coefficient is a value expressing pollutant generation per unit area and unit time for a specific land use (Novotny and Olem, 1994).

The use of unit area loading or export coefficients has been used extensively in estimating loading contributions from different land uses (Beaulac 1980, Reckhow et al. 1980, Reckhow and Simpson 1980, Uttormark et al. 1974). The concept is straightforward: different land use areas contribute different loads to receiving waters. By summing the amount of pollutant exported per unit area of land use in the watershed, the total pollutant load to the receiving system can be calculated.

These export coefficients are usually based on average annual loads. The approach provides estimates of current or existing loading, as well as reductions in pollutant export for each land use required to achieve a target TMDL or LRS pollutant load. The accuracy of the estimates is dependent on good land use data, and appropriate pollutant export coefficients for the region. EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables. This watershed component of this tool can estimate phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The FLUX module of the BATHTUB software program estimates watershed nutrient loads or fluxes to a lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified.

Universal Soil Loss Equation:

The Universal Soil Loss Equation (USLE), and variations of the USLE, are the most widely used methods for predicting soil loss. When applied properly, the USLE can be used as a means to estimate loads of sediment and sediment-associated pollutants for TMDLs or LRSs. The USLE is empirical, meaning that it was developed from statistical regression analyses of a large database of runoff and soil loss data from numerous watersheds. It does not describe specific erosion processes. The USLE was designed to predict long-term average annual soil erosion for combinations of crop systems and management practices with specified soil types, rainfall patterns, and topography.

Required model inputs to the USLE consist of:

- Rainfall erosivity index factor
- Soil-erodibility factor
- Slope length factor reflecting local topography
- Cropping-management factor
- Conservation practice factor

Most of the required inputs for application of the USLE are tabulated by county Natural Resources Conservation Service (NRCS) offices.

There are also variants to the USLE: the Revised USLE (RUSLE) and the Modified USLE (MUSLE). The RUSLE is a computerized update of the USLE incorporating new data and making some improvements. The basic USLE equation is retained, but the technology for evaluating the factor values has been altered and new data introduced to evaluate the terms for specific conditions. The MUSLE is a modification of USLE, with the rainfall energy factor of the USLE replaced with a runoff energy factor. MUSLE allows for estimation of soil erosion on an event-specific basis.

While the USLE was originally designed to consider soil/sediment loading only, it is also commonly used to define loads from pollutants that are tightly bound to soils. In these situations, the USLE is used to define the sediment load, with the result multiplied by a pollutant concentration factor (mass of pollutant per mass of soil) to define pollutant load.

The USLE is among the simplest of the available models for estimating sediment and sediment-associated loads. It requires the least amount of input data for its application and consequently does not ensure a high level of accuracy. It is well suited for screening-level calculations, but is less suited for detailed applications. This is because it is an empirical model that does not explicitly represent site-specific physical processes. Furthermore, the annual average time scale of the USLE is poorly suited for model calibration purposes, as field data are rarely available to define erosion on an annual average basis. In addition, the USLE considers erosion only, and does not explicitly consider the amount of sediment that is delivered to stream locations of interest. It is best used in situations where data are available to define annual loading rates, which allows for site-specific determination of the fraction of eroded sediment that is delivered to the surface water.

<u>Generalized Watershed Loading Functions Model (AVGWLF)/MapShed:</u>

The Generalized Watershed Loading Functions Model (AVGWLF) simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Sediment loadings are provided on a monthly basis. AVGWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the USLE (with monthly rainfall-runoff coefficients). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible.

GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads. It lacks the ability to calculate the sediment delivery ratio; however, a delivery ratio can be specified by the user. Because the model performs on a continuous simulation basis, it is more amenable to site-specific calibration than USLE. It is noted that Penn State University, developers of AVGWLF, is discontinuing support of the AVGWLF model in support of the MapShed model. MapShed essentially duplicates the functionality of AVGWLF model, but used non-commercial GIS software.

Long Term Hydrologic Impact Analysis (L-THIA):

L-THIA is a web-based screening level model to evaluate the changes in runoff, recharge, nutrients and sediment loads due to proposed land use changes. L-THIA gives long-term average annual runoff for a land use configuration, based on actual long-term climate data (30 yrs of daily precipitation data) for that area. By using many years of climate data in the analysis, L-THIA focuses on the average impact, rather than an extreme year or storm.

Data input requirements for L-THIA are minimal and include long-term precipitation, area of actual and the proposed land use changes and hydrologic soil groups of land use changes. The user can choose basic or detailed input options depending on the choices of land use that need to be evaluated. An ArcView 3.x GIS version of L-THIA is available which allows the user to prepare input, conduct simulations and process results within the GIS environment. This advanced version of L-THIA can be applied with minimum level of GIS skills.

L-THIA employs the curve number (CN) approach to estimate runoff. Antecedent moisture content (AMC) in the soil is estimated by precipitation data and CN is adjusted in accordance with the changes in AMC. Nonpoint source pollution masses are estimated based on Event Mean Concentration (EMC) data and estimated runoff. Built in EMC values can be replaced with site specific values. L-THIA will generate estimated runoff volumes and depths, and expected nonpoint source pollution loadings to water bodies. Results can be displayed in tables, bar charts, and pie charts. As a quick and easy-to-use approach, L-THIA's results can be used to generate community awareness of potential long-term problems and to support planning aimed at minimizing disturbance of critical areas. L-THIA is an ideal tool to assist in the evaluation of potential effects of land use change and to identify the best location of a particular land use so as to have minimum impact on a community's natural environment.

Spreadsheet Tool for Estimating Pollutant Load (STEPL):

Spreadsheet Tool for Estimating Pollutant Load (STEPL), developed for EPA Office of Water by Tetra-Tech, Inc., employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices.

For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

Annualized Agricultural Nonpoint Source Pollution Model (AnnAGNPS)

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a joint USDA-Agricultural Research Service and -Natural Resources Conservation Service system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. AnnAGNPS is one component (or module) of AGNPS and is a watershed-scale, continuous simulation model that operates on a daily time step and is designed to predict the impact of management on water, sediment, nutrients, and pesticides in agricultural watersheds. The sheet and rill erosion model internal to AnnAGNPS is based upon RUSLE, with additional routines added to allow for continuous simulation and more detailed consideration of sediment delivery.

AnnAGNPS was originally developed for use in agricultural watersheds, but has been adapted to allow consideration of construction sources. AnnAGNPS provides more spatial detail than GWLF and is therefore more rigorous in calculating the delivery of eroded sediment to the receiving water. This additional computational ability carries with it the cost of requiring more detailed information describing the topography of the watershed, as well as requiring more time to set up and apply the model.

Hydrologic Simulation Program – FORTRAN (HSPF):

The Hydrologic Simulation Program – FORTRAN (HSPF) uses continuous rainfall and other meteorological records to compute stream flow hydrographs and pollutographs. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). Although BASINS was designed as a multipurpose analysis tool to promote the integration of point and nonpoint sources in watershed and water quality-based applications, it also includes a suite of water quality models. One such model is Nonpoint Source Model (NPSM). NPSM is a simplified version of HSPF that is linked with a graphical user interface within the GIS environment of BASINS. LSPC is another variant of the HSPF model, consisting of the equations used by HSPF recoded into the C++ programming language.

HSPF provides a more detailed description of urban areas than AnnAGNPS and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. The BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

Storm Water Management Model (SWMM):

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. SWMM is designed to be able to describe both single events and continuous simulation over longer periods of time. SWMM is commonly used to simulate urban hydraulics, although its sediment transport capabilities are not as robust as some of the other models described here.

Soil & Water Assessment Tool (SWAT):

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of EPA's BASINS software. SWAT is a continuous time model (i.e., a long-term yield model). The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas and can be used in mixed-use watersheds.

Appendix E. Candidate Water Quality Methodologies and Modeling Frameworks

Candidate water quality methodologies and modeling frameworks are described below.

Spreadsheet Approaches:

A wide range of simple methods are available to describe the relationship between pollutant loads and receiving water quality, for a variety of situations including rivers and lakes. These methods are documented in Mills et al. (1985). These approaches do not require specific computer software, and are designed to be implemented on a hand calculator or computer spreadsheet. These approaches have the benefit of relatively low data requirements, as well as being easy to apply. Because of their simplistic nature, these approaches are best considered as screening procedures incapable of producing highly accurate results. They do provide good initial estimates of the primary cause-effect relationships.

The load duration curve approach is foremost among the spreadsheet approaches. The load duration curve approach uses stream flows and observed concentrations for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results in what is called a flow duration curve; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature.

EUTROMOD:

EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, distributed by the North American Lake Management Society (Reckhow 1990). The modeling system first estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The model accounts for both point and nonpoint source loads. Statistical algorithms are based on regression analyses performed on cross-sectional lake data. These algorithms predict in-lake phosphorus, nitrogen, hypolimnetic dissolved oxygen, chlorophyll, and trihalomethane precursor concentrations, and transparency (Secchi depth). The model also estimates the likelihood of blue-green bacteria dominance in the lake. Lake morphometry and hydrologic characteristics are incorporated in these algorithms. EUTROMOD also has algorithms for estimating uncertainty associated with the trophic state variables and hydrologic variability and estimating the confidence interval about the most likely values for the various trophic state indicators.

BATHTUB:

BATHTUB is a software program for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker 1986). It was developed and is distributed by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constituent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, chlorophyll concentrations, and Secchi depth (transparency). Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and in-lake data. Both tabular and graphical displays are available from the program.

QUAL2E/QUAL2K:

QUAL2K is a one-dimensional water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. One of the QUAL2K developers is a LimnoTech team member and therefore our team is qualified to customize QUAL2K for application to Illinois impaired water bodies. The predecessor to QUAL2K, called QUAL2E, is also available and has been successfully applied in the development of many Illinois TMDLs, but is no longer officially supported by EPA.

The primary advantages of using QUAL2K (and QUAL2E) include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

WASP7:

WASP7 is EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP7 has also been successfully linked with other one, two, and three dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP7 can also accept user-specified advective and dispersive flows. WASP7 provides separate submodels for conventional and toxic pollutants. The EUTRO7 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI7 submodel simulates the transformation of up to three different chemicals and three different solids classes.

The primary advantage of using WASP7 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it contains limited hydrodynamic capabilities and must often obtain hydrodynamic results from other models.

CE-QUAL-RIV1:

CE-QUAL-RIV1 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. Water quality state variables consist of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included as external forcing functions specified by the user.

The primary advantage of CE-QUAL-RIV1 is its direct link to an efficient hydrodynamic model. This makes it especially suitable to describe river systems affected by dams or experiencing extremely rapid changes in flow. Its primary disadvantage is that it simulates conventional pollutants only, and contains limited eutrophication kinetics. In addition, the effort and data required to support the CE-QUAL-RIV1 hydrodynamic routines may not be necessary in naturally flowing rivers.

HSPF:

HSPF (Hydrological Simulation Program - FORTRAN) is a one-dimensional modeling system for simulation of watershed hydrology, point and nonpoint source loadings, and receiving water quality for both conventional pollutants and toxicants (Bicknell et al. 1993). It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The water quality component of HSPF allows dynamic simulation of both conventional pollutants (i.e., dissolved oxygen, nutrients, and phytoplankton) and toxics. The toxics routines combine organic chemical process kinetics with sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the upper sediment bed and overlying water column. HSPF is also linked into EPA's BASINS modeling system.

The primary advantage of HSPF is that it exists as part of a linked watershed/receiving water modeling package. Nonpoint source loading and hydrodynamic results are automatically linked to the HSPF water quality submodel, such that no external linkages need be developed.

CE-QUAL-W2:

CE-QUAL-W2 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. CE-QUAL-W2 simulates variations in water quality in the longitudinal and lateral directions, and was developed to address water quality issues in long, narrow reservoirs. Water quality state variables consist of temperature, algae, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, and dissolved iron.

The primary advantage of CE-QUAL-W2 is the ability to simulate the onset and breakdown of vertical temperature stratification and resulting water quality impacts. It will be the most appropriate model for those cases where these vertical variations are an important water quality consideration. In unstratified systems, the effort and data required to support the CE-QUAL-W2 hydrodynamic routines may not be necessary.

EFDC:

EFDC (Environmental Fluid Dynamics Code) is a three-dimensional hydrodynamic and water quality model supported by the U. S. EPA Ecosystems Research Division. EFDC simulates variations in water quality in the longitudinal, lateral and vertical directions, and was developed to address water quality issues in rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. EFDC transports salinity, heat, cohesive or noncohesive sediments, and toxic contaminants that can be described by equilibrium partitioning between the aqueous and solid phases. Unique features of EFDC are its ability to simulate wetting and drying cycles, and that it includes a near field mixing zone model that is fully coupled with a far-field transport of salinity, temperature, sediment, contaminant, and eutrophication variables. It also contains hydraulic structure representation, vegetative resistance, and Lagrangian particle tracking. EFDC accepts radiation stress fields from wave refraction-diffraction models, thus allowing the simulation of longshore currents and sediment transport.

The primary advantage of EFDC is the ability to combine three-dimensional hydrodynamic simulation with a wide range of water quality modeling capabilities in a single model. The primary disadvantages are that data needs and computational requirements can be extremely high.

Appendix F.
Public Meeting Notice

NOTICE OF PUBLIC MEETING

Bonpas Creek Watershed
(Edwards, Lawrence, Richland and Wabash Counties)

The Illinois Environmental Protection Agency (IEPA) Bureau of Water will hold a public meeting on

Thursday, May 1, 2014 (8:00 am)

at the

Edwards County Fairgrounds Exhibition Building
(Across from Edwards County SWCD)
90 West Pine Street
Albion, Illinois

The purpose of this meeting is to provide an opportunity for the public to receive information and comment on the draft Total Maximum Daily Load (TMDL) concerning impairments to 4 water body segments within the Bonpas Creek Watershed. The segments and potential causes of impairment are: two segments of Bonpas Creek (Atrazine, Manganese, Dissolved Oxygen, Sedimentation/Siltation, Fecal Coliform), West Salem New Reservoir (Total Phosphorus), West Salem Old Reservoir (Total Phosphorus).

This report includes watershed characterization, data analysis and selection of potential models that will be used to determine the pollutant loading capacity and reductions necessary to meet designated uses and water quality standards.

The IEPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act. A TMDL is the sum of the allowable amounts of a single pollutant (phosphorus, metals, etc.) that a waterbody can receive from all contributing sources and still meet water quality standards or designated uses.

Stakeholders and participants will also be asked for input and ideas to be applied to the draft Stage 1 report. An additional public meeting will be held in the future to discuss the next stage of the TMDL.

The draft stage one report for the Bonpas Creek Watershed will be available on-line at www.epa.state.il.us/public-notices. A hard copy of the draft report will be available for viewing at the Edwards County SWCD office, West Salem Village Hall during business hours. Questions about the TMDL should be directed to the project manager, Margaret Fertaly by phone at 618-993-7200 or email Margaret.Fertaly@illinois.gov or contact Abel Haile (see contact information below).

Closure of the Meeting Record

The meeting record will close as of midnight, June 2, 2014. Written comments need not be notarized but must be postmarked before midnight and mailed to:

Abel Haile, Manager, Planning (TMDL) Unit
Watershed Management Section, Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276
Phone 217-782-3362

TDD (Hearing impaired) 217-782-9143
E-mail: Abel.Haile@illinois.gov
Fax: 217-785-1225

Attachment 2. 2015 IEPA Stage 2 Monitoring Data

2015 Bonpas Creek Data

ORDER	AMPLER_NAM	Lab Sample #	ab Chlorophyll	STATION_CODE	SampleDate	SampleTime	Temp_Air_C	Temp_Water_C	IC_CONDUCTAN	VED_OXYGEN	DOSAT	PH	Calibration	HYDROLAB_NO
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54993222	MLF	SJ50262	SJ50295	BC-02	06-Oct-15	9:30	20	16.8	335	3	29	7.7	757	A35223
54993223	MLF	NA	NA	BC-02	06-Oct-15	13:30	27	18.8	340	3.9	40	7.7	757	A35223
54993226	MLF	SJ50264	SJ50294	BC-04	06-Oct-15	10:45	20	18.3	321	4.6	48	7.8	757	A35223
54993227	MLF	NA	NA	BC-04	06-Oct-15	12:30	25	19.6	323	5.2	56	7.8	757	A35223
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54993175	MLF	NA	NA	BC-04	22-Sep-15	13:00	26	18.6	509	5.9	60	7.6	759	A35223
54993174	MLF	SI51151	NA	BC-04	22-Sep-15	11:00	23	16.4	501	3.7	37	7.7	759	A35223
54993173	MLF	NA	NA	BC-05	22-Sep-15	13:30	27	18.6	389	5.2	53	7.6	759	A35223
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54993131	MLF	NA	NA	BC-04	26-Aug-15	12:50	25	20.9	437	7	80	8.1	757	A35223
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ORDER	UMBER_EV	Bridge_Side	WEATHER	COMMENTS	TRUEPHYLL	PESTICIDE	MPLER_US	HPYLL VOL	TRIPID	SIT_NUMB	ROUND	OFFICE	BACTERIA	l Dilution 1	l Dilution 2	l Dilution 3	Count (#/1
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54993174	COF	USSB	Sunny		FALSE	FALSE	HHB	-99	Field Data			Marion	FALSE				-99
54993173			Sunny	No water sample taken; hydrolab readings only.	FALSE	FALSE		-99	Field Data			Marion	FALSE				-99
54993172	COF	USSB	Sunny		FALSE	FALSE	WBS	-99	Field Data			Marion	FALSE				-99
54993124	COF	USSB	Mostly Cloudy	water is stagnant	TRUE	FALSE	HHB	500	Field Data		1	Marion	FALSE				-99
54993125		USSB	Mostly Cloudy		FALSE	FALSE		-99	Field Data		1	Marion	FALSE				-99
54993127		USSB	Mostly Cloudy		FALSE	FALSE		-99	Field Data		1	Marion	FALSE				-99
54993126	COF	USSB	Mostly Cloudy		TRUE	FALSE	WBS	710	Field Data		1	Marion	FALSE				-99
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ORDER	l Remark C	l Flow Velo	ed Dischar	Stage	Program	EnterDate	nsiveCondi	eneral lab I	general pdf	FCB lab ID	FCB pdf	rophyll lab	lorophyll p	ther lab ID	other pdf	diment lab	ediment p	ampleDept	mpleDepth
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54993126		0.1	-99	Normal	TMDL	03-Sep-15	None		FALSE		FALSE		FALSE		FALSE		FALSE	-99	0
54993131		0.1	-99	Normal	TMDL	03-Sep-15	None		FALSE		FALSE		FALSE		FALSE		FALSE	-99	0
54993130		0.1	-99	Normal	TMDL	03-Sep-15	None		FALSE		FALSE		FALSE		FALSE		FALSE	-99	0
54993128		0	-99	Normal	TMDL	03-Sep-15	None		FALSE		FALSE		FALSE		FALSE		FALSE	-99	0
54993129		0	-99	Normal	TMDL	03-Sep-15	None		FALSE		FALSE		FALSE		FALSE		FALSE	-99	0

IEPA SourceFile	MonitoringProgram	Station	CollectionDate	Parameter	Result	ReportingLimit	Units	SampleMedium	Notes	Method BOD only
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	CBOD, 5 day	ND	2	mg/L	Water	Low flow, preliminary data	Carbonaceous BOD, 5 day, by Standard Method 5210B
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.23	0.1	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Ammonia as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Nitrogen, Kjeldahl	0.38	0.5	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Phosphorus as P (total)	0.053	0.005	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Total Suspended Solids	31	4	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Volatile Suspended Solids	8	4	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Phosphorus as P (dissolved)	0.011	0.005	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Chlorophyll-A (corr)	9.08	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Chlorophyll-A (unco)	9.78	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Chlorophyll-C	0.51	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	26-Aug-15	Pheophytin-A	0.64	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	BOD 5DAY	2.7	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.52	0.1	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Ammonia as N	0.09	0.1	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Nitrogen, Kjeldahl	0.84	0.5	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Phosphorus as P (total)	0.209	0.005	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Total Suspended Solids	297	4	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Volatile Suspended Solids	25	4	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	22-Sep-15	Phosphorus as P (dissolved)	0.014	0.005	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	BOD 5DAY	3.8	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.33	0.1	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Ammonia as N	0.12	0.1	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Nitrogen, Kjeldahl	1.01	0.5	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Phosphorus as P (total)	0.282	0.005	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Total Suspended Solids	527	4	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Volatile Suspended Solids	35	4	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Phosphorus as P (dissolved)	0.012	0.005	mg/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Chlorophyll-A (corr)	4.81	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Chlorophyll-A (unco)	7.57	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Chlorophyll-C	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-01_2015_prelim data.xlsx	Special Study	BC-01	6-Oct-15	Pheophytin-A	4.17	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	CBOD, 5 day	ND	2	mg/L	Water	Low flow, preliminary data	Carbonaceous BOD, 5 day, by Standard Method 5210B
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.101	0.1	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Ammonia as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Nitrogen, Kjeldahl	0.56	0.5	mg/L	Water	Low flow, preliminary data	

IEPA SourceFile	MonitoringProgram	Station	CollectionDate	Parameter	Result	ReportingLimit	Units	SampleMedium	Notes	Method BOD only
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Phosphorus as P (total)	0.104	0.005	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Total Suspended Solids	12	4	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Volatile Suspended Solids	6	4	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Phosphorus as P (dissolved)	0.062	0.005	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Chlorophyll-A (corr)	1.13	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Chlorophyll-A (unco)	1.29	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Chlorophyll-C	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	26-Aug-15	Pheophytin-A	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	BOD 5DAY	ND	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.062	0.1	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Ammonia as N	0.03	0.1	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Nitrogen, Kjeldahl	1	0.5	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Phosphorus as P (total)	0.115	0.005	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Total Suspended Solids	10	4	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Volatile Suspended Solids	4	4	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	22-Sep-15	Phosphorus as P (dissolved)	0.061	0.005	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	BOD 5DAY	2	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.407	0.1	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Ammonia as N	0.11	0.1	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Nitrogen, Kjeldahl	1	0.5	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Phosphorus as P (total)	0.135	0.005	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Total Suspended Solids	10	4	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Volatile Suspended Solids	4	4	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Phosphorus as P (dissolved)	0.081	0.005	mg/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Chlorophyll-A (corr)	0.53	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Chlorophyll-A (unco)	1.03	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Chlorophyll-C	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-02_2015_prelim data.xlsx	Special Study	BC-02	6-Oct-15	Pheophytin-A	0.77	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	CBOD, 5 day	ND	2	mg/L	Water	Low flow, preliminary data	Carbonaceous BOD, 5 day, by Standard Method 5210B
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.146	0.1	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Ammonia as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Nitrogen, Kjeldahl	0.48	0.5	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Phosphorus as P (total)	0.062	0.005	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Total Suspended Solids	13	4	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Volatile Suspended Solids	7	4	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Phosphorus as P (dissolved)	0.023	0.005	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Chlorophyll-A (corr)	10.4	0.5	ug/L	Water	Low flow, preliminary data	

IEPA SourceFile	MonitoringProgram	Station	CollectionDate	Parameter	Result	ReportingLimit	Units	SampleMedium	Notes	Method BOD only
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Chlorophyll-A (unco)	10.7	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Chlorophyll-B	0.61	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Chlorophyll-C	0.71	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	26-Aug-15	Pheophytin-A	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	BOD 5DAY	ND	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Ammonia as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Nitrogen, Kjeldahl	0.71	0.5	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Phosphorus as P (total)	0.08	0.005	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Total Suspended Solids	30	4	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Volatile Suspended Solids	8	4	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	22-Sep-15	Phosphorus as P (dissolved)	0.015	0.005	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	BOD 5DAY	3.1	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.194	0.1	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Ammonia as N	0.18	0.1	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Nitrogen, Kjeldahl	1.32	0.5	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Phosphorus as P (total)	0.184	0.005	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Total Suspended Solids	23	4	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Volatile Suspended Solids	6	4	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Phosphorus as P (dissolved)	0.069	0.005	mg/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Chlorophyll-A (corr)	5.87	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Chlorophyll-A (unco)	6.59	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Chlorophyll-C	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-05_2015_prelim data.xlsx	Special Study	BC-05	6-Oct-15	Pheophytin-A	0.85	0.5	ug/L	Water	Low flow, preliminary data	

IEPA measured flows can be found in "2015 Field flow measurements" worksheet

IEPASourceFile	MonitoringProgram	Station	CollectionDate	Parameter	Result	ReportingLimit	Units	SampleMedium	Notes	Method
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Total Suspended Solids	5	4	mg/l	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Total Suspended Solids	20	4	mg/l	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Total Suspended Solids	6	4	mg/l	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	CBOD, 5 day	ND	2	mg/L	Water	Low flow, preliminary data	Carbonaceous BOD, 5 day, by Standard Method 5210B
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Ammonia as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Nitrogen, Kjeldahl	0.44	0.5	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Phosphorus as P (total)	0.047	0.005	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Volatile Suspended Solids	6	4	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Phosphorus as P (dissolved)	0.03	0.005	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Chlorophyll-A (corr)	2.67	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Chlorophyll-A (unco)	2.97	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Chlorophyll-C	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	26-Aug-15	Pheophytin-A	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	BOD 5DAY	2	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.032	0.1	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Ammonia as N	ND	0.1	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Nitrogen, Kjeldahl	0.81	0.5	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Phosphorus as P (total)	0.085	0.005	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Volatile Suspended Solids	5	4	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	22-Sep-15	Phosphorus as P (dissolved)	0.04	0.005	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	BOD 5DAY	2.2	2	mg/L	Water	Low flow, preliminary data	Biochemical Oxygen Demand, 5 day, by Standard Method 5210B
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.154	0.1	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Ammonia as N	0.03	0.1	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Nitrogen, Kjeldahl	0.87	0.5	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Phosphorus as P (total)	0.16	0.005	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Volatile Suspended Solids	4	4	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Phosphorus as P (dissolved)	0.121	0.005	mg/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Chlorophyll-A (corr)	1.87	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Chlorophyll-A (unco)	1.94	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Chlorophyll-B	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Chlorophyll-C	ND	0.5	ug/L	Water	Low flow, preliminary data	
BC-04_2015_prelim data.xlsx	Special Study	BC-04	6-Oct-15	Pheophytin-A	ND	0.5	ug/L	Water	Low flow, preliminary data	

IEPA Bonpas Creek stream measurements - 2015

Station	Description	Sample Date	Sample Time	Water width	Ave. depth (ft)	Flow (ft/sec)	Estimated discharge (cfs)	Channel Ht. (ft)	Channel width (ft)	Photos	Sample Location	Comments
BC-01	Route 1 north of Grayville	8/26/2015	8:45	18	0.7	0	0	17	45	#1 lkg. DS, #2 lkg. US	measured 35' us of bridge	
BC-02	Route 15 east of Browns	8/26/2015	9:25	18	0.5	0.2	1.8	11	60	# 3 lkg. DS, #4 lkg. US	measured 85' us of bridge	
BC-05	Edwards Co. 1750N southeast of West Salem	8/26/2015	10:10	30	1.2	0.01*	0.36	11	60	#5 lkg. DS, #6 lkg. US	measured ~ 285' us of bridge	
BC-04	Wabash Co. 2320N northeast of West Salem	8/26/2015	11:05	1.3	0.1	1	0.13	9	45	#7 lkg. DS, #8 lkg. US	discharge estimated under bridge; channel measured 70' ds of bridge	
BC-01	Route 1 north of Grayville	9/22/2015	8:45	23	0.7	0	0	15	43	us lkg. DS, ds lkg. US	85' us of bridge	stagnant
BC-02	Route 15 east of Browns	9/22/2015	9:30	20	0.4	0.1	0.8	11	57	us lkg. DS, ds lkg. US	55' us of bridge	
BC-05	Edwards Co. 1750N southeast of West Salem	9/22/2015	10:15	31	2.8	0	0	13	55	us lkg. DS, ds lkg. US	105' us of bridge	
BC-04	Wabash Co. 2320N northeast of West Salem	9/22/2015	11:00	16	1.4	0.1	2.24	9	38	ds lkg. US, us lkg. DS	110' us of bridge	
BC-01	Route 1 north of Grayville	10/6/2015	8:45	23	0.5	0	0	15	43	ds lkg. US, us lkg. DS	85' us of bridge	
BC-02	Route 15 east of Browns	10/6/2015	9:30	23	0.8	0.1	1.84	11	55	ds lkg. US, us lkg. DS	50' us of bridge	
BC-05	Edwards Co. 1750N southeast of West Salem	10/6/2015	10:00	31	1.9	0	0	13	53	us lkg. DS, ds lkg. US	100' us of bridge	
BC-04	Wabash Co. 2320N northeast of West Salem	10/6/2015	10:45	16	0.8	0	0	9	35	us lkg. DS, ds lkg. US	100' us of bridge	

Notes from IEPA:

- Flow is an estimate/measurement of the surface flow of a stream at a given point, simply representing the average velocity (across the stream width) of the water at that location.
- Estimated discharge is an estimate/measurement of the overall volume of water moving through a given point in the stream. This incorporates not only the flow rate, but also the depth and width of the stream at the given location.

Attachment 3:

QUAL2E Model Files

Calibration input

Calibration output

♀ * * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *
Version 3.22 -- May 1996

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-2E PROGRAM TITLES
TITLE01		Bonpas Creek DO TMDL ILEPA13A
TITLE02		Setup run for 8/26/15, highest low-flow run
TITLE03	NO	CONSERVATIVE MINERAL I
TITLE04	NO	CONSERVATIVE MINERAL II
TITLE05	NO	CONSERVATIVE MINERAL III
TITLE06	YES	TEMPERATURE
TITLE07	YES	5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08	YES	ALGAE AS CHL-A IN UG/L
TITLE09	YES	PHOSPHORUS CYCLE AS P IN MG/L
TITLE10		(ORGANIC-P; DISSOLVED-P)
TITLE11	YES	NITROGEN CYCLE AS N IN MG/L
TITLE12		(ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	FECAL COLIFORM IN NO./100 ML
TITLE15	NO	ARBITRARY NON-CONSERVATIVE
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	0.00000		0.00000
NOWRITE OPTIONAL SUMMARY	0.00000		0.00000
NO FLOW AUGMENTATION	0.00000		0.00000
STEADY STATE	0.00000		0.00000
NO TRAPEZOIDAL CHANNELS	0.00000		0.00000
NO PRINT LCD/SOLAR DATA	0.00000		0.00000
NO PLOT DO AND BOD	0.00000		0.00000
FIXED DNSTM CONC (YES=1)=	0.00000	D-ULT BOD CONV K COEF =	0.23000
INPUT METRIC =	0.00000	UTPUT METRIC =	0.00000
NUMBER OF REACHES =	5.00000	UMBER OF JUNCTIONS =	

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0.00000
         NUM OF HEADWATERS       =   1.00000          UMBER OF POINT LOADS   =
6.00000
         TIME STEP (HOURS)       =   1.00000          NTH. COMP. ELEMENT (MI)=
0.50000
         MAXIMUM ROUTE TIME (HRS)=  60.00000          IME INC. FOR RPT2 (HRS)=
1.00000
         LATITUDE OF BASIN (DEG) =  38.38000          ONGITUDE OF BASIN (DEG)=
-87.97000
         STANDARD MERIDIAN (DEG) =   0.00000          AY OF YEAR START TIME  =
238.00000
         EVAP. COEF.,(AE)        =   0.00068          VAP. COEF.,(BE)        =
0.00027
         ELEV. OF BASIN (ELEV)   = 373.00000          UST ATTENUATION COEF.  =
0.06000
         ENDATA1                     0.00000
0.00000

          $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

         CARD TYPE                                                  CARD TYPE
         O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300                 O UPTAKE BY NO2 OXID(MG
O/MG N)=    1.1400
         O PROD  BY ALGAE (MG O/MG A)   =    1.8000                 O UPTAKE BY ALGAE (MG
O/MG A)  =    1.9000
         N CONTENT OF ALGAE (MG N/MG A) =    0.0900                 P CONTENT OF ALGAE (MG
P/MG A) =    0.0140
         ALG MAX SPEC GROWTH RATE(1/DAY)=    2.0000                 ALGAE RESPIRATION RATE
(1/DAY)=     0.1050
         N HALF SATURATION CONST (MG/L) =    0.0300                 P HALF SATURATION CONST
 (MG/L)=    0.0050
         LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0030                 NLIN
SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
         LIGHT FUNCTION OPTION (LFNOPT) =    2.0000                 LIGHT SAT'N COEF
(BTU/FT2-MIN) =    0.6600
         DAILY AVERAGING OPTION (LAVOPT)=    3.0000                 LIGHT AVERAGING FACTOR
(INT)  =    0.9000
         NUMBER OF DAYLIGHT HOURS (DLH) =   13.3000                 TOTAL DAILY SOLR RAD
(BTU/FT-2)= 1500.0000
         ALGY GROWTH CALC OPTION(LGROPT)=    2.0000                 ALGAL PREF FOR NH3-N
(PREFN)   =    0.1000
         ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500                 NITRIFICATION
INHIBITION COEF  =    0.6000
         ENDATA1A                            0.0000
            0.0000

          $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS)
$$$

         CARD TYPE     RATE CODE     THETA VALUE

         THETA( 1)      BOD DECA        1.047     DFLT
         THETA( 2)      BOD SETT        1.024     DFLT
         THETA( 3)      OXY TRAN        1.024     DFLT
         THETA( 4)      SOD RATE        1.000     USER
         THETA( 5)      ORGN DEC        1.047     DFLT
         THETA( 6)      ORGN SET        1.024     DFLT
         THETA( 7)      NH3 DECA        1.083     DFLT
         THETA( 8)      NH3 SRCE        1.074     DFLT
         THETA( 9)      NO2 DECA        1.047     DFLT
         THETA(10)      PORG DEC        1.047     DFLT
         THETA(11)      PORG SET        1.024     DFLT
         THETA(12)      DISP SRC        1.074     DFLT
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         THETA(13)      ALG GROW        1.047     DFLT
         THETA(14)      ALG RESP        1.047     DFLT
         THETA(15)      ALG SETT        1.024     DFLT
         THETA(16)      COLI DEC        1.047     DFLT
         THETA(17)      ANC DECA        1.000     DFLT
         THETA(18)      ANC SETT        1.024     DFLT
         THETA(19)      ANC SRCE        1.000     DFLT
         ENDATA1B

          $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

         CARD TYPE           REACH ORDER AND IDENT              R. MI/KM
R. MI/KM
         STREAM REACH     1.0   RCH= Hdwtr, RM 38-4     FR         47.5    TO
  38.0
         STREAM REACH     2.0   RCH= RM 38.0 to 28.     FR         38.0    TO
  28.0
         STREAM REACH     3.0   RCH= RM 28.0 to 18.     FR         28.0    TO
  18.0
         STREAM REACH     4.0   RCH= RM 18.0 to 8.0     FR         28.0    TO
   8.0
         STREAM REACH     5.0   RCH= RM 8.0 to 0.0      FR          8.0    TO
   0.0
         ENDATA2          0.0                                       0.0
   0.0

          $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

         CARD TYPE                  REACH  AVAIL HDWS TARGET     ORDER OF AVAIL
SOURCES
         ENDATA3                     0.         0.       0.0   0.   0.   0.   0.   0.
  0.

          $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

         CARD TYPE        REACH ELEMENTS/REACH             COMPUTATIONAL FLAGS
         FLAG FIELD        1.       19.
1.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.0.
         FLAG FIELD        2.       20.
2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
         FLAG FIELD        3.       20.
2.2.2.2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.
         FLAG FIELD        4.       20.
2.6.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.6.2.
         FLAG FIELD        5.       16.
6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.
         ENDATA4           0.        0.
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

          $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

         CARD TYPE        REACH  COEF-DSPN  COEFQV    EXPOQV    COEFQH   EXPOQH
CMANN
         HYDRAULICS        1.    100.00     0.170     0.000     0.670     0.000
0.020
         HYDRAULICS        2.    100.00     0.170     0.000     0.670     0.000
0.020
         HYDRAULICS        3.    100.00     0.170     0.000     0.600     0.000
0.020
         HYDRAULICS        4.    100.00     0.170     0.000     0.630     0.000
0.020
         HYDRAULICS        5.    100.00     0.170     0.000     0.630     0.000
0.020
```

ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	451.00	0.06	0.90	79.00	53.00	29.23	5.40	1.00
TEMP/LCD	2.	415.00	0.06	0.90	79.00	53.00	29.23	5.40	1.00
TEMP/LCD	3.	393.00	0.06	0.90	79.00	53.00	29.23	5.40	1.00
TEMP/LCD	4.	379.00	0.06	0.90	79.00	53.00	29.23	5.40	1.00
TEMP/LCD	5.	374.00	0.06	0.90	79.00	53.00	29.23	5.40	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.05	0.00	0.017	1.	0.65	0.000	0.00000
REACT COEF	2.	0.05	0.00	0.019	1.	0.65	0.000	0.00000
REACT COEF	3.	0.05	0.00	0.030	1.	0.65	0.000	0.00000
REACT COEF	4.	0.05	0.00	0.035	1.	0.65	0.000	0.00000
REACT COEF	5.	0.05	0.00	0.040	1.	0.65	0.000	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	2.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	3.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	4.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	5.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5	CKANC	SETANC	SRCANC
					CKCOLI			
ALGAE/OTHER	1.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	2.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	3.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	4.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	5.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	6.85	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	68.00	6.85	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	3.	70.00	4.95	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	4.	67.55	4.80	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	5.	64.94	7.15	1.00	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.67	0.43	0.05	0.00	0.10	0.00	0.03
INITIAL COND-2	2.	2.67	0.43	0.05	0.00	0.10	0.00	0.03
INITIAL COND-2	3.	10.40	0.45	0.05	0.00	0.15	0.00	0.02
INITIAL COND-2	4.	1.13	0.55	0.05	0.00	0.10	0.00	0.06
INITIAL COND-2	5.	9.08	0.37	0.05	0.00	1.23	0.00	0.01
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	68.00	6.00	1.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.090	68.00	6.00	1.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.070	70.00	6.00	1.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.290	67.55	6.00	1.00	0.00	0.00	0.00	0.00	0.00

```
        INCR INFLOW-1          5.     0.010     64.94      6.00      1.00      0.00
   0.00      0.00      0.00      0.00
        ENDATA8                0.     0.000      0.00      0.00      0.00      0.00
   0.00      0.00      0.00      0.00

         $$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A,
NITROGEN, AND PHOSPHORUS) $$$

        CARD TYPE            REACH    CHL-A     ORG-N     NH3-N     NO2-N     NO3-N
   ORG-P     DIS-P
        INCR INFLOW-2          1.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          2.      0.08      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          3.      0.07      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          4.      0.29      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          5.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        ENDATA8A               0.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00

         $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

        CARD TYPE                 JUNCTION ORDER AND IDENT         UPSTRM   JUNCTION
 TRIB
        ENDATA9                   0.                                 0.        0.
  0.

         $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

        CARD TYPE    HDWTR     NAME                FLOW      TEMP      D.O.       BOD
    CM-1      CM-2      CM-3
                     ORDER
        HDWTR-NFK      1.         BonpasCK         0.08     68.00      6.85      1.00
    0.00      0.00      0.00
        ENDATA10       0.                          0.00      0.00      0.00      0.00
    0.00      0.00      0.00

         $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN,
PHOSPHORUS,
                             COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

        CARD TYPE     HDWTR     ANC     COLI     CHL-A    ORG-N    NH3-N    NO2-N
NO3-N    ORG-P    DIS-P
                      ORDER
        HEADWTR-2       1.     0.00 0.00E+00     2.70     0.43     0.05     0.00
 0.10     0.00     0.03
        ENDATA10A       0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

         $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

                      POINT
        CARD TYPE      LOAD    NAME                EFF      FLOW     TEMP     D.O.
 BOD      CM-1     CM-2     CM-3
                      ORDER
        POINTLD-1      1.     Claremont           0.00     0.00    70.00     7.90
4.00      0.00     0.00     0.00
        POINTLD-1      2.     WstSalemN           0.00     0.07    70.00     7.90
4.00      0.00     0.00     0.00
        POINTLD-1      3.     WstSalemS           0.00     0.04    70.00     7.90
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```
4.00      0.00     0.00     0.00
         POINTLD-1      4.     VigoCoal        0.00     0.00    70.00     7.90
0.00      0.00     0.00     0.00
         POINTLD-1      5.     Bellmont        0.00     0.00    70.00     7.90
4.00      0.00     0.00     0.00
         POINTLD-1      6.    BrownsStp        0.00     0.00    70.00     7.90
4.00      0.00     0.00     0.00
         ENDATA11       0.                     0.00     0.00     0.00     0.00
0.00      0.00     0.00     0.00

          $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN,
PHOSPHORUS,
                              COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT)
$$$

                       POINT
         CARD TYPE      LOAD     ANC      COLI     CHL-A    ORG-N    NH3-N    NO2-N
N03-N    ORG-P    DIS-P
                       ORDER
         POINTLD-2       1.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       2.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       3.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       4.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       5.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       6.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         ENDATA11A       0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

          $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

                                DAM   RCH   ELE    ADAM    BDAM    FDAM    HDAM

         ENDATA12                  0.    0.    0.    0.00    0.00    0.00    0.00

          $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

              CARD TYPE               TEMP       D.O.      BOD       CM-1      CM-2
    CM-3       ANC      COLI

         ENDATA13                     DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED

          $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

              CARD TYPE               CHL-A     ORG-N     NH3-N     NO2-N     NH3-N
   ORG-P     DIS-P

         ENDATA13A                    DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED
♀
♀
 STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
 ---------------------------------------------------------


                       NUMBER OF
         ITERATION   NONCONVERGENT
                       ELEMENTS
```

1	36
2	0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 1153.298 BTU/FT-2 (312.971 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 13.1

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	22.22	9	120.15	17	0.00
2	54.84	10	95.71	18	0.00
3	85.70	11	66.05	19	0.00
4	112.27	12	33.80	20	0.00
5	132.11	13	4.74	21	0.00
6	143.42	14	0.00	22	0.00
7	145.16	15	0.00	23	0.00
8	137.14	16	0.00	24	0.00

♀

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	94
ALGAE GROWTH RATE	2	90
ALGAE GROWTH RATE	3	83
ALGAE GROWTH RATE	4	72
ALGAE GROWTH RATE	5	55
ALGAE GROWTH RATE	6	47
ALGAE GROWTH RATE	7	36
ALGAE GROWTH RATE	8	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	9	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
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1. LIGHT AVERAGING OPTION. LAVOPT= 3

METHOD: AVERAGE OF HOURLY SOLAR VALUES

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 1153.298 BTU/FT-2 (312.971 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 13.1
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): N/A

HOURLY VALUES OF SOLAR RADIATION (LANGLEYS)

1	6.03	9	32.60	17	0.00
2	14.88	10	25.97	18	0.00
3	23.26	11	17.92	19	0.00

4	30.47	12	9.17	20	0.00
5	35.85	13	1.29	21	0.00
6	38.92	14	0.00	22	0.00
7	39.39	15	0.00	23	0.00
8	37.22	16	0.00	24	0.00

2. LIGHT FUNCTION OPTION: LFNOPT= 2

SMITH FUNCTION, WITH 71% IMAX = 0.179 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 2

MINIMUM OF NITROGEN, PHOSPHORUS: FL*MIN(FN,FP)

♀

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER   1
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	47.50	47.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
2	1	2	47.00	46.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
3	1	3	46.50	46.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
4	1	4	46.00	45.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
5	1	5	45.50	45.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
6	1	6	45.00	44.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
7	1	7	44.50	44.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
8	1	8	44.00	43.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
9	1	9	43.50	43.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
10	1	10	43.00	42.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
11	1	11	42.50	42.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
12	1	12	42.00	41.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
13	1	13	41.50	41.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
14	1	14	41.00	40.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
15	1	15	40.50	40.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93

16	1	16	40.00	39.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
17	1	17	39.50	39.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
18	1	18	39.00	38.50	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93
19	1	19	38.50	38.00	0.08	0.00	0.00	0.170	0.180	0.670	0.702	1.24	5.39	0.47	0.93

20	2	1	38.00	37.50	0.08	0.00	0.00	0.170	0.180	0.670	0.742	1.31	5.50	0.50	0.93
21	2	2	37.50	37.00	0.09	0.00	0.00	0.170	0.180	0.670	0.781	1.38	5.60	0.52	0.93
22	2	3	37.00	36.50	0.09	0.00	0.00	0.170	0.180	0.670	0.821	1.45	5.70	0.55	0.93
23	2	4	36.50	36.00	0.10	0.00	0.00	0.170	0.180	0.670	0.860	1.52	5.81	0.58	0.93
24	2	5	36.00	35.50	0.10	0.00	0.00	0.170	0.180	0.670	0.900	1.59	5.91	0.60	0.93
25	2	6	35.50	35.00	0.11	0.00	0.00	0.170	0.180	0.670	0.939	1.66	6.02	0.63	0.93
26	2	7	35.00	34.50	0.11	0.00	0.00	0.170	0.180	0.670	0.979	1.73	6.12	0.66	0.93
27	2	8	34.50	34.00	0.12	0.00	0.00	0.170	0.180	0.670	1.018	1.80	6.23	0.68	0.93
28	2	9	34.00	33.50	0.12	0.00	0.00	0.170	0.180	0.670	1.058	1.87	6.33	0.71	0.93
29	2	10	33.50	33.00	0.13	0.00	0.00	0.170	0.180	0.670	1.097	1.94	6.43	0.74	0.93
30	2	11	33.00	32.50	0.13	0.00	0.00	0.170	0.180	0.670	1.137	2.01	6.54	0.76	0.93
31	2	12	32.50	32.00	0.13	0.00	0.00	0.170	0.180	0.670	1.176	2.08	6.64	0.79	0.93
32	2	13	32.00	31.50	0.14	0.00	0.00	0.170	0.180	0.670	1.216	2.15	6.75	0.81	0.93
33	2	14	31.50	31.00	0.14	0.00	0.00	0.170	0.180	0.670	1.255	2.22	6.85	0.84	0.93
34	2	15	31.00	30.50	0.15	0.00	0.00	0.170	0.180	0.670	1.295	2.29	6.96	0.87	0.93
35	2	16	30.50	30.00	0.15	0.00	0.00	0.170	0.180	0.670	1.335	2.36	7.06	0.89	0.93
36	2	17	30.00	29.50	0.16	0.00	0.00	0.170	0.180	0.670	1.374	2.43	7.16	0.92	0.93
37	2	18	29.50	29.00	0.16	0.00	0.00	0.170	0.180	0.670	1.414	2.50	7.27	0.95	0.93
38	2	19	29.00	28.50	0.17	0.00	0.00	0.170	0.180	0.670	1.453	2.57	7.37	0.97	0.93
39	2	20	28.50	28.00	0.17	0.00	0.00	0.170	0.180	0.670	1.493	2.64	7.48	1.00	0.93

40	3	1	28.00	27.50	0.17	0.00	0.00	0.170	0.180	0.600	1.701	2.69	7.66	1.02	0.85
41	3	2	27.50	27.00	0.18	0.00	0.00	0.170	0.180	0.600	1.735	2.75	7.75	1.04	0.85
42	3	3	27.00	26.50	0.18	0.00	0.00	0.170	0.180	0.600	1.770	2.80	7.84	1.06	0.85

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 2
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	BOTTOM WIDTH FT	VOLUME K-FT-3	X-SECT AREA K-FT-2	DSPRSN AREA FT-2	COEF FT-2/S
43	3	4	26.50	26.00	0.18	0.00	0.00	0.170	0.180	0.600	1.804	2.86	7.93	1.08	0.85
44	3	5	26.00	25.50	0.19	0.00	0.00	0.170	0.180	0.600	1.838	2.91	8.02	1.10	0.85
45	3	6	25.50	25.00	0.19	0.00	0.00	0.170	0.180	0.600	1.873	2.97	8.11	1.12	0.85
46	3	7	25.00	24.50	0.19	0.00	0.00	0.170	0.180	0.600	1.907	3.02	8.20	1.14	0.85
47	3	8	24.50	24.00	0.20	0.00	0.00	0.170	0.180	0.600	1.941	3.07	8.29	1.16	0.85
48	3	9	24.00	23.50	0.20	0.00	0.00	0.170	0.180	0.600	1.975	3.13	8.38	1.19	0.85
49	3	10	23.50	23.00	0.21	0.00	0.00	0.170	0.180	0.600	2.010	3.18	8.47	1.21	0.85
50	3	11	23.00	22.50	0.21	0.00	0.00	0.170	0.180	0.600	2.044	3.24	8.56	1.23	0.85
51	3	12	22.50	22.00	0.29	0.07	0.00	0.170	0.180	0.600	2.804	4.44	10.57	1.68	0.85
52	3	13	22.00	21.50	0.29	0.00	0.00	0.170	0.180	0.600	2.838	4.50	10.66	1.70	0.85
53	3	14	21.50	21.00	0.29	0.00	0.00	0.170	0.180	0.600	2.873	4.55	10.75	1.72	0.85
54	3	15	21.00	20.50	0.30	0.00	0.00	0.170	0.180	0.600	2.907	4.60	10.84	1.74	0.85
55	3	16	20.50	20.00	0.30	0.00	0.00	0.170	0.180	0.600	2.941	4.66	10.93	1.76	0.85
56	3	17	20.00	19.50	0.30	0.00	0.00	0.170	0.180	0.600	2.975	4.71	11.02	1.79	0.85
57	3	18	19.50	19.00	0.31	0.00	0.00	0.170	0.180	0.600	3.010	4.77	11.11	1.81	0.85
58	3	19	19.00	18.50	0.31	0.00	0.00	0.170	0.180	0.600	3.044	4.82	11.20	1.83	0.85
59	3	20	18.50	18.00	0.31	0.00	0.00	0.170	0.180	0.600	3.078	4.88	11.30	1.85	0.85
60	4	1	28.00	27.50	0.33	0.00	0.01	0.170	0.180	0.630	3.067	5.10	11.42	1.93	0.88
61	4	2	27.50	27.00	0.38	0.04	0.01	0.170	0.180	0.630	3.548	5.90	12.69	2.24	0.88
62	4	3	27.00	26.50	0.39	0.00	0.01	0.170	0.180	0.630	3.683	6.13	13.05	2.32	0.88
63	4	4	26.50	26.00	0.41	0.00	0.01	0.170	0.180	0.630	3.819	6.35	13.41	2.41	0.88
64	4	5	26.00	25.50	0.42	0.00	0.01	0.170	0.180	0.630	3.954	6.58	13.77	2.49	0.88
65	4	6	25.50	25.00	0.44	0.00	0.01	0.170	0.180	0.630	4.090	6.80	14.12	2.58	0.88
66	4	7	25.00	24.50	0.45	0.00	0.01	0.170	0.180	0.630	4.225	7.03	14.48	2.66	0.88
67	4	8	24.50	24.00	0.47	0.00	0.01	0.170	0.180	0.630	4.360	7.25	14.84	2.75	0.88

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 68   4   9   24.00   23.50    0.48    0.00    0.01   0.170   0.180    0.630
4.496        7.48       15.20         2.83     0.88
 69   4  10   23.50   23.00    0.50    0.00    0.01   0.170   0.180    0.630
4.631        7.70       15.55         2.92     0.88
 70   4  11   23.00   22.50    0.51    0.00    0.01   0.170   0.180    0.630
4.767        7.93       15.91         3.00     0.88
 71   4  12   22.50   22.00    0.53    0.00    0.01   0.170   0.180    0.630
4.902        8.15       16.27         3.09     0.88
 72   4  13   22.00   21.50    0.54    0.00    0.01   0.170   0.180    0.630
5.037        8.38       16.63         3.17     0.88
 73   4  14   21.50   21.00    0.55    0.00    0.01   0.170   0.180    0.630
5.173        8.60       16.98         3.26     0.88
 74   4  15   21.00   20.50    0.57    0.00    0.01   0.170   0.180    0.630
5.308        8.83       17.34         3.34     0.88
 75   4  16   20.50   20.00    0.58    0.00    0.01   0.170   0.180    0.630
5.444        9.05       17.70         3.43     0.88
 76   4  17   20.00   19.50    0.60    0.00    0.01   0.170   0.180    0.630
5.579        9.28       18.05         3.51     0.88
 77   4  18   19.50   19.00    0.61    0.00    0.01   0.170   0.180    0.630
5.714        9.50       18.41         3.60     0.88
 78   4  19   19.00   18.50    0.63    0.00    0.01   0.170   0.180    0.630
5.850        9.73       18.77         3.69     0.88
 79   4  20   18.50   18.00    0.64    0.00    0.01   0.170   0.180    0.630
5.985        9.95       19.13         3.77     0.88


 80   5   1    8.00    7.50    0.64    0.00    0.00   0.170   0.180    0.630
5.991        9.96       19.14         3.77     0.88
 81   5   2    7.50    7.00    0.64    0.00    0.00   0.170   0.180    0.630
5.997        9.97       19.16         3.78     0.88
 82   5   3    7.00    6.50    0.64    0.00    0.00   0.170   0.180    0.630
6.003        9.98       19.17         3.78     0.88
 83   5   4    6.50    6.00    0.64    0.00    0.00   0.170   0.180    0.630
6.008        9.99       19.19         3.79     0.88
 84   5   5    6.00    5.50    0.64    0.00    0.00   0.170   0.180    0.630
6.014       10.00       19.20         3.79     0.88
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     3
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                          ** HYDRAULICS SUMMARY **

ELE RCH ELE   BEGIN     END           POINT    INCR            TRVL
                  BOTTOM      X-SECT   DSPRSN
ORD NUM NUM     LOC     LOC    FLOW    SRCE    FLOW     VEL    TIME    DEPTH
WIDTH       VOLUME        AREA         AREA     COEF
               MILE    MILE     CFS     CFS     CFS     FPS     DAY       FT
FT       K-FT-3      K-FT-2        FT-2   FT-2/S

 85   5   6    5.50    5.00    0.64    0.00    0.00   0.170   0.180    0.630
6.020       10.01       19.22         3.79     0.88
 86   5   7    5.00    4.50    0.65    0.00    0.00   0.170   0.180    0.630
6.026       10.02       19.23         3.80     0.88
 87   5   8    4.50    4.00    0.65    0.00    0.00   0.170   0.180    0.630
6.032       10.03       19.25         3.80     0.88
 88   5   9    4.00    3.50    0.65    0.00    0.00   0.170   0.180    0.630
6.038       10.04       19.27         3.80     0.88
 89   5  10    3.50    3.00    0.65    0.00    0.00   0.170   0.180    0.630
6.043       10.05       19.28         3.81     0.88
 90   5  11    3.00    2.50    0.65    0.00    0.00   0.170   0.180    0.630
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6.049        10.06       19.30        3.81     0.88
 91   5  12    2.50    2.00    0.65    0.00    0.00   0.170   0.180    0.630
6.055        10.07       19.31        3.81     0.88
 92   5  13    2.00    1.50    0.65    0.00    0.00   0.170   0.180    0.630
6.061        10.08       19.33        3.82     0.88
 93   5  14    1.50    1.00    0.65    0.00    0.00   0.170   0.180    0.630
6.067        10.09       19.34        3.82     0.88
 94   5  15    1.00    0.50    0.65    0.00    0.00   0.170   0.180    0.630
6.073        10.10       19.36        3.83     0.88
 95   5  16    0.50    0.00    0.65    0.00    0.00   0.170   0.180    0.630
6.078        10.11       19.37        3.83     0.88


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     4
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                        ***** STEADY STATE SIMULATION *****

                                                        ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L       1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  1   1   8.86   1   0.65   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   2   8.84   1   0.65   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   3   8.83   1   0.65   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   4   8.83   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   5   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   6   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   7   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   8   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   9   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  10   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  11   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  12   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  13   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  14   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  15   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  16   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  17   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
```

```
  1  18   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  19   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  2   1   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   2   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   3   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   4   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   5   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   6   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   7   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   8   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   9   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  10   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  11   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  12   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  13   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  14   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  15   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  16   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  17   8.82   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  18   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  19   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  20   8.81   1   0.66   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  3   1   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   2   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   3   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                  OUTPUT PAGE NUMBER     5
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                  ***** STEADY STATE SIMULATION *****

                                                  ** REACTION COEFFICIENT SUMMARY **
```

```
RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L       1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  3   4   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   5   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   6   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   7   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   8   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   9   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  10   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.93
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  11   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.93
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  12   8.79   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.98
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  13   8.79   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  14   8.80   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.97
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  15   8.80   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  16   8.80   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  17   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  18   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  19   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3  20   8.81   1   0.66   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  4   1   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   2   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.96
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   3   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   4   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.95
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   5   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   6   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   7   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   8   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   9   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  10   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
```

```
  4  11   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  12   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  13   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  14   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  15   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  16   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  17   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  18   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  19   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  20   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  5   1   8.82   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   2   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.94
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   3   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.93
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   4   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.93
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   5   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.93
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     6
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                 ***** STEADY STATE SIMULATION *****

                                                 ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
        MG/L       1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  5   6   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.93
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   7   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   8   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   9   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  10   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  11   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  12   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  13   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.92
```

```
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  14   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.91
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  15   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.91
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  16   8.81   1   0.66   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.91
0.00   0.00   0.00   0.00   0.00   0.00   0.00


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     7
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                ***** STEADY STATE SIMULATION *****

                                                   ** WATER QUALITY VARIABLES **

RCH ELE               CM-1   CM-2   CM-3
                                    ANC
NUM NUM        TEMP                        DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI          CHLA
              DEG-F                       MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML         UG/L

  1   1      68.25   0.00   0.00   0.00   6.64   0.99   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   2.86
  1   2      68.41   0.00   0.00   0.00   6.45   0.98   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   3.03
  1   3      68.52   0.00   0.00   0.00   6.27   0.97   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   3.22
  1   4      68.60   0.00   0.00   0.00   6.12   0.96   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   3.41
  1   5      68.65   0.00   0.00   0.00   5.98   0.96   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   3.62
  1   6      68.69   0.00   0.00   0.00   5.86   0.95   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   3.84
  1   7      68.71   0.00   0.00   0.00   5.75   0.94   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   4.07
  1   8      68.73   0.00   0.00   0.00   5.66   0.93   0.43   0.05   0.00   0.10
0.58   0.00   0.03   0.03.00E+00   0.00   4.32
  1   9      68.74   0.00   0.00   0.00   5.57   0.92   0.43   0.05   0.00   0.09
0.58   0.00   0.03   0.03.00E+00   0.00   4.58
  1  10      68.75   0.00   0.00   0.00   5.50   0.91   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   4.85
  1  11      68.75   0.00   0.00   0.00   5.43   0.90   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   5.14
  1  12      68.75   0.00   0.00   0.00   5.37   0.90   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   5.45
  1  13      68.76   0.00   0.00   0.00   5.32   0.89   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   5.77
  1  14      68.76   0.00   0.00   0.00   5.27   0.88   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   6.12
  1  15      68.76   0.00   0.00   0.00   5.23   0.87   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   6.48
  1  16      68.76   0.00   0.00   0.00   5.20   0.86   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   6.86
  1  17      68.76   0.00   0.00   0.00   5.17   0.86   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   7.27
  1  18      68.76   0.00   0.00   0.00   5.14   0.85   0.43   0.05   0.00   0.09
0.57   0.00   0.03   0.03.00E+00   0.00   7.69
  1  19      68.76   0.00   0.00   0.00   5.12   0.84   0.43   0.05   0.00   0.08
0.57   0.00   0.03   0.03.00E+00   0.00   8.14
```

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  2   1      68.73   0.00   0.00   0.00   5.10   0.84   0.41   0.04   0.00   0.08
0.53   0.00   0.03   0.03.00E+00   0.00   8.14
  2   2      68.71   0.00   0.00   0.00   5.10   0.84   0.39   0.04   0.00   0.07
0.51   0.00   0.02   0.02.00E+00   0.00   8.15
  2   3      68.70   0.00   0.00   0.00   5.10   0.84   0.37   0.04   0.00   0.07
0.48   0.00   0.02   0.02.00E+00   0.00   8.17
  2   4      68.69   0.00   0.00   0.00   5.12   0.84   0.35   0.04   0.00   0.06
0.46   0.00   0.02   0.02.00E+00   0.00   8.19
  2   5      68.69   0.00   0.00   0.00   5.14   0.84   0.34   0.04   0.00   0.06
0.44   0.00   0.02   0.02.00E+00   0.00   8.23
  2   6      68.69   0.00   0.00   0.00   5.17   0.84   0.33   0.03   0.00   0.06
0.42   0.00   0.02   0.02.00E+00   0.00   8.27
  2   7      68.69   0.00   0.00   0.00   5.21   0.84   0.31   0.03   0.00   0.05
0.40   0.00   0.02   0.02.00E+00   0.00   8.31
  2   8      68.69   0.00   0.00   0.00   5.24   0.84   0.30   0.03   0.00   0.05
0.38   0.00   0.02   0.02.00E+00   0.00   8.36
  2   9      68.69   0.00   0.00   0.00   5.28   0.84   0.29   0.03   0.00   0.05
0.37   0.00   0.02   0.02.00E+00   0.00   8.40
  2  10      68.69   0.00   0.00   0.00   5.32   0.84   0.28   0.03   0.00   0.04
0.35   0.00   0.02   0.02.00E+00   0.00   8.45
  2  11      68.70   0.00   0.00   0.00   5.36   0.83   0.27   0.03   0.00   0.04
0.34   0.00   0.01   0.02.00E+00   0.00   8.50
  2  12      68.70   0.00   0.00   0.00   5.40   0.83   0.26   0.03   0.00   0.04
0.33   0.00   0.01   0.01.00E+00   0.00   8.54
  2  13      68.70   0.00   0.00   0.00   5.44   0.83   0.25   0.03   0.00   0.04
0.32   0.00   0.01   0.01.00E+00   0.00   8.59
  2  14      68.70   0.00   0.00   0.00   5.48   0.83   0.25   0.02   0.00   0.03
0.30   0.00   0.01   0.01.00E+00   0.00   8.62
  2  15      68.70   0.00   0.00   0.00   5.52   0.83   0.24   0.02   0.00   0.03
0.29   0.00   0.01   0.01.00E+00   0.00   8.66
  2  16      68.70   0.00   0.00   0.00   5.56   0.82   0.23   0.02   0.00   0.03
0.28   0.00   0.01   0.01.00E+00   0.00   8.69
  2  17      68.71   0.00   0.00   0.00   5.60   0.82   0.23   0.02   0.00   0.03
0.28   0.00   0.01   0.01.00E+00   0.00   8.71
  2  18      68.71   0.00   0.00   0.00   5.63   0.82   0.22   0.02   0.00   0.03
0.27   0.00   0.01   0.01.00E+00   0.00   8.73
  2  19      68.71   0.00   0.00   0.00   5.67   0.82   0.21   0.02   0.00   0.02
0.26   0.00   0.01   0.01.00E+00   0.00   8.74
  2  20      68.71   0.00   0.00   0.00   5.70   0.81   0.21   0.02   0.00   0.02
0.25   0.00   0.01   0.01.00E+00   0.00   8.74


  3   1      68.74   0.00   0.00   0.00   5.55   0.81   0.20   0.02   0.00   0.02
0.25   0.00   0.01   0.01.00E+00   0.00   8.76
  3   2      68.76   0.00   0.00   0.00   5.43   0.81   0.20   0.02   0.00   0.02
0.24   0.00   0.01   0.01.00E+00   0.00   8.77
  3   3      68.77   0.00   0.00   0.00   5.32   0.80   0.20   0.02   0.00   0.02
0.23   0.00   0.01   0.01.00E+00   0.00   8.77
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     8
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                      ***** STEADY STATE SIMULATION *****

                                                         ** WATER QUALITY VARIABLES **

RCH ELE             CM-1   CM-2   CM-3
                                  ANC
NUM NUM      TEMP                          DO     BOD    ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI         CHLA
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                DEG-F                         MG/L    MG/L    MG/L    MG/L    MG/L    MG/L
MG/L    MG/L    MG/L    MG/L #/100ML          UG/L

  3   4         68.78   0.00   0.00    0.00   5.22    0.80    0.19    0.02    0.00    0.02
0.23   0.00     0.01    0.01.00E+00    0.00   8.76
  3   5         68.78   0.00   0.00    0.00   5.15    0.80    0.19    0.02    0.00    0.02
0.22   0.00     0.01    0.01.00E+00    0.00   8.74
  3   6         68.78   0.00   0.00    0.00   5.08    0.79    0.19    0.02    0.00    0.01
0.22   0.00     0.01    0.01.00E+00    0.00   8.71
  3   7         68.78   0.00   0.00    0.00   5.02    0.79    0.18    0.02    0.00    0.01
0.21   0.00     0.01    0.01.00E+00    0.00   8.67
  3   8         68.78   0.00   0.00    0.00   4.98    0.79    0.18    0.02    0.00    0.01
0.21   0.00     0.01    0.01.00E+00    0.00   8.62
  3   9         68.79   0.00   0.00    0.00   4.94    0.78    0.18    0.02    0.00    0.01
0.21   0.00     0.01    0.01.00E+00    0.00   8.56
  3  10         68.78   0.00   0.00    0.00   4.91    0.78    0.18    0.02    0.00    0.01
0.20   0.00     0.01    0.01.00E+00    0.00   8.48
  3  11         68.78   0.00   0.00    0.00   4.88    0.78    0.17    0.01    0.00    0.01
0.20   0.00     0.01    0.01.00E+00    0.00   8.40
  3  12         69.00   0.00   0.00    0.00   5.54    1.60    0.13    0.01    0.00    0.01
0.14   0.00     0.00    0.01.00E+00    0.00   6.11
  3  13         68.92   0.00   0.00    0.00   5.47    1.58    0.12    0.01    0.00    0.01
0.14   0.00     0.00    0.01.00E+00    0.00   6.01
  3  14         68.87   0.00   0.00    0.00   5.41    1.56    0.12    0.01    0.00    0.01
0.14   0.00     0.00    0.01.00E+00    0.00   5.91
  3  15         68.83   0.00   0.00    0.00   5.36    1.54    0.12    0.01    0.00    0.01
0.14   0.00     0.00    0.01.00E+00    0.00   5.80
  3  16         68.81   0.00   0.00    0.00   5.31    1.52    0.12    0.01    0.00    0.01
0.14   0.00     0.00    0.01.00E+00    0.00   5.69
  3  17         68.80   0.00   0.00    0.00   5.27    1.50    0.12    0.01    0.00    0.00
0.13   0.00     0.00    0.01.00E+00    0.00   5.58
  3  18         68.79   0.00   0.00    0.00   5.24    1.48    0.12    0.01    0.00    0.00
0.13   0.00     0.00    0.00.00E+00    0.00   5.47
  3  19         68.78   0.00   0.00    0.00   5.21    1.46    0.12    0.01    0.00    0.00
0.13   0.00     0.00    0.00.00E+00    0.00   5.35
  3  20         68.78   0.00   0.00    0.00   5.19    1.44    0.12    0.01    0.00    0.00
0.13   0.00     0.00    0.00.00E+00    0.00   5.23


  4   1         68.73   0.00   0.00    0.00   5.13    1.41    0.11    0.01    0.00    0.00
0.12   0.00     0.00    0.00.00E+00    0.00   4.95
  4   2         68.79   0.00   0.00    0.00   5.32    1.63    0.10    0.01    0.00    0.00
0.11   0.00     0.00    0.00.00E+00    0.00   4.23
  4   3         68.74   0.00   0.00    0.00   5.26    1.59    0.09    0.01    0.00    0.00
0.10   0.00     0.00    0.00.00E+00    0.00   4.01
  4   4         68.71   0.00   0.00    0.00   5.22    1.56    0.09    0.01    0.00    0.00
0.10   0.00     0.00    0.00.00E+00    0.00   3.81
  4   5         68.70   0.00   0.00    0.00   5.18    1.53    0.09    0.01    0.00    0.00
0.10   0.00     0.00    0.00.00E+00    0.00   3.62
  4   6         68.68   0.00   0.00    0.00   5.15    1.49    0.08    0.01    0.00    0.00
0.09   0.00     0.00    0.00.00E+00    0.00   3.43
  4   7         68.68   0.00   0.00    0.00   5.13    1.47    0.08    0.01    0.00    0.00
0.09   0.00     0.00    0.00.00E+00    0.00   3.26
  4   8         68.68   0.00   0.00    0.00   5.11    1.44    0.08    0.01    0.00    0.00
0.09   0.00     0.00    0.00.00E+00    0.00   3.10
  4   9         68.67   0.00   0.00    0.00   5.10    1.41    0.08    0.01    0.00    0.00
0.08   0.00     0.00    0.00.00E+00    0.00   2.94
  4  10         68.67   0.00   0.00    0.00   5.09    1.39    0.07    0.01    0.00    0.00
0.08   0.00     0.00    0.00.00E+00    0.00   2.80
  4  11         68.68   0.00   0.00    0.00   5.09    1.36    0.07    0.01    0.00    0.00
0.08   0.00     0.00    0.00.00E+00    0.00   2.66
  4  12         68.68   0.00   0.00    0.00   5.09    1.34    0.07    0.00    0.00    0.00
0.08   0.00     0.00    0.00.00E+00    0.00   2.53
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  4  13       68.68   0.00   0.00   0.00   5.09   1.32   0.07   0.00   0.00   0.00
0.07   0.00   0.00   0.00.00E+00   0.00   2.40
  4  14       68.68   0.00   0.00   0.00   5.09   1.30   0.07   0.00   0.00   0.00
0.07   0.00   0.00   0.00.00E+00   0.00   2.28
  4  15       68.68   0.00   0.00   0.00   5.09   1.28   0.07   0.00   0.00   0.00
0.07   0.00   0.00   0.00.00E+00   0.00   2.17
  4  16       68.68   0.00   0.00   0.00   5.10   1.26   0.06   0.00   0.00   0.00
0.07   0.00   0.00   0.00.00E+00   0.00   2.06
  4  17       68.68   0.00   0.00   0.00   5.10   1.25   0.06   0.00   0.00   0.00
0.07   0.00   0.00   0.00.00E+00   0.00   1.96
  4  18       68.68   0.00   0.00   0.00   5.11   1.23   0.06   0.00   0.00   0.00
0.07   0.00   0.00   0.00.00E+00   0.00   1.87
  4  19       68.69   0.00   0.00   0.00   5.11   1.21   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.77
  4  20       68.69   0.00   0.00   0.00   5.12   1.20   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.69


  5   1       68.70   0.00   0.00   0.00   5.06   1.19   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.64
  5   2       68.71   0.00   0.00   0.00   5.01   1.18   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.58
  5   3       68.72   0.00   0.00   0.00   4.96   1.16   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.53
  5   4       68.72   0.00   0.00   0.00   4.92   1.15   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.48
  5   5       68.73   0.00   0.00   0.00   4.88   1.14   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.44
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     9
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                          ***** STEADY STATE SIMULATION *****

                                                             ** WATER QUALITY VARIABLES **

RCH ELE               CM-1   CM-2   CM-3
                                    ANC
NUM NUM        TEMP                                 DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI                 CHLA
              DEG-F                                MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML              UG/L

  5   6       68.73   0.00   0.00   0.00   4.84   1.13   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.39
  5   7       68.73   0.00   0.00   0.00   4.81   1.12   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.34
  5   8       68.73   0.00   0.00   0.00   4.79   1.11   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.30
  5   9       68.73   0.00   0.00   0.00   4.76   1.10   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.26
  5  10       68.73   0.00   0.00   0.00   4.74   1.09   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.22
  5  11       68.73   0.00   0.00   0.00   4.72   1.08   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.18
  5  12       68.73   0.00   0.00   0.00   4.71   1.07   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.14
  5  13       68.73   0.00   0.00   0.00   4.69   1.06   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.10
  5  14       68.73   0.00   0.00   0.00   4.68   1.05   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   1.06
  5  15       68.73   0.00   0.00   0.00   4.67   1.04   0.06   0.00   0.00   0.00
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0.06   0.00   0.00   0.00.00E+00   0.00   1.03
  5  16       68.73   0.00   0.00   0.00   4.66   1.03   0.06   0.00   0.00   0.00
0.06   0.00   0.00   0.00.00E+00   0.00   0.99
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         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    10
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                        ***** STEADY STATE SIMULATION *****

                                                                 ** ALGAE DATA **

                                                                                  NH3-N
         ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE               ALGY    ALGY    ALGY   A P/R     NET          NH3   FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH    RESP    SETT   RATIO     P-R         PREF  N-UPTKE
EXTCO       LIGHT   NITRGN   PHSPRS
                   UG/L   1/DAY   1/DAY   FT/DA       *   MG/L-D          *       *
 1/FT            *        *        *

  1   1   1        2.86    0.57    0.11    0.10    5.12    0.05         0.10    0.05
 0.02        0.34    0.83     0.86
  2   1   2        3.03    0.57    0.11    0.10    5.11    0.05         0.10    0.05
 0.02        0.34    0.83     0.86
  3   1   3        3.22    0.57    0.11    0.10    5.11    0.05         0.10    0.05
 0.02        0.34    0.83     0.86
  4   1   4        3.41    0.57    0.11    0.10    5.11    0.06         0.10    0.05
 0.02        0.34    0.83     0.86
  5   1   5        3.62    0.57    0.11    0.10    5.10    0.06         0.10    0.05
 0.02        0.34    0.83     0.86
  6   1   6        3.84    0.57    0.11    0.10    5.10    0.06         0.10    0.05
 0.02        0.34    0.83     0.85
  7   1   7        4.07    0.57    0.11    0.10    5.09    0.07         0.10    0.05
 0.02        0.34    0.83     0.85
  8   1   8        4.32    0.57    0.11    0.10    5.09    0.07         0.10    0.05
 0.02        0.34    0.83     0.85
  9   1   9        4.58    0.57    0.11    0.10    5.08    0.08         0.10    0.05
 0.02        0.34    0.83     0.85
 10   1  10        4.85    0.57    0.11    0.10    5.07    0.08         0.10    0.05
 0.02        0.34    0.83     0.85
 11   1  11        5.14    0.57    0.11    0.10    5.07    0.09         0.10    0.05
 0.03        0.34    0.83     0.85
 12   1  12        5.45    0.57    0.11    0.10    5.06    0.09         0.10    0.06
 0.03        0.34    0.82     0.85
 13   1  13        5.77    0.57    0.11    0.10    5.05    0.10         0.10    0.06
 0.03        0.34    0.82     0.85
 14   1  14        6.12    0.57    0.11    0.10    5.04    0.10         0.10    0.06
 0.03        0.34    0.82     0.85
 15   1  15        6.48    0.57    0.11    0.10    5.04    0.11         0.10    0.06
 0.03        0.34    0.82     0.85
 16   1  16        6.86    0.57    0.11    0.10    5.03    0.11         0.10    0.06
 0.03        0.34    0.82     0.85
 17   1  17        7.27    0.57    0.11    0.10    5.02    0.12         0.10    0.06
 0.03        0.34    0.82     0.85
 18   1  18        7.69    0.57    0.11    0.10    5.01    0.13         0.10    0.06
 0.03        0.34    0.82     0.85
 19   1  19        8.14    0.56    0.11    0.10    4.99    0.13         0.10    0.06
 0.03        0.34    0.81     0.84
```

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 20   2   1        8.14    0.56    0.11    0.10    4.93    0.13         0.10    0.06
 0.03          0.34    0.80     0.84
 21   2   2        8.15    0.55    0.11    0.10    4.87    0.13         0.10    0.06
 0.03          0.34    0.79     0.83
 22   2   3        8.17    0.54    0.11    0.10    4.81    0.13         0.10    0.06
 0.03          0.34    0.78     0.82
 23   2   4        8.19    0.53    0.11    0.10    4.74    0.12         0.10    0.06
 0.03          0.34    0.77     0.81
 24   2   5        8.23    0.53    0.11    0.10    4.68    0.12         0.10    0.06
 0.03          0.34    0.76     0.80
 25   2   6        8.27    0.52    0.11    0.10    4.61    0.12         0.10    0.06
 0.03          0.34    0.75     0.79
 26   2   7        8.31    0.51    0.11    0.10    4.55    0.12         0.10    0.06
 0.03          0.34    0.74     0.78
 27   2   8        8.36    0.51    0.11    0.10    4.48    0.12         0.10    0.07
 0.04          0.34    0.73     0.78
 28   2   9        8.40    0.50    0.11    0.10    4.41    0.12         0.10    0.07
 0.04          0.34    0.72     0.77
 29   2  10        8.45    0.49    0.11    0.10    4.34    0.11         0.10    0.07
 0.04          0.34    0.71     0.76
 30   2  11        8.50    0.48    0.11    0.10    4.27    0.11         0.10    0.07
 0.04          0.34    0.70     0.75
 31   2  12        8.54    0.47    0.11    0.10    4.20    0.11         0.10    0.07
 0.04          0.34    0.69     0.74
 32   2  13        8.59    0.47    0.11    0.10    4.13    0.11         0.10    0.07
 0.04          0.34    0.67     0.73
 33   2  14        8.62    0.46    0.11    0.10    4.06    0.11         0.10    0.08
 0.04          0.34    0.66     0.72
 34   2  15        8.66    0.45    0.11    0.10    3.99    0.11         0.10    0.08
 0.04          0.34    0.65     0.71
 35   2  16        8.69    0.44    0.11    0.10    3.91    0.10         0.10    0.08
 0.04          0.34    0.64     0.70
 36   2  17        8.71    0.43    0.11    0.10    3.84    0.10         0.10    0.08
 0.04          0.34    0.63     0.69
 37   2  18        8.73    0.42    0.11    0.10    3.76    0.10         0.10    0.08
 0.04          0.34    0.61     0.68
 38   2  19        8.74    0.42    0.11    0.10    3.68    0.10         0.10    0.09
 0.04          0.34    0.60     0.67
 39   2  20        8.74    0.41    0.11    0.10    3.61    0.09         0.10    0.09
 0.04          0.34    0.59     0.66


 40   3   1        8.76    0.40    0.11    0.10    3.54    0.09         0.10    0.09
 0.04          0.34    0.58     0.65
 41   3   2        8.77    0.39    0.11    0.10    3.47    0.09         0.10    0.10
 0.04          0.34    0.57     0.65
 42   3   3        8.77    0.38    0.11    0.10    3.39    0.09         0.10    0.10
 0.04          0.34    0.55     0.64
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    11
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                         ***** STEADY STATE SIMULATION *****

                                                                 ** ALGAE DATA **

                                                                                  NH3-N
         ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE               ALGY    ALGY    ALGY   A P/R     NET          NH3   FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH    RESP    SETT   RATIO     P-R         PREF  N-UPTKE
EXTCO        LIGHT   NITRGN   PHSPRS
```

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                    UG/L    1/DAY    1/DAY   FT/DA       *   MG/L-D          *         *
1/FT              *        *        *

43   3    4        8.76     0.38     0.11     0.10     3.32     0.08         0.10     0.10
0.04             0.34     0.54     0.63
44   3    5        8.74     0.37     0.11     0.10     3.25     0.08         0.10     0.11
0.04             0.34     0.53     0.62
45   3    6        8.71     0.36     0.11     0.10     3.17     0.08         0.10     0.11
0.04             0.34     0.52     0.61
46   3    7        8.67     0.35     0.11     0.10     3.09     0.07         0.10     0.12
0.04             0.34     0.50     0.60
47   3    8        8.62     0.34     0.11     0.10     3.02     0.07         0.10     0.12
0.04             0.34     0.49     0.59
48   3    9        8.56     0.33     0.11     0.10     2.94     0.07         0.10     0.13
0.04             0.34     0.48     0.58
49   3   10        8.48     0.32     0.11     0.10     2.87     0.06         0.10     0.14
0.04             0.34     0.47     0.57
50   3   11        8.40     0.32     0.11     0.10     2.79     0.06         0.10     0.14
0.04             0.34     0.45     0.56
51   3   12        6.11     0.26     0.11     0.10     2.29     0.03         0.10     0.15
0.03             0.34     0.37     0.48
52   3   13        6.01     0.25     0.11     0.10     2.23     0.03         0.10     0.15
0.03             0.34     0.36     0.47
53   3   14        5.91     0.25     0.11     0.10     2.17     0.03         0.10     0.16
0.03             0.34     0.35     0.47
54   3   15        5.80     0.24     0.11     0.10     2.12     0.03         0.10     0.17
0.03             0.34     0.34     0.46
55   3   16        5.69     0.23     0.11     0.10     2.06     0.02         0.10     0.18
0.03             0.34     0.34     0.45
56   3   17        5.58     0.23     0.11     0.10     2.01     0.02         0.10     0.18
0.03             0.34     0.33     0.45
57   3   18        5.47     0.22     0.11     0.10     1.96     0.02         0.10     0.19
0.03             0.34     0.32     0.44
58   3   19        5.35     0.22     0.11     0.10     1.91     0.02         0.10     0.20
0.03             0.34     0.31     0.43
59   3   20        5.23     0.21     0.11     0.10     1.86     0.02         0.10     0.21
0.03             0.34     0.30     0.43


60   4    1        4.95     0.20     0.11     0.10     1.77     0.02         0.10     0.22
0.02             0.34     0.29     0.41
61   4    2        4.23     0.18     0.11     0.10     1.56     0.01         0.10     0.23
0.02             0.34     0.25     0.38
62   4    3        4.01     0.17     0.11     0.10     1.50     0.01         0.10     0.24
0.02             0.34     0.24     0.36
63   4    4        3.81     0.16     0.11     0.10     1.43     0.01         0.10     0.24
0.02             0.34     0.23     0.35
64   4    5        3.62     0.15     0.11     0.10     1.37     0.01         0.10     0.25
0.02             0.34     0.22     0.34
65   4    6        3.43     0.15     0.11     0.10     1.32     0.00         0.10     0.26
0.02             0.34     0.21     0.33
66   4    7        3.26     0.14     0.11     0.10     1.26     0.00         0.10     0.27
0.02             0.34     0.21     0.32
67   4    8        3.10     0.14     0.11     0.10     1.22     0.00         0.10     0.28
0.02             0.34     0.20     0.31
68   4    9        2.94     0.13     0.11     0.10     1.17     0.00         0.10     0.29
0.02             0.34     0.19     0.31
69   4   10        2.80     0.13     0.11     0.10     1.13     0.00         0.10     0.30
0.02             0.34     0.18     0.30
70   4   11        2.66     0.12     0.11     0.10     1.09     0.00         0.10     0.31
0.02             0.34     0.18     0.29
71   4   12        2.53     0.12     0.11     0.10     1.05     0.00         0.10     0.31
0.02             0.34     0.17     0.28
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ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	LIGHT *	NITRGN *	PHSPRS *
72	4	13	2.40	0.11	0.11	0.10	1.01	0.00	0.10	0.32	0.02	0.34	0.16	0.28
73	4	14	2.28	0.11	0.11	0.10	0.98	0.00	0.10	0.33	0.02	0.34	0.16	0.27
74	4	15	2.17	0.11	0.11	0.10	0.95	0.00	0.10	0.34	0.02	0.34	0.15	0.26
75	4	16	2.06	0.10	0.11	0.10	0.92	0.00	0.10	0.34	0.02	0.34	0.15	0.26
76	4	17	1.96	0.10	0.11	0.10	0.89	0.00	0.10	0.35	0.02	0.34	0.14	0.25
77	4	18	1.87	0.10	0.11	0.10	0.86	0.00	0.10	0.36	0.02	0.34	0.14	0.25
78	4	19	1.77	0.09	0.11	0.10	0.84	0.00	0.10	0.36	0.02	0.34	0.14	0.24
79	4	20	1.69	0.09	0.11	0.10	0.81	0.00	0.10	0.37	0.02	0.34	0.13	0.24
80	5	1	1.64	0.09	0.11	0.10	0.80	0.00	0.10	0.38	0.01	0.34	0.13	0.24
81	5	2	1.58	0.09	0.11	0.10	0.80	0.00	0.10	0.38	0.01	0.34	0.13	0.23
82	5	3	1.53	0.09	0.11	0.10	0.79	0.00	0.10	0.39	0.01	0.34	0.13	0.23
83	5	4	1.48	0.09	0.11	0.10	0.78	0.00	0.10	0.39	0.01	0.34	0.13	0.23
84	5	5	1.44	0.09	0.11	0.10	0.77	0.00	0.10	0.40	0.01	0.34	0.13	0.23

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 12
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ALGAE GROWTH RATE ATTEN FACTORS

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	LIGHT *	NITRGN *	PHSPRS *
85	5	6	1.39	0.09	0.11	0.10	0.77	0.00	0.10	0.40	0.01	0.34	0.12	0.23
86	5	7	1.34	0.09	0.11	0.10	0.76	0.00	0.10	0.41	0.01	0.34	0.12	0.23
87	5	8	1.30	0.09	0.11	0.10	0.75	0.00	0.10	0.41	0.01	0.34	0.12	0.23
88	5	9	1.26	0.08	0.11	0.10	0.75	0.00	0.10	0.42	0.01	0.34	0.12	0.23
89	5	10	1.22	0.08	0.11	0.10	0.74	0.00	0.10	0.42	0.01	0.34	0.12	0.23
90	5	11	1.18	0.08	0.11	0.10	0.74	0.00	0.10	0.43	0.01	0.34	0.12	0.23
91	5	12	1.14	0.08	0.11	0.10	0.73	0.00	0.10	0.43	0.01	0.34	0.12	0.23
92	5	13	1.10	0.08	0.11	0.10	0.73	0.00	0.10	0.43	0.01	0.34	0.12	0.22
93	5	14	1.06	0.08	0.11	0.10	0.72	0.00	0.10	0.44				

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 0.01           0.34     0.12     0.22
 94   5  15         1.03     0.08     0.11     0.10     0.72     0.00         0.10     0.44
 0.01           0.34     0.12     0.22
 95   5  16         0.99     0.08     0.11     0.10     0.71     0.00         0.10     0.44
 0.01           0.34     0.12     0.22
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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 13
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	68.25	8.86	6.64	2.22	0.00	0.98	38.11	1.45	-0.05	-0.90	0.05	0.00	0.00
2	1	2	68.41	8.84	6.45	2.40	0.00	0.98	0.00	1.57	-0.05	-0.90	0.05	0.00	0.00
3	1	3	68.52	8.83	6.27	2.56	0.00	0.98	0.00	1.67	-0.05	-0.90	0.05	0.00	0.00
4	1	4	68.60	8.83	6.12	2.70	0.00	0.97	0.00	1.77	-0.05	-0.90	0.06	0.00	0.00
5	1	5	68.65	8.82	5.98	2.84	0.00	0.97	0.00	1.86	-0.05	-0.90	0.06	0.00	0.00
6	1	6	68.69	8.82	5.86	2.95	0.00	0.97	0.00	1.94	-0.05	-0.90	0.06	0.00	0.00
7	1	7	68.71	8.81	5.75	3.06	0.00	0.97	0.00	2.01	-0.05	-0.90	0.07	0.00	0.00
8	1	8	68.73	8.81	5.66	3.16	0.00	0.97	0.00	2.07	-0.05	-0.90	0.07	0.00	0.00
9	1	9	68.74	8.81	5.57	3.24	0.00	0.96	0.00	2.13	-0.05	-0.90	0.08	0.00	0.00
10	1	10	68.75	8.81	5.50	3.31	0.00	0.96	0.00	2.18	-0.05	-0.90	0.08	0.00	0.00
11	1	11	68.75	8.81	5.43	3.38	0.00	0.96	0.00	2.22	-0.05	-0.90	0.09	0.00	0.00
12	1	12	68.75	8.81	5.37	3.44	0.00	0.96	0.00	2.26	-0.05	-0.90	0.09	0.00	0.00
13	1	13	68.76	8.81	5.32	3.49	0.00	0.96	0.00	2.29	-0.05	-0.90	0.10	0.00	0.00
14	1	14	68.76	8.81	5.27	3.54	0.00	0.96	0.00	2.32	-0.04	-0.90	0.10	0.00	0.00
15	1	15	68.76	8.81	5.23	3.58	0.00	0.96	0.00	2.35	-0.04	-0.90	0.11	0.00	0.00
16	1	16	68.76	8.81	5.20	3.61	0.00	0.96	0.00	2.37	-0.04	-0.90	0.11	0.00	0.00
17	1	17	68.76	8.81	5.17	3.64	0.00	0.96	0.00	2.39	-0.04	-0.90	0.12	0.00	0.00
18	1	18	68.76	8.81	5.14	3.66	0.00	0.95	0.00	2.41	-0.04	-0.90	0.13	0.00	0.00
19	1	19	68.76	8.81	5.12	3.69	0.00	0.95	0.00	2.42	-0.04	-0.90	0.13	0.00	0.00

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 20   2   1  68.73    8.81    5.10    3.71    0.00    0.95          1.78    2.44
-0.04   -1.00    0.13    0.00    0.00
 21   2   2  68.71    8.81    5.10    3.72    0.00    0.95          1.69    2.44
-0.04   -1.00    0.13    0.00    0.00
 22   2   3  68.70    8.82    5.10    3.71    0.00    0.95          1.61    2.43
-0.04   -1.00    0.13    0.00    0.00
 23   2   4  68.69    8.82    5.12    3.70    0.00    0.95          1.53    2.42
-0.04   -1.00    0.12    0.00    0.00
 24   2   5  68.69    8.82    5.14    3.67    0.00    0.95          1.47    2.41
-0.04   -1.00    0.12    0.00    0.00
 25   2   6  68.69    8.82    5.17    3.64    0.00    0.96          1.40    2.39
-0.04   -1.00    0.12    0.00    0.00
 26   2   7  68.69    8.82    5.21    3.61    0.00    0.96          1.35    2.37
-0.04   -1.00    0.12    0.00    0.00
 27   2   8  68.69    8.82    5.24    3.57    0.00    0.96          1.29    2.34
-0.04   -1.00    0.12    0.00    0.00
 28   2   9  68.69    8.82    5.28    3.53    0.00    0.96          1.25    2.32
-0.04   -1.00    0.12    0.00    0.00
 29   2  10  68.69    8.82    5.32    3.49    0.00    0.96          1.20    2.29
-0.04   -1.00    0.11    0.00    0.00
 30   2  11  68.70    8.82    5.36    3.45    0.00    0.96          1.16    2.27
-0.04   -1.00    0.11    0.00    0.00
 31   2  12  68.70    8.82    5.40    3.41    0.00    0.96          1.12    2.24
-0.04   -1.00    0.11    0.00    0.00
 32   2  13  68.70    8.82    5.44    3.37    0.00    0.96          1.08    2.21
-0.04   -1.00    0.11    0.00    0.00
 33   2  14  68.70    8.82    5.48    3.33    0.00    0.96          1.05    2.19
-0.04   -1.00    0.11    0.00    0.00
 34   2  15  68.70    8.82    5.52    3.29    0.00    0.96          1.02    2.16
-0.04   -1.00    0.11    0.00    0.00
 35   2  16  68.70    8.82    5.56    3.26    0.00    0.96          0.99    2.14
-0.04   -1.00    0.10    0.00    0.00
 36   2  17  68.71    8.82    5.60    3.22    0.00    0.97          0.96    2.11
-0.04   -1.00    0.10    0.00    0.00
 37   2  18  68.71    8.81    5.63    3.18    0.00    0.97          0.93    2.09
-0.04   -1.00    0.10    0.00    0.00
 38   2  19  68.71    8.81    5.67    3.14    0.00    0.97          0.91    2.06
-0.04   -1.00    0.10    0.00    0.00
 39   2  20  68.71    8.81    5.70    3.11    0.00    0.97          0.88    2.04
-0.04   -1.00    0.09    0.00    0.00


 40   3   1  68.74    8.81    5.55    3.26    0.00    0.96          0.67    2.14
-0.04   -1.77    0.09    0.00    0.00
 41   3   2  68.76    8.81    5.43    3.38    0.00    0.96          0.66    2.22
-0.04   -1.77    0.09    0.00    0.00
 42   3   3  68.77    8.81    5.32    3.49    0.00    0.96          0.65    2.29
-0.04   -1.77    0.09    0.00    0.00
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         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    14
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                   ***** STEADY STATE SIMULATION *****

                                                       ** DISSOLVED OXYGEN DATA **

                                                                    COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE              DO              DO     DAM     NIT
ORD NUM NUM    TEMP     SAT      DO     DEF   INPUT   INHIB      F-FNCTN   OXYGN
                NET
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			DEG-F	MG/L	MG/L	MG/L	MG/L	FACT	INPUT	REAIR	C-BOD	SOD	P-R	NH3-N	NO2-N
43	3	4	68.78	8.81	5.22	3.58	0.00	0.96	0.63	2.35	-0.04	-1.77	0.08	0.00	0.00
44	3	5	68.78	8.81	5.15	3.66	0.00	0.95	0.62	2.41	-0.04	-1.77	0.08	0.00	0.00
45	3	6	68.78	8.81	5.08	3.73	0.00	0.95	0.61	2.45	-0.04	-1.77	0.08	0.00	0.00
46	3	7	68.78	8.81	5.02	3.78	0.00	0.95	0.60	2.49	-0.04	-1.77	0.07	0.00	0.00
47	3	8	68.78	8.81	4.98	3.83	0.00	0.95	0.59	2.52	-0.04	-1.77	0.07	0.00	0.00
48	3	9	68.79	8.81	4.94	3.87	0.00	0.95	0.58	2.54	-0.04	-1.77	0.07	0.00	0.00
49	3	10	68.78	8.81	4.91	3.90	0.00	0.95	0.57	2.56	-0.04	-1.77	0.06	0.00	0.00
50	3	11	68.78	8.81	4.88	3.92	0.00	0.95	0.56	2.58	-0.04	-1.77	0.06	0.00	0.00
51	3	12	69.00	8.79	5.54	3.25	0.00	0.96	11.78	2.14	-0.08	-1.77	0.03	0.00	0.00
52	3	13	68.92	8.79	5.47	3.32	0.00	0.96	0.40	2.19	-0.08	-1.77	0.03	0.00	0.00
53	3	14	68.87	8.80	5.41	3.39	0.00	0.96	0.40	2.23	-0.08	-1.77	0.03	0.00	0.00
54	3	15	68.83	8.80	5.36	3.45	0.00	0.96	0.39	2.27	-0.08	-1.77	0.03	0.00	0.00
55	3	16	68.81	8.80	5.31	3.49	0.00	0.96	0.39	2.30	-0.08	-1.77	0.02	0.00	0.00
56	3	17	68.80	8.81	5.27	3.53	0.00	0.96	0.38	2.32	-0.08	-1.77	0.02	0.00	0.00
57	3	18	68.79	8.81	5.24	3.57	0.00	0.96	0.38	2.34	-0.08	-1.77	0.02	0.00	0.00
58	3	19	68.78	8.81	5.21	3.60	0.00	0.96	0.38	2.36	-0.07	-1.77	0.02	0.00	0.00
59	3	20	68.78	8.81	5.19	3.62	0.00	0.96	0.37	2.38	-0.07	-1.77	0.02	0.00	0.00
60	4	1	68.73	8.81	5.13	3.68	0.00	0.95	1.47	2.41	-0.07	-1.96	0.02	0.00	0.00
61	4	2	68.79	8.81	5.32	3.48	0.00	0.96	5.55	2.29	-0.08	-1.96	0.01	0.00	0.00
62	4	3	68.74	8.81	5.26	3.55	0.00	0.96	1.23	2.33	-0.08	-1.96	0.01	0.00	0.00
63	4	4	68.71	8.81	5.22	3.60	0.00	0.96	1.18	2.36	-0.08	-1.96	0.01	0.00	0.00
64	4	5	68.70	8.82	5.18	3.63	0.00	0.96	1.14	2.38	-0.08	-1.96	0.01	0.00	0.00
65	4	6	68.68	8.82	5.15	3.66	0.00	0.95	1.11	2.40	-0.08	-1.96	0.00	0.00	0.00
66	4	7	68.68	8.82	5.13	3.69	0.00	0.95	1.07	2.42	-0.07	-1.96	0.00	0.00	0.00
67	4	8	68.68	8.82	5.11	3.70	0.00	0.95	1.04	2.43	-0.07	-1.96	0.00	0.00	0.00
68	4	9	68.67	8.82	5.10	3.72	0.00	0.95	1.01	2.44	-0.07	-1.96	0.00	0.00	0.00
69	4	10	68.67	8.82	5.09	3.72	0.00	0.95	0.98	2.44	-0.07	-1.96	0.00	0.00	0.00
70	4	11	68.68	8.82	5.09	3.73	0.00	0.95	0.95	2.45	-0.07	-1.96	0.00	0.00	0.00
71	4	12	68.68	8.82	5.09	3.73	0.00	0.95	0.92	2.45	-0.07	-1.96	0.00	0.00	0.00

72	4	13	68.68	8.82	5.09	3.73	0.00	0.95	0.90	2.45	-0.07	-1.96	0.00	0.00	0.00
73	4	14	68.68	8.82	5.09	3.73	0.00	0.95	0.87	2.45	-0.07	-1.96	0.00	0.00	0.00
74	4	15	68.68	8.82	5.09	3.73	0.00	0.95	0.85	2.44	-0.07	-1.96	0.00	0.00	0.00
75	4	16	68.68	8.82	5.10	3.72	0.00	0.95	0.83	2.44	-0.06	-1.96	0.00	0.00	0.00
76	4	17	68.68	8.82	5.10	3.72	0.00	0.95	0.81	2.44	-0.06	-1.96	0.00	0.00	0.00
77	4	18	68.68	8.82	5.11	3.71	0.00	0.95	0.79	2.43	-0.06	-1.96	0.00	0.00	0.00
78	4	19	68.69	8.82	5.11	3.70	0.00	0.95	0.77	2.43	-0.06	-1.96	0.00	0.00	0.00
79	4	20	68.69	8.82	5.12	3.69	0.00	0.95	0.76	2.42	-0.06	-1.96	0.00	0.00	0.00
80	5	1	68.70	8.82	5.06	3.75	0.00	0.95	0.03	2.46	-0.06	-2.24	0.00	0.00	0.00
81	5	2	68.71	8.81	5.01	3.81	0.00	0.95	0.03	2.50	-0.06	-2.24	0.00	0.00	0.00
82	5	3	68.72	8.81	4.96	3.85	0.00	0.95	0.03	2.53	-0.06	-2.24	0.00	0.00	0.00
83	5	4	68.72	8.81	4.92	3.90	0.00	0.95	0.03	2.56	-0.06	-2.24	0.00	0.00	0.00
84	5	5	68.73	8.81	4.88	3.94	0.00	0.95	0.03	2.58	-0.06	-2.24	0.00	0.00	0.00

♀

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 15
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
85	5	6	68.73	8.81	4.84	3.97	0.00	0.95	0.03	2.60	-0.06	-2.24	0.00	0.00	0.00
86	5	7	68.73	8.81	4.81	4.00	0.00	0.94	0.03	2.62	-0.06	-2.24	0.00	0.00	0.00
87	5	8	68.73	8.81	4.79	4.03	0.00	0.94	0.03	2.64	-0.06	-2.24	0.00	0.00	0.00
88	5	9	68.73	8.81	4.76	4.05	0.00	0.94	0.03	2.66	-0.06	-2.24	0.00	0.00	0.00
89	5	10	68.73	8.81	4.74	4.07	0.00	0.94	0.03	2.67	-0.06	-2.24	0.00	0.00	0.00
90	5	11	68.73	8.81	4.72	4.09	0.00	0.94	0.03	2.68	-0.06	-2.24	0.00	0.00	0.00
91	5	12	68.73	8.81	4.71	4.11	0.00	0.94	0.03	2.69	-0.05	-2.24	0.00	0.00	0.00
92	5	13	68.73	8.81	4.69	4.12	0.00	0.94	0.03	2.70	-0.05	-2.24	0.00	0.00	0.00
93	5	14	68.73	8.81	4.68	4.13	0.00	0.94	0.03	2.71	-0.05	-2.24	0.00	0.00	0.00

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 94   5  15   68.73     8.81     4.67     4.14     0.00     0.94            0.03     2.72
-0.05    -2.24     0.00     0.00     0.00
 95   5  16   68.73     8.81     4.66     4.15     0.00     0.94            0.03     2.73
-0.05    -2.24     0.00     0.00     0.00
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♀ * * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *
Version 3.22 -- May 1996

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-2E PROGRAM TITLES
TITLE01		Bonpas Creek DO TMDL ILEPA13A
TITLE02		Final calibration 9/22/15, low flow with WSS
TITLE03	NO	CONSERVATIVE MINERAL I
TITLE04	NO	CONSERVATIVE MINERAL II
TITLE05	NO	CONSERVATIVE MINERAL III
TITLE06	YES	TEMPERATURE
TITLE07	YES	5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08	YES	ALGAE AS CHL-A IN UG/L
TITLE09	YES	PHOSPHORUS CYCLE AS P IN MG/L
TITLE10		(ORGANIC-P; DISSOLVED-P)
TITLE11	YES	NITROGEN CYCLE AS N IN MG/L
TITLE12		(ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	FECAL COLIFORM IN NO./100 ML
TITLE15	NO	ARBITRARY NON-CONSERVATIVE
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE			CARD TYPE		
LIST DATA INPUT		0.00000			0.00000
NOWRITE OPTIONAL SUMMARY		0.00000			0.00000
NO FLOW AUGMENTATION		0.00000			0.00000
STEADY STATE		0.00000			0.00000
NO TRAPEZOIDAL CHANNELS		0.00000			0.00000
NO PRINT LCD/SOLAR DATA		0.00000			0.00000
NO PLOT DO AND BOD		0.00000			0.00000
FIXED DNSTM CONC (YES=1)=		0.00000	D-ULT BOD CONV K COEF	=	0.23000
INPUT METRIC	=	0.00000	UTPUT METRIC	=	0.00000
NUMBER OF REACHES	=	5.00000	UMBER OF JUNCTIONS	=	

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0.00000
         NUM OF HEADWATERS       =   1.00000         UMBER OF POINT LOADS   =
6.00000
         TIME STEP (HOURS)       =   1.00000         NTH. COMP. ELEMENT (MI)=
0.50000
         MAXIMUM ROUTE TIME (HRS)=  60.00000         IME INC. FOR RPT2 (HRS)=
1.00000
         LATITUDE OF BASIN (DEG) =  38.38000         ONGITUDE OF BASIN (DEG)=
-87.97000
         STANDARD MERIDIAN (DEG) =   0.00000         AY OF YEAR START TIME  =
264.00000
         EVAP. COEF.,(AE)        =   0.00068         VAP. COEF.,(BE)        =
0.00027
         ELEV. OF BASIN (ELEV)   = 373.00000         UST ATTENUATION COEF.  =
0.06000
         ENDATA1                     0.00000
0.00000

          $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

         CARD TYPE                                            CARD TYPE
         O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300           O UPTAKE BY NO2 OXID(MG
O/MG N)=    1.1400
         O PROD  BY ALGAE (MG O/MG A)   =    1.8000           O UPTAKE BY ALGAE (MG
O/MG A)  =    1.9000
         N CONTENT OF ALGAE (MG N/MG A) =    0.0900           P CONTENT OF ALGAE (MG
P/MG A) =    0.0140
         ALG MAX SPEC GROWTH RATE(1/DAY)=    2.0000           ALGAE RESPIRATION RATE
(1/DAY)=     0.1050
         N HALF SATURATION CONST (MG/L) =    0.0300           P HALF SATURATION CONST
 (MG/L)=    0.0050
         LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0030           NLIN
SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
         LIGHT FUNCTION OPTION (LFNOPT) =    2.0000           LIGHT SAT'N COEF
(BTU/FT2-MIN) =    0.6600
         DAILY AVERAGING OPTION (LAVOPT)=    3.0000           LIGHT AVERAGING FACTOR
(INT)  =    0.9000
         NUMBER OF DAYLIGHT HOURS (DLH) =   13.3000           TOTAL DAILY SOLR RAD
(BTU/FT-2)= 1500.0000
         ALGY GROWTH CALC OPTION(LGROPT)=    2.0000           ALGAL PREF FOR NH3-N
(PREFN)   =    0.1000
         ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500           NITRIFICATION
INHIBITION COEF  =    0.6000
         ENDATA1A                            0.0000
            0.0000

          $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS)
$$$

         CARD TYPE     RATE CODE     THETA VALUE

         THETA( 1)      BOD DECA        1.047     DFLT
         THETA( 2)      BOD SETT        1.024     DFLT
         THETA( 3)      OXY TRAN        1.024     DFLT
         THETA( 4)      SOD RATE        1.000     USER
         THETA( 5)      ORGN DEC        1.047     DFLT
         THETA( 6)      ORGN SET        1.024     DFLT
         THETA( 7)      NH3 DECA        1.083     DFLT
         THETA( 8)      NH3 SRCE        1.074     DFLT
         THETA( 9)      NO2 DECA        1.047     DFLT
         THETA(10)      PORG DEC        1.047     DFLT
         THETA(11)      PORG SET        1.024     DFLT
         THETA(12)      DISP SRC        1.074     DFLT
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         THETA(13)      ALG GROW        1.047     DFLT
         THETA(14)      ALG RESP        1.047     DFLT
         THETA(15)      ALG SETT        1.024     DFLT
         THETA(16)      COLI DEC        1.047     DFLT
         THETA(17)      ANC DECA        1.000     DFLT
         THETA(18)      ANC SETT        1.024     DFLT
         THETA(19)      ANC SRCE        1.000     DFLT
         ENDATA1B

          $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

         CARD TYPE           REACH ORDER AND IDENT              R. MI/KM
R. MI/KM
         STREAM REACH     1.0   RCH= Hdwtr, RM 38-4     FR         47.5    TO
  38.0
         STREAM REACH     2.0   RCH= RM 38.0 to 28.     FR         38.0    TO
  28.0
         STREAM REACH     3.0   RCH= RM 28.0 to 18.     FR         28.0    TO
  18.0
         STREAM REACH     4.0   RCH= RM 18.0 to 8.0     FR         28.0    TO
   8.0
         STREAM REACH     5.0   RCH= RM 8.0 to 0.0      FR          8.0    TO
   0.0
         ENDATA2          0.0                                       0.0
   0.0

          $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

         CARD TYPE                  REACH  AVAIL HDWS TARGET     ORDER OF AVAIL
SOURCES
         ENDATA3                     0.         0.       0.0   0.   0.   0.   0.   0.
  0.

          $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

         CARD TYPE        REACH ELEMENTS/REACH             COMPUTATIONAL FLAGS
         FLAG FIELD        1.       19.
1.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.0.
         FLAG FIELD        2.       20.
2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
         FLAG FIELD        3.       20.
2.2.2.2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.
         FLAG FIELD        4.       20.
2.6.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.6.2.
         FLAG FIELD        5.       16.
6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.
         ENDATA4           0.        0.
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

          $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

         CARD TYPE        REACH  COEF-DSPN  COEFQV    EXPOQV    COEFQH   EXPOQH
CMANN
         HYDRAULICS        1.    100.00     0.083     0.000     0.350     0.000
0.020
         HYDRAULICS        2.    100.00     0.083     0.000     0.350     0.000
0.020
         HYDRAULICS        3.    100.00     0.104     0.000     0.500     0.000
0.020
         HYDRAULICS        4.    100.00     0.078     0.000     0.450     0.000
0.020
         HYDRAULICS        5.    100.00     0.078     0.000     0.450     0.000
0.020
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         ENDATA5            0.      0.00     0.000     0.000     0.000     0.000
0.000

          $$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

         CARD TYPE                             DUST      CLOUD    DRY BULB  WET BULB
  ATM               SOLAR RAD
                         REACH   ELEVATION     COEF      COVER      TEMP      TEMP
PRESSURE     WIND   ATTENUATION
         TEMP/LCD           1.      451.00     0.06       0.90     76.10     53.00
 29.23       5.40      1.00
         TEMP/LCD           2.      415.00     0.06       0.90     76.10     53.00
 29.23       5.40      1.00
         TEMP/LCD           3.      393.00     0.06       0.90     76.10     53.00
 29.23       5.40      1.00
         TEMP/LCD           4.      379.00     0.06       0.90     76.10     53.00
 29.23       5.40      1.00
         TEMP/LCD           5.      374.00     0.06       0.90     76.10     53.00
 29.23       5.40      1.00
         ENDATA5A           0.        0.00     0.00       0.00      0.00      0.00
  0.00       0.00      0.00

          $$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION)
$$$

         CARD TYPE        REACH     K1         K3        SOD          K2OPT     K2
COEQK2    OR   EXPQK2
                                                         RATE
TSIV COEF  OR    SLOPE

FOR OPT 8      FOR OPT 8
         REACT COEF         1.      0.05       0.00      0.017          1.      0.65
 0.000       0.00000
         REACT COEF         2.      0.05       0.00      0.019          1.      0.65
 0.000       0.00000
         REACT COEF         3.      0.05       0.00      0.030          1.      0.65
 0.000       0.00000
         REACT COEF         4.      0.05       0.00      0.035          1.      0.65
 0.000       0.00000
         REACT COEF         5.      0.05       0.00      0.040          1.      0.65
 0.000       0.00000
         ENDATA6            0.      0.00       0.00      0.000          0.      0.00
 0.000       0.00000

           $$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

         CARD TYPE             REACH    CKNH2     SETNH2      CKNH3       SNH3      CKNO2
   CKPORG   SETPORG     SPO4
         N AND P COEF             1.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00       0.00
         N AND P COEF             2.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00       0.00
         N AND P COEF             3.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00       0.00
         N AND P COEF             4.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00       0.00
         N AND P COEF             5.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00       0.00
         ENDATA6A                 0.      0.00       0.00       0.00       0.00       0.00
    0.00       0.00       0.00

          $$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$
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CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALGAE/OTHER	1.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	2.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	3.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	4.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ALGAE/OTHER	5.	50.00	0.10	0.01	0.00	0.00	0.00	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	63.50	4.80	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	63.50	4.80	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	3.	64.40	4.55	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	4.	63.10	3.50	1.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	5.	63.10	3.50	1.00	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.27	0.81	0.00	0.00	0.03	0.00	0.04
INITIAL COND-2	2.	2.27	0.81	0.00	0.00	0.03	0.00	0.04
INITIAL COND-2	3.	8.14	0.71	0.00	0.00	0.00	0.00	0.01
INITIAL COND-2	4.	0.50	0.97	0.03	0.00	0.00	0.00	0.01
INITIAL COND-2	5.	0.50	0.97	0.03	0.00	0.06	0.00	0.06
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	63.50	6.00	1.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.030	63.50	6.00	1.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.020	64.40	6.00	1.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.040	63.10	6.00	1.00	0.00	0.00	0.00	0.00	0.00

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        INCR INFLOW-1          5.     0.000     63.10      6.00      1.00      0.00
    0.00      0.00      0.00      0.00
        ENDATA8                0.     0.000      0.00      0.00      0.00      0.00
    0.00      0.00      0.00      0.00

         $$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A,
NITROGEN, AND PHOSPHORUS) $$$

        CARD TYPE            REACH    CHL-A     ORG-N     NH3-N     NO2-N     NO3-N
   ORG-P     DIS-P
        INCR INFLOW-2          1.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
        INCR INFLOW-2          2.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
        INCR INFLOW-2          3.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
        INCR INFLOW-2          4.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
        INCR INFLOW-2          5.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
        ENDATA8A               0.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00

         $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

        CARD TYPE               JUNCTION ORDER AND IDENT         UPSTRM   JUNCTION
 TRIB
        ENDATA9                 0.                                 0.         0.
  0.

         $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

        CARD TYPE    HDWTR     NAME                 FLOW      TEMP      D.O.       BOD
     CM-1      CM-2      CM-3
                     ORDER
        HDWTR-NFK      1.         BonpasCK       0.03     63.50      4.80      1.00
     0.00      0.00      0.00
        ENDATA10       0.                        0.00      0.00      0.00      0.00
     0.00      0.00      0.00

         $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN,
PHOSPHORUS,
                             COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

        CARD TYPE     HDWTR     ANC     COLI    CHL-A    ORG-N    NH3-N    NO2-N
NO3-N    ORG-P    DIS-P
                      ORDER
        HEADWTR-2       1.     0.00 0.00E+00     2.70     0.81     0.00     0.03
 0.10     0.00     0.08
        ENDATA10A       0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

         $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

                      POINT
        CARD TYPE       LOAD    NAME                 EFF      FLOW     TEMP     D.O.
 BOD     CM-1     CM-2     CM-3
                      ORDER
        POINTLD-1       1.     Claremont          0.00      0.00    70.00     7.90
4.00     0.00     0.00      0.00
        POINTLD-1       2.     WstSalemN          0.00      0.07    70.00     7.40
4.00     0.00     0.00      0.00
        POINTLD-1       3.     WstSalemS          0.00      0.04    70.00     7.40
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4.00      0.00     0.00      0.00
         POINTLD-1      4.     VigoCoal        0.00     0.00    70.00     7.90
0.00      0.00     0.00      0.00
         POINTLD-1      5.     Bellmont        0.00     0.00    70.00     7.90
4.00      0.00     0.00      0.00
         POINTLD-1      6.    BrownsStp        0.00     0.00    70.00     7.90
4.00      0.00     0.00      0.00
         ENDATA11       0.                     0.00     0.00     0.00     0.00
0.00      0.00     0.00      0.00

          $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN,
PHOSPHORUS,
                              COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT)
$$$

                        POINT
         CARD TYPE       LOAD     ANC     COLI    CHL-A    ORG-N    NH3-N    NO2-N
N03-N    ORG-P    DIS-P
                        ORDER
         POINTLD-2       1.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       2.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       3.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       4.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       5.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       6.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         ENDATA11A       0.      0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

          $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

                                DAM   RCH   ELE    ADAM    BDAM    FDAM    HDAM

         ENDATA12                  0.    0.    0.    0.00    0.00    0.00    0.00

          $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

              CARD TYPE               TEMP       D.O.      BOD       CM-1      CM-2
    CM-3       ANC      COLI

         ENDATA13                     DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED

          $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

              CARD TYPE               CHL-A     ORG-N     NH3-N     NO2-N     NH3-N
   ORG-P     DIS-P

         ENDATA13A                    DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED
♀
♀
 STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
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                        NUMBER OF
         ITERATION   NONCONVERGENT
                        ELEMENTS
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1	95
2	0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 947.366 BTU/FT-2 (257.087 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 12.0

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	10.47	9	100.10	17	0.00
2	42.46	10	74.49	18	0.00
3	73.00	11	44.13	19	0.00
4	98.92	12	11.59	20	0.00
5	117.78	13	0.00	21	0.00
6	127.81	14	0.00	22	0.00
7	128.07	15	0.00	23	0.00
8	118.54	16	0.00	24	0.00

♀

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	95
ALGAE GROWTH RATE	2	95
ALGAE GROWTH RATE	3	95
ALGAE GROWTH RATE	4	94
ALGAE GROWTH RATE	5	90
ALGAE GROWTH RATE	6	70
ALGAE GROWTH RATE	7	13
ALGAE GROWTH RATE	8	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	9	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
----

1. LIGHT AVERAGING OPTION. LAVOPT= 3

METHOD: AVERAGE OF HOURLY SOLAR VALUES

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 947.366 BTU/FT-2 (257.087 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 12.0
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): N/A

HOURLY VALUES OF SOLAR RADIATION (LANGLEYS)

1	2.84	9	27.16	17	0.00
2	11.52	10	20.22	18	0.00
3	19.81	11	11.98	19	0.00

4	26.84	12	3.14	20	0.00
5	31.96	13	0.00	21	0.00
6	34.69	14	0.00	22	0.00
7	34.76	15	0.00	23	0.00
8	32.17	16	0.00	24	0.00

2. LIGHT FUNCTION OPTION: LFNOPT= 2

SMITH FUNCTION, WITH 71% IMAX = 0.179 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 2

MINIMUM OF NITROGEN, PHOSPHORUS: FL*MIN(FN,FP)

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER   1
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	47.50	47.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
2	1	2	47.00	46.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
3	1	3	46.50	46.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
4	1	4	46.00	45.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
5	1	5	45.50	45.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
6	1	6	45.00	44.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
7	1	7	44.50	44.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
8	1	8	44.00	43.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
9	1	9	43.50	43.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
10	1	10	43.00	42.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
11	1	11	42.50	42.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
12	1	12	42.00	41.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
13	1	13	41.50	41.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
14	1	14	41.00	40.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
15	1	15	40.50	40.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26

16	1	16	40.00	39.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
17	1	17	39.50	39.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
18	1	18	39.00	38.50	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
19	1	19	38.50	38.00	0.03	0.00	0.00	0.083	0.368	0.350	1.033	0.95	4.57	0.36	0.26
20	2	1	38.00	37.50	0.03	0.00	0.00	0.083	0.368	0.350	1.084	1.00	4.71	0.38	0.26
21	2	2	37.50	37.00	0.03	0.00	0.00	0.083	0.368	0.350	1.136	1.05	4.85	0.40	0.26
22	2	3	37.00	36.50	0.03	0.00	0.00	0.083	0.368	0.350	1.188	1.10	4.98	0.42	0.26
23	2	4	36.50	36.00	0.04	0.00	0.00	0.083	0.368	0.350	1.239	1.15	5.12	0.43	0.26
24	2	5	36.00	35.50	0.04	0.00	0.00	0.083	0.368	0.350	1.291	1.19	5.26	0.45	0.26
25	2	6	35.50	35.00	0.04	0.00	0.00	0.083	0.368	0.350	1.343	1.24	5.39	0.47	0.26
26	2	7	35.00	34.50	0.04	0.00	0.00	0.083	0.368	0.350	1.394	1.29	5.53	0.49	0.26
27	2	8	34.50	34.00	0.04	0.00	0.00	0.083	0.368	0.350	1.446	1.34	5.66	0.51	0.26
28	2	9	34.00	33.50	0.04	0.00	0.00	0.083	0.368	0.350	1.497	1.38	5.80	0.52	0.26
29	2	10	33.50	33.00	0.04	0.00	0.00	0.083	0.368	0.350	1.549	1.43	5.94	0.54	0.26
30	2	11	33.00	32.50	0.05	0.00	0.00	0.083	0.368	0.350	1.601	1.48	6.07	0.56	0.26
31	2	12	32.50	32.00	0.05	0.00	0.00	0.083	0.368	0.350	1.652	1.53	6.21	0.58	0.26
32	2	13	32.00	31.50	0.05	0.00	0.00	0.083	0.368	0.350	1.704	1.57	6.35	0.60	0.26
33	2	14	31.50	31.00	0.05	0.00	0.00	0.083	0.368	0.350	1.756	1.62	6.48	0.61	0.26
34	2	15	31.00	30.50	0.05	0.00	0.00	0.083	0.368	0.350	1.807	1.67	6.62	0.63	0.26
35	2	16	30.50	30.00	0.05	0.00	0.00	0.083	0.368	0.350	1.859	1.72	6.76	0.65	0.26
36	2	17	30.00	29.50	0.06	0.00	0.00	0.083	0.368	0.350	1.910	1.77	6.89	0.67	0.26
37	2	18	29.50	29.00	0.06	0.00	0.00	0.083	0.368	0.350	1.962	1.81	7.03	0.69	0.26
38	2	19	29.00	28.50	0.06	0.00	0.00	0.083	0.368	0.350	2.014	1.86	7.16	0.70	0.26
39	2	20	28.50	28.00	0.06	0.00	0.00	0.083	0.368	0.350	2.065	1.91	7.30	0.72	0.26
40	3	1	28.00	27.50	0.06	0.00	0.00	0.104	0.294	0.500	1.173	1.55	5.74	0.59	0.45
41	3	2	27.50	27.00	0.06	0.00	0.00	0.104	0.294	0.500	1.192	1.57	5.79	0.60	0.45
42	3	3	27.00	26.50	0.06	0.00	0.00	0.104	0.294	0.500	1.212	1.60	5.84	0.61	0.45

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 2
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
43	3	4	26.50	26.00	0.06	0.00	0.00	0.104	0.294	0.500	1.231	1.62	5.89	0.62	0.45
44	3	5	26.00	25.50	0.06	0.00	0.00	0.104	0.294	0.500	1.250	1.65	5.94	0.62	0.45
45	3	6	25.50	25.00	0.07	0.00	0.00	0.104	0.294	0.500	1.269	1.68	5.99	0.63	0.45
46	3	7	25.00	24.50	0.07	0.00	0.00	0.104	0.294	0.500	1.288	1.70	6.04	0.64	0.45
47	3	8	24.50	24.00	0.07	0.00	0.00	0.104	0.294	0.500	1.308	1.73	6.09	0.65	0.45
48	3	9	24.00	23.50	0.07	0.00	0.00	0.104	0.294	0.500	1.327	1.75	6.14	0.66	0.45
49	3	10	23.50	23.00	0.07	0.00	0.00	0.104	0.294	0.500	1.346	1.78	6.19	0.67	0.45
50	3	11	23.00	22.50	0.07	0.00	0.00	0.104	0.294	0.500	1.365	1.80	6.24	0.68	0.45
51	3	12	22.50	22.00	0.14	0.07	0.00	0.104	0.294	0.500	2.731	3.60	9.85	1.37	0.45
52	3	13	22.00	21.50	0.14	0.00	0.00	0.104	0.294	0.500	2.750	3.63	9.90	1.38	0.45
53	3	14	21.50	21.00	0.14	0.00	0.00	0.104	0.294	0.500	2.769	3.66	9.95	1.38	0.45
54	3	15	21.00	20.50	0.15	0.00	0.00	0.104	0.294	0.500	2.788	3.68	10.00	1.39	0.45
55	3	16	20.50	20.00	0.15	0.00	0.00	0.104	0.294	0.500	2.808	3.71	10.05	1.40	0.45
56	3	17	20.00	19.50	0.15	0.00	0.00	0.104	0.294	0.500	2.827	3.73	10.10	1.41	0.45
57	3	18	19.50	19.00	0.15	0.00	0.00	0.104	0.294	0.500	2.846	3.76	10.15	1.42	0.45
58	3	19	19.00	18.50	0.15	0.00	0.00	0.104	0.294	0.500	2.865	3.78	10.20	1.43	0.45
59	3	20	18.50	18.00	0.15	0.00	0.00	0.104	0.294	0.500	2.885	3.81	10.26	1.44	0.45
60	4	1	28.00	27.50	0.15	0.00	0.00	0.078	0.392	0.450	4.330	5.14	13.81	1.95	0.31
61	4	2	27.50	27.00	0.19	0.04	0.00	0.078	0.392	0.450	5.442	6.46	16.74	2.45	0.31
62	4	3	27.00	26.50	0.19	0.00	0.00	0.078	0.392	0.450	5.499	6.53	16.89	2.47	0.31
63	4	4	26.50	26.00	0.20	0.00	0.00	0.078	0.392	0.450	5.556	6.60	17.04	2.50	0.31
64	4	5	26.00	25.50	0.20	0.00	0.00	0.078	0.392	0.450	5.613	6.67	17.19	2.53	0.31
65	4	6	25.50	25.00	0.20	0.00	0.00	0.078	0.392	0.450	5.670	6.74	17.34	2.55	0.31
66	4	7	25.00	24.50	0.20	0.00	0.00	0.078	0.392	0.450	5.726	6.80	17.49	2.58	0.31
67	4	8	24.50	24.00	0.20	0.00	0.00	0.078	0.392	0.450	5.783	6.87	17.64	2.60	0.31

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 68   4   9   24.00   23.50    0.21    0.00    0.00   0.078   0.392    0.450
5.840        6.94       17.79         2.63     0.31
 69   4  10   23.50   23.00    0.21    0.00    0.00   0.078   0.392    0.450
5.897        7.01       17.95         2.65     0.31
 70   4  11   23.00   22.50    0.21    0.00    0.00   0.078   0.392    0.450
5.954        7.07       18.10         2.68     0.31
 71   4  12   22.50   22.00    0.21    0.00    0.00   0.078   0.392    0.450
6.011        7.14       18.25         2.71     0.31
 72   4  13   22.00   21.50    0.21    0.00    0.00   0.078   0.392    0.450
6.068        7.21       18.40         2.73     0.31
 73   4  14   21.50   21.00    0.22    0.00    0.00   0.078   0.392    0.450
6.125        7.28       18.55         2.76     0.31
 74   4  15   21.00   20.50    0.22    0.00    0.00   0.078   0.392    0.450
6.182        7.34       18.70         2.78     0.31
 75   4  16   20.50   20.00    0.22    0.00    0.00   0.078   0.392    0.450
6.239        7.41       18.85         2.81     0.31
 76   4  17   20.00   19.50    0.22    0.00    0.00   0.078   0.392    0.450
6.296        7.48       19.00         2.83     0.31
 77   4  18   19.50   19.00    0.22    0.00    0.00   0.078   0.392    0.450
6.353        7.55       19.15         2.86     0.31
 78   4  19   19.00   18.50    0.23    0.00    0.00   0.078   0.392    0.450
6.410        7.62       19.30         2.88     0.31
 79   4  20   18.50   18.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31


 80   5   1    8.00    7.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 81   5   2    7.50    7.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 82   5   3    7.00    6.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 83   5   4    6.50    6.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 84   5   5    6.00    5.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     3
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                 ***** STEADY STATE SIMULATION *****

                                                      ** HYDRAULICS SUMMARY **

ELE RCH ELE   BEGIN     END            POINT    INCR            TRVL
                  BOTTOM      X-SECT   DSPRSN
ORD NUM NUM     LOC     LOC    FLOW    SRCE    FLOW     VEL    TIME    DEPTH
WIDTH     VOLUME        AREA         AREA     COEF
               MILE    MILE     CFS     CFS     CFS     FPS     DAY       FT
FT       K-FT-3      K-FT-2        FT-2   FT-2/S

 85   5   6    5.50    5.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 86   5   7    5.00    4.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 87   5   8    4.50    4.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 88   5   9    4.00    3.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 89   5  10    3.50    3.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 90   5  11    3.00    2.50    0.23    0.00    0.00   0.078   0.392    0.450
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6.467        7.68       19.45         2.91     0.31
 91   5  12    2.50    2.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 92   5  13    2.00    1.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 93   5  14    1.50    1.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 94   5  15    1.00    0.50    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31
 95   5  16    0.50    0.00    0.23    0.00    0.00   0.078   0.392    0.450
6.467        7.68       19.45         2.91     0.31


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     4
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                    ***** STEADY STATE SIMULATION *****

                                                    ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L       1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  1   1   9.17   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.75
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   2   9.11   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   3   9.09   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   4   9.09   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   5   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   6   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   7   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   8   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   9   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  10   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  11   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  12   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  13   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  14   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  15   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  16   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  17   9.08   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
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  1  18   9.08   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  19   9.08   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  2   1   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   2   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   3   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   4   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   5   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   6   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   7   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   8   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   9   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  10   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  11   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.78
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  12   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.79
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  13   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.79
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  14   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.79
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  15   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.79
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  16   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.79
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  17   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.80
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  18   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.80
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  19   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.80
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  20   9.09   1    0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.80
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  3   1   9.09   1    0.63   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.79
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   2   9.09   1    0.63   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.77
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   3   9.09   1    0.63   0.05   0.00   0.03   0.00   0.00   0.01   0.00   1.75
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     5
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                   ***** STEADY STATE SIMULATION *****

                                                   ** REACTION COEFFICIENT SUMMARY **
```

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
3	4	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	5	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	6	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	8	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	10	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11	9.09	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	12	8.97	1	0.64	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	13	9.03	1	0.64	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	14	9.06	1	0.64	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	15	9.07	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	16	9.08	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	17	9.08	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	18	9.08	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	19	9.08	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	20	9.08	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	9.09	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	9.05	1	0.64	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	9.07	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	9.08	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	9.08	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	6	9.08	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7	9.09	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	8	9.09	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	9	9.09	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	10	9.09	1	0.63	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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  4  11   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  12   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  13   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  14   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  15   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  16   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  17   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  18   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  19   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  20   9.09   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.73
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  5   1   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.71
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   2   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.70
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   3   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.69
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   4   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.68
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   5   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     6
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                         ***** STEADY STATE SIMULATION *****

                                                         ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
         MG/L        1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  5   6   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   7   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   8   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   9   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  10   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  11   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  12   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  13   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.64
```

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0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  14   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  15   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  16   9.08   1   0.63   0.05   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     7
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                 ***** STEADY STATE SIMULATION *****

                                                    ** WATER QUALITY VARIABLES **

RCH ELE                CM-1   CM-2   CM-3
                                     ANC
NUM NUM         TEMP                        DO     BOD    ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP   DIS-P   SUM-P   COLI          CHLA
               DEG-F                        MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L    MG/L    MG/L #/100ML         UG/L

  1   1      65.14   0.00   0.00   0.00   4.74   0.98   0.81   0.00   0.02   0.11
0.94   0.00   0.08   0.08.00E+00   0.00   2.76
  1   2      65.71   0.00   0.00   0.00   4.68   0.97   0.81   0.00   0.01   0.12
0.94   0.00   0.08   0.08.00E+00   0.00   2.84
  1   3      65.91   0.00   0.00   0.00   4.64   0.95   0.81   0.00   0.01   0.12
0.94   0.00   0.08   0.08.00E+00   0.00   2.92
  1   4      65.98   0.00   0.00   0.00   4.61   0.93   0.81   0.00   0.00   0.12
0.94   0.00   0.08   0.08.00E+00   0.00   3.01
  1   5      66.01   0.00   0.00   0.00   4.59   0.92   0.81   0.00   0.00   0.12
0.94   0.00   0.08   0.08.00E+00   0.00   3.09
  1   6      66.02   0.00   0.00   0.00   4.57   0.90   0.81   0.00   0.00   0.12
0.94   0.00   0.08   0.08.00E+00   0.00   3.19
  1   7      66.02   0.00   0.00   0.00   4.56   0.89   0.81   0.00   0.00   0.12
0.94   0.00   0.08   0.08.00E+00   0.00   3.28
  1   8      66.02   0.00   0.00   0.00   4.55   0.87   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.37
  1   9      66.02   0.00   0.00   0.00   4.54   0.86   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.47
  1  10      66.02   0.00   0.00   0.00   4.54   0.84   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.57
  1  11      66.02   0.00   0.00   0.00   4.53   0.83   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.67
  1  12      66.02   0.00   0.00   0.00   4.53   0.81   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.77
  1  13      66.02   0.00   0.00   0.00   4.53   0.80   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.88
  1  14      66.02   0.00   0.00   0.00   4.53   0.78   0.81   0.00   0.00   0.12
0.93   0.00   0.08   0.08.00E+00   0.00   3.98
  1  15      66.02   0.00   0.00   0.00   4.53   0.77   0.81   0.00   0.00   0.11
0.93   0.00   0.08   0.08.00E+00   0.00   4.09
  1  16      66.02   0.00   0.00   0.00   4.53   0.76   0.81   0.00   0.00   0.11
0.93   0.00   0.08   0.08.00E+00   0.00   4.20
  1  17      66.02   0.00   0.00   0.00   4.53   0.75   0.81   0.00   0.00   0.11
0.93   0.00   0.08   0.08.00E+00   0.00   4.31
  1  18      66.02   0.00   0.00   0.00   4.53   0.73   0.81   0.00   0.00   0.11
0.93   0.00   0.08   0.08.00E+00   0.00   4.42
  1  19      66.02   0.00   0.00   0.00   4.53   0.72   0.81   0.00   0.00   0.11
0.92   0.00   0.08   0.08.00E+00   0.00   4.53
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  2   1      65.97   0.00   0.00   0.00   4.49   0.72   0.78   0.00   0.00   0.10
0.88   0.00   0.07   0.07.00E+00   0.00   4.41
  2   2      65.96   0.00   0.00   0.00   4.47   0.72   0.74   0.00   0.00   0.10
0.84   0.00   0.07   0.07.00E+00   0.00   4.29
  2   3      65.96   0.00   0.00   0.00   4.47   0.72   0.71   0.00   0.00   0.09
0.80   0.00   0.07   0.07.00E+00   0.00   4.18
  2   4      65.96   0.00   0.00   0.00   4.48   0.72   0.68   0.00   0.00   0.09
0.77   0.00   0.06   0.06.00E+00   0.00   4.07
  2   5      65.96   0.00   0.00   0.00   4.49   0.72   0.65   0.00   0.00   0.08
0.74   0.00   0.06   0.06.00E+00   0.00   3.96
  2   6      65.96   0.00   0.00   0.00   4.52   0.72   0.63   0.00   0.00   0.08
0.71   0.00   0.06   0.06.00E+00   0.00   3.85
  2   7      65.96   0.00   0.00   0.00   4.55   0.72   0.60   0.00   0.00   0.07
0.68   0.00   0.06   0.06.00E+00   0.00   3.74
  2   8      65.96   0.00   0.00   0.00   4.58   0.71   0.58   0.00   0.00   0.07
0.65   0.00   0.05   0.05.00E+00   0.00   3.63
  2   9      65.97   0.00   0.00   0.00   4.61   0.71   0.56   0.00   0.00   0.07
0.63   0.00   0.05   0.05.00E+00   0.00   3.53
  2  10      65.97   0.00   0.00   0.00   4.64   0.71   0.55   0.00   0.00   0.06
0.61   0.00   0.05   0.05.00E+00   0.00   3.42
  2  11      65.97   0.00   0.00   0.00   4.68   0.71   0.53   0.00   0.00   0.06
0.59   0.00   0.05   0.05.00E+00   0.00   3.31
  2  12      65.97   0.00   0.00   0.00   4.71   0.70   0.51   0.00   0.00   0.06
0.57   0.00   0.05   0.05.00E+00   0.00   3.20
  2  13      65.97   0.00   0.00   0.00   4.74   0.70   0.50   0.00   0.00   0.06
0.55   0.00   0.04   0.05.00E+00   0.00   3.10
  2  14      65.97   0.00   0.00   0.00   4.78   0.70   0.48   0.00   0.00   0.05
0.54   0.00   0.04   0.04.00E+00   0.00   2.99
  2  15      65.97   0.00   0.00   0.00   4.81   0.69   0.47   0.00   0.00   0.05
0.52   0.00   0.04   0.04.00E+00   0.00   2.88
  2  16      65.97   0.00   0.00   0.00   4.84   0.69   0.46   0.00   0.00   0.05
0.50   0.00   0.04   0.04.00E+00   0.00   2.78
  2  17      65.98   0.00   0.00   0.00   4.86   0.69   0.44   0.00   0.00   0.05
0.49   0.00   0.04   0.04.00E+00   0.00   2.67
  2  18      65.98   0.00   0.00   0.00   4.89   0.68   0.43   0.00   0.00   0.05
0.48   0.00   0.04   0.04.00E+00   0.00   2.57
  2  19      65.98   0.00   0.00   0.00   4.92   0.68   0.42   0.00   0.00   0.04
0.46   0.00   0.04   0.04.00E+00   0.00   2.47
  2  20      65.98   0.00   0.00   0.00   4.94   0.68   0.41   0.00   0.00   0.04
0.45   0.00   0.04   0.04.00E+00   0.00   2.37


  3   1      65.98   0.00   0.00   0.00   4.71   0.67   0.40   0.00   0.00   0.04
0.45   0.00   0.04   0.04.00E+00   0.00   2.35
  3   2      65.98   0.00   0.00   0.00   4.43   0.67   0.40   0.00   0.00   0.04
0.44   0.00   0.04   0.04.00E+00   0.00   2.33
  3   3      65.98   0.00   0.00   0.00   4.21   0.66   0.39   0.00   0.00   0.04
0.43   0.00   0.03   0.04.00E+00   0.00   2.31
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     8
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                  ***** STEADY STATE SIMULATION *****

                                                     ** WATER QUALITY VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                   ANC
NUM NUM       TEMP                             DO     BOD    ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI             CHLA
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                DEG-F                              MG/L    MG/L    MG/L    MG/L    MG/L    MG/L
MG/L    MG/L    MG/L    MG/L #/100ML               UG/L

  3   4         65.98   0.00   0.00    0.00    4.03    0.66    0.39    0.00    0.00    0.04
0.42    0.00    0.03    0.03.00E+00    0.00    2.29
  3   5         65.98   0.00   0.00    0.00    3.89    0.66    0.38    0.00    0.00    0.04
0.42    0.00    0.03    0.03.00E+00    0.00    2.27
  3   6         65.98   0.00   0.00    0.00    3.78    0.65    0.37    0.00    0.00    0.04
0.41    0.00    0.03    0.03.00E+00    0.00    2.25
  3   7         65.98   0.00   0.00    0.00    3.69    0.65    0.37    0.00    0.00    0.04
0.40    0.00    0.03    0.03.00E+00    0.00    2.22
  3   8         65.98   0.00   0.00    0.00    3.63    0.64    0.36    0.00    0.00    0.03
0.40    0.00    0.03    0.03.00E+00    0.00    2.19
  3   9         65.98   0.00   0.00    0.00    3.58    0.64    0.36    0.00    0.00    0.03
0.39    0.00    0.03    0.03.00E+00    0.00    2.16
  3  10         65.99   0.00   0.00    0.00    3.54    0.64    0.35    0.00    0.00    0.03
0.39    0.00    0.03    0.03.00E+00    0.00    2.13
  3  11         65.99   0.00   0.00    0.00    3.52    0.64    0.35    0.00    0.00    0.03
0.38    0.00    0.03    0.03.00E+00    0.00    2.10
  3  12         67.10   0.00   0.00    0.00    5.11    2.27    0.17    0.00    0.00    0.02
0.19    0.00    0.02    0.02.00E+00    0.00    1.03
  3  13         66.53   0.00   0.00    0.00    4.98    2.23    0.17    0.00    0.00    0.02
0.19    0.00    0.01    0.02.00E+00    0.00    0.99
  3  14         66.26   0.00   0.00    0.00    4.87    2.19    0.17    0.00    0.00    0.02
0.19    0.00    0.01    0.02.00E+00    0.00    0.96
  3  15         66.12   0.00   0.00    0.00    4.79    2.15    0.17    0.00    0.00    0.02
0.19    0.00    0.01    0.02.00E+00    0.00    0.92
  3  16         66.06   0.00   0.00    0.00    4.72    2.12    0.17    0.00    0.00    0.02
0.18    0.00    0.01    0.02.00E+00    0.00    0.89
  3  17         66.03   0.00   0.00    0.00    4.66    2.08    0.17    0.00    0.00    0.01
0.18    0.00    0.01    0.02.00E+00    0.00    0.86
  3  18         66.01   0.00   0.00    0.00    4.61    2.04    0.17    0.00    0.00    0.01
0.18    0.00    0.01    0.01.00E+00    0.00    0.83
  3  19         66.00   0.00   0.00    0.00    4.58    2.01    0.17    0.00    0.00    0.01
0.18    0.00    0.01    0.01.00E+00    0.00    0.79
  3  20         66.00   0.00   0.00    0.00    4.55    1.97    0.17    0.00    0.00    0.01
0.18    0.00    0.01    0.01.00E+00    0.00    0.76


  4   1         65.99   0.00   0.00    0.00    4.26    1.93    0.16    0.00    0.00    0.01
0.18    0.00    0.01    0.01.00E+00    0.00    0.72
  4   2         66.31   0.00   0.00    0.00    4.58    2.28    0.13    0.00    0.00    0.01
0.14    0.00    0.01    0.01.00E+00    0.00    0.54
  4   3         66.11   0.00   0.00    0.00    4.43    2.23    0.13    0.00    0.00    0.01
0.14    0.00    0.01    0.01.00E+00    0.00    0.51
  4   4         66.03   0.00   0.00    0.00    4.31    2.17    0.13    0.00    0.00    0.01
0.14    0.00    0.01    0.01.00E+00    0.00    0.47
  4   5         66.00   0.00   0.00    0.00    4.22    2.12    0.13    0.00    0.00    0.01
0.14    0.00    0.01    0.01.00E+00    0.00    0.44
  4   6         65.99   0.00   0.00    0.00    4.15    2.07    0.12    0.00    0.00    0.01
0.14    0.00    0.01    0.01.00E+00    0.00    0.41
  4   7         65.99   0.00   0.00    0.00    4.10    2.03    0.12    0.00    0.00    0.01
0.13    0.00    0.01    0.01.00E+00    0.00    0.38
  4   8         65.99   0.00   0.00    0.00    4.06    1.98    0.12    0.00    0.00    0.01
0.13    0.00    0.01    0.01.00E+00    0.00    0.35
  4   9         65.99   0.00   0.00    0.00    4.03    1.93    0.12    0.00    0.00    0.01
0.13    0.00    0.01    0.01.00E+00    0.00    0.32
  4  10         65.99   0.00   0.00    0.00    4.01    1.89    0.12    0.00    0.00    0.01
0.13    0.00    0.01    0.01.00E+00    0.00    0.30
  4  11         65.99   0.00   0.00    0.00    4.00    1.85    0.12    0.00    0.00    0.01
0.13    0.00    0.01    0.01.00E+00    0.00    0.28
  4  12         65.99   0.00   0.00    0.00    3.99    1.81    0.12    0.00    0.00    0.01
0.13    0.00    0.01    0.01.00E+00    0.00    0.26
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  4  13      65.99   0.00   0.00   0.00   3.98   1.77   0.12   0.00   0.00   0.01
0.13   0.00   0.01   0.01.00E+00   0.00   0.24
  4  14      65.99   0.00   0.00   0.00   3.98   1.73   0.12   0.00   0.00   0.01
0.13   0.00   0.01   0.01.00E+00   0.00   0.22
  4  15      65.99   0.00   0.00   0.00   3.98   1.69   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.21
  4  16      65.99   0.00   0.00   0.00   3.98   1.65   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  4  17      65.99   0.00   0.00   0.00   3.98   1.62   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.18
  4  18      65.99   0.00   0.00   0.00   3.99   1.58   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.16
  4  19      65.99   0.00   0.00   0.00   3.99   1.55   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.15
  4  20      65.99   0.00   0.00   0.00   4.00   1.51   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.14


  5   1      66.00   0.00   0.00   0.00   3.85   1.49   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.13
  5   2      66.00   0.00   0.00   0.00   3.74   1.46   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.12
  5   3      66.00   0.00   0.00   0.00   3.65   1.43   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.11
  5   4      66.00   0.00   0.00   0.00   3.57   1.41   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.10
  5   5      66.00   0.00   0.00   0.00   3.52   1.38   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.10
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     9
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                        ** WATER QUALITY VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                   ANC
NUM NUM        TEMP                         DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI          CHLA
              DEG-F                        MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML          UG/L

  5   6      66.00   0.00   0.00   0.00   3.47   1.36   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.09
  5   7      66.00   0.00   0.00   0.00   3.43   1.33   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.08
  5   8      66.00   0.00   0.00   0.00   3.40   1.31   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.08
  5   9      66.00   0.00   0.00   0.00   3.38   1.28   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.07
  5  10      66.00   0.00   0.00   0.00   3.36   1.26   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.07
  5  11      66.00   0.00   0.00   0.00   3.35   1.24   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.06
  5  12      66.00   0.00   0.00   0.00   3.34   1.21   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.06
  5  13      66.00   0.00   0.00   0.00   3.33   1.19   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.06
  5  14      66.00   0.00   0.00   0.00   3.33   1.17   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.05
  5  15      66.00   0.00   0.00   0.00   3.32   1.15   0.11   0.00   0.00   0.01
```

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0.12   0.00   0.01   0.01.00E+00   0.00   0.05
  5  16       66.00   0.00   0.00   0.00   3.32   1.13   0.11   0.00   0.00   0.01
0.12   0.00   0.01   0.01.00E+00   0.00   0.04


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    10
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                  ***** STEADY STATE SIMULATION *****

                                                           ** ALGAE DATA **

                                                                          NH3-N
         ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE              ALGY    ALGY    ALGY   A P/R     NET          NH3   FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH    RESP    SETT   RATIO     P-R         PREF  N-UPTKE
EXTCO        LIGHT   NITRGN   PHSPRS
                   UG/L   1/DAY   1/DAY   FT/DA      *   MG/L-D           *       *
 1/FT            *        *        *

  1   1   1        2.76    0.44    0.10    0.10    4.23    0.03          0.10    0.00
 0.02          0.30    0.79     0.94
  2   1   2        2.84    0.45    0.10    0.10    4.28    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  3   1   3        2.92    0.45    0.10    0.10    4.31    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  4   1   4        3.01    0.45    0.10    0.10    4.32    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  5   1   5        3.09    0.46    0.10    0.10    4.33    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  6   1   6        3.19    0.46    0.10    0.10    4.33    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  7   1   7        3.28    0.46    0.10    0.10    4.32    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  8   1   8        3.37    0.46    0.10    0.10    4.32    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
  9   1   9        3.47    0.45    0.10    0.10    4.31    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
 10   1  10        3.57    0.45    0.10    0.10    4.31    0.04          0.10    0.00
 0.02          0.30    0.80     0.94
 11   1  11        3.67    0.45    0.10    0.10    4.30    0.05          0.10    0.00
 0.02          0.30    0.80     0.94
 12   1  12        3.77    0.45    0.10    0.10    4.29    0.05          0.10    0.00
 0.02          0.30    0.80     0.94
 13   1  13        3.88    0.45    0.10    0.10    4.28    0.05          0.10    0.00
 0.02          0.30    0.80     0.94
 14   1  14        3.98    0.45    0.10    0.10    4.27    0.05          0.10    0.00
 0.02          0.30    0.79     0.94
 15   1  15        4.09    0.45    0.10    0.10    4.26    0.05          0.10    0.00
 0.02          0.30    0.79     0.94
 16   1  16        4.20    0.45    0.10    0.10    4.25    0.05          0.10    0.00
 0.02          0.30    0.79     0.94
 17   1  17        4.31    0.45    0.10    0.10    4.24    0.05          0.10    0.00
 0.02          0.30    0.79     0.94
 18   1  18        4.42    0.45    0.10    0.10    4.23    0.05          0.10    0.00
 0.02          0.30    0.79     0.94
 19   1  19        4.53    0.44    0.10    0.10    4.22    0.06          0.10    0.00
 0.02          0.30    0.79     0.94
```

20	2	1	4.41	0.44	0.10	0.10	4.17	0.05	0.10	0.00			
0.02											0.30	0.77	0.94
21	2	2	4.29	0.43	0.10	0.10	4.11	0.05	0.10	0.00			
0.02											0.30	0.76	0.93
22	2	3	4.18	0.43	0.10	0.10	4.05	0.05	0.10	0.00			
0.02											0.30	0.75	0.93
23	2	4	4.07	0.42	0.10	0.10	4.00	0.05	0.10	0.00			
0.02											0.30	0.74	0.93
24	2	5	3.96	0.41	0.10	0.10	3.94	0.04	0.10	0.00			
0.02											0.30	0.73	0.92
25	2	6	3.85	0.41	0.10	0.10	3.89	0.04	0.10	0.00			
0.02											0.30	0.72	0.92
26	2	7	3.74	0.40	0.10	0.10	3.83	0.04	0.10	0.00			
0.02											0.30	0.71	0.92
27	2	8	3.63	0.40	0.10	0.10	3.78	0.04	0.10	0.00			
0.02											0.30	0.70	0.91
28	2	9	3.53	0.39	0.10	0.10	3.72	0.04	0.10	0.00			
0.02											0.30	0.69	0.91
29	2	10	3.42	0.39	0.10	0.10	3.67	0.03	0.10	0.00			
0.02											0.30	0.68	0.91
30	2	11	3.31	0.38	0.10	0.10	3.61	0.03	0.10	0.00			
0.02											0.30	0.67	0.91
31	2	12	3.20	0.37	0.10	0.10	3.56	0.03	0.10	0.00			
0.02											0.30	0.66	0.90
32	2	13	3.10	0.37	0.10	0.10	3.51	0.03	0.10	0.00			
0.02											0.30	0.65	0.90
33	2	14	2.99	0.36	0.10	0.10	3.45	0.03	0.10	0.00			
0.02											0.30	0.64	0.90
34	2	15	2.88	0.36	0.10	0.10	3.40	0.03	0.10	0.00			
0.02											0.30	0.63	0.89
35	2	16	2.78	0.35	0.10	0.10	3.35	0.02	0.10	0.00			
0.02											0.30	0.62	0.89
36	2	17	2.67	0.35	0.10	0.10	3.30	0.02	0.10	0.00			
0.02											0.30	0.61	0.89
37	2	18	2.57	0.34	0.10	0.10	3.25	0.02	0.10	0.00			
0.02											0.30	0.60	0.89
38	2	19	2.47	0.34	0.10	0.10	3.20	0.02	0.10	0.00			
0.02											0.30	0.59	0.88
39	2	20	2.37	0.33	0.10	0.10	3.15	0.02	0.10	0.00			
0.02											0.30	0.59	0.88
40	3	1	2.35	0.33	0.10	0.10	3.11	0.02	0.10	0.00			
0.02											0.30	0.58	0.88
41	3	2	2.33	0.32	0.10	0.10	3.08	0.02	0.10	0.00			
0.02											0.30	0.57	0.88
42	3	3	2.31	0.32	0.10	0.10	3.04	0.02	0.10	0.00			
0.02											0.30	0.57	0.87

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 11
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

NH3-N

ALGAE GROWTH RATE ATTEN FACTORS

ELE RCH ELE ALGY ALGY ALGY A P/R NET NH3 FRACT
LIGHT
ORD NUM NUM CHLA GRWTH RESP SETT RATIO P-R PREF N-UPTKE
EXTCO LIGHT NITRGN PHSPRS

```
                  UG/L    1/DAY    1/DAY   FT/DA       *   MG/L-D          *        *
1/FT                *         *        *

43   3    4       2.29     0.32     0.10    0.10    3.01     0.02        0.10     0.00
0.02             0.30     0.56     0.87
44   3    5       2.27     0.31     0.10    0.10    2.98     0.02        0.10     0.00
0.02             0.30     0.55     0.87
45   3    6       2.25     0.31     0.10    0.10    2.94     0.02        0.10     0.00
0.02             0.30     0.55     0.87
46   3    7       2.22     0.31     0.10    0.10    2.91     0.02        0.10     0.00
0.02             0.30     0.54     0.87
47   3    8       2.19     0.30     0.10    0.10    2.88     0.02        0.10     0.00
0.02             0.30     0.53     0.86
48   3    9       2.16     0.30     0.10    0.10    2.84     0.02        0.10     0.00
0.02             0.30     0.53     0.86
49   3   10       2.13     0.30     0.10    0.10    2.81     0.01        0.10     0.00
0.02             0.30     0.52     0.86
50   3   11       2.10     0.29     0.10    0.10    2.78     0.01        0.10     0.00
0.02             0.30     0.52     0.86
51   3   12       1.03     0.20     0.10    0.10    1.87     0.00        0.10     0.00
0.01             0.30     0.35     0.75
52   3   13       0.99     0.20     0.10    0.10    1.85     0.00        0.10     0.00
0.01             0.30     0.34     0.75
53   3   14       0.96     0.19     0.10    0.10    1.84     0.00        0.10     0.00
0.01             0.30     0.34     0.75
54   3   15       0.92     0.19     0.10    0.10    1.82     0.00        0.10     0.00
0.01             0.30     0.34     0.75
55   3   16       0.89     0.19     0.10    0.10    1.80     0.00        0.10     0.00
0.01             0.30     0.34     0.75
56   3   17       0.86     0.19     0.10    0.10    1.79     0.00        0.10     0.00
0.01             0.30     0.33     0.74
57   3   18       0.83     0.19     0.10    0.10    1.78     0.00        0.10     0.00
0.01             0.30     0.33     0.74
58   3   19       0.79     0.19     0.10    0.10    1.76     0.00        0.10     0.00
0.01             0.30     0.33     0.74
59   3   20       0.76     0.18     0.10    0.10    1.75     0.00        0.10     0.00
0.01             0.30     0.32     0.74


60   4    1       0.72     0.18     0.10    0.10    1.72     0.00        0.10     0.00
0.01             0.30     0.32     0.74
61   4    2       0.54     0.16     0.10    0.10    1.46     0.00        0.10     0.00
0.01             0.30     0.27     0.69
62   4    3       0.51     0.15     0.10    0.10    1.45     0.00        0.10     0.00
0.01             0.30     0.27     0.69
63   4    4       0.47     0.15     0.10    0.10    1.43     0.00        0.10     0.00
0.01             0.30     0.27     0.69
64   4    5       0.44     0.15     0.10    0.10    1.42     0.00        0.10     0.00
0.01             0.30     0.26     0.68
65   4    6       0.41     0.15     0.10    0.10    1.40     0.00        0.10     0.00
0.01             0.30     0.26     0.68
66   4    7       0.38     0.15     0.10    0.10    1.39     0.00        0.10     0.00
0.01             0.30     0.26     0.68
67   4    8       0.35     0.14     0.10    0.10    1.37     0.00        0.10     0.00
0.01             0.30     0.26     0.68
68   4    9       0.32     0.14     0.10    0.10    1.36     0.00        0.10     0.00
0.01             0.30     0.25     0.67
69   4   10       0.30     0.14     0.10    0.10    1.35     0.00        0.10     0.00
0.01             0.30     0.25     0.67
70   4   11       0.28     0.14     0.10    0.10    1.34     0.00        0.10     0.00
0.01             0.30     0.25     0.67
71   4   12       0.26     0.14     0.10    0.10    1.32     0.00        0.10     0.00
0.01             0.30     0.25     0.67
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 72   4  13        0.24    0.14    0.10    0.10    1.31    0.00         0.10    0.00
 0.01         0.30    0.24     0.67
 73   4  14        0.22    0.14    0.10    0.10    1.30    0.00         0.10    0.00
 0.01         0.30    0.24     0.66
 74   4  15        0.21    0.14    0.10    0.10    1.29    0.00         0.10    0.00
 0.01         0.30    0.24     0.66
 75   4  16        0.19    0.13    0.10    0.10    1.28    0.00         0.10    0.00
 0.01         0.30    0.24     0.66
 76   4  17        0.18    0.13    0.10    0.10    1.27    0.00         0.10    0.00
 0.01         0.30    0.24     0.66
 77   4  18        0.16    0.13    0.10    0.10    1.26    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 78   4  19        0.15    0.13    0.10    0.10    1.25    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 79   4  20        0.14    0.13    0.10    0.10    1.24    0.00         0.10    0.00
 0.01         0.30    0.23     0.65


 80   5   1        0.13    0.13    0.10    0.10    1.24    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 81   5   2        0.12    0.13    0.10    0.10    1.24    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 82   5   3        0.11    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 83   5   4        0.10    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 84   5   5        0.10    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
♀
        STREAM QUALITY SIMULATION
                  OUTPUT PAGE NUMBER    12
        QUAL-2E STREAM QUALITY ROUTING MODEL
          Version 3.22  --  May 1996
                                                   ***** STEADY STATE SIMULATION *****

                                                            ** ALGAE DATA **

                                                                                 NH3-N
        ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE               ALGY    ALGY    ALGY   A P/R     NET          NH3   FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH    RESP    SETT   RATIO     P-R         PREF  N-UPTKE
EXTCO        LIGHT   NITRGN   PHSPRS
                   UG/L   1/DAY   1/DAY   FT/DA      *   MG/L-D           *       *
 1/FT           *        *        *

 85   5   6        0.09    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 86   5   7        0.08    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 87   5   8        0.08    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 88   5   9        0.07    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 89   5  10        0.07    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 90   5  11        0.06    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 91   5  12        0.06    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 92   5  13        0.06    0.13    0.10    0.10    1.23    0.00         0.10    0.00
 0.01         0.30    0.23     0.65
 93   5  14        0.05    0.13    0.10    0.10    1.23    0.00         0.10    0.00
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 0.01          0.30     0.23     0.65
 94   5  15        0.05     0.13     0.10     0.10     1.23     0.00         0.10     0.00
 0.01          0.30     0.23     0.65
 95   5  16        0.04     0.13     0.10     0.10     1.23     0.00         0.10     0.00
 0.01          0.30     0.23     0.65


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    13
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                         ** DISSOLVED OXYGEN DATA **

                                                                      COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE                DO               DO      DAM      NIT
ORD NUM NUM     TEMP       SAT      DO      DEF    INPUT    INHIB       F-FNCTN   OXYGN
                 NET
               DEG-F     MG/L     MG/L     MG/L     MG/L     FACT         INPUT   REAIR
C-BOD      SOD      P-R   NH3-N   NO2-N

  1   1   1  65.14     9.17     4.74     4.44     0.00     0.94         13.04    2.78
-0.05   -1.72    0.03    0.00    -0.04
  2   1   2  65.71     9.11     4.68     4.43     0.00     0.94          0.00    2.79
-0.05   -1.72    0.04    0.00    -0.02
  3   1   3  65.91     9.09     4.64     4.45     0.00     0.94          0.00    2.81
-0.05   -1.72    0.04    0.00    -0.01
  4   1   4  65.98     9.09     4.61     4.47     0.00     0.94          0.00    2.83
-0.04   -1.72    0.04    0.00    -0.01
  5   1   5  66.01     9.08     4.59     4.49     0.00     0.94          0.00    2.85
-0.04   -1.72    0.04    0.00     0.00
  6   1   6  66.02     9.08     4.57     4.51     0.00     0.94          0.00    2.86
-0.04   -1.72    0.04    0.00     0.00
  7   1   7  66.02     9.08     4.56     4.52     0.00     0.94          0.00    2.86
-0.04   -1.72    0.04    0.00     0.00
  8   1   8  66.02     9.08     4.55     4.53     0.00     0.93          0.00    2.87
-0.04   -1.72    0.04    0.00     0.00
  9   1   9  66.02     9.08     4.54     4.54     0.00     0.93          0.00    2.88
-0.04   -1.72    0.04    0.00     0.00
 10   1  10  66.02     9.08     4.54     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.04    0.00     0.00
 11   1  11  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 12   1  12  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 13   1  13  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 14   1  14  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 15   1  15  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 16   1  16  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 17   1  17  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.04   -1.72    0.05    0.00     0.00
 18   1  18  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.03   -1.72    0.05    0.00     0.00
 19   1  19  66.02     9.08     4.53     4.55     0.00     0.93          0.00    2.88
-0.03   -1.72    0.06    0.00     0.00
```

```
 20   2   1  65.97    9.09    4.49    4.60    0.00    0.93          0.78    2.91
-0.03   -1.92    0.05    0.00    0.00
 21   2   2  65.96    9.09    4.47    4.62    0.00    0.93          0.74    2.92
-0.03   -1.92    0.05    0.00    0.00
 22   2   3  65.96    9.09    4.47    4.62    0.00    0.93          0.71    2.93
-0.03   -1.92    0.05    0.00    0.00
 23   2   4  65.96    9.09    4.48    4.61    0.00    0.93          0.68    2.92
-0.03   -1.92    0.05    0.00    0.00
 24   2   5  65.96    9.09    4.49    4.59    0.00    0.93          0.65    2.91
-0.03   -1.92    0.04    0.00    0.00
 25   2   6  65.96    9.09    4.52    4.57    0.00    0.93          0.63    2.89
-0.03   -1.92    0.04    0.00    0.00
 26   2   7  65.96    9.09    4.55    4.54    0.00    0.93          0.60    2.87
-0.03   -1.92    0.04    0.00    0.00
 27   2   8  65.96    9.09    4.58    4.51    0.00    0.94          0.58    2.85
-0.03   -1.92    0.04    0.00    0.00
 28   2   9  65.97    9.09    4.61    4.48    0.00    0.94          0.56    2.83
-0.03   -1.92    0.04    0.00    0.00
 29   2  10  65.97    9.09    4.64    4.44    0.00    0.94          0.54    2.81
-0.03   -1.92    0.03    0.00    0.00
 30   2  11  65.97    9.09    4.68    4.41    0.00    0.94          0.53    2.79
-0.03   -1.92    0.03    0.00    0.00
 31   2  12  65.97    9.09    4.71    4.38    0.00    0.94          0.51    2.77
-0.03   -1.92    0.03    0.00    0.00
 32   2  13  65.97    9.09    4.74    4.34    0.00    0.94          0.49    2.75
-0.03   -1.92    0.03    0.00    0.00
 33   2  14  65.97    9.09    4.78    4.31    0.00    0.94          0.48    2.73
-0.03   -1.92    0.03    0.00    0.00
 34   2  15  65.97    9.09    4.81    4.28    0.00    0.94          0.47    2.71
-0.03   -1.92    0.03    0.00    0.00
 35   2  16  65.97    9.09    4.84    4.25    0.00    0.95          0.45    2.69
-0.03   -1.92    0.02    0.00    0.00
 36   2  17  65.98    9.09    4.86    4.22    0.00    0.95          0.44    2.67
-0.03   -1.92    0.02    0.00    0.00
 37   2  18  65.98    9.09    4.89    4.20    0.00    0.95          0.43    2.66
-0.03   -1.92    0.02    0.00    0.00
 38   2  19  65.98    9.09    4.92    4.17    0.00    0.95          0.42    2.64
-0.03   -1.92    0.02    0.00    0.00
 39   2  20  65.98    9.09    4.94    4.14    0.00    0.95          0.41    2.62
-0.03   -1.92    0.02    0.00    0.00


 40   3   1  65.98    9.09    4.71    4.38    0.00    0.94          0.33    2.77
-0.03   -2.12    0.02    0.00    0.00
 41   3   2  65.98    9.09    4.43    4.65    0.00    0.93          0.33    2.95
-0.03   -2.12    0.02    0.00    0.00
 42   3   3  65.98    9.09    4.21    4.88    0.00    0.92          0.32    3.09
-0.03   -2.12    0.02    0.00    0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    14
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                              ***** STEADY STATE SIMULATION *****

                                                  ** DISSOLVED OXYGEN DATA **

                                                               COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE              DO              DO     DAM     NIT
ORD NUM NUM     TEMP     SAT      DO     DEF   INPUT   INHIB      F-FNCTN   OXYGN
                 NET
```

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                   DEG-F     MG/L     MG/L     MG/L     MG/L     FACT           INPUT    REAIR
C-BOD      SOD       P-R    NH3-N    NO2-N

 43   3   4   65.98     9.09     4.03     5.05     0.00     0.91             0.32     3.20
-0.03    -2.12      0.02     0.00     0.00
 44   3   5   65.98     9.09     3.89     5.19     0.00     0.90             0.31     3.29
-0.03    -2.12      0.02     0.00     0.00
 45   3   6   65.98     9.09     3.78     5.30     0.00     0.90             0.31     3.36
-0.03    -2.12      0.02     0.00     0.00
 46   3   7   65.98     9.09     3.69     5.39     0.00     0.89             0.30     3.41
-0.03    -2.12      0.02     0.00     0.00
 47   3   8   65.98     9.09     3.63     5.46     0.00     0.89             0.30     3.45
-0.03    -2.12      0.02     0.00     0.00
 48   3   9   65.98     9.09     3.58     5.51     0.00     0.88             0.30     3.49
-0.03    -2.12      0.02     0.00     0.00
 49   3  10   65.99     9.09     3.54     5.54     0.00     0.88             0.29     3.51
-0.03    -2.12      0.01     0.00     0.00
 50   3  11   65.99     9.09     3.52     5.57     0.00     0.88             0.29     3.52
-0.03    -2.12      0.01     0.00     0.00
 51   3  12   67.10     8.97     5.11     3.86     0.00     0.95            12.56     2.48
-0.11    -2.12      0.00     0.00     0.00
 52   3  13   66.53     9.03     4.98     4.05     0.00     0.95             0.14     2.58
-0.11    -2.12      0.00     0.00     0.00
 53   3  14   66.26     9.06     4.87     4.19     0.00     0.95             0.14     2.66
-0.10    -2.12      0.00     0.00     0.00
 54   3  15   66.12     9.07     4.79     4.29     0.00     0.94             0.14     2.72
-0.10    -2.12      0.00     0.00     0.00
 55   3  16   66.06     9.08     4.72     4.36     0.00     0.94             0.14     2.76
-0.10    -2.12      0.00     0.00     0.00
 56   3  17   66.03     9.08     4.66     4.42     0.00     0.94             0.14     2.80
-0.10    -2.12      0.00     0.00     0.00
 57   3  18   66.01     9.08     4.61     4.47     0.00     0.94             0.14     2.83
-0.10    -2.12      0.00     0.00     0.00
 58   3  19   66.00     9.08     4.58     4.51     0.00     0.94             0.14     2.85
-0.10    -2.12      0.00     0.00     0.00
 59   3  20   66.00     9.08     4.55     4.53     0.00     0.93             0.14     2.87
-0.09    -2.12      0.00     0.00     0.00


 60   4   1   65.99     9.09     4.26     4.82     0.00     0.92             0.20     3.05
-0.09    -2.75      0.00     0.00     0.00
 61   4   2   66.31     9.05     4.58     4.47     0.00     0.94             3.82     2.84
-0.11    -2.75      0.00     0.00     0.00
 62   4   3   66.11     9.07     4.43     4.64     0.00     0.93             0.16     2.94
-0.11    -2.75      0.00     0.00     0.00
 63   4   4   66.03     9.08     4.31     4.77     0.00     0.92             0.16     3.02
-0.10    -2.75      0.00     0.00     0.00
 64   4   5   66.00     9.08     4.22     4.86     0.00     0.92             0.16     3.08
-0.10    -2.75      0.00     0.00     0.00
 65   4   6   65.99     9.08     4.15     4.93     0.00     0.92             0.15     3.12
-0.10    -2.75      0.00     0.00     0.00
 66   4   7   65.99     9.09     4.10     4.98     0.00     0.91             0.15     3.16
-0.10    -2.75      0.00     0.00     0.00
 67   4   8   65.99     9.09     4.06     5.02     0.00     0.91             0.15     3.18
-0.09    -2.75      0.00     0.00     0.00
 68   4   9   65.99     9.09     4.03     5.05     0.00     0.91             0.15     3.20
-0.09    -2.75      0.00     0.00     0.00
 69   4  10   65.99     9.09     4.01     5.07     0.00     0.91             0.15     3.21
-0.09    -2.75      0.00     0.00     0.00
 70   4  11   65.99     9.09     4.00     5.09     0.00     0.91             0.15     3.22
-0.09    -2.75      0.00     0.00     0.00
 71   4  12   65.99     9.09     3.99     5.10     0.00     0.91             0.15     3.23
-0.09    -2.75      0.00     0.00     0.00
```

72	4	13	65.99	9.09	3.98	5.10	0.00	0.91	0.14	3.23	-0.08	-2.75	0.00	0.00	0.00
73	4	14	65.99	9.09	3.98	5.11	0.00	0.91	0.14	3.23	-0.08	-2.75	0.00	0.00	0.00
74	4	15	65.99	9.09	3.98	5.11	0.00	0.91	0.14	3.23	-0.08	-2.75	0.00	0.00	0.00
75	4	16	65.99	9.09	3.98	5.10	0.00	0.91	0.14	3.23	-0.08	-2.75	0.00	0.00	0.00
76	4	17	65.99	9.09	3.98	5.10	0.00	0.91	0.14	3.23	-0.08	-2.75	0.00	0.00	0.00
77	4	18	65.99	9.09	3.99	5.10	0.00	0.91	0.14	3.23	-0.08	-2.75	0.00	0.00	0.00
78	4	19	65.99	9.09	3.99	5.09	0.00	0.91	0.14	3.22	-0.07	-2.75	0.00	0.00	0.00
79	4	20	65.99	9.09	4.00	5.09	0.00	0.91	0.13	3.22	-0.07	-2.75	0.00	0.00	0.00
80	5	1	66.00	9.08	3.85	5.23	0.00	0.90	0.00	3.31	-0.07	-3.14	0.00	0.00	0.00
81	5	2	66.00	9.08	3.74	5.35	0.00	0.89	0.00	3.38	-0.07	-3.14	0.00	0.00	0.00
82	5	3	66.00	9.08	3.65	5.44	0.00	0.89	0.00	3.44	-0.07	-3.14	0.00	0.00	0.00
83	5	4	66.00	9.08	3.57	5.51	0.00	0.88	0.00	3.49	-0.07	-3.14	0.00	0.00	0.00
84	5	5	66.00	9.08	3.52	5.57	0.00	0.88	0.00	3.53	-0.07	-3.14	0.00	0.00	0.00

♀

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 15
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
85	5	6	66.00	9.08	3.47	5.61	0.00	0.88	0.00	3.55	-0.06	-3.14	0.00	0.00	0.00
86	5	7	66.00	9.08	3.43	5.65	0.00	0.87	0.00	3.58	-0.06	-3.14	0.00	0.00	0.00
87	5	8	66.00	9.08	3.40	5.68	0.00	0.87	0.00	3.60	-0.06	-3.14	0.00	0.00	0.00
88	5	9	66.00	9.08	3.38	5.70	0.00	0.87	0.00	3.61	-0.06	-3.14	0.00	0.00	0.00
89	5	10	66.00	9.08	3.36	5.72	0.00	0.87	0.00	3.62	-0.06	-3.14	0.00	0.00	0.00
90	5	11	66.00	9.08	3.35	5.73	0.00	0.87	0.00	3.63	-0.06	-3.14	0.00	0.00	0.00
91	5	12	66.00	9.08	3.34	5.74	0.00	0.87	0.00	3.64	-0.06	-3.14	0.00	0.00	0.00
92	5	13	66.00	9.08	3.33	5.75	0.00	0.86	0.00	3.64	-0.06	-3.14	0.00	0.00	0.00
93	5	14	66.00	9.08	3.33	5.76	0.00	0.86	0.00	3.64	-0.06	-3.14	0.00	0.00	0.00

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 94   5  15   66.00    9.08    3.32    5.76    0.00    0.86          0.00    3.65
-0.05   -3.14    0.00    0.00    0.00
 95   5  16   66.00    9.08    3.32    5.76    0.00    0.86          0.00    3.65
-0.05   -3.14    0.00    0.00    0.00
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♀ * * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *

Version 3.22 -- May 1996

$$$ (PROBLEM TITLES) $$$

CARD TYPE QUAL-2E PROGRAM TITLES

ITLE01 Bonpas Creek DO TMDL ILEPA13A

TITLE02 Calibration run for October 6, 2015. Medium low flow. WSS-

TITLE03 NO CONSERVATIVE MINERAL I

TITLE04 NO CONSERVATIVE MINERAL II

TITLE05 NO CONSERVATIVE MINERAL III

TITLE06 YES TEMPERATURE

TITLE07 YES 5-DAY BIOCHEMICAL OXYGEN DEMAND

TITLE08 YES ALGAE AS CHL-A IN UG/L

TITLE09 YES PHOSPHORUS CYCLE AS P IN MG/L

TITLE10 (ORGANIC-P; DISSOLVED-P)

TITLE11 YES NITROGEN CYCLE AS N IN MG/L

TITLE12 (ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)

TITLE13 YES DISSOLVED OXYGEN IN MG/L

TITLE14 NO FECAL COLIFORM IN NO./100 ML

TITLE15 NO ARBITRARY NON-CONSERVATIVE

ENDTITLE

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE CARD TYPE

LIST DATA INPUT 0.00000
0.00000

NOWRITE OPTIONAL SUMMARY 0.00000
0.00000

NO FLOW AUGMENTATION 0.00000
0.00000

STEADY STATE 0.00000
0.00000

NO TRAPEZOIDAL CHANNELS 0.00000
0.00000

NO PRINT LCD/SOLAR DATA 0.00000
0.00000

NO PLOT DO AND BOD 0.00000
0.00000

FIXED DNSTM CONC (YES=1)= 0.00000 D-ULT BOD CONV K COEF =
0.23000

INPUT METRIC = 0.00000 UTPUT METRIC =
0.00000

NUMBER OF REACHES = 5.00000 UMBER OF JUNCTIONS =

```
0.00000
          NUM OF HEADWATERS       =   1.00000          UMBER OF POINT LOADS   =
6.00000
          TIME STEP (HOURS)       =   1.00000          NTH. COMP. ELEMENT (MI)=
0.50000
          MAXIMUM ROUTE TIME (HRS)=  60.00000          IME INC. FOR RPT2 (HRS)=
1.00000
          LATITUDE OF BASIN (DEG) =  38.38000          ONGITUDE OF BASIN (DEG)=
-87.97000
          STANDARD MERIDIAN (DEG) =   0.00000          AY OF YEAR START TIME  =
278.00000
          EVAP. COEF.,(AE)        =   0.00068          VAP. COEF.,(BE)        =
0.00027
          ELEV. OF BASIN (ELEV)   = 373.00000          UST ATTENUATION COEF.  =
0.06000
          ENDATA1                     0.00000
0.00000

           $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

          CARD TYPE                                               CARD TYPE
          O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300          O UPTAKE BY NO2 OXID(MG
O/MG N)=    1.1400
          O PROD  BY ALGAE (MG O/MG A)   =    1.8000          O UPTAKE BY ALGAE (MG
O/MG A)  =    1.9000
          N CONTENT OF ALGAE (MG N/MG A) =    0.0900          P CONTENT OF ALGAE (MG
P/MG A) =    0.0140
          ALG MAX SPEC GROWTH RATE(1/DAY)=    2.0000          ALGAE RESPIRATION RATE
(1/DAY)=     0.1050
          N HALF SATURATION CONST (MG/L) =    0.0300          P HALF SATURATION CONST
 (MG/L)=    0.0050
          LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0030          NLIN
SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
          LIGHT FUNCTION OPTION (LFNOPT) =    2.0000          LIGHT SAT'N COEF
(BTU/FT2-MIN) =    0.6600
          DAILY AVERAGING OPTION (LAVOPT)=    3.0000          LIGHT AVERAGING FACTOR
(INT)  =    0.9000
          NUMBER OF DAYLIGHT HOURS (DLH) =   13.3000          TOTAL DAILY SOLR RAD
(BTU/FT-2)= 1500.0000
          ALGY GROWTH CALC OPTION(LGROPT)=    2.0000          ALGAL PREF FOR NH3-N
(PREFN)   =    0.1000
          ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500          NITRIFICATION
INHIBITION COEF  =    0.6000
          ENDATA1A                            0.0000
             0.0000

           $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS)
$$$

          CARD TYPE     RATE CODE     THETA VALUE

          THETA( 1)      BOD DECA        1.047     DFLT
          THETA( 2)      BOD SETT        1.024     DFLT
          THETA( 3)      OXY TRAN        1.024     DFLT
          THETA( 4)      SOD RATE        1.000     USER
          THETA( 5)      ORGN DEC        1.047     DFLT
          THETA( 6)      ORGN SET        1.024     DFLT
          THETA( 7)      NH3 DECA        1.083     DFLT
          THETA( 8)      NH3 SRCE        1.074     DFLT
          THETA( 9)      NO2 DECA        1.047     DFLT
          THETA(10)      PORG DEC        1.047     DFLT
          THETA(11)      PORG SET        1.024     DFLT
          THETA(12)      DISP SRC        1.074     DFLT
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         THETA(13)      ALG GROW       1.047     DFLT
         THETA(14)      ALG RESP       1.047     DFLT
         THETA(15)      ALG SETT       1.024     DFLT
         THETA(16)      COLI DEC       1.047     DFLT
         THETA(17)      ANC DECA       1.000     DFLT
         THETA(18)      ANC SETT       1.024     DFLT
         THETA(19)      ANC SRCE       1.000     DFLT
         ENDATA1B

          $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

         CARD TYPE           REACH ORDER AND IDENT              R. MI/KM
R. MI/KM
         STREAM REACH     1.0   RCH= Hdwtr, RM 38-4     FR         47.5    TO
  38.0
         STREAM REACH     2.0   RCH= RM 38.0 to 28.     FR         38.0    TO
  28.0
         STREAM REACH     3.0   RCH= RM 28.0 to 18.     FR         28.0    TO
  18.0
         STREAM REACH     4.0   RCH= RM 18.0 to 8.0     FR         28.0    TO
   8.0
         STREAM REACH     5.0   RCH= RM 8.0 to 0.0      FR          8.0    TO
   0.0
         ENDATA2          0.0                                       0.0
   0.0

          $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

         CARD TYPE                     REACH  AVAIL HDWS TARGET     ORDER OF AVAIL
SOURCES
         ENDATA3                        0.         0.       0.0   0.   0.   0.   0.   0.
  0.

          $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

         CARD TYPE        REACH ELEMENTS/REACH             COMPUTATIONAL FLAGS
         FLAG FIELD        1.       19.
1.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.0.
         FLAG FIELD        2.       20.
2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
         FLAG FIELD        3.       20.
2.2.2.2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.
         FLAG FIELD        4.       20.
2.6.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.6.2.
         FLAG FIELD        5.       16.
6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.
         ENDATA4           0.        0.
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

          $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

         CARD TYPE        REACH  COEF-DSPN  COEFQV    EXPOQV    COEFQH   EXPOQH
CMANN
         HYDRAULICS        1.    100.00     0.170     0.000     0.350     0.000
0.020
         HYDRAULICS        2.    100.00     0.170     0.000     0.350     0.000
0.020
         HYDRAULICS        3.    100.00     0.170     0.000     0.500     0.000
0.020
         HYDRAULICS        4.    100.00     0.170     0.000     0.450     0.000
0.020
         HYDRAULICS        5.    100.00     0.170     0.000     0.450     0.000
0.020
```

ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	451.00	0.06	0.90	72.50	53.00	29.23	5.40	1.00
TEMP/LCD	2.	415.00	0.06	0.90	72.50	53.00	29.23	5.40	1.00
TEMP/LCD	3.	393.00	0.06	0.90	72.50	53.00	29.23	5.40	1.00
TEMP/LCD	4.	379.00	0.06	0.90	72.50	53.00	29.23	5.40	1.00
TEMP/LCD	5.	374.00	0.06	0.90	72.50	53.00	29.23	5.40	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.05	0.00	0.017	1.	0.65	0.000	0.00000
REACT COEF	2.	0.05	0.00	0.019	1.	0.65	0.000	0.00000
REACT COEF	3.	0.05	0.00	0.030	1.	0.65	0.000	0.00000
REACT COEF	4.	0.05	0.00	0.035	1.	0.65	0.000	0.00000
REACT COEF	5.	0.05	0.00	0.040	1.	0.65	0.000	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	2.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	3.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	4.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
N AND P COEF	5.	0.00	0.00	0.01	0.00	2.00	0.00	0.00	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

```
       CARD TYPE           REACH    ALPHAO     ALGSET     EXCOEF       CK5       CKANC
SETANC    SRCANC
                                                                    CKCOLI
       ALGAE/OTHER           1.      50.00       0.10       0.01      0.00       0.00
  0.00      0.00
       ALGAE/OTHER           2.      50.00       0.10       0.01      0.00       0.00
  0.00      0.00
       ALGAE/OTHER           3.      50.00       0.10       0.01      0.00       0.00
  0.00      0.00
       ALGAE/OTHER           4.      50.00       0.10       0.01      0.00       0.00
  0.00      0.00
       ALGAE/OTHER           5.      50.00       0.10       0.01      0.00       0.00
  0.00      0.00
       ENDATA6B              0.       0.00       0.00       0.00      0.00       0.00
  0.00      0.00

        $$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

       CARD TYPE           REACH    TEMP       D.O.       BOD        CM-1       CM-2
  CM-3      ANC       COLI
       INITIAL COND-1        1.      66.10       4.90       1.00      0.00       0.00
  0.00      0.00      0.00
       INITIAL COND-1        2.      66.10       4.90       1.00      0.00       0.00
  0.00      0.00      0.00
       INITIAL COND-1        3.      63.50       4.05       1.00      0.00       0.00
  0.00      0.00      0.00
       INITIAL COND-1        4.      64.00       3.45       1.00      0.00       0.00
  0.00      0.00      0.00
       INITIAL COND-1        5.      64.00       3.45       1.00      0.00       0.00
  0.00      0.00      0.00
       ENDATA7               0.       0.00       0.00       0.00      0.00       0.00
  0.00      0.00      0.00

        $$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND
PHOSPHORUS) $$$

       CARD TYPE           REACH    CHL-A      ORG-N      NH3-N      NO2-N      NO3-N
 ORG-P     DIS-P
       INITIAL COND-2        1.       1.87       0.84       0.03      0.00       0.15
  0.00      0.12
       INITIAL COND-2        2.       1.87       0.84       0.03      0.00       0.15
  0.00      0.12
       INITIAL COND-2        3.       5.87       1.14       0.18      0.00       0.19
  0.00      0.07
       INITIAL COND-2        4.       0.53       0.89       0.11      0.00       0.41
  0.00      0.08
       INITIAL COND-2        5.       4.81       0.89       0.11      0.00       0.41
  0.00      0.08
       ENDATA7A              0.       0.00       0.00       0.00      0.00       0.00
  0.00      0.00

        $$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

       CARD TYPE           REACH     FLOW       TEMP       D.O.        BOD       CM-1
  CM-2      CM-3      ANC       COLI
       INCR INFLOW-1         1.      0.000     66.10       6.00       1.00       0.00
  0.00      0.00      0.00      0.00
       INCR INFLOW-1         2.      0.040     66.10       6.00       1.00       0.00
  0.00      0.00      0.00      0.00
       INCR INFLOW-1         3.      0.040     63.50       6.00       1.00       0.00
  0.00      0.00      0.00      0.00
       INCR INFLOW-1         4.      0.130     64.00       6.00       1.00       0.00
  0.00      0.00      0.00      0.00
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        INCR INFLOW-1          5.     0.000     64.00      6.00      1.00      0.00
   0.00      0.00      0.00      0.00
        ENDATA8                0.     0.000      0.00      0.00      0.00      0.00
   0.00      0.00      0.00      0.00

         $$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A,
NITROGEN, AND PHOSPHORUS) $$$

        CARD TYPE            REACH    CHL-A     ORG-N     NH3-N     NO2-N     NO3-N
   ORG-P     DIS-P
        INCR INFLOW-2          1.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          2.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          3.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          4.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        INCR INFLOW-2          5.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00
        ENDATA8A               0.      0.00      0.00      0.00      0.00      0.00
   0.00      0.00

         $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

        CARD TYPE               JUNCTION ORDER AND IDENT        UPSTRM   JUNCTION
 TRIB
        ENDATA9                 0.                                0.         0.
  0.

         $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

        CARD TYPE    HDWTR     NAME               FLOW      TEMP      D.O.       BOD
    CM-1      CM-2      CM-3
                     ORDER
        HDWTR-NFK      1.  BonpasCK               0.04     66.10      4.90      1.00
    0.00      0.00      0.00
        ENDATA10       0.                         0.00      0.00      0.00      0.00
    0.00      0.00      0.00

         $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN,
PHOSPHORUS,
                             COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

        CARD TYPE     HDWTR     ANC     COLI     CHL-A    ORG-N    NH3-N    NO2-N
NO3-N    ORG-P    DIS-P
                      ORDER
        HEADWTR-2       1.     0.00 0.00E+00     1.90     0.84     0.03     0.00
 0.15     0.00     0.12
        ENDATA10A       0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

         $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

                      POINT
        CARD TYPE      LOAD    NAME               EFF      FLOW     TEMP     D.O.
 BOD      CM-1     CM-2     CM-3
                      ORDER
        POINTLD-1      1.     Claremont          0.00     0.00    70.00     7.90
4.00      0.00     0.00     0.00
        POINTLD-1      2.     WstSalemN          0.00     0.05    70.00     7.90
4.00      0.00     0.00     0.00
        POINTLD-1      3.     WstSalemS          0.00     0.04    70.00     7.90
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4.00     0.00     0.00     0.00
         POINTLD-1      4.     VigoCoal        0.00     0.00    70.00     7.90
0.00     0.00     0.00     0.00
         POINTLD-1      5.     Bellmont        0.00     0.00    70.00     7.90
4.00     0.00     0.00     0.00
         POINTLD-1      6.    BrownsStp        0.00     0.00    70.00     7.90
4.00     0.00     0.00     0.00
         ENDATA11       0.                     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00

          $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN,
PHOSPHORUS,
                             COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT)
$$$

                       POINT
         CARD TYPE      LOAD     ANC      COLI    CHL-A    ORG-N    NH3-N    NO2-N
N03-N    ORG-P    DIS-P
                       ORDER
         POINTLD-2       1.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       2.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       3.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       4.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       5.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         POINTLD-2       6.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
         ENDATA11A       0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

          $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

                               DAM   RCH   ELE    ADAM    BDAM    FDAM    HDAM

         ENDATA12                 0.    0.    0.    0.00    0.00    0.00    0.00

          $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

              CARD TYPE              TEMP       D.O.      BOD       CM-1      CM-2
    CM-3       ANC      COLI

         ENDATA13                    DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED

          $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

              CARD TYPE              CHL-A     ORG-N     NH3-N     NO2-N     NH3-N
   ORG-P     DIS-P

         ENDATA13A                   DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED
♀
♀
 STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
 ------------------------------------------------------------


                       NUMBER OF
         ITERATION   NONCONVERGENT
                       ELEMENTS
```

1	39
2	0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION =   826.859 BTU/FT-2   (224.385 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 11.4

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	5.60	9	87.50	17	0.00
2	34.90	10	61.69	18	0.00
3	64.83	11	31.38	19	0.00
4	89.99	12	2.66	20	0.00
5	108.02	13	0.00	21	0.00
6	117.20	14	0.00	22	0.00
7	116.66	15	0.00	23	0.00
8	106.43	16	0.00	24	0.00

♀

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	95
ALGAE GROWTH RATE	2	95
ALGAE GROWTH RATE	3	76
ALGAE GROWTH RATE	4	73
ALGAE GROWTH RATE	5	61
ALGAE GROWTH RATE	6	45
ALGAE GROWTH RATE	7	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	8	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
----

1. LIGHT AVERAGING OPTION.   LAVOPT= 3

METHOD: AVERAGE OF HOURLY SOLAR VALUES

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 826.859 BTU/FT-2 (224.385 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 11.4
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): N/A

HOURLY VALUES OF SOLAR RADIATION (LANGLEYS)

1	1.52	9	23.75	17	0.00
2	9.47	10	16.74	18	0.00
3	17.59	11	8.51	19	0.00
4	24.42	12	0.72	20	0.00

5	29.31	13	0.00	21	0.00
6	31.81	14	0.00	22	0.00
7	31.66	15	0.00	23	0.00
8	28.88	16	0.00	24	0.00

2. LIGHT FUNCTION OPTION: LFNOPT= 2

SMITH FUNCTION, WITH 71% IMAX = 0.179 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 2

MINIMUM OF NITROGEN, PHOSPHORUS: FL*MIN(FN,FP)

♀

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER   1
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	47.50	47.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
2	1	2	47.00	46.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
3	1	3	46.50	46.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
4	1	4	46.00	45.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
5	1	5	45.50	45.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
6	1	6	45.00	44.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
7	1	7	44.50	44.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
8	1	8	44.00	43.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
9	1	9	43.50	43.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
10	1	10	43.00	42.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
11	1	11	42.50	42.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
12	1	12	42.00	41.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
13	1	13	41.50	41.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
14	1	14	41.00	40.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
15	1	15	40.50	40.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
16	1	16	40.00	39.50	0.04	0.00	0.00	0.170	0.180	0.350					

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0.672        0.62       3.62          0.24     0.54
 17   1  17   39.50   39.00    0.04    0.00     0.00   0.170   0.180    0.350
0.672        0.62       3.62          0.24     0.54
 18   1  18   39.00   38.50    0.04    0.00     0.00   0.170   0.180    0.350
0.672        0.62       3.62          0.24     0.54
 19   1  19   38.50   38.00    0.04    0.00     0.00   0.170   0.180    0.350
0.672        0.62       3.62          0.24     0.54


 20   2   1   38.00   37.50    0.04    0.00     0.00   0.170   0.180    0.350
0.706        0.65       3.71          0.25     0.54
 21   2   2   37.50   37.00    0.04    0.00     0.00   0.170   0.180    0.350
0.739        0.68       3.80          0.26     0.54
 22   2   3   37.00   36.50    0.05    0.00     0.00   0.170   0.180    0.350
0.773        0.71       3.89          0.27     0.54
 23   2   4   36.50   36.00    0.05    0.00     0.00   0.170   0.180    0.350
0.807        0.75       3.98          0.28     0.54
 24   2   5   36.00   35.50    0.05    0.00     0.00   0.170   0.180    0.350
0.840        0.78       4.07          0.29     0.54
 25   2   6   35.50   35.00    0.05    0.00     0.00   0.170   0.180    0.350
0.874        0.81       4.16          0.31     0.54
 26   2   7   35.00   34.50    0.05    0.00     0.00   0.170   0.180    0.350
0.908        0.84       4.24          0.32     0.54
 27   2   8   34.50   34.00    0.06    0.00     0.00   0.170   0.180    0.350
0.941        0.87       4.33          0.33     0.54
 28   2   9   34.00   33.50    0.06    0.00     0.00   0.170   0.180    0.350
0.975        0.90       4.42          0.34     0.54
 29   2  10   33.50   33.00    0.06    0.00     0.00   0.170   0.180    0.350
1.008        0.93       4.51          0.35     0.54
 30   2  11   33.00   32.50    0.06    0.00     0.00   0.170   0.180    0.350
1.042        0.96       4.60          0.36     0.54
 31   2  12   32.50   32.00    0.06    0.00     0.00   0.170   0.180    0.350
1.076        0.99       4.69          0.38     0.54
 32   2  13   32.00   31.50    0.07    0.00     0.00   0.170   0.180    0.350
1.109        1.02       4.78          0.39     0.54
 33   2  14   31.50   31.00    0.07    0.00     0.00   0.170   0.180    0.350
1.143        1.06       4.87          0.40     0.54
 34   2  15   31.00   30.50    0.07    0.00     0.00   0.170   0.180    0.350
1.176        1.09       4.95          0.41     0.54
 35   2  16   30.50   30.00    0.07    0.00     0.00   0.170   0.180    0.350
1.210        1.12       5.04          0.42     0.54
 36   2  17   30.00   29.50    0.07    0.00     0.00   0.170   0.180    0.350
1.244        1.15       5.13          0.44     0.54
 37   2  18   29.50   29.00    0.08    0.00     0.00   0.170   0.180    0.350
1.277        1.18       5.22          0.45     0.54
 38   2  19   29.00   28.50    0.08    0.00     0.00   0.170   0.180    0.350
1.311        1.21       5.31          0.46     0.54
 39   2  20   28.50   28.00    0.08    0.00     0.00   0.170   0.180    0.350
1.345        1.24       5.40          0.47     0.54


 40   3   1   28.00   27.50    0.08    0.00     0.00   0.170   0.180    0.500
0.965        1.27       5.19          0.48     0.73
 41   3   2   27.50   27.00    0.08    0.00     0.00   0.170   0.180    0.500
0.988        1.30       5.25          0.49     0.73
 42   3   3   27.00   26.50    0.09    0.00     0.00   0.170   0.180    0.500
1.012        1.34       5.31          0.51     0.73
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     2
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                   ***** STEADY STATE SIMULATION *****
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** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
43	3	4	26.50	26.00	0.09	0.00	0.00	0.170	0.180	0.500	1.035	1.37	5.37	0.52	0.73
44	3	5	26.00	25.50	0.09	0.00	0.00	0.170	0.180	0.500	1.059	1.40	5.44	0.53	0.73
45	3	6	25.50	25.00	0.09	0.00	0.00	0.170	0.180	0.500	1.082	1.43	5.50	0.54	0.73
46	3	7	25.00	24.50	0.09	0.00	0.00	0.170	0.180	0.500	1.106	1.46	5.56	0.55	0.73
47	3	8	24.50	24.00	0.10	0.00	0.00	0.170	0.180	0.500	1.129	1.49	5.62	0.56	0.73
48	3	9	24.00	23.50	0.10	0.00	0.00	0.170	0.180	0.500	1.153	1.52	5.68	0.58	0.73
49	3	10	23.50	23.00	0.10	0.00	0.00	0.170	0.180	0.500	1.176	1.55	5.75	0.59	0.73
50	3	11	23.00	22.50	0.10	0.00	0.00	0.170	0.180	0.500	1.200	1.58	5.81	0.60	0.73
51	3	12	22.50	22.00	0.16	0.05	0.00	0.170	0.180	0.500	1.871	2.47	7.58	0.94	0.73
52	3	13	22.00	21.50	0.16	0.00	0.00	0.170	0.180	0.500	1.894	2.50	7.64	0.95	0.73
53	3	14	21.50	21.00	0.16	0.00	0.00	0.170	0.180	0.500	1.918	2.53	7.70	0.96	0.73
54	3	15	21.00	20.50	0.16	0.00	0.00	0.170	0.180	0.500	1.941	2.56	7.76	0.97	0.73
55	3	16	20.50	20.00	0.17	0.00	0.00	0.170	0.180	0.500	1.965	2.59	7.83	0.98	0.73
56	3	17	20.00	19.50	0.17	0.00	0.00	0.170	0.180	0.500	1.988	2.62	7.89	0.99	0.73
57	3	18	19.50	19.00	0.17	0.00	0.00	0.170	0.180	0.500	2.012	2.66	7.95	1.01	0.73
58	3	19	19.00	18.50	0.17	0.00	0.00	0.170	0.180	0.500	2.035	2.69	8.01	1.02	0.73
59	3	20	18.50	18.00	0.17	0.00	0.00	0.170	0.180	0.500	2.059	2.72	8.08	1.03	0.73
60	4	1	28.00	27.50	0.18	0.00	0.01	0.170	0.180	0.450	2.373	2.82	8.64	1.07	0.67
61	4	2	27.50	27.00	0.22	0.04	0.01	0.170	0.180	0.450	2.941	3.49	10.14	1.32	0.67
62	4	3	27.00	26.50	0.23	0.00	0.01	0.170	0.180	0.450	3.026	3.60	10.37	1.36	0.67
63	4	4	26.50	26.00	0.24	0.00	0.01	0.170	0.180	0.450	3.111	3.70	10.59	1.40	0.67
64	4	5	26.00	25.50	0.24	0.00	0.01	0.170	0.180	0.450	3.196	3.80	10.81	1.44	0.67
65	4	6	25.50	25.00	0.25	0.00	0.01	0.170	0.180	0.450	3.281	3.90	11.04	1.48	0.67
66	4	7	25.00	24.50	0.26	0.00	0.01	0.170	0.180	0.450	3.366	4.00	11.26	1.51	0.67
67	4	8	24.50	24.00	0.26	0.00	0.01	0.170	0.180	0.450	3.451	4.10	11.49	1.55	0.67
68	4	9	24.00	23.50	0.27	0.00	0.01	0.170	0.180	0.450					

```
3.536        4.20       11.71          1.59     0.67
 69   4  10   23.50   23.00    0.28    0.00     0.01   0.170   0.180    0.450
3.621        4.30       11.94          1.63     0.67
 70   4  11   23.00   22.50    0.28    0.00     0.01   0.170   0.180    0.450
3.706        4.40       12.16          1.67     0.67
 71   4  12   22.50   22.00    0.29    0.00     0.01   0.170   0.180    0.450
3.791        4.50       12.38          1.71     0.67
 72   4  13   22.00   21.50    0.30    0.00     0.01   0.170   0.180    0.450
3.876        4.60       12.61          1.74     0.67
 73   4  14   21.50   21.00    0.30    0.00     0.01   0.170   0.180    0.450
3.961        4.71       12.83          1.78     0.67
 74   4  15   21.00   20.50    0.31    0.00     0.01   0.170   0.180    0.450
4.046        4.81       13.06          1.82     0.67
 75   4  16   20.50   20.00    0.32    0.00     0.01   0.170   0.180    0.450
4.131        4.91       13.28          1.86     0.67
 76   4  17   20.00   19.50    0.32    0.00     0.01   0.170   0.180    0.450
4.216        5.01       13.51          1.90     0.67
 77   4  18   19.50   19.00    0.33    0.00     0.01   0.170   0.180    0.450
4.301        5.11       13.73          1.94     0.67
 78   4  19   19.00   18.50    0.34    0.00     0.01   0.170   0.180    0.450
4.386        5.21       13.95          1.97     0.67
 79   4  20   18.50   18.00    0.34    0.00     0.01   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67


 80   5   1    8.00    7.50    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 81   5   2    7.50    7.00    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 82   5   3    7.00    6.50    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 83   5   4    6.50    6.00    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 84   5   5    6.00    5.50    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     3
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                         ***** STEADY STATE SIMULATION *****

                                                              ** HYDRAULICS SUMMARY **

ELE RCH ELE   BEGIN     END            POINT    INCR            TRVL
                    BOTTOM      X-SECT   DSPRSN
ORD NUM NUM     LOC     LOC     FLOW    SRCE    FLOW     VEL    TIME    DEPTH
WIDTH      VOLUME        AREA          AREA     COEF
               MILE    MILE     CFS     CFS     CFS     FPS     DAY        FT
FT       K-FT-3      K-FT-2        FT-2   FT-2/S

 85   5   6    5.50    5.00    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 86   5   7    5.00    4.50    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 87   5   8    4.50    4.00    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 88   5   9    4.00    3.50    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 89   5  10    3.50    3.00    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
 90   5  11    3.00    2.50    0.34    0.00     0.00   0.170   0.180    0.450
4.471        5.31       14.18          2.01     0.67
```

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 91   5  12    2.50    2.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471       5.31       14.18        2.01     0.67
 92   5  13    2.00    1.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471       5.31       14.18        2.01     0.67
 93   5  14    1.50    1.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471       5.31       14.18        2.01     0.67
 94   5  15    1.00    0.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471       5.31       14.18        2.01     0.67
 95   5  16    0.50    0.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471       5.31       14.18        2.01     0.67


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     4
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                  ***** STEADY STATE SIMULATION *****

                                                  ** REACTION COEFFICIENT SUMMARY **

RCH ELE     DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  1   1   9.18   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.75
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   2   9.24   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.71
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   3   9.28   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.69
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   4   9.29   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.68
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   5   9.30   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   6   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   7   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   8   9.31   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   9   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  10   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  11   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  12   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  13   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  14   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  15   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  16   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  17   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  18   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
```

```
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  19   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  2   1   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   2   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   3   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   4   9.31   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   5   9.31   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   6   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   7   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   8   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   9   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  10   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  11   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  12   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  13   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  14   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  15   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  16   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  17   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  18   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  19   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  20   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.68
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  3   1   9.31   1   0.61   0.04   0.00   0.03   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   2   9.32   1   0.61   0.04   0.00   0.03   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   3   9.32   1   0.61   0.04   0.00   0.03   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     5
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                     ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
```

```
ORGP    ORGP    DISP    COLI     ANC     ANC     ANC
NUM NUM      SAT OPT   REAIR   DECAY    SETT    RATE   DECAY    SETT   DECAY    SRCE   DECAY
DECAY    SETT    SRCE   DECAY   DECAY    SETT    SRCE
          MG/L         1/DAY   1/DAY   1/DAY   G/F2D   1/DAY   1/DAY   1/DAY MG/F2D   1/DAY
1/DAY   1/DAY MG/F2D   1/DAY   1/DAY   1/DAY MG/F2D

  3   4   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.62
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3   5   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.61
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3   6   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.60
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3   7   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.59
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3   8   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.58
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3   9   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.58
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  10   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.58
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  11   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.57
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  12   9.17   1    0.63    0.05    0.00    0.03    0.00    0.00    0.01    0.00    1.76
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  13   9.22   1    0.62    0.05    0.00    0.03    0.00    0.00    0.01    0.00    1.73
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  14   9.26   1    0.62    0.05    0.00    0.03    0.00    0.00    0.01    0.00    1.71
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  15   9.28   1    0.62    0.05    0.00    0.03    0.00    0.00    0.01    0.00    1.70
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  16   9.30   1    0.62    0.05    0.00    0.03    0.00    0.00    0.01    0.00    1.69
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  17   9.30   1    0.62    0.05    0.00    0.03    0.00    0.00    0.01    0.00    1.68
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  18   9.31   1    0.62    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.67
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  19   9.31   1    0.62    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.67
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  3  20   9.32   1    0.61    0.04    0.00    0.03    0.00    0.00    0.01    0.00    1.67
0.00   0.00   0.00    0.00    0.00    0.00    0.00


  4   1   9.32   1    0.61    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.66
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   2   9.25   1    0.62    0.05    0.00    0.04    0.00    0.00    0.01    0.00    1.72
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   3   9.28   1    0.62    0.05    0.00    0.04    0.00    0.00    0.01    0.00    1.70
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   4   9.29   1    0.62    0.05    0.00    0.04    0.00    0.00    0.01    0.00    1.69
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   5   9.30   1    0.62    0.05    0.00    0.04    0.00    0.00    0.01    0.00    1.68
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   6   9.31   1    0.62    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.67
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   7   9.31   1    0.62    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.66
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   8   9.31   1    0.61    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.66
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4   9   9.32   1    0.61    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.65
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  10   9.32   1    0.61    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.65
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  11   9.32   1    0.61    0.04    0.00    0.04    0.00    0.00    0.01    0.00    1.65
```

```
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  12   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  13   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  14   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  15   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  16   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  17   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  18   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  19   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4  20   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  5   1   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   2   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   3   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   4   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.60
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   5   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.59
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     6
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                     ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
         MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  5   6   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.59
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   7   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.58
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   8   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.57
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   9   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.57
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  10   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.56
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  11   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.56
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  12   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.55
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  13   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.55
0.00   0.00   0.00   0.00   0.00   0.00   0.00
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  5  14   9.32   1    0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.54
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  15   9.32   1    0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.54
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  16   9.32   1    0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.54
0.00   0.00   0.00   0.00   0.00   0.00   0.00


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     7
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                        ***** STEADY STATE SIMULATION *****

                                                           ** WATER QUALITY VARIABLES **

RCH ELE                CM-1   CM-2   CM-3
                                     ANC
NUM NUM       TEMP                          DO    BOD    ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI            CHLA
             DEG-F                         MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML          UG/L

  1   1      65.04   0.00   0.00   0.00   4.76   0.99   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.92
  1   2      64.47   0.00   0.00   0.00   4.64   0.98   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.94
  1   3      64.15   0.00   0.00   0.00   4.53   0.98   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.96
  1   4      63.98   0.00   0.00   0.00   4.43   0.97   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.98
  1   5      63.89   0.00   0.00   0.00   4.34   0.96   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.00
  1   6      63.84   0.00   0.00   0.00   4.26   0.95   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.02
  1   7      63.81   0.00   0.00   0.00   4.19   0.94   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.04
  1   8      63.79   0.00   0.00   0.00   4.13   0.94   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.06
  1   9      63.78   0.00   0.00   0.00   4.07   0.93   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.08
  1  10      63.78   0.00   0.00   0.00   4.02   0.92   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.10
  1  11      63.78   0.00   0.00   0.00   3.97   0.91   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.12
  1  12      63.78   0.00   0.00   0.00   3.93   0.91   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.14
  1  13      63.78   0.00   0.00   0.00   3.90   0.90   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.16
  1  14      63.78   0.00   0.00   0.00   3.86   0.89   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.18
  1  15      63.78   0.00   0.00   0.00   3.83   0.89   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.20
  1  16      63.77   0.00   0.00   0.00   3.81   0.88   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.22
  1  17      63.77   0.00   0.00   0.00   3.78   0.87   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.24
  1  18      63.77   0.00   0.00   0.00   3.76   0.86   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.26
  1  19      63.77   0.00   0.00   0.00   3.74   0.86   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.28
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  2   1      63.83   0.00   0.00   0.00   3.76   0.86   0.80   0.03   0.00   0.14
0.97   0.00   0.11   0.11.00E+00   0.00   2.19
  2   2      63.86   0.00   0.00   0.00   3.78   0.86   0.76   0.03   0.00   0.13
0.92   0.00   0.11   0.11.00E+00   0.00   2.11
  2   3      63.87   0.00   0.00   0.00   3.81   0.86   0.73   0.03   0.00   0.13
0.88   0.00   0.10   0.10.00E+00   0.00   2.03
  2   4      63.88   0.00   0.00   0.00   3.84   0.86   0.70   0.02   0.00   0.12
0.85   0.00   0.10   0.10.00E+00   0.00   1.96
  2   5      63.88   0.00   0.00   0.00   3.88   0.86   0.67   0.02   0.00   0.12
0.81   0.00   0.10   0.10.00E+00   0.00   1.90
  2   6      63.87   0.00   0.00   0.00   3.92   0.85   0.65   0.02   0.00   0.11
0.78   0.00   0.09   0.09.00E+00   0.00   1.83
  2   7      63.87   0.00   0.00   0.00   3.96   0.85   0.62   0.02   0.00   0.11
0.75   0.00   0.09   0.09.00E+00   0.00   1.78
  2   8      63.87   0.00   0.00   0.00   4.00   0.85   0.60   0.02   0.00   0.10
0.72   0.00   0.08   0.09.00E+00   0.00   1.72
  2   9      63.86   0.00   0.00   0.00   4.04   0.85   0.58   0.02   0.00   0.10
0.70   0.00   0.08   0.08.00E+00   0.00   1.67
  2  10      63.86   0.00   0.00   0.00   4.08   0.85   0.56   0.02   0.00   0.10
0.68   0.00   0.08   0.08.00E+00   0.00   1.62
  2  11      63.86   0.00   0.00   0.00   4.13   0.85   0.54   0.02   0.00   0.09
0.65   0.00   0.08   0.08.00E+00   0.00   1.57
  2  12      63.86   0.00   0.00   0.00   4.17   0.84   0.53   0.02   0.00   0.09
0.63   0.00   0.07   0.07.00E+00   0.00   1.53
  2  13      63.85   0.00   0.00   0.00   4.21   0.84   0.51   0.02   0.00   0.09
0.61   0.00   0.07   0.07.00E+00   0.00   1.48
  2  14      63.85   0.00   0.00   0.00   4.25   0.84   0.50   0.02   0.00   0.08
0.60   0.00   0.07   0.07.00E+00   0.00   1.44
  2  15      63.85   0.00   0.00   0.00   4.29   0.84   0.48   0.02   0.00   0.08
0.58   0.00   0.07   0.07.00E+00   0.00   1.40
  2  16      63.85   0.00   0.00   0.00   4.33   0.84   0.47   0.02   0.00   0.08
0.56   0.00   0.07   0.07.00E+00   0.00   1.37
  2  17      63.84   0.00   0.00   0.00   4.37   0.83   0.46   0.02   0.00   0.08
0.55   0.00   0.06   0.06.00E+00   0.00   1.33
  2  18      63.84   0.00   0.00   0.00   4.40   0.83   0.44   0.01   0.00   0.07
0.53   0.00   0.06   0.06.00E+00   0.00   1.30
  2  19      63.84   0.00   0.00   0.00   4.44   0.83   0.43   0.01   0.00   0.07
0.52   0.00   0.06   0.06.00E+00   0.00   1.26
  2  20      63.84   0.00   0.00   0.00   4.47   0.83   0.42   0.01   0.00   0.07
0.51   0.00   0.06   0.06.00E+00   0.00   1.23


  3   1      63.80   0.00   0.00   0.00   4.28   0.82   0.41   0.01   0.00   0.07
0.49   0.00   0.06   0.06.00E+00   0.00   1.22
  3   2      63.78   0.00   0.00   0.00   4.11   0.82   0.40   0.01   0.00   0.07
0.48   0.00   0.06   0.06.00E+00   0.00   1.20
  3   3      63.77   0.00   0.00   0.00   3.97   0.82   0.39   0.01   0.00   0.06
0.47   0.00   0.05   0.06.00E+00   0.00   1.19
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     8
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                 ***** STEADY STATE SIMULATION *****

                                                    ** WATER QUALITY VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                   ANC
NUM NUM       TEMP                           DO    BOD    ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI           CHLA
             DEG-F                          MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
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MG/L   MG/L   MG/L   MG/L #/100ML        UG/L

  3   4      63.76   0.00   0.00   0.00   3.86   0.82   0.38   0.01   0.00   0.06
0.46   0.00   0.05   0.05.00E+00   0.00   1.18
  3   5      63.76   0.00   0.00   0.00   3.77   0.81   0.37   0.01   0.00   0.06
0.45   0.00   0.05   0.05.00E+00   0.00   1.16
  3   6      63.76   0.00   0.00   0.00   3.69   0.81   0.37   0.01   0.00   0.06
0.44   0.00   0.05   0.05.00E+00   0.00   1.15
  3   7      63.75   0.00   0.00   0.00   3.63   0.81   0.36   0.01   0.00   0.06
0.43   0.00   0.05   0.05.00E+00   0.00   1.14
  3   8      63.75   0.00   0.00   0.00   3.58   0.81   0.35   0.01   0.00   0.06
0.42   0.00   0.05   0.05.00E+00   0.00   1.13
  3   9      63.75   0.00   0.00   0.00   3.54   0.80   0.34   0.01   0.00   0.06
0.41   0.00   0.05   0.05.00E+00   0.00   1.11
  3  10      63.75   0.00   0.00   0.00   3.51   0.80   0.34   0.01   0.00   0.06
0.40   0.00   0.05   0.05.00E+00   0.00   1.10
  3  11      63.75   0.00   0.00   0.00   3.49   0.80   0.33   0.01   0.00   0.05
0.40   0.00   0.05   0.05.00E+00   0.00   1.09
  3  12      65.21   0.00   0.00   0.00   4.84   1.90   0.21   0.01   0.00   0.03
0.25   0.00   0.03   0.03.00E+00   0.00   0.70
  3  13      64.66   0.00   0.00   0.00   4.75   1.87   0.21   0.01   0.00   0.03
0.25   0.00   0.03   0.03.00E+00   0.00   0.69
  3  14      64.32   0.00   0.00   0.00   4.67   1.84   0.21   0.01   0.00   0.03
0.25   0.00   0.03   0.03.00E+00   0.00   0.68
  3  15      64.11   0.00   0.00   0.00   4.61   1.82   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.67
  3  16      63.98   0.00   0.00   0.00   4.55   1.79   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.66
  3  17      63.89   0.00   0.00   0.00   4.50   1.77   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.66
  3  18      63.84   0.00   0.00   0.00   4.46   1.75   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.65
  3  19      63.81   0.00   0.00   0.00   4.43   1.73   0.20   0.01   0.00   0.03
0.23   0.00   0.03   0.03.00E+00   0.00   0.64
  3  20      63.79   0.00   0.00   0.00   4.40   1.70   0.19   0.01   0.00   0.03
0.23   0.00   0.03   0.03.00E+00   0.00   0.63


  4   1      63.78   0.00   0.00   0.00   4.30   1.67   0.19   0.01   0.00   0.03
0.22   0.00   0.03   0.03.00E+00   0.00   0.60
  4   2      64.42   0.00   0.00   0.00   4.73   2.01   0.15   0.00   0.00   0.02
0.18   0.00   0.02   0.02.00E+00   0.00   0.48
  4   3      64.16   0.00   0.00   0.00   4.61   1.97   0.15   0.00   0.00   0.02
0.17   0.00   0.02   0.02.00E+00   0.00   0.46
  4   4      64.00   0.00   0.00   0.00   4.51   1.93   0.14   0.00   0.00   0.02
0.17   0.00   0.02   0.02.00E+00   0.00   0.44
  4   5      63.90   0.00   0.00   0.00   4.43   1.89   0.14   0.00   0.00   0.02
0.16   0.00   0.02   0.02.00E+00   0.00   0.43
  4   6      63.85   0.00   0.00   0.00   4.36   1.85   0.13   0.00   0.00   0.02
0.16   0.00   0.02   0.02.00E+00   0.00   0.41
  4   7      63.82   0.00   0.00   0.00   4.30   1.82   0.13   0.00   0.00   0.02
0.16   0.00   0.02   0.02.00E+00   0.00   0.39
  4   8      63.80   0.00   0.00   0.00   4.25   1.78   0.13   0.00   0.00   0.02
0.15   0.00   0.02   0.02.00E+00   0.00   0.38
  4   9      63.78   0.00   0.00   0.00   4.21   1.75   0.12   0.00   0.00   0.02
0.15   0.00   0.02   0.02.00E+00   0.00   0.36
  4  10      63.78   0.00   0.00   0.00   4.18   1.72   0.12   0.00   0.00   0.02
0.15   0.00   0.02   0.02.00E+00   0.00   0.35
  4  11      63.77   0.00   0.00   0.00   4.15   1.69   0.12   0.00   0.00   0.02
0.14   0.00   0.02   0.02.00E+00   0.00   0.34
  4  12      63.77   0.00   0.00   0.00   4.13   1.66   0.12   0.00   0.00   0.02
0.14   0.00   0.02   0.02.00E+00   0.00   0.32
  4  13      63.77   0.00   0.00   0.00   4.11   1.63   0.11   0.00   0.00   0.02
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0.14   0.00   0.02   0.02.00E+00   0.00   0.31
  4  14       63.77   0.00   0.00   0.00   4.10   1.60   0.11   0.00   0.00   0.02
0.13   0.00   0.02   0.02.00E+00   0.00   0.30
  4  15       63.77   0.00   0.00   0.00   4.09   1.58   0.11   0.00   0.00   0.02
0.13   0.00   0.02   0.02.00E+00   0.00   0.29
  4  16       63.77   0.00   0.00   0.00   4.08   1.55   0.11   0.00   0.00   0.02
0.13   0.00   0.01   0.01.00E+00   0.00   0.27
  4  17       63.77   0.00   0.00   0.00   4.08   1.53   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.26
  4  18       63.77   0.00   0.00   0.00   4.07   1.51   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.25
  4  19       63.77   0.00   0.00   0.00   4.07   1.49   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.24
  4  20       63.76   0.00   0.00   0.00   4.07   1.47   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.23


  5   1       63.76   0.00   0.00   0.00   3.97   1.45   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.23
  5   2       63.76   0.00   0.00   0.00   3.87   1.44   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.22
  5   3       63.76   0.00   0.00   0.00   3.79   1.43   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.22
  5   4       63.76   0.00   0.00   0.00   3.71   1.42   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.22
  5   5       63.76   0.00   0.00   0.00   3.65   1.41   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.21
♀
         STREAM QUALITY SIMULATION
                  OUTPUT PAGE NUMBER     9
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                  ***** STEADY STATE SIMULATION *****

                                                     ** WATER QUALITY VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                   ANC
NUM NUM        TEMP                          DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI           CHLA
              DEG-F                        MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML          UG/L

  5   6       63.76   0.00   0.00   0.00   3.58   1.40   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.21
  5   7       63.76   0.00   0.00   0.00   3.53   1.39   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.20
  5   8       63.76   0.00   0.00   0.00   3.48   1.38   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.20
  5   9       63.76   0.00   0.00   0.00   3.44   1.36   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  5  10       63.76   0.00   0.00   0.00   3.40   1.35   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  5  11       63.76   0.00   0.00   0.00   3.36   1.34   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  5  12       63.76   0.00   0.00   0.00   3.33   1.33   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.18
  5  13       63.76   0.00   0.00   0.00   3.30   1.32   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.18
  5  14       63.76   0.00   0.00   0.00   3.27   1.31   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.17
  5  15       63.76   0.00   0.00   0.00   3.25   1.30   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.17
```

5 16 63.76 0.00 0.00 0.00 3.23 1.29 0.10 0.00 0.00 0.02
0.12 0.00 0.01 0.01.00E+00 0.00 0.17

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 10
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS: LIGHT *	NITRGN *	PHSPRS *
1	1	1	1.92	0.43	0.10	0.10	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
2	1	2	1.94	0.43	0.10	0.10	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
3	1	3	1.96	0.42	0.10	0.10	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
4	1	4	1.98	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
5	1	5	2.00	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
6	1	6	2.02	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
7	1	7	2.04	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
8	1	8	2.06	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.86	0.96
9	1	9	2.08	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.86	0.96
10	1	10	2.10	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.86	0.96
11	1	11	2.12	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
12	1	12	2.14	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
13	1	13	2.16	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
14	1	14	2.18	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
15	1	15	2.20	0.42	0.09	0.09	4.19	0.03	0.10	0.02	0.02	0.27	0.85	0.96
16	1	16	2.22	0.42	0.09	0.09	4.19	0.03	0.10	0.02	0.02	0.27	0.85	0.96
17	1	17	2.24	0.42	0.09	0.09	4.18	0.03	0.10	0.02	0.02	0.27	0.85	0.96
18	1	18	2.26	0.42	0.09	0.09	4.18	0.03	0.10	0.02	0.02	0.27	0.85	0.96
19	1	19	2.28	0.42	0.09	0.09	4.18	0.03	0.10	0.02	0.02	0.27	0.85	0.96
20	2	1	2.19	0.41	0.09	0.09	4.15	0.02	0.10	0.02				

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 0.02         0.27     0.85     0.96
 21   2   2       2.11     0.41     0.09     0.09     4.12     0.02          0.10     0.02
 0.02         0.27     0.84     0.96
 22   2   3       2.03     0.41     0.09     0.09     4.09     0.02          0.10     0.02
 0.02         0.27     0.83     0.95
 23   2   4       1.96     0.40     0.09     0.09     4.06     0.02          0.10     0.02
 0.02         0.27     0.83     0.95
 24   2   5       1.90     0.40     0.09     0.09     4.03     0.02          0.10     0.02
 0.02         0.27     0.82     0.95
 25   2   6       1.83     0.40     0.09     0.09     4.00     0.02          0.10     0.02
 0.02         0.27     0.82     0.95
 26   2   7       1.78     0.40     0.09     0.09     3.97     0.02          0.10     0.02
 0.02         0.27     0.81     0.95
 27   2   8       1.72     0.39     0.09     0.09     3.94     0.02          0.10     0.02
 0.02         0.27     0.80     0.94
 28   2   9       1.67     0.39     0.09     0.09     3.91     0.02          0.10     0.02
 0.02         0.27     0.80     0.94
 29   2  10       1.62     0.39     0.09     0.09     3.88     0.02          0.10     0.02
 0.01         0.27     0.79     0.94
 30   2  11       1.57     0.38     0.09     0.09     3.86     0.02          0.10     0.02
 0.01         0.27     0.79     0.94
 31   2  12       1.53     0.38     0.09     0.09     3.83     0.02          0.10     0.02
 0.01         0.27     0.78     0.94
 32   2  13       1.48     0.38     0.09     0.09     3.80     0.01          0.10     0.02
 0.01         0.27     0.78     0.93
 33   2  14       1.44     0.38     0.09     0.09     3.77     0.01          0.10     0.02
 0.01         0.27     0.77     0.93
 34   2  15       1.40     0.37     0.09     0.09     3.75     0.01          0.10     0.02
 0.01         0.27     0.76     0.93
 35   2  16       1.37     0.37     0.09     0.09     3.72     0.01          0.10     0.02
 0.01         0.27     0.76     0.93
 36   2  17       1.33     0.37     0.09     0.09     3.69     0.01          0.10     0.02
 0.01         0.27     0.75     0.93
 37   2  18       1.30     0.37     0.09     0.09     3.67     0.01          0.10     0.02
 0.01         0.27     0.75     0.93
 38   2  19       1.26     0.36     0.09     0.09     3.64     0.01          0.10     0.02
 0.01         0.27     0.74     0.92
 39   2  20       1.23     0.36     0.09     0.09     3.62     0.01          0.10     0.02
 0.01         0.27     0.74     0.92


 40   3   1       1.22     0.36     0.09     0.09     3.59     0.01          0.10     0.02
 0.01         0.27     0.73     0.92
 41   3   2       1.20     0.35     0.09     0.09     3.56     0.01          0.10     0.02
 0.01         0.27     0.73     0.92
 42   3   3       1.19     0.35     0.09     0.09     3.54     0.01          0.10     0.02
 0.01         0.27     0.72     0.92
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    11
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                        ***** STEADY STATE SIMULATION *****

                                                                ** ALGAE DATA **

                                                                                  NH3-N
         ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE               ALGY     ALGY     ALGY    A P/R      NET          NH3    FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH     RESP     SETT    RATIO      P-R          PREF  N-UPTKE
EXTCO        LIGHT   NITRGN   PHSPRS
                   UG/L   1/DAY    1/DAY    FT/DA       *    MG/L-D           *        *
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1/FT            *         *         *

43   3   4        1.18    0.35    0.09    0.09    3.51    0.01        0.10    0.02
0.01          0.27     0.72     0.91
44   3   5        1.16    0.35    0.09    0.09    3.49    0.01        0.10    0.02
0.01          0.27     0.71     0.91
45   3   6        1.15    0.34    0.09    0.09    3.47    0.01        0.10    0.02
0.01          0.27     0.71     0.91
46   3   7        1.14    0.34    0.09    0.09    3.44    0.01        0.10    0.02
0.01          0.27     0.70     0.91
47   3   8        1.13    0.34    0.09    0.09    3.42    0.01        0.10    0.02
0.01          0.27     0.70     0.91
48   3   9        1.11    0.34    0.09    0.09    3.40    0.01        0.10    0.02
0.01          0.27     0.69     0.91
49   3  10        1.10    0.34    0.09    0.09    3.37    0.01        0.10    0.02
0.01          0.27     0.69     0.90
50   3  11        1.09    0.33    0.09    0.09    3.35    0.01        0.10    0.02
0.01          0.27     0.68     0.90
51   3  12        0.70    0.29    0.10    0.10    2.85    0.00        0.10    0.02
0.01          0.27     0.58     0.86
52   3  13        0.69    0.29    0.10    0.10    2.83    0.00        0.10    0.02
0.01          0.27     0.58     0.85
53   3  14        0.68    0.28    0.10    0.10    2.81    0.00        0.10    0.02
0.01          0.27     0.57     0.85
54   3  15        0.67    0.28    0.10    0.10    2.80    0.00        0.10    0.02
0.01          0.27     0.57     0.85
55   3  16        0.66    0.28    0.09    0.09    2.78    0.00        0.10    0.02
0.01          0.27     0.57     0.85
56   3  17        0.66    0.28    0.09    0.09    2.76    0.00        0.10    0.02
0.01          0.27     0.56     0.85
57   3  18        0.65    0.27    0.09    0.09    2.75    0.00        0.10    0.02
0.01          0.27     0.56     0.85
58   3  19        0.64    0.27    0.09    0.09    2.73    0.00        0.10    0.02
0.01          0.27     0.56     0.84
59   3  20        0.63    0.27    0.09    0.09    2.72    0.00        0.10    0.02
0.01          0.27     0.55     0.84


60   4   1        0.60    0.27    0.09    0.09    2.67    0.00        0.10    0.02
0.01          0.27     0.54     0.84
61   4   2        0.48    0.24    0.10    0.10    2.41    0.00        0.10    0.02
0.01          0.27     0.49     0.81
62   4   3        0.46    0.24    0.10    0.10    2.37    0.00        0.10    0.02
0.01          0.27     0.48     0.80
63   4   4        0.44    0.23    0.09    0.09    2.34    0.00        0.10    0.02
0.01          0.27     0.48     0.80
64   4   5        0.43    0.23    0.09    0.09    2.30    0.00        0.10    0.02
0.01          0.27     0.47     0.79
65   4   6        0.41    0.23    0.09    0.09    2.27    0.00        0.10    0.02
0.01          0.27     0.46     0.79
66   4   7        0.39    0.22    0.09    0.09    2.24    0.00        0.10    0.02
0.01          0.27     0.46     0.78
67   4   8        0.38    0.22    0.09    0.09    2.20    0.00        0.10    0.02
0.01          0.27     0.45     0.78
68   4   9        0.36    0.22    0.09    0.09    2.17    0.00        0.10    0.02
0.01          0.27     0.44     0.78
69   4  10        0.35    0.21    0.09    0.09    2.14    0.00        0.10    0.02
0.01          0.27     0.44     0.77
70   4  11        0.34    0.21    0.09    0.09    2.11    0.00        0.10    0.02
0.01          0.27     0.43     0.77
71   4  12        0.32    0.21    0.09    0.09    2.09    0.00        0.10    0.02
0.01          0.27     0.43     0.76
72   4  13        0.31    0.20    0.09    0.09    2.06    0.00        0.10    0.02
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 0.01          0.27     0.42     0.76
 73   4  14        0.30    0.20    0.09    0.09    2.03    0.00         0.10    0.02
 0.01          0.27     0.41     0.76
 74   4  15        0.29    0.20    0.09    0.09    2.00    0.00         0.10    0.02
 0.01          0.27     0.41     0.75
 75   4  16        0.27    0.20    0.09    0.09    1.98    0.00         0.10    0.02
 0.01          0.27     0.40     0.75
 76   4  17        0.26    0.19    0.09    0.09    1.95    0.00         0.10    0.02
 0.01          0.27     0.40     0.74
 77   4  18        0.25    0.19    0.09    0.09    1.93    0.00         0.10    0.02
 0.01          0.27     0.39     0.74
 78   4  19        0.24    0.19    0.09    0.09    1.91    0.00         0.10    0.02
 0.01          0.27     0.39     0.74
 79   4  20        0.23    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73


 80   5   1        0.23    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 81   5   2        0.22    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 82   5   3        0.22    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 83   5   4        0.22    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 84   5   5        0.21    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
♀
        STREAM QUALITY SIMULATION
                  OUTPUT PAGE NUMBER    12
        QUAL-2E STREAM QUALITY ROUTING MODEL
          Version 3.22  --  May 1996
                                                    ***** STEADY STATE SIMULATION *****

                                                             ** ALGAE DATA **

                                                                              NH3-N
        ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE              ALGY    ALGY    ALGY   A P/R     NET          NH3   FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH    RESP    SETT   RATIO     P-R         PREF  N-UPTKE
EXTCO         LIGHT   NITRGN   PHSPRS
                   UG/L   1/DAY   1/DAY   FT/DA       *   MG/L-D           *       *
 1/FT            *        *        *

 85   5   6        0.21    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 86   5   7        0.20    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 87   5   8        0.20    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 88   5   9        0.19    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 89   5  10        0.19    0.19    0.09    0.09    1.88    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 90   5  11        0.19    0.19    0.09    0.09    1.87    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 91   5  12        0.18    0.19    0.09    0.09    1.87    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 92   5  13        0.18    0.19    0.09    0.09    1.87    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
 93   5  14        0.17    0.19    0.09    0.09    1.87    0.00         0.10    0.02
 0.01          0.27     0.38     0.73
```

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 94   5  15        0.17    0.19    0.09    0.09    1.87    0.00        0.10    0.02
 0.01         0.27     0.38     0.73
 95   5  16        0.17    0.19    0.09    0.09    1.87    0.00        0.10    0.02
 0.01         0.27     0.38     0.73
```

♀

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 13
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	65.04	9.18	4.76	4.42	0.00	0.94	27.26	2.77	-0.05	-1.72	0.02	0.00	0.00
2	1	2	64.47	9.24	4.64	4.61	0.00	0.94	0.00	2.86	-0.04	-1.72	0.02	0.00	0.00
3	1	3	64.15	9.28	4.53	4.75	0.00	0.93	0.00	2.94	-0.04	-1.72	0.02	0.00	0.00
4	1	4	63.98	9.29	4.43	4.87	0.00	0.93	0.00	3.00	-0.04	-1.72	0.02	0.00	0.00
5	1	5	63.89	9.30	4.34	4.96	0.00	0.93	0.00	3.06	-0.04	-1.72	0.02	0.00	0.00
6	1	6	63.84	9.31	4.26	5.05	0.00	0.92	0.00	3.11	-0.04	-1.72	0.02	0.00	0.00
7	1	7	63.81	9.31	4.19	5.12	0.00	0.92	0.00	3.15	-0.04	-1.72	0.02	0.00	0.00
8	1	8	63.79	9.31	4.13	5.19	0.00	0.92	0.00	3.19	-0.04	-1.72	0.02	0.00	0.00
9	1	9	63.78	9.32	4.07	5.25	0.00	0.91	0.00	3.23	-0.04	-1.72	0.02	0.00	0.00
10	1	10	63.78	9.32	4.02	5.30	0.00	0.91	0.00	3.26	-0.04	-1.72	0.02	0.00	0.00
11	1	11	63.78	9.32	3.97	5.34	0.00	0.91	0.00	3.28	-0.04	-1.72	0.02	0.00	0.00
12	1	12	63.78	9.32	3.93	5.38	0.00	0.91	0.00	3.31	-0.04	-1.72	0.02	0.00	0.00
13	1	13	63.78	9.32	3.90	5.42	0.00	0.90	0.00	3.33	-0.04	-1.72	0.02	0.00	0.00
14	1	14	63.78	9.32	3.86	5.45	0.00	0.90	0.00	3.35	-0.04	-1.72	0.02	0.00	0.00
15	1	15	63.78	9.32	3.83	5.48	0.00	0.90	0.00	3.37	-0.04	-1.72	0.03	0.00	0.00
16	1	16	63.77	9.32	3.81	5.51	0.00	0.90	0.00	3.39	-0.04	-1.72	0.03	0.00	0.00
17	1	17	63.77	9.32	3.78	5.54	0.00	0.90	0.00	3.40	-0.04	-1.72	0.03	0.00	0.00
18	1	18	63.77	9.32	3.76	5.56	0.00	0.90	0.00	3.42	-0.04	-1.72	0.03	0.00	0.00
19	1	19	63.77	9.32	3.74	5.58	0.00	0.89	0.00	3.43	-0.04	-1.72	0.03	0.00	0.00

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 20   2   1  63.83    9.31    3.76    5.55    0.00    0.89         1.59    3.42
-0.04   -1.92    0.02    0.00    0.00
 21   2   2  63.86    9.31    3.78    5.53    0.00    0.90         1.52    3.40
-0.04   -1.92    0.02    0.00    0.00
 22   2   3  63.87    9.31    3.81    5.50    0.00    0.90         1.45    3.39
-0.04   -1.92    0.02    0.00    0.00
 23   2   4  63.88    9.31    3.84    5.47    0.00    0.90         1.39    3.36
-0.04   -1.92    0.02    0.00    0.00
 24   2   5  63.88    9.31    3.88    5.43    0.00    0.90         1.34    3.34
-0.04   -1.92    0.02    0.00    0.00
 25   2   6  63.87    9.31    3.92    5.39    0.00    0.90         1.28    3.32
-0.04   -1.92    0.02    0.00    0.00
 26   2   7  63.87    9.31    3.96    5.35    0.00    0.91         1.24    3.29
-0.04   -1.92    0.02    0.00    0.00
 27   2   8  63.87    9.31    4.00    5.31    0.00    0.91         1.19    3.27
-0.04   -1.92    0.02    0.00    0.00
 28   2   9  63.86    9.31    4.04    5.27    0.00    0.91         1.15    3.24
-0.04   -1.92    0.02    0.00    0.00
 29   2  10  63.86    9.31    4.08    5.22    0.00    0.91         1.11    3.22
-0.04   -1.92    0.02    0.00    0.00
 30   2  11  63.86    9.31    4.13    5.18    0.00    0.92         1.08    3.19
-0.04   -1.92    0.02    0.00    0.00
 31   2  12  63.86    9.31    4.17    5.14    0.00    0.92         1.04    3.16
-0.04   -1.92    0.02    0.00    0.00
 32   2  13  63.85    9.31    4.21    5.10    0.00    0.92         1.01    3.14
-0.04   -1.92    0.01    0.00    0.00
 33   2  14  63.85    9.31    4.25    5.06    0.00    0.92         0.98    3.11
-0.04   -1.92    0.01    0.00    0.00
 34   2  15  63.85    9.31    4.29    5.02    0.00    0.92         0.95    3.09
-0.04   -1.92    0.01    0.00    0.00
 35   2  16  63.85    9.31    4.33    4.98    0.00    0.93         0.93    3.06
-0.04   -1.92    0.01    0.00    0.00
 36   2  17  63.84    9.31    4.37    4.94    0.00    0.93         0.90    3.04
-0.04   -1.92    0.01    0.00    0.00
 37   2  18  63.84    9.31    4.40    4.91    0.00    0.93         0.88    3.02
-0.04   -1.92    0.01    0.00    0.00
 38   2  19  63.84    9.31    4.44    4.87    0.00    0.93         0.86    3.00
-0.04   -1.92    0.01    0.00    0.00
 39   2  20  63.84    9.31    4.47    4.84    0.00    0.93         0.83    2.98
-0.04   -1.92    0.01    0.00    0.00


 40   3   1  63.80    9.31    4.28    5.04    0.00    0.92         0.81    3.10
-0.04   -2.12    0.01    0.00    0.00
 41   3   2  63.78    9.32    4.11    5.20    0.00    0.92         0.79    3.20
-0.04   -2.12    0.01    0.00    0.00
 42   3   3  63.77    9.32    3.97    5.34    0.00    0.91         0.78    3.28
-0.04   -2.12    0.01    0.00    0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    14
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                    ***** STEADY STATE SIMULATION *****

                                                        ** DISSOLVED OXYGEN DATA **

                                                                   COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE               DO              DO     DAM     NIT
ORD NUM NUM     TEMP     SAT      DO     DEF   INPUT   INHIB      F-FNCTN   OXYGN
                 NET
               DEG-F     MG/L    MG/L    MG/L    MG/L    FACT        INPUT   REAIR
```

```
C-BOD     SOD      P-R   NH3-N   NO2-N

 43   3   4  63.76    9.32    3.86    5.46    0.00    0.90        0.76    3.35
-0.04   -2.12    0.01    0.00    0.00
 44   3   5  63.76    9.32    3.77    5.55    0.00    0.90        0.74    3.41
-0.04   -2.12    0.01    0.00    0.00
 45   3   6  63.76    9.32    3.69    5.63    0.00    0.89        0.73    3.46
-0.04   -2.12    0.01    0.00    0.00
 46   3   7  63.75    9.32    3.63    5.69    0.00    0.89        0.71    3.50
-0.04   -2.12    0.01    0.00    0.00
 47   3   8  63.75    9.32    3.58    5.74    0.00    0.88        0.70    3.53
-0.04   -2.12    0.01    0.00    0.00
 48   3   9  63.75    9.32    3.54    5.78    0.00    0.88        0.68    3.55
-0.04   -2.12    0.01    0.00    0.00
 49   3  10  63.75    9.32    3.51    5.81    0.00    0.88        0.67    3.57
-0.04   -2.12    0.01    0.00    0.00
 50   3  11  63.75    9.32    3.49    5.83    0.00    0.88        0.65    3.58
-0.04   -2.12    0.01    0.00    0.00
 51   3  12  65.21    9.17    4.84    4.32    0.00    0.95       15.62    2.71
-0.09   -2.12    0.00    0.00    0.00
 52   3  13  64.66    9.22    4.75    4.47    0.00    0.94        0.41    2.78
-0.09   -2.12    0.00    0.00    0.00
 53   3  14  64.32    9.26    4.67    4.59    0.00    0.94        0.41    2.84
-0.08   -2.12    0.00    0.00    0.00
 54   3  15  64.11    9.28    4.61    4.67    0.00    0.94        0.40    2.89
-0.08   -2.12    0.00    0.00    0.00
 55   3  16  63.98    9.30    4.55    4.75    0.00    0.93        0.40    2.93
-0.08   -2.12    0.00    0.00    0.00
 56   3  17  63.89    9.30    4.50    4.80    0.00    0.93        0.40    2.96
-0.08   -2.12    0.00    0.00    0.00
 57   3  18  63.84    9.31    4.46    4.85    0.00    0.93        0.39    2.98
-0.08   -2.12    0.00    0.00    0.00
 58   3  19  63.81    9.31    4.43    4.88    0.00    0.93        0.39    3.00
-0.08   -2.12    0.00    0.00    0.00
 59   3  20  63.79    9.32    4.40    4.91    0.00    0.93        0.38    3.02
-0.08   -2.12    0.00    0.00    0.00


 60   4   1  63.78    9.32    4.30    5.01    0.00    0.92        1.20    3.08
-0.07   -2.75    0.00    0.00    0.00
 61   4   2  64.42    9.25    4.73    4.52    0.00    0.94        8.19    2.80
-0.09   -2.75    0.00    0.00    0.00
 62   4   3  64.16    9.28    4.61    4.66    0.00    0.94        0.94    2.88
-0.09   -2.75    0.00    0.00    0.00
 63   4   4  64.00    9.29    4.51    4.78    0.00    0.93        0.91    2.95
-0.09   -2.75    0.00    0.00    0.00
 64   4   5  63.90    9.30    4.43    4.87    0.00    0.93        0.89    3.00
-0.09   -2.75    0.00    0.00    0.00
 65   4   6  63.85    9.31    4.36    4.95    0.00    0.93        0.86    3.04
-0.08   -2.75    0.00    0.00    0.00
 66   4   7  63.82    9.31    4.30    5.01    0.00    0.92        0.84    3.08
-0.08   -2.75    0.00    0.00    0.00
 67   4   8  63.80    9.31    4.25    5.06    0.00    0.92        0.82    3.11
-0.08   -2.75    0.00    0.00    0.00
 68   4   9  63.78    9.32    4.21    5.10    0.00    0.92        0.80    3.14
-0.08   -2.75    0.00    0.00    0.00
 69   4  10  63.78    9.32    4.18    5.14    0.00    0.92        0.78    3.16
-0.08   -2.75    0.00    0.00    0.00
 70   4  11  63.77    9.32    4.15    5.17    0.00    0.92        0.77    3.18
-0.08   -2.75    0.00    0.00    0.00
 71   4  12  63.77    9.32    4.13    5.19    0.00    0.92        0.75    3.19
-0.07   -2.75    0.00    0.00    0.00
 72   4  13  63.77    9.32    4.11    5.21    0.00    0.92        0.73    3.20
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-0.07    -2.75    0.00    0.00    0.00
 73   4  14   63.77    9.32    4.10    5.22    0.00    0.91         0.72    3.21
-0.07    -2.75    0.00    0.00    0.00
 74   4  15   63.77    9.32    4.09    5.23    0.00    0.91         0.70    3.21
-0.07    -2.75    0.00    0.00    0.00
 75   4  16   63.77    9.32    4.08    5.24    0.00    0.91         0.69    3.22
-0.07    -2.75    0.00    0.00    0.00
 76   4  17   63.77    9.32    4.08    5.24    0.00    0.91         0.67    3.22
-0.07    -2.75    0.00    0.00    0.00
 77   4  18   63.77    9.32    4.07    5.25    0.00    0.91         0.66    3.22
-0.07    -2.75    0.00    0.00    0.00
 78   4  19   63.77    9.32    4.07    5.25    0.00    0.91         0.65    3.23
-0.07    -2.75    0.00    0.00    0.00
 79   4  20   63.76    9.32    4.07    5.25    0.00    0.91         0.63    3.23
-0.07    -2.75    0.00    0.00    0.00


 80   5   1   63.76    9.32    3.97    5.35    0.00    0.91         0.00    3.29
-0.07    -3.14    0.00    0.00    0.00
 81   5   2   63.76    9.32    3.87    5.44    0.00    0.90         0.00    3.35
-0.06    -3.14    0.00    0.00    0.00
 82   5   3   63.76    9.32    3.79    5.53    0.00    0.90         0.00    3.40
-0.06    -3.14    0.00    0.00    0.00
 83   5   4   63.76    9.32    3.71    5.60    0.00    0.89         0.00    3.44
-0.06    -3.14    0.00    0.00    0.00
 84   5   5   63.76    9.32    3.65    5.67    0.00    0.89         0.00    3.49
-0.06    -3.14    0.00    0.00    0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    15
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                   ***** STEADY STATE SIMULATION *****

                                                       ** DISSOLVED OXYGEN DATA **

                                                                    COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE              DO              DO     DAM     NIT
ORD NUM NUM     TEMP     SAT      DO     DEF   INPUT   INHIB      F-FNCTN   OXYGN
                 NET
              DEG-F     MG/L    MG/L    MG/L    MG/L    FACT        INPUT   REAIR
C-BOD      SOD    P-R    NH3-N   NO2-N

 85   5   6   63.76    9.32    3.58    5.73    0.00    0.88         0.00    3.52
-0.06    -3.14    0.00    0.00    0.00
 86   5   7   63.76    9.32    3.53    5.79    0.00    0.88         0.00    3.56
-0.06    -3.14    0.00    0.00    0.00
 87   5   8   63.76    9.32    3.48    5.84    0.00    0.88         0.00    3.59
-0.06    -3.14    0.00    0.00    0.00
 88   5   9   63.76    9.32    3.44    5.88    0.00    0.87         0.00    3.62
-0.06    -3.14    0.00    0.00    0.00
 89   5  10   63.76    9.32    3.40    5.92    0.00    0.87         0.00    3.64
-0.06    -3.14    0.00    0.00    0.00
 90   5  11   63.76    9.32    3.36    5.96    0.00    0.87         0.00    3.66
-0.06    -3.14    0.00    0.00    0.00
 91   5  12   63.76    9.32    3.33    5.99    0.00    0.86         0.00    3.68
-0.06    -3.14    0.00    0.00    0.00
 92   5  13   63.76    9.32    3.30    6.02    0.00    0.86         0.00    3.70
-0.06    -3.14    0.00    0.00    0.00
 93   5  14   63.76    9.32    3.27    6.04    0.00    0.86         0.00    3.72
-0.06    -3.14    0.00    0.00    0.00
 94   5  15   63.76    9.32    3.25    6.07    0.00    0.86         0.00    3.73
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-0.06   -3.14    0.00    0.00    0.00
 95   5  16   63.76    9.32    3.23    6.09    0.00    0.86         0.00    3.74
-0.06   -3.14    0.00    0.00    0.00
```

♀ * * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *
Version 3.22 -- May 1996

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-2E PROGRAM TITLES
ITLE01		Bonpas Creek DO TMDL ILEPA13A
TITLE02		Calibration run for October 6, 2015. WSS-High BOD
TITLE03	NO	CONSERVATIVE MINERAL I
TITLE04	NO	CONSERVATIVE MINERAL II
TITLE05	NO	CONSERVATIVE MINERAL III
TITLE06	YES	TEMPERATURE
TITLE07	YES	5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08	YES	ALGAE AS CHL-A IN UG/L
TITLE09	YES	PHOSPHORUS CYCLE AS P IN MG/L
TITLE10		(ORGANIC-P; DISSOLVED-P)
TITLE11	YES	NITROGEN CYCLE AS N IN MG/L
TITLE12		(ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	FECAL COLIFORM IN NO./100 ML
TITLE15	NO	ARBITRARY NON-CONSERVATIVE
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	0.00000		0.00000
NOWRITE OPTIONAL SUMMARY	0.00000		0.00000
NO FLOW AUGMENTATION	0.00000		0.00000
STEADY STATE	0.00000		0.00000
NO TRAPEZOIDAL CHANNELS	0.00000		0.00000
NO PRINT LCD/SOLAR DATA	0.00000		0.00000
NO PLOT DO AND BOD	0.00000		0.00000
FIXED DNSTM CONC (YES=1)=	0.00000	D-ULT BOD CONV K COEF =	0.23000
INPUT METRIC =	0.00000	UTPUT METRIC =	0.00000
NUMBER OF REACHES =	5.00000	UMBER OF JUNCTIONS =	0.00000

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         NUM OF HEADWATERS        =   1.00000          UMBER OF POINT LOADS   =
6.00000
         TIME STEP (HOURS)        =   1.00000          NTH. COMP. ELEMENT (MI)=
0.50000
         MAXIMUM ROUTE TIME (HRS)=  60.00000          IME INC. FOR RPT2 (HRS)=
1.00000
         LATITUDE OF BASIN (DEG) =  38.38000          ONGITUDE OF BASIN (DEG)=
-87.97000
         STANDARD MERIDIAN (DEG) =   0.00000          AY OF YEAR START TIME  =
278.00000
         EVAP. COEF.,(AE)        =   0.00068          VAP. COEF.,(BE)        =
0.00027
         ELEV. OF BASIN (ELEV)   = 373.00000          UST ATTENUATION COEF.  =
0.06000
         ENDATA1                     0.00000
0.00000

          $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

         CARD TYPE                                               CARD TYPE
         O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300              O UPTAKE BY NO2 OXID(MG
O/MG N)=    1.1400
         O PROD  BY ALGAE (MG O/MG A)   =    1.8000              O UPTAKE BY ALGAE (MG
O/MG A)  =    1.9000
         N CONTENT OF ALGAE (MG N/MG A) =    0.0900              P CONTENT OF ALGAE (MG
P/MG A) =    0.0140
         ALG MAX SPEC GROWTH RATE(1/DAY)=    2.0000              ALGAE RESPIRATION RATE
(1/DAY)=     0.1050
         N HALF SATURATION CONST (MG/L) =    0.0300              P HALF SATURATION CONST
 (MG/L)=    0.0050
         LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0030              NLIN
SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
         LIGHT FUNCTION OPTION (LFNOPT) =    2.0000              LIGHT SAT'N COEF
(BTU/FT2-MIN) =    0.6600
         DAILY AVERAGING OPTION (LAVOPT)=    3.0000              LIGHT AVERAGING FACTOR
(INT)  =    0.9000
         NUMBER OF DAYLIGHT HOURS (DLH) =   13.3000              TOTAL DAILY SOLR RAD
(BTU/FT-2)= 1500.0000
         ALGY GROWTH CALC OPTION(LGROPT)=    2.0000              ALGAL PREF FOR NH3-N
(PREFN)   =    0.1000
         ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500              NITRIFICATION
INHIBITION COEF  =    0.6000
         ENDATA1A                            0.0000
            0.0000

          $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS)
$$$

         CARD TYPE     RATE CODE     THETA VALUE

         THETA( 1)      BOD DECA        1.047     DFLT
         THETA( 2)      BOD SETT        1.024     DFLT
         THETA( 3)      OXY TRAN        1.024     DFLT
         THETA( 4)      SOD RATE        1.000     USER
         THETA( 5)      ORGN DEC        1.047     DFLT
         THETA( 6)      ORGN SET        1.024     DFLT
         THETA( 7)      NH3 DECA        1.083     DFLT
         THETA( 8)      NH3 SRCE        1.074     DFLT
         THETA( 9)      NO2 DECA        1.047     DFLT
         THETA(10)      PORG DEC        1.047     DFLT
         THETA(11)      PORG SET        1.024     DFLT
         THETA(12)      DISP SRC        1.074     DFLT
         THETA(13)      ALG GROW        1.047     DFLT
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         THETA(14)      ALG RESP        1.047     DFLT
         THETA(15)      ALG SETT        1.024     DFLT
         THETA(16)      COLI DEC        1.047     DFLT
         THETA(17)      ANC DECA        1.000     DFLT
         THETA(18)      ANC SETT        1.024     DFLT
         THETA(19)      ANC SRCE        1.000     DFLT
         ENDATA1B

          $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

         CARD TYPE           REACH ORDER AND IDENT              R. MI/KM
R. MI/KM
         STREAM REACH     1.0   RCH= Hdwtr, RM 38-4     FR         47.5    TO
  38.0
         STREAM REACH     2.0   RCH= RM 38.0 to 28.     FR         38.0    TO
  28.0
         STREAM REACH     3.0   RCH= RM 28.0 to 18.     FR         28.0    TO
  18.0
         STREAM REACH     4.0   RCH= RM 18.0 to 8.0     FR         28.0    TO
   8.0
         STREAM REACH     5.0   RCH= RM 8.0 to 0.0      FR          8.0    TO
   0.0
         ENDATA2          0.0                                       0.0
   0.0

          $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

         CARD TYPE                  REACH  AVAIL HDWS TARGET     ORDER OF AVAIL
SOURCES
         ENDATA3                     0.         0.       0.0   0.   0.   0.   0.   0.
  0.

          $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

         CARD TYPE        REACH ELEMENTS/REACH             COMPUTATIONAL FLAGS
         FLAG FIELD        1.       19.
1.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.0.
         FLAG FIELD        2.       20.
2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
         FLAG FIELD        3.       20.
2.2.2.2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.
         FLAG FIELD        4.       20.
2.6.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.6.2.
         FLAG FIELD        5.       16.
6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.
         ENDATA4           0.        0.
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

          $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

         CARD TYPE        REACH  COEF-DSPN  COEFQV    EXPOQV    COEFQH   EXPOQH
CMANN
         HYDRAULICS        1.    100.00     0.170     0.000     0.350     0.000
0.020
         HYDRAULICS        2.    100.00     0.170     0.000     0.350     0.000
0.020
         HYDRAULICS        3.    100.00     0.170     0.000     0.500     0.000
0.020
         HYDRAULICS        4.    100.00     0.170     0.000     0.450     0.000
0.020
         HYDRAULICS        5.    100.00     0.170     0.000     0.450     0.000
0.020
         ENDATA5           0.      0.00     0.000     0.000     0.000     0.000
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0.000

          $$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

         CARD TYPE                                 DUST     CLOUD   DRY BULB  WET BULB
  ATM              SOLAR RAD
                        REACH   ELEVATION     COEF      COVER      TEMP       TEMP
PRESSURE     WIND   ATTENUATION
         TEMP/LCD          1.      451.00      0.06       0.90      72.50      53.00
 29.23       5.40      1.00
         TEMP/LCD          2.      415.00      0.06       0.90      72.50      53.00
 29.23       5.40      1.00
         TEMP/LCD          3.      393.00      0.06       0.90      72.50      53.00
 29.23       5.40      1.00
         TEMP/LCD          4.      379.00      0.06       0.90      72.50      53.00
 29.23       5.40      1.00
         TEMP/LCD          5.      374.00      0.06       0.90      72.50      53.00
 29.23       5.40      1.00
         ENDATA5A          0.        0.00      0.00       0.00       0.00       0.00
  0.00       0.00      0.00

          $$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION)
$$$

         CARD TYPE        REACH     K1         K3        SOD         K2OPT     K2
COEQK2    OR   EXPQK2
                                                         RATE

TSIV COEF  OR    SLOPE

FOR OPT 8      FOR OPT 8
         REACT COEF        1.      0.05       0.00      0.017         1.       0.65
 0.000       0.00000
         REACT COEF        2.      0.05       0.00      0.019         1.       0.65
 0.000       0.00000
         REACT COEF        3.      0.05       0.00      0.030         1.       0.65
 0.000       0.00000
         REACT COEF        4.      0.05       0.00      0.035         1.       0.65
 0.000       0.00000
         REACT COEF        5.      0.05       0.00      0.040         1.       0.65
 0.000       0.00000
         ENDATA6           0.      0.00       0.00      0.000         0.       0.00
 0.000       0.00000

           $$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

         CARD TYPE           REACH    CKNH2     SETNH2     CKNH3       SNH3     CKNO2
   CKPORG   SETPORG     SPO4
         N AND P COEF          1.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00      0.00
         N AND P COEF          2.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00      0.00
         N AND P COEF          3.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00      0.00
         N AND P COEF          4.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00      0.00
         N AND P COEF          5.      0.00       0.00       0.01       0.00       2.00
    0.00       0.00      0.00
         ENDATA6A              0.      0.00       0.00       0.00       0.00       0.00
    0.00       0.00      0.00

          $$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

         CARD TYPE           REACH    ALPHAO    ALGSET    EXCOEF       CK5      CKANC
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  SETANC    SRCANC
                                                                          CKCOLI
         ALGAE/OTHER          1.      50.00      0.10      0.01      0.00      0.00
   0.00      0.00
         ALGAE/OTHER          2.      50.00      0.10      0.01      0.00      0.00
   0.00      0.00
         ALGAE/OTHER          3.      50.00      0.10      0.01      0.00      0.00
   0.00      0.00
         ALGAE/OTHER          4.      50.00      0.10      0.01      0.00      0.00
   0.00      0.00
         ALGAE/OTHER          5.      50.00      0.10      0.01      0.00      0.00
   0.00      0.00
         ENDATA6B             0.       0.00      0.00      0.00      0.00      0.00
   0.00      0.00

          $$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

         CARD TYPE          REACH    TEMP       D.O.      BOD       CM-1      CM-2
   CM-3       ANC      COLI
         INITIAL COND-1       1.      66.10      4.90      1.00      0.00      0.00
   0.00      0.00      0.00
         INITIAL COND-1       2.      66.10      4.90      1.00      0.00      0.00
   0.00      0.00      0.00
         INITIAL COND-1       3.      63.50      4.05      1.00      0.00      0.00
   0.00      0.00      0.00
         INITIAL COND-1       4.      64.00      3.45      1.00      0.00      0.00
   0.00      0.00      0.00
         INITIAL COND-1       5.      64.00      3.45      1.00      0.00      0.00
   0.00      0.00      0.00
         ENDATA7              0.       0.00      0.00      0.00      0.00      0.00
   0.00      0.00      0.00

          $$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND
PHOSPHORUS) $$$

         CARD TYPE          REACH    CHL-A     ORG-N     NH3-N     NO2-N     NO3-N
  ORG-P     DIS-P
         INITIAL COND-2       1.       1.87      0.84      0.03      0.00      0.15
   0.00      0.12
         INITIAL COND-2       2.       1.87      0.84      0.03      0.00      0.15
   0.00      0.12
         INITIAL COND-2       3.       5.87      1.14      0.18      0.00      0.19
   0.00      0.07
         INITIAL COND-2       4.       0.53      0.89      0.11      0.00      0.41
   0.00      0.08
         INITIAL COND-2       5.       4.81      0.89      0.11      0.00      0.41
   0.00      0.08
         ENDATA7A             0.       0.00      0.00      0.00      0.00      0.00
   0.00      0.00

          $$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

         CARD TYPE          REACH     FLOW      TEMP      D.O.       BOD      CM-1
   CM-2      CM-3      ANC       COLI
         INCR INFLOW-1        1.      0.000     66.10      6.00      1.00      0.00
   0.00      0.00      0.00      0.00
         INCR INFLOW-1        2.      0.040     66.10      6.00      1.00      0.00
   0.00      0.00      0.00      0.00
         INCR INFLOW-1        3.      0.040     63.50      6.00      1.00      0.00
   0.00      0.00      0.00      0.00
         INCR INFLOW-1        4.      0.130     64.00      6.00      1.00      0.00
   0.00      0.00      0.00      0.00
         INCR INFLOW-1        5.      0.000     64.00      6.00      1.00      0.00
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    0.00      0.00      0.00      0.00
         ENDATA8               0.    0.000      0.00      0.00      0.00      0.00
    0.00      0.00      0.00      0.00

          $$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A,
NITROGEN, AND PHOSPHORUS) $$$

         CARD TYPE           REACH    CHL-A     ORG-N     NH3-N     NO2-N     NO3-N
   ORG-P    DIS-P
         INCR INFLOW-2         1.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
         INCR INFLOW-2         2.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
         INCR INFLOW-2         3.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
         INCR INFLOW-2         4.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
         INCR INFLOW-2         5.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00
         ENDATA8A              0.      0.00      0.00      0.00      0.00      0.00
    0.00      0.00

          $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

         CARD TYPE              JUNCTION ORDER AND IDENT        UPSTRM   JUNCTION
 TRIB
         ENDATA9                0.                                0.         0.
  0.

          $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

         CARD TYPE    HDWTR     NAME              FLOW      TEMP      D.O.       BOD
     CM-1      CM-2      CM-3
                      ORDER
         HDWTR-NFK      1.  BonpasCK              0.04     66.10      4.90      1.00
     0.00      0.00      0.00
         ENDATA10       0.                        0.00      0.00      0.00      0.00
     0.00      0.00      0.00

          $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN,
PHOSPHORUS,
                             COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

         CARD TYPE     HDWTR     ANC     COLI    CHL-A    ORG-N    NH3-N    NO2-N
NO3-N    ORG-P    DIS-P
                       ORDER
         HEADWTR-2       1.     0.00 0.00E+00     1.90     0.84     0.03     0.00
 0.15     0.00     0.12
         ENDATA10A       0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

          $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

                       POINT
         CARD TYPE      LOAD    NAME              EFF     FLOW     TEMP     D.O.
 BOD     CM-1     CM-2     CM-3
                       ORDER
         POINTLD-1      1.     Claremont         0.00     0.00    70.00     7.90
4.00     0.00     0.00     0.00
         POINTLD-1      2.     WstSalemN         0.00     0.05    70.00     7.90
4.00     0.00     0.00     0.00
         POINTLD-1      3.     WstSalemS         0.00     0.04    70.00     7.90
120.00     0.00     0.00     0.00
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        POINTLD-1      4.      VigoCoal         0.00     0.00    70.00     7.90
0.00     0.00     0.00     0.00
        POINTLD-1      5.      Bellmont         0.00     0.00    70.00     7.90
4.00     0.00     0.00     0.00
        POINTLD-1      6.     BrownsStp         0.00     0.00    70.00     7.90
4.00     0.00     0.00     0.00
        ENDATA11       0.                       0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00

          $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN,
PHOSPHORUS,
                              COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT)
$$$

                         POINT
        CARD TYPE        LOAD     ANC     COLI    CHL-A    ORG-N    NH3-N    NO2-N
N03-N    ORG-P    DIS-P
                         ORDER
        POINTLD-2         1.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
        POINTLD-2         2.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
        POINTLD-2         3.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
        POINTLD-2         4.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
        POINTLD-2         5.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
        POINTLD-2         6.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00
        ENDATA11A         0.     0.00 0.00E+00     0.00     0.00     0.00     0.00
 0.00     0.00     0.00

          $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

                                DAM   RCH   ELE    ADAM    BDAM    FDAM    HDAM

        ENDATA12                   0.    0.    0.    0.00    0.00    0.00    0.00

          $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

             CARD TYPE              TEMP      D.O.      BOD       CM-1      CM-2
    CM-3       ANC      COLI

        ENDATA13                    DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED

          $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

             CARD TYPE              CHL-A     ORG-N     NH3-N     NO2-N     NH3-N
   ORG-P     DIS-P

        ENDATA13A                   DOWNSTREAM BOUNDARY CONCENTRATIONS ARE
UNCONSTRAINED
♀
♀
 STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
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                         NUMBER OF
        ITERATION      NONCONVERGENT
                         ELEMENTS
```

```
           1              39
           2               0
```

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION =   826.859 BTU/FT-2   (224.385 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 11.4

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	5.60	9	87.50	17	0.00
2	34.90	10	61.69	18	0.00
3	64.83	11	31.38	19	0.00
4	89.99	12	2.66	20	0.00
5	108.02	13	0.00	21	0.00
6	117.20	14	0.00	22	0.00
7	116.66	15	0.00	23	0.00
8	106.43	16	0.00	24	0.00

♀

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	95
ALGAE GROWTH RATE	2	95
ALGAE GROWTH RATE	3	76
ALGAE GROWTH RATE	4	73
ALGAE GROWTH RATE	5	61
ALGAE GROWTH RATE	6	45
ALGAE GROWTH RATE	7	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	8	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
----

1. LIGHT AVERAGING OPTION.   LAVOPT= 3

METHOD: AVERAGE OF HOURLY SOLAR VALUES

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 826.859 BTU/FT-2 (224.385 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 11.4
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): N/A

HOURLY VALUES OF SOLAR RADIATION (LANGLEYS)

1	1.52	9	23.75	17	0.00
2	9.47	10	16.74	18	0.00
3	17.59	11	8.51	19	0.00
4	24.42	12	0.72	20	0.00
5	29.31	13	0.00	21	0.00

6	31.81	14	0.00	22	0.00
7	31.66	15	0.00	23	0.00
8	28.88	16	0.00	24	0.00

2. LIGHT FUNCTION OPTION: LFNOPT= 2

SMITH FUNCTION, WITH 71% IMAX = 0.179 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 2

MINIMUM OF NITROGEN, PHOSPHORUS: FL*MIN(FN,FP)

♀

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER   1
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	47.50	47.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
2	1	2	47.00	46.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
3	1	3	46.50	46.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
4	1	4	46.00	45.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
5	1	5	45.50	45.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
6	1	6	45.00	44.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
7	1	7	44.50	44.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
8	1	8	44.00	43.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
9	1	9	43.50	43.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
10	1	10	43.00	42.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
11	1	11	42.50	42.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
12	1	12	42.00	41.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
13	1	13	41.50	41.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
14	1	14	41.00	40.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
15	1	15	40.50	40.00	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54
16	1	16	40.00	39.50	0.04	0.00	0.00	0.170	0.180	0.350	0.672	0.62	3.62	0.24	0.54

```
 17   1  17   39.50   39.00    0.04    0.00    0.00   0.170   0.180    0.350
0.672        0.62        3.62         0.24     0.54
 18   1  18   39.00   38.50    0.04    0.00    0.00   0.170   0.180    0.350
0.672        0.62        3.62         0.24     0.54
 19   1  19   38.50   38.00    0.04    0.00    0.00   0.170   0.180    0.350
0.672        0.62        3.62         0.24     0.54


 20   2   1   38.00   37.50    0.04    0.00    0.00   0.170   0.180    0.350
0.706        0.65        3.71         0.25     0.54
 21   2   2   37.50   37.00    0.04    0.00    0.00   0.170   0.180    0.350
0.739        0.68        3.80         0.26     0.54
 22   2   3   37.00   36.50    0.05    0.00    0.00   0.170   0.180    0.350
0.773        0.71        3.89         0.27     0.54
 23   2   4   36.50   36.00    0.05    0.00    0.00   0.170   0.180    0.350
0.807        0.75        3.98         0.28     0.54
 24   2   5   36.00   35.50    0.05    0.00    0.00   0.170   0.180    0.350
0.840        0.78        4.07         0.29     0.54
 25   2   6   35.50   35.00    0.05    0.00    0.00   0.170   0.180    0.350
0.874        0.81        4.16         0.31     0.54
 26   2   7   35.00   34.50    0.05    0.00    0.00   0.170   0.180    0.350
0.908        0.84        4.24         0.32     0.54
 27   2   8   34.50   34.00    0.06    0.00    0.00   0.170   0.180    0.350
0.941        0.87        4.33         0.33     0.54
 28   2   9   34.00   33.50    0.06    0.00    0.00   0.170   0.180    0.350
0.975        0.90        4.42         0.34     0.54
 29   2  10   33.50   33.00    0.06    0.00    0.00   0.170   0.180    0.350
1.008        0.93        4.51         0.35     0.54
 30   2  11   33.00   32.50    0.06    0.00    0.00   0.170   0.180    0.350
1.042        0.96        4.60         0.36     0.54
 31   2  12   32.50   32.00    0.06    0.00    0.00   0.170   0.180    0.350
1.076        0.99        4.69         0.38     0.54
 32   2  13   32.00   31.50    0.07    0.00    0.00   0.170   0.180    0.350
1.109        1.02        4.78         0.39     0.54
 33   2  14   31.50   31.00    0.07    0.00    0.00   0.170   0.180    0.350
1.143        1.06        4.87         0.40     0.54
 34   2  15   31.00   30.50    0.07    0.00    0.00   0.170   0.180    0.350
1.176        1.09        4.95         0.41     0.54
 35   2  16   30.50   30.00    0.07    0.00    0.00   0.170   0.180    0.350
1.210        1.12        5.04         0.42     0.54
 36   2  17   30.00   29.50    0.07    0.00    0.00   0.170   0.180    0.350
1.244        1.15        5.13         0.44     0.54
 37   2  18   29.50   29.00    0.08    0.00    0.00   0.170   0.180    0.350
1.277        1.18        5.22         0.45     0.54
 38   2  19   29.00   28.50    0.08    0.00    0.00   0.170   0.180    0.350
1.311        1.21        5.31         0.46     0.54
 39   2  20   28.50   28.00    0.08    0.00    0.00   0.170   0.180    0.350
1.345        1.24        5.40         0.47     0.54


 40   3   1   28.00   27.50    0.08    0.00    0.00   0.170   0.180    0.500
0.965        1.27        5.19         0.48     0.73
 41   3   2   27.50   27.00    0.08    0.00    0.00   0.170   0.180    0.500
0.988        1.30        5.25         0.49     0.73
 42   3   3   27.00   26.50    0.09    0.00    0.00   0.170   0.180    0.500
1.012        1.34        5.31         0.51     0.73
♀
          STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     2
          QUAL-2E STREAM QUALITY ROUTING MODEL
            Version 3.22  --  May 1996
                                               ***** STEADY STATE SIMULATION *****
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** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	BOTTOM WIDTH FT	VOLUME K-FT-3	AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
43	3	4	26.50	26.00	0.09	0.00	0.00	0.170	0.180	0.500	1.035	1.37	5.37	0.52	0.73
44	3	5	26.00	25.50	0.09	0.00	0.00	0.170	0.180	0.500	1.059	1.40	5.44	0.53	0.73
45	3	6	25.50	25.00	0.09	0.00	0.00	0.170	0.180	0.500	1.082	1.43	5.50	0.54	0.73
46	3	7	25.00	24.50	0.09	0.00	0.00	0.170	0.180	0.500	1.106	1.46	5.56	0.55	0.73
47	3	8	24.50	24.00	0.10	0.00	0.00	0.170	0.180	0.500	1.129	1.49	5.62	0.56	0.73
48	3	9	24.00	23.50	0.10	0.00	0.00	0.170	0.180	0.500	1.153	1.52	5.68	0.58	0.73
49	3	10	23.50	23.00	0.10	0.00	0.00	0.170	0.180	0.500	1.176	1.55	5.75	0.59	0.73
50	3	11	23.00	22.50	0.10	0.00	0.00	0.170	0.180	0.500	1.200	1.58	5.81	0.60	0.73
51	3	12	22.50	22.00	0.16	0.05	0.00	0.170	0.180	0.500	1.871	2.47	7.58	0.94	0.73
52	3	13	22.00	21.50	0.16	0.00	0.00	0.170	0.180	0.500	1.894	2.50	7.64	0.95	0.73
53	3	14	21.50	21.00	0.16	0.00	0.00	0.170	0.180	0.500	1.918	2.53	7.70	0.96	0.73
54	3	15	21.00	20.50	0.16	0.00	0.00	0.170	0.180	0.500	1.941	2.56	7.76	0.97	0.73
55	3	16	20.50	20.00	0.17	0.00	0.00	0.170	0.180	0.500	1.965	2.59	7.83	0.98	0.73
56	3	17	20.00	19.50	0.17	0.00	0.00	0.170	0.180	0.500	1.988	2.62	7.89	0.99	0.73
57	3	18	19.50	19.00	0.17	0.00	0.00	0.170	0.180	0.500	2.012	2.66	7.95	1.01	0.73
58	3	19	19.00	18.50	0.17	0.00	0.00	0.170	0.180	0.500	2.035	2.69	8.01	1.02	0.73
59	3	20	18.50	18.00	0.17	0.00	0.00	0.170	0.180	0.500	2.059	2.72	8.08	1.03	0.73
60	4	1	28.00	27.50	0.18	0.00	0.01	0.170	0.180	0.450	2.373	2.82	8.64	1.07	0.67
61	4	2	27.50	27.00	0.22	0.04	0.01	0.170	0.180	0.450	2.941	3.49	10.14	1.32	0.67
62	4	3	27.00	26.50	0.23	0.00	0.01	0.170	0.180	0.450	3.026	3.60	10.37	1.36	0.67
63	4	4	26.50	26.00	0.24	0.00	0.01	0.170	0.180	0.450	3.111	3.70	10.59	1.40	0.67
64	4	5	26.00	25.50	0.24	0.00	0.01	0.170	0.180	0.450	3.196	3.80	10.81	1.44	0.67
65	4	6	25.50	25.00	0.25	0.00	0.01	0.170	0.180	0.450	3.281	3.90	11.04	1.48	0.67
66	4	7	25.00	24.50	0.26	0.00	0.01	0.170	0.180	0.450	3.366	4.00	11.26	1.51	0.67
67	4	8	24.50	24.00	0.26	0.00	0.01	0.170	0.180	0.450	3.451	4.10	11.49	1.55	0.67
68	4	9	24.00	23.50	0.27	0.00	0.01	0.170	0.180	0.450	3.536	4.20	11.71	1.59	0.67

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 69   4  10   23.50   23.00    0.28    0.00    0.01   0.170   0.180    0.450
3.621        4.30       11.94         1.63     0.67
 70   4  11   23.00   22.50    0.28    0.00    0.01   0.170   0.180    0.450
3.706        4.40       12.16         1.67     0.67
 71   4  12   22.50   22.00    0.29    0.00    0.01   0.170   0.180    0.450
3.791        4.50       12.38         1.71     0.67
 72   4  13   22.00   21.50    0.30    0.00    0.01   0.170   0.180    0.450
3.876        4.60       12.61         1.74     0.67
 73   4  14   21.50   21.00    0.30    0.00    0.01   0.170   0.180    0.450
3.961        4.71       12.83         1.78     0.67
 74   4  15   21.00   20.50    0.31    0.00    0.01   0.170   0.180    0.450
4.046        4.81       13.06         1.82     0.67
 75   4  16   20.50   20.00    0.32    0.00    0.01   0.170   0.180    0.450
4.131        4.91       13.28         1.86     0.67
 76   4  17   20.00   19.50    0.32    0.00    0.01   0.170   0.180    0.450
4.216        5.01       13.51         1.90     0.67
 77   4  18   19.50   19.00    0.33    0.00    0.01   0.170   0.180    0.450
4.301        5.11       13.73         1.94     0.67
 78   4  19   19.00   18.50    0.34    0.00    0.01   0.170   0.180    0.450
4.386        5.21       13.95         1.97     0.67
 79   4  20   18.50   18.00    0.34    0.00    0.01   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67


 80   5   1    8.00    7.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 81   5   2    7.50    7.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 82   5   3    7.00    6.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 83   5   4    6.50    6.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 84   5   5    6.00    5.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     3
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                         ***** STEADY STATE SIMULATION *****

                                                              ** HYDRAULICS SUMMARY **

ELE RCH ELE   BEGIN      END            POINT    INCR            TRVL
                  BOTTOM      X-SECT   DSPRSN
ORD NUM NUM      LOC      LOC    FLOW    SRCE    FLOW     VEL    TIME    DEPTH
WIDTH      VOLUME          AREA          AREA     COEF
                 MILE    MILE     CFS     CFS     CFS     FPS     DAY       FT
FT      K-FT-3      K-FT-2        FT-2   FT-2/S

 85   5   6    5.50    5.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 86   5   7    5.00    4.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 87   5   8    4.50    4.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 88   5   9    4.00    3.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 89   5  10    3.50    3.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 90   5  11    3.00    2.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01     0.67
 91   5  12    2.50    2.00    0.34    0.00    0.00   0.170   0.180    0.450
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4.471        5.31       14.18         2.01      0.67
 92   5  13    2.00    1.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01      0.67
 93   5  14    1.50    1.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01      0.67
 94   5  15    1.00    0.50    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01      0.67
 95   5  16    0.50    0.00    0.34    0.00    0.00   0.170   0.180    0.450
4.471        5.31       14.18         2.01      0.67


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     4
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                        ***** STEADY STATE SIMULATION *****

                                                        ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY   SRCE  DECAY
DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY
1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  1   1   9.18   1   0.63   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.75
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   2   9.24   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.71
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   3   9.28   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.69
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   4   9.29   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.68
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   5   9.30   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   6   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   7   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   8   9.31   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   9   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  10   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  11   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  12   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  13   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  14   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  15   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  16   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  17   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1  18   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
```

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  1  19   9.32   1   0.61   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  2   1   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   2   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.61
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   3   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   4   9.31   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   5   9.31   1   0.62   0.05   0.00   0.02   0.00   0.00   0.01   0.00   1.62
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   6   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   7   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   8   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   9   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  10   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  11   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  12   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.65
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  13   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  14   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  15   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  16   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  17   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  18   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  19   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.67
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2  20   9.31   1   0.62   0.04   0.00   0.02   0.00   0.00   0.01   0.00   1.68
0.00   0.00   0.00   0.00   0.00   0.00   0.00


  3   1   9.31   1   0.61   0.04   0.00   0.03   0.00   0.00   0.01   0.00   1.66
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   2   9.32   1   0.61   0.04   0.00   0.03   0.00   0.00   0.01   0.00   1.64
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   3   9.32   1   0.61   0.04   0.00   0.03   0.00   0.00   0.01   0.00   1.63
0.00   0.00   0.00   0.00   0.00   0.00   0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     5
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                     ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3    NH3    NO2
ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
```

NUM	NUM	SAT MG/L	OPT	REAIR 1/DAY	DECAY 1/DAY	SETT 1/DAY	RATE G/F2D	DECAY 1/DAY	SETT 1/DAY	DECAY 1/DAY	SRCE MG/F2D	DECAY 1/DAY	DECAY 1/DAY	SETT 1/DAY	SRCE MG/F2D	DECAY 1/DAY	DECAY 1/DAY	SETT 1/DAY	SRCE MG/F2D
3	4	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	5	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	6	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	8	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	10	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	12	9.17	1	0.63	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	13	9.22	1	0.62	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	14	9.26	1	0.62	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	15	9.28	1	0.62	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	16	9.30	1	0.62	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	17	9.30	1	0.62	0.05	0.00	0.03	0.00	0.00	0.01	0.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	18	9.31	1	0.62	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	19	9.31	1	0.62	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	20	9.32	1	0.61	0.04	0.00	0.03	0.00	0.00	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	9.32	1	0.61	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	9.25	1	0.62	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	9.28	1	0.62	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	9.29	1	0.62	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	9.30	1	0.62	0.05	0.00	0.04	0.00	0.00	0.01	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	6	9.31	1	0.62	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7	9.31	1	0.62	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	8	9.31	1	0.61	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	9	9.32	1	0.61	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	10	9.32	1	0.61	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	11	9.32	1	0.61	0.04	0.00	0.04	0.00	0.00	0.01	0.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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  4  12    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.52
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  13    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.51
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  14    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.51
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  15    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.50
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  16    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.50
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  17    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.50
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  18    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.50
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  19    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.50
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  4  20    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.50
0.00   0.00   0.00    0.00    0.00    0.00    0.00


  5   1    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.48
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   2    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.46
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   3    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.44
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   4    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.43
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   5    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.41
0.00   0.00   0.00    0.00    0.00    0.00    0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     6
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                        ***** STEADY STATE SIMULATION *****

                                                        ** REACTION COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD     BOD     SOD    ORGN    ORGN     NH3     NH3     NO2
ORGP   ORGP   DISP    COLI     ANC     ANC     ANC
NUM NUM     SAT OPT  REAIR  DECAY   SETT    RATE   DECAY    SETT   DECAY    SRCE   DECAY
DECAY   SETT   SRCE   DECAY   DECAY    SETT    SRCE
         MG/L        1/DAY  1/DAY  1/DAY   G/F2D  1/DAY   1/DAY   1/DAY MG/F2D   1/DAY
1/DAY  1/DAY MG/F2D  1/DAY   1/DAY   1/DAY MG/F2D

  5   6    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.40
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   7    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.38
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   8    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.37
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5   9    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.36
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5  10    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.35
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5  11    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.34
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5  12    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.33
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5  13    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.32
0.00   0.00   0.00    0.00    0.00    0.00    0.00
  5  14    9.32    1    0.61    0.04    0.00    0.04   0.00    0.00    0.01    0.00    1.32
```

```
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  15   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.31
0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  16   9.32   1   0.61   0.04   0.00   0.04   0.00   0.00   0.01   0.00   1.31
0.00   0.00   0.00   0.00   0.00   0.00   0.00


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     7
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                 ***** STEADY STATE SIMULATION *****

                                                    ** WATER QUALITY VARIABLES **

RCH ELE                CM-1   CM-2   CM-3
                                     ANC
NUM NUM       TEMP                           DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI             CHLA
             DEG-F                          MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML           UG/L

  1   1      65.04   0.00   0.00   0.00   4.76   0.99   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.92
  1   2      64.47   0.00   0.00   0.00   4.64   0.98   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.94
  1   3      64.15   0.00   0.00   0.00   4.53   0.98   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.96
  1   4      63.98   0.00   0.00   0.00   4.43   0.97   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   1.98
  1   5      63.89   0.00   0.00   0.00   4.34   0.96   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.00
  1   6      63.84   0.00   0.00   0.00   4.26   0.95   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.02
  1   7      63.81   0.00   0.00   0.00   4.19   0.94   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.04
  1   8      63.79   0.00   0.00   0.00   4.13   0.94   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.06
  1   9      63.78   0.00   0.00   0.00   4.07   0.93   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.08
  1  10      63.78   0.00   0.00   0.00   4.02   0.92   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.10
  1  11      63.78   0.00   0.00   0.00   3.97   0.91   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.12
  1  12      63.78   0.00   0.00   0.00   3.93   0.91   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.14
  1  13      63.78   0.00   0.00   0.00   3.90   0.90   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.16
  1  14      63.78   0.00   0.00   0.00   3.86   0.89   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.18
  1  15      63.78   0.00   0.00   0.00   3.83   0.89   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.20
  1  16      63.77   0.00   0.00   0.00   3.81   0.88   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.22
  1  17      63.77   0.00   0.00   0.00   3.78   0.87   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.24
  1  18      63.77   0.00   0.00   0.00   3.76   0.86   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.26
  1  19      63.77   0.00   0.00   0.00   3.74   0.86   0.84   0.03   0.00   0.15
1.02   0.00   0.12   0.12.00E+00   0.00   2.28
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  2   1      63.83   0.00   0.00   0.00   3.76   0.86   0.80   0.03   0.00   0.14
0.97   0.00   0.11   0.11.00E+00   0.00   2.19
  2   2      63.86   0.00   0.00   0.00   3.78   0.86   0.76   0.03   0.00   0.13
0.92   0.00   0.11   0.11.00E+00   0.00   2.11
  2   3      63.87   0.00   0.00   0.00   3.81   0.86   0.73   0.03   0.00   0.13
0.88   0.00   0.10   0.10.00E+00   0.00   2.03
  2   4      63.88   0.00   0.00   0.00   3.84   0.86   0.70   0.02   0.00   0.12
0.85   0.00   0.10   0.10.00E+00   0.00   1.96
  2   5      63.88   0.00   0.00   0.00   3.88   0.86   0.67   0.02   0.00   0.12
0.81   0.00   0.10   0.10.00E+00   0.00   1.90
  2   6      63.87   0.00   0.00   0.00   3.92   0.85   0.65   0.02   0.00   0.11
0.78   0.00   0.09   0.09.00E+00   0.00   1.83
  2   7      63.87   0.00   0.00   0.00   3.96   0.85   0.62   0.02   0.00   0.11
0.75   0.00   0.09   0.09.00E+00   0.00   1.78
  2   8      63.87   0.00   0.00   0.00   4.00   0.85   0.60   0.02   0.00   0.10
0.72   0.00   0.08   0.09.00E+00   0.00   1.72
  2   9      63.86   0.00   0.00   0.00   4.04   0.85   0.58   0.02   0.00   0.10
0.70   0.00   0.08   0.08.00E+00   0.00   1.67
  2  10      63.86   0.00   0.00   0.00   4.08   0.85   0.56   0.02   0.00   0.10
0.68   0.00   0.08   0.08.00E+00   0.00   1.62
  2  11      63.86   0.00   0.00   0.00   4.13   0.85   0.54   0.02   0.00   0.09
0.65   0.00   0.08   0.08.00E+00   0.00   1.57
  2  12      63.86   0.00   0.00   0.00   4.17   0.84   0.53   0.02   0.00   0.09
0.63   0.00   0.07   0.07.00E+00   0.00   1.53
  2  13      63.85   0.00   0.00   0.00   4.21   0.84   0.51   0.02   0.00   0.09
0.61   0.00   0.07   0.07.00E+00   0.00   1.48
  2  14      63.85   0.00   0.00   0.00   4.25   0.84   0.50   0.02   0.00   0.08
0.60   0.00   0.07   0.07.00E+00   0.00   1.44
  2  15      63.85   0.00   0.00   0.00   4.29   0.84   0.48   0.02   0.00   0.08
0.58   0.00   0.07   0.07.00E+00   0.00   1.40
  2  16      63.85   0.00   0.00   0.00   4.33   0.84   0.47   0.02   0.00   0.08
0.56   0.00   0.07   0.07.00E+00   0.00   1.37
  2  17      63.84   0.00   0.00   0.00   4.37   0.83   0.46   0.02   0.00   0.08
0.55   0.00   0.06   0.06.00E+00   0.00   1.33
  2  18      63.84   0.00   0.00   0.00   4.40   0.83   0.44   0.01   0.00   0.07
0.53   0.00   0.06   0.06.00E+00   0.00   1.30
  2  19      63.84   0.00   0.00   0.00   4.44   0.83   0.43   0.01   0.00   0.07
0.52   0.00   0.06   0.06.00E+00   0.00   1.26
  2  20      63.84   0.00   0.00   0.00   4.47   0.83   0.42   0.01   0.00   0.07
0.51   0.00   0.06   0.06.00E+00   0.00   1.23


  3   1      63.80   0.00   0.00   0.00   4.28   0.82   0.41   0.01   0.00   0.07
0.49   0.00   0.06   0.06.00E+00   0.00   1.22
  3   2      63.78   0.00   0.00   0.00   4.11   0.82   0.40   0.01   0.00   0.07
0.48   0.00   0.06   0.06.00E+00   0.00   1.20
  3   3      63.77   0.00   0.00   0.00   3.97   0.82   0.39   0.01   0.00   0.06
0.47   0.00   0.05   0.06.00E+00   0.00   1.19
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     8
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                    ***** STEADY STATE SIMULATION *****

                                                       ** WATER QUALITY VARIABLES **

RCH ELE                CM-1   CM-2   CM-3
                                     ANC
NUM NUM       TEMP                                 DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI                 CHLA
             DEG-F                               MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML                UG/L
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  3   4      63.76   0.00   0.00   0.00   3.86   0.82   0.38   0.01   0.00   0.06
0.46   0.00   0.05   0.05.00E+00   0.00   1.18
  3   5      63.76   0.00   0.00   0.00   3.77   0.81   0.37   0.01   0.00   0.06
0.45   0.00   0.05   0.05.00E+00   0.00   1.16
  3   6      63.76   0.00   0.00   0.00   3.69   0.81   0.37   0.01   0.00   0.06
0.44   0.00   0.05   0.05.00E+00   0.00   1.15
  3   7      63.75   0.00   0.00   0.00   3.63   0.81   0.36   0.01   0.00   0.06
0.43   0.00   0.05   0.05.00E+00   0.00   1.14
  3   8      63.75   0.00   0.00   0.00   3.58   0.81   0.35   0.01   0.00   0.06
0.42   0.00   0.05   0.05.00E+00   0.00   1.13
  3   9      63.75   0.00   0.00   0.00   3.54   0.80   0.34   0.01   0.00   0.06
0.41   0.00   0.05   0.05.00E+00   0.00   1.11
  3  10      63.75   0.00   0.00   0.00   3.51   0.80   0.34   0.01   0.00   0.06
0.40   0.00   0.05   0.05.00E+00   0.00   1.10
  3  11      63.75   0.00   0.00   0.00   3.49   0.80   0.33   0.01   0.00   0.05
0.40   0.00   0.05   0.05.00E+00   0.00   1.09
  3  12      65.21   0.00   0.00   0.00   4.84   1.90   0.21   0.01   0.00   0.03
0.25   0.00   0.03   0.03.00E+00   0.00   0.70
  3  13      64.66   0.00   0.00   0.00   4.75   1.87   0.21   0.01   0.00   0.03
0.25   0.00   0.03   0.03.00E+00   0.00   0.69
  3  14      64.32   0.00   0.00   0.00   4.67   1.84   0.21   0.01   0.00   0.03
0.25   0.00   0.03   0.03.00E+00   0.00   0.68
  3  15      64.11   0.00   0.00   0.00   4.61   1.82   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.67
  3  16      63.98   0.00   0.00   0.00   4.55   1.79   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.66
  3  17      63.89   0.00   0.00   0.00   4.50   1.77   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.66
  3  18      63.84   0.00   0.00   0.00   4.46   1.75   0.20   0.01   0.00   0.03
0.24   0.00   0.03   0.03.00E+00   0.00   0.65
  3  19      63.81   0.00   0.00   0.00   4.43   1.73   0.20   0.01   0.00   0.03
0.23   0.00   0.03   0.03.00E+00   0.00   0.64
  3  20      63.79   0.00   0.00   0.00   4.40   1.70   0.19   0.01   0.00   0.03
0.23   0.00   0.03   0.03.00E+00   0.00   0.63


  4   1      63.78   0.00   0.00   0.00   4.30   1.69   0.19   0.01   0.00   0.03
0.22   0.00   0.03   0.03.00E+00   0.00   0.60
  4   2      64.42   0.00   0.00   0.00   4.54  20.95   0.15   0.00   0.00   0.02
0.18   0.00   0.02   0.02.00E+00   0.00   0.48
  4   3      64.16   0.00   0.00   0.00   4.26  20.22   0.15   0.00   0.00   0.02
0.17   0.00   0.02   0.02.00E+00   0.00   0.46
  4   4      64.00   0.00   0.00   0.00   4.02  19.54   0.14   0.00   0.00   0.02
0.17   0.00   0.02   0.02.00E+00   0.00   0.44
  4   5      63.90   0.00   0.00   0.00   3.81  18.90   0.14   0.00   0.00   0.02
0.16   0.00   0.02   0.02.00E+00   0.00   0.43
  4   6      63.85   0.00   0.00   0.00   3.65  18.29   0.13   0.00   0.00   0.02
0.16   0.00   0.02   0.02.00E+00   0.00   0.41
  4   7      63.82   0.00   0.00   0.00   3.51  17.71   0.13   0.00   0.00   0.02
0.16   0.00   0.02   0.02.00E+00   0.00   0.39
  4   8      63.80   0.00   0.00   0.00   3.39  17.16   0.13   0.00   0.00   0.02
0.15   0.00   0.02   0.02.00E+00   0.00   0.38
  4   9      63.78   0.00   0.00   0.00   3.30  16.64   0.12   0.00   0.00   0.02
0.15   0.00   0.02   0.02.00E+00   0.00   0.36
  4  10      63.78   0.00   0.00   0.00   3.22  16.15   0.12   0.00   0.00   0.02
0.15   0.00   0.02   0.02.00E+00   0.00   0.35
  4  11      63.77   0.00   0.00   0.00   3.16  15.67   0.12   0.00   0.00   0.02
0.14   0.00   0.02   0.02.00E+00   0.00   0.34
  4  12      63.77   0.00   0.00   0.00   3.11  15.22   0.12   0.00   0.00   0.02
0.14   0.00   0.02   0.02.00E+00   0.00   0.32
  4  13      63.77   0.00   0.00   0.00   3.08  14.79   0.11   0.00   0.00   0.02
0.14   0.00   0.02   0.02.00E+00   0.00   0.31
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  4  14       63.77   0.00   0.00   0.00   3.05  14.38   0.11   0.00   0.00   0.02
0.13   0.00   0.02   0.02.00E+00   0.00   0.30
  4  15       63.77   0.00   0.00   0.00   3.03  13.99   0.11   0.00   0.00   0.02
0.13   0.00   0.02   0.02.00E+00   0.00   0.29
  4  16       63.77   0.00   0.00   0.00   3.02  13.61   0.11   0.00   0.00   0.02
0.13   0.00   0.01   0.01.00E+00   0.00   0.27
  4  17       63.77   0.00   0.00   0.00   3.02  13.25   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.26
  4  18       63.77   0.00   0.00   0.00   3.02  12.91   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.25
  4  19       63.77   0.00   0.00   0.00   3.02  12.58   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.24
  4  20       63.76   0.00   0.00   0.00   3.03  12.26   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.23


  5   1       63.76   0.00   0.00   0.00   2.92  12.16   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.23
  5   2       63.76   0.00   0.00   0.00   2.81  12.07   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.22
  5   3       63.76   0.00   0.00   0.00   2.72  11.97   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.22
  5   4       63.76   0.00   0.00   0.00   2.64  11.87   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.22
  5   5       63.76   0.00   0.00   0.00   2.57  11.78   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.21
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER     9
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                    ***** STEADY STATE SIMULATION *****

                                                       ** WATER QUALITY VARIABLES **

RCH ELE                 CM-1   CM-2   CM-3
                                      ANC
NUM NUM        TEMP                             DO    BOD   ORGN   NH3N   NO2N   NO3N
SUM-N   ORGP  DIS-P  SUM-P   COLI             CHLA
              DEG-F                           MG/L   MG/L   MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L #/100ML             UG/L

  5   6       63.76   0.00   0.00   0.00   2.51  11.68   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.21
  5   7       63.76   0.00   0.00   0.00   2.45  11.59   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.20
  5   8       63.76   0.00   0.00   0.00   2.40  11.50   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.20
  5   9       63.76   0.00   0.00   0.00   2.36  11.41   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  5  10       63.76   0.00   0.00   0.00   2.32  11.31   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  5  11       63.76   0.00   0.00   0.00   2.29  11.22   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.19
  5  12       63.76   0.00   0.00   0.00   2.26  11.13   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.18
  5  13       63.76   0.00   0.00   0.00   2.23  11.04   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.18
  5  14       63.76   0.00   0.00   0.00   2.21  10.96   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.17
  5  15       63.76   0.00   0.00   0.00   2.19  10.87   0.10   0.00   0.00   0.02
0.12   0.00   0.01   0.01.00E+00   0.00   0.17
  5  16       63.76   0.00   0.00   0.00   2.17  10.78   0.10   0.00   0.00   0.02
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0.12 0.00 0.01 0.01.00E+00 0.00 0.17

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 10
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS: LIGHT *	NITRGN *	PHSPRS *
1	1	1	1.92	0.43	0.10	0.10	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
2	1	2	1.94	0.43	0.10	0.10	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
3	1	3	1.96	0.42	0.10	0.10	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
4	1	4	1.98	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
5	1	5	2.00	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
6	1	6	2.02	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
7	1	7	2.04	0.42	0.09	0.09	4.20	0.02	0.10	0.02	0.02	0.27	0.86	0.96
8	1	8	2.06	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.86	0.96
9	1	9	2.08	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.86	0.96
10	1	10	2.10	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.86	0.96
11	1	11	2.12	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
12	1	12	2.14	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
13	1	13	2.16	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
14	1	14	2.18	0.42	0.09	0.09	4.19	0.02	0.10	0.02	0.02	0.27	0.85	0.96
15	1	15	2.20	0.42	0.09	0.09	4.19	0.03	0.10	0.02	0.02	0.27	0.85	0.96
16	1	16	2.22	0.42	0.09	0.09	4.19	0.03	0.10	0.02	0.02	0.27	0.85	0.96
17	1	17	2.24	0.42	0.09	0.09	4.18	0.03	0.10	0.02	0.02	0.27	0.85	0.96
18	1	18	2.26	0.42	0.09	0.09	4.18	0.03	0.10	0.02	0.02	0.27	0.85	0.96
19	1	19	2.28	0.42	0.09	0.09	4.18	0.03	0.10	0.02	0.02	0.27	0.85	0.96
20	2	1	2.19	0.41	0.09	0.09	4.15	0.02	0.10	0.02	0.02	0.27	0.85	0.96

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 21   2   2        2.11    0.41    0.09    0.09    4.12    0.02        0.10    0.02
 0.02          0.27     0.84     0.96
 22   2   3        2.03    0.41    0.09    0.09    4.09    0.02        0.10    0.02
 0.02          0.27     0.83     0.95
 23   2   4        1.96    0.40    0.09    0.09    4.06    0.02        0.10    0.02
 0.02          0.27     0.83     0.95
 24   2   5        1.90    0.40    0.09    0.09    4.03    0.02        0.10    0.02
 0.02          0.27     0.82     0.95
 25   2   6        1.83    0.40    0.09    0.09    4.00    0.02        0.10    0.02
 0.02          0.27     0.82     0.95
 26   2   7        1.78    0.40    0.09    0.09    3.97    0.02        0.10    0.02
 0.02          0.27     0.81     0.95
 27   2   8        1.72    0.39    0.09    0.09    3.94    0.02        0.10    0.02
 0.02          0.27     0.80     0.94
 28   2   9        1.67    0.39    0.09    0.09    3.91    0.02        0.10    0.02
 0.02          0.27     0.80     0.94
 29   2  10        1.62    0.39    0.09    0.09    3.88    0.02        0.10    0.02
 0.01          0.27     0.79     0.94
 30   2  11        1.57    0.38    0.09    0.09    3.86    0.02        0.10    0.02
 0.01          0.27     0.79     0.94
 31   2  12        1.53    0.38    0.09    0.09    3.83    0.02        0.10    0.02
 0.01          0.27     0.78     0.94
 32   2  13        1.48    0.38    0.09    0.09    3.80    0.01        0.10    0.02
 0.01          0.27     0.78     0.93
 33   2  14        1.44    0.38    0.09    0.09    3.77    0.01        0.10    0.02
 0.01          0.27     0.77     0.93
 34   2  15        1.40    0.37    0.09    0.09    3.75    0.01        0.10    0.02
 0.01          0.27     0.76     0.93
 35   2  16        1.37    0.37    0.09    0.09    3.72    0.01        0.10    0.02
 0.01          0.27     0.76     0.93
 36   2  17        1.33    0.37    0.09    0.09    3.69    0.01        0.10    0.02
 0.01          0.27     0.75     0.93
 37   2  18        1.30    0.37    0.09    0.09    3.67    0.01        0.10    0.02
 0.01          0.27     0.75     0.93
 38   2  19        1.26    0.36    0.09    0.09    3.64    0.01        0.10    0.02
 0.01          0.27     0.74     0.92
 39   2  20        1.23    0.36    0.09    0.09    3.62    0.01        0.10    0.02
 0.01          0.27     0.74     0.92


 40   3   1        1.22    0.36    0.09    0.09    3.59    0.01        0.10    0.02
 0.01          0.27     0.73     0.92
 41   3   2        1.20    0.35    0.09    0.09    3.56    0.01        0.10    0.02
 0.01          0.27     0.73     0.92
 42   3   3        1.19    0.35    0.09    0.09    3.54    0.01        0.10    0.02
 0.01          0.27     0.72     0.92
♀
         STREAM QUALITY SIMULATION
                  OUTPUT PAGE NUMBER    11
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                         ***** STEADY STATE SIMULATION *****

                                                                  ** ALGAE DATA **

                                                                                    NH3-N
         ALGAE GROWTH RATE ATTEN FACTORS
ELE RCH ELE               ALGY    ALGY    ALGY   A P/R     NET         NH3   FRACT
LIGHT
ORD NUM NUM        CHLA   GRWTH    RESP    SETT   RATIO     P-R        PREF  N-UPTKE
EXTCO         LIGHT   NITRGN   PHSPRS
                   UG/L   1/DAY   1/DAY   FT/DA       *   MG/L-D          *       *
 1/FT             *        *        *
```

43	3	4	1.18	0.35	0.09	0.09	3.51	0.01	0.10	0.02	0.01	0.27	0.72	0.91
44	3	5	1.16	0.35	0.09	0.09	3.49	0.01	0.10	0.02	0.01	0.27	0.71	0.91
45	3	6	1.15	0.34	0.09	0.09	3.47	0.01	0.10	0.02	0.01	0.27	0.71	0.91
46	3	7	1.14	0.34	0.09	0.09	3.44	0.01	0.10	0.02	0.01	0.27	0.70	0.91
47	3	8	1.13	0.34	0.09	0.09	3.42	0.01	0.10	0.02	0.01	0.27	0.70	0.91
48	3	9	1.11	0.34	0.09	0.09	3.40	0.01	0.10	0.02	0.01	0.27	0.69	0.91
49	3	10	1.10	0.34	0.09	0.09	3.37	0.01	0.10	0.02	0.01	0.27	0.69	0.90
50	3	11	1.09	0.33	0.09	0.09	3.35	0.01	0.10	0.02	0.01	0.27	0.68	0.90
51	3	12	0.70	0.29	0.10	0.10	2.85	0.00	0.10	0.02	0.01	0.27	0.58	0.86
52	3	13	0.69	0.29	0.10	0.10	2.83	0.00	0.10	0.02	0.01	0.27	0.58	0.85
53	3	14	0.68	0.28	0.10	0.10	2.81	0.00	0.10	0.02	0.01	0.27	0.57	0.85
54	3	15	0.67	0.28	0.10	0.10	2.80	0.00	0.10	0.02	0.01	0.27	0.57	0.85
55	3	16	0.66	0.28	0.09	0.09	2.78	0.00	0.10	0.02	0.01	0.27	0.57	0.85
56	3	17	0.66	0.28	0.09	0.09	2.76	0.00	0.10	0.02	0.01	0.27	0.56	0.85
57	3	18	0.65	0.27	0.09	0.09	2.75	0.00	0.10	0.02	0.01	0.27	0.56	0.85
58	3	19	0.64	0.27	0.09	0.09	2.73	0.00	0.10	0.02	0.01	0.27	0.56	0.84
59	3	20	0.63	0.27	0.09	0.09	2.72	0.00	0.10	0.02	0.01	0.27	0.55	0.84

60	4	1	0.60	0.27	0.09	0.09	2.67	0.00	0.10	0.02	0.01	0.27	0.54	0.84
61	4	2	0.48	0.24	0.10	0.10	2.41	0.00	0.10	0.02	0.01	0.27	0.49	0.81
62	4	3	0.46	0.24	0.10	0.10	2.37	0.00	0.10	0.02	0.01	0.27	0.48	0.80
63	4	4	0.44	0.23	0.09	0.09	2.34	0.00	0.10	0.02	0.01	0.27	0.48	0.80
64	4	5	0.43	0.23	0.09	0.09	2.30	0.00	0.10	0.02	0.01	0.27	0.47	0.79
65	4	6	0.41	0.23	0.09	0.09	2.27	0.00	0.10	0.02	0.01	0.27	0.46	0.79
66	4	7	0.39	0.22	0.09	0.09	2.24	0.00	0.10	0.02	0.01	0.27	0.46	0.78
67	4	8	0.38	0.22	0.09	0.09	2.20	0.00	0.10	0.02	0.01	0.27	0.45	0.78
68	4	9	0.36	0.22	0.09	0.09	2.17	0.00	0.10	0.02	0.01	0.27	0.44	0.78
69	4	10	0.35	0.21	0.09	0.09	2.14	0.00	0.10	0.02	0.01	0.27	0.44	0.77
70	4	11	0.34	0.21	0.09	0.09	2.11	0.00	0.10	0.02	0.01	0.27	0.43	0.77
71	4	12	0.32	0.21	0.09	0.09	2.09	0.00	0.10	0.02	0.01	0.27	0.43	0.76
72	4	13	0.31	0.20	0.09	0.09	2.06	0.00	0.10	0.02	0.01	0.27	0.42	0.76

73	4	14	0.30	0.20	0.09	0.09	2.03	0.00	0.10	0.02	0.01	0.27	0.41	0.76
74	4	15	0.29	0.20	0.09	0.09	2.00	0.00	0.10	0.02	0.01	0.27	0.41	0.75
75	4	16	0.27	0.20	0.09	0.09	1.98	0.00	0.10	0.02	0.01	0.27	0.40	0.75
76	4	17	0.26	0.19	0.09	0.09	1.95	0.00	0.10	0.02	0.01	0.27	0.40	0.74
77	4	18	0.25	0.19	0.09	0.09	1.93	0.00	0.10	0.02	0.01	0.27	0.39	0.74
78	4	19	0.24	0.19	0.09	0.09	1.91	0.00	0.10	0.02	0.01	0.27	0.39	0.74
79	4	20	0.23	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
80	5	1	0.23	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
81	5	2	0.22	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
82	5	3	0.22	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
83	5	4	0.22	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
84	5	5	0.21	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73

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STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 12
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
85	5	6	0.21	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
86	5	7	0.20	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
87	5	8	0.20	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
88	5	9	0.19	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
89	5	10	0.19	0.19	0.09	0.09	1.88	0.00	0.10	0.02	0.01	0.27	0.38	0.73
90	5	11	0.19	0.19	0.09	0.09	1.87	0.00	0.10	0.02	0.01	0.27	0.38	0.73
91	5	12	0.18	0.19	0.09	0.09	1.87	0.00	0.10	0.02	0.01	0.27	0.38	0.73
92	5	13	0.18	0.19	0.09	0.09	1.87	0.00	0.10	0.02	0.01	0.27	0.38	0.73
93	5	14	0.17	0.19	0.09	0.09	1.87	0.00	0.10	0.02	0.01	0.27	0.38	0.73
94	5	15	0.17	0.19	0.09	0.09	1.87	0.00	0.10	0.02				

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 0.01         0.27     0.38     0.73
 95   5  16        0.17     0.19     0.09     0.09     1.87     0.00        0.10     0.02
 0.01         0.27     0.38     0.73


♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    13
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                         ***** STEADY STATE SIMULATION *****

                                                             ** DISSOLVED OXYGEN DATA **

                                                                          COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE                DO              DO      DAM      NIT
ORD NUM NUM     TEMP      SAT       DO     DEF    INPUT    INHIB        F-FNCTN    OXYGN
                 NET
               DEG-F     MG/L     MG/L    MG/L     MG/L     FACT          INPUT    REAIR
C-BOD      SOD      P-R   NH3-N   NO2-N

  1   1   1   65.04     9.18     4.76     4.42     0.00     0.94        27.26     2.77
-0.05   -1.72    0.02    0.00    0.00
  2   1   2   64.47     9.24     4.64     4.61     0.00     0.94         0.00     2.86
-0.04   -1.72    0.02    0.00    0.00
  3   1   3   64.15     9.28     4.53     4.75     0.00     0.93         0.00     2.94
-0.04   -1.72    0.02    0.00    0.00
  4   1   4   63.98     9.29     4.43     4.87     0.00     0.93         0.00     3.00
-0.04   -1.72    0.02    0.00    0.00
  5   1   5   63.89     9.30     4.34     4.96     0.00     0.93         0.00     3.06
-0.04   -1.72    0.02    0.00    0.00
  6   1   6   63.84     9.31     4.26     5.05     0.00     0.92         0.00     3.11
-0.04   -1.72    0.02    0.00    0.00
  7   1   7   63.81     9.31     4.19     5.12     0.00     0.92         0.00     3.15
-0.04   -1.72    0.02    0.00    0.00
  8   1   8   63.79     9.31     4.13     5.19     0.00     0.92         0.00     3.19
-0.04   -1.72    0.02    0.00    0.00
  9   1   9   63.78     9.32     4.07     5.25     0.00     0.91         0.00     3.23
-0.04   -1.72    0.02    0.00    0.00
 10   1  10   63.78     9.32     4.02     5.30     0.00     0.91         0.00     3.26
-0.04   -1.72    0.02    0.00    0.00
 11   1  11   63.78     9.32     3.97     5.34     0.00     0.91         0.00     3.28
-0.04   -1.72    0.02    0.00    0.00
 12   1  12   63.78     9.32     3.93     5.38     0.00     0.91         0.00     3.31
-0.04   -1.72    0.02    0.00    0.00
 13   1  13   63.78     9.32     3.90     5.42     0.00     0.90         0.00     3.33
-0.04   -1.72    0.02    0.00    0.00
 14   1  14   63.78     9.32     3.86     5.45     0.00     0.90         0.00     3.35
-0.04   -1.72    0.02    0.00    0.00
 15   1  15   63.78     9.32     3.83     5.48     0.00     0.90         0.00     3.37
-0.04   -1.72    0.03    0.00    0.00
 16   1  16   63.77     9.32     3.81     5.51     0.00     0.90         0.00     3.39
-0.04   -1.72    0.03    0.00    0.00
 17   1  17   63.77     9.32     3.78     5.54     0.00     0.90         0.00     3.40
-0.04   -1.72    0.03    0.00    0.00
 18   1  18   63.77     9.32     3.76     5.56     0.00     0.90         0.00     3.42
-0.04   -1.72    0.03    0.00    0.00
 19   1  19   63.77     9.32     3.74     5.58     0.00     0.89         0.00     3.43
-0.04   -1.72    0.03    0.00    0.00


 20   2   1   63.83     9.31     3.76     5.55     0.00     0.89         1.59     3.42
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-0.04   -1.92    0.02    0.00    0.00
 21   2   2   63.86    9.31    3.78    5.53    0.00    0.90         1.52    3.40
-0.04   -1.92    0.02    0.00    0.00
 22   2   3   63.87    9.31    3.81    5.50    0.00    0.90         1.45    3.39
-0.04   -1.92    0.02    0.00    0.00
 23   2   4   63.88    9.31    3.84    5.47    0.00    0.90         1.39    3.36
-0.04   -1.92    0.02    0.00    0.00
 24   2   5   63.88    9.31    3.88    5.43    0.00    0.90         1.34    3.34
-0.04   -1.92    0.02    0.00    0.00
 25   2   6   63.87    9.31    3.92    5.39    0.00    0.90         1.28    3.32
-0.04   -1.92    0.02    0.00    0.00
 26   2   7   63.87    9.31    3.96    5.35    0.00    0.91         1.24    3.29
-0.04   -1.92    0.02    0.00    0.00
 27   2   8   63.87    9.31    4.00    5.31    0.00    0.91         1.19    3.27
-0.04   -1.92    0.02    0.00    0.00
 28   2   9   63.86    9.31    4.04    5.27    0.00    0.91         1.15    3.24
-0.04   -1.92    0.02    0.00    0.00
 29   2  10   63.86    9.31    4.08    5.22    0.00    0.91         1.11    3.22
-0.04   -1.92    0.02    0.00    0.00
 30   2  11   63.86    9.31    4.13    5.18    0.00    0.92         1.08    3.19
-0.04   -1.92    0.02    0.00    0.00
 31   2  12   63.86    9.31    4.17    5.14    0.00    0.92         1.04    3.16
-0.04   -1.92    0.02    0.00    0.00
 32   2  13   63.85    9.31    4.21    5.10    0.00    0.92         1.01    3.14
-0.04   -1.92    0.01    0.00    0.00
 33   2  14   63.85    9.31    4.25    5.06    0.00    0.92         0.98    3.11
-0.04   -1.92    0.01    0.00    0.00
 34   2  15   63.85    9.31    4.29    5.02    0.00    0.92         0.95    3.09
-0.04   -1.92    0.01    0.00    0.00
 35   2  16   63.85    9.31    4.33    4.98    0.00    0.93         0.93    3.06
-0.04   -1.92    0.01    0.00    0.00
 36   2  17   63.84    9.31    4.37    4.94    0.00    0.93         0.90    3.04
-0.04   -1.92    0.01    0.00    0.00
 37   2  18   63.84    9.31    4.40    4.91    0.00    0.93         0.88    3.02
-0.04   -1.92    0.01    0.00    0.00
 38   2  19   63.84    9.31    4.44    4.87    0.00    0.93         0.86    3.00
-0.04   -1.92    0.01    0.00    0.00
 39   2  20   63.84    9.31    4.47    4.84    0.00    0.93         0.83    2.98
-0.04   -1.92    0.01    0.00    0.00


 40   3   1   63.80    9.31    4.28    5.04    0.00    0.92         0.81    3.10
-0.04   -2.12    0.01    0.00    0.00
 41   3   2   63.78    9.32    4.11    5.20    0.00    0.92         0.79    3.20
-0.04   -2.12    0.01    0.00    0.00
 42   3   3   63.77    9.32    3.97    5.34    0.00    0.91         0.78    3.28
-0.04   -2.12    0.01    0.00    0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    14
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                         ** DISSOLVED OXYGEN DATA **

                                                                     COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE               DO              DO     DAM     NIT
ORD NUM NUM     TEMP     SAT      DO     DEF   INPUT   INHIB       F-FNCTN   OXYGN
                 NET
               DEG-F    MG/L    MG/L    MG/L    MG/L    FACT         INPUT   REAIR
C-BOD     SOD     P-R   NH3-N   NO2-N
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43	3	4	63.76	9.32	3.86	5.46	0.00	0.90	0.76	3.35	-0.04	-2.12	0.01	0.00	0.00
44	3	5	63.76	9.32	3.77	5.55	0.00	0.90	0.74	3.41	-0.04	-2.12	0.01	0.00	0.00
45	3	6	63.76	9.32	3.69	5.63	0.00	0.89	0.73	3.46	-0.04	-2.12	0.01	0.00	0.00
46	3	7	63.75	9.32	3.63	5.69	0.00	0.89	0.71	3.50	-0.04	-2.12	0.01	0.00	0.00
47	3	8	63.75	9.32	3.58	5.74	0.00	0.88	0.70	3.53	-0.04	-2.12	0.01	0.00	0.00
48	3	9	63.75	9.32	3.54	5.78	0.00	0.88	0.68	3.55	-0.04	-2.12	0.01	0.00	0.00
49	3	10	63.75	9.32	3.51	5.81	0.00	0.88	0.67	3.57	-0.04	-2.12	0.01	0.00	0.00
50	3	11	63.75	9.32	3.49	5.83	0.00	0.88	0.65	3.58	-0.04	-2.12	0.01	0.00	0.00
51	3	12	65.21	9.17	4.84	4.32	0.00	0.95	15.62	2.71	-0.09	-2.12	0.00	0.00	0.00
52	3	13	64.66	9.22	4.75	4.47	0.00	0.94	0.41	2.78	-0.09	-2.12	0.00	0.00	0.00
53	3	14	64.32	9.26	4.67	4.59	0.00	0.94	0.41	2.84	-0.08	-2.12	0.00	0.00	0.00
54	3	15	64.11	9.28	4.61	4.67	0.00	0.94	0.40	2.89	-0.08	-2.12	0.00	0.00	0.00
55	3	16	63.98	9.30	4.55	4.75	0.00	0.93	0.40	2.93	-0.08	-2.12	0.00	0.00	0.00
56	3	17	63.89	9.30	4.50	4.80	0.00	0.93	0.40	2.96	-0.08	-2.12	0.00	0.00	0.00
57	3	18	63.84	9.31	4.46	4.85	0.00	0.93	0.39	2.98	-0.08	-2.12	0.00	0.00	0.00
58	3	19	63.81	9.31	4.43	4.88	0.00	0.93	0.39	3.00	-0.08	-2.12	0.00	0.00	0.00
59	3	20	63.79	9.32	4.40	4.91	0.00	0.93	0.38	3.02	-0.08	-2.12	0.00	0.00	0.00

60	4	1	63.78	9.32	4.30	5.01	0.00	0.92	1.20	3.08	-0.08	-2.75	0.00	0.00	0.00
61	4	2	64.42	9.25	4.54	4.70	0.00	0.93	8.19	2.92	-0.96	-2.75	0.00	0.00	0.00
62	4	3	64.16	9.28	4.26	5.02	0.00	0.92	0.94	3.10	-0.92	-2.75	0.00	0.00	0.00
63	4	4	64.00	9.29	4.02	5.28	0.00	0.91	0.91	3.25	-0.88	-2.75	0.00	0.00	0.00
64	4	5	63.90	9.30	3.81	5.49	0.00	0.90	0.89	3.38	-0.85	-2.75	0.00	0.00	0.00
65	4	6	63.85	9.31	3.65	5.66	0.00	0.89	0.86	3.48	-0.82	-2.75	0.00	0.00	0.00
66	4	7	63.82	9.31	3.51	5.81	0.00	0.88	0.84	3.57	-0.80	-2.75	0.00	0.00	0.00
67	4	8	63.80	9.31	3.39	5.92	0.00	0.87	0.82	3.64	-0.77	-2.75	0.00	0.00	0.00
68	4	9	63.78	9.32	3.30	6.02	0.00	0.86	0.80	3.70	-0.75	-2.75	0.00	0.00	0.00
69	4	10	63.78	9.32	3.22	6.09	0.00	0.86	0.78	3.75	-0.72	-2.75	0.00	0.00	0.00
70	4	11	63.77	9.32	3.16	6.16	0.00	0.85	0.77	3.78	-0.70	-2.75	0.00	0.00	0.00
71	4	12	63.77	9.32	3.11	6.20	0.00	0.85	0.75	3.81	-0.68	-2.75	0.00	0.00	0.00
72	4	13	63.77	9.32	3.08	6.24	0.00	0.84	0.73	3.84	-0.66	-2.75	0.00	0.00	0.00

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 73   4  14   63.77    9.32    3.05    6.27    0.00    0.84         0.72    3.85
-0.65   -2.75    0.00    0.00    0.00
 74   4  15   63.77    9.32    3.03    6.28    0.00    0.84         0.70    3.86
-0.63   -2.75    0.00    0.00    0.00
 75   4  16   63.77    9.32    3.02    6.30    0.00    0.84         0.69    3.87
-0.61   -2.75    0.00    0.00    0.00
 76   4  17   63.77    9.32    3.02    6.30    0.00    0.84         0.67    3.87
-0.59   -2.75    0.00    0.00    0.00
 77   4  18   63.77    9.32    3.02    6.30    0.00    0.84         0.66    3.87
-0.58   -2.75    0.00    0.00    0.00
 78   4  19   63.77    9.32    3.02    6.30    0.00    0.84         0.65    3.87
-0.56   -2.75    0.00    0.00    0.00
 79   4  20   63.76    9.32    3.03    6.29    0.00    0.84         0.63    3.87
-0.55   -2.75    0.00    0.00    0.00


 80   5   1   63.76    9.32    2.92    6.40    0.00    0.83         0.00    3.94
-0.55   -3.14    0.00    0.00    0.00
 81   5   2   63.76    9.32    2.81    6.50    0.00    0.82         0.00    4.00
-0.54   -3.14    0.00    0.00    0.00
 82   5   3   63.76    9.32    2.72    6.60    0.00    0.80         0.00    4.05
-0.54   -3.14    0.00    0.00    0.00
 83   5   4   63.76    9.32    2.64    6.68    0.00    0.80         0.00    4.10
-0.53   -3.14    0.00    0.00    0.00
 84   5   5   63.76    9.32    2.57    6.75    0.00    0.79         0.00    4.15
-0.53   -3.14    0.00    0.00    0.00
♀
         STREAM QUALITY SIMULATION
                   OUTPUT PAGE NUMBER    15
         QUAL-2E STREAM QUALITY ROUTING MODEL
           Version 3.22  --  May 1996
                                                     ***** STEADY STATE SIMULATION *****

                                                         ** DISSOLVED OXYGEN DATA **

                                                                        COMPONENTS OF
DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE             DO              DO     DAM     NIT
ORD NUM NUM     TEMP    SAT      DO    DEF   INPUT   INHIB        F-FNCTN   OXYGN
                NET
              DEG-F    MG/L    MG/L    MG/L    MG/L    FACT         INPUT   REAIR
C-BOD      SOD     P-R   NH3-N   NO2-N

 85   5   6   63.76    9.32    2.51    6.81    0.00    0.78         0.00    4.19
-0.52   -3.14    0.00    0.00    0.00
 86   5   7   63.76    9.32    2.45    6.87    0.00    0.77         0.00    4.22
-0.52   -3.14    0.00    0.00    0.00
 87   5   8   63.76    9.32    2.40    6.92    0.00    0.76         0.00    4.25
-0.52   -3.14    0.00    0.00    0.00
 88   5   9   63.76    9.32    2.36    6.96    0.00    0.76         0.00    4.28
-0.51   -3.14    0.00    0.00    0.00
 89   5  10   63.76    9.32    2.32    7.00    0.00    0.75         0.00    4.30
-0.51   -3.14    0.00    0.00    0.00
 90   5  11   63.76    9.32    2.29    7.03    0.00    0.75         0.00    4.32
-0.50   -3.14    0.00    0.00    0.00
 91   5  12   63.76    9.32    2.26    7.06    0.00    0.74         0.00    4.34
-0.50   -3.14    0.00    0.00    0.00
 92   5  13   63.76    9.32    2.23    7.09    0.00    0.74         0.00    4.36
-0.50   -3.14    0.00    0.00    0.00
 93   5  14   63.76    9.32    2.21    7.11    0.00    0.73         0.00    4.37
-0.49   -3.14    0.00    0.00    0.00
 94   5  15   63.76    9.32    2.19    7.13    0.00    0.73         0.00    4.38
-0.49   -3.14    0.00    0.00    0.00
```

```
 95   5  16   63.76     9.32     2.17     7.14     0.00     0.73            0.00     4.39
-0.48    -3.14     0.00     0.00     0.00
```

Attachment 4: BATHTUB Model Files

New West Salem Reservoir

Calibration input

Calibration output

Old West Salem Reservoir

Calibration input

Calibration output

New West Salem
File: **S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_calibration.btb**
Description:

Single reservoir (23.2 acres)
2 segments

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.071	0.0
Evaporation (m)	0.9906	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	4	CANF &BACH, RESERV
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.045	3.96	0.23	3.8	0.12	0.16	0	1.38	0	0	0	45	0	0	0
2	Segment 2 upstream	1	2	0.049	2.44	0.41	2.4	0.12	0	0	1.68	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	216	639	0	0	124.4	0.526	0.432	0.0038	0	0	0	0	0	0	0	0
2	0	0	140	304	0	0	85.1	0.388	0.432	0.0015	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Nonpoint inflow	1	1	0.12	0.0386	0	0	0	268.7	0	0	0	0	0	0	0
2	Tributary to upstream segmen	2	1	1.53	0.4942	0	0	0	268.7	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	Trib Name	1	2	3	4	5	6	7	8
1	Nonpoint inflow	0.07	0.05	0.05	0.5	0.2	0	0	0
2	Tributary to upstream segmen	0	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Categ	Land Use Name	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

New West Salem

File: **S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_**

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	1	Nonpoint inflow	Type:	Monitored Inflow
--------Segment:	2	Segment 2 upstream		
Outflow Segment:	1	Segment 1		
Tributary:	2	Tributary to upstream segment	Type:	Monitored Inflow

New West Salem

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Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	0.5	0.3298	12.0	1.0	1.2	0.1	0.0
2	Segment 2 upstream	1	0.5	0.2400	10.2	1.7	1.2	0.4	0.6

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.0	4.0	3.8	0.2	0.2	0.2	1.2
2	Segment 2 upstream	0.0	2.4	2.4	0.4	0.1	0.1	3.4
Totals		0.1	3.2			0.3		

New West Salem

File: S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_calibration.btb

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	Nonpoint inflow	0.1	0.0	0.00E+00	0.00	0.32
2	1	2	Tributary to upstream segm	1.5	0.5	0.00E+00	0.00	0.32
PRECIPITATION				0.1	0.1	0.00E+00	0.00	1.07
TRIBUTARY INFLOW				1.6	0.5	0.00E+00	0.00	0.32
***TOTAL INFLOW				1.7	0.6	0.00E+00	0.00	0.36
ADVECTIVE OUTFLOW				1.7	0.5	0.00E+00	0.00	0.31
***TOTAL OUTFLOW				1.7	0.5	0.00E+00	0.00	0.31
***EVAPORATION					0.1	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	Nonpoint inflow	10.4	1.2%	0.00E+00		0.00	268.7	86.4
2	1	2	Tributary to upstream segm	132.8	15.0%	0.00E+00		0.00	268.7	86.8
PRECIPITATION				2.8	0.3%	0.00E+00		0.00	28.0	30.0
INTERNAL LOAD				739.6	83.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				143.2	16.2%	0.00E+00		0.00	268.7	86.8
***TOTAL INFLOW				885.6	100.0%	0.00E+00		0.00	1398.0	507.8
ADVECTIVE OUTFLOW				120.3	13.6%	2.95E+03		0.45	222.6	69.0
***TOTAL OUTFLOW				120.3	13.6%	2.95E+03		0.45	222.6	69.0
***RETENTION				765.3	86.4%	2.95E+03		0.07		

Overflow Rate (m/yr)	5.7	Nutrient Resid. Time (yrs)	0.0597
Hydraulic Resid. Time (yrs)	0.5510	Turnover Ratio	16.8
Reservoir Conc (mg/m3)	177	Retention Coef.	0.864

New West Salem

File: S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_calibration.bt

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Segment 1**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Nonpoint inflow	0.0	6.6%	10.4	1.3%	269
PRECIPITATION			0.0	8.2%	1.4	0.2%	28
INTERNAL LOAD			0.0	0.0%	739.6	90.3%	
TRIBUTARY INFLOW			0.0	6.6%	10.4	1.3%	269
ADVECTIVE INFLOW			0.5	85.2%	67.7	8.3%	136
***TOTAL INFLOW			0.6	100.0%	819.1	100.0%	1400
ADVECTIVE OUTFLOW			0.5	92.4%	120.3	14.7%	223
NET DIFFUSIVE OUTFLOW			0.0	0.0%	49.5	6.0%	
***TOTAL OUTFLOW			0.5	92.4%	169.8	20.7%	314
***EVAPORATION			0.0	7.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	649.3	79.3%	

Hyd. Residence Time = 0.3298 yrs
Overflow Rate = 12.0 m/yr
Mean Depth = 4.0 m

Component: TOTAL P **Segment: 2 Segment 2 upstream**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
2	1	Tributary to upstream segm	0.5	90.4%	132.8	72.3%	269
PRECIPITATION			0.1	9.6%	1.5	0.8%	28
TRIBUTARY INFLOW			0.5	90.4%	132.8	72.3%	269
NET DIFFUSIVE INFLOW			0.0	0.0%	49.5	26.9%	
***TOTAL INFLOW			0.5	100.0%	183.7	100.0%	336
ADVECTIVE OUTFLOW			0.5	91.1%	67.7	36.9%	136
***TOTAL OUTFLOW			0.5	91.1%	67.7	36.9%	136
***EVAPORATION			0.0	8.9%	0.0	0.0%	
***RETENTION			0.0	0.0%	116.0	63.1%	

Hyd. Residence Time = 0.2400 yrs
Overflow Rate = 10.2 m/yr
Mean Depth = 2.4 m

New West Salem
File: S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_calibration.btb

Water Balance Terms (hm3/yr)			Averaging Period =		1.00	Years			
			Inflows		Storage	Outflows------>		Downstr	
Seg	**Name**	**External**	**Precip**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Evap**
1	Segment 1	0	0	0	0	1	0	0	0
2	Segment 2 upstream	0	0	0	0	0	0	1	0
Net		1	0	0	0	1	0	0	0

Mass Balance Terms (kg/yr) Based Upon			Predicted	Reservoir & Outflow Concentrations			Component:	TOTAL P	
		Inflows-->			Storage	Outflows----->		Net	Net
Seg	**Name**	**External**	**Atmos**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Retention**
1	Segment 1	10	1	68	0	120	0	49	-90
2	Segment 2 upstream	133	1	0	0	68	0	-49	116
Net		143	3	0	0	120	0	0	26

New West Salem

File: **S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSale**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment:	**3**	**Area-Wtd Mean**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	177.4	0.45	92.7%	176.4	500.39	92.6%
CHL-A MG/M3				103.9	0.47	99.9%
SECCHI M				0.4	0.00	11.4%
ANTILOG PC-1				5336.4	0.32	99.1%
ANTILOG PC-2				16.0	0.23	95.9%
TURBIDITY 1/M	1.5		85.3%	1.5		85.3%
ZMIX * TURBIDITY	4.6	0.09	68.8%	4.6	0.09	68.8%
ZMIX / SECCHI				7.1	0.09	75.3%
CHL-A * SECCHI				44.9	0.34	98.2%
CHL-A / TOTAL P				0.6	328.98	95.9%
FREQ(CHL-a>10) %				100.0	0.00	99.9%
FREQ(CHL-a>20) %				98.7	0.02	99.9%
FREQ(CHL-a>30) %				94.4	0.06	99.9%
FREQ(CHL-a>40) %				87.4	0.11	99.9%
FREQ(CHL-a>50) %				78.9	0.17	99.9%
FREQ(CHL-a>60) %				69.9	0.23	99.9%
CARLSON TSI-P	78.4	0.08	92.7%	78.4	62.43	92.6%
CARLSON TSI-CHLA				76.0	0.04	99.9%
CARLSON TSI-SEC				72.1	0.00	88.6%

Segment:	**1**	**Segment 1**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	222.6	0.45	95.6%	216.0	639.00	95.3%
CHL-A MG/M3				124.4	0.53	100.0%
SECCHI M				0.4	0.00	11.4%
ANTILOG PC-1				6335.5	0.50	99.3%
ANTILOG PC-2				18.2	0.35	97.6%
TURBIDITY 1/M	1.4		82.4%	1.4		82.4%
ZMIX * TURBIDITY	5.2	0.12	74.4%	5.2	0.12	74.4%
ZMIX / SECCHI				8.8	0.12	85.3%
CHL-A * SECCHI				53.7	0.53	99.1%
CHL-A / TOTAL P				0.6	620.39	95.5%
FREQ(CHL-a>10) %				100.0	0.00	100.0%
FREQ(CHL-a>20) %				99.6	0.01	100.0%
FREQ(CHL-a>30) %				97.6	0.05	100.0%
FREQ(CHL-a>40) %				93.6	0.11	100.0%
FREQ(CHL-a>50) %				87.7	0.19	100.0%
FREQ(CHL-a>60) %				80.7	0.28	100.0%

New West Salem

File: **S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_calibration.**

Segment	**Name**
1	Segment 1
2	Segment 2 upstream
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	Mean
TOTAL P MG/M3	222.6	136.0	177.4
TURBIDITY 1/M	1.4	1.7	1.5
ZMIX * TURBIDITY	5.2	4.0	4.6
CARLSON TSI-P	82.1	75.0	78.4

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	Mean
TOTAL P MG/M3	216.0	140.0	176.4
CHL-A MG/M3	124.4	85.1	103.9
SECCHI M	0.4	0.4	0.4
ANTILOG PC-1	6335.5	4418.8	5336.4
ANTILOG PC-2	18.2	14.1	16.0
TURBIDITY 1/M	1.4	1.7	1.5
ZMIX * TURBIDITY	5.2	4.0	4.6
ZMIX / SECCHI	8.8	5.6	7.1
CHL-A * SECCHI	53.7	36.8	44.9
CHL-A / TOTAL P	0.6	0.6	0.6
FREQ(CHL-a>10) %	100.0	99.9	100.0
FREQ(CHL-a>20) %	99.6	97.9	98.7
FREQ(CHL-a>30) %	97.6	91.5	94.4
FREQ(CHL-a>40) %	93.6	81.8	87.4
FREQ(CHL-a>50) %	87.7	70.8	78.9
FREQ(CHL-a>60) %	80.7	60.0	69.9
CARLSON TSI-P	81.7	75.4	78.4
CARLSON TSI-CHLA	77.9	74.2	76.0
CARLSON TSI-SEC	72.1	72.1	72.1

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	Mean
TOTAL P MG/M3	1.0	1.0	1.0
TURBIDITY 1/M	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0
CARLSON TSI-P	1.0	1.0	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	Mean
TOTAL P MG/M3	138024.0	42560.0	88260.9

New West Salem

File: **S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem**

T Statistics Compare Observed and Predicted Means Using the Following Error Terms:

1 = Observed Water Quality Error Only

2 = Error Typical of Model Development Dataset

3 = Observed & Predicted Error

Segment: **Area-Wtd Mean**

		Observed		Predicted		Obs/Pred	T-Statistics ---->		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	176.4	500.39	177.4	0.45	0.99	0.00	-0.02	0.00

Segment: **1** **Segment 1**

		Observed		Predicted		Obs/Pred	T-Statistics ---->		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	216.0	639.00	222.6	0.45	0.97	0.00	-0.11	0.00

Segment: **2** **Segment 2 upstream**

		Observed		Predicted		Obs/Pred	T-Statistics ---->		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	140.0	304.00	136.0	0.48	1.03	0.00	0.11	0.00

New West Salem

File: S:\ILEPA13A\03_Bonpas_Creek\Bonpas-Stage_3\BATHTUB_Info\2000_NewWestSalem_calibration.btb

Variable = TOTAL P MG/M3 **R^2 = 0.98**

Global Calibration Factor = 1.00 **CV = 0.45**

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	**Group**	**Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**SE**	**t**
1	1	Segment 1	1.00	0.00	222.6	0.45	216.0	639.00	-0.03	639.00	0.00
2	2	Segment 2 upstream	1.00	0.00	136.0	0.48	140.0	304.00	0.03	304.00	0.00
3	1	Area-Wtd Mean			177.4	0.45	176.4	500.39	-0.01	500.39	0.00

Old West Salem
File: C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb
Description:
Single reservoir (2.25 acres)1 segment

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.071	0.0
Evaporation (m)	0.9906	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.0091	5.7912	0.233	5.1	0.12	0.7	0	1.11	0	0	0	25	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	174	150.8	0	0	91.14	0	0.5588	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Nonpoint inflow	1	1	0.68	0.2197	0	0	0	133.8	0	0	0	0	0	0	0
2	Inflow from New West Salem	1	3	1.66	0.44	0	0	0	157	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	Trib Name	1	2	3	4	5	6	7	8
1	Nonpoint inflow	0.07	0.05	0.05	0.5	0.2	0	0	0
2	Inflow from New West Salem	0	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Categ	Land Use Name	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Old West Salem

File: **C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb**

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	1	Nonpoint inflow	Type:	Monitored Inflow
Tributary:	2	Inflow from New West Salem	Type:	Point Source

Old West Salem

File: C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Dispersion--------> Velocity km/yr	Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	0.7	0.0798	72.6	2.9	0.1	0.3	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.0	5.8	5.1	0.2	0.1	0.0	6.0
Totals		0.0	5.8			0.1		

Old West Salem

File: C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb

Overall Water & Nutrient Balances

Overall Water Balance

Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Nonpoint inflow	0.7	0.2	0.00E+00	0.00	0.32
2	3	1	Inflow from New West Saler	1.7	0.4	0.00E+00	0.00	0.27
PRECIPITATION				0.0	0.0	0.00E+00	0.00	1.07
TRIBUTARY INFLOW				0.7	0.2	0.00E+00	0.00	0.32
POINT-SOURCE INFLOW				1.7	0.4	0.00E+00	0.00	0.27
***TOTAL INFLOW				2.3	0.7	0.00E+00	0.00	0.28
ADVECTIVE OUTFLOW				2.3	0.7	0.00E+00	0.00	0.28
***TOTAL OUTFLOW				2.3	0.7	0.00E+00	0.00	0.28
***EVAPORATION					0.0	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Nonpoint inflow	29.4	16.2%	0.00E+00		0.00	133.8	43.2
2	3	1	Inflow from New West Saler	69.1	38.0%	0.00E+00		0.00	157.0	41.6
PRECIPITATION				0.3	0.2%	0.00E+00		0.00	28.0	30.0
INTERNAL LOAD				83.1	45.7%	0.00E+00		0.00		
TRIBUTARY INFLOW				29.4	16.2%	0.00E+00		0.00	133.8	43.2
POINT-SOURCE INFLOW				69.1	38.0%	0.00E+00		0.00	157.0	41.6
***TOTAL INFLOW				181.8	100.0%	0.00E+00		0.00	271.6	77.4
ADVECTIVE OUTFLOW				118.1	65.0%	2.83E+03		0.45	178.9	50.3
***TOTAL OUTFLOW				118.1	65.0%	2.83E+03		0.45	178.9	50.3
***RETENTION				63.7	35.0%	2.83E+03		0.83		

Overflow Rate (m/yr)	72.6	Nutrient Resid. Time (yrs)	0.0518
Hydraulic Resid. Time (yrs)	0.0798	Turnover Ratio	19.3
Reservoir Conc (mg/m3)	179	Retention Coef.	0.350

Old West Salem

File: C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Segment 1**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Nonpoint inflow	0.2	32.8%	29.4	16.2%	134
2	3	Inflow from New West Sale	0.4	65.7%	69.1	38.0%	157
PRECIPITATION			0.0	1.5%	0.3	0.2%	28
INTERNAL LOAD			0.0	0.0%	83.1	45.7%	
TRIBUTARY INFLOW			0.2	32.8%	29.4	16.2%	134
POINT-SOURCE INFLOW			0.4	65.7%	69.1	38.0%	157
***TOTAL INFLOW			0.7	100.0%	181.8	100.0%	272
ADVECTIVE OUTFLOW			0.7	98.7%	118.1	65.0%	179
***TOTAL OUTFLOW			0.7	98.7%	118.1	65.0%	179
***EVAPORATION			0.0	1.3%	0.0	0.0%	
***RETENTION			0.0	0.0%	63.7	35.0%	

Hyd. Residence Time =	0.0798	yrs
Overflow Rate =	72.6	m/yr
Mean Depth =	5.8	m

Old West Salem

File: C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb

Water Balance Terms (hm3/yr) **Averaging Period = 1.00 Years**

			Inflows		Storage	Outflows------>		Downstr	
Seg	**Name**	**External**	**Precip**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Evap**
1	Segment 1	1	0	0	0	1	0	0	0
Net		1	0	0	0	1	0	0	0

Mass Balance Terms (kg/yr) Based Upon Predicted Reservoir & Outflow Concentrations Component: TOTAL P

		Inflows-->			Storage	Outflows----->		Net	Net
Seg	**Name**	**External**	**Atmos**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Retention**
1	Segment 1	98	0	0	0	118	0	0	-19
Net		98	0	0	0	118	0	0	-19

Old West Salem

File: **C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Segment 1**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	178.9	0.45	92.8%	174.0	150.80	92.4%
CHL-A MG/M3				91.1		99.8%
SECCHI M				0.6		19.3%
ANTILOG PC-1				3710.1		98.1%
ANTILOG PC-2				18.0		97.5%
TURBIDITY 1/M	1.1		75.2%	1.1		75.2%
ZMIX * TURBIDITY	5.7	0.12	77.5%	5.7	0.12	77.5%
ZMIX / SECCHI				9.1	0.12	86.8%
CHL-A * SECCHI				50.9		98.8%
CHL-A / TOTAL P				0.5	146.41	93.9%
FREQ(CHL-a>10) %				99.9		99.8%
FREQ(CHL-a>20) %				98.4		99.8%
FREQ(CHL-a>30) %				93.1		99.8%
FREQ(CHL-a>40) %				84.6		99.8%
FREQ(CHL-a>50) %				74.5		99.8%
FREQ(CHL-a>60) %				64.2		99.8%
CARLSON TSI-P	78.9	0.08	92.8%	78.5	27.28	92.4%
CARLSON TSI-CHLA				74.9		99.8%
CARLSON TSI-SEC				68.4		80.7%

Old West Salem

File: **C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb**

Segment	Name
1	Segment 1

PREDICTED CONCENTRATIONS:

Variable Segment-->	1
TOTAL P MG/M3	178.9
TURBIDITY 1/M	1.1
ZMIX * TURBIDITY	5.7
CARLSON TSI-P	78.9

OBSERVED CONCENTRATIONS:

Variable Segment-->	1
TOTAL P MG/M3	174.0
CHL-A MG/M3	91.1
SECCHI M	0.6
ANTILOG PC-1	3710.1
ANTILOG PC-2	18.0
TURBIDITY 1/M	1.1
ZMIX * TURBIDITY	5.7
ZMIX / SECCHI	9.1
CHL-A * SECCHI	50.9
CHL-A / TOTAL P	0.5
FREQ(CHL-a>10) %	99.9
FREQ(CHL-a>20) %	98.4
FREQ(CHL-a>30) %	93.1
FREQ(CHL-a>40) %	84.6
FREQ(CHL-a>50) %	74.5
FREQ(CHL-a>60) %	64.2
CARLSON TSI-P	78.5
CARLSON TSI-CHLA	74.9
CARLSON TSI-SEC	68.4

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1
TOTAL P MG/M3	1.0
TURBIDITY 1/M	1.0
ZMIX * TURBIDITY	1.0
CARLSON TSI-P	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1
TOTAL P MG/M3	26239.2
ZMIX * TURBIDITY	0.7

ZMIX / SECCHI	1.1
CHL-A / TOTAL P	76.7
CARLSON TSI-P	2142.6

PREDICTED STANDARD ERRORS

Variable Segment-->	1
TOTAL P MG/M3	80.5
ZMIX * TURBIDITY	0.7
CARLSON TSI-P	6.4

Old West Salem

File: **C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb**

T Statistics Compare Observed and Predicted Means Using the Following Error Terms:

1 = Observed Water Quality Error Only

2 = Error Typical of Model Development Dataset

3 = Observed & Predicted Error

Segment:	1	Segment 1							
	Observed		Predicted		Obs/Pred	T-Statistics ---->			
Variable	Mean	CV	Mean	CV	Ratio	T1	T2	T3
TOTAL P MG/M3	174.0	150.80	178.9	0.45	0.97	0.00	-0.10	0.00

Old West Salem

File: C:\Program Files (x86)\Simple_Tools\Bathtub\2000_OldWestSalem_inputs.btb

Variable = TOTAL P MG/M3 **R^2 = 1.00**

Global Calibration Factor = 1.00 CV = 0.45

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	**Group**	**Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**SE**	**t**
1	1	Segment 1	1.00	0.00	178.9	0.45	174.0	150.80	-0.03	150.80	0.00

Attachment 5: Load Duration Curve Analysis
Fecal Coliform
Atrazine

WQS 9 ug/l

Flow Duration Curve **LOAD**

Flow (in cfs, at Bonpas Creek mouth)	% of Time Exceeded	Load for Curve (cfs*ug/l)	Convert load to lbs/day
0.00	99.98	0	0
0.00	98.88	0	0
0.00	97.97	0	0
0.00	96.52	0	0
0.16	90.91	1	0
0.27	89.29	2	0
0.72	85.21	6	0
0.83	84.51	7	0
0.94	83.87	8	0
1.05	83.28	9	0
1.16	82.61	10	0
1.17	82.59	11	0
1.34	81.88	12	0
1.46	81.50	13	0
1.58	81.25	14	0
1.71	80.87	15	0
1.83	80.56	16	0
1.95	80.29	18	0
2.07	80.07	19	0
2.19	79.77	20	0
2.31	79.50	21	0
2.44	79.08	22	0
2.56	78.78	23	0
2.68	78.43	24	0
2.80	78.10	25	0
2.92	77.85	26	0
3.05	77.56	27	0
3.29	77.15	30	0
4.51	75.41	41	0
5.60	73.52	50	0
6.70	72.08	60	0
7.80	70.85	70	0
8.89	69.58	80	0
9.99	68.39	90	0
11.08	67.29	100	1
13.40	65.83	121	1
15.83	64.28	143	1
18.27	61.75	164	1
20.71	60.30	186	1
23.14	59.65	208	1
37.76	51.43	340	2
51.16	46.49	460	2
57.25	44.45	515	3
68.21	41.64	614	3
85.26	38.03	767	4
99.88	35.80	899	5
110.84	34.36	998	5
113.28	34.14	1019	5
213.15	27.23	1918	10
236.30	26.31	2127	11
342.26	23.48	3080	17
444.58	21.49	4001	22
666.26	18.54	5996	32
744.21	17.49	6698	36
806.33	16.86	7257	39
998.78	14.59	8989	48
1108.40	13.28	9976	54
1485.99	9.72	13374	72
1632.15	8.76	14689	79
1766.13	7.99	15895	86
2423.86	5.70	21815	118
2545.67	5.12	22911	124
2691.83	4.52	24226	131
3288.66	2.60	29598	160
3470.00	2.32	31230	168
4750.00	0.84	42750	231
5663.80	0.32	50974	275
6370.25	0.13	57332	309
6382.43	0.11	57442	310
6431.15	0.09	57880	312
6613.86	0.08	59525	321
6626.04	0.06	59634	322
6650.40	0.05	59854	323

Observed Data

Date	Flow (in cfs, at Bonpas Creek mouth)	Concentration (ug/l)	Percentile	Load (cfs*ug/L)	Load converted to lbs/day
06-Mar-06	15.8	0.1	64.28	2	0.01
17-May-06	668.7	9.9	18.54	6620	35.71
28-Jun-06	191.2	2.7	34.14	516	2.78
21-Jun-99	11.2	3.2	67.29	36	0.19
28-Jul-99	5.2	1.5	75.41	8	0.04

	# samples > 9	# samplestotal	Max ug/l	% red. Needed
0 - 20	1	1	9.9	9%
20 - 40	0	1	2.7	-233%
40 - 100	0	3	3.2	-181%

6833.10	0.03	61498	332
7015.81	0.02	63142	341

Flow (in cfs, at Bonpas Creek mouth)	% of Time Exceeded	Load for Curve (cfs*cfu/100 ml)	Convert load to cfu/day
0.00	99.98	0	0
0.00	99.87	0	0
0.00	99.54	0	0
0.00	98.77	0	0
0.16	91.00	32	29
0.27	89.41	54	49
0.72	85.25	144	131
0.83	84.59	166	151
0.94	83.91	188	171
1.05	83.31	209	190
1.16	82.67	231	210
1.17	82.59	234	213
1.34	82.20	268	244
1.46	81.87	292	266
1.58	81.49	317	288
1.71	81.24	341	310
1.83	80.86	365	332
1.95	80.54	390	354
2.07	80.27	414	376
2.19	80.05	438	399
2.31	79.74	463	421
2.44	79.49	487	443
2.56	79.06	512	465
2.68	78.76	536	487
2.80	78.41	560	509
2.92	78.08	585	532
3.05	77.83	609	554
3.29	77.31	658	598
4.51	75.41	901	819
5.60	73.52	1,121	1,019
6.70	72.08	1,340	1,218
7.80	70.85	1,559	1,417
8.89	69.58	1,778	1,617
9.99	68.52	1,998	1,816
11.08	67.29	2,217	2,015
13.40	65.83	2,680	2,436
15.83	64.28	3,167	2,879
18.27	62.47	3,654	3,322
20.71	60.99	4,141	3,765
23.14	59.65	4,628	4,208
37.76	51.66	7,552	6,865
51.16	46.54	10,231	9,301
57.25	44.48	11,449	10,409
68.21	41.74	13,642	12,402
85.26	38.27	17,052	15,502
99.88	35.89	19,976	18,160
110.84	34.36	22,168	20,153
113.28	34.17	22,655	20,596
213.15	27.37	42,631	38,755
236.30	26.36	47,259	42,963
342.26	23.49	68,453	62,230
444.58	21.49	88,916	80,832
666.26	18.56	133,252	121,138
744.21	17.52	148,842	135,311
806.33	16.86	161,266	146,606
998.78	14.59	199,756	181,596
1108.40	13.30	221,680	201,527
1485.99	9.78	297,197	270,179
1632.15	8.76	326,430	296,754
1766.13	8.00	353,226	321,115
2423.86	5.70	484,773	440,702
2545.67	5.14	509,133	462,848
2691.83	4.54	538,366	489,423
3288.66	2.62	657,732	597,938
3470.00	2.32	694,000	630,909
4750.00	0.84	950,000	863,636
5663.80	0.32	1,132,760	1,029,782
6370.25	0.13	1,274,051	1,158,228
6382.43	0.11	1,276,487	1,160,443
6431.15	0.09	1,286,231	1,169,301
6613.86	0.08	1,322,772	1,202,520
6626.04	0.06	1,325,208	1,204,734
6650.40	0.05	1,330,080	1,209,163
6833.10	0.03	1,366,620	1,242,382
7015.81	0.02	1,403,161	3.43E+13

Date	Flow (in cfs, at Bonpas Creek mouth)	Concentration (cfu/100 ml)	Percentile	Load (cfs*cfu/100 ml)	Load converted to cfu/day
5/24/1999	45.1	720	51.66	32448	7.94E+11
6/22/1999	8.8	440	70.85	3859	9.44E+10
9/30/1999	0.0	360	98.77	0	0.00E+00
5/25/2000	15.8	380	64.28	6017	1.47E+11
6/28/2000	1388.5	1020	13.30	1416316	3.47E+13
8/1/2000	415.3	15400	23.49	6396319	1.57E+14
9/28/2000	137.6	1820	34.17	250498	6.13E+12
10/30/2000	1.9	166	80.54	324	7.92E+09
5/16/2001	2.7	64	78.76	171	4.20E+09
6/5/2001	371.5	9000	23.49	3343470	8.18E+13
8/15/2001	1.0	420	83.91	409	1.00E+10
9/12/2001	1.1	210	83.31	230	5.63E+09
10/24/2001	344.7	2000	23.49	689400	1.69E+13
5/22/2002	964.7	42	16.86	40516	9.91E+11
8/8/2002	0.1	20	98.77	1	3.58E+07
9/5/2002	0.0	30	98.77	0	0.00E+00
5/25/2004	99.9	780	35.89	77905	1.91E+12
6/22/2004	584.7	11000	21.49	6431155	1.57E+14
8/3/2004	24.4	2100	59.65	51157	1.25E+12
9/14/2004	8.6	450	70.85	3892	9.52E+10
5/9/2005	20.7	250	60.99	5177	1.27E+11
8/23/2005	0.6	100	89.41	58	1.43E+09
9/29/2005	0.0	115	98.77	4	1.03E+08
10/26/2005	0.0	64	98.77	0	0.00E+00
5/17/2006	668.7	3900	18.56	2607906	6.38E+13
6/28/2006	191.2	2700	34.17	516319	1.26E+13
8/9/2006	1242.4	9200	13.30	11429916	2.80E+14
9/11/2006	1.2	78	82.59	94	2.30E+09
10/16/2006	58.5	155	44.48	9062	2.22E+11

	# samples > 200	# samples May - Oct	Max cfu	% red. Needed
0 - 30	8	9	15400	99%
30 - 60	4	5	2100	90%
60 - 100	7	15	450	56%

Attachment 6: Stage 3 Public Notice

NOTICE OF PUBLIC MEETING

Bonpas Creek Watershed

(Edwards, Lawrence, Richland and Wabash Counties)

The Illinois Environmental Protection Agency (IEPA) Bureau of Water will hold a public meeting on

Thursday, November 15, 2018 (8:00 am)

at the

Edwards County Fairgrounds Exhibition Building
(Across from Edwards County SWCD)
90 West Pine Street
Albion, Illinois

The purpose of this meeting is to provide an opportunity for the public to receive information and comment on the draft Total Maximum Daily Load (TMDL) concerning impairments to 4 (four) waterbody segments within the Bonpas Creek Watershed -- Bonpas Creek (IL_BC-02, IL_BC-04), New West Salem Reservoir (IL_RBQ), and Old West Salem Reservoir (IL_RBZN).

The potential causes of impairment for these segments are Atrazine, Dissolved Oxygen (DO), Fecal Coliform, and Phosphorus. In addition, a Load Reduction Strategy (LRS) has been developed for Sedimentation/Siltation.

This Draft TMDL report includes watershed characterization, data analysis, and pollutant loading capacity analysis that have been used to determine the reductions necessary to meet designated uses and water quality standards. Also included is an implementation plan designed to meet the reductions needed.

Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act. A TMDL is the sum of the allowable amounts of a single pollutant (such as phosphorus, metals, etc.) that a waterbody can receive from all contributing sources and still meet water quality standards or designated uses.

Stakeholders and participants will also be asked for input on potential nonpoint source Best Management practices and projects that could be included as part of the implementation plan in the final draft Stage 3 report.

The draft Stage 3 report for Bonpas Creek Watershed TMDL is available on-line at www.epa.state.il.us/public-notices. A hard copy of the draft report is available for viewing at the Edwards County SWCD Office, West Salem Village Hall during business hours.

Questions about the draft TMDL report should be directed to the project manager, Margaret Fertaly by phone at 618-993-7200 or email **Margaret.Fertaly@illinois.gov,** or contact Abel Haile by phone at 217-782-3362 or email (see contact information below).

Closure of the Meeting Record

The meeting record will close as of midnight, December 15, 2018. Written comments need not be notarized but must be postmarked before midnight and mailed to:

Abel Haile, Manager, Planning (TMDL) Unit
Watershed Management Section, Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P. 0. Box 19276
Springfield, IL 62794-9276
Phone 217-782-3362

TDD (Hearing impaired) 217-782-9143
E-mail: Abel.Haile@illinois.gov
Fax: 217-785-1225

Attachment 7: Responsiveness Summary

Responsiveness Summary

Bonpas Creek Watershed

Total Maximum Daily Load

The responsiveness summary responds to questions and comments received during the public comment period from November 15, 2018, through December 15, 2018.

What is a TMDL?

A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant. **The Bonpas Creek Watershed** TMDL report contains a plan detailing the actions necessary to reduce pollutant loads to the impaired water bodies and ensure compliance with applicable water quality standards. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations thereunder.

Background

The watershed targeted for TMDL development is the **Bonpas Creek Watershed** located in Lawrence, Wabash, Richland and Edwards Counties in southeastern Illinois. The watershed study area is approximately 177,734 acres in size.

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List. Illinois EPA has developed TMDLs for pollutants that have numeric water quality standards in Bonpas Creek Watershed. Therefore, Fecal Coliform, and Atrazine TMDLs were developed for Bonpas Creek (IL_BC-02), and phosphorus (Total) for New West Salem Reservoir (IL_RBQ). These waterbodies are listed as impaired in the 2012-2018 *Draft Illinois Integrated Water Quality Reports and Section 303(d) List.*

In addition, a Load Reduction Strategy (LRS) was developed for pollutant(s) that do not have numeric water quality standard. These include Old West Salem Reservoir (IL_RBZN): phosphorus (Total) because the waterbody has surface area less than 20 acres as defined in IL. Adm. Section 302.205, and Bonpas Creek (IL_BC-02): sedimentation/siltation.

Illinois EPA contracted with LimnoTech (a TMDL Consultant) to prepare the TMDL report for the Bonpas Creek River Watershed project.

Public Meetings

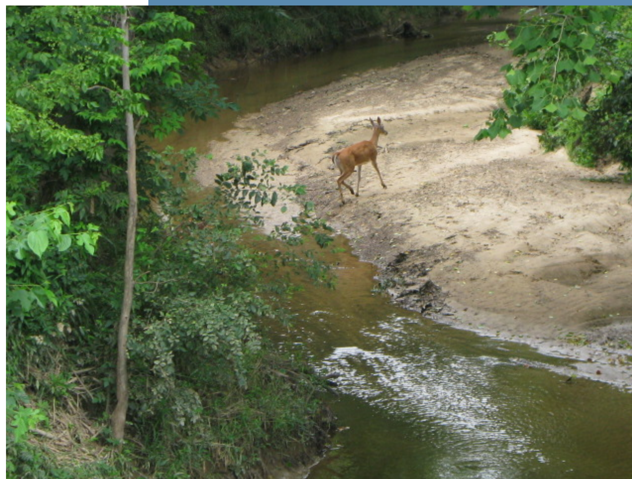
The draft Stage 1 public meeting was held on May 1, 2014 in Albion, Illinois. The public comment period for the Stage 1 meeting closed on June 2, 2014.

The draft Stage 3 public meeting was held on November 15, 2018, at 8:00 am, at the Edwards County Fairgrounds Exhibition Building (Across from Edwards County SWCD) in Albion, Illinois. Approximately 20 people participated in the public meeting and the public comment period ended at midnight on December 15, 2018.

Illinois EPA provided public notice for all meetings by placing a display-ad, The Navigator Journal Register (the local newspaper in Albion, Illinois). In addition, a direct mailing was sent to several stakeholders/Permittees in the watershed. The notice gave the date, time, location, and purpose of the meeting. The notice also provided references on how to obtain additional information about the draft TMDL report, the TMDL program, and other related information. A hard copy of the draft TMDL report was available for viewing at the Edwards County SWCD Office, West Salem Village Hall during business, and electronically on the Agency's webpage: https://www2.illinois.gov/epa/publicnotices/Documents/Bonpas%20Creek%20Watershed%20Stage%203%20Public%20Notice.pdf.

Questions & Comments

Illinois EPA did not receive any public comments.

Watershed Implementation Plan

To Achieve the TMDLs and Load Reduction Strategy in the Bonpas Creek Watershed

Prepared for:
Illinois EPA

March 2019

LimnoTech

Water | Scientists
Environment | Engineers

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501 Avis Drive
Ann Arbor, MI 48108
734.332.1200
www.limno.com

Watershed Implementation Plan To Achieve the TMDLs and Load Reduction Strategy in the Bonpas Creek Watershed

Prepared for:
Illinois EPA

March 2019

Prepared by:
LimnoTech

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1 Introduction to the Implementation Plan

The Bonpas Creek watershed is located in Richland, Lawrence, Edwards and Wabash Counties; however, all water quality issues addressed by this watershed implementation plan are within three water bodies location in Edwards and Wabash Counties. This watershed implementation plan was prepared to document the conditions causing water body impairments and the plan to address those impairments. Specifically the plan is intended to address only those impairments identified in the State of Illinois 2012-2016 Integrated Water Quality Report and Section 303(d) List[1], and refined based on the findings discussed in the Stage 3 report. Figure 1-1 shows the Bonpas Creek watershed and identifies the impaired waterbodies that are the focus of this plan.

Section 303(d) of the Clean Water Act and USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses under technology-based controls. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991). Load Reduction Strategies (LRSs) are being completed for causes that do not have numeric standards. LRSs for causes of impairment with target criteria consist of loading capacity and the percent reduction needed to meet the target criteria. This watershed implementation plan is intended to address the three TMDLs and two LRSs in the Bonpas Creek watershed.

The TMDL and LRS process and results for the Bonpas Creek watershed waterbodies are documented elsewhere (LimnoTech, 2017). The waterbody segments and impairments that are the focus of this implementation plan are shown in Table 1-1.

Table 1-1. Impaired Waterbody Summary

Waterbody/Segment Name	Impaired Designated Use	Size (mile/acre)	Impairment Cause	TMDL or LRS?
Bonpas Cr / IL_BC-02	Aquatic life	28.95	Atrazine	TMDL
Bonpas Cr / IL_BC-02	Primary contact recreation	28.95	Fecal coliform	TMDL
Bonpas Cr / IL_BC-02	Aquatic life	28.95	Sedimentation/siltation	LRS
New West Salem Reservoir / IL_RBQ	Aesthetic quality	23[a]	Phosphorus (Total)	TMDL
Old West Salem Reservoir / IL_RBZN	Aesthetic quality	2[b]	Phosphorus (Total)	LRS

[a] The area of this reservoir, initially reported by IEPA to be 32 acres, was updated for this report based on a GIS analysis conducted to support lake modeling.

[1] Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, called the 303(d) list. The final State of Illinois 2014 Integrated Water Quality Report and Section 303(d) List - 2014 (IEPA, 2014) and the final State of Illinois 2016 Integrated Water Quality Report and Section 303(d) List – 2016 are available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. This work began before the 2014 and 2016 reports were available, and therefore focuses on assessments based on the 2012 303(d) list, modified to reflect the Stage 3 report, which resulted in the removal of several impairment causes.

[b] A Load Reduction Strategy is being conducted for this waterbody because its surface area is less than the threshold area (20 acres) IEPA uses to define lakes.

As described in the Stage 3 report, TMDLs and Load Reduction Strategies were calculated for each impaired lake and stream segment. This information is summarized in Table 1-2. Because the fecal coliform and atrazine loads and reductions vary by flow, with higher reductions required at higher flows, the loads and percent reductions presented in the table below were calculated for the high flow conditions.

Table 1-2. TMDLs and LRSs

Stream (Segment)	Current load (lbs/day)	Load capacity (lbs/day)*	Percent Reduction	TMDL or LRS?
Bonpas Cr / IL_BC-02 Atrazine*	77.4	70.4	9%	TMDL
Bonpas Cr / IL_BC-02 Fecal coliform*	3.6E+14	4.67E+12	99%	TMDL
Bonpas Cr / IL_BC-02 Sedimentation/siltation	427	149	65%	LRS
New West Salem Reservoir / IL_RBQ Phosphorus (total)	0.88	0.44	50%	TMDL
Old West Salem Reservoir / IL_RBZN Phosphorus (total)	0.36	0.24	33%	LRS

*Fecal coliform loads are in units of cfu/day. The fecal coliform and atrazine load reduction percentages vary based on flow and the most stringent reductions are presented. Numbers are rounded, and may not sum exactly.

In summary, it is important to note that this watershed implementation plan is specifically intended to address excess pollutant loadings identified above and is not intended to address other watershed conditions that may exist in the Bonpas Creek watershed. A comprehensive watershed characterization was developed and is presented in Section 2 of this plan, which provides a solid baseline of relevant information necessary to understand the sources of identified impairments and identify appropriate and effective actions to address them. Sections 3 through 11 are organized and written to address the nine key watershed plan elements identified by USEPA in the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* for achieving improvements in water quality (USEPA, 2008).

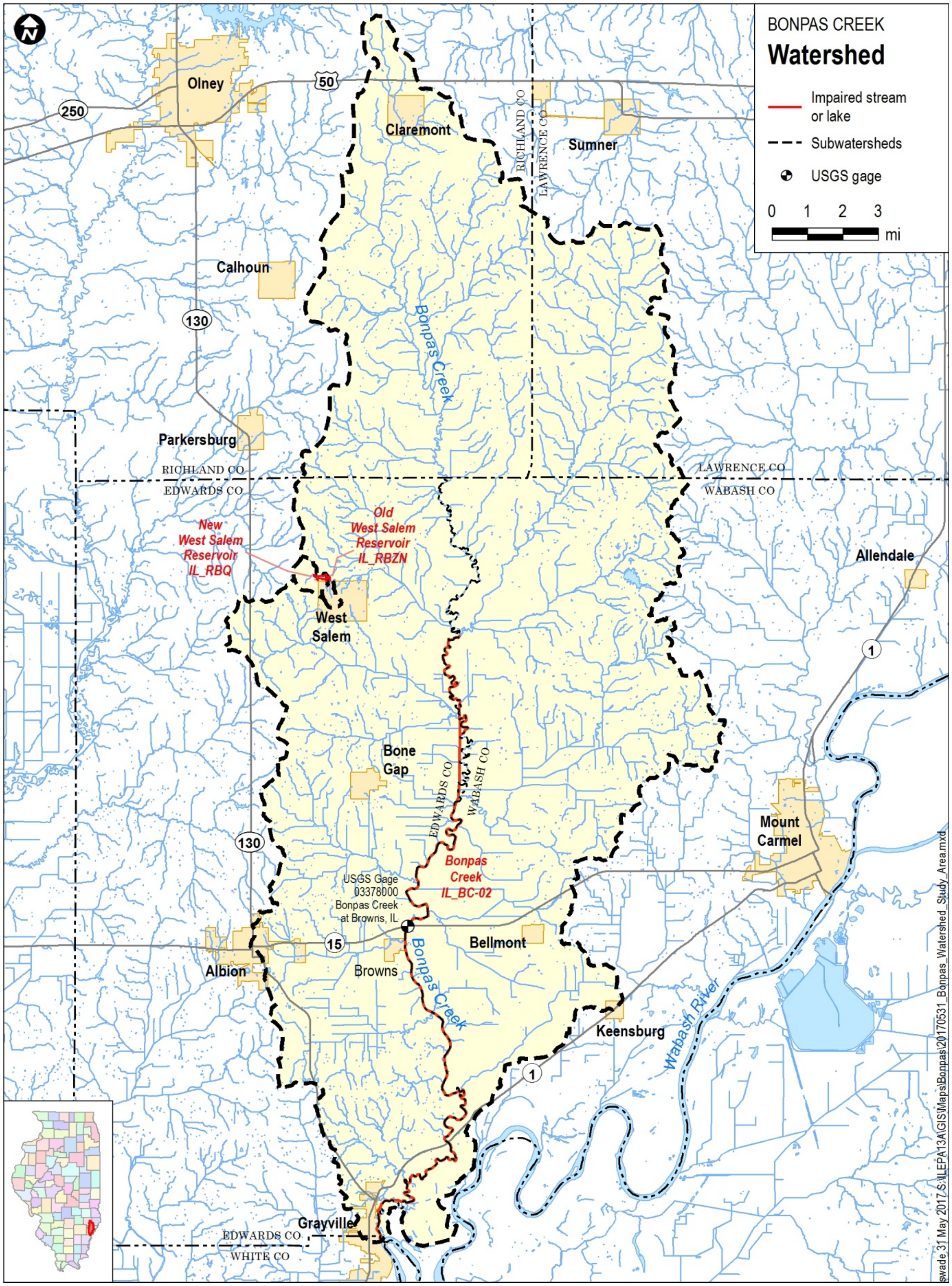

Figure 1-1. The Bonpas Creek Watershed, Showing Impaired Waterbodies

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2 Watershed Characterization

As stated in Section 1, this implementation plan was prepared to address excess atrazine, fecal coliform and sediment in the downstream reach of Bonpas Creek, and excess phosphorus loading to two reservoirs identified by the State of Illinois. The sections that follow provide a broad overview of the characteristics of the Bonpas Creek watershed.

2.1 Watershed Boundaries and Geographic Focus of the Plan

The Bonpas Creek watershed covers 177,734 acres (277 mi^2) in southeastern Illinois, and is located in Lawrence, Wabash, Richland and Edwards Counties. The impaired stream and lake segments are identified on the map in Figure 2-1, along with the eight, 12-digit hydrologic unit codes (HUCs) located within the Bonpas Creek watershed.

2.2 Watershed Characteristics

The Bonpas Creek watershed was characterized by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, local agencies are being contacted to obtain information on cropping practices, tillage practices and best management practices (BMPs), and other land uses employed.

After the watershed boundaries for the impaired waterbodies in the project watershed were delineated from topographic and stream network (hydrography) information, other relevant information was obtained. This spatial information was supplemented from various other publicly available sources. The following watershed characteristics are described in this section:

- Topography
- Climate and Hydrology
- Geology
- Soils
- Demographics and Urbanization
- Land Cover

2.2.1 Topography

The highest elevations (approximately 604 feet) in the Bonpas Creek watershed are at the far northern end of the watershed. The lowest elevation (359 feet) is where Bonpas Creek drains into the Wabash River, at the far southern end of the watershed.

Slopes in the Bonpas Creek watershed range from 0% to 117%, with an area-weighted average slope of 2.7%. A topographic map of the watershed is presented as Figure 2-2.

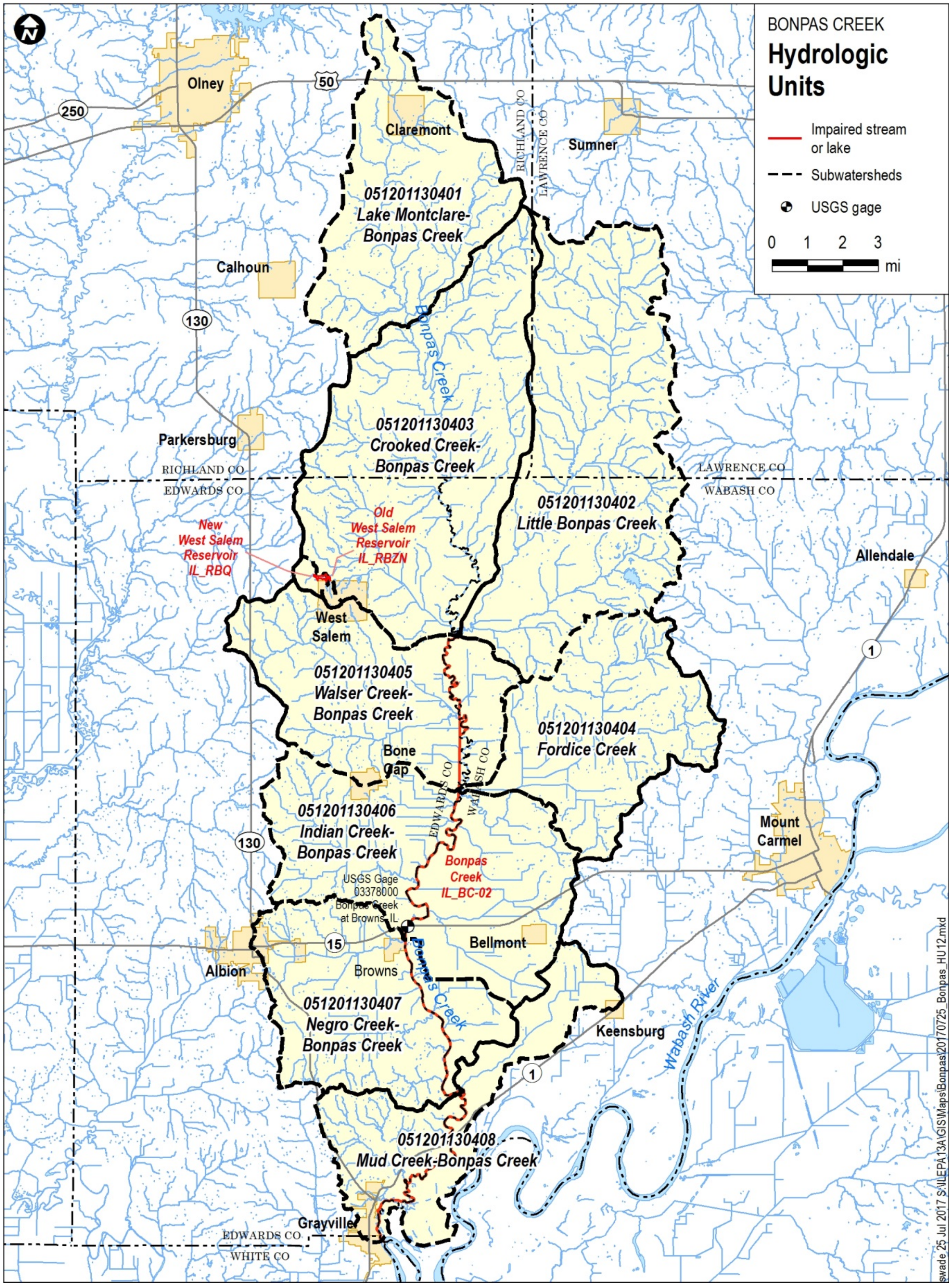

Figure 2-1. Hydrologic Units of the Bonpas Creek Watershed

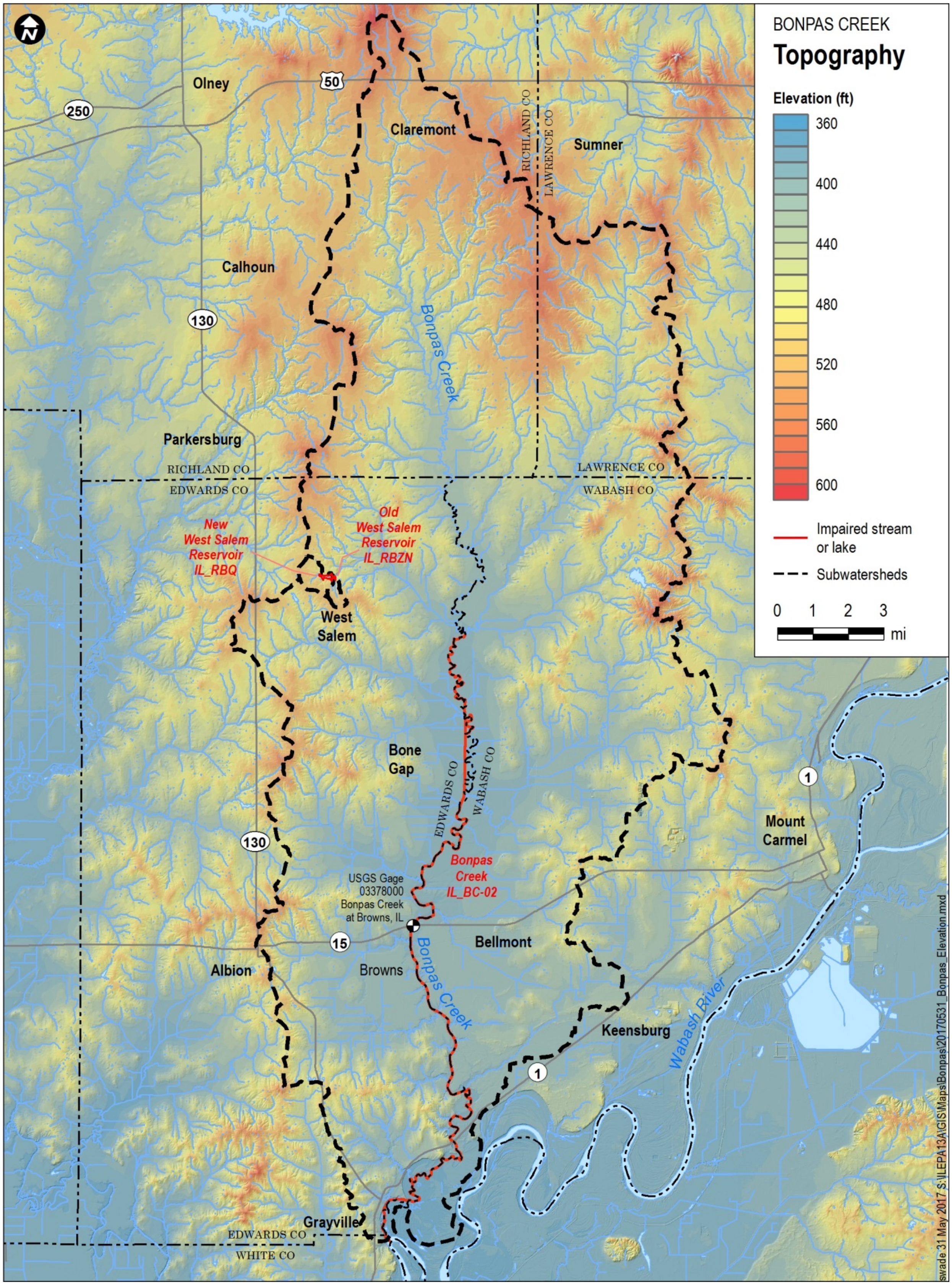

Figure 2-2. Topography of the Bonpas Creek Watershed

2.2.2 Climate and Hydrology

The drainage in Bonpas Creek is generally north-to-south, with a classic dendritic pattern modified somewhat by channelization. Bonpas Creek is a tributary to the Wabash River. There is an active United States Geological Survey (USGS) streamflow gage in the watershed, located on Bonpas Creek near Browns, at the county road 15 bridge (gage 03378000). The gage is about 14 miles upstream from the confluence with the Wabash River. The drainage area at this gage is 228 square miles and daily discharge measurements are available from 1941 to present.

Flow duration curves represent the percentage of time that a specified streamflow is equaled or exceeded during a given period. Such analyses are a summary of the past hydrologic events (in this case, daily discharge). Figure 2-3 illustrates the frequency that certain volumes of flow occurred in Bonpas Creek over the available flow record (1941-present). Flows of zero cfs are observed throughout the flow record, although most (79%) occur between August and November. Based on input received from the public, flooding has been identified as an issue near the mouth of Bonpas Creek

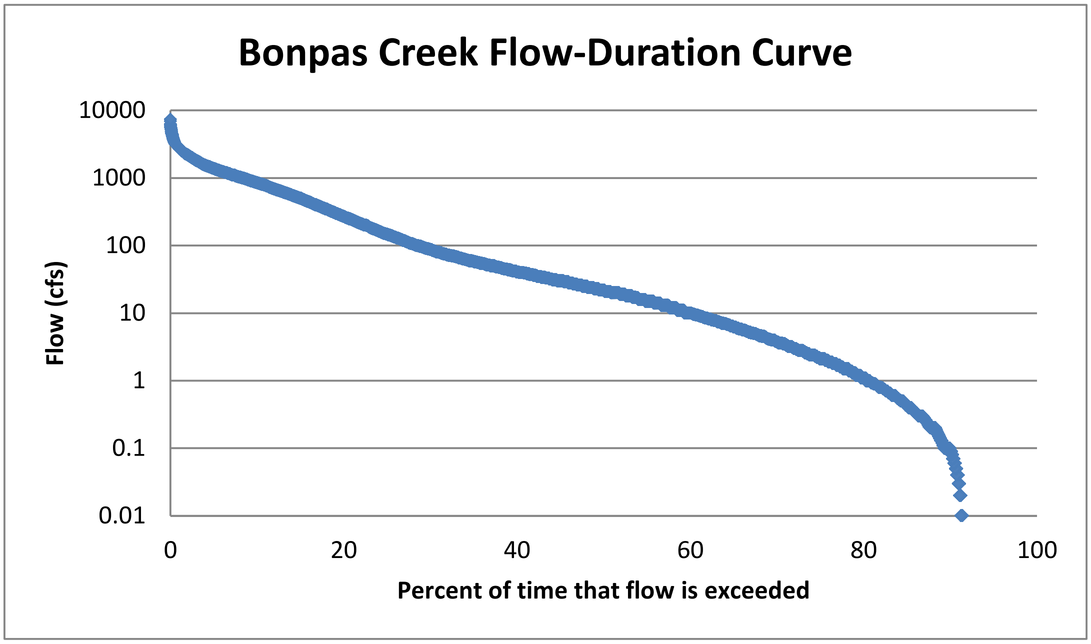

Figure 2-3. Flow Duration Curve, USGS Station 03378000, Bonpas Creek near Browns, IL 10/1/1941 through 9/30/2012.

The Bonpas Creek watershed lies in a temperate climate zone with cold, snowy winters and hot, wet summers. The National Weather Service (NWS) maintains a weather station near the Bonpas watershed in Olney, Illinois. The station has been active since 1901. Olney lies in Richland County and is on the north end of the watershed, approximately 5 miles west of Claremont and the Bonpas Creek headwaters. Precipitation information from this station should fairly accurately represent climate conditions observed in the Bonpas Creek watershed.

Precipitation data are available from 1901 up to present. The 112 years of historical precipitation data for Station 116446 in Olney average 42.5 inches of precipitation each year. The highest monthly average occurs in May, when about 4.7 inches can be expected. The lowest monthly average occurs in February (2.5 inches). Monthly average precipitation is shown in Figure 2-4. The most intense storms, based upon the daily maximum precipitation, generally come in spring and fall. Winter exhibits the most mild storm events. Average monthly temperatures are depicted in Figure 2-5.

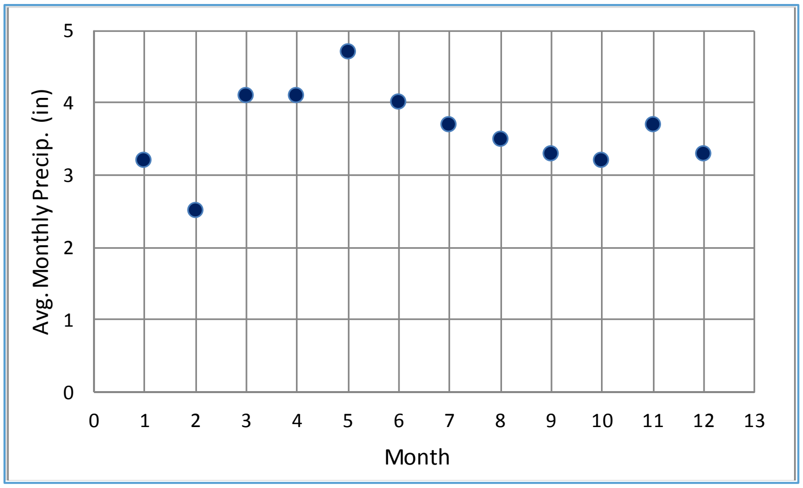

Figure 2-4. Average Monthly Precipitation in the Bonpas Creek Watershed

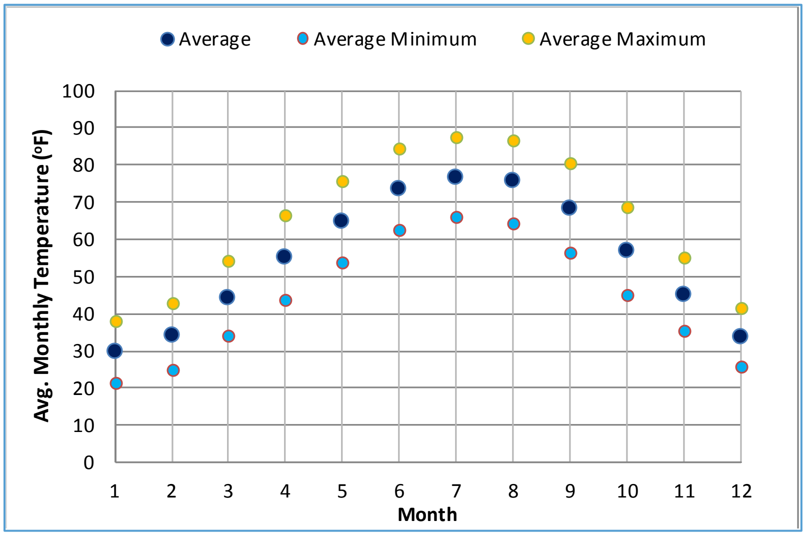

Figure 2-5. Average Monthly Air Temperature in the Bonpas Creek Watershed

2.2.3 Geology

Bedrock geology in the Bonpas Creek watershed is predominantly (98.2%) Pennsylvanian shale, with a minor area of Pennsylvanian limestone (Figure 2-6).

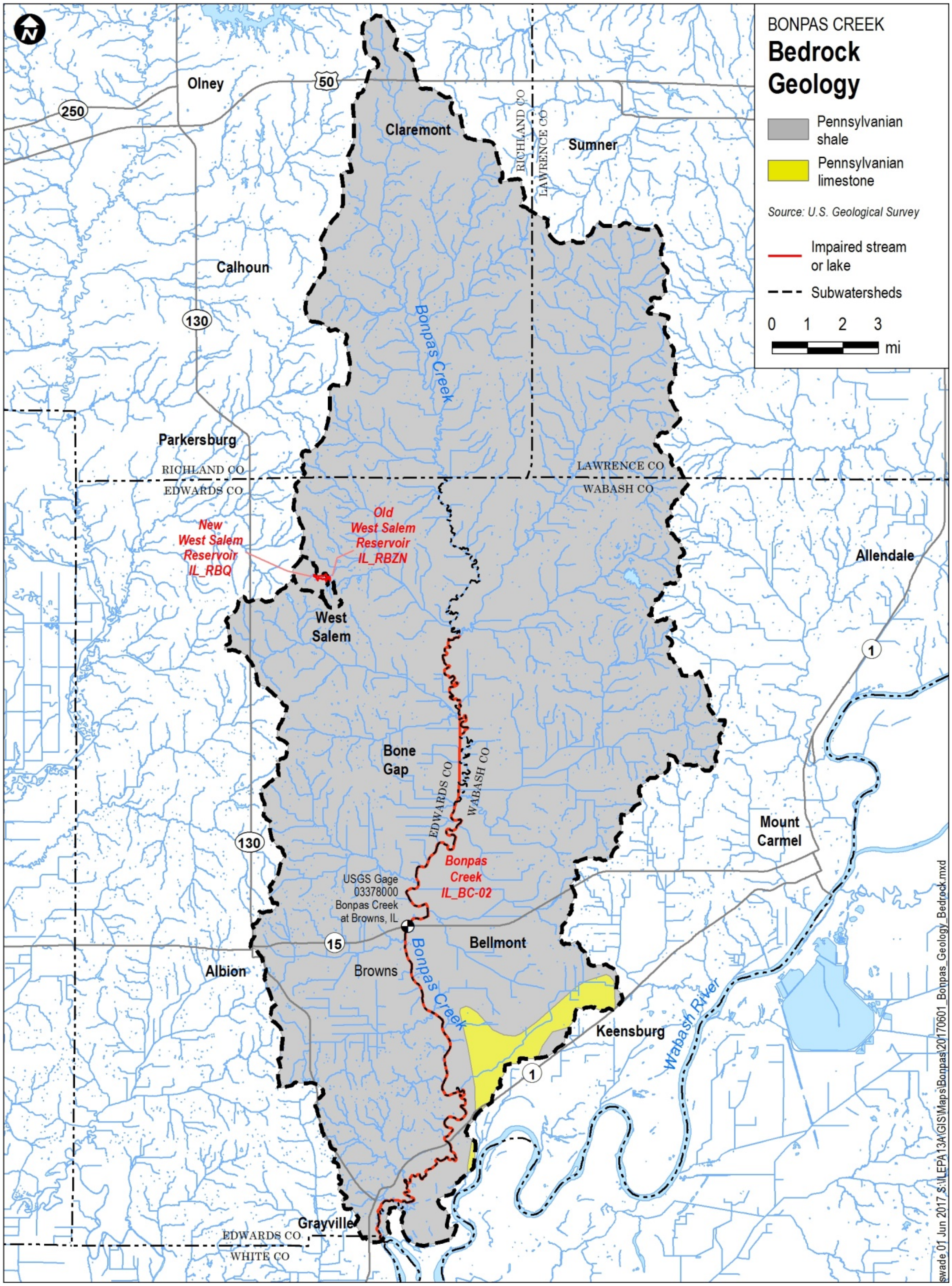

Figure 2-6. Geologic Units in the Bonpas Creek Watershed

Surface geology of the Bonpas Creek watershed, like most of Illinois, is dominated by glacial drift. Glacial drift thickness is variable within the Bonpas Creek watershed, ranging from less than 25 feet to more than 200 feet (see Figure 2-7). Approximately 2.8% of the watershed has glacial drift more than 100 feet thick.

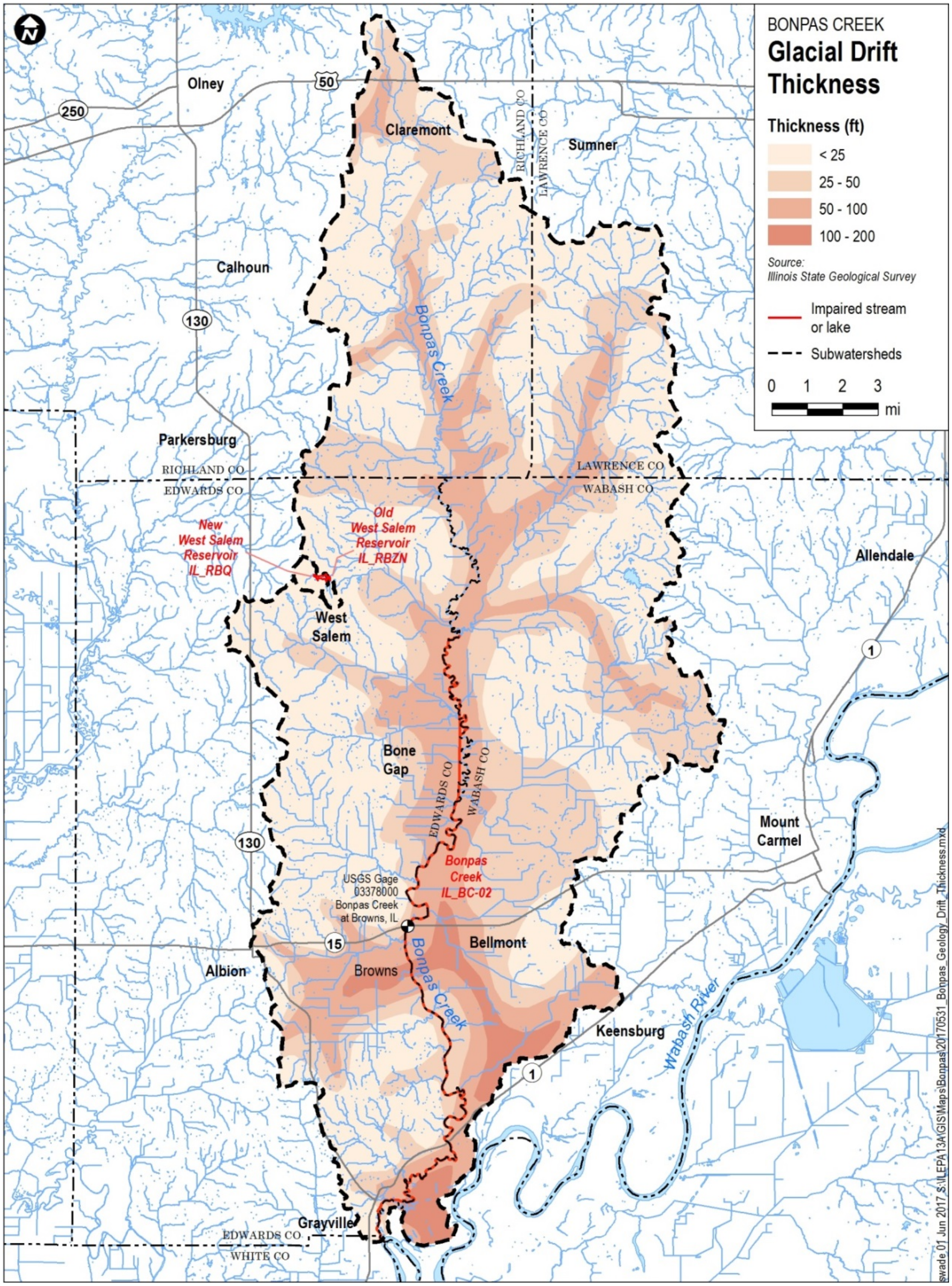

Figure 2-7. Glacial Drift Thickness in the Bonpas Creek Watershed

2.2.4 Soils

Together with topography, the nature of soils in a watershed play an important role in the amount of runoff generated and soil erosion. The Natural Resources Conservation Service's (NRCS) Soil Survey Geographic (SSURGO) database was reviewed to characterize study area soils. The target watershed has rich silt loam soils, lying predominately on slopes less than 2%. The most common soil types in the watershed are silt loam (76%) and silty clay loam (9%). The remaining soil types occur in much smaller percentages in the watershed. Soil texture distribution is shown in Figure 2-8 and a map of soil texture classes in the Bonpas Creek watershed is shown in Figure 2-10.

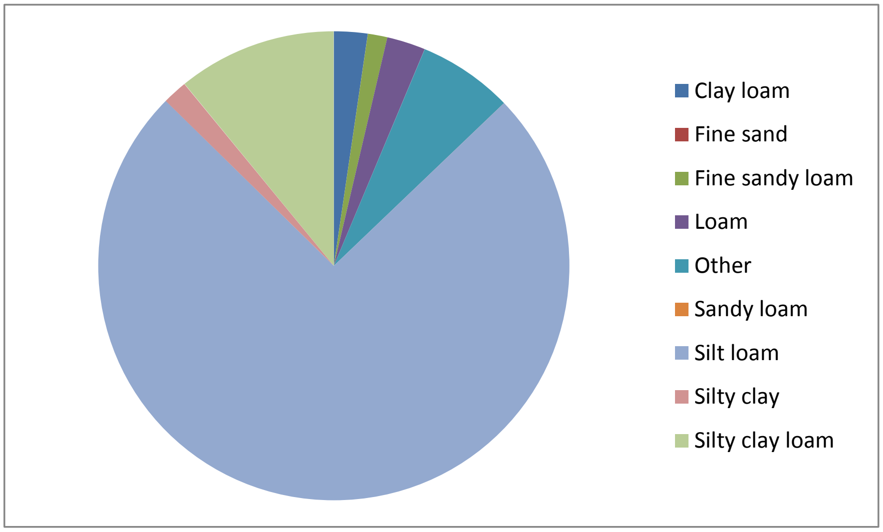

Figure 2-8. Distribution of Soil Texture Classes in the Bonpas Creek Watershed

The most predominant hydrologic soil group is C (63%), followed by D (15%). 9% of the watershed soils are hydrologic soil group B/C and 8% are C/D (Figure 2-9). Hydrologic soil groups are mapped in Figure 2-11.

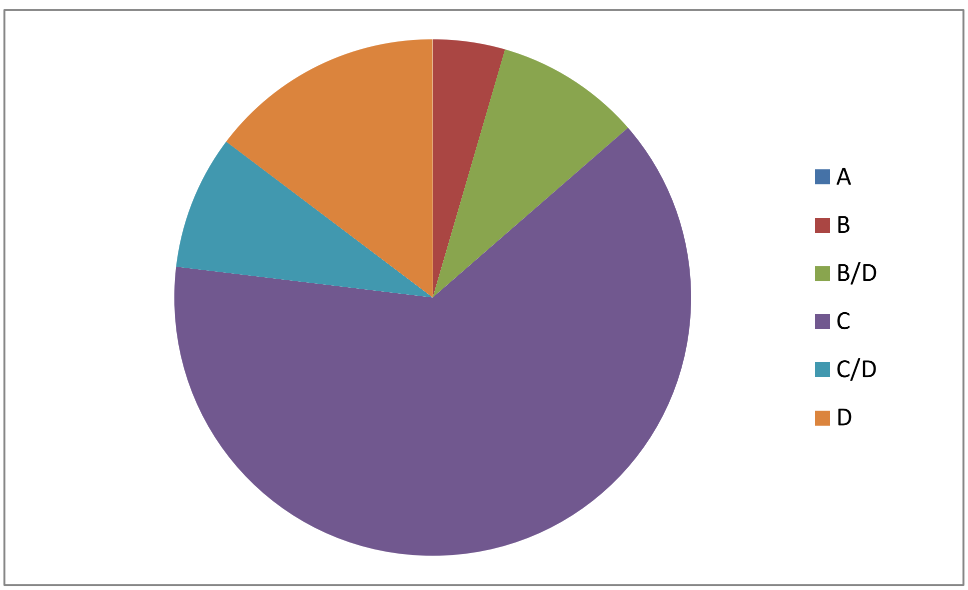

Figure 2-9. Distribution of Hydrologic Soil Groups (HSG) in the Bonpas Creek Watershed

Note that less than ½% of the watershed HSG is unclassified and are not shown.

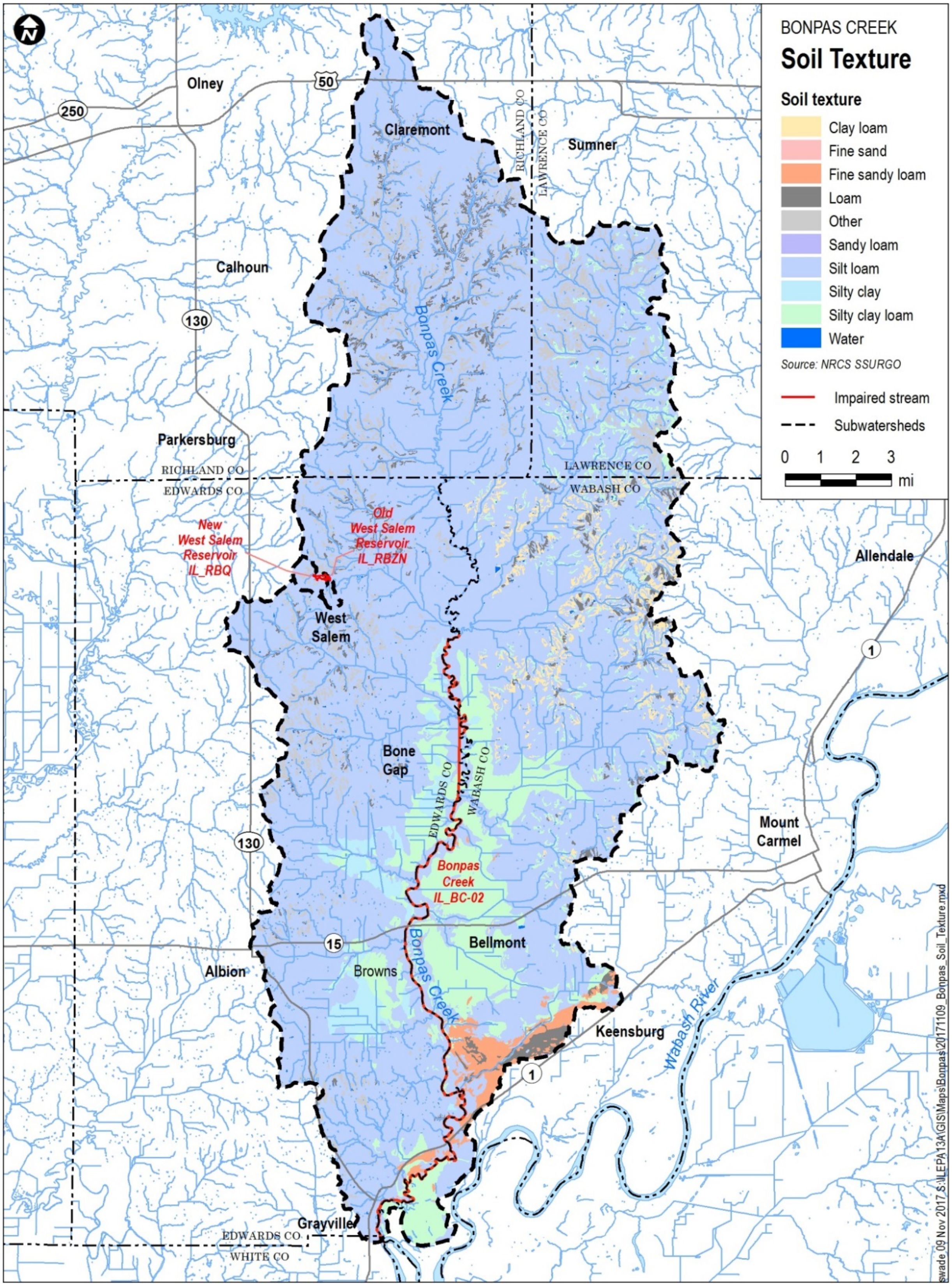

Figure 2-10. Soil Texture Classes in the Bonpas Creek Watershed

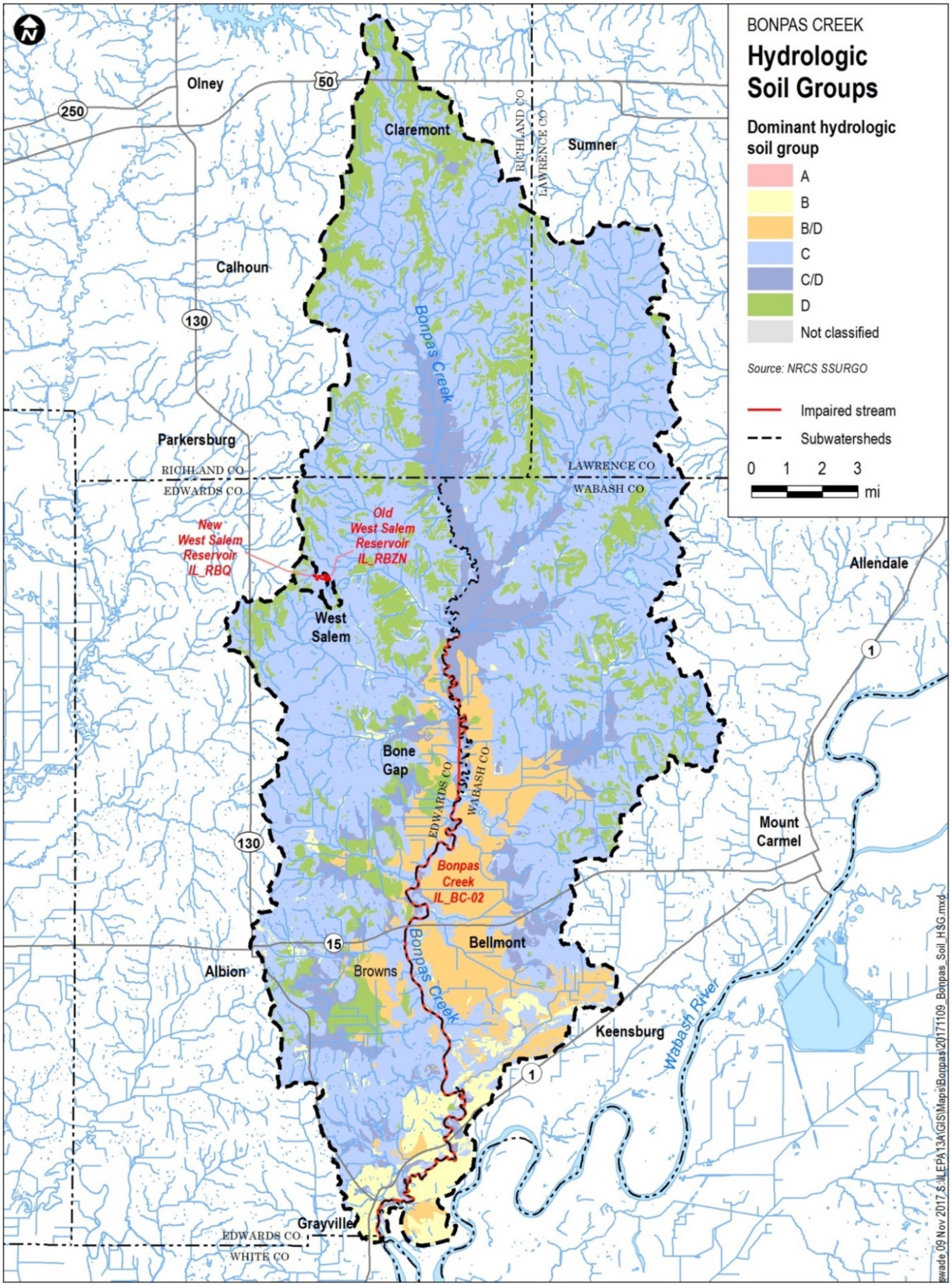

Figure 2-11. Hydrologic Soil Groups in the Bonpas Creek Watershed

The preceding discussion of topography, soil texture and hydrologic soil group classifications paint a picture of a watershed with steeper slopes near the headwaters, and flatter regions farther downstream, with poorly to very poorly drained soils dominating. According to soil drainage classification by the Natural Resource Conservation Service (NRCS, Figure 2-12), 13% of soil in the Bonpas Creek watershed is classified as “very poorly drained” or “poorly drained”, with another 46% classified as “somewhat poorly drained”. 27% of soil in the watershed is classified as “well drained” or “moderately well drained”.

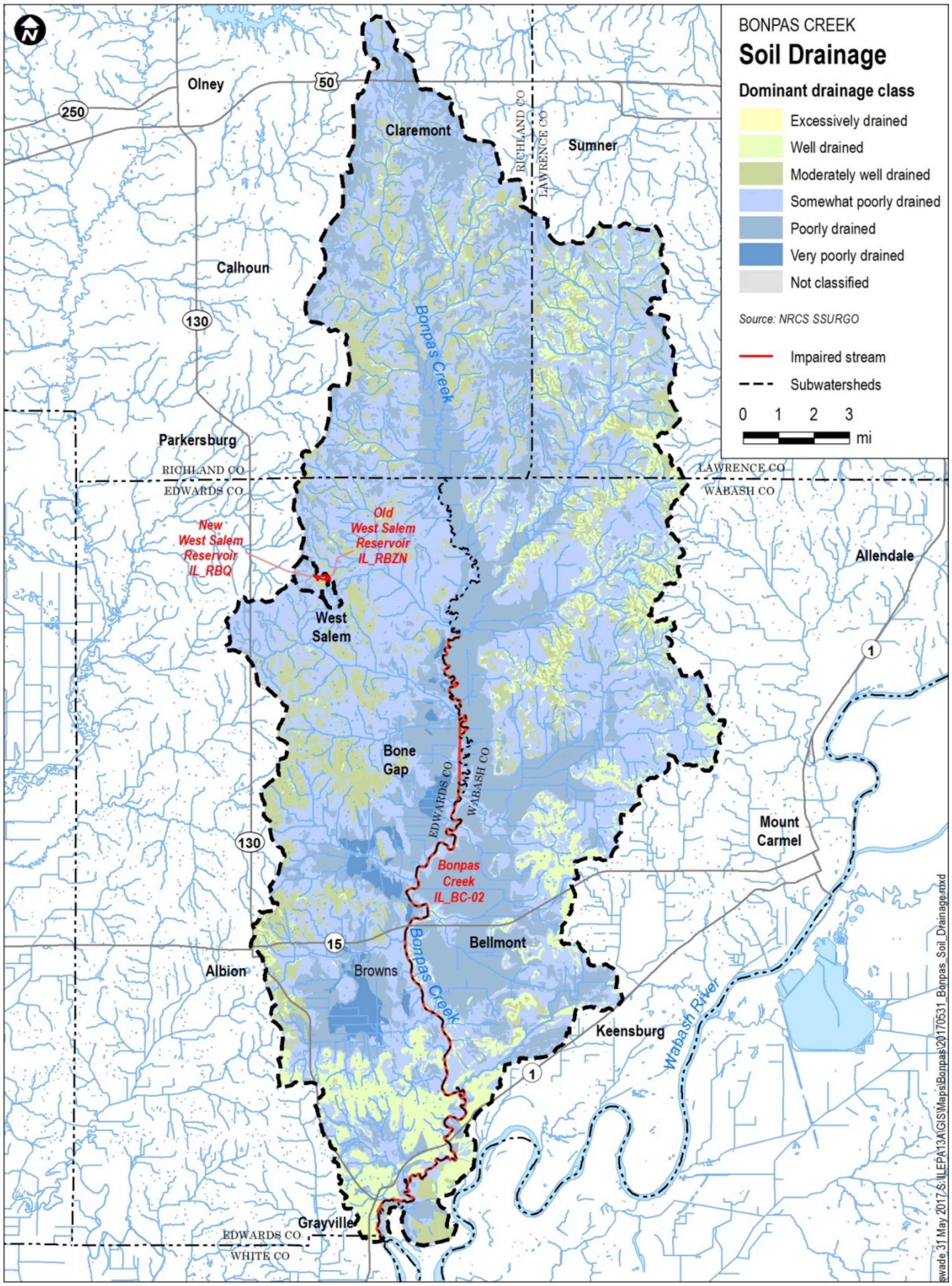

Figure 2-12. Soil Drainage Classification in the Bonpas Creek Watershed

Groundwater in some areas of the Bonpas Creek watershed is very shallow (Figure 2-13), with 27% of the watershed having an annual minimum water table depth of 15 cm (~6 inches). Overall, 88% of the watershed has an annual minimum water table depth of 77 cm (~30 in.) or less. Furthermore, 27% of the soils in the watershed are classified as hydric (Figure 2-13). These conditions suggest that roughly a quarter of the Bonpas Creek watershed may have been covered by wetlands in the past.

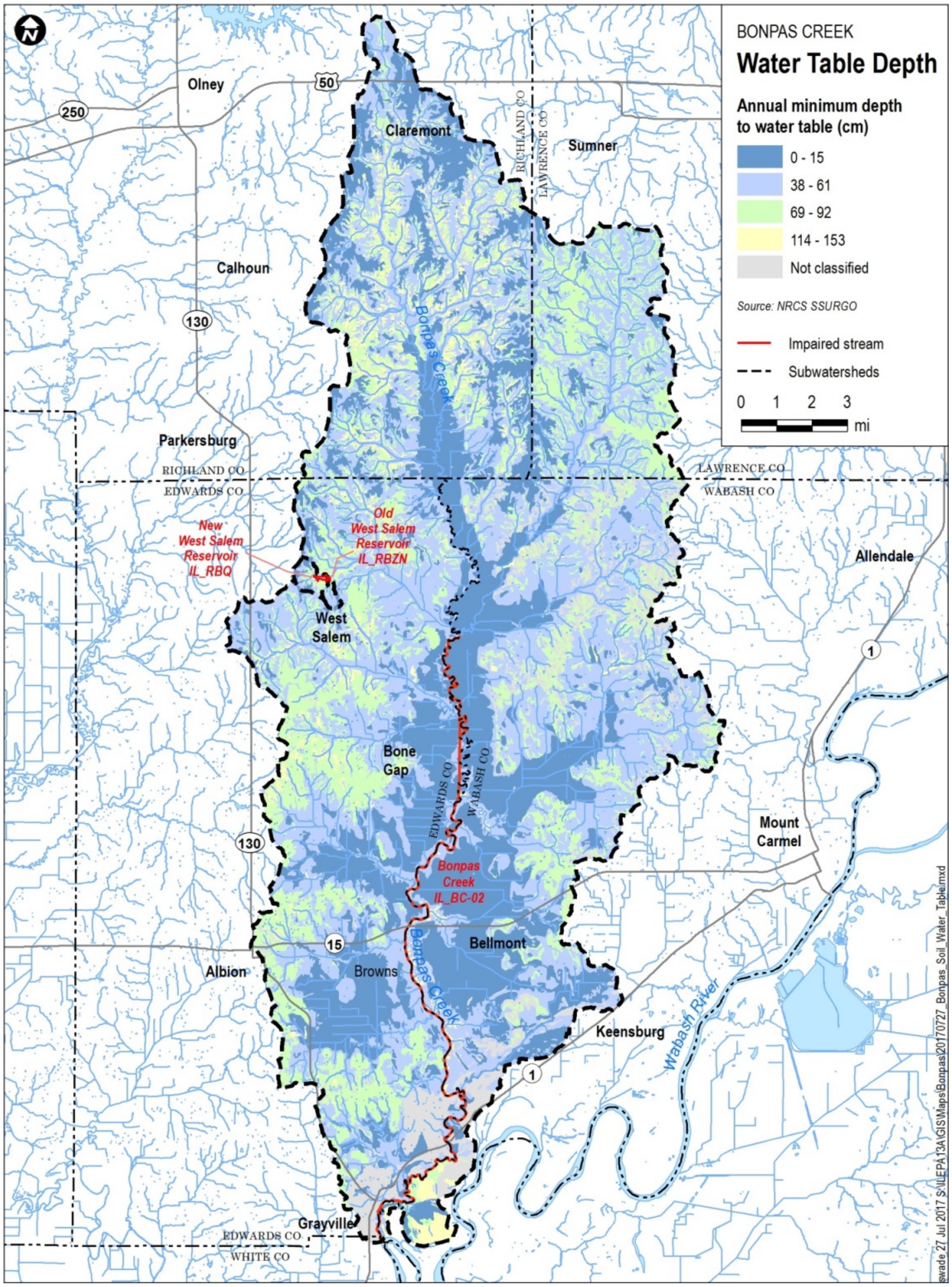

Figure 2-13. Depth to Groundwater in the Bonpas Creek Watershed

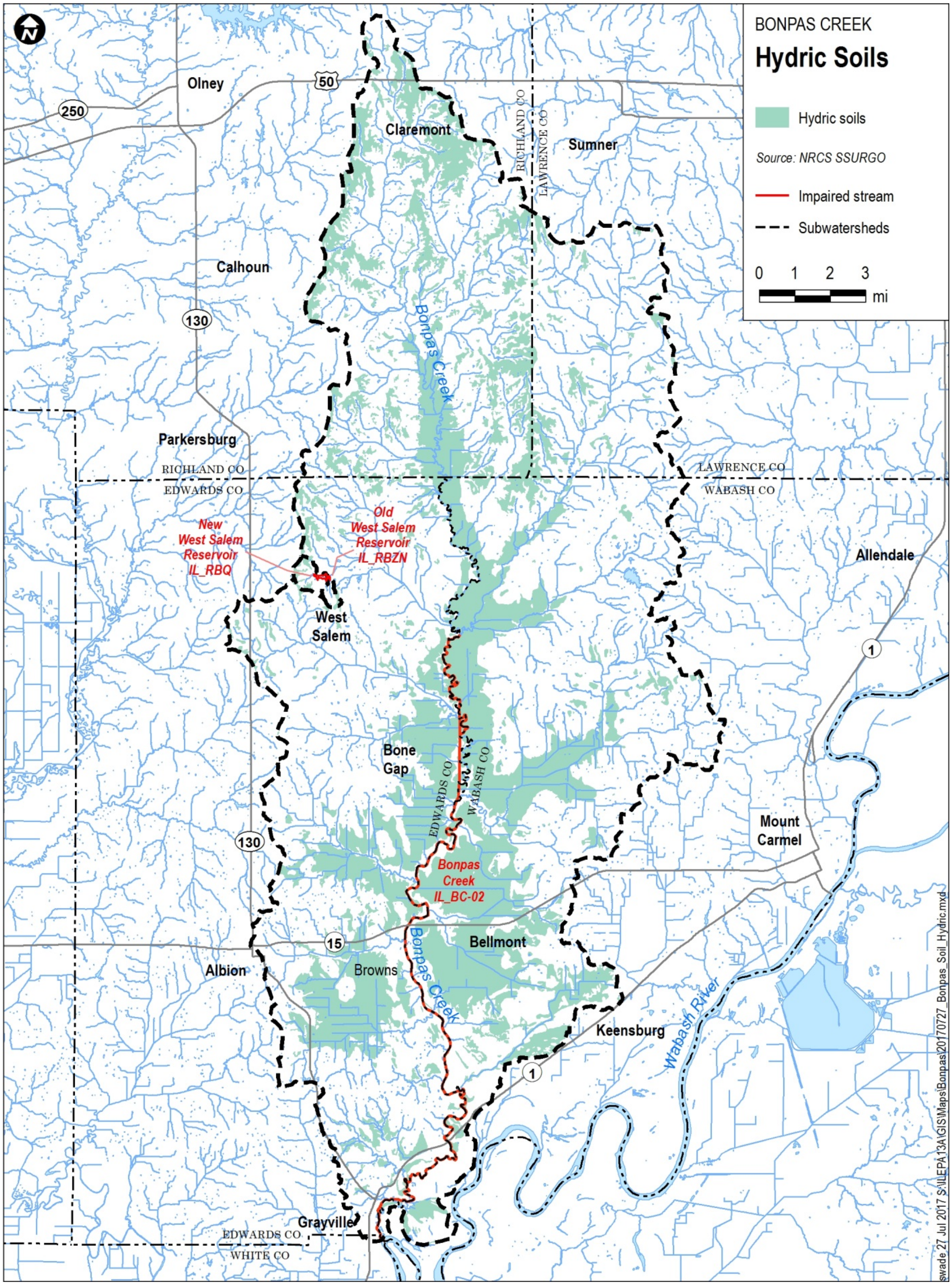

Figure 2-14. Hydric Soils in the Bonpas Creek Watershed

The NRCS classifies the agricultural quality of soils and 41% of the Bonpas Creek watershed is classified as "prime farmland if drained". Another 29% of the Bonpas Creek watershed is classified as "prime farmland" and 30% is classified as "not prime farmland" (Figure 2-15).

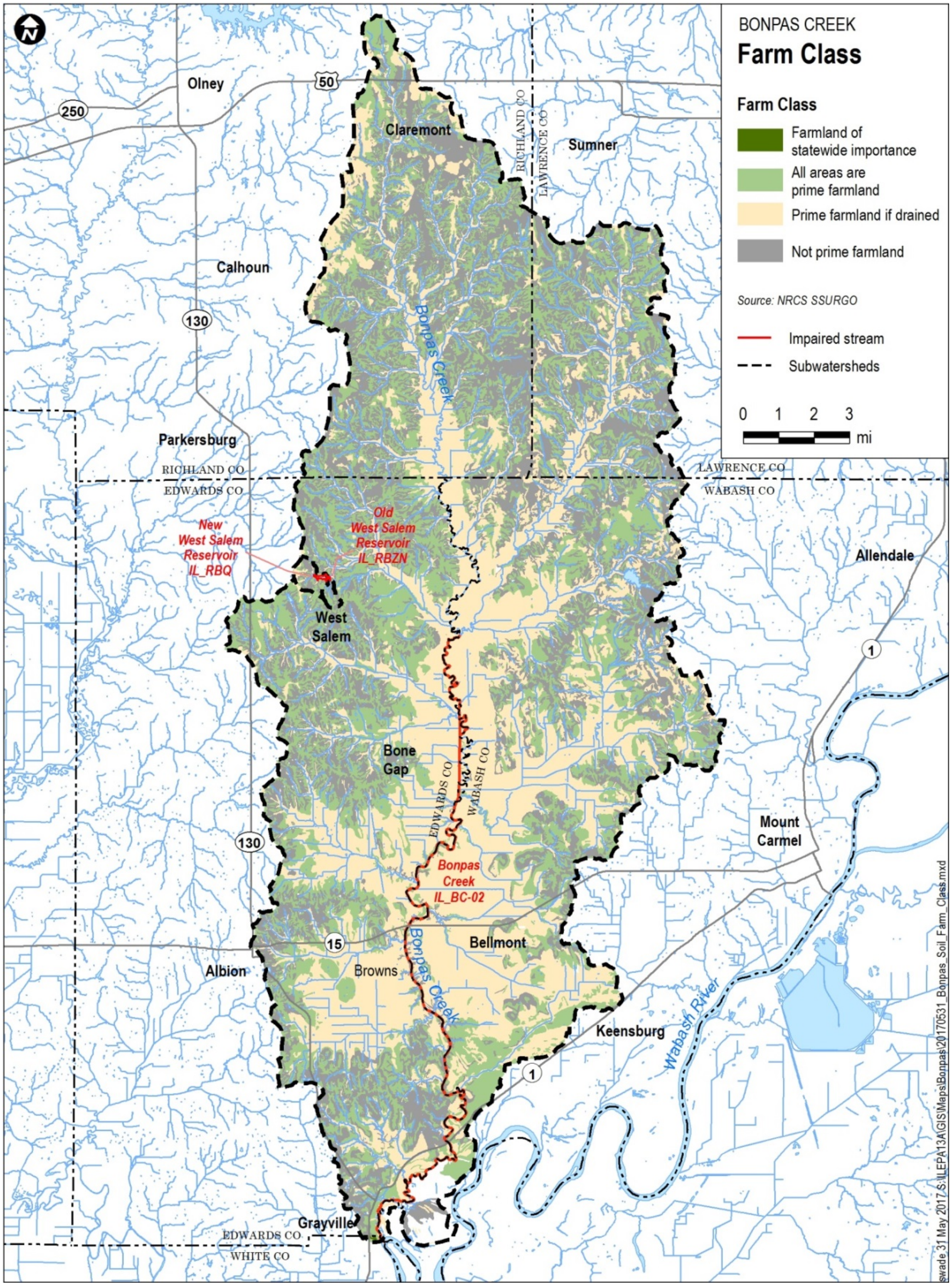

Figure 2-15. Farmland Quality in the Bonpas Creek Watershed

Fifty percent of soil in the Bonpas Creek watershed is classified as having high erodibility and 49% is classified as having moderate erodibility (Figure 2-15). Less than 1% of the soil is classified as having low erodibility.

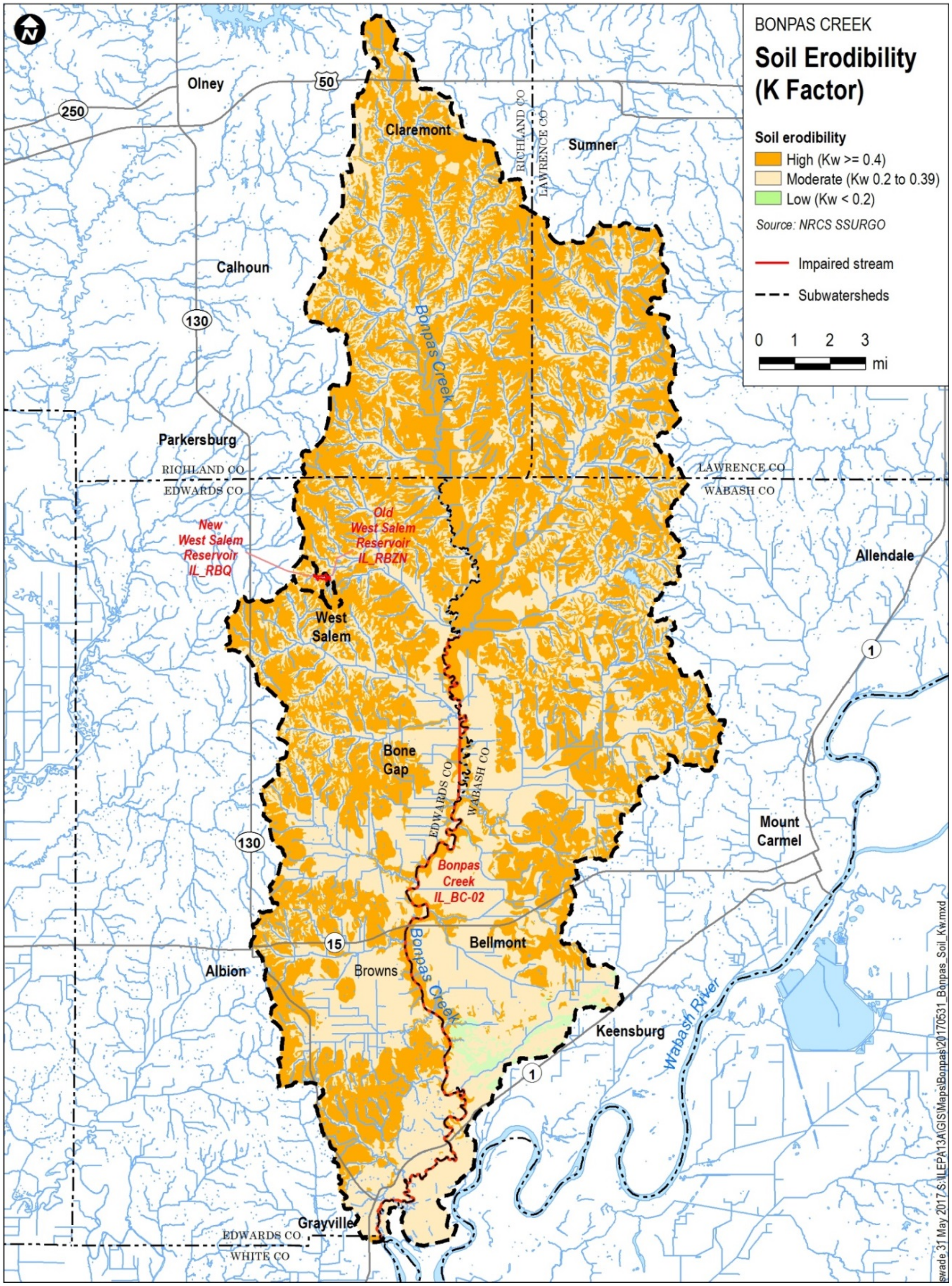

Figure 2-16. Soil Erodibility in the Bonpas Creek Watershed

2.2.5 Demographics and Urbanization

Population statistics and projections are available on a county basis. A majority of the watershed lies in Edwards and Wabash Counties. According to the United States Census Bureau, the population of Edwards County was 6,523, Lawrence County was 16,377, Richland County was 15,930, and Wabash County was 11,492, as of July 1, 2016, which is the most recent data available[2]. The total 2016 population of these four counties equals 50,322, down from a total 4-county population of 51,734 in 2010. Population in all four counties decreased from 2010 to 2016.

Urbanization in the watershed is centered in the towns of Claremont, West Salem, Bone Gap, Browns, Albion and Bellmont (Table 2-1). The land cover data indicates that the watershed is approximately 7% urbanized, but very little of it is considered heavily developed. Any urban areas in this region are considered low intensity development.

Table 2-1. Estimated Population[3] of Major Towns in the Bonpas Creek Watershed

Town	2000 Estimated Population
Claremont	212
West Salem	1001
Bone Gap	272
Browns	175
Albion	1933
Bellmont	297

2.2.6 Land Cover

Using the 2011 Cropland Data Layer (CDL) for Illinois from the NRCS, it is apparent that the Bonpas Creek watershed is predominantly agricultural with approximately 65% of the watershed being cultivated crops and 12% being pasture and hay. Forest covers approximately 15% of the watershed and the remainder consists of developed open areas (Figure 2-17 and Table 2-2). Of the cultivated crops, nearly all of them are corn and soybeans. Corn accounts for 49% while soybeans account for 45%. Most of the remainder is a double crop of winter wheat/soybeans. Land cover is mapped in Figure 2-18.

Table 2-2. Bonpas Creek Land Cover

Classification	Acres
Cultivated crop	116,350
Developed	2,029
Developed, open	9,763
Forest	27,209
Grassland/pasture/hay	21,651
Water/Wetlands	731
Barren	2
Total	**177,734**

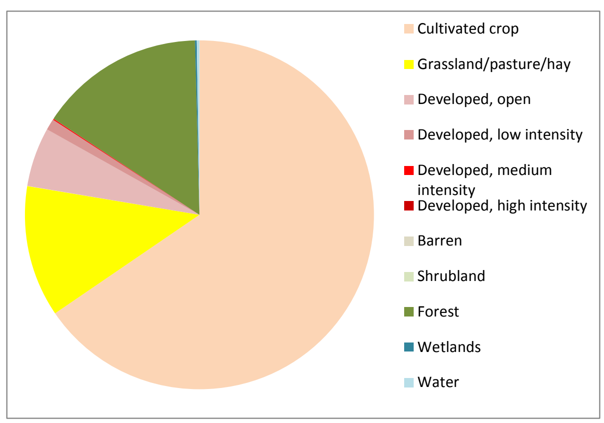

Figure 2-17. Bonpas Creek Watershed Land Cover Distribution

[2] https://www.census.gov/quickfacts/table/HCN010212/17075, accessed 5/31/17.
[3] Estimated 2000 populations obtained from Wikipedia on 5/31/17.

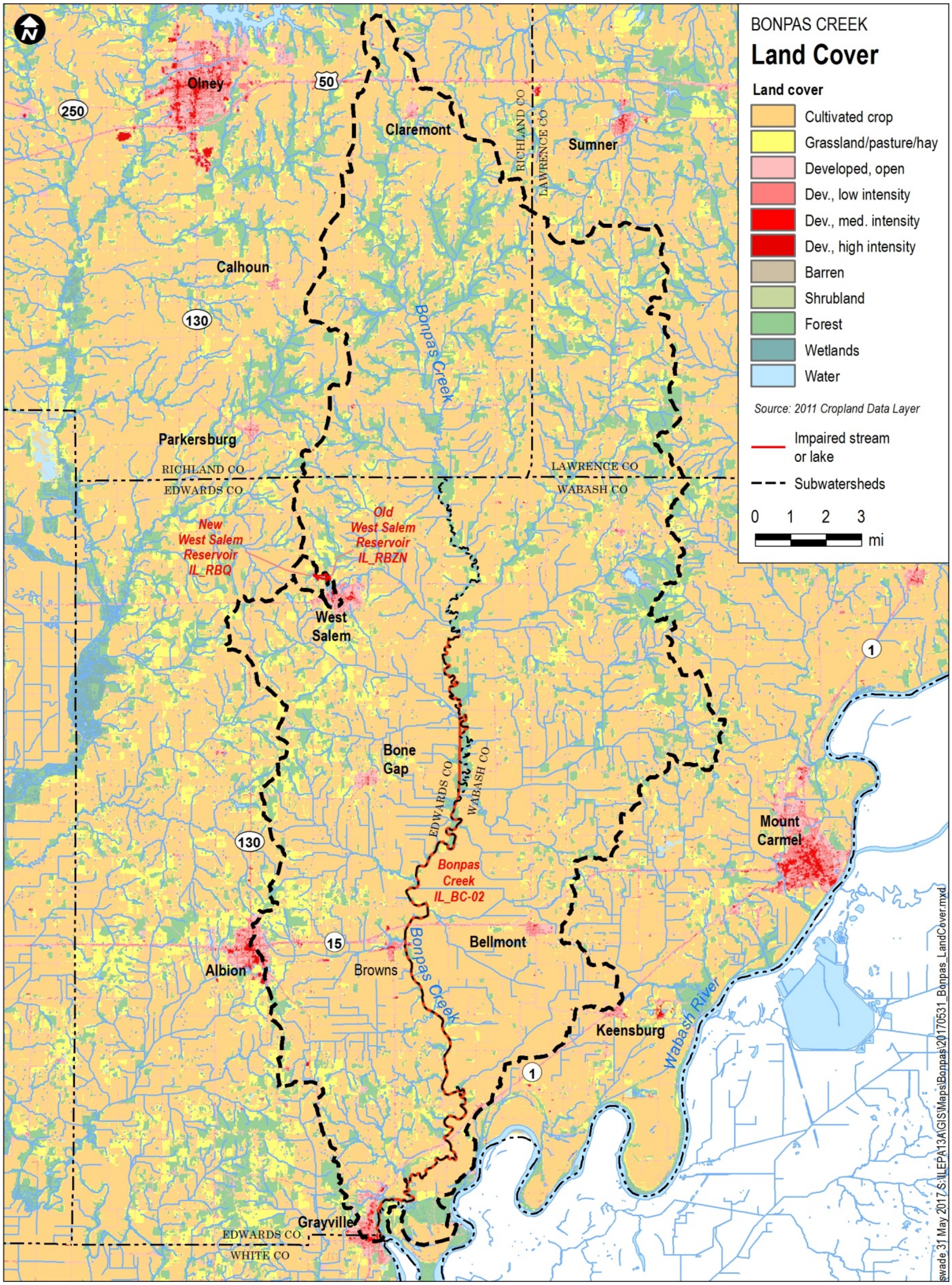

Figure 2-18. Land Cover in the Bonpas Creek Watershed

2.3 Additional Information Gathering

In addition to the desktop characterization described above, supplemental watershed inventory information was collected through a watershed tour and interviews with public officials. Additional information was obtained during a public meeting. These activities are described below.

2.3.1 Watershed Tour

A tour of the Bonpas Creek watershed was conducted in June 2013. This tour focused on the parts of the watershed containing impaired waters. The objectives of the watershed tour were:

- To verify observations made during the desktop analysis.
- To observe conditions at, and immediately upstream of, Illinois EPA water quality sampling locations.
- To identify concerns or potential causes of water quality impairment not previously identified

Most stream observations were made from bridge crossings or within a short hike of bridge crossings. A windshield survey of developed areas (towns) was conducted, but given the dominance of agriculture in the watershed, this contributed little information.

One significant observation made during the watershed tour was the prevalence of streambank erosion at all locations visited, including the lakes. Gully erosion was observed in the agricultural fields. Tile drains were observed as pipes protruding from streambanks, in some cases several feet above water level. Bonpas Creek and its tributaries were mud-colored, with the exception of the smallest streams. In many cases, cropland was observed to extend to the edge of the streams.

2.3.2 Interviews with Local Officials

In addition to the extensive desktop watershed study and the watershed tour, the following local officials were contacted for information on a range of relevant subjects:

- Wabash County Public Health Department – private sewage disposal units in Wabash County.
- Illinois EPA – source identification, mining, facility inspection reports, CAFOs, sampling, watershed groups.
- NRCS – past implementation of watershed projects

These interviews did not reveal new information, but confirmed information previously developed, as well as the understanding of pollutant sources.

2.3.3 Public Input

A public meeting was conducted at the Edwards County Fairgrounds Exhibition Building in Albion, Illinois on May 1, 2014 at 8:00 am, to present the findings of the watershed characterization and gather any additional information available from the public. The meeting was advertised in the Navigator & Journal Register on April 16, 2014 and public notices were mailed directly to the Soil and Water Conservation Districts, the Natural Resource Conservation Service, Illinois Farm Bureau and NPDES permittees in the watershed. A hard copy of the draft report was available for viewing prior to the meeting at the Edwards County SWCD office and West Salem Village Hall and the report was available on-line at www.epa.state.il.us/public-notices. Approximately sixty people attended the meeting, in addition to the meeting organizers. A background presentation was made on the watershed characterization, covering the following topics:

- The TMDL process and water quality goals;
- Target water quality issues in the Bonpas Creek watershed; and
- Potential sources of pollutants.

Questions were invited and input was requested at the meeting. The public in attendance was in overall agreement with the findings of the watershed characterization.

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3 Identification of Causes of Impairment and Pollutant Sources

As stated previously, the purpose of this watershed implementation plan is to address excess atrazine, fecal coliform and sediment loads to Bonpas Creek segment IL_BC-02, and excess phosphorus loading to West Salem Old and West Salem New Reservoirs. TMDLs have been developed for atrazine (Bonpas Creek), fecal coliform (Bonpas Creek) and phosphorus (New West Salem Reservoir), and load reduction strategies have been developed for sediment (Bonpas Creek) and phosphorus (Old West Salem Reservoir) (Figure 3-1) and additional detail is found in the Stage 3 report for the Bonpas Creek watershed. Illinois regulations do not require TMDLs for lakes < 20 acres in size, which is why a load reduction strategy, instead of a TMDL, was developed for Old West Salem Reservoir (2 acres).

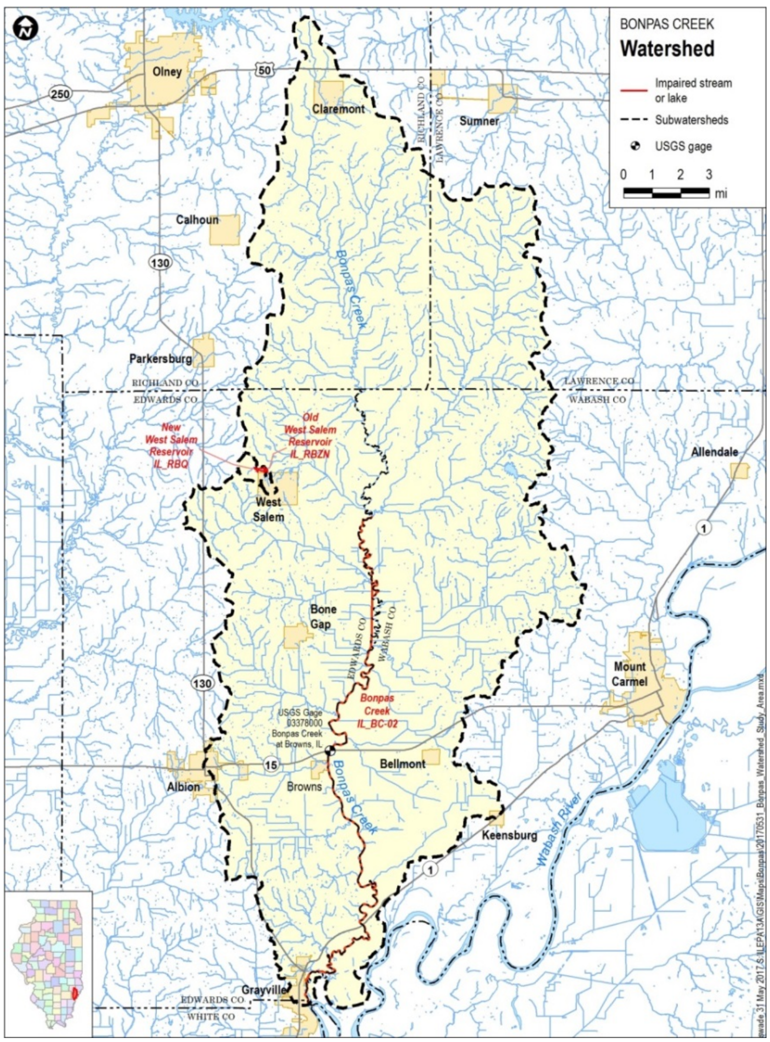

Figure 3-1. Study area map

3.1 Identification of Potential Pollutant Sources

West Salem Old and West Salem New reservoirs are identified as impaired due to excess phosphorus. Past experience shows there are several potential sources of excessive phosphorus, including:

- Agricultural runoff (phosphorus added as fertilizer and/or manure and bound to soil particles)
- Developed area runoff (phosphours added as fertilizer and bound to soil particles)
- Legacy phosphorus in lake sediments (bound to soil particles that settle to the lake bottom)
- Shoreline erosion (bound to soil particles)

The downstream segment of Bonpas Creek (segment BC-02) is identified as impaired due to sedimentation, fecal coliform and atrazine. Past experience shows that there are several potential sources of excessive sediment, fecal coliform and atrazine loading in predominantly agricultural watersheds:

- Agricultural runoff (sediment from field erosion, fecal coliform from manure, atrazine from crop application)
- Point sources (fecal coliform from wastewater treatment facilities)
- Streambank erosion (sediment from bank erosion)

Each of these potential sources is evaluated below, by pollutant.

3.2 Assessment of Potential Sources, by Pollutant

Pollutant sources were evaluated using the watershed characterization information presented in Section 2, available monitoring data, simple watershed modeling, GIS analysis of watershed characteristics, a site visit and calls to local agencies.

3.2.1 Phosphorus loads to New West Salem and Old West Salem Reservoirs

Due to the absence of tributary monitoring data, long-term average phosphorus loading was estimated for the two phosphorus-impaired lakes using land use distribution data and unit area loading rates from literature. These results indicate agricultural runoff (cultivated crops and pasture/hay comprise 74% of land use in this subwatershed) is the most significant source of phosphorus to New West Salem Reservoir, and runoff from developed lands (73% of land use in this subwatershed)) is the most significant phosphorus source to Old West Salem Reservoir, followed by agricultural runoff.

Table 3-1. Phosphorus Load Estimate by Source (Surface runoff only)

Source	Old West Salem Reservoir	New West Salem Reservoir
Cultivated crop	32%	92%
Developed	62%	1%
Forest	2%	2%
Grassland/pasture/hay	4%	4%

Historical phosphorus loads to the lakes may accumulate in bottom sediments, and the resulting unusually high sediment phosphorus can subsequently be introduced into water over time. These areas are known as legacy sediment sources. In-lake phosphorus data collected at various depths indicates phosphorus is entering the water column from legacy phosphorus in the lake bottom sediments. Legacy phosphorus loads from the sediments could be confirmed with sediment sampling and remediation could be pursued by dredging out the sediments.

Site observations also point to shoreline erosion as another phosphorus source, but the load from this source is difficult to quantify and is expected to be small compared to other sources.

3.2.2 Sediment loads to Bonpas Creek

Sediment loads from surface runoff and streambank erosion were calculated within Model My Watershed[4], which implements GWLF-E for runoff loads and estimates the watershed average lateral streambank erosion (LER) using an empirical method. This empirical method for streambank erosion is based on the average monthly flow, and a regression factor based on five key watershed parameters including animal density, curve number soil erodibility (k factor), mean watershed slope and percent of developed land in the watershed. This method was developed by Evans et al., 2003 based on sediment loading data from several watersheds within Pennsylvania. After a value for the LER has been computed, the total sediment load from streambank erosion within the watershed is calculated by multiplying the LER by the total length of streams in the watershed, the average streambank height, and the average soil bulk density. Within Model My Watershed, the default values for average streambank height of 1.5 m and 1500 kg/m3are used for and soil bulk density, respectively. Runoff from cropland is calculated to contribute 48% of the total sediment load, and streambank erosion is calculated to contribute 51% of the total sediment loads. Runoff from the remaining land cover categories in the watershed contributes 1% or less of the total load each. Severe streambank erosion was observed in many locations (Figure 3-2).

Figure 3-2. Examples of streambank erosion in the Bonpas Creek watershed

[4] https://app.wikiwatershed.org/

3.2.3 Atrazine loads to Bonpas Creek

Atrazine is a widely used herbicide, used in particular on corn to control broadleaf and grassy weeds. It is sprayed on crops during the spring and summer months, where it is absorbed into weeds and stops photosynthesis. It generally breaks down in soil, but moisture delays the degradation. The half-life of atrazine is about 146 days in soils and is about 742 days in water. Although there are strict requirements for usage, atrazine can wash off plants and soil during rain events and enter local waterbodies. This runoff can be exacerbated by agricultural tile drainage. Research into the health effects of atrazine is ongoing, but it is a regulated contaminant under the Safe Drinking Water Act.

As described previously in the atrazine TMDL, the only atrazine water quality standard violation was observed during a period of high flow. Because atrazine is only applied to cropland, runoff from cropland is identified as the primary source. Because tile drains are also a possible pathway to transport atrazine to Bonpas Creek from cropland, the probability of tile drains in the Bonpas Creek watershed is shown in Figure 3-3.

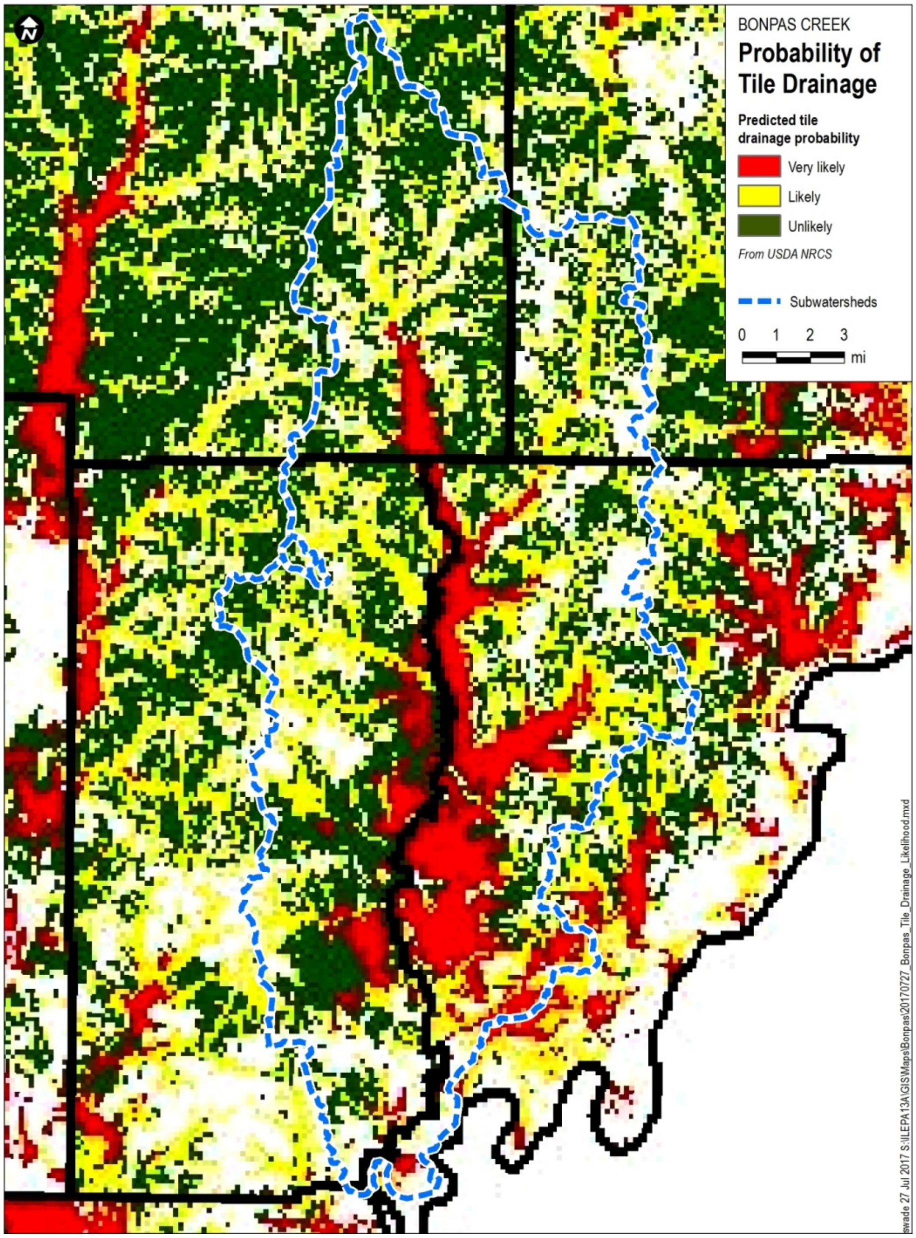

Figure 3-3. NRCS Probability of Tile Drainage

3.2.4 Fecal coliform loads to Bonpas Creek

Fecal coliform monitoring data collected in Bonpas Creek show a correlation between flow and fecal coliform concentrations. The majority of the water quality standard violations occur at higher creek flow conditions indicating fecal coliform is primarily coming from a wet weather source. Potential sources of fecal coliform during wet weather include nonpoint source runoff including runoff carrying waste from livestock, wildlife and pets. Sewage treatment plants and failing septic systems/surface discharging systems may also contribute, however, due to the low effluent flow of the sewage treatment plants in the watershed (<0.04 MGD), they are not identified as contributing significant fecal coliform loads to the creek. Septic systems and aeration units (water is aerated, treated with chlorine and discharged to the surface) are used for sewage treatment in rural areas. Improperly functioning septic systems and aeration units would have a larger impact on the creek during dry weather, but could also have an impact during wet weather conditions, if the septic system was not working properly or the surface discharge was not chlorinated. The contribution of these sources is not known, but a ballpark load was calculated, using literature values and assumptions regarding per capita flows (90 gal/person/day), 5% failure rate and homes served by septic (665). It is possible that failing onsite systems could contribute 4% of the current bacteria load, and as such they are identified as a potential source that should be investigated further. This plan recommends coordination with the local health department to identify systems in need of improvement or repair.

Livestock can contribute fecal coliform loads via waste runoff, and if the animals are not fenced away from waterways, they may be a direct source to the streams. According to the most recent (2012) census of agriculture (NASS, 2017), cattle farms are the most common type of livestock farm within Edwards, Lawrence, Richland and Wabash Counties, but there are almost five times as many hogs as cattle suggesting hogs are more concentrated (Table 3-2). There are three permitted confined animal feeding operations (CAFOs) in the watershed which are dairy (medium), swine (large) and pasture beef (small) facilities (Figure 3-4).

The potential fecal coliform load from livestock was calculated using available information. First, the number of animals in the Bonpas Creek watershed was approximated by scaling the countywide numbers to the area of the watershed in each county. Fecal coliform loads were calculated for the two most common livestock, cattle and hogs, based on manure produced/animal and literature values describing the concentration of bacteria in manure (USEPA, 2001;
http://www.agronext.iastate.edu/immag/pubs/smanure.pdf; and
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcs143_014211).

This load is an estimate of what is produced. The load that reaches the stream is expected to be less due to bacterial decay, reductions from existing vegetative filters and other management practices to capture or treat bacteria, and other factors. However, this calculation showed that livestock could potentially contribute up to 50% of the current fecal coliform load, although the true contribution is uncertain.

Table 3-2. Livestock and Poultry Census Data (2012) and Estimated Fecal Load Generated

Census Item	# of Farms	# of Animals	**Fecal coliform/yr**
Cattle, including calves - inventory	60	2493	6.4E+16
Hogs – inventory	6	12060	2.5E+15
Sheep, including lambs - inventory	5	38	
Goats	10	85	
Equine	44	219	
Poultry totals - hatched, measured in head	19	Not available	

Fecal coliform loads in runoff may also originate from wildlife although their contribution is unknown. Management measures that slow and filter runoff will help reduce loads from these sources.

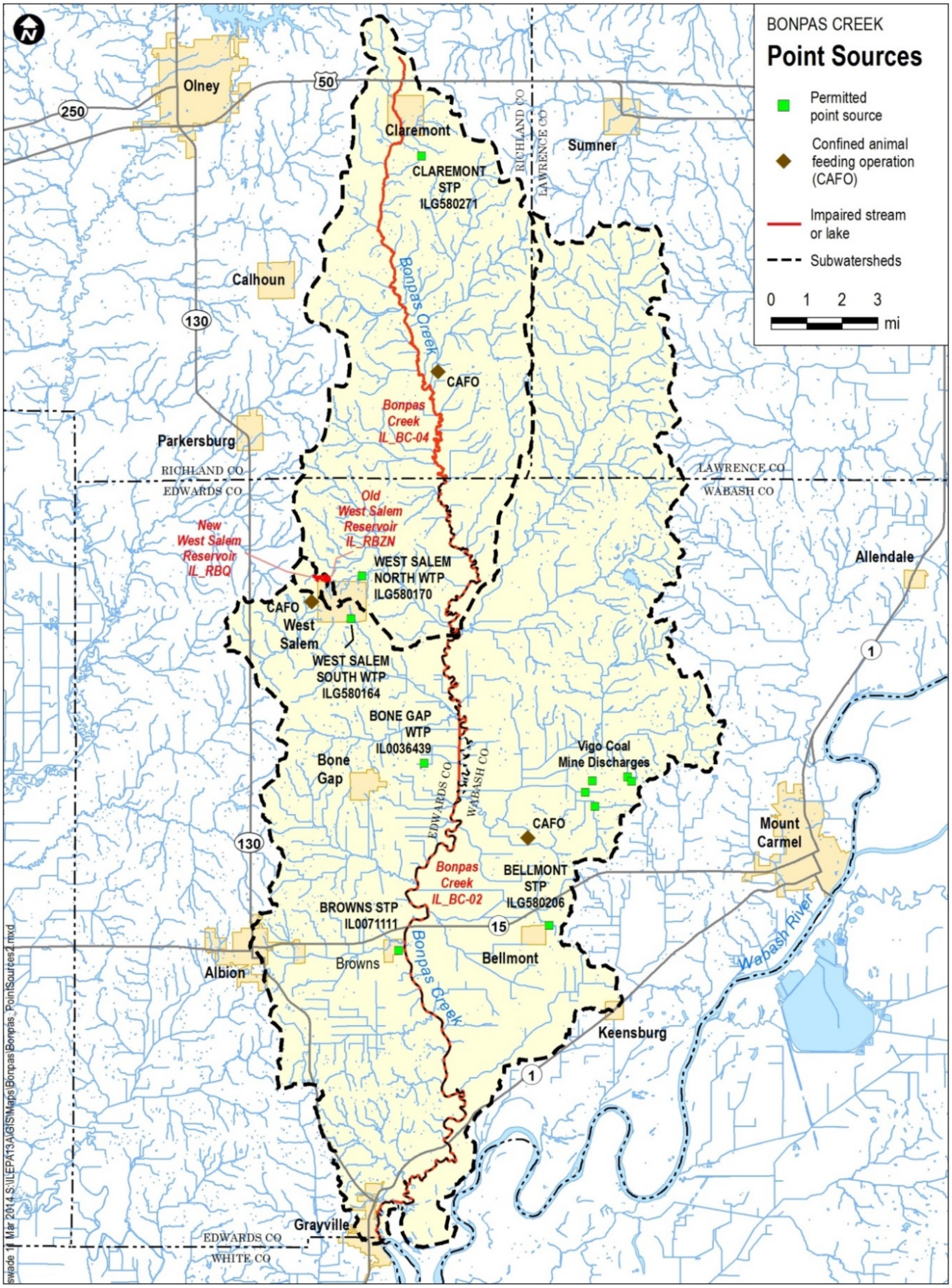

Figure 3-4. Permitted NPDES Dischargers in the Bonpas Creek Watershed.

3.3 Summary of Priority Sources of Pollutants

Based on the watershed characterization and evaluation of potential sources of pollutants in the Bonpas Creek watershed, the following conclusions regarding priority sources of are supported:

- Runoff is the primary pathway for phosphorus, sediment, atrazine and fecal coliform loading to the impaired waterbodies, with streambank erosion also contributing to sediment loading.
- The primary source of phosphorus loading to Old West Salem Reservoir is runoff from developed lands and cropland. The primary source of phosphorus loading to New West Salem reservoir is runoff from cropland. Specific sources within these watersheds cannot be further identified with available data. Monitoring data showing higher concentrations at the bottom of the lake suggest that phosphorus from legacy sources is entering the lakes from the bottom sediments.
- In Bonpas Creek (IL-BC-02), runoff from cultivated cropland is the most likely source of atrazine.
- In Bonpas Creek (IL-BC-02), runoff from cultivated cropland and streambank erosion are both significant sources of sediment.
- In Bonpas Creek (IL-BC-02), runoff from agricultural lands with livestock is a significant contributor of fecal coliform bacteria. Failing septic systems or surface discharging systems may also be contributing a smaller portion of the bacteria load. Other sources such as wildlife may also be contributing, but their contribution is unknown.

The controls described in subsequent sections of this implementation plan are focused on reducing phosphorus, fecal coliform, atrazine and sediment from these sources.

4 Recommended Management Measures

Recommended non-point source control measures to reduce pollutant loading in the Bonpas Creek watershed are discussed in this section.

4.1 TMDL and Load Reduction Targets

4.1.1 Phosphorus

The Bonpas Creek Stage 3 Report (LimnoTech, 2017) presents the total phosphorus LRS and total phosphorus TMDL for Old West Salem and New West Salem reservoirs, respectively. The percent reduction in phosphorus load is presented in Table 4-1. For purposes of this implementation plan, a watershed model was developed to calculate current phosphorus loads from different land uses (USEPA, 2000), as well as livestock and septic systems. These results were used in conjunction with percent reductions to determine the actual loads that can be reduced by controls targeted at different sources. Table 4-1 presents the current average annual phosphorus load for each lake, the percent load reduction needed and the targeted load of total phosphorus to be reduced in each subwatershed.

Table 4-1. Total Phosphorus Reduction Targets

Stream (Segment)	Current Average Annual Phosphorus Load (lbs/yr)	Target Percent Reduction	Target Average Annual Phosphorus Load to be Reduced (lbs/yr)
Old West Salem Reservoir (IL_RBZN)	131.4	33% (LRS)	43.8
New West Salem Reservoir (IL_RBQ)	321.2	50% (TMDL)	160.6

Based on watershed modeling, non-point source phosphorus are predominantly (92%) from cultivated cropland in the New West Salem Reservoir watershed, and from developed land (62%) and cultivated cropland (32%) in the Old West Salem Reservoir watershed.

Table 4-2. Total Modeled Phosphorus Loads by Source for New and Old West Salem Reservoirs

	New West Salem Reservoir		Old West Salem Reservoir	
Land Use	Annual Average Phosphorus Load (lbs)	% of Total	Annual Average Phosphorus Load (lbs)	% of Total
Cultivated crop	296	92%	14	11%
Developed	3	1%	97	74%
Forest	6	2%	10	8%
Grassland/pasture/hay	13	4%	9.7	7%

* Numbers may not sum exactly due to rounding

4.1.2 Atrazine

Atrazine is an herbicide applied to agricultural crops for weed control and management practices should focus on reducing atrazine in cropland runoff. The Bonpas Creek Stage 3 Report (LimnoTech, 2017) presents the atrazine TMDL for Bonpas Creek (IL_BC-02), with reductions of up to 9% in current loads needed during wet weather to meet the TMDL target. There were no dry weather violations of the atrazine target measured.

Table 4-3 presents the current atrazine load for Bonpas Creek, the percent load reduction needed and the targeted load of atrazine to be reduced. The current load was calculated using the median flow in the higher (0-20 percentile) flow interval (1449.45 cfs at Bonpas station BC-02) multiplied by the measured instream concentration (9.9 ug/l) in this flow interval. The 9% reduction was applied to the current load to determine the load of atrazine that needs to be reduced (Table 4-3).

Table 4-3. Atrazine Reduction Targets

Stream (Segment)	Current Atrazine Load (lbs/day)	Target Percent Reduction	Target Atrazine Load to be Reduced (lbs/day)
Bonpas Creek (IL_BC-02)	77.4	9%	7

4.1.3 Fecal coliform

The Bonpas Creek Stage 3 Report (LimnoTech, 2017) presents the fecal coliform TMDL for Bonpas Creek (IL_BC-02). Reductions are needed over a range of flow conditions; however, the largest reductions (99%) are needed during the highest flow conditions.

Table 4-4 presents the current fecal coliform load for Bonpas Creek, the percent load reduction needed and the targeted load of fecal coliform to be reduced. The current load was calculated using the median flow in the higher (0 – 30 percentile) flow interval (954.9 cfs at Bonpas station BC-02) multiplied by the highest instream concentration (15,400 cfu/100 ml) in this flow interval. The 99% reduction was applied to the current load to determine load of fecal coliform that needs to be reduced (Table 4-4).

Table 4-4. Fecal Coliform Reduction Target

Stream (Segment)	Current Fecal Coliform Load (cfu/day)	Target Percent Reduction	Target Fecal Coliform Load to be Reduced (cfu/day)
Bonpas Creek (IL_BC-02)	3.6E+14	99%	3.55E+14

Based on estimated fecal coliform loads calculated from livestock data, available monitoring data from permitted sewage treatment plants and a conversation with the local health department regarding septic systems, it is likely that the most significant source of fecal coliform loads is agricultural runoff from land with livestock. Fecal coliform loads generated from livestock (cattle and hogs) are estimated to be 6.6E+16 cfu/yr (1.8E+14 cfu/day), supporting the conclusion that this source may be significant. Septic systems or surface discharging systems in need of repair may also contribute bacteria loads, with an estimated load of 5.2E+15 cfu/yr (1.4 E+13 cfu/day).

4.1.4 Sediment

The Bonpas Creek Stage 3 Report (LimnoTech, 2016) presents the TSS LRS for Bonpas Creek (IL_BC-02). The percent reduction in TSS load is presented in Table 4-5. For purposes of this implementation plan, a watershed model was developed to calculate the current TSS load contribution from different sources. These results were used in conjunction with percent reductions to determine the actual loads that can be reduced by controls targeted at different sources. Table 4-5 presents the current average annual TSS load, the percent load reduction needed and the load of TSS to be reduced to meet the LRS target.

Table 4-5. TSS Reduction Target

Stream (Segment)	Current Average TSS Load (lbs/yr)	Target Percent Reduction	Target Average Annual TSS Load Reduction (lbs/yr)
Bonpas Creek (IL_BC-02)	155,867 lbs/yr	65%	101,496

The load contribution by source was calculated using watershed modeling, and the data-based TSS loads, scaled by source are shown in Table 4-6. TSS loads are split fairly evenly between runoff from cropland and streambank erosion.

Table 4-6. TSS Loads by Source

Land Use	Annual Average TSS Load (lbs)	% of Total
Non-cropland	1,559	1%
Cropland generalized agriculture	74,816	48%
Streambank erosion	79,492	51%
OVERALL	**155,867**	**100%**

* Numbers may not sum to 100% due to rounding

4.2 Potential Management Practices

The TMDLs and LRSs defined necessary load reductions needed to meet targets. The previous section described the sources that should be targeted preferentially to achieve the largest reductions. There are many potential management measures that could be implemented to reduce pollutant loads. Local officials were contacted to assess which practices would be the best fit for the Bonpas Creek watershed, recognizing runoff is a predominant pollutant source. These are described below along with other potential management practices commonly used in Illinois. These are:

- Conservation Tillage
- Conservation Buffers
- Cover Crops
- Treatment Wetlands
- Nutrient Management Plans
- Livestock Management Controls
- Sediment Control Basins (includes terraces, dry dams, ponds and water & sediment control basins)

- Streambank Stabilization
- Septic System Maintenance

Each of these is briefly described below.

4.2.1 Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (Simmons and Nafziger, undated). This reduction in erosion also reduces the amount of phosphorus lost from the land and delivered to the streams. The NRCS has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (Simmons and Nafziger, undated). Conservation tillage/crop residue management systems are recognized as a cost-effective means of significantly reducing soil erosion and maintaining productivity.

Corn accounts for around 49% of the crop production in the Bonpas Creek watershed and soybeans account for around 45%. The remainder is a double crop of winter wheat/soybeans. Based on Illinois Department of Agriculture Soil Conservation Transect Survey Report results for 2013, weighted by county for the watershed, approximately 55% of corn is conventionally tilled. Roughly three-quarters (74%) all of the soybeans have some form of conservation tillage. Conventional tillage has a higher soil loss rate than other forms of conservation tillage for both corn and soybeans. Based on the figures shown in Table 4-7, approximately 38% of cropland is not currently managed using conservation tillage. The largest opportunities to increase conservation tillage exist in Wabash (84% conventional tillage) and Richland (78% conventional tillage) Counties.

Table 4-7. Illinois Soil Conservation Transect Survey Reports for Bonpas Creek Corn and Soybeans (2013), Based on County-Wide Numbers Scaled to the Project Watershed

	Corn tillage (%)	Soybean tillage (%)
No Till	28%	42%
Mulch Till	7%	18%
Reduced Till	11%	13%
Conventional Till	55%	26%

Source: https://www.agr.state.il.us/illinois-soil-conservation-transect-survey-reports

The implementation of additional conservation tillage measures for corn and soybeans is expected to result in reduced phosphorus and sediment loss. In systems where surface soil test phosphorus values are within recommended ranges, researchers have found that total phosphorus export from no-till fields may be reduced up to 67% when compared to conventional tillage due to the reduction in sediment load and associated phosphorus (DeLaune & Sij, 2012). The Illinois Nutrient Loss Reduction Strategy estimates phosphorus loss is decreased by 50% if reduced tillage is applied to soils which were experiencing soil losses greater than "T", the tolerable soil loss (IDOA and IEPA, 2015). However, fields which are losing soil in excess of "T" tend to be more sloped than the flat soils found in the study watersheds. In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006). Total sediment loss from no till is 78% less than conventional till (DeLaune & Sij, 2012). A range of estimates are available for assessing the costs of moving to a no-till system. The Illinois Nutrient Loss Reduction Strategy assigns savings of $17/acre when moving from conventional to reduced tillage (IDOA and IEPA, 2015). SWCD estimates from another region of Illinois indicate the cost of no till and strip till is $33.33/acre, but costs were not provided for mulch-till. Overall, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (Simmons and Nafziger, undated).

4.2.2 Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants, generally by slowing the rate of runoff, while filtering sediment and nutrients as well as other pollutants. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. The total cost of buffers presented in the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015), taking costs related to lost income potential, planting and maintenance is $294/acre.

Based on the NHD high-resolution flowlines (streams), there are roughly 670 miles of streams in the Bonpas Creek watershed. A GIS analysis was conducted to identify stream lengths that already have some sort of buffer, and found that 328 miles of streams are already buffered by vegetation (grass, shrubs, trees, wetlands), indicating 342 miles of streams (51% of the stream miles in the watershed) could benefit from this control.

Filter strips and similar vegetative control methods can be very effective in trapping sediment and nutrients, and reducing the velocity of runoff flow, allowing greater infiltration of dissolved pollutants. According to the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015), the total phosphorus reduction per acre for buffers on cropland ranges from 25 to 50%, with a median removal rate of 37.5%. According to an Illinois EPA fact sheet[5], the sediment reduction per acre for buffers ranges from 70 to 95%, with an average removal rate of 82.5%. The effectiveness of grass buffers on reducing atrazine is variable, ranging from roughly 50% - 70% (Lafrance et al., 2010), with reductions as high as 99.5% in Lafrance et al. (2001), indicating that grass buffers are an effective measure for achieving the atrazine target. One study of vegetated buffers to reduce fecal coliform bacteria runoff from dairy pastures (Downing and Gamroth, 2007) found that the presence of a vegetated buffer of any size generally reduced the median bacteria concentration in runoff by more than 99%.

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Partners for Conservation Fund, provides cost sharing for conservation practices including field borders and filter strips[6] . The Department of Agriculture distributes funding for the cost-share program to Illinois' Soil and Water Conservation Districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever[7], VIEW guides a committee of local stakeholders through a watershed landscape planning process. Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

4.2.3 Cover Crops

Cover crops are grasses, legumes, rye or forbs that are planted seasonally to cover soil when it would usually be bare (Miller et al., 2012; IDOA and IEPA, 2015). While these crops are not usually sold or utilized agronomically, they have other benefits which make them useful to producers. Cover crops are planted for a variety of purposes including erosion reduction from wind and water, increasing soil organic

[5] http://www.epa.state.il.us/water/conservation/lake-notes/shoreline-buffer.pdf
[6] http://www.agr.state.il.us/C2000
[7] http://www.treesforever.org/Illinois_Buffer_Partnership

matter and capturing, recycling, or redistributing excess soil nutrients. Cover crops can benefit water quality through three pathways – by increasing the soil's ability to infiltrate rainfall, by scavenging and taking up nutrients, and by intercepting raindrop impact in order to reduce soil crusting and erosion (Miller et al., 2012).

Cover crops effectively reduce both nitrate-nitrogen and total phosphorus losses while also improving soil tilth and other important properties (IDOA and IEPA, 2015). The Illinois Nutrient Loss Reduction Strategy indicates cover crops can reduce total phosphorus by 30% per acre (IDOA and IEPA, 2015). According to IDOA and IEPA, 2015, cover crops may introduce additional management challenges, particularly in adverse years. Establishing cover crops may be difficult in years with dry summers and falls. Cover crop planting and termination operations may also introduce logistical issues on farms. Landowners and producers in the watershed are encouraged to work with their local agronomist, certified crop advisor, or seed retailer to determine the type of cover crops that would best suit their soil types and cropping operations. Based on the Illinois EQIP payment schedule[8], the cost of cover crops ranges from $36.24 to $88.10/acre. An average cost of $63.16 is assumed in this implementation plan.

4.2.4 Treatment Wetlands

Soils in the Bonpas Creek watershed are poorly drained and, as previously discussed, drainage has likely been enhanced using tile drains in much of the watershed. The exact areas with tile drains is unknown, but the previous section presents a map showing areas likely to have time drains which are areas closer to the mainstem of Bonpas Creek, which coincide with areas of shallower groundwater. Site visit observations confirm the existence of tile drains in the watershed.

Treatment wetlands have been shown to be effective at reducing phosphorus from tile drain flow, if they are properly sited and sized. A pilot study on an experimental farm indicates that treatment wetlands that intercepted tile drains removed approximately 47-57 percent of the total phosphorus from water (IDOA and IEPA, 2015).

According to IDOA and IEPA (2015), the reduction practice is the construction of 5 acres of wetland for every 100 acres of production, and costs are $60.63/acre/yr if a wetland is assumed to provide treatment for 20 years, the farmland taken out of production is charged against the remaining cropland, and $3 per acre yearly maintenance cost. Using the reported total costs (IDOA & IEPA, 2015), inclusive of the per acre purchase price, and dividing the total out over 20 years produces annual costs of $683/acre. Of note, this practice represents a large decrease in income-generating potential if the acreage taken out of cropland was agronomically productive ground.

4.2.5 Nutrient Management Plans

Nutrient management plans are designed to minimize nutrient losses from agricultural lands and improve nutrient use efficiency of the crop, and therefore minimize the amount of phosphorus transported to waterbodies. Because agriculture is the most common land use in the watershed (roughly 90%), controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the streams. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (USEPA, 2003).

Nutrient management is defined as managing the amount, source, placement, form, and timing of plant nutrients and soil amendments (NRCS Illinois, 2013). The NRCS Practice Standard for nutrient management notes that this practice applies on all lands where plant nutrients and soil amendments are applied. Additional details regarding nutrient management are provided in the NRCS Illinois Practice

[8] https://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/

Standard (NRCS Illinois, 2013 and chapter 8 of the Illinois Agronomy Handbook (Fernandez and Hoeft, undated), and two example practices are described below.

- Site-specific or variable-rate nutrient application: "This application method uses several remote sensing technologies, yield monitors, global positioning systems, geographical information systems, and variable-rate technology (VRT). These technologies can improve the efficacy of fertilization and promote more environmentally sound placement of fertilizer compared to single-rate applications derived from the conventional practice of collecting a composite soil sample to represent a large area of the field. Research has shown that this technology often reduces the amount of fertilizer applied over an entire field. However, one of the drawbacks of this placement method is the expense associated with these technologies. Also, VRT can only be as accurate as the soil test information used to guide the application rate" (Fernandez and Hoeft, undated).

- Deep fertilizer placement: "With this system any combination of N, P, and K can be injected at a depth of 4 to 8 inches. The knife spacing varies, but generally it is 15 to 18 inches apart for close-grown crops such as wheat and 30 inches for row crops. (Fernandez and Hoeft, undated). This practice may be beneficial (as long as the subsurface band application does not create a channel for water and soil movement) in areas where the potential for surface water runoff is high.

The Illinois Agronomy Handbook (Fernandez and Hoeft, undated) gives a broad overview of phosphorus recommendations in Chapter 8. For producers in the Bonpas Creek watershed, it is important to keep in mind that they are in a region of "low" available subsoil phosphorus. This means it is recommended that soil test values be built up to 50 pounds per acre (measured by Bray P_1) to ensure corn and soybean crop yields will not be restricted by phosphorus availability (Fernandez and Hoeft, undated). Soils testing between 50 and 70 pounds per acre should have fertilizer applied only in the amount of expected removal of the current crop while soils showing greater than 70 pounds per acre of phosphorus will experience no agronomic advantage in additional application (Fernandez and Hoeft, undated).

Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil where it is subject to transport (NRCS, 2006). Tillage will incorporate this surface-applied fertilizer; however a no-till system will leave the phosphorus on the surface. In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality. It is recommended that nutrient management plans be developed and implemented based on soil testing conducted at least every four years and applied to all cropland acres in the watershed.

The approximate cost of developing ($4/acre) and implementing ($12/acre) a nutrient management plan totals $16/acre. This cost may be offset in part by savings associated with using less fertilizer. For example, a study in Iowa showed that improved nutrient management on cornfields led to a savings of about $5/acre (EPA, 2003).

Phosphorus rate reduction resulting from implementation of nutrient management plans was estimated to reduce TP export by 7%. This estimate was provided by the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015).

4.2.6 Livestock Management Controls

BMPs to reduce fecal coliform from livestock include activities on the grounds to manage manure and reduce runoff and the proper siting, construction and management of lagoons, settling basins and holding ponds, to reduce groundwater and surface water impacts. Land application of manure can be environmentally beneficial, and a few examples of land application BMPs to reduce nutrient and bacteria runoff include: development of a manure management plan, scheduling application times that are compatible with crop rotations, having sufficient land available to land apply, locating land application sites away from valleys, and applying manure on fields that are not highly erodible. Many more examples can be found on-line[9]. There are a large number of EQIP-eligible conservation practices for confined livestock and manure management, as well as grazing land operations, including ponds (payment cap of $20,000 per pond), roofs and covers (payment cap of $100,000), and fencing (no payment cap listed).[10]

In addition to manure management and runoff reduction from livestock areas, the appropriate management of pasture or grazing-based livestock production can minimize nutrient and fecal coliform losses by eliminating uncontrolled livestock access to streams, providing shade and water sources away from streams, and maintaining healthy grass stands that reduce runoff (IDOA and IEPA, 2015). Fencing, together with the development of alternate watering systems can help restrict livestock access to streams. . USEPA (2003) reports that livestock exclusion from waterways and other grazing management measures could reduce fecal coliform counts by 29% to 46% percent. Farm ponds can be designed to capture runoff and provide water for livestock. When installed in line with the stream, ponds can reduce sediment, nutrient and bacteria loading. Fencing should be placed outside of the filter strip/riparian area. Wildlife access is harder to restrict with fencing and buffers that filter runoff are likely to be more effective than measures aimed at restricting wildlife access to the streams. Fencing costs are variable, and based on the Illinois EQIP and RCPP-EQIP payment schedule[7], can range from $0.79/foot to $4.89/foot. An average cost of $2.02/foot is assumed for this implementation plan.

4.2.7 Sediment Control Basins (includes terraces, dry dams, ponds and water & sediment control basins (WASCOB))

Sediment control basins are defined here to include water and sediment control basins, terraces, dry dams, and ponds and are designed to trap sediments prior to reaching a receiving water. Sediment control basins trap runoff and the associated sediment load from upgradient areas, slowing runoff and reducing gully erosion. Water is released slowly, reducing peak runoff flows and streamflow erosivity/streambank erosion.

Sediment control basins are usually designed to capture drainage from an area of 30 acres or less and should be large enough to control runoff from at least a 10-year, 24-hour storm. The local NRCS is a great resource for information regarding design, installation and funding. Replanting or reseeding may be needed to maintain vegetation, and trapped sediment may need to be periodically removed. Locations are determined based on slopes, tillage, and crop management, and the local NRCS can often provide information and advice for design and installation.

Terracing implemented on steeper slopes can reduce runoff flow volume and velocity, as well as soil erosion. Terrace systems have been shown to remove as much as 85 percent of sediment and 70 percent of total phosphorus from runoff (USEPA 2003).

4.2.8 Streambank Stabilization

Streambank erosion is prevalent within the Bonpas Creek watershed, and roughly half of the sediment load to the creek is estimated to originate from this source based on Model My Watershed calculations described in Section 3.2.2. Bank erosion can be caused by erosive streamflows, and one way to address streambank erosion is to reduce peak runoff flows using some of the measures described previously in this section. Erosion can also be addressed by stabilizing streambanks. There are many options for

[9] http://www.epa.illinois.gov/topics/pollution-prevention/fact-sheets/bmp-pork/index and http://web.extension.illinois.edu/sfmm/beef.cfm
[10] https://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/

streambank stabilization, ranging from vegetating the banks (e.g., using willows and seed), to heavy armoring using rocks and rip-rap.

The willow-post method for streambank stabilization has been described by the Illinois State Water Survey (ISWS) in Miscellaneous Publication 130. This method uses native willow cuttings to stabilize eroding streambanks. The willow roots work to bind the soil together and the foliage slows floodwaters near the eroding bank. ISWS reports that this method has been used most successfully along streams in agricultural floodplains without tree cover, and that it is most effective when erosion control is implemented on land upstream of the eroded bank. "On land sloping more than 2%, reduced till and no-till farming should be practiced. Pasture and timber areas on steep slopes should be managed for adequate vegetative cover in order to slow water runoff." Dense tree cover can prevent groundcover growth, so vegetation should not be used for streambank stabilization in heavily shaded, wooded areas. An additional consideration is that vegetation is very hard to establish on banks that are frequently wet.

Costs are highly variable depending on a variety of site-specific factors. Installation costs for the willow-post method range from $7 to $15 per foot, with little or no maintenance. These costs are low compared to 'traditional methods' that rely on riprap, cement or steel retaining structures. ISWS reports costs for traditional methods ranging from $50 to $200 per foot, and notes that these require maintenance and repair through the year. Illinois NRCS Engineering Standard Drawings for Streambank Stabilization can be found online at:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/il/technical/engineering/?cid=nrcs141p2_030565

4.2.9 Septic system maintenance

Routine maintenance of a septic system can extend the life of the system, and prevent failure and ultimately replacement. To keep a septic tank in good working order, routine cleanings should be scheduled every two to three years with a reputable provider. The cost to pump a typical septic tank is variable, but on average costs approximately $250, depending on the number of gallons pumped and the disposal fee for the area. This is much less than the cost of installing a new system ($8,000 - $10,000).

Health departments typically provide inspection of new system installations, septic system permits, and provide homeowner problem consultation/complaint investigations, and may be a good resource for disseminating information on septic system maintenance. The National Small Flows Clearinghouse is another good resource for information on septic systems. http://www.nesc.wvu.edu/subpages/septic.cfm

4.3 Summary of Management Measure Applicability

Many management measures are available for reducing pollutant loads. Past implementation in the Bonpas Creek watershed, including ongoing work in the Crooked Creek subwatershed (HUC 0512-01130403, Figure 2-1) under the National Water Quality Initiative, provides an indication of which measured are likely to be most readily adopted. Table 4-8 below summarizes the identified measures and provides an assessment of potential applicability for this watershed based on feedback from local agencies.

Table 4-8. Assessment of Applicability for Bonpas Creek Watershed

Management Measure	Currently used?	Potential within Bonpas Creek watershed
Conservation tillage	Yes	Commonly used in Edwards County. Larger potential in Lawrence, Richland and Wabash Counties due to lower adoption.
Conservation buffers	Yes	Successful in Crooked Creek subwatershed.
Cover crops	Yes	Successful in Crooked Creek subwatershed. Great potential for expanding cover crops
Treatment wetlands	Unknown	Unknown
Nutrient management plans	Yes	Successful in Crooked Creek subwatershed. Viable option
Livestock management controls	Unknown	Low interest noted in Crooked Creek subwatershed. High cost may be a hurdle.
Sediment basins	Yes	See ~90% flow reduction
Streambank stabilization	Unknown	Rock is preferred. Willow posts not popular
Septic system maintenance	Unknown	Unknown

4.4 Recommended Management Measures

Based on the preceding information, recommended non-point source management measures to reduce pollutant loading in the Bonpas Creek watershed are discussed in the following sections.

4.4.1 New West Salem Reservoir

The watershed draining to New West Salem Reservoir covers approximately 411 acres and has an average annual phosphorus load reduction target of 50% (160.6 lbs/yr). Land use this watershed is mostly (255 acres or 62%) cultivated cropland (Figure 4-1).

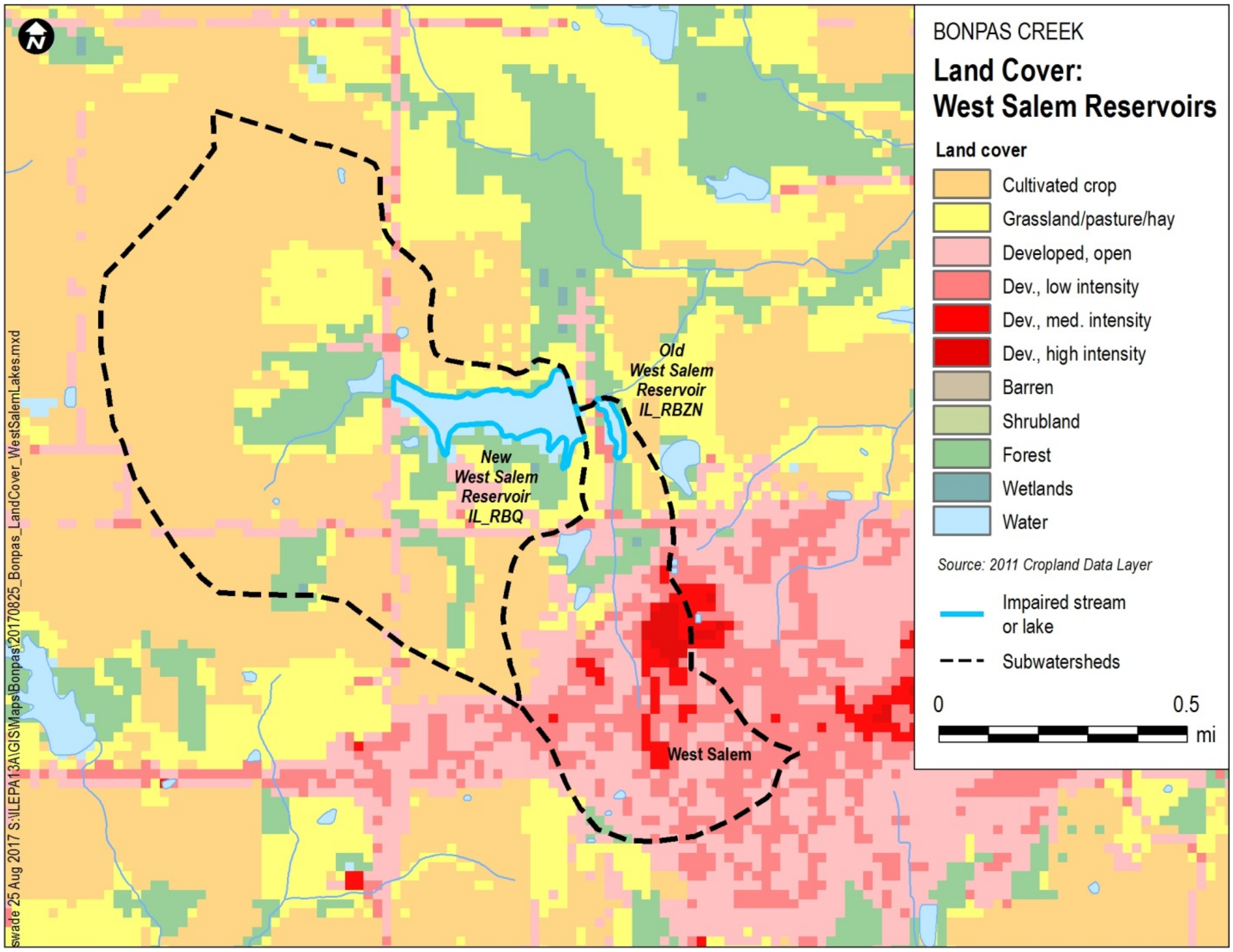

Figure 4-1. Land Cover in the Two Reservoir Watersheds.

The non-point source phosphorus load reduction target for the New West Salem Reservoir watershed is 50%. This load reduction target will require aggressive implementation of management measures, including the following:

- ***Conservation Tillage*** –Because conservation tillage is already a common practice in Edwards County, is relatively easy to implement, does not affect the quantity of productive land and has a relatively high typical phosphorus removal rate (67%), it is the primary recommended measure. If conservation tillage can be implemented on the estimated 8% of agricultural land (20 acres) in the New West Salem Reservoir watershed that is currently not managed using conservation tillage, approximately 23% of the phosphorus load can be controlled.
- ***Conservation Buffers*** – Based on the spatial analysis described in Section 4.2.2, roughly 84% of stream length and shoreline lengths in the New West Salem Reservoir watershed are currently buffered. Assuming that conservation buffers have a width of 35 feet and control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on half of the currently unbuffered stream would add buffers to 0.14 miles of stream (1 acre total), controlling about 4% of agricultural and developed land. At a median removal effectiveness of 37.5%, this would reduce phosphorus loading in the New West Salem Reservoir watershed by about an additional 1.3%.

- ***Cover Crops*** – The quantity of land in the New West Salem Reservoir watershed managed using cover crops is not known, but is assumed to be 5% or less for this plan. If cover crops are added to the management of the remaining 95% of agricultural land (242 acres), with an estimated phosphorus reduction rate of 30%, phosphorus load from these lands can be reduced another 26%.
- ***Nutrient Management Plans*** – As described in Section 4.2.5, nutrient management plans are estimated to be 7% effective at phosphorus reduction. If implemented on all cropland acres in the New West Salem Reservoir watershed (255 acres), they would reduce total phosphorus loading by 6%.

Combined, the management measures described above would provide a total load reduction of 56.3% (180.8 lbs/yr), which is greater than the target 50% (160.6 lbs/yr). Because the management measures would not all work independently, and some would function in series, the cumulative total removal is likely less than the cumulative total calculated. Based on the discussion above, the recommend management measures for the New West Salem Reservoir watershed are summarized in Table 4-9.

Table 4-9. Recommended Management Measures for the New West Salem Reservoir Watershed

Management Measure	Percent of P Load Controlled	Acres
Conservation Tillage	23%	20
Conservation Buffers	1.3%	1
Cover Crops	26%	242
Nutrient Management Plans	6%	255

4.4.2 Old West Salem Reservoir

The watershed draining to Old West Salem Reservoir covers approximately 170 acres and has an average annual phosphorus load reduction target of 33% (43.8 lbs/yr). Land use this watershed is mostly (125 acres or 74%) developed land (Figure 4-1). Agricultural land comprises only 30 acres (less than 20% of the watershed area). Although this watershed has a significant amount of developed land, 89% of which is low density or open space, practices for developed areas can be significantly more expensive to implement. Therefore, agricultural practices, stream buffers and treatment wetlands are recommended preferentially, with the latter two capable of reducing phosphorus loads from all land uses in this watershed, depending on placement.

The non-point source phosphorus load reduction target for the Old West Salem Reservoir watershed is 33%, This load reduction target will require aggressive implementation of management measures, including the following:

- ***Conservation Tillage*** – Because conservation tillage is already a common practice in Edwards County, is relatively easy to implement, does not affect the quantity of productive land and has a relatively high typical phosphorus removal rate (67%), it is the primary recommended measure for agricultural cropland. If conservation tillage can be implemented on the estimated 8% (1.4 acres) of agricultural land that is currently not managed using conservation tillage, approximately 2% of the phosphorus load can be controlled.
- ***Conservation Buffers*** – Based on the spatial analysis described above, only about 29% of streams in the Old West Salem Reservoir watershed are currently buffered. Assuming that 35-foot wide conservation buffers control runoff from land within an eighth of a mile of the stream, each

mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on half of the currently unbuffered stream would add buffers to 0.32 miles of stream (3 acres), controlling about 1% of developed land. At a median removal effectiveness of 37.5%, this would reduce phosphorus loading in the Old West Salem Reservoir watershed by about an additional 6%.

- ***Cover Crops*** – The quantity of land in the Old West Salem Reservoir watershed managed using cover crops is not known, but is assumed to be 5% or less for this plan. If cover crops are added to the management of the remaining 95% of agricultural land (17 acres), with an estimated phosphorus reduction rate of 30%, current phosphorus load from these lands can be reduced another 3%.
- ***Nutrient Management Plans*** – As described in Section 4.2.5, nutrient management plans are estimated to be 7% effective at phosphorus reduction. If implemented everywhere (18 acres) in the Old West Salem subwatershed, they would reduce total phosphorus loading by 1%.
- ***Treatment Wetlands or Sediment Basins***– If the four common management measures described above are implemented in the Old West Salem watershed, at the aggressive levels of implementation described, their combined, estimated phosphorus load reduction will be 15%, which would fall short of the 33% target by 18%. This remaining load would have to be controlled by other means and of the measures described here, the most effective would be sediment basins or treatment wetlands. Sediment basins are estimated to have a phosphorus removal effectiveness of 70% and wetlands are estimated to have a median phosphorus removal effectiveness of 52%. To achieve the additional 18% phosphorus reduction, sediment basins would be needed to treat runoff from roughly 30% (43 acres) of agricultural and developed land in the subwatershed. Alternatively, treatment wetlands will be needed for treat runoff from roughly 40% (57 acres) of agricultural and developed land in the subwatershed. If space is available, an in-lake sedimentation basin could be implemented to capture and treat runoff before it reaches the main body of the lake.

Combined, the management measures described above would provide a total load reduction of 12% (15.7 lbs/yr), less than the target 33%. Furthermore, the management measures would not all work independently, but some would function in series, reducing the cumulative total removal. The remaining phosphorus reduction needed to reach the 33% target will have to be achieved using other measures such as treatment wetlands and water/sediment control basins. Based on the discussion above, the recommend management measures for the Old West Salem Reservoir subwatershed are summarized in Table 4-10.

Table 4-10. Recommended Management Measures for the Old West Salem Reservoir Watershed

Management Measure	Percent of P Load Controlled	Acres
Conservation Tillage	2%	1.4
Conservation Buffers	6%	3
Cover Crops	3%	17
Nutrient Management Plans	1%	18
Treatment Wetlands and/or Basins	Variable to Reach 33% Target	

4.4.3 Bonpas Creek (IL_BC-02)

Sediment, fecal coliform and atrazine loads need to be reduced to meet TMDL and LRS targets in Bonpas Creek segment IL_BC-02). As discussed previously, the predominant source of these pollutants is: runoff from agricultural lands (sediment, atrazine, fecal coliform), and streambank erosion (sediment).

Agricultural cropland (116,350 acres or 65%) and pastureland (21,651 or 12%) are the dominant land uses in the watershed (Figure 4-2).

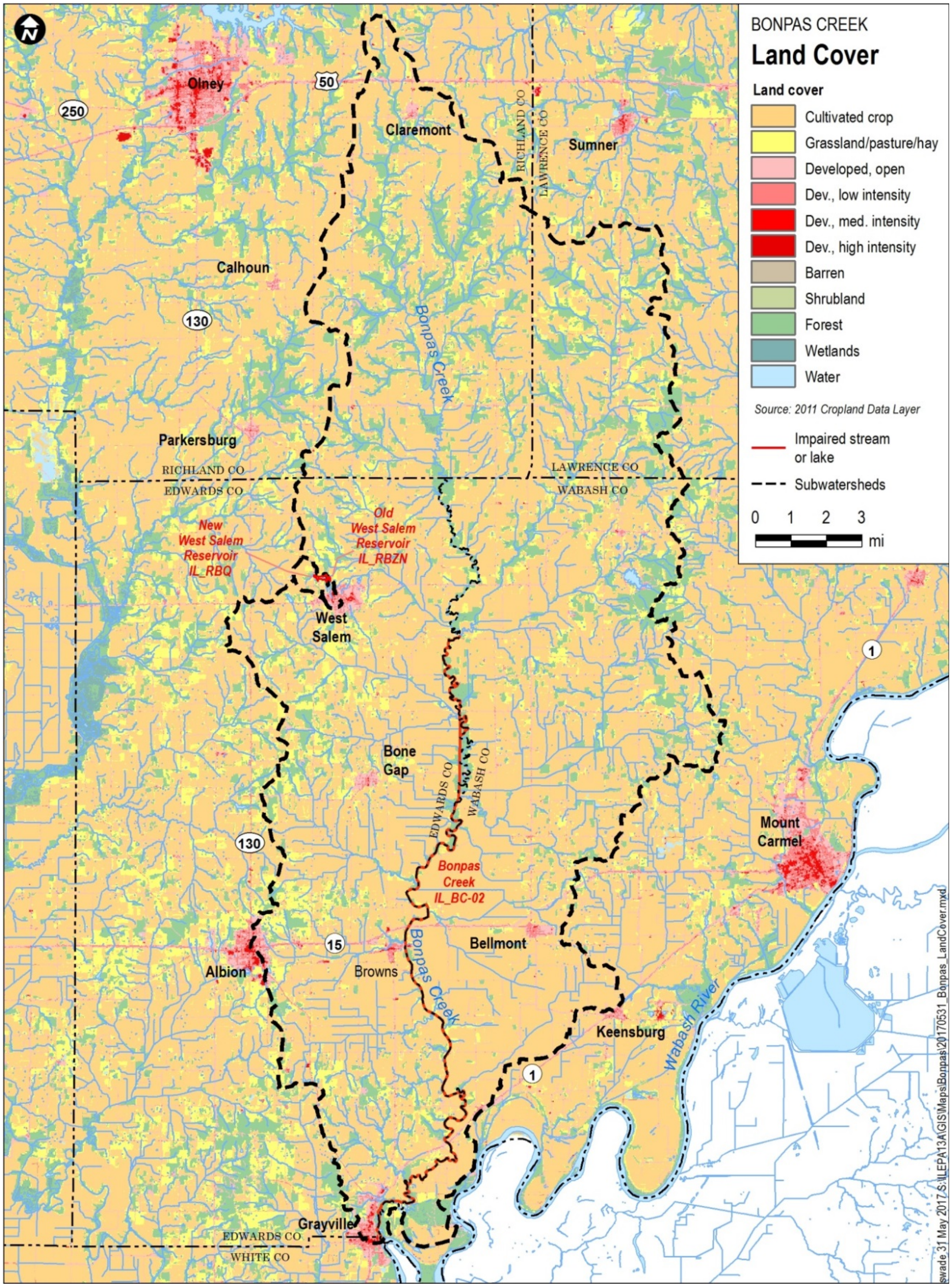

Figure 4-2. Land Cover in the Bonpas Creek Subwatershed.

4.4.3.a Sediment

The non-point source sediment load reduction target for the Bonpas Creek watershed is 65% and will require aggressive implementation of management measures to reduce sediment from agricultural runoff and streambank erosion, including the following:

- ***Conservation Tillage*** – Of the 116,350 acres of cultivated cropland, roughly 109,369 acres are corn and soybeans. Of this, roughly 39% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on conventionally tilled acres (44,969 acres), this would reduce sediment loading in the Bonpas Creek watershed by approximately 8% of the total sediment load.
- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 49% of streams in the Bonpas Creek watershed are currently buffered. Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on all currently unbuffered stream would add buffers to 342 miles of stream (2,902 acres), controlling about 24% of runoff from agricultural land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in the Bonpas Creek watershed by approximately 10%.
- ***Cover Crops –*** The quantity of land in the Bonpas watershed managed using cover crops is not known, but is assumed to be 5% or less for this plan. If cover crops are added to the management of the remaining 95% of agricultural land (110,532 acres), with an estimated sediment reduction rate of 50%, sediment load from these lands can be reduced another 24%.
- ***Streambank Stabilization –*** The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 670 miles of streams in the Bonpas Creek watershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 23% of the eroding streambanks (154 miles) would reduce sediment loads to the target of 65%.

Based on the discussion above, the recommend management measures for the Bonpas Creek watershed are summarized in Table 4-11. If fully implemented, these measures would results in a 65% sediment load reduction (277.6 lbs/day). Conservation tillage is another measure that would work to reduce sediment loads, and could be used in combination with or in place of another measure described above if there is interest in this measure.

Table 4-11. Recommended Sediment Management Measures for the Bonpas Creek Watershed

Management Measure	Percent of Sediment Load Controlled	Acres
Conservation Tillage	8%	44,969
Conservation Buffers	10%	2,902
Cover Crops	24%	110,532
Streambank Stabilization	23%	154 miles

4.4.3.b Atrazine

The non-point source atrazine load reduction target for the Bonpas Creek watershed is 9% and the source if runoff from agricultural cropland. Grass buffers are recommended for the Bonpas Creek watershed as they would not require a change in atrazine application. Other measures anticipated to effectively reduce atrazine loads to Bonpas Creek are also described below.

- ***Conservation buffers*** – A 5-meter grass buffer along the edge of agricultural cropland is recommended to slow runoff flow, increase infiltration and reduce the mass export of atrazine. The effectiveness of grass buffers is variable, ranging from roughly 50% - 70% (Caron et al, 2010), with reductions as high as 99.5% in Lafrance et al. (2001), indicating that grass buffers are an effective measure for achieving the atrazine target. Using an effectiveness of 50%, 5-meter width grass buffers should be placed to filter 18% (~21,000 acres) of agricultural cropland in the Bonpas Creek watershed. Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land on each side of the stream. This translates to 131 miles of buffer along both banks of streams, capturing agricultural cropland runoff. Note that a mapping analysis identified roughly 300 miles of streams bordered by agricultural cropland, indicating sufficient opportunity for grass buffers.
- ***Tank-mixing with other herbicides*** –According to Purdue University, a low-rate atrazine pre-mix tank-mixed with another broadleaf herbicide can reduce the amount of atrazine applied by 30 to 50 percent, without sacrificing overall weed control (University of Illinois Extension and Illinois Department of Agriculture, undated). A 30% reduction in the amount of atrazine applied to cropland would exceed the 9% reduction targeted for this watershed.
- ***Apply atrazine post emergence*** – This approach will allow application rates to be reduced up to 75%. However, there is a short time frame to apply atrazine post-emergence, so fields with the greatest potential for runoff to Bonpas Creek should be targeted (University of Illinois Extension and Illinois Department of Agriculture, undated). These areas include cropland close to Bonpas Creek or its tributaries, or areas with claypan soils or other subsoil layers that restrict infiltration (i.e., hydrologic group C and D soils which have the greatest runoff rates). Areas with hydrologic group C and D soils are found primarily along tributaries to Bonpas Creek. An attempt should be made to delay application if heavy rains are forecast for the next few days, because research has shown that heavy rains after application can cause significant loss of herbicide in runoff.

Based on the discussion above, the recommend management measures for the Bonpas Creek watershed are summarized in Table 4-12. Grass buffers implemented along 131 miles of streams (both banks) will reduce atrazine loads to the target amount. Controls implemented for sediment and bacteria that focus on runoff reduction may also further reduce atrazine loads to Bonpas Creek. Other controls that would also work to reduce atrazine are tank mixing with other herbicides and application of atrazine post emergence.

Table 4-12. Recommended Atrazine Management Measure for the Bonpas Creek Watershed

Management Measure	Percent of Atrazine Load Controlled	Acres
Grass buffers	9%	521

4.4.3.c Fecal coliform

The non-point source fecal coliform load reduction target for the Bonpas Creek watershed varies from 56-99% over a range of flows, with the highest reduction required at the higher flows. Attainment of this target will require aggressive implementation of management measures to reduce fecal coliform bacteria from nonpoint source runoff, including the following:

- ***Conservation buffers:*** One study of vegetated buffers to reduce fecal coliform bacteria runoff from dairy pastures (Downing and Gamroth, 2007) found that the presence of a vegetated buffer of any size generally reduced the median bacteria concentration in runoff by more than 99%. 51% (342 miles) of the streams in the Bonpas Creek watershed are currently without a buffer. Buffers on these streams totaling 2,902 acres are calculated to reduce current fecal coliform loads by 23%.
- ***Restrict Livestock Access to Bonpas Creek:*** The extent to which livestock currently have access to Bonpas Creek and its tributaries is unknown, although a GIS analysis indicates there are 63 stream miles traversing land with pasture/hay. For this analysis, it was assumed the livestock are located on pasture/hay land only, although field reconnaissance is recommended to identify pasture/hayland that currently support livestock with stream access. Restricting livestock access to the creeks will not only reduce bacteria loads, but will also reduce streambank erosion. USEPA (2003) reports that livestock exclusion from waterways and other grazing management measures could reduce fecal coliform counts by 29% to 46% percent. Fecal loads delivered to Bonpas Creek generated by cattle and hogs can be estimated using literature values, county-wide livestock counts, and assumptions regarding their distribution. If these loads are reduced by 29% (to be conservative), adding fencing 63 miles of streams could reduce fecal coliform loads by 15%. This value is highly uncertain because current livestock access to Bonpas Creek and its tributaries is unknown.
- ***Septic maintenance:*** Maintenance of septic systems can ensure they are performing as designed, and do not contribute bacteria or other pollutants to local waterways. If all low and medium intensity development (1998 acres) is assumed to be serviced by onsite systems, and it is assumed that there is one house/3 acres, then there are an estimated 665 onsite systems in the Bonpas Creek watershed. Assuming a failure rate of 5%, then 33 systems would be in need of maintenance or repair. If these were contributing a volume of 90 gallons/person/day for 2.5 people/household, with a raw sewage concentration of 5.01E+07 cfu/100 ml, the load generated would equal 5.2E+15 cfu/yr. Maintenance of failing systems would eliminate this load, reducing current loads by 4% (assuming assumptions regarding this load are accurate).

Based on the discussion above, the recommend management measures for the Bonpas Creek watershed are summarized in Table 4-13. If fully implemented, these measures would results in a 41% fecal coliform load reduction (5.39E+16 cfu/yr). Attainment of a 99% reduction may not be feasible without a more detailed investigation of sources and targeted controls on the largest contributing sources.

Table 4-13. Recommended Fecal Coliform Management Measures for the Bonpas Creek Watershed

Management Measure	Percent of Bacteria Load Controlled	Units
Conservation buffers	23%	2,902 acres
Livestock management	15%	63 miles fencing*
Septic maintenance	4%	33 systems

*63 miles of streams traverse land classified as pasture/hay, and this calculation assumes that this land supports livestock. This is likely an overestimate and field reconnaissance should be conducted to identify stream lengths with livestock access.

4.5 Summary of Recommended Non-Point Source Management Measures

Based on the preceding discussion, extensive implementation of non-point source management measures are needed to achieve the target load reductions for the Bonpas Creek watershed. These management measures are summarized by waterbody subwatershed in Table 4-14, along with quantities required for each management measure.

Table 4-14. Summary of Management Measures Recommended for the Bonpas Creek Watershed to Achieve Pollutant Load Reduction Targets.

Management measure	Bonpas Creek	Old West Salem Reservoir	New West Salem Reservoir
Conservation Tillage (acres)	44,969 acres (sediment)	1.4	20.4
Conservation Buffers (stream miles)*	131 miles (atrazine) 342 miles (sediment and fecal)	0.32	0.14
Cover Crops (acres)	110,532 acres (sediment)	17	242
Nutrient Management Plans (acres)		18	255
Treatment wetlands (acres)**		3	
Livestock management***	124 miles (~63 miles * both sides of streams)		
Streambank stabilization (miles)	154 miles (sediment)		
Septic maintenance	33 systems		

*Width can vary significantly; an average width of 35 feet is assumed

** It is assumed that 5 acres of constructed wetland will be required for every 100 acres of agricultural land from which runoff/tile drainage is captured. Wetland areas rounded to the nearest acre.

*** This calculation is based on an analysis of stream length traversing pasture/hay land cover, but it is recognized that livestock will not have access to streams on all of this land. A field reconnaissance would be required to identify locations where livestock currently have access to streams and could benefit from fencing.

4.6 Estimated Cost of Recommended Management Measures

The overall capital cost of implementing the recommended non-point source management measures in the Bonpas Creek watershed were estimated on a unit cost basis. Unit costs for on-field or edge-of-field measures were obtained from various sources such as the Illinois Nutrient Loss Reduction Strategy, and where possible, are specific to Illinois.

- ***Conservation Tillage*** – The estimated cost of no till and strip till is estimated to be $33.33/acre.
- ***Conservation Buffers*** – The estimated cost of critical area planting is variable and may be as high as $350/acre. The total cost of buffers presented in the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015), taking costs related to lost income potential, planting and maintenance is $294/acre, possibly reflecting geographic variability in farmland value. For purposes of this plan, the higher value of $350/acre is used.
- ***Cover Crops*** – The estimated the cost of cover crops to be $63.16/acre.
- ***Nutrient Management Plans*** – The estimated cost of developing ($4/acre) and implementing ($12/acre) a nutrient management plan totals $16/acre.
- ***Constructed Wetlands*** – According to 2015 Illinois Nutrient Loss Reduction Strategy, constructed wetlands cost $60.63/acre/yr. if a wetland is assumed to provide treatment for 20 years, the farmland taken out of production is charged against the remaining cropland, and $3 per acre yearly maintenance cost. Using the reported total costs, inclusive of the per acre purchase price, and dividing the total out over 20 years produces annual costs of $683/acre.
- ***Livestock Management*** – Fencing is assumed to cost $2.02/foot, based on the average cost from the Illinois EQIP and RCPP-EQIP payment schedule.
- ***Streambank Stabilization*** – Streambank stabilization costs vary significantly depending on the method used (e.g., willow post vs. armoring with rock) and site conditions. The cost of $200/foot is used for estimation purposes, but the actual cost will need to be reevaluated based on the site and selected method.
- ***Septic Maintenance*** – The cost to pump a typical septic tank is variable, but on average costs $250, depending on the number of gallons pumped and the disposal fee for the area. New systems can cost between $8,000 and $10,000.

Using these unit costs, the total cost for implementation of recommended management measures can be estimated, as summarized in Table 4-15.

Table 4-15. Estimated Cost of Management Measures Recommended for the Bonpas Creek Watershed to Achieve Pollutant Load Reduction Targets (assumes 20 years of implementation).

Management measure	Unit Cost	Bonpas Creek	Old West Salem Reservoir	New West Salem Reservoir
Conservation Tillage	$33.33/acre/yr	$1,497,468	$47	$680
Conservation Buffers*	$350/acre	$1,015,636	$950	$416
Cover Crops	$63.16/acre/yr	$6,981,201	$1074	
Nutrient Management Plans	$16/acre/yr		$288	
Treatment wetlands	$683/acre		$2049	
Livestock management**	$2.02/foot fencing	$1,322,534		
Streambank stabilization (miles)	$200/foot	$162,624,000		
Septic maintenance	$250/system	$8,250		
Totals		**$173,449,090**	**$4,408**	**$1,095**

*Width is assumed to be 35 feet on each side of the stream.

**The current miles of stream with livestock access is not known and should be identified through field reconnaissance. This cost assumes the entire length (63 miles) of stream traversing pasture/hay supports livestock, which is very likely an overestimate.

Based on these estimates, the total estimated cost for implementing recommended management measures in the Bonpas Creek watershed is $173,449,090.

4.7 Bonpas Creek Subwatershed Prioritization

Implementation of management measures works well if the area targeted is of a manageable size. The watersheds draining to New and West Old Salem Reservoirs are small enough that they do not need to be further subdivided for scheduling implementation. In contrast, the Bonpas Creek watershed is very large, and it is recommended that HUC-12s be used to focus implementation.

One factor for prioritizing the 12-digit HUCs in the Bonpas Creek watershed is whether the HUC drains directly to the impaired downstream reach of Bonpas Creek. Another factor is the modeled sediment loading rate because larger reductions can potentially be attained from areas generating the largest sediment loads per unit area. Finally modeled runoff was considered, because runoff is a primary pathway for dissolved pollutant transport, and contributes to streambank erosion. An initial high-medium-low ranking is provided in Table 4-16. This ranking is provided for guidance only, and should be carefully reviewed by people familiar with the watershed, and revised to also factor in known problem areas, and public interest.

Table 4-16. Prioritization of 12-digit HUCs

HUC12	HUC 12 Name	Direct tributary to downstream, impaired segment?	Sediment unit area loading rank (1-8, with 8 being highest)	Runoff rank (1-8, with 8 being highest)	Initial recommended priority for implementation (High, Medium, Low)
051201130407	Negro Creek-Bonpas Creek	Yes	8	7	High
051201130405	Walser Creek-Bonpas Creek	Yes	7	5	High
051201130406	Indian Creek-Bonpas Creek	Yes	5	8	High
051201130403	Crooked Creek-Bonpas Creek	Yes	6	6	High
051201130404	Fordice Creek	Yes	2	3	Medium
051201130401	Lake Montclare-Bonpas Creek	No	3	4	Medium
051201130402	Little Bonpas Creek	Yes	1	1	Low
051201130408	Mud Creek-Bonpas Creek	Yes*	4	2	Low

*The most downstream portion of Bonpas Creek is affected by backwater from the Wabash River, and this HUC is therefore given the lowest priority.

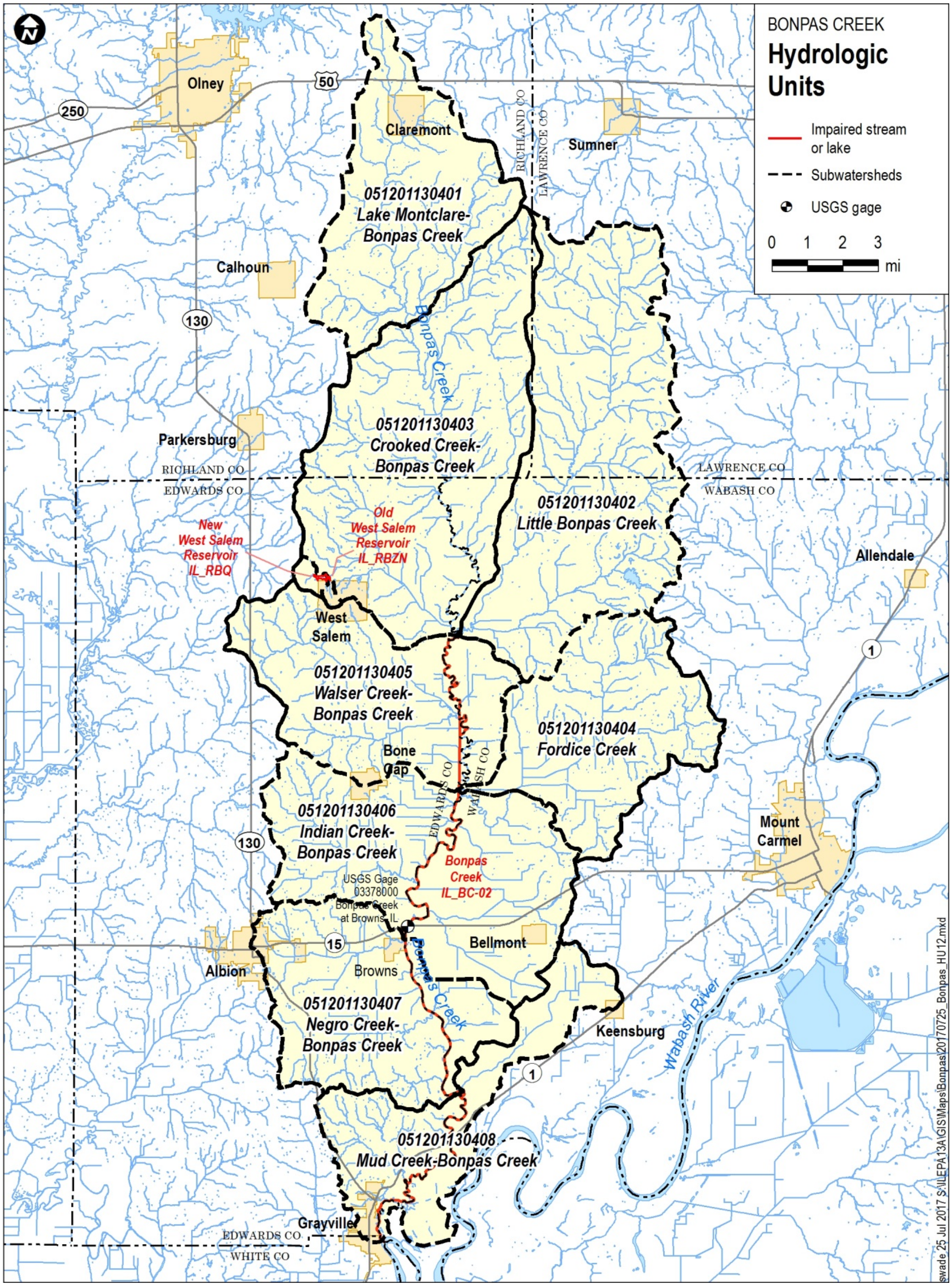

Figure 4-3. HUC 12s in the Bonpas Creek Watershed

4.8 Potential Funding Sources

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Table 4-17 presents potential funding sources for the recommended controls. This is not an exhaustive source of funding opportunities, but is intended to facilitate the pursuit of funding from applicable sources. Other programs and funding sources may also be available beyond those identified herein. Additional information regarding potential funding sources is provided below.

Table 4-17. Potential Funding Sources for Recommended Conservation Practices

Conservation Practice	Applicable, potential funding sources
Conservation Buffers	Funded under EQIP as field border (386), riparian herbaceous cover (390), or riparian forest buffer (391). Also funded under the Conservation Practices Cost-Share Program.
Conservation Tillage	Funded under EQIP as residue and tillage management, no-till (329). Also funded under the Conservation Practices Cost-Share Program, with some restrictions.
Cover Crops	Funded under EQIP as cover crop (340). Both cover and green manure crops are also funded under the Conservation Practices Cost-Share Program, with some restrictions.
Livestock Management Controls	Funded under EQIP as fence (382) and access control (472).
Nutrient Management Plans	Funded under EQIP as comprehensive nutrient management plan (102), nutrient management plan - written (104), and nutrient management (590). Both nutrient management planning and implementation are also funded under the Conservation Practices Cost-Share Program.
Treatment wetlands	Funded under EQIP as constructed wetland (656) and wetland restoration (657). Wetland reserve easements are also available to help protect, restore, ad enhance wetlands through the Agricultural Conservation Easement Program.
Water & Sediment Control Basins	Funded under EQIP as sediment basin (350) and water and sediment control basin (638). This practice is also funded under the Conservation Practices Cost-Share Program.
Streambank Stabilization	The Streambank Stabilization and Restoration Program provides support for low cost techniques to stabilize eroding stream banks.
Watershed Planning	Water Quality Management Planning Grants are available to regional public comprehensive planning organizations and other entities to carry out water quality management planning activities.

4.8.1 Federal Programs

Clean Water Act Section 319 grants[11] to address nonpoint source pollution. Section 319(h) of the Clean Water Act provides Federal funding for states and tribal agencies for the implementation of approved nonpoint source (NPS) management programs. These funds are received and administered by the Illinois EPA. Funding under these grants is used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. This program funds the establishment and management of conservation tillage, cover crops, filter strips, wetlands, and other agriculturally-related BMPs, specifically in watersheds with approved management plans that address reducing nutrient loading to Illinois waters. Of the total project cost, up to 60% can be awarded through the fund. Grantees must provide at least 40% of the costs as an in-kind match or cash. Funds can be used to develop watershed-based plans and for the implementation of watershed-based plans, including the development of information and education programs, and for the installation of best management practices. This is a reimbursement program. Applications are due each year by close of business on August 1st to the Illinois EPA.

Conservation Reserve Program[12] administered by the Farm Service Agency. The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length.

Agricultural Conservation Easement Program (ACEP)[13] This program is administered by the NRCS in Illinois and is a voluntary program offering landowners the opportunity to protect, restore, and enhance agricultural land and wetlands on their property. This program includes the Wetland Reserve Easement Program (WREP). The NRCS provides technical and financial support to help landowners with their restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.

Environmental Quality Incentive Program (EQIP)[14] This program is administered by the NRCS in Illinois and provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. Contracts may last for up to 10 years. Special payment schedules are in place for socially disadvantaged, beginning and limited resource farmers, Indian tribes, and veterans.

Application is a competitive process and EQIP applicants compete for funds by 'funding pool', a process that allows similar applicants to be grouped together for consideration. Payments are set by practice and are provided to the participants after the implementation of activities identified in their EQIP plan of operations. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. As part of the changes contained

[11] http://www.epa.state.il.us/water/financial-assistance/non-point.html
[12] http://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index
[13] http://www.nrcs.usda.gov/ wps/portal/nrcs/detail/national/programs/easements/acep
[14] general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/il/programs/financial/eqip/

within the 2014 Farm Bill, the former Wildlife Habitat Incentive Program (WHIP), which provided both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat, was folded in the EQIP program. Additional changes include un-waivable payment limits of $450,000.

Conservation Stewardship Program (CSP)[15] This program is administered by the NRCS in Illinois and assists agricultural producers with the maintenance and continued improvement of their in-place conservation systems. In addition, the program can provide assistance in the adoption of additional conservation practices which address priority resource concerns. These resource concerns can be water quality/quantity, habitat quality, soil quality, air quality, and energy conservation. Two payment types are offered, both on five-year contracts: a supplemental payment for adopting resource-conserving crop rotations, and annual payments for the adoption or installation of new conservation activities or maintenance of existing practices.

4.8.2 State Programs

Partners for Conservation (PFC) Cost-share Program[16] The Illinois Department of Agriculture administers several initiatives through the PFC cost-share program that promotes nutrient management, conservation tillage and the use of cover crops. Conservation practices that are eligible for cost-share assistance through PFC include terraces, grassed waterways, water and sediment control basins, grade stabilization structures, crop residue management, cover crops and nutrient management plans.

This program is designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. New programs under this fund must meet two key criteria:

1. They must be voluntary, and based on incentives rather than government regulation.
2. They must be broad-based, locally-organized efforts, incorporating the interests and participation of local communities, and of private, public and corporate landowners.

The Sustainable Agriculture Grant Program administered through this fund is seeking proposals from parties wishing to complete on-farm research or demonstrations, outreach and education, or university research in the area of agricultural sustainability. Up to $20,000 of support is available per grant.

Conservation Practices Cost-Share Program. Another component of Partners for Conservation Fund, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.

Illinois Conservation Reserve Enhancement Program (CREP)[17]. As an outgrowth of the Conservation Reserve Program, CREP pays the owners of environmentally sensitive land an annual rental rate in exchange for ceasing production and implementing conservation practices. In Illinois, the focus is placed on the Illinois and Kaskaskia River Watersheds.. CREP is different from CRP in that CREP focuses on the partnership between state and/or tribal agencies and the federal government. As of 2016, there are 126,805 acres enrolled in the Federal CREP program in Illinois at an average rental rate of $212.30 per acre. Approximately 90,990 acres are protected by CREP easements executed by the State (Illinois CREP, 2016). FSA administers the Federal component of CREP as they do for CRP. The Illinois Department of Natural Resources (IDNR) along with the local SWCD administers the State component and also provides

15 http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/
16 http://www.agr.state.il.us/C2000
17 http://www.dnr.illinois.gov/conservation/CREP/ Pages/default.aspx

technical assistance. Once the Federal CRP contract has expired, the State component of CREP extends the benefits of the established conservation practices through 15 or 35-year extensions, or in perpetuity with a permanent easement. If a landowner chooses to enroll in a permanent easement, they have the option of enrolling and receiving payment on adjacent additional acres, which would not otherwise be eligible for CRP or CREP, due to a lack of cropping history.

Water Quality Management Planning Grants[18]. Grants are available to regional public comprehensive planning organizations and other entities to carry out water quality management planning activities that protect water quality in Illinois. Projects must address water quality issues.

Grant funds can be used to determine the nature, extent, and causes of point and nonpoint source water pollution; develop water quality management plans; develop technical and administrative guidance tools for water pollution control; develop preliminary designs for best management practices (BMPs) to address water quality problems; implement administrative water pollution controls; and educate the public about the impact and importance of water pollution control.

Illinois EPA receives these funds through Section 604b of the Clean Water Act and administers the program within Illinois. The project period is two years unless otherwise approved. This is a reimbursement program.

Streambank Stabilization and Restoration Program (SSRP). The Illinois Department of Agriculture, with assistance from Soil and Water Conservation Districts, administers the SSRP. This program, funded through Partners for Conservation, provides support for using low-cost techniques (e.g., rock riffles, stone toe protection and bendway weirs) to stabilize eroding stream banks.

[18] http://epa.illinois.gov/topics/water-quality/watershed-management/wqmp/grants/index

5 Public Engagement, Education and Information

The pollutants of concern are predominantly from non-point sources, including agricultural land used for crop cultivation and livestock management, and implementation of recommended nonpoint source management measures will be completely voluntary. The previous section provided an initial priority ranking of subwatersheds; however, the final ranking should consider public interest in adopting management measures. Wet weather monitoring is strongly recommended to identify specific areas generating higher pollutant loads.

Achieving the pollutant load reduction targets in the watershed will require organized and sustained efforts in public engagement, education and information. Such efforts will create a culture of stewardship, a broad understanding of the need for pollutant control and increase the implementation of management measures to reduce pollutant loads.

5.1 Watershed Group Formation

The Bonpas Conservancy District has been active in the Bonpas Creek watershed in the past, working with the NRCS and others to implement practices to reduce pollutant loads. The NRCS and SWCD have also been actively engaging local landowners for decades to identify and implement practices to reduce pollutant loads, most recently in the Crooked Creek subwatershed.

It is recommended that the Bonpas Conservancy District, NRCS and SWCD staff continue to serve as the primary watershed group in the Bonpas Creek watershed. This group should meet to identify whether there are additional stakeholders with an interest in improving water quality, and develop a plan to reach out to these stakeholders. Potential stakeholders may include Illinois EPA, County Health Departments, Farm Service Agency staff, local producers, and other interested residents. Functions of a citizen-driven watershed group are numerous, including:

- Provide a forum for like-minded citizens to discuss issues, actions and priorities for the watershed;
- Be a source of watershed information for the public;
- Organize meetings and watershed events;
- Create vehicles for distributing watershed information such as newsletters, blogs, e-mailings and a web site; and
- Solicit donations and obtain grant funding from government agencies and foundations.

This watershed group will likely need to complete the following tasks to help it accomplish its goals:

- Inform the public that a watershed plan has been developed to gain interest in implementing recommended actions.
- Educate the public on the plan and benefits of the plan.
- Develop a web page and social media outlets which are appropriate for their target audience. These should allow the group to provide updates, post callouts for volunteer events, gather and display data, and present progress.

- Create 1-2 page fact sheets or brochures which can be distributed at public meetings and events. This educational material should educate landowners and community members on their opportunities to implement best management practices and the influence these practices may have on their local water quality. It is ideal to have promotional material which is targeted to residential landowners (perhaps including information on septics) and agricultural landowners.
- Identify local events where their outreach can have an effective impact on the watershed community. This might be a local festival, a school science fair, a library event, or anywhere where people from the community gather and there is an opportunity to set up a booth or hand out flyers.

This group will want to think carefully about how to cultivate the membership to be sure that all relevant members of the community can be represented. It can be important to have members from many different sectors: agribusiness operators, recreation groups, rural non-farm and farm residents, urban/suburban residents, environmental interests, elected officials, and farmers (both those who own the land they farm and who rent).

5.2 Public Education and Outreach

Group activities should include public education and outreach to inform watershed residents of the problems with in the watershed, share the implementation plan, and to solicit input on controls that stakeholders are willing to implement. Once the core membership has been formed, the watershed group will be well positioned to plan further outreach to the general public. To promote buy-in, the group should be prepared to offer insight into what any member of the community may do to advance watershed health. This could include developing strategic plans for unique watershed users – both by geography and by topic. For example, residents of the reservoir watersheds may want to develop their own group focused on phosphorus load reduction. Livestock producers may want to form a separate group focused on issues unique to livestock production. Past successes in the Crooked Creek subwatershed, or other locations in the Bonpas Creek watershed should be shared, to encourage more wide-spread adoption of measures that have been successful. Funding opportunities described in this report should also be shared with interested landowners. Table 5-1 presents details regarding public information and education, and milestones are presented in Section 6.

As is clear from the prior section, the first scheduled task should be to convene a watershed group. The existing Bonpas Conservancy District would likely serve as the lead organization to convene the group, or as a foundation group to build on, if there is a need to expand membership to reach a diversity of stakeholder groups. This group should meet to identify and reach out to additional stakeholders, and should also begin compiling past reports and information regarding implementation. The first year of implementation should be devoted to solidifying this group, understanding measures already implemented and their success, and beginning the public outreach and education aspects of implementation, as described in Table 5-1. Guidance for subsequent years is also provided in this table.

Table 5-1. Information & Education Plan Start-Up Schedule

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Organize watershed group	General public	Inform the public and local agencies that the group is expanding	Immediately following plan completion	Bonpas Conservancy District (IEPA, County Health Departments, NRCS, SWCD, agricultural retailer)	Establishment of a watershed group within 1 year of plan completion, including designation of a coordinator or coordinating committee and if desired, development of a logo.	No cost, assuming the coordinator is a volunteer and a volunteer develops the logo (if desired).
Develop a website for the Bonpas Conservancy District and link to any partner websites	All stakeholders	Develop a website to keep people informed about watershed issues and opportunities.	Immediately following plan completion	Bonpas Conservancy District	Establishment of a website and other social media accounts. Website should minimally include information on the watershed, watershed group and goals, the watershed plan, contact information, email addresses, links, downloads, and a calendar.	$500/year for direct costs to establish a new website. This assumes a watershed group member with aptitude for web development can set up and maintain the site for free.
Compile and review information describing previous implementation and planning	Watershed group	Identify where work has been done, and document what's been successful, who was involved and time frame of the work.	Immediately following watershed group formation	Bonpas Conservancy District (NRCS, SWCD)	Summary of existing documents and past implementation success compiled.	No cost if using existing resources.

Table 5-1 (continued)

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Inform the general public that an implementation plan has been developed for the Bonpas Creek watershed to gain interest in implementing recommended actions	General public	Inform the public about the plan and share information on how public may participate in implementation via existing media newspapers, newsletters and social media	Immediately following watershed group formation	Bonpas Conservancy District (NRCS, SWCD)	Majority of the public in the watershed are well educated on watershed conditions and know who to contact to get involved.	No cost if using existing resources. If desired, flyers and posters could be developed. Approximate costs would be: $34 for 25 brochures Price based on costs to develop a brochure using preset options http://www.fedex.com/us/office/brochure-printing.html $210 for three mounted posters Assumes 3 posters (22" x 28"). Pricing based on http://www.fedex.com/us/office/poster-printing.html
Identify priority actions for years 2-5	Watershed group	Review initial priority ranking of HUC 12 subwatersheds and other factors that may impact ranking (shovel-ready projects, public interest, past success, fund availability, etc.)	Immediately following watershed group formation	Bonpas Conservancy District (NRCS, SWCD, USEPA, IEPA)	Watershed group agrees on priority actions for years 2-5, that can be funded by available grants, government programs, etc.	No cost if using existing resources

Table 5-1 (continued)

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Educate private landowners along Bonpas Creek and tributaries how to properly manage their land to reduce pollutant loads.	Private land owners along Bonpas Creek, tributaries	Conduct workshops for riparian land owners that recommend pollutant controls, funding sources, and qualified contractors.	Once every five years	Bonpas Conservancy District or Consultant (NRCS, SWCD, IEPA)	Private land owners recognize the benefits of watershed controls.	$3,000 per event
Hold an annual watershed tour for elected officials and others interested in watershed activities	Elected officials; all stakeholders	Offer an annual bus tour of the Bonpas Creek watershed for elected officials and others to see restoration areas, areas that are in need of improvement and failed projects	Annually	Municipalities, NRCS, SWCD	Elected officials become more familiar with existing and potential restoration projects and learn more about what is/is not working. Decisions regarding future proposed projects are better informed	$2,000 per event
Implement demonstration projects or highlight existing case studies within the watershed	Elected officials; general public; all stakeholders	Use many forms of media to inform the public when and where demonstration projects are implemented (radio, newspapers, social media, websites, etc.)	Immediately following plan completion and when projects are implemented	Bonpas Conservancy District (NRCS, SWCD)	The majority of the public in the watershed know about demonstration projects, their benefits and where they are located. The public begins to accept and support watershed improvement projects	$3,000/project

Table 5-1 (continued)

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Install "Bonpas Creek Watershed" signs along major roads in the watershed	General Public	Design and install signs at key points along major roads in the watershed that inform drivers and passengers that they are entering the Bonpas Creek watershed.	Following plan completion	Municipalities	Signs will increase the public's awareness of the watershed boundary, and will alert them to areas that have an impact on water quality in the creek.	$5,000 for five signs

6 Implementation Schedule and Milestones

This section describes an implementation schedule for the recommended measures described in Section 4. These should begin in year 2, after the public engagement, education and outreach program described in Section 5 has been initiated. This schedule should be followed concurrently with the monitoring described in Section 7.

As described in Section 4.7, watershed modeling suggests that four 12-digit HUCs should be prioritized based their higher runoff sediment loading rates, although other factors such as public interest also need to be considered. The four 12-digit HUCs are Negro Creek-Bonpas Creek, Walser Creek-Bonpas Creek, Indian Creek-Bonpas Creek, Crooked Creek-Bonpas Creek. Fordice Creek and Lake Montclare-Bonpas Creek have medium priority and Little Bonpas Creek and Mud Creek-Bonpas Creek have the lowest priority for implementation (See Table 6-1). These priorities should be reviewed and adjusted as new monitoring data are generated, and additional information is compiled.

Table 6-1. Prioritization of 12-digit HUCs

HUC12	HUC 12 Name	Initial recommended priority for implementation (High, Medium, Low)
051201130407	Negro Creek-Bonpas Creek	High
051201130405	Walser Creek-Bonpas Creek	High
051201130406	Indian Creek-Bonpas Creek	High
051201130403	Crooked Creek-Bonpas Creek	High
051201130404	Fordice Creek	Medium
051201130401	Lake Montclare-Bonpas Creek	Medium
051201130402	Little Bonpas Creek	Low
051201130408	Mud Creek-Bonpas Creek	Low

*The most downstream portion of Bonpas Creek is affected by backwater from the Wabash River, and this HUC is therefore given the lowest priority.

The planned schedule for implementation of management measures is presented in Table 6-2 and 6-3.

Table 6-2. Management Measure Implementation Schedule, Years 2-5[19] for Old and New West Salem Reservoirs

Year	Management Measure Action (New West Salem Reservoir)	Management Measure Action (Old West Salem Reservoir)	Milestones/Measures of Success
2	Prepare nutrient management plans for 255 acres	Prepare nutrient management plans for 18 acres	Acres covered by new nutrient management plans
2	Establish cover crop practices on 242 acres and conservation tillage on 20.4 acres	Establish cover crop practices on 17 acres and conservation tillage on 1.4 acres	Acres of cover crop and conservation tillage practices started
2		Identify candidate sites for constructed wetlands (3 acres) and 0.32 miles conservation buffers	Viable sites identified, suitable for grant application
3		Prepare grant applications for constructed wetlands projects.	Grant applications submitted.
3-4	Establish conservation buffers for 0.14 miles of streams	Establish conservation buffers for 0.32 miles of streams	Stream miles with new conservation buffers
4-5		Begin construction of wetlands	Acres of new constructed wetlands
5		Conduct 5-year review of implementation plan and prepare updated plan	Completion of updated implementation plan, based on 5-year review

Table 6-3. Management Measure Implementation Schedule, Years 2-5[19]for Bonpas Creek

Year	Management Measure Action	Milestones/Measures of Success
2	Identify candidate sites for conservation buffers and conservation tillage. Identify potential locations with failing onsite systems.	Viable sites identified, suitable for grant application
2	Establish cover crop practices on 27,633 acres (25% of target) , focusing in high priority subwatersheds	Acres of cover crop
2-3	Begin work to establish conservation tillage on 22,484 acres (half of target)	Acres of conservation tillage started
2-3	Conduct a streambank erosion inventory to identify priority locations for streambank stabilization.	Completion of streambank erosion inventory. Viable sites identified and stream miles to be stabilized
3	Communicate with Health Department and landowners with failing systems to develop a plan and identify funding to improve onsite systems.	Development of a plan and identification of a funding source to improve failing onsite systems.
3-4	Establish conservation buffers for 171 miles in the Bonpas Creek watershed (half of target).	Stream miles with new conservation buffers
3-4	Begin streambank stabilization in areas identified as having the most severe erosion, ultimately targeting 154 miles	Miles of streambank stabilized

[19] Implementation of management measures dependent on funding availability and landowner cooperation. Schedule may be adjusted annually.

Table 6-3 (continued)

Year	Management Measure Action	Milestones/Measures of Success
4	Identify candidate sites for additional conservation buffers (171 acres) and conservation tillage (22,484 acres) (remaining 50% of target).	Viable site identified, suitable for grant application
4	Establish conservation buffers (171 acres) and conservation tillage (22,484 acres)	Stream miles with new conservation buffers and acres of conservation tillage established
4	Establish cover crop practices on 27,633 acres (25% of target), focusing in high priority subwatersheds	Acres of cover crop
5	Conduct 5-year review of implementation plan and prepare updated plan	Completion of updated implementation plan, based on 5-year review

In year five, the Bonpas Conservancy District watershed group will conduct a five-year review of the implementation plan to assess the need for modifications. Public input will be obtained through public meetings, social media feedback and internet-based polling of residents. Based on this review and assessment, the plan may be updated to reflect realities of funding availability, implementation rate of management measures in the first five years, findings of annual monitoring and changing priorities. The implementation schedule for year 6 through year 10 presented in Table 6-4 may be adjusted significantly based on the five-year assessment.

Table 6-4. Management Measure Implementation Schedule, Years 6-10[20] for Bonpas Creek

Year	Management Measure Action	Milestones/Measures of Success
6	Identify candidate sites for fencing livestock out of streams in the Bonpas Creek watershed	Viable sites identified and stream miles identified for fencing
6-7	Establish fencing to prohibit livestock access to streams	Stream miles with new fences
6-9	Establish cover crop practices on 27,633 acres (25% of target, focusing on high and medium priority subwatersheds.	Acres of cover crop practices started
7-8	Establish cover crop practices on 27,633 acres (25% of target, focusing on high and medium priority subwatersheds.	Acres of cover crop practices started
10	Conduct 10-year review of implementation plan and prepare updated plan	Completion of updated implementation plan, based on 10-year review

Under this schedule, by the end of year ten, all management measures will have been implemented or begun. Ten years of monitoring data will be available to support water quality assessment of streams in the watershed and to assess the effectiveness of management measures. In year ten, the Bonpas Conservancy District watershed group will again conduct a review of the implementation plan to assess the need for modifications and plan activities for years 10-20. Because of the great uncertainty regarding funding availability, landowner cooperation, implementation rates of management measures in the first ten years, outcomes of annual monitoring and changing priorities, a detailed schedule for years 10 through 20 is not included here.

[20] Implementation of management measures dependent on funding availability and landowner cooperation. Schedule may be adjusted annually.

6.1 Implementation Milestones

As outlined above, there are several interim milestones that should be evaluated to assess progress as the implementation plan moves forward. With the exception of the initial convening the watershed group, all measureable milestones should be finalized by the group. Achievement of these milestones will assure the watershed group that they are making progress in their role. However, additional criteria should be developed which will specifically document the group's progress at improving water quality. These criteria should be decided by the watershed group after formation, but should include the following elements:

- A defined plan for documenting and tracking pollutant concentrations over time.
- A mechanism for tracking implementation of practices in each watershed, or documenting interest in or commitments to implementing practices for future follow-up.
- A mechanism for including the following concepts in their tracking of water quality:
    - Annual fluctuations in precipitation and/or temperature
    - Appreciable adoption of best management practices
    - The addition or removal of any point source facilities
    - The patterns displayed by the dominant crops in the watershed (was there a drought which impacted the crops ability to accumulate biomass, did the planting occur early or late, etc.)
    - The season and 7-day prior conditions during which the samples were taken
- The target concentrations

The watershed group should acknowledge that it may be difficult to determine progress at an early stage of implementation. As enumerated above, any number of factors may alter the in-stream concentrations on a year to year basis. It may be necessary to plan for a multi-year effort which will allow the longer term collection of data and determination of a long term concentration average.

Implementation milestones proposed for tracking progress toward water quality goals are described in Table 6-5, and assume year one of implementation is in 2019. These milestones should be reviewed by the watershed group leading implementation and adjusted to reflect local knowledge and preferred practices.

Table 6-5. Implementation Milestones for Water Quality

Milestone	Detailed Description	Milestone Date
TP reduction to Old West Salem Reservoir	36% of target reductions through implementation of nutrient management plans, cover crops and conservation tillage	End of 2022
	100% of target reductions through implementation of constructed wetlands	End of 2024
TP reduction to New West Salem Reservoir	100% of target reductions through implementation of nutrient management plans, cover crops and conservation tillage and conservation buffers	End of 2024
TSS reduction to Bonpas Creek (and associated reductions in fecal coliform and atrazine)	~25% of target reductions through implementation of cover crops and conservation tillage on focused in the highest priority subwatersheds identified by stakeholders.	End of 2022
	~50% of target reductions through implementation of conservation buffers and beginning implementation of streambank stabilization on the areas with the most severe erosion	End of 2024
	100% of target reductions through implementation of additional conservation buffers, conservation tillage, cover crops and streambank stabilization, implementing the most successful practices identified through regular monitoring and adaptive management.	End of 2027
Fecal coliform reduction	~30% of target reductions through implementation of conservation buffers and maintenance or improvement to failing septic systems.	End of 2023
	~43% of target reductions through implementation of fencing	End of 2028
	100% of target reductions by implementing the most successful practices identified through regular monitoring and management.	End of 2040

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7 Monitoring

A monitoring program is valuable for measuring and tracking water quality improvements. Illinois EPA conducts a variety of lake and stream monitoring programs, including: a statewide Ambient Water Quality Monitoring Network; an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program. Illinois EPA does not sample any waterbodies in the Bonpas Creek watershed under their Ambient Water Quality Monitoring program[21].

Illinois EPA recently sampled Bonpas Creek station BC-02 (Figure 7-1) as part of the 2016 Intensive Basin Survey. This watershed will likely be sampled again in 2021, as part of IEPA's five-year rotating schedule. Monitoring by Illinois EPA at 5-year intervals at station BC-02 (see Figure 7-1) will provide information on the change in pollutant concentrations over time, reflecting improvements following implementation of management measures.

The watershed group should encourage IEPA to monitor additional locations during the 2021 Intensive Basin Survey, and to monitor this watershed under their Ambient Water Quality Monitoring Network program, as part of the Wabash River Basin monitoring to help assess progress in reducing pollutant loads.

Additional monitoring is also recommended to supplement data collected by Illinois EPA. It may be possible that sampling can be conducted by volunteers to reduce costs. Local sewage treatment plants could be contacted to see if they are willing to donate laboratory analytical services. Prior to monitoring, it is recommended that a Quality Assurance Project Plan (QAPP) be developed. If external funding for monitoring is required, the watershed group will need to identify funding sources potentially from USEPA grant programs. Once funding is secured and the monitoring points identified, the watershed group will conduct the sampling. The frequency of sampling and number of sampling locations will depend on available resources. The group should plan to interface with IEPA about sampling events within the Bonpas Creek watershed to help them assess pollutant load reductions.

7.1 Stream Monitoring

There are two recommended aspects of this supplemental sampling for streams:

1. A minimum of monthly sampling at station BC-02 (shown in green in Figure 7-1) in years when Illinois EPA does not conduct sampling at that station. Both low and high flow conditions should be targeted over the course of the year.
2. A minimum of monthly sampling at the new stations, as shown in Figure 7-1 (shown as blue squares). Both low and high flow conditions should be targeted over the course of the year.

Annual sampling will provide more frequent data which will help identify temporal trends, as well as patterns related to weather. In addition, more frequent data will allow better discernment of the impacts of management measures as they are implemented.

[21] http://www.epa.state.il.us/water/water-quality/monitoring-strategy/monitoring-strategy-2015-2020.pdf

Additional sampling locations will create a richer data set to assess water quality in streams and may provide a means to better observe the effects of management measures by providing upstream/downstream sampling pairs.

Stream sampling should include fecal coliform, atrazine and total suspended sediment. Where possible, flow measurement should be conducted as a component of watershed monitoring, although the USGS flow gage on Bonpas Creek can be used if additional flow measurements are not possible.

Water quality monitoring should include a component of sampling during or immediately after rain events, preferably in the spring when higher runoff volumes are likely.

7.2 Lake Monitoring

IEPA has historically sampled Old West Salem Reservoir at one location and New West Salem Reservoir at two locations (near the western end of the lake and near the outlet). Lake sampling should include measurements of total phosphorus concentrations at these locations for comparison to past data for trend assessment. Monitoring in the tributaries draining to the lakes has not been conducted in the past, but could also be initiated near the point where the streams enter the lakes, to characterize the phosphorus concentrations entering the lakes.

7.3 Schedule

A schedule for guiding monitoring activities is shown in Table 7-1. As shown here, planning should be completed by the end of year 1, so implementation of the monitoring program can be started in year 2 to provide information on baseline stream water quality conditions.

Table 7-1. Watershed Monitoring Schedule

Year	Action	Notes	Milestones/Measures of Success
1	Plan sampling; line up laboratory analysis services	Sampling should include total and dissolved phosphorus, total suspended solids, fecal coliform and atrazine concentrations; plan should include sampling locations map	Written plan
1	Prepare QAPP	Illinois EPA can provide examples	Written QAPP
1	Present sampling plan to public; seek volunteers	The sampling plan should be presented at the first annual public watershed meeting	See Section 7
2	Prepare sampling schedule	Based on volunteer availability and availability of laboratory resources, plan sampling schedule	Sampling schedule posted to web site
2	Seek supplemental funding	If needed, apply for grants to support sampling program	Grant(s) for supplemental funding
2	Conduct sampling	Collect samples as planned	Completion of sampling event(s) by local watershed group
2	Evaluate results; review program; determine need for changes	Identify successes, problems, challenges from initial sampling; revise plan accordingly	Revised sampling plan
3-10	Implement sampling program	Review program every year and identify new resources, areas for improvement. Results should be evaluated for trends over time, as well as compared to target pollutant concentrations to determine whether goals have been attained.	

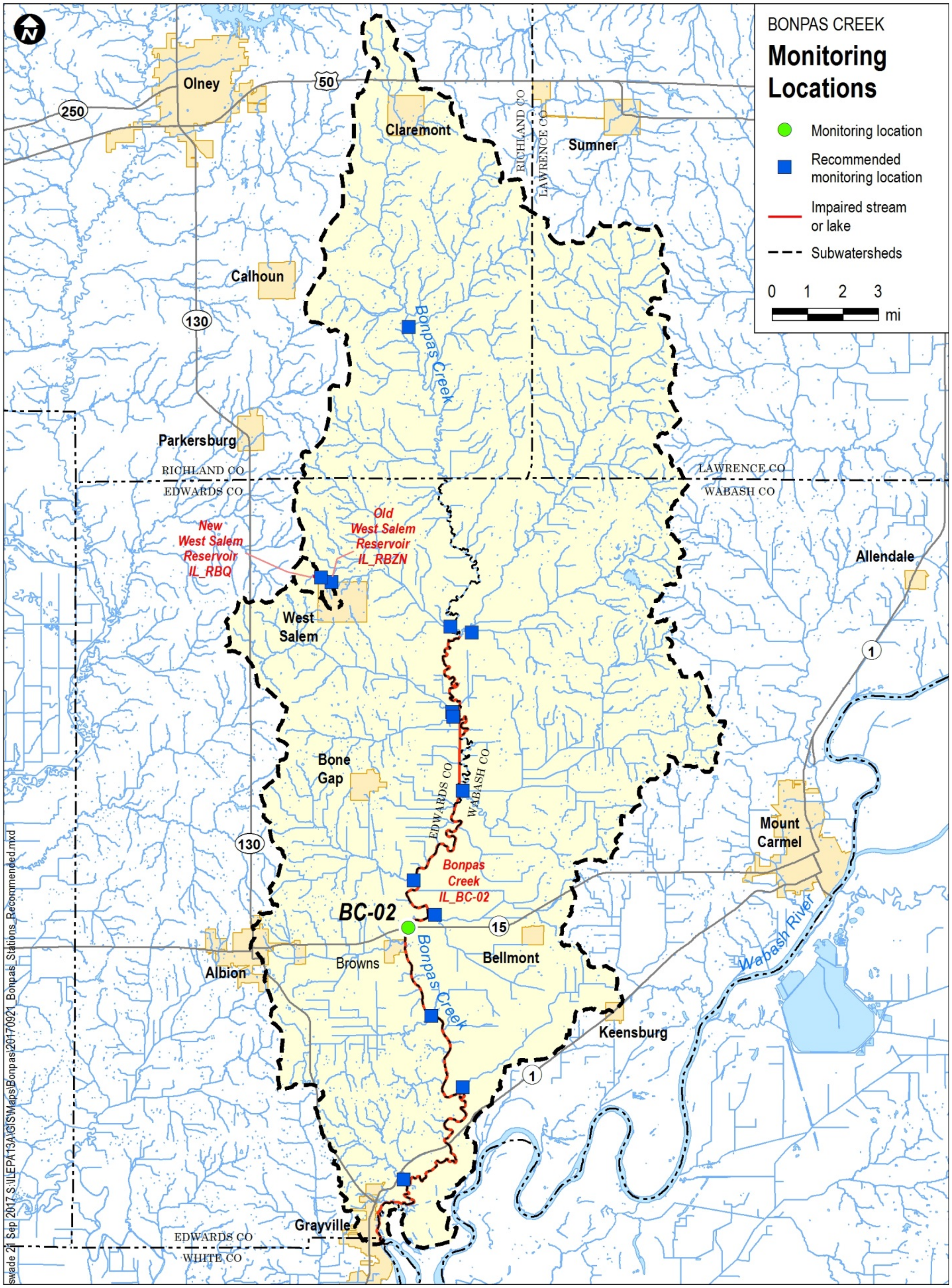

Figure 7-1. Illinois EPA Monitoring Locations and Recommended Monitoring Locations

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