Illinois
Environmental
Protection Agency

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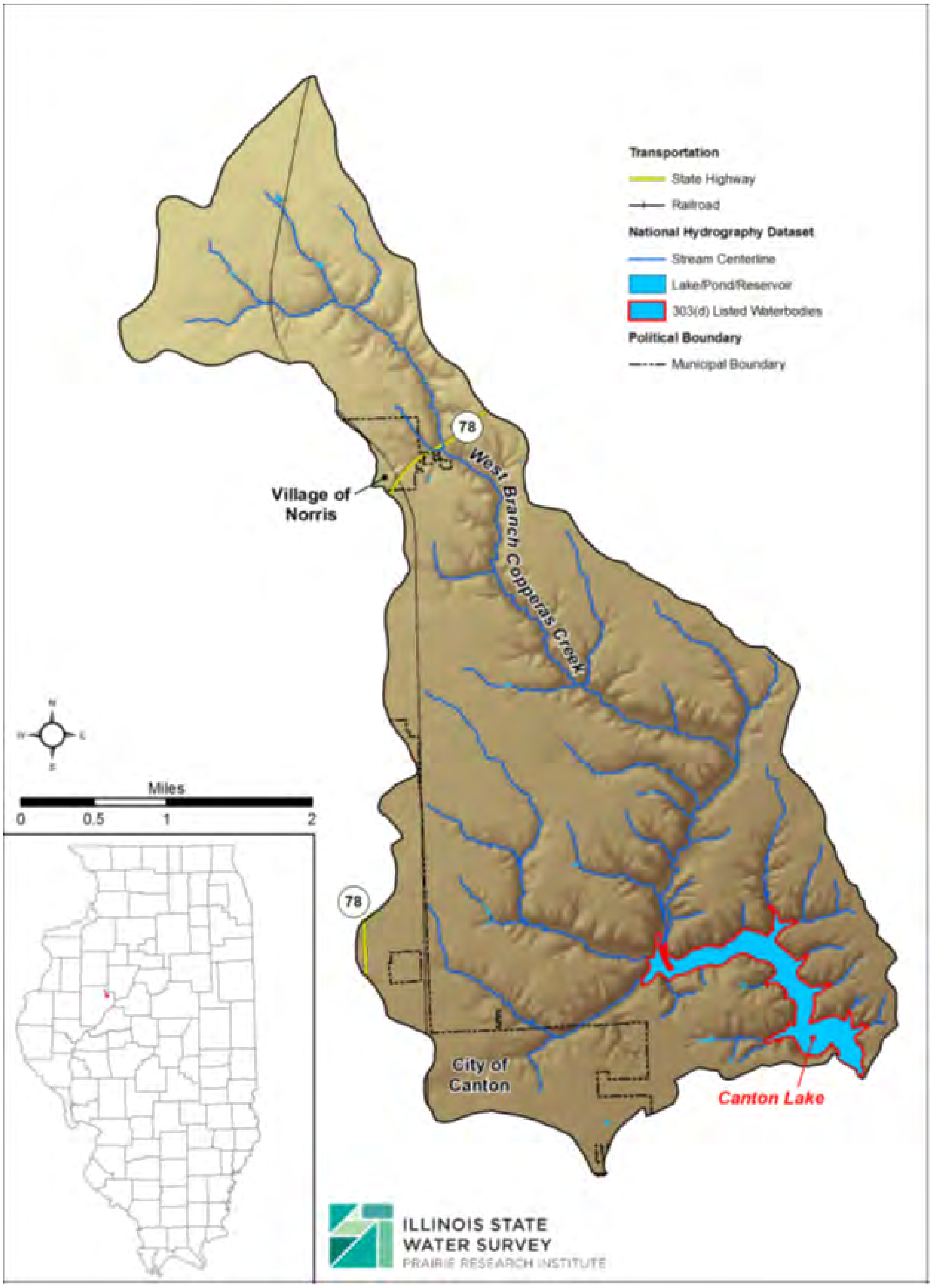
IEPA/BOW/17-002

Canton Lake Watershed TMDL Report



TMDL Development for the Canton Lake Watershed, Illinois

This file contains the following documents:

1) U.S. EPA Approval letter and Decision Document for the Final TMDL Report

2) Phase 1 TMDL Development

3) Phase II TMDL Development

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

JUN 28 2017

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 a final Total Maximum Daily Load (TMDL) for phosphorus for Canton Lake, including supporting documentation and follow up information. The waterbody is located in west-central Illinois. The TMDL for phosphorus submitted by the Illinois Environmental Protection Agency addresses the impaired designated General Use for the waterbody.

The TMDL meets 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 one TMDL for 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 this TMDL 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,

Linda Holst

for Christopher Korleski
Director, Water Division

Enclosure

cc: Abel Haile, IEPA

TMDL: Canton Lake, Fulton County, Illinois
Date:

DECISION DOCUMENT FOR THE APPROVAL OF THE CANTON LAKE, 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 a TMDL for total phosphorus (TP) for Canton Lake (Lake ID: RDD) in west-central Illinois. Canton Lake is located in Fulton County. The lake is a reservoir formed from West Branch Copperas Creek, which was dammed in 1939 to provide a drinking water supply for the City of Canton.

The watershed for Canton Lake is relatively small, approximately 9,600 acres and inflow to the lake is from West Branch Copperas Creek and several smaller tributaries. The lake is 230 acres in size, and averages fourteen feet in depth, with a maximum depth of 29 feet. The lake discharges through a spillway at the southern end of the lake (Figure 2-2 of the TMDL).

Distribution of land use: The land use for Canton Lake is mainly agricultural and forest in nature, with most of the agricultural land use in row crop (corn/soybean). Urban and open space makes up most of the remaining land use (Section 2.2 of the TMDL). Table 1 of this Decision Document contains the land use for Canton Lake.

Table 1 Land use in acres in the Canton Lake Watershed

Land Use	Watershed %
Row Crops	64
Forest	21
Urban and open space	9
Wetland	3
Other	3
Total	100

Problem Identification:

Canton Lake was added to the 2006 303(d) list for being impaired due to high levels of phosphorus and suspended solids. IEPA reviewed data back to 1977 and determined that the lake had elevated TP average concentrations for 60-80% of the samples. Water quality sampling performed in 2011-2012 documented exceedences of the water quality criteria at all three lake sample locations (Table 5-21 of the TMDL). The median whole lake TP concentration in 2011 was 0.085 mg/L (WQS = 0.05 mg/L), and almost all lake samples (91%) exceeded the WQS for TP.

Pollutants of Concern:

The pollutant of concern is total phosphorus (TP). However, IEPA determined that reductions in sediment will be needed to fully restore Canton Lake (Section 5.3.2 of the TMDL). Although TP reductions are the focus of the TMDL, Sections 8 (Reasonable Assurance) and Section 10 (Implementation Plan) of this Decision Document contain additional discussion of sediment reduction efforts. IEPA noted that the lake is losing volume as more sediment enters the system.

Pollutant:
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 turbidity, 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 public health, the public value of the impaired water resource, the likelihood of completing the TMDL in an expedient manner, the inclusion of a strong base of existing data and the restorability of the water body, the technical capability and the willingness of local partners to assist with the TMDL, and the appropriate sequencing of TMDLs within a watershed or basin.

Source Identification (point and nonpoint sources):
Point Source Identification: One point source is located in the watershed, a large cattle operation (Dare Farms). The operation is large enough to be considered a Concentrated Animal Feeding Operation (CAFO). There are two National Pollution Discharge Elimination System (NPDES) permit holders near Canton Lake; the Canton wastewater treatment facility (WWTF), and the Canton Water Treatment System. Neither of these facilities discharge to the Canton Lake watershed. The area is not subject to the Municipal Separate Storm Sewer System (MS4) requirements. There was a Combined Sewer Overflow (CSO) discharge located in the watershed. The City of Canton separated the stormwater system and the sanitary system in 2011. The CSO discharge may have impacted the 2011-2012 water quality data, but no longer is a source of TP to the lake (Section 5.4 of the TMDL).

Nonpoint Source Identification: The potential nonpoint sources for the Canton Lake phosphorus TMDL are:

Non-regulated stormwater runoff: Non-regulated stormwater runoff can add phosphorus to the lake. The sources of phosphorus in stormwater include organic material such as leaves, animal/pet wastes, fertilizers, etc. Runoff from row-cop agriculture is a significant source of TP and associated total suspended solids (TSS). IEPA noted that the use of chemical and manure fertilizer has decreased in the watershed from 2007-2012 (Section 5.4.2.1 of the TMDL). Tillage practices in the watershed are also reducing TP and TSS loads.

Animal Operations: Runoff from agricultural lands may contain significant amounts of nutrients, organic material and organic-rich sediment which may lead to impairments in Canton Lake. 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. Stormwater runoff may contribute nutrients and organic-rich sediment to surface waters from livestock manure, fertilizers, vegetation and erodible soils. 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 nutrient concentrations. This nutrient deposition may also contribute to downstream impairments.

Lake shoreline erosion: Shoreline erosion due to wave action and changing water levels can add TSS and associated TP loads to the lake (Section 5.4.2.9 of the TMDL). Phosphorus is often attached to soil particles, and shoreline erosion can contribute locally large amounts of phosphorus-rich soil to the lake.

Streambank erosion: IEPA noted that streambank erosion can contribute TSS and TP loads to the lake. IEPA reviewed aerial phots and noted that there is significant forest area along the main tributary streams, and it is unlikely that streambank erosion is a significant source of TP.

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 phosphorus. IEPA reviewed available septic system data and, using GIS information, was able to estimate the number of homes on septic systems in the watershed. IEPA determined that septic systems are a limited source of TP in the watershed.

Internal loading: The release of phosphorus from lake sediments via physical disturbance from wind mixing the water column, and anoxic release of TP from deeper sediments, may contribute internal phosphorus loading to Canton Lake. Phosphorus may build up in the bottom waters of the lake and may be resuspended or mixed into the water column. Modeling analysis indicates internal loading is a minor source of TP (Section 5.4.2.5 of the TMDL)

Population and future growth trends: The population for the watershed is fairly small, less than 5,000 people. The City of Canton (population 14,307) is located west of the lake, partially within the watershed. The Village of Norris (population 210) is located within the Canton Lake watershed. IEPA does not expect any future growth in the watershed (Section 8.3.4 of the TMDL).

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 Canton Lake 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 General Use standard that applies to Canton Lake is the aesthetic quality and public water supply uses. The lake is meeting the public water supply use, but is impaired for the aesthetic quality use (Section 4.2 of the TMDL).

Criteria: IEPA has a lake criterion for phosphorus of 0.05 mg/L (Title 35, Section 302.205).

Target: The water quality target for this TMDL is the water quality criterion of 0.05 mg/L TP.

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 Canton Lake for phosphorus is described in Section 7 of the final TMDL.

To determine the watershed loadings into Canton Lake, IEPA used GWLF (Generalized Watershed Loading Function). GWLF is a monthly time-step model used to predict runoff, sediment, and nutrients from watersheds with mixed land uses. GWLF can be used for both sediment and phosphorus TMDLs. The runoff is simulated using daily precipitation, the runoff curve number and antecedent moisture. The sediment load is estimated with the USLE (Universal Soil Loss Equation). Dissolved nutrients are simulated using event mean concentrations. The loads generated by individual sources were aggregated to produce the total load (Section 7.1.1 of the TMDL).

Once the watershed data were incorporated into GWLF, the flow was calibrated based upon monitoring data. Then, the Curve Numbers were adjusted to best match the observed flows. The flow calibration met the "very good" to "good" statistical error parameters as noted in Table 2 of the TMDL. Although no TMDL was specifically calculated for TSS, IEPA modeled TSS loads into the lake (Section 7.2.1.3 of the TMDL).

After the lake inputs were calculated, IEPA used CE-QUAL-W2 to determine the water quality based upon the TP loading. CE-QUAL-W2 is a laterally averaged, two-dimensional (longitudinal and vertical) hydrodynamic and water quality model. It is best suited for relatively long and narrow water bodies such as Canton Lake. The hydrodynamic component of the model predicts water surface elevations, velocities, and temperatures, while the water quality component simulates 21 constituents, including nutrients, phytoplankton, and dissolved oxygen (DO) interactions. CE-QUAL-W2 models basic eutrophication processes such as relationships among temperature, nutrients, algae, dissolved oxygen, organic matter, and sediment in stratified or nonstratified systems. A predominant feature of the model is its ability to compute the two-dimensional velocity field for narrow systems that stratify. The model was used to determine the load needed to meet or maintain water quality standards for the lake (Section 7.1 of the TMDL).

The model parameters were adjusted until the model predictions fit the sample data. Once the data were calibrated, the source loads were reduced until the in-lake concentration met the appropriate WQS (Section 8.3 of the TMDL). To account for internal loading of TP, IEPA modeled the impacts of low dissolved oxygen on TP entering the water column from sediments (Section 8.3.1.2 of the TMDL). IEPA determined that while there is some TP entering the water column, it only occurs over a relatively small portion of the lake, and averages 2.6% of the overall load. As a result, IEPA determined that a separate LA for internal loading was not needed.

IEPA subdivided the loading capacity among the WLA, LA and MOS components of the TMDL. These calculations were based on the critical condition, the spring/early summer time, which is typically when loading is the highest. Modeling results showed that the current load of TP is above the WQS. Table 2 of this Decision Document shows the TMDL summary for Canton Lake. The allocations result in an approximate 55% reduction in watershed loading.

Table 2 TMDL summary for Canton Lake

Category	TP (lbs/d)
Existing load	52.1
Reduction	55%
Wasteload Allocation	0
Load Allocation	17.6
Margin of Safety	5.8
Loading capacity (TMDL)	**23.4**

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 LA for the lake is found in Table 2 of this Decision Document, and was calculated to be 17.6 lbs/day (Section 8.3.6 of the TMDL). Since IEPA determined there are no point sources of TP in the watershed aside from the CAFO , which has a WLA = 0, all the loading capacity was allocated to the load allocation. The sources of TP in the watershed are nonpoint source runoff from row crop agricultural fields, failing septics, streambank erosion, and lake bank erosion. IEPA did not assign LA to the source categories, however, as discussed in Sections 8 and 10 of this Decision Document, IEPA did provide further analysis of how reductions from the various 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:
IEPA determined there are no active point sources of phosphorus in the watersheds. The only existing point source is a CAFO facility, Dare Farms (ILA010083). IEPA assigned a WLA of 0 to the CAFO based upon the requirements of the NPDES permit (Section 8.3.5 of the TMDL). As noted in Section 1 of this Decision Document, there are two NPDES permit holders near Canton Lake; the Canton WWTF and the Canton Water Treatment System. Neither facility discharges to the Canton Lake watershed. The City of Canton separated the stormwater system and the sanitary system in 2011 (Section 5.4 of the TMDL). The area is not subject to the municipal separate storm sewer system (MS4) requirements.

The WLA is 0 for the Canton Lake phosphorus TMDL.

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:
The Canton Lake TMDL incorporated an explicit MOS of 25% of the TMDL (Table 2 of this Decision Document; Section 8.3.3 of the TMDL). IEPA noted that the 25% is reasonable due to the results of the model calibration and the differences between the observed and calibrated

values. The average TP concentration from the TP data is 0.087 mg/L, and the average TP concentration simulated by the CE-QUAL-W2 model is 0.070, corresponding to a 25% difference. This results in a MOS of 5.8 lbs/day.

EPA finds that the TMDL document submitted by IEPA has an appropriate explicit 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:
IEPA accounted for seasonal variation via the modeling process. As noted in Section 8.3.8 of the TMDL, the model inputs focused on the April-October period over 13 years, corresponding to when the lake water quality data were collected, as well as representing the impact of where the TP loadings were the greatest. The CE-QUAL-W2 model was run to determine annual loads as well as daily loads, to allow Best Management Practices (BMPs) to be utilized year-round.

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:
Section 9 of the TMDL discusses reasonable assurance for Canton Lake. Reasonable assurance does not strictly apply to the Canton Lake TMDL, as there are no point sources contributing to the impairment. However, IEPA provided information on controls of TP that will be targeted to the watershed.

Section 9.3.1 of the TMDL discusses various BMPs that, when implemented, will significantly reduce phosphorus to attain WQS. IEPA noted that reductions in sediment are also needed to attain standards, and therefore included discussions of sediment reductions resulting from the implementation of the BMPs. For example, the BMP analysis explains that changing from conventional/reduced tillage to no-till/strip till will reduce TP by 50%, and sediment by a similar amount (Section 9.3.1.1 of the TMDL). Details on the BMPs are found in Section 10 of this Decision Document.

IEPA also identified Highly Erodible Land (HEL), where soil type and slope indicate that soils will be more highly erodible. Figure 13 of the TMDL identifies known HEL lands. IEPA noted that not all of the watershed has been analyzed for erosion status, and that more lands will likely be identified as HEL. IEPA calculated that at least 21% of the cropland in the county could be classified as HEL.

Reasonable assurance is also demonstrated by the City of Canton. The city has a set of ordinances designed to protect the lake for public health and as a resource. For example, the City required existing septic systems to be inspected by the Fulton County Health Department, and replaced if found to be failing. The City also has a Master Plan that limits the construction around Canton Lake and much of the watershed, to ensure impacts are reduced or eliminated. Cost estimates for the BMPs were provided in Section 9.3.2 of the TMDL. The cost rates are based upon Environmental Quality Incentives Program (EQIP) payment rates.

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 (Section 9.4 of the TMDL). There were three lake monitoring sites used to gather data for the TMDL. The TMDL document recommends monitoring continue at these sites, and suggests three additional sites be monitored, at the mouth of the three main tributaries to Canton Lake. These sites were monitored by the

Illinois State Water Survey (ISWS). The TMDL suggests these sites would be useful in determining BMP effectiveness as well as providing additional data on water quality.

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 Section 9 of the TMDL. These options are directed for sediment reductions as well as TP reductions.

The potential BMPs are:

- Cover crops
- No-till/strip till
- Water and Sediment Control Basins (WASCB)
- 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 TP and TSS loads. For example, the effectiveness of filter strips along streambanks was discussed. IEPA noted that the upper 1/3 of most tributaries in the watershed are bordered by cropland. Compared to the land use maps in the TMDL, IEPA determined about 3200 acres could benefit from filter strip BMPs (Section 9.3.1.2 of the TMDL).

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 December 6, 2012, to describe the watershed plan and TMDL process. The public comment period for the draft TMDL opened on March 2, 2017 and closed on April 5, 2017. A public meeting was held on March 22, 2017, in Waverly, 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 Canton City Hall and Parlin-Ingersoll Public Library. The draft TMDL was also made available at the website http://www.epa.state.il.us/water/tmdl/. No 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 May 2, 2017, EPA received the Canton Lake, Illinois TMDL, and a submittal letter from Sanjay Sofat, IEPA to Chris Korleski, 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 waterbody and the pollutant 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 TMDL for Canton Lake satisfies all of the elements of an approvable TMDL. This approval is for one TMDL for phosphorus for one waterbody.

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.

Canton Lake TMDL Development
Phase I Report

FINAL

June 2017

Prepared for
Illinois Environmental Protection Agency

Prepared by
Illinois State Water Survey

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1. Goals and Objectives for Canton Lake Watershed

1.1 Total Maximum Daily Load Overview

Section 303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (US EPA) Water Quality Planning and Management Regulations (40CFR Part 130) require states to identify water bodies that do not meet water quality standards and to determine the Total Maximum Daily Load (TMDL) for pollutants causing impairment. However, it is important to note that Total Maximum Daily Load (TMDL) has several connotations. First, it is a numerical value establishing the maximum amount of a pollutant that can be received by a water body without violating water quality standards and designated uses. Second, the process of establishing this numerical value is often called a TMDL. Third, TMDL is also used to describe the program that drives the process.

Under the Clean Water Act, Section 303(d), the State of Illinois is required to biannually produce a list of waters in which water quality standards are not met. Such waters are designated as impaired with respect to their designated uses and are often referred to as the 303(d) listed waters. TMDL studies are required by the Clean Water Act for all waters that are designated as impaired, addressing each constituent identified as a cause of the impairment.

For each constituent, the TMDL is determined using the following general formula:

$$TMDL = WLA + LA + MOS + RC$$

where WLA is Waste Load Allocation and refers to a load discharged to a water body by point sources; LA is Load Allocation and refers to a load that enters the water body from non-point sources and natural background; MOS is Margin of Safety that accounts for uncertainty; and RC is Reserve Capacity that allows for future growth.

The Illinois Environmental Protection Agency (IEPA) has traditionally utilized a three-stage approach to TMDL development. Stage 1 provides for watershed characterization, data analyses, and methodology development. Stage 2, if determined to be necessary during Stage 1, consists of monitoring and data collection. Stage 3 includes TMDL calculation, typically using computer simulation models, and the development of TMDL scenarios and an implementation plan. For those constituents that contribute to the impairment but do not have a numeric water quality standard, the IEPA utilizes the development of Load Reduction Strategies (LRS). Development of an LRS follows the same general assessment and evaluation methods as a TMDL. However, it does not allocate TMDL to individual point and nonpoint sources as WLA and LA, respectively.

This project includes activities normally associated with Stage 1 and Stage 2. This approach represents a joint endeavor of the IEPA and the Illinois State Water Survey (ISWS) to conduct scientifically-based TMDLs using data adequate for load calculation, water quality assessment, source tracking, and model calibration. For this TMDL, Stage 1 and Stage 2 are being carried out simultaneously, collecting one year of stream water quality and discharge data for analyses and modeling approach recommendations and an additional six months of data for model development and verification of stream conditions. The integrated monitoring effort is essential to enable a realistic TMDL determination and to support credible recommendations. Consequently, we will refer to this combined approach as Phase I, and, to remain consistent, we will refer to Stage 3 as Phase II.

1.2 TMDL Goals and Objectives for Canton Lake Watershed

The overall goals and objectives of the TMDL study for the Canton Lake are:

- Collect intensive water quality and discharge data to describe pollutant loadings to the impaired water body
- Gather and analyze data describing the impaired water body's watershed
- Assess water quality of the impaired water body and its tributaries
- Identify potential pollutant sources and key issues associated with the impairments
- Determine current load allocations to pollutant sources within the contributing watershed
- Determine the load reductions necessary to meet water quality standards
- Develop an implementation plan that will accomplish needed load reductions
- Inform and involve the stakeholders during all stages of TMDL development

The IEPA releases Integrated Water Quality Reports every two years, and these present a detailed assessment of Illinois streams and lakes. The two latest reports, 2014 and 2016 list Canton Lake as impaired for, total phosphorus, total suspended solids, and mercury (Table 1-1). The TMDL will be developed for total phosphorus only.

Table 1-1. Causes of impairment for Canton Lake (from IEPA, 2014, 2016).

Water body	IEPA Segment ID	Impaired use	Causes of Impairment
Canton Lake	RDD		
		Aesthetic Quality	Total Phosphorus
			Total Suspended Solids
		Fish Consumption	Mercury

1.3 Report Overview

This section provides an overview of the remaining sections of this report:

Section 2. Canton Lake Watershed Characterization describes watershed characteristics such as land use, soils, topography, population, and climate data. This section also includes stream and reservoir data.

Section 3. Public Participation and Involvement discusses and provides a schedule of the events planned to provide for public participation and involvement throughout the TMDL development process.

Section 4. Canton Lake Water Quality Standards defines water quality standards applicable to Canton Lake based on its designated uses.

Section 5. Water Quality Conditions presents water quality data available for the Canton Lake watershed. Historical data as well as data collected during this project are presented. This section also includes discussion on point and non-point source contributions.

Section 6. TMDL Approach summarizes observations and conclusions from previous sections. This section also discusses a recommended approach for modeling potential causes of impairment during Phase II of TMDL development for Canton Lake.

2. Canton Lake Watershed Characterization

2.1 Canton Lake Watershed Location

Canton Lake is an impounding reservoir on the West Branch Copperas Creek in western Illinois (Figure 2-1 and Figure 2-2). West Branch Copperas Creek originates in northeast Fulton County and flows in a southeasterly direction towards the Illinois River. The lake's spillway is located approximately 5.9 river miles above the confluence of West Branch Copperas Creek with the Illinois River. The Canton Lake watershed drains approximately 15 square miles (9,600 acres) and is located entirely within Fulton County. The Canton Lake watershed is a sub-watershed of HUC 10 watershed 0713000304.

Figure 2-1. Canton Lake

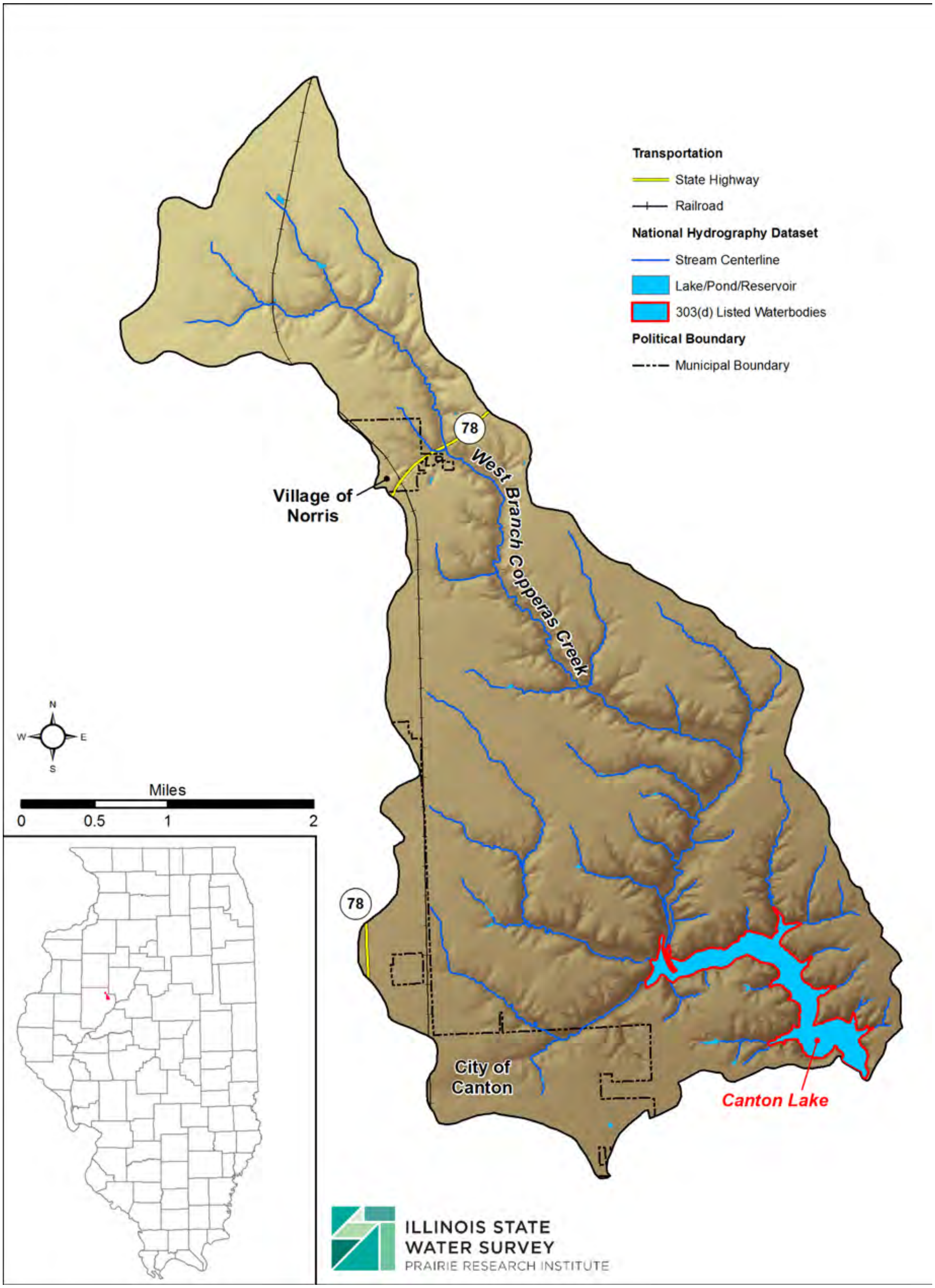

Figure 2-2. Canton Lake watershed

2.2 Land Use

Land use/land cover data were obtained from the Illinois Gap Analysis land cover classification (IDOA, 2000). Data were compiled using 1999-2000 satellite imagery collected from three dates during the spring, summer, and fall seasons of 1999 and 2000 at a 30x30 meter resolution. The 1999-2000 land cover data (Table 2-1, Figure 2-3) show nearly two-thirds of the watershed is dedicated to agriculture and crops. During the time of imagery acquisition, corn was the prevalent crop in the area, followed by soybeans. However, row crops are typically rotated, so the percentage of the watershed planted in each will vary year to year. The second highest major land cover category in the watershed is forested land. The 1999-2000 land cover data estimate more than 20% of the watershed is forested. Forested areas are found primarily along West Branch Copperas Creek and its major tributaries. Approximately 10% of the watershed is developed/urban area, located predominantly in the southwestern portion of the watershed. A detailed examination of aerial photography from 1999 and 2009 showed only minimal change in land cover during this time period.

Table 2-1. 1999-2000 Land cover in the Canton Lake watershed

Land Use Category	% Area	Total %
AGRICULTURAL LAND		63.70%
Corn	27.60%	
Soybeans	26.50%	
Rural Grassland	9.37%	
Winter Wheat	0.22%	
FORESTED LAND		21.21%
Upland: Dry-Mesic	15.88%	
Upland: Mesic	2.93%	
Partial Canopy/Savanna Upland	1.44%	
Upland: Dry	0.96%	
URBAN AND BUILT-UP LAND		8.99%
Urban Open Space	3.94%	
Low/Medium Density	3.76%	
High Density	1.29%	
WETLAND		3.28%
Floodplain Forest: Wet-Mesic	2.01%	
Floodplain Forest: Wet	0.97%	
Seasonally/Temporarily Flooded	0.23%	
Shallow Marsh/Wet Meadow	0.05%	
Shallow Water	0.01%	
OTHER		2.81%
Surface Water	2.79%	
Barren and Exposed Land	0.01%	

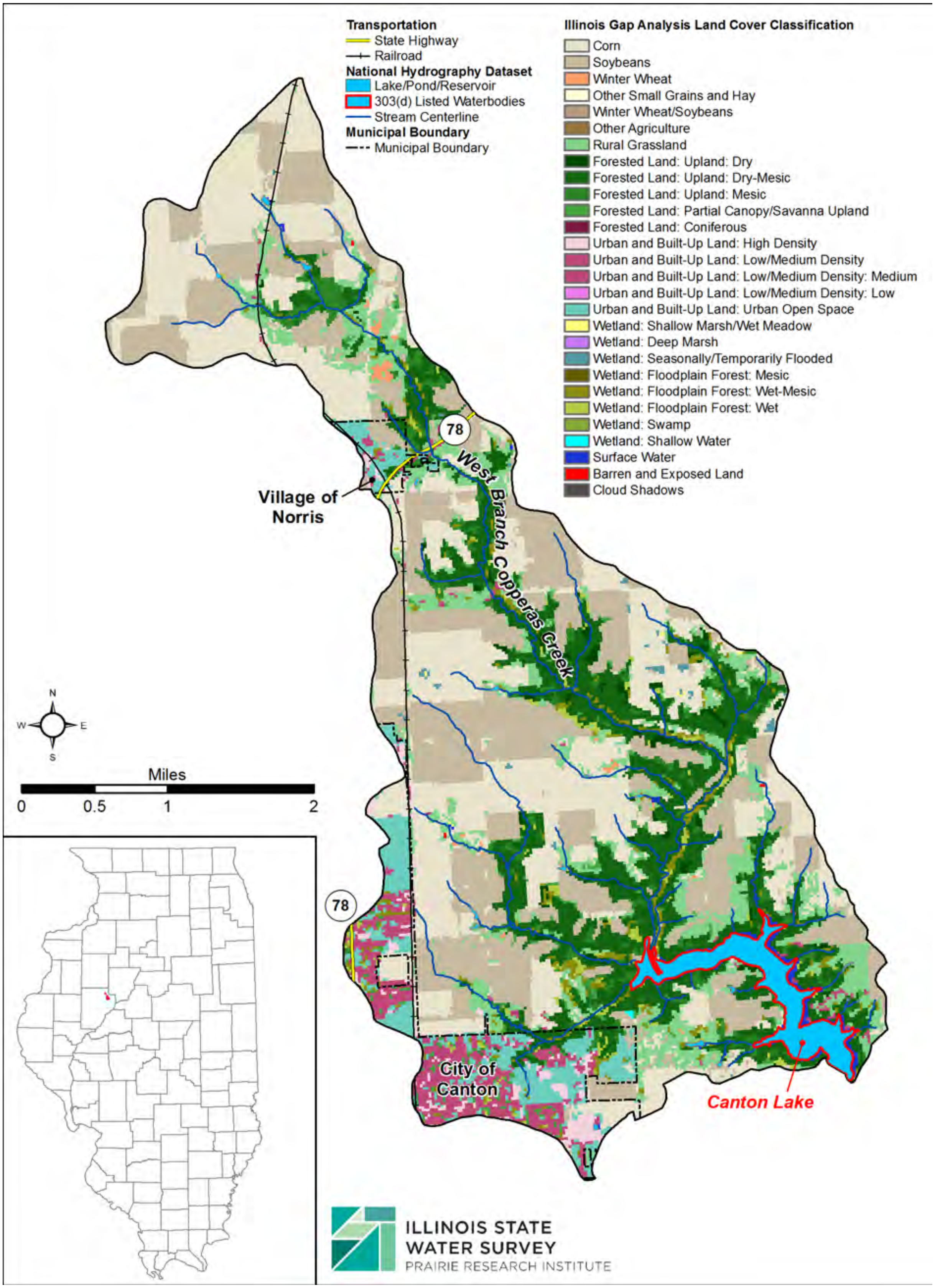

Figure 2-3. 1999-2000 Land cover in the Canton Lake Watershed

2.3 Soils

The most detailed soil information available was obtained in electronic form from the Soil Survey Geographic (SSURGO) database for Illinois, produced by the Natural Resources Conservation Service (NRCS, 2010). SSURGO datasets are completed on a county scale, and their level of mapping detail matches the original printed county soil surveys. SSURGO maps delineate map units or areas with similar soil components that exhibit similar characteristics. These map units are linked to an attribute database that provides information on individual soil characteristics as well as aggregated information for entire map units.

Soils are mostly classified as silt loam or silty clay loam (USDA, 2001). The drainage class of soils within the Canton Lake watershed is summarized in Table 2-2 and displayed by the map unit in Figure 2-4. The majority of soils in the watershed (54%) are classified as well drained or moderately well drained.

Hydrologic soil groups in conjunction with land use, land management practices, and hydrologic conditions determine the runoff curve number for a location (NRCS, 2009). In hydrologic models, runoff curve numbers can be used to estimate direct runoff from rainfall. Table 2-3 and Figure 2-5 show the distribution of hydrologic soil groups based on the properties of the major soil in each map unit within the Canton Lake watershed. The majority of soils (64%) fall into hydrologic soil group B, where the potential for runoff is moderately low for saturated soils and water transmission through the soil is unimpeded. Group C soils comprise 26% of the watershed and describe soils with moderately high runoff potential when saturated. Group D soils have high runoff potential when saturated and are extremely rare in this watershed. Soils designated by the NRCS as B/D are those which would be classified as Group D without the presence of tile drains; when drained, the soils behave more like Group B soils.

Soil erosion is common on steeper slopes near streams and can seriously impact aquatic life by altering channel capacity and geometry. Quiet-water pools along streams are in particular danger of sediment accumulation through erosion as well as accumulation of pesticides and other chemicals adsorbed to the eroded soils (IDNR, 2001a).

The NRCS maintains records of lands considered highly erodible. Highly erodible land (HEL) determinations are made using 1990 soils information and soil map units. The soils information used is always the information that was available in January 1990 for the county, which provides a level playing field for participants of farm programs that rely on HEL determinations. A soil map unit is considered highly erodible if the predominant soil type is highly susceptible to erosion. Potential highly erodible land (PHEL) is an area that cannot be determined as either HEL or non-HEL using the available 1990 data alone and requires a field survey to classify it (USDA NRCS, 2011).

Only 5% of the Canton Lake watershed is classified as highly erodible land (HEL). Fifteen percent of the watershed is classified as non-HEL and the majority of the watershed (80%) is not classified as either HEL or non-HEL (Table 2-4). HEL areas typically occur near stream channels, and NHEL areas are typically located in upland areas with gentler slopes (Figure 2-6).

Table 2-2. Drainage class of soils in the Canton Lake watershed

Drainage Class	Percent Coverage
Well drained	32%
Moderately well drained	22%
Somewhat poorly drained	36%
Poorly drained	7%
Water	2%

Table 2-3. Hydrologic soil groups in the Canton Lake watershed

Group	Percent Coverage
B	64%
B/D	7%
C	26%
D	< 0.1%
Water	3%

Table 2-4. Highly erodible land in the Canton Lake watershed

Group	Percent Coverage
Highly Erodible Land	5%
Non Highly Erodible Land	15%
Not Classified	80%

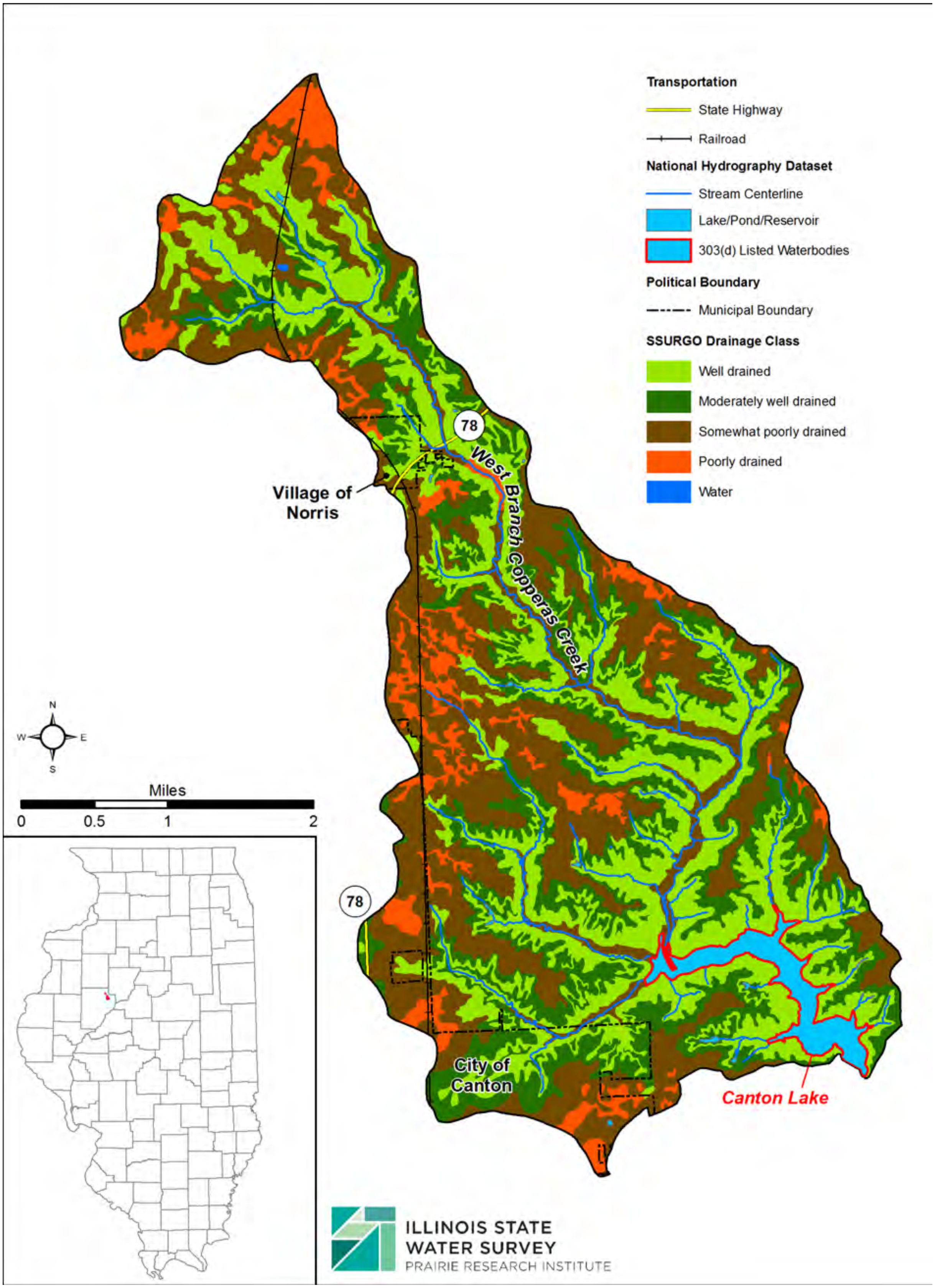

Figure 2-4. Canton Lake watershed soil drainage classes

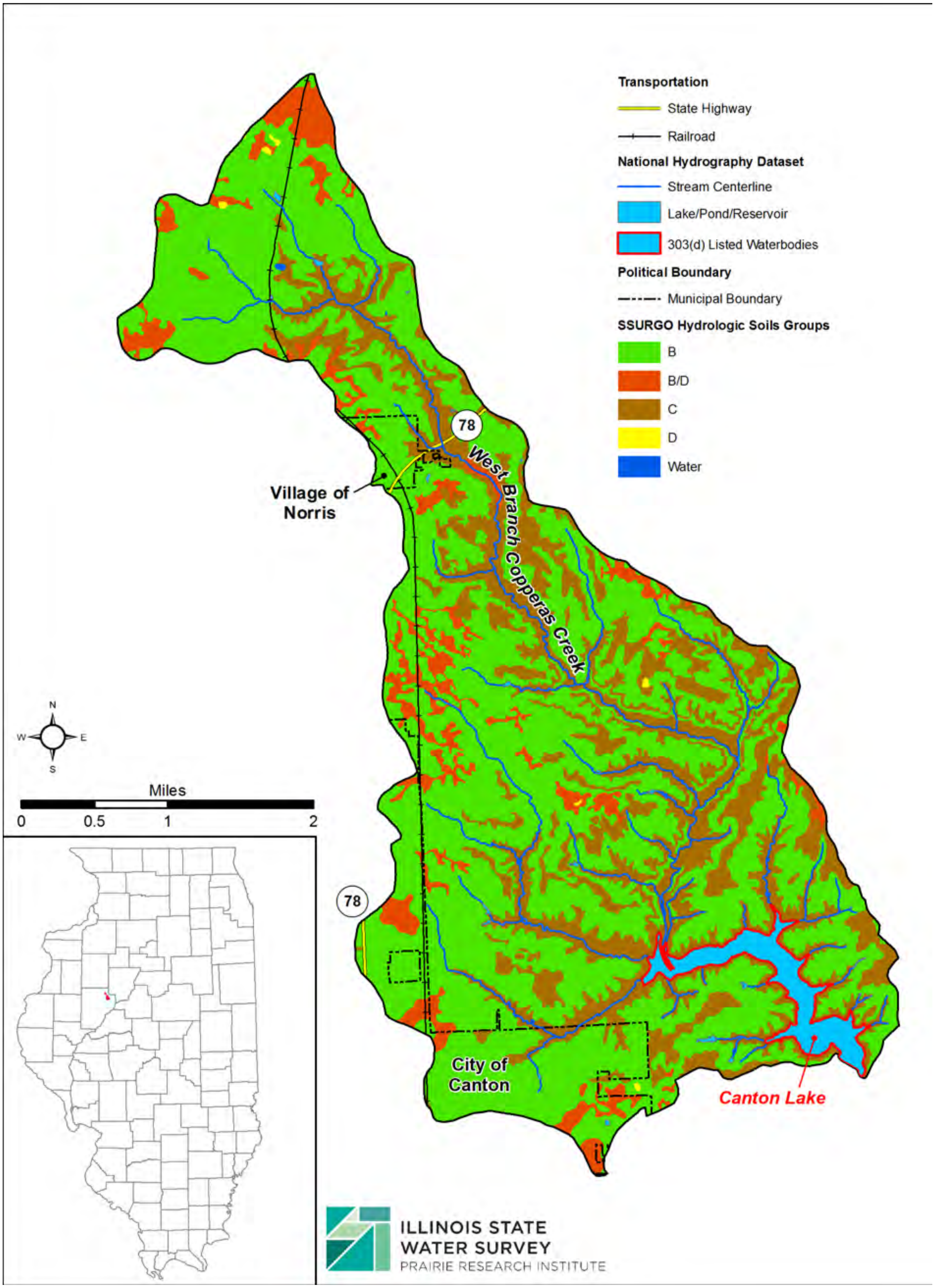

Figure 2-5. Canton Lake watershed hydrologic soils groups

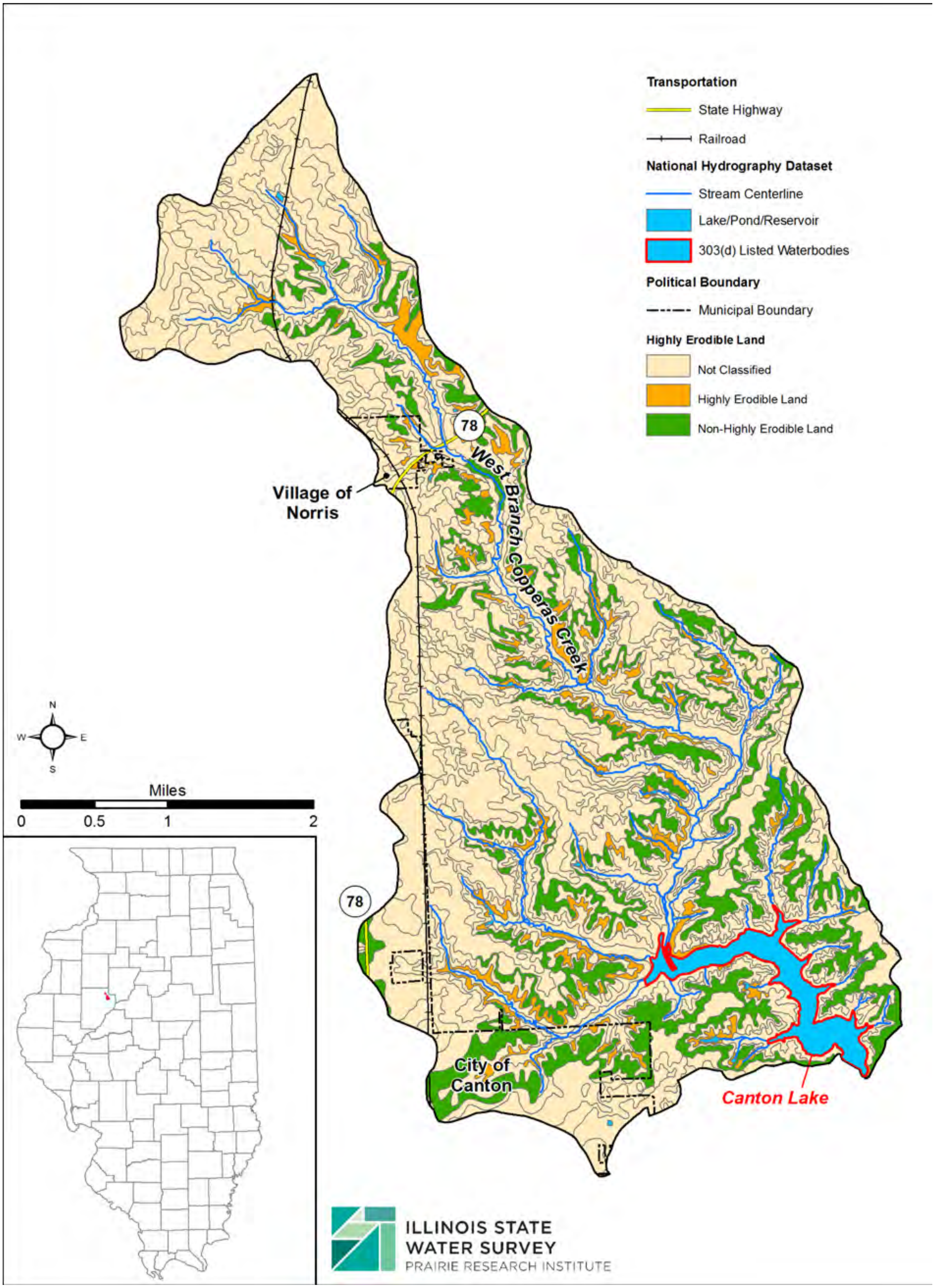

Figure 2-6. Canton Lake watershed erodible lands

2.4 Topography

Topographic information was obtained from the U.S. Geological Survey (USGS) National Elevation Dataset (NED). The USGS (2010) distributes the NED as a seamless layer via the internet. The digital elevation data obtained were at a resolution of 10 meters (1/3 Arc Second). All elevations presented are in North American Vertical Datum of 1988 (NAVD 88). Land surface elevations in the Canton Lake watershed range from 776 feet along the northern edges of the study area to 568 feet near Canton Lake (Figure 2-7).

2.5 Geology

Bedrock geology data were obtained from the Illinois Natural Resources Geospatial Data Clearinghouse (ISGS, 2005). The data were provided at a scale of 1:500,000 and are in North American Datum of 1983 (NAD 83). The geology of the study area consists of Carbondale bedrock in the south and Shelburn-Patoka bedrock in the north (Figure 2-8).

Loess thickness data were obtained from the Illinois State Geological Survey (ISGS, 1997). The data were provided at a scale of 1:500,000 and are in NAD 83. Loess deposits in the entire Canton Lake watershed are approximately 10 feet thick (Figure 2-9). This is typical of the region and for areas near the Illinois River (IDNR, 2001a).

Glacial drift data were obtained from the Illinois Natural Resources Geospatial Data Clearinghouse (ISGS, 1994). The data were provided at a nominal scale of 1:500,000 and are in NAD 83. Glacial drift thickness in the Canton Lake watershed ranges from less than 25 feet to between 50 to 100 feet (Figure 2-10). This is a relatively thin deposit when compared to nearby regions in Illinois which can exceed over 500 feet in thickness (IDNR, 2001a).

2.6 Aquifer

Aquifer data were obtained from the Illinois Natural Resources Geospatial Data Clearinghouse (ISGS, unpublished). The data were provided at a scale of 1:500,000 and are in NAD 83. This data source defines potable water as water containing less than 2,500 milligrams per liter (mg/l) total dissolved solids (TDS). The entire Canton Lake watershed rests above a non-potable aquifer at a depth greater than 500 feet that yields water containing 2,500 to 10,000 mg/l of TDS (Figure 2-11).

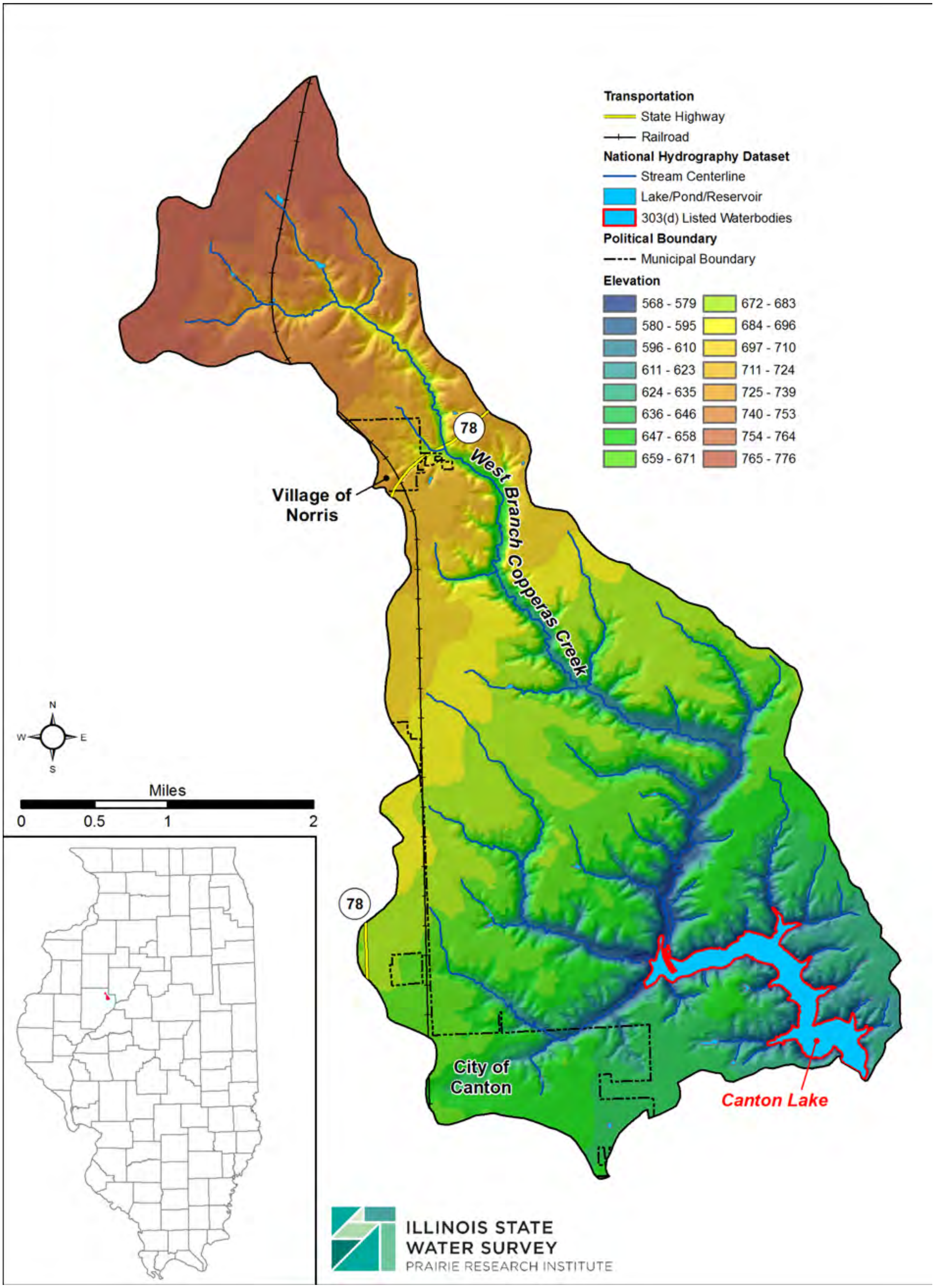

Figure 2-7. Canton Lake watershed elevation

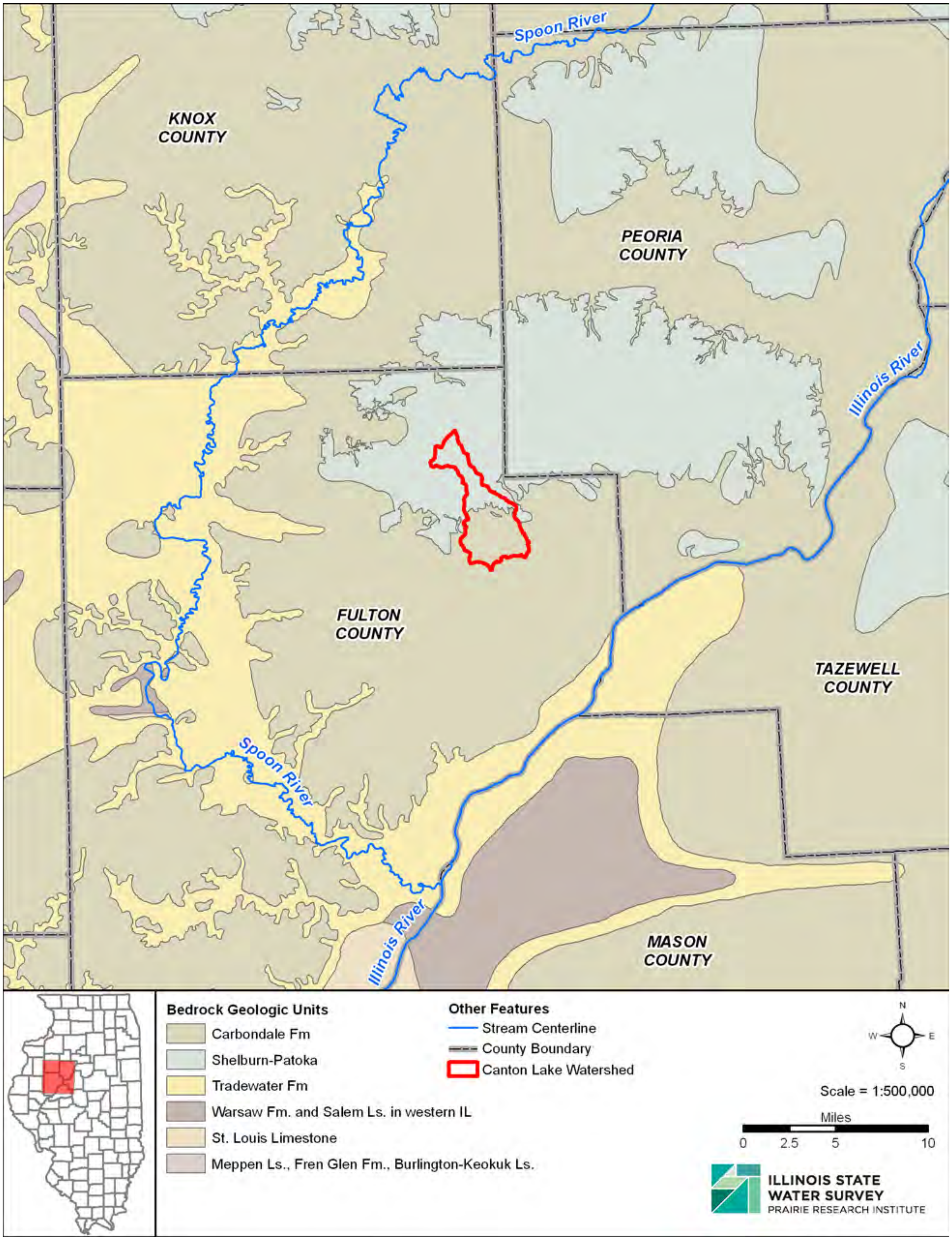

Figure 2-8. Bedrock geology of the Canton Lake watershed

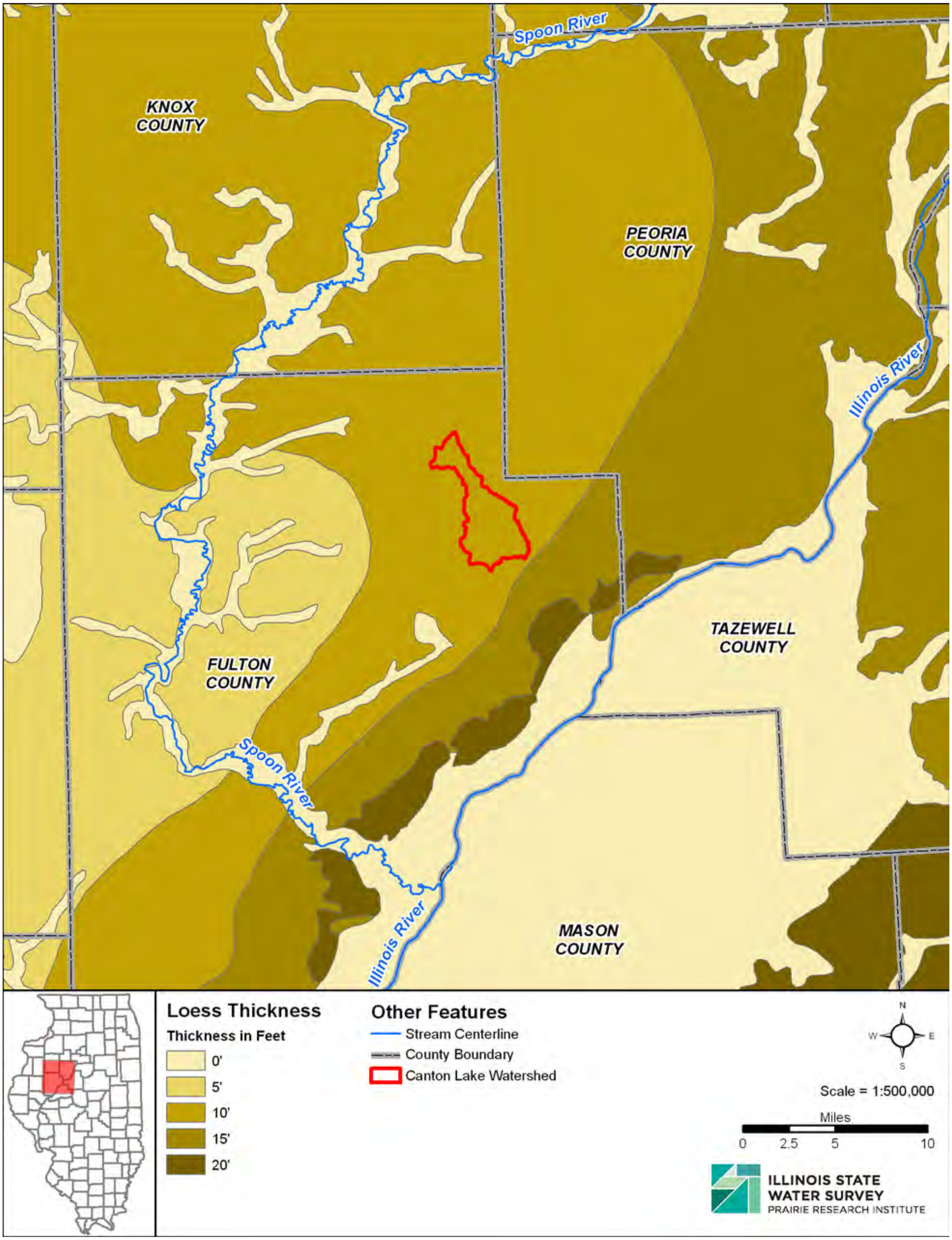

Figure 2-9. Loess thickness in the Canton Lake watershed

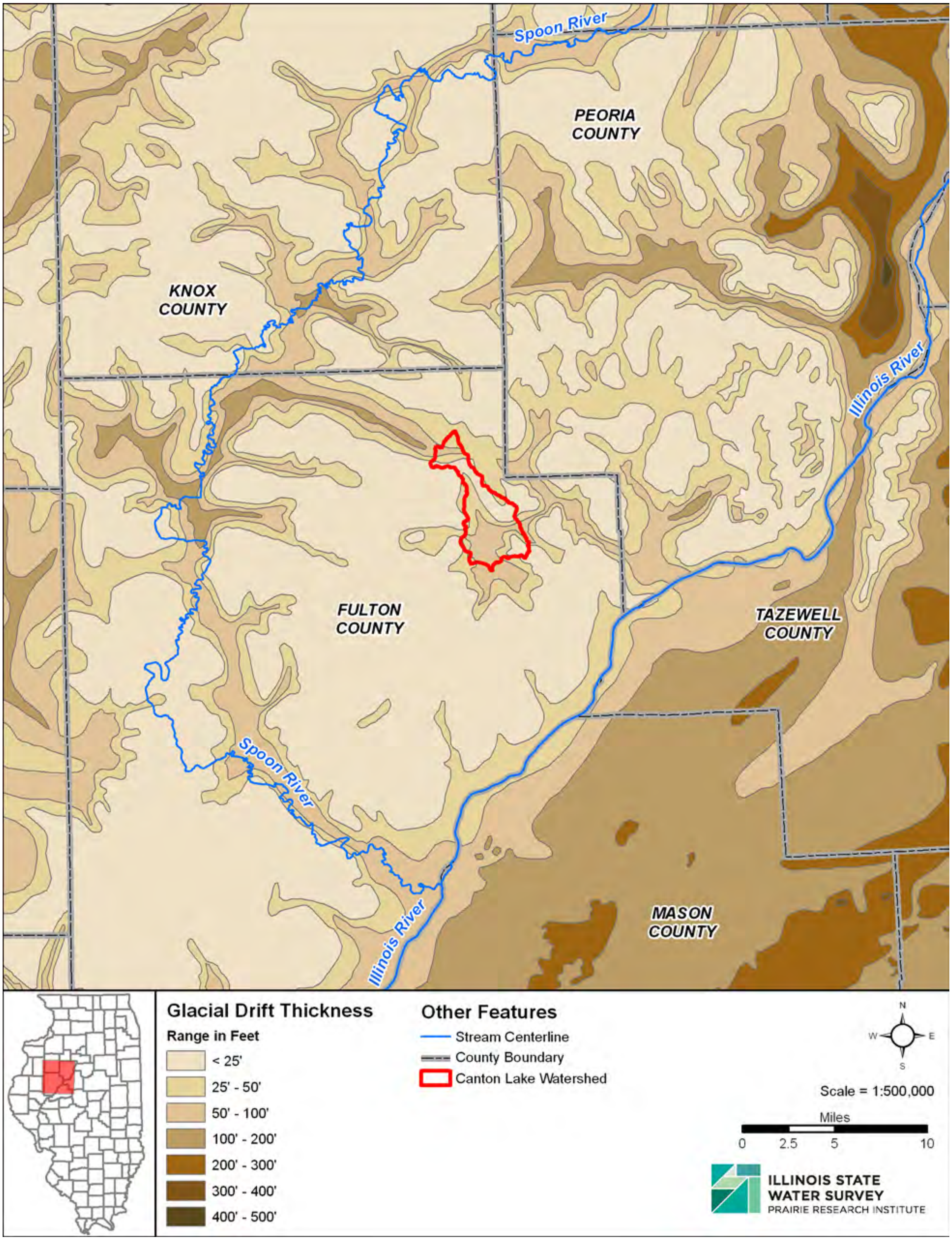

Figure 2-10. Glacial drift thickness in the Canton Lake watershed

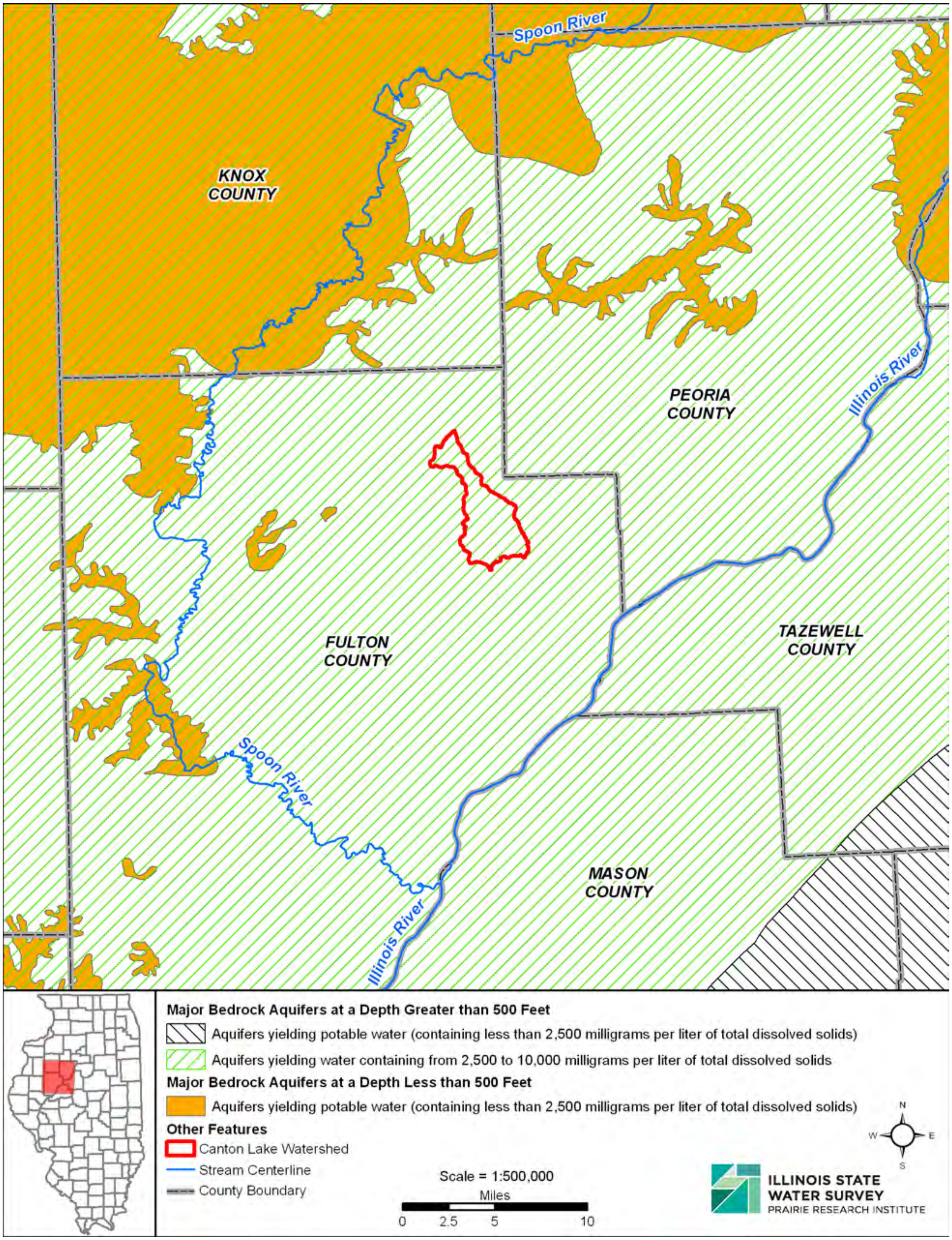

Figure 2-11. Major bedrock aquifers in the Canton Lake watershed

2.7 Population

Maps delineating census blocks from the 2000 U.S. Census were obtained as Geographic Information System (GIS) shapefiles from the U.S. Census TIGER website (U.S. Census Bureau, 2010b). Data on population by block were obtained from the U.S. Census American FactFinder website (U.S. Census Bureau, 2010a). Population densities within the Canton Lake watershed were estimated by dividing the population in each block by that block's area. The census blocks were then clipped to the Canton Lake watershed boundary and the total watershed population was estimated based on the percentage of area located within the watershed. The total estimated population within the watershed is 4,306 persons. The population density is highest in the southwestern edge of the watershed, which contains part of the City of Canton. Two additional communities, Norris and Brereton, reside partially or wholly within the watershed. Outside of these areas the watershed generally has a low density of less than 50 persons per square mile.

2.8 Climate Data

The climate of this area is continental, defined as changeable weather with warm summers and cold winters (IDNR, 1998). The temperature and precipitation data presented in this report were obtained from the Midwest Regional Climate Center (MRCC, 2010). In order to provide temperature and precipitation values that are representative of recent climatic conditions, some of the climate data presented are climate "normals", a 30-year average computed by the National Climatic Data Center every 10 years (NCDC, 2005). The climate normals computed for the period 1971-2000 are the most recent data available.

2.8.1 Temperature

Temperature data were obtained from the MRCC Applied Climate System (MACS) for Peoria, IL (Station ID 116711). Peoria is located approximately 17 miles east of the study area (Figure 2-12) and has the longest period of record (1896-2011) in the area. The average maximum and minimum temperatures for Peoria are displayed by month in Figure 2-13. A summary of temperature data for Peoria is presented in Table 2-5. The maximum and minimum temperatures presented are the normal temperatures from 1971 to 2000, and the extreme temperatures presented are from anytime during Peoria's period of record (1901-2010). With an average high temperature of 86° F, the warmest month in Peoria is July. The lowest temperatures occur in December, January, and February when both maximum and minimum values average less than 40° F. The warmest day on record at Peoria occurred on July 15, 1936 when temperatures reached 113° F. The low on February 13, 1905 of -26° F is the lowest temperature on record at Peoria.

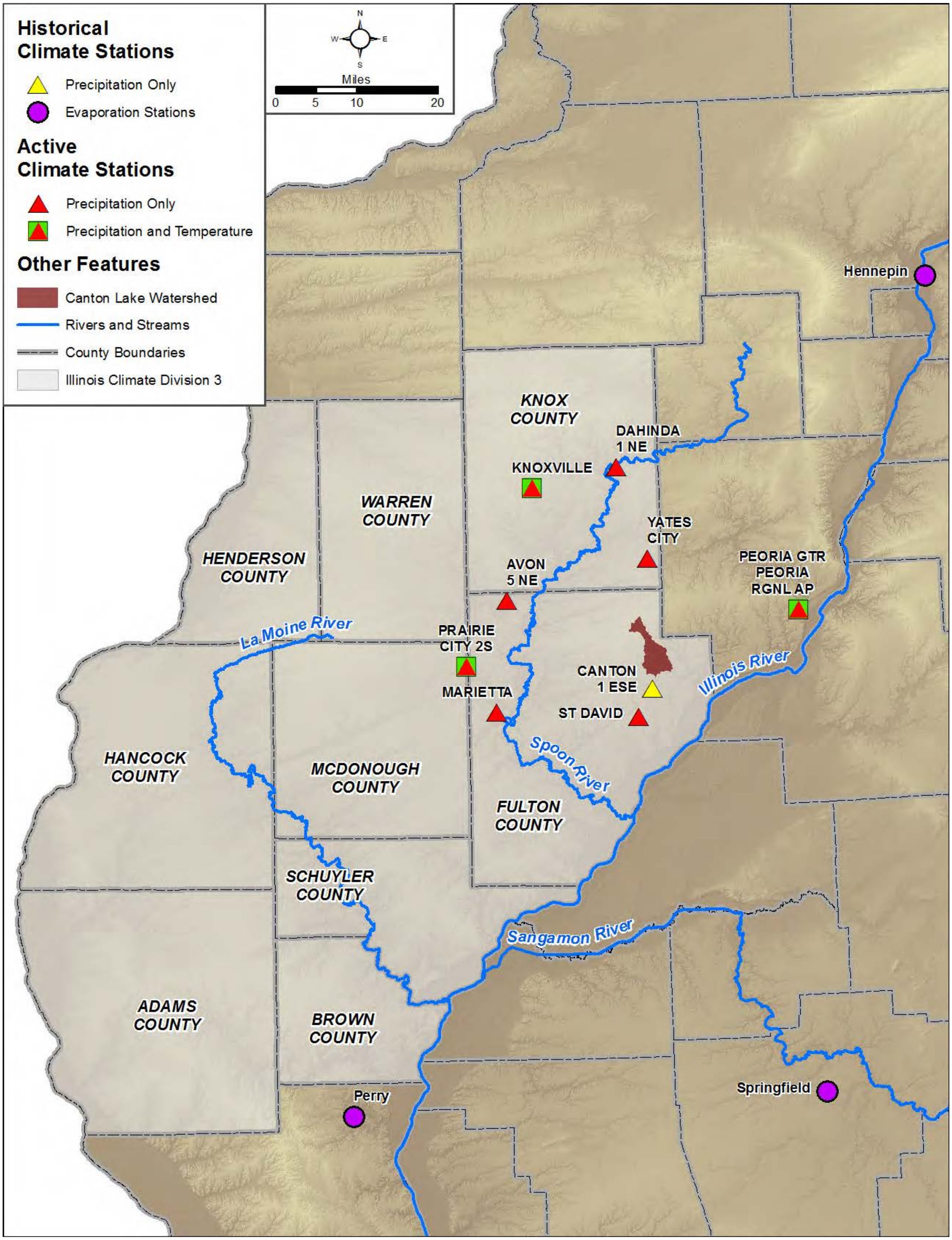

Figure 2-12. Climate stations near the Canton Lake study area

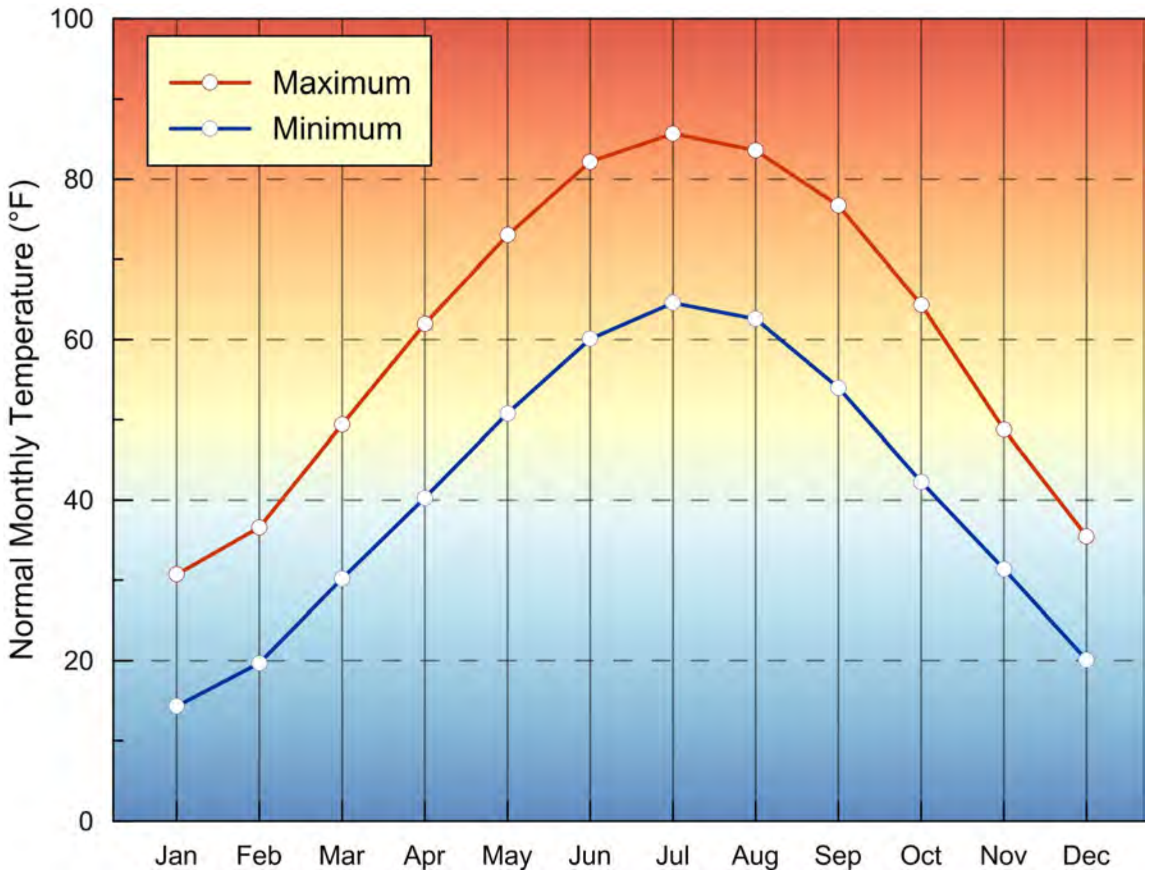

Figure 2-13. Normal monthly temperatures at Peoria, IL, 1971-2000

Table 2-5. Temperature summary for Peoria, IL (°F)

	Average High	Average Low	Record High (Year)	Record Low (Year)
January	30.7	14.3	71 (1909)	-25 (1977)
February	36.6	19.7	74 (1932)	-26 (1905)
March	49.4	30.2	87 (1907)	-11 (1943)
April	62.0	40.3	92 (1899)	14 (1920)
May	73.0	50.8	104 (1934)	25 (1966)
June	82.2	60.1	105 (1934)	39 (1945)
July	85.7	64.6	113 (1936)	46 (1911)
August	83.6	62.6	106 (1936)	41 (1910)
September	76.7	54.0	104 (1899)	24 (1942)
October	64.4	42.3	93 (2006)	7 (1925)
November	48.8	31.4	81 (1937)	-2 (1977)
December	35.5	20.1	71 (1970)	-24 (1924)

2.8.2 Precipitation

Precipitation data for Canton, IL (Station ID 111250) were available from MACS from 1940 to 2004. The Canton precipitation station was discontinued in 2004, but a new station, approximately 7 miles southwest of the study area, was established at St. David, IL in 2005 (Figure 2-14).

The normal monthly variation in precipitation at Canton is displayed in Figure 2-14 and Table 2-6. Annual average precipitation at Canton is approximately 40 inches. More rain falls in the late spring and early summer than other times during the year. The month of May averaged 4.79 inches of precipitation from 1971 to 2000. However the wettest month on record is September 1961, when a total of 13 inches of precipitation fell.

Snowfall at Canton can be expected from November to April, though it is most common from December to March. The month of January historically has the highest amount of total snowfall, averaging 7.6 inches from 1971 to 2000.

In addition to the seasonal variation in precipitation, there can also be considerable variability in the annual totals. Because the precipitation record at Canton ended in 2004, precipitation data for the Western Illinois climate division (CD 3) is presented in Figure 2-15. The wettest year on record for this nine-county region was 1973 (54.57 inches) with 16.63 inches above normal. The driest year on record was 1988 (22.14 inches), 15.8 inches below normal.

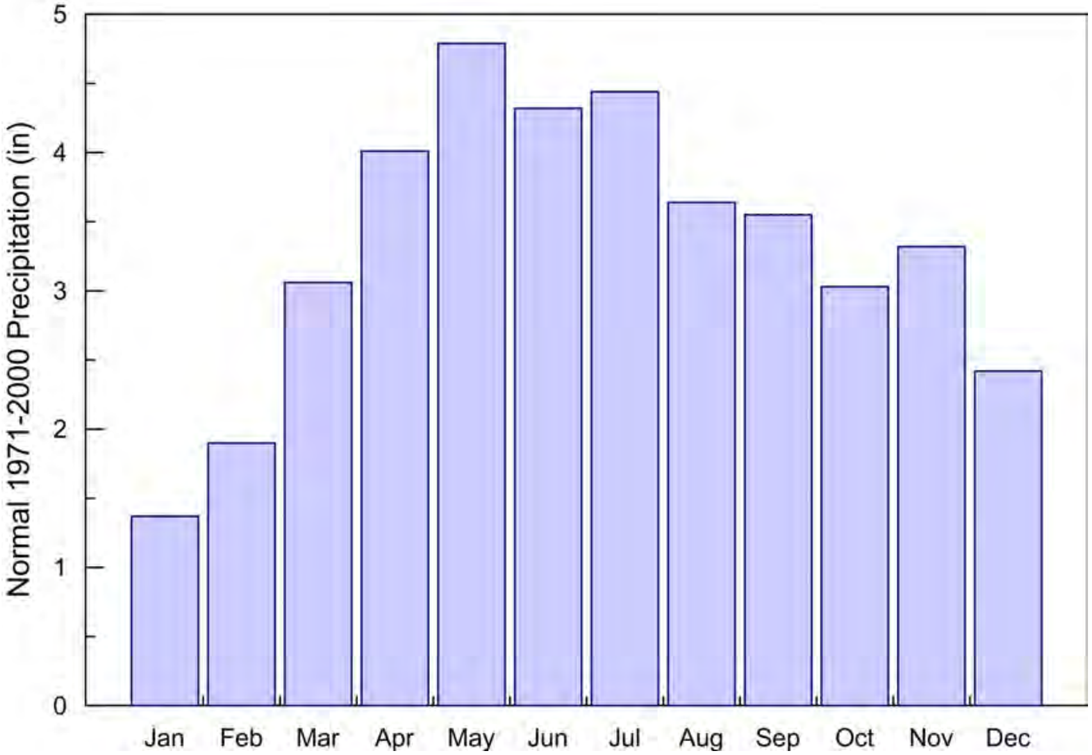

Figure 2-14. Normal monthly precipitation at Canton, IL

Table 2-6. Monthly distribution of precipitation at Canton, IL (inches)

	Average	*Record High (Year)*	*Record Low (Year)*
January	1.37	7.35 (1965)	0.19 (1956)
February	1.90	5.54 (1997)	0 (2003)
March	3.06	6.75 (1944)	0.24 (1994)
April	4.01	7.88 (1967)	0.92 (1986)
May	4.79	11.94 (1998)	0.44 (1964)
June	4.32	10.38 (1990)	0.72 (1988)
July	4.44	12.66 (1993)	0.18 (1947)
August	3.64	9.52 (1977)	0.55 (1992)
September	3.55	13.00 (1961)	0.02 (1979)
October	3.03	10.46 (1941)	0.05 (1964)
November	3.32	10.09 (1985)	0.13 (1999)
December	2.42	8.92 (1982)	0 (2000)
Annual	39.85	63.51 (1993)	21.54 (1988)

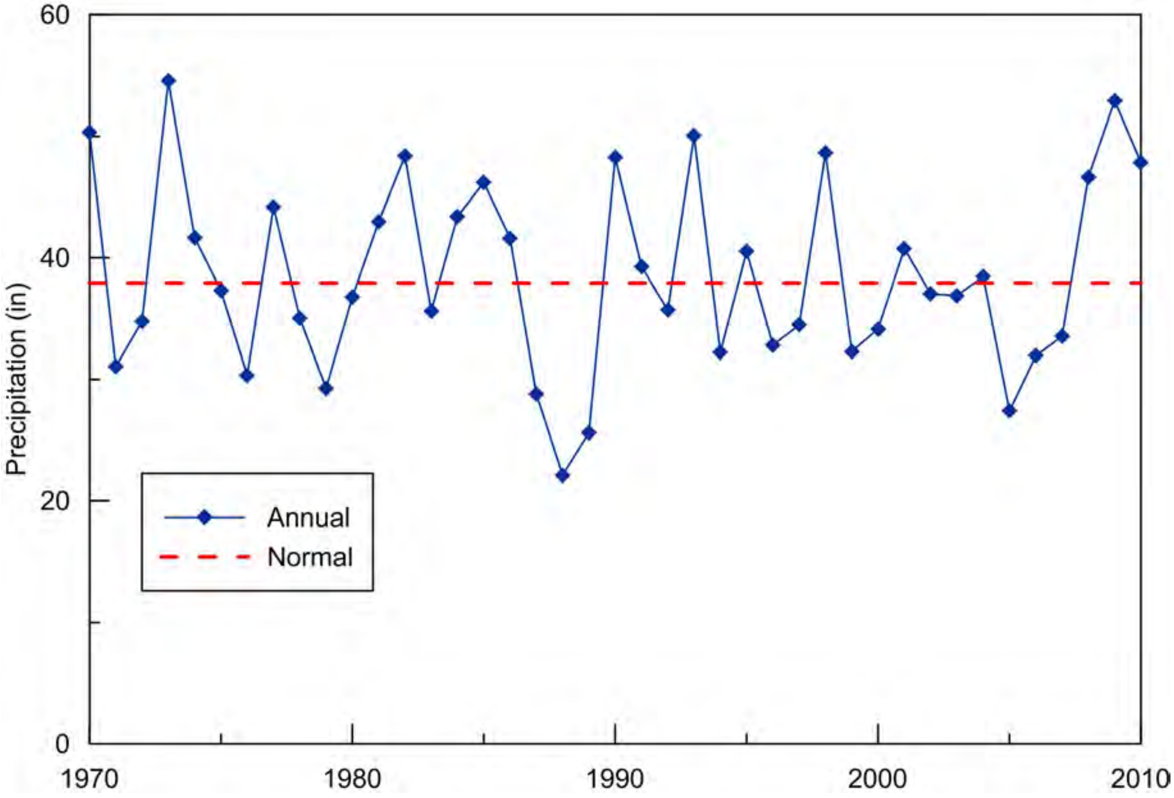

Figure 2-15. Annual and normal precipitation in Illinois climate division 3

2.8.3 Evaporation

Evaporative losses can be a significant component of the water budget for a reservoir. Because there can be considerable spatial and temporal variation in evaporation rates across Illinois, observed data for the period of interest should be used whenever possible. Pan evaporation data are available from the State Climatologist Office website at the Illinois State Water Survey (ISWS, 2011a). The ISWS website provides pan evaporation data for the warm season for nine sites across Illinois. Data from Springfield, Perry, and Hennepin were selected because of their proximity to the watershed (Figure 2-12) and their ranges in period of record (Table 2-7).

Table 2-7. Selected pan evaporation stations in Illinois

Station	Period of Record	
Perry	Apr-Sep	1996-2002
Springfield	Apr-Oct	1980-1990
Hennepin	May-Oct	1980-2005

Table 2-8 shows average pan evaporation at each station for their respective periods of record. Evaporation is typically highest in the summer months, May-August, during which time a loss of 7 to 9 inches/month can be expected. The highest evaporation rate measured was nearly 12 inches at Springfield in June 1988; Hennepin did not report data May-June 1988. Evaporation measured at Hennepin is lower than at Perry and Springfield. While the average evaporation rates presented for Springfield are higher than that measured at Perry, that difference appears to be due to the differing periods of record rather than a directional variation. The average evaporation May-September at Perry, Springfield, and Hennepin is 36.6, 38.6, and 33.3 inches, respectively. To estimate the evaporation rate from a natural body of water, pan evaporation data should be multiplied by a correction factor of 0.75 (ISWS, 2011a).

Table 2-8. Average pan evaporation data (inches/month)

Station	Apr	May	Jun	Jul	Aug	Sep	Oct
Perry	5.56	7.12	7.70	8.41	7.44	5.92	
Springfield	6.03	7.72	8.64	8.82	7.49	5.96	4.51
Hennepin		6.64	7.16	7.57	6.90	5.00	4.60

2.9 Surface Water Data

When investigating the water quality of an impounding reservoir, three types of surface water quantity information are critical: (1) the capacity of the reservoir, (2) inflow to the reservoir, and (3) outflow from the reservoir.

2.9.1 Reservoir Data

Canton Lake (IEPA Waterbody ID: IL_RDD) is an impounding reservoir created by damming the West Branch of Copperas Creek in 1939. The reservoir was constructed to serve as the water supply for the City of Canton. On a monthly basis between 1/2000 and 12/2011, an average of 63.24 million gallons of water was withdrawn from Canton Lake for drinking water purposes, with 50.27 million gallons being the minimum amount withdrawn (2/2006), and 77.12 million gallons being the maximum amount withdrawn (3/2000). The chronology of construction activities on the reservoir along with surveys to measure its capacity are outlined in Table 2-9.

Table 2-9. Canton Lake historical capacity information

Year	**Event**	**Estimated Capacity Added**	**Measured Capacity**	
		(MG)	(MG)	(ac-ft)
1939	Reservoir built		1145	3513
1951	Spillway raised 6 inches	36		
1960	Illinois State Water Survey Sedimentation Survey		985	3023
1971	Spillway raised 24 inches	163		
1986	City of Canton Sedimentation Survey		976	2994
1992	City of Canton Sedimentation Survey		984	3018

Recent (2010-2016) IEPA Integrated Water Quality Reports report Canton Lake as having a surface area of 250 acres. However, the high-resolution NHD indicates a surface area of approximately 230 acres for Canton Lake. In order to resolve this discrepancy, ISWS personnel obtained field measurements on July 8, 2011 to confirm this reduced surface area. The edge of water measurements did confirm that the surface area has been significantly reduced. Performing detailed bathymetric measurements were beyond the scope of this field reconnaissance, so a new surface area was not computed. In addition to edge-of-water measurements, depths were measured at select locations within the lake. The maximum depth measured was 29 feet.

Canton Lake's drainage area is more than 40 times larger than its surface area. Generally lakes with high ratios of watershed area to lake area are prone to poorer water quality than those lakes with lower ratios. Based on ratios computed for all of the lakes in the Illinois Natural History Survey's *Compendium of 143 Illinois Lakes* (Austen et al., 1993), the mean and median ratios of watershed to surface area for lakes in Illinois are 33 and 16, respectively.

Canton Lake is one of 36 reservoirs that provide month-end lake levels to the Illinois State Water Survey as part of its monthly Illinois Water and Climate Summary (http://www.isws.illinois.edu/warm/climate.asp). Reporting of reservoir information to ISWS is voluntary, and the method for determining lake level is at the discretion of the volunteer observer. This information is used primarily to help researchers and decision-makers identify drought conditions and assess their severity. ISWS hydrologists have participated in the Governor's Drought Response Task Force, which is activated during drought situations, with the benefit of this data. As a result of this effort, the Illinois State Water Survey has 20 years of month-end reservoir levels for Canton Lake.

2.9.2 Streamflow Data

To understand the hydrology of a watershed it is important to have long-term streamgage records. Unfortunately there are no active USGS streamgages in the Canton Lake watershed, nor has there ever been an active USGS streamgage in the watershed. The location of USGS streamgages near the Canton Lake watershed are listed in Table 2-10 and presented in Figure 2-16.

Table 2-10. Selected USGS streamgages near the Canton Lake watershed

USGS ID	Station Name	Drainage Area (mi^2)	Period of Record
05568800	Indian Creek near Wyoming, IL	62.7	1960-Present
05569500	Spoon River at London Mills, IL	1072.0	1943-Present
05570000	Spoon River at Seville, IL	1636.0	1914-Present
05584400	Drowning Fork at Bushnell, IL	26.3	1960-1983
05584500	La Moine River at Colmar, IL	655.0	1945-Present
05585000	La Moine River at Ripley, IL	1293.0	1921-Present

As part of the monitoring being conducted for this Phase I study, three streamgages were installed in the Canton Lake watershed between March, 2011 and November, 2012. While having this streamflow information at these three sites will be extremely valuable to this study, there can be significant variation in streamflows both within a year and from year to year, so it is also important to understand how this short-term record compares to the long-term annual and seasonal streamflows for the region.

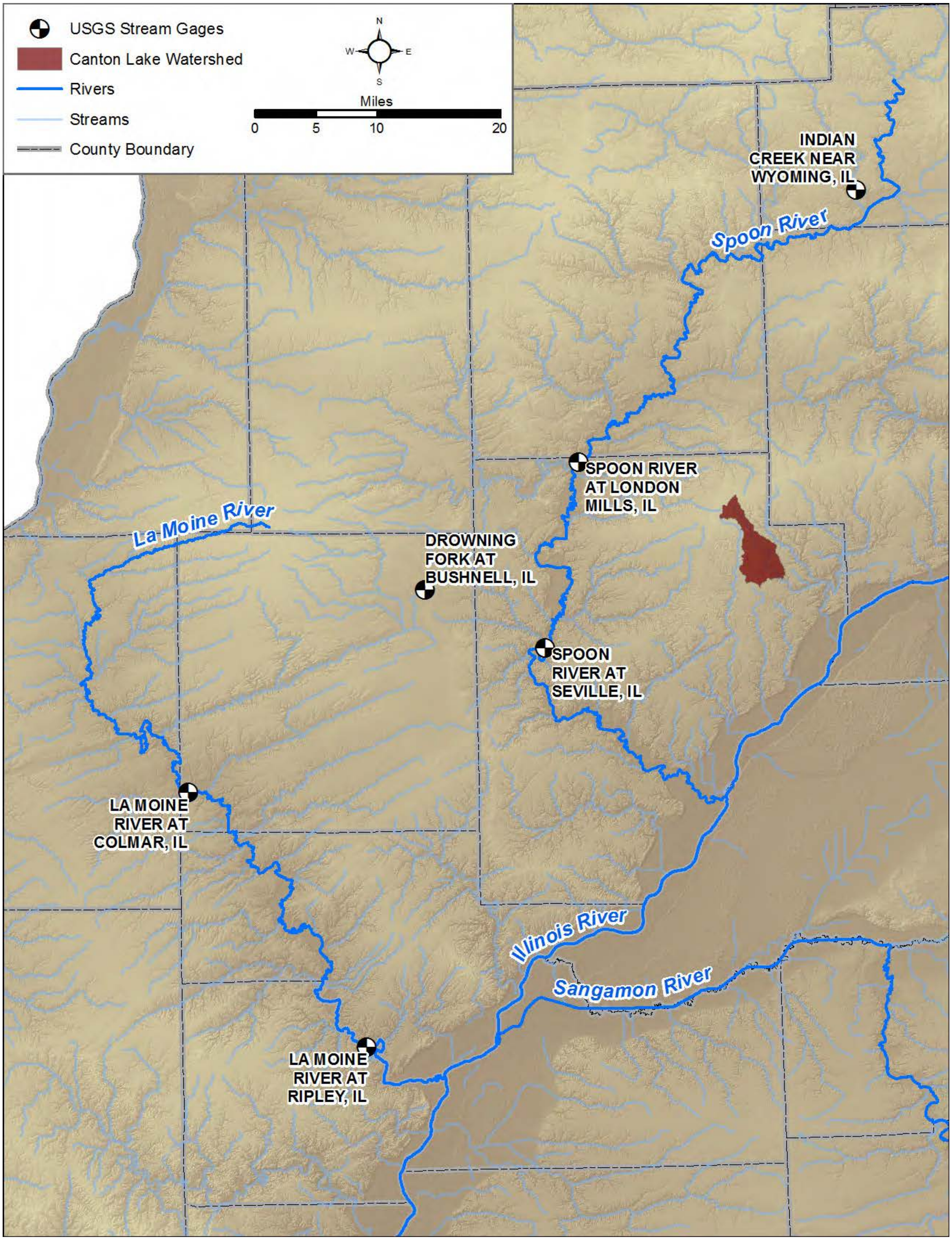

Figure 2-16. Selected USGS streamgages near the Canton Lake watershed

Annual Flow Variability. Precipitation is the largest driver in the annual variation of streamflow for a given site. While the magnitude of annual flows measured at the nearby USGS sites will vary dramatically due to their range in drainage areas, streamflow can be normalized as inches of runoff for each watershed. Displaying the streamflow as runoff illustrates the similar annual flows for gaged streams in this area of the state, despite differences in drainage area (Figure 2-17). When compared to the annual precipitation for west central Illinois (Figure 2-15), the relationship between precipitation and streamflow is especially evident in the years during and immediately following extreme precipitation deficits and/or surpluses. During the past 40 years, the greatest runoff at the two Spoon River sites and the two La Moine River sites occurred in 1993 and 2010, respectively. The annual runoff ranged from 25 to 30 inches at all five active gages in 1993 and exceeded 30 inches at the two La Moine River gages in 2010. During the past 40 years, the drought of 1988-1989 was the driest two-year period at these sites; annual runoff totaled less than 5 inches in 1989 at all five active gages. Due to this large range in possible flows, it will be important to determine whether the short term streamflow data collected for this study are representative of wet, dry, or average conditions.

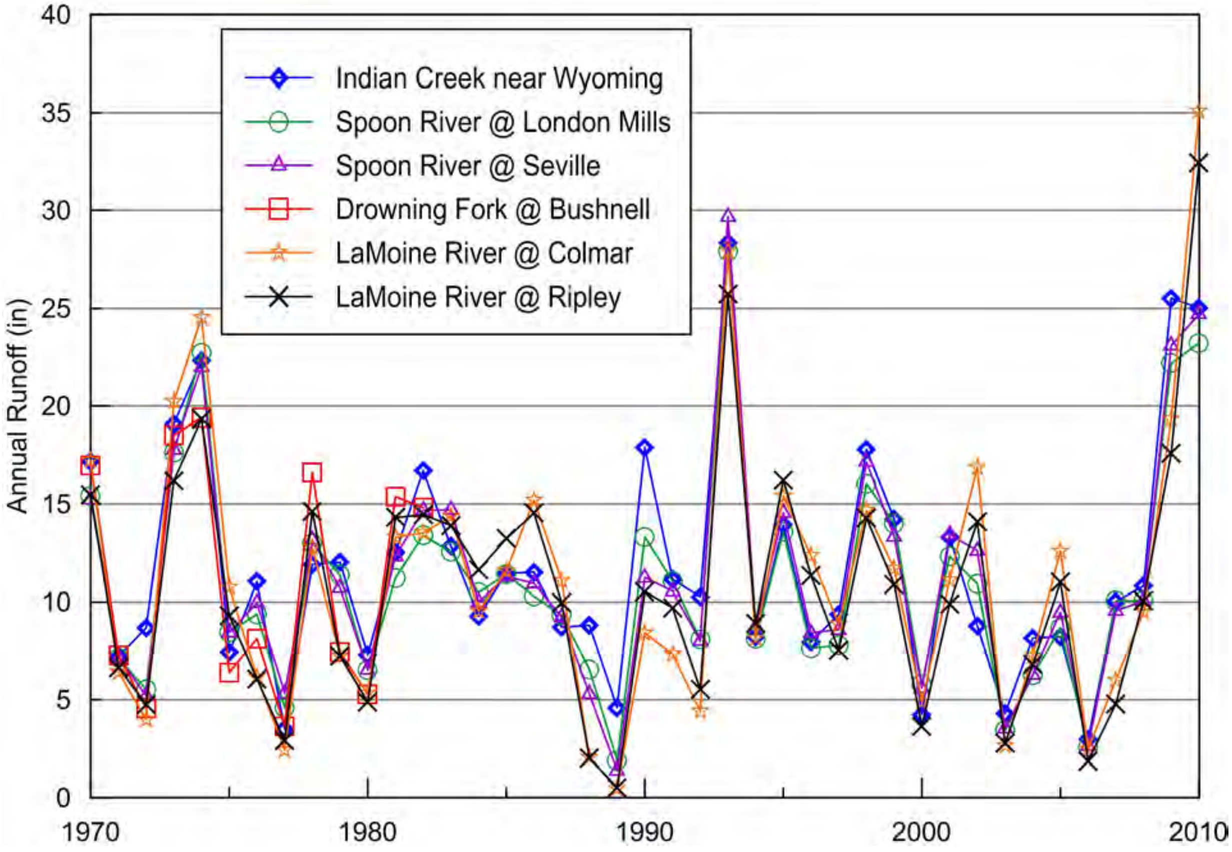

Figure 2-17. Annual runoff for selected USGS streamgages, 1970-2010

Seasonal Flow Variability. Even though the Indian Creek gage is located outside of the Canton Lake watershed, it is still suitable for describing seasonal variation in flows as it is located in the bordering Spoon River basin, a watershed with similar characteristics. This gage is one of the few active streamgages in western Illinois with a drainage area less than 100 square miles. The Indian Creek gage is located downstream of the Toulon STP, so the contributions of this point source would need to be accounted for if this gage is used to estimate flows in the Canton Lake watershed. While the magnitude of flows will differ, its record is still useful for describing the monthly variations in flow typical for small streams in this region.

Mean daily flow values for each month were averaged to determine the monthly average streamflow for that month/year. The monthly average streamflow was computed in this manner for each month of Indian Creek's 50-year record and ranked. The maximum, mean, and minimum of these monthly streamflow values are presented in Figure 2-18. Flows tend to be greatest during the spring through early summer months, March-June, and flows are typically at their lowest during late summer and fall, August-October.

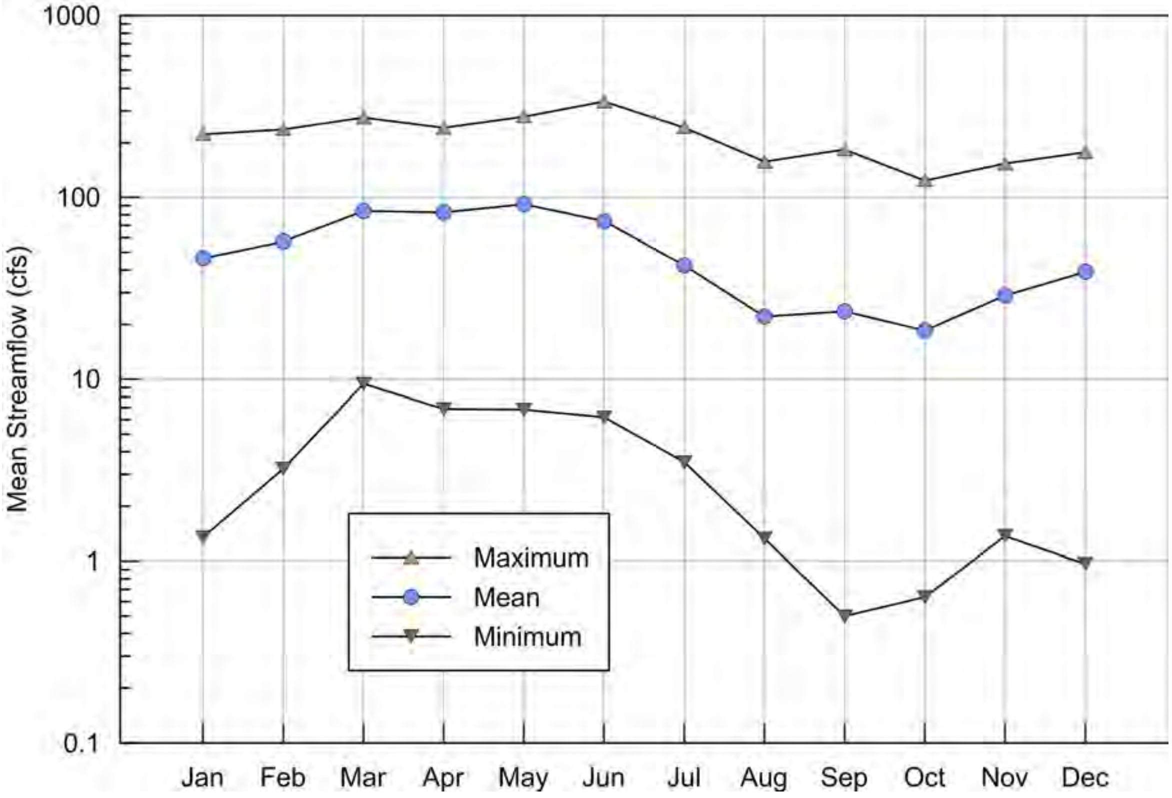

Figure 2-18. Monthly average streamflow for Indian Creek near Wyoming, IL (USGS Gage 05568800), 1960-2010

3. Public Participation and Involvement

3.1 Canton Lake Watershed Public Participation and Involvement

The general public living within a proposed TMDL watershed has an important role in the design, development, and successful implementation of any TMDL impacting that watershed. Local citizens often have unique information and perspectives concerning historic and current activities within a watershed that improve our understanding. In addition, the local citizenry will be integral to the acceptance and successful implementation of the different watershed practices that may be proposed as a result of the TMDL process. The early establishment of an open dialogue with the public also helps alleviate any concerns the local citizenry have about the purpose and extent of any regulatory impacts associated with the TMDL.

To meet these objectives the ISWS, along with the IEPA, held a public meeting at the Donaldson Community Center in Canton, IL on December 6, 2012. This meeting was an opportunity for the public to receive information and comment on the draft Phase I report. There were 45 attendees at this public meeting. A similar meeting will be held following completion of the draft Phase II report. That report will be updated after the Phase II public meeting occurs.

ISWS staff have met and/or contacted the directors of the City of Canton Water Department, City of Canton Wastewater Department, and the Road Commissioner for Canton Township. All departments and individuals contacted have been extremely helpful and supportive of this effort.

4. Canton Lake Water Quality Standards

This section of the report provides information on the water quality standards and designated uses as they apply to Canton Lake. The water quality standards are set by the Illinois Pollution Control Board (IPCB) to protect designated beneficial uses of surface waters, including aquatic life, indigenous aquatic life, primary contact (swimming), public and food processing water supply (drinking water), secondary contact, aesthetic quality, and fish consumption.

A detailed description of the assessment process can be found in the IEPA Integrated Water Quality Reports (IEPA 2014, 2016) for each designated beneficial use. First, the designated use attainment is determined by analyzing various types of information including biological, physicochemical, physical habitat, and toxicity data. If the water body is determined to be impaired, additional information is analyzed to determine potential causes and sources of impairment.

4.1 Designated Uses for Canton Lake

In Illinois, all streams and inland lakes are designated as general use waters unless there is a specific designation for these waters. The general use standards "protect the State's water for aquatic life …, wildlife, agricultural use, secondary contact use and most industrial uses and ensure the aesthetic quality of the State's aquatic environment. Primary contact uses are protected for all General Use waters whose physical configuration permits such use." (Ill. Adm. Code 302.202). Waters designated for multiple uses must meet the most stringent requirements. Table 4-1 summarizes designated uses and applicable water quality standards in Illinois.

Canton Lake provides potable water to an estimated population of 20,000 people in the City of Canton and surrounding areas (City of Canton, 2009). Although the primary source of drinking water for the City of Canton was switched to a collector well along the Illinois River near Banner, IL in mid-2012, Canton Lake remains a backup source of drinking water. Thus, public and food processing water supply use is one of the designated uses and all standards associated with it must be met in addition to any requirements associated with aquatic life, primary and secondary contact, aesthetic quality, and fish consumption uses.

Table 4-1. Designated uses and water quality standards applicable to Canton Lake

Illinois Waters	**Designated Use**	**Applicable Water Quality Standards**
All streams and inland lakes unless specified otherwise	Aquatic Life	General Use
	Fish Consumption	
	Primary Contact*	
	Secondary Contact	
All streams and inland lakes where water is withdrawn for human consumption	Public and Food Processing Water Supply	Public and Food Processing
All inland lakes	Aesthetic Quality	General Use

Notes: *Primary contact use is protected for all general use waters whose configuration permits such use.

4.2 Causes of Impairment

The 2014 and 2016 Illinois Integrated Water Quality Reports (IEPA 2014, 2016) list Canton Lake as impaired with respect to aesthetic quality, and fish consumption. Table 4-2 lists causes of impairment for the impaired designated uses as determined by the IEPA between 2016 and 2010. The extent of this study was based on the most recent 2014 and 2016 Illinois Integrated Water Quality Reports (IEPA 2014, 2016).

Table 4-2. Causes of impairment for Canton Lake by designated use (IEPA 2016, 2014, 2012, 2010)

Assessment Cycle	Aesthetic Quality	Fish Consumption	Public Water Supply
2016	Phosphorus (Total), Total Suspended Solids,	Mercury[+]	
2014	Phosphorus (Total), Total Suspended Solids,	Mercury[+]	
2012	Phosphorus (Total), Total Suspended Solids, Color, Macrophytes, Algae	Mercury[+]	Manganese
2010	Total Suspended Solids, Macrophytes, Algae	Mercury[+]	Manganese, Total Dissolved Solids

Note: [+]Mercury impairment is not addressed in this study.

4.3 Applicable Water Quality Standards

In Illinois, all waters must meet water quality standards for general use unless site specific standards are defined. All General Use and Public and Food Processing Water Supply Use standards are applicable to Canton Lake as specified in Title 35 Ill. Adm. Code, Part 302, Sections 302.100–302.307. Table 4-3 lists numerical values for water quality standards and guidelines for water quality constituents identified as causes of impairment.

Table 4-3. Numerical water quality standards for impairment causes

Impairment Cause	Water Quality Standard	Applicable Designated Use
Phosphorus (Total)	0.05 mg/l*	Aesthetic Quality

Notes: All water quality standards are applicable at all times and are compared to all water quality observations

* Applicable for lakes and reservoirs with a surface area of 8.1 hectares (20 acres) or more, and any stream at the point where it enters any such reservoir or lake

There is no numeric standard for Total Suspended Solids. The narrative criterion requires the waters of the State of Illinois to be free from “sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin” (Ill. Adm. Code, Section 302.203).

Changes in assessment methodology were implemented beginning with the 2012 assessments, removing total suspended solids as a possible cause of Aesthetic Quality Use impairment. The IEPA now uses the Aesthetic Quality Index (AQI) to help evaluate whether designated use is being met (IEPA, 2014, 2016). AQI is determined using the median Trophic State Index (calculated from total phosphorus, chlorophyll a, and Secchi disk transparency), macrophyte coverage, and median non-volatile suspended solids concentration.

5. Water Quality Conditions

This section reviews water quality data available in the watershed and discusses potential point and nonpoint sources and associated causes of impairment. Historical data were collected from the IEPA database as well as downloaded from Legacy STORET and STORET Warehouse. Additional historical data were identified via a search of ISWS publications. Results of the 12 month monitoring effort conducted as a part of this study are also summarized.

5.1 Data Sources

Historical data as well as data collected in this project are presented to further characterize Canton Lake watershed. Water quality data from Canton Lake are directly relevant in determining impairments for the studied segment. Additional data from the tributaries contributing to the lake can aid in identification of sources of impairment and in Phase II TMDL development.

5.1.1 IEPA Data

Six historical water quality stations in the watershed have data relevant to the TMDL constituents. Three stations are located on tributaries to Canton Lake and three on Canton Lake (Table 5-1). The stations are displayed in Figure 5-1. Historical water quality data analyzed in this study were collected as parts of various IEPA monitoring efforts during the years listed in Table 5-2. The Ambient Lake Monitoring Program (ALMP) and Volunteer Lake Monitoring Program (VLMP) collect water quality and sediment samples and record field observations of lake conditions. Together these programs produced the bulk of the historical data available for the Canton Lake watershed. In 1992, an intensive study of Canton Lake was conducted under the Illinois Clean Lakes Program, which included additional data collection beyond the scheduled ambient lake monitoring, as well as intensive data collection at three tributary sites.

Table 5-1. Historical water quality stations

Station Code	Location	Waterbody	Agency
RDD-1 (RD-B05-D-1)	CANTON L SITE 1 NEAR DAM	Canton Lake	IEPA
RDD-2 (RD-B05-D-2)	CANTON L .75 M1 SE OF NEW DOCK SITE 2	Canton Lake	IEPA
RDD-3 (RD-B05-D-3)	CANTON L SITE 3 POINT OFF OF NEW DOCK	Canton Lake	IEPA
RDD 01*	CANTON TRIB 1 T7NR5ES30NE	West Branch Copperas Creek	IEPA
RDD 02	CANTON TRIB 2 T7NR5ES18NW	West Branch Copperas Creek	IEPA
RDD 03	CANTON TRIB 3 T7NR4ES13NE	Unnamed Trib West Branch Copperas Creek	IEPA

Note: * Site located on West Branch of Copperas Creek immediately downstream of Canton Lake.

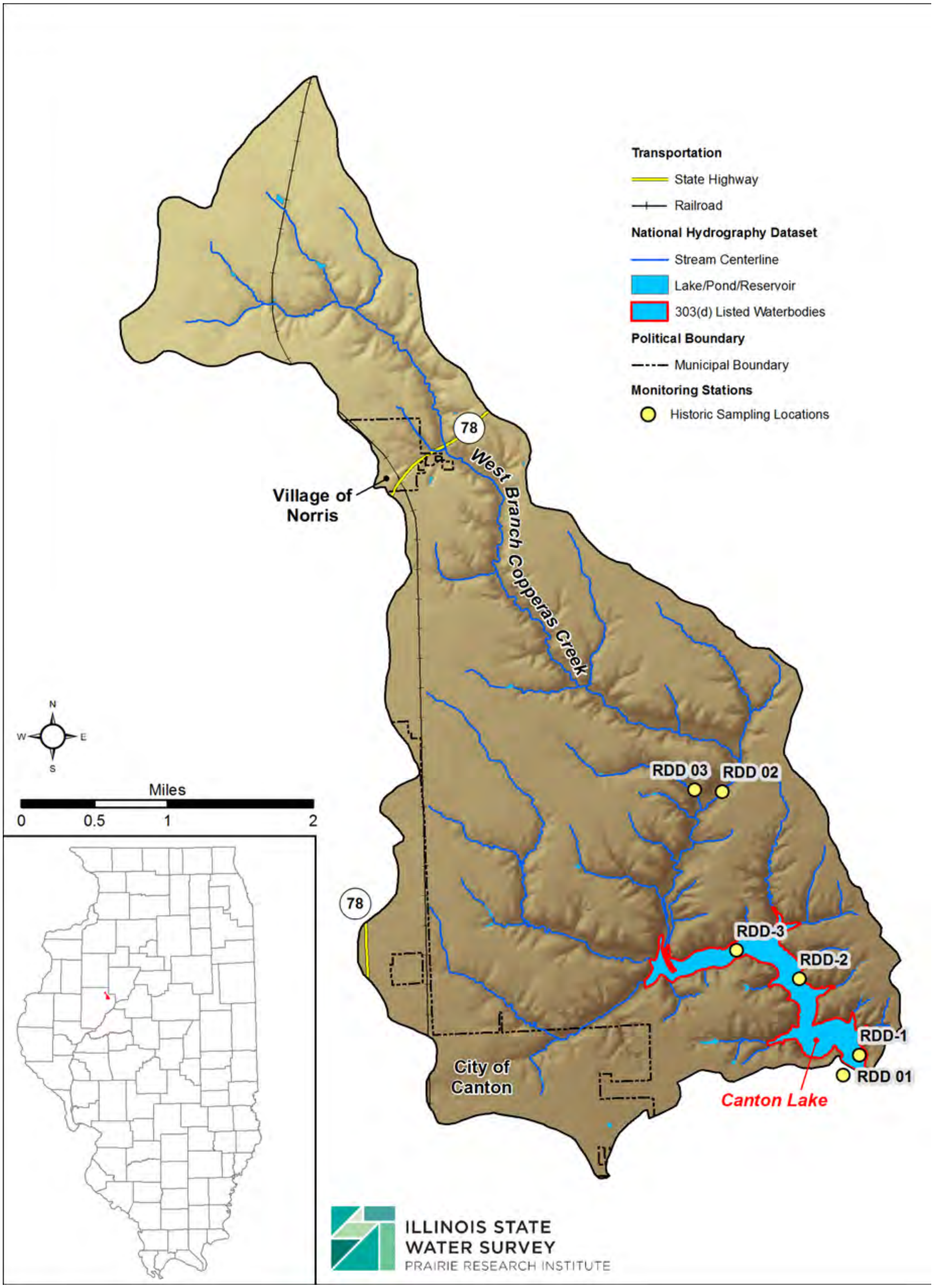

Figure 5-1. Location of historical water quality stations

Table 5-2. IEPA historical water quality data availability

Site Code	Site Type	Constituent	1977	1979	1981	1985	1992	1999	2003	2006	2009	2010	2011
RDD-1	Lake	TP, TSS	X	X	X	X	X	X	X	X	X	X	X
RDD-2	Lake	TP, TSS	X	X	X	X	X	X	X	X	X	X	X
RDD-3	Lake	TP, TSS	X	X	X	X	X	X	X	X	X	X	X
RDD 01	Stream	TP, TSS					X						
RDD 02	Stream	TP, TSS					X						
RDD 03	Stream	TP, TSS					X						

Notes: TP = total phosphorus, TSS = total suspended solids.

5.1.2 ISWS Historical Data

Canton Lake was included in a study the ISWS conducted to assess bottom conditions for Illinois impoundments (Roseboom et al., 1979). Samples for Canton Lake were collected at a single site located at the deepest portion of the lake (32 feet) between April and October 1978 (Table 5-3 and Figure 5-2). Various depths were sampled, including the sediment–water interface as well as the bottom sediments themselves. The interface sample was obtained 3 cm (1.18 inches) above the sediment. Samples were analyzed for a limited number of constituents, including dissolved oxygen, temperature, iron, manganese, ammonia, and phosphorus. Only physical characteristics were measured for sediment samples.

Table 5-3. ISWS historical water quality station

Station Code	Location	Water body	Agency
CL	Canton Lake, deepest point near dam (A-B)	Canton Lake	ISWS

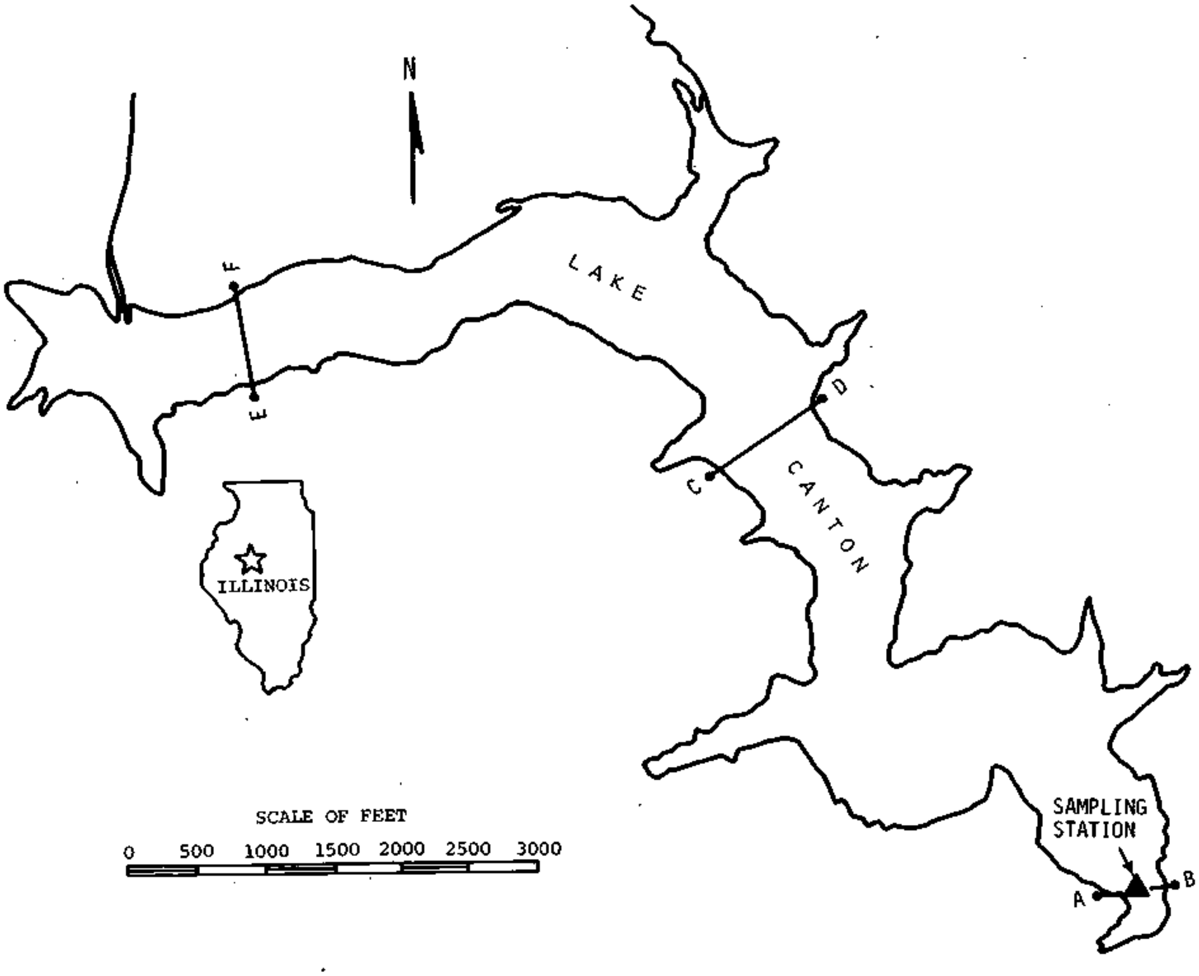

Figure 5-2. Location of ISWS lake water quality stations (Roseboom et al., 1979)

5.1.3 Project-Related Monitoring

New data were collected at six water quality stations beginning in March 2011. Monitoring continued at all sites through October 2012; however, only data collected between March 1, 2011 and February 29, 2012 are presented in this report. However, the additional eight months of data will be used for the modeling efforts associated with Phase II. Watershed monitoring activities carried out during this project are described in detail in the project Quality Assurance Project Plan (QAPP) and summarized below (ISWS, 2011b).

Data collection for Phase I TMDL Development for Canton Lake included monitoring of Canton Lake and its tributaries. The monitoring is designed to quantify current loads and to identify contributions from different sources and locations. Sampling is carried out at two levels identified as base sampling and supplemental sampling.

The monitoring sites for Canton Lake are listed in Table 5-4, along with the constituents sampled. The location of the sampling sites for Canton Lake is shown in Figure 5-3. Five stations were located on tributaries draining to Canton Lake and one at the Canton Lake outfall.

Table 5-4. Sampling locations for Canton Lake TMDLs

Station Code	*Stream & Location*	*Site Type*	*ISWS Data*			*WQ Sampling*
			Stage Record	Streamflow Record	Instantaneous Discharge	TP, TSS
RDD-T1	Canton Lake spillway	B	X	X		X
RDD-T2	West Br Copperas Creek, U/S of the lake	B	X	X		X
RDD-T4	Unnamed tributary, D/S of Canton CSO	B	X	X		X
RDD-T7	West Br Copperas Creek, U/S of Norris	S			X	X
RDD-T6	West Br Copperas Creek, D/S of Norris	S			X	X
RDD-T5	Unnamed tributary	S			X	X

Note: U/S = upstream; D/S = downstream; B=Base site (weekly + storm sampling); S= Supplemental site (biweekly sampling); CSO= Combined Sewer Overflow

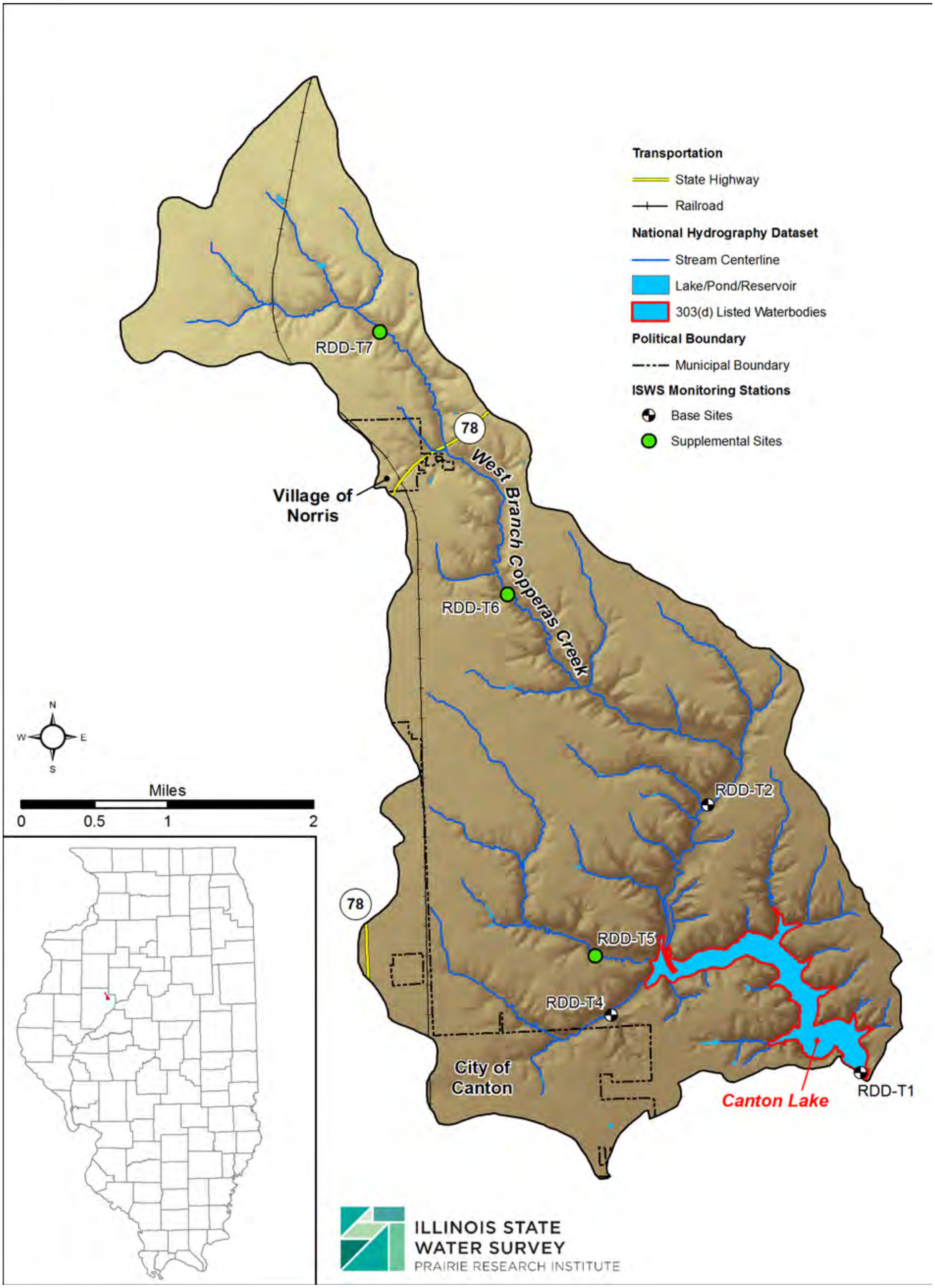

Figure 5-3. Location of the project water quality stations

Base sampling consisted of routine weekly sampling with additional storm sampling. All base sampling sites were equipped with gaging equipment (15-min gage record). At each base site discharge measurements were performed throughout the range of water levels experienced in order to develop a rating curve that allows for the development of a continuous record of streamflow. Automated pump samplers were installed at all base sampling locations to ensure samples are obtained during runoff events. These samplers are slaved to the stage sensor, allowing sample frequency to be driven by changes in stage. This sampling strategy when conducted at a gaged site provided representative samples from across the entire stage record so that accurate constituent loadings delivered to and retained in the lake could be determined. Canton Lake spillway, one of the base sites, is shown in Figure 5-4.

Supplemental sampling consisted of biweekly discharge measurements and concurrent manual collection of water quality samples. Discharge measurements were performed at supplemental sites only at the time of sample collection. This provides less detailed data for load estimation at these locations than base sampling, but did allow inputs from different contributing areas to be assessed and helped in identifying critical constituent source areas.

Water quality samples were analyzed for Total Phosphorus (TP) and Total Suspended Solids (TSS).

Figure 5-4. Canton Lake Spillway (base station RDD-T1)

Table 5-5 shows statistics for instantaneous discharge at the time of sampling. While continuous discharge data are available for station RDD-T1 from March 24, 2011 and for stations RDD-T2 and RDD-T4 from March 23, 2011, the statistics presented here focus on conditions during water quality sample collection. Additional flow analysis can be found in Section 5.2 Flow Data Analysis (page 52).

All tributary sites were found dry with zero discharge at some point during water quality sampling. In those cases a sample was collected from a pool, if present. Canton Lake spillway (station RDD-T1) was always sampled regardless of whether there was an outflow or not. Samples were marked as “zero discharge” samples.

It is important to note that significantly higher discharges were sampled at the base sites than at the supplemental sites. This is due to several reasons, including base stations being located on the most significant tributaries of the lake, a weekly versus biweekly sampling interval, and additional efforts to collect samples during storms at the base gages.

Table 5-5. Discharges during water quality sampling, project data (cfs)

Station Code	Start Date	End Date	Number Measurements	Minimum	Average	Maximum	Number Zero Discharges
RDD-T1	3/15/2011	2/29/2012	65*	0	38.0	717	35
RDD-T2	3/15/2011	2/29/2012	75*	0	24.6	305	4
RDD-T4	3/15/2011	2/29/2012	75*	0	8.25	177	8
RDD-T5	3/8/2011	2/22/2012	21	0	2.07	17.6	2
RDD-T6	3/8/2011	2/22/2012	26	0	5.62	71.5	5
RDD-T7	3/8/2011	2/22/2012	26	0	2.51	25.3	7

Note: * Continuous gage data available, statistics shown only for times when water quality samples were collected

5.1.4 ISWS Groundwater Data

The ISWS historical well database contains 20 records with water quality information for what appears as 11 wells or groups of wells located within or near the Canton Lake watershed (Table 5-6). Well locations are specified using the Public Land Survey System (Townships, Ranges, Sections, and Plot numbers). Wells with no plot number specified are designated with an asterisk in Table 5-6 and can only be plotted by section location in Figure 5-5. There are four wells with depths less than 100 feet, two wells between 100 and approximately 300 feet deep, two wells between 900 and 1,000 feet deep, two wells approximately 1,700 feet deep, and one well without a recorded depth. Water quality data for wells in the subsequent parts of this report are summarized by Township, Range, and Section.

Table 5-6. Records in ISWS historical well database for Canton Lake watershed

Record ID	Group	Township	Range	Section	Plot	Date	Depth
48950	1	07N	04E	11	5H	9/5/2000	43
48951	1	07N	04E	11	5H	9/5/2000	43
48952	1	07N	04E	11	5H	9/5/2000	43
6727	2	07N	04E	11	8H	8/14/1979	301
6728	3	07N	04E	14	*	10/1/1922	*
6731	4	07N	04E	26	*	3/1/1940	47
CITY OF CANTON - 1	5	07N	05E	30	3F	10/6/1989	1720
46058	6	07N	05E	30	4E	4/24/1989	142
TOM KEPPLE -	7	08N	04E	21	*	10/20/1997	28
TOM KEPPLE -	7	08N	04E	21	*	10/20/1997	28
6770	8	08N	04E	34	*	2/1/1919	960
6771	9	08N	04E	34	*	10/1/1922	935
NORRIS – 26896	10	08N	04E	34	3B	6/1/1966	1702
NORRIS – 27009	10	08N	04E	34	3B	9/20/1971	1702
NORRIS – 27010	10	08N	04E	34	3B	7/31/1974	1702
NORRIS – 27012	10	08N	04E	34	3B	6/12/1976	1702
NORRIS – 27013	10	08N	04E	34	3B	12/20/1976	1702
NORRIS – 27014	10	08N	04E	34	3B	9/18/1978	1702
NORRIS – 27015	10	08N	04E	34	3B	11/3/1980	1702
47432	11	08N	04E	34	8H	6/30/1994	55

Notes: * Number is not specified

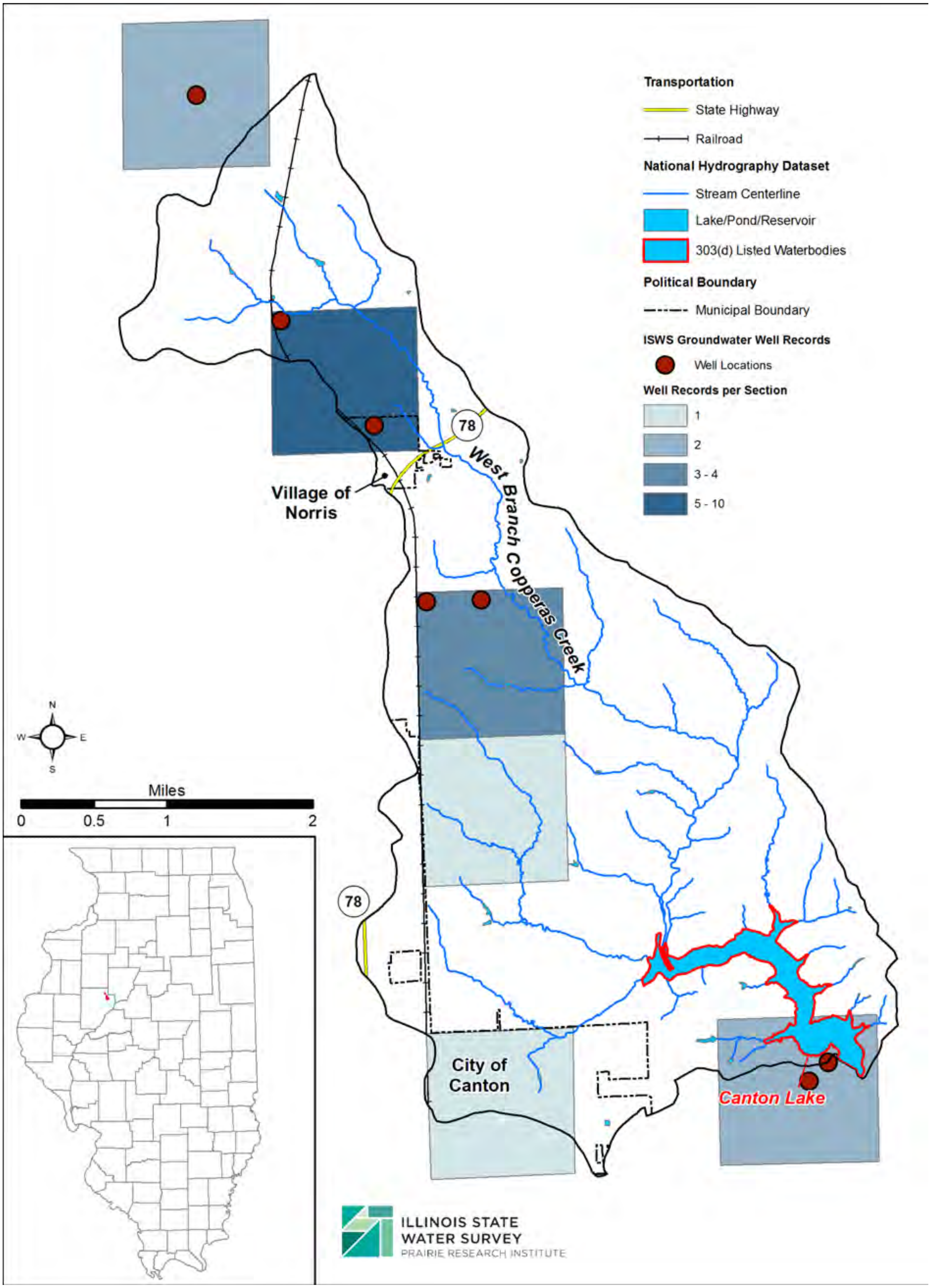

Figure 5-5. Location of wells in ISWS historical well database

5.1.5 Capital Resource Development Company Data

The Capital Resource Development Company, LLC (CRDC) collected samples at six stream sites and six wells in Canton Lake watershed as a part of application materials for a coal mine permit (Table 5-7). This permit was withdrawn by the CRDC in 2013 after the public hearings for both the NPDES permit and for the 401 water quality certification. The stations are displayed in Figure 5-6. No results were reported for the site NC-2, probably because of lack of flow at the selected location. Groundwater results were reported for two wells only, MW-1 and MW-4.

Table 5-7. Capital Resource Development Company water quality stations

Station Code	Location	Water body	Agency
NC-1	Brereton Road	West Branch Copperas Creek	CRDC
NC-2	Brereton Road app. 0.35 mi east of Shorty's Road	Unnamed Trib West Branch Copperas Creek	CRDC
NC-4	Downstream of proposed Pond #3	Unnamed Trib West Branch Copperas Creek	CRDC
NC-5	Downstream of proposed Pond #6	Unnamed Trib West Branch Copperas Creek	CRDC
NC-6	Cypress Road	West Branch Copperas Creek	CRDC
NC-9	Brereton Road west of Shortys Road	Unnamed Trib West Branch Copperas Creek	CRDC

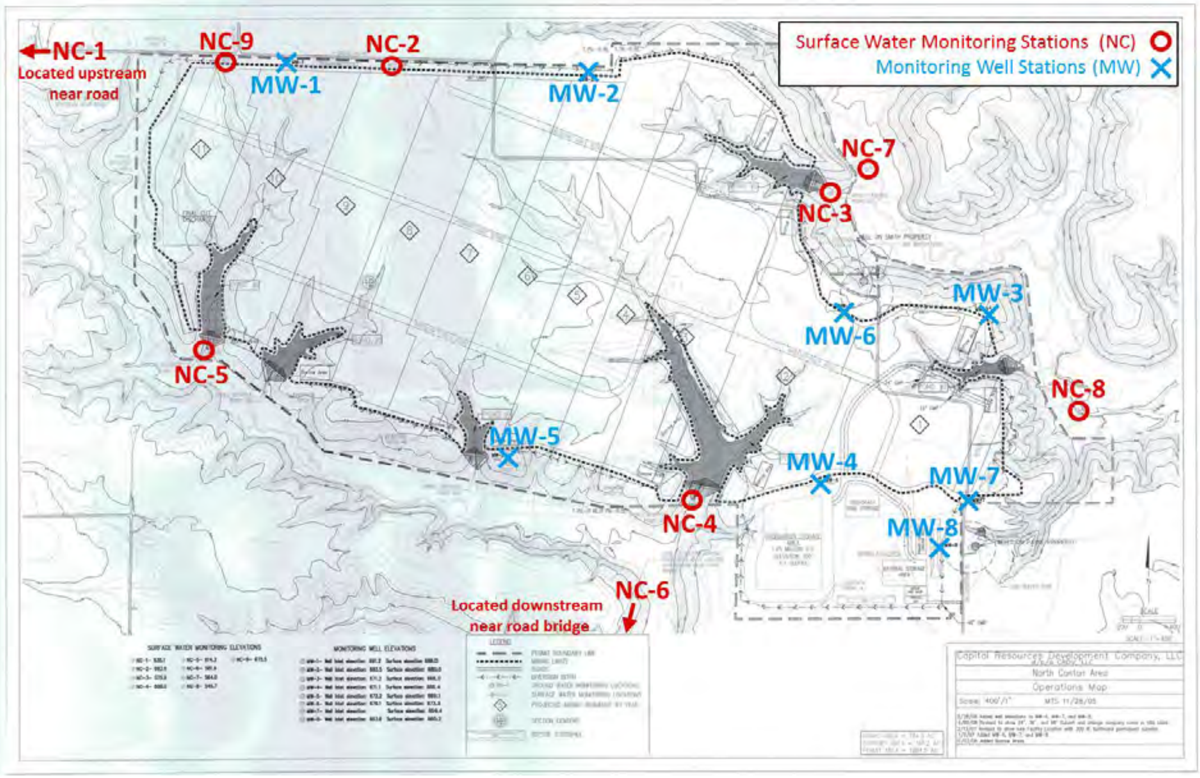

Figure 5-6. Location of Capital Resource Development Company monitoring stations (IEPA, 2011)

5.2 Flow Data Analysis

Historical and current USGS streamflow data as well as data collected during this project are presented to characterize flows in the Canton Lake watershed.

5.2.1 Climate Conditions during Project Monitoring

Monthly precipitation totals at St. David, IL during the first year of project monitoring (March 2011-February 2012) are presented in Figure 5-7. Normal monthly precipitation totals typically vary 2-6 inches per month. From March 2011 to February 2012, monthly precipitation varied from less than 0.5 inches in August and October to more than 9 inches in April 2011. The monthly precipitation departure from normal is presented in Figure 5-8. April and June had above average rainfall, but six of the next eight months experienced a precipitation deficit. The total rainfall during the first project year was 37.7 inches, more than 5 inches below normal.

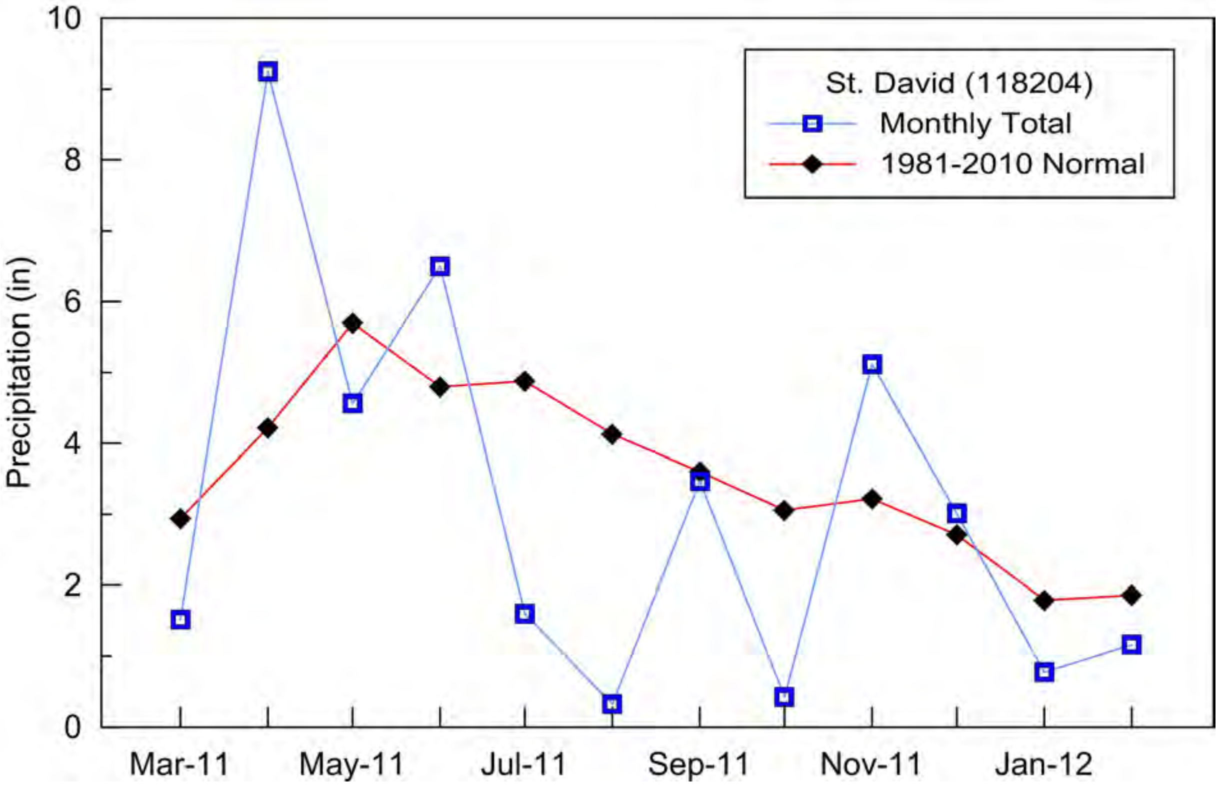

Figure 5-7. Monthly precipitation totals at St. David, IL during study period (March 2011-February 2012), as compared to normal conditions (1981-2010)

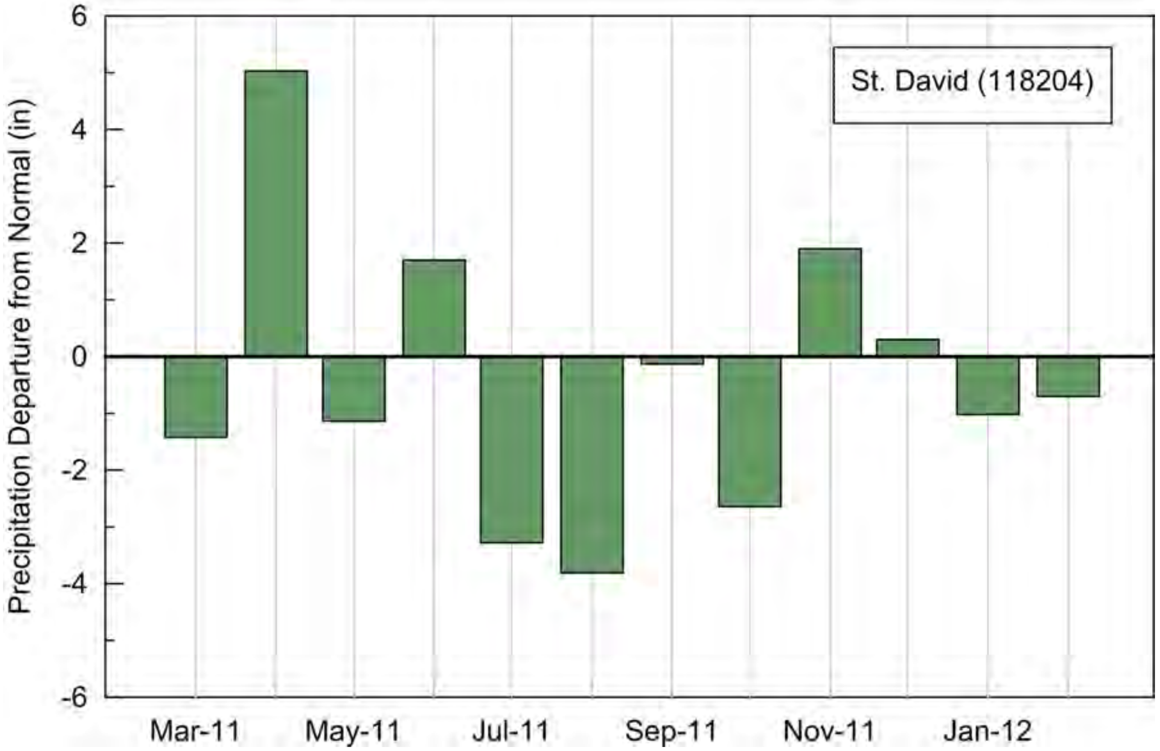

Figure 5-8. Monthly precipitation departures from normal at St. David, IL during study period (March 2011-February 2012)

Average maximum and minimum temperatures at Peoria, IL for the first year of project monitoring are presented in Figure 5-9. Temperature ranges during the first few months of the study were normal. July, however, was warmer than normal. August was slightly warmer than normal, and September was cooler than normal. The remainder of the year (Oct-Feb) sustained above average temperatures.

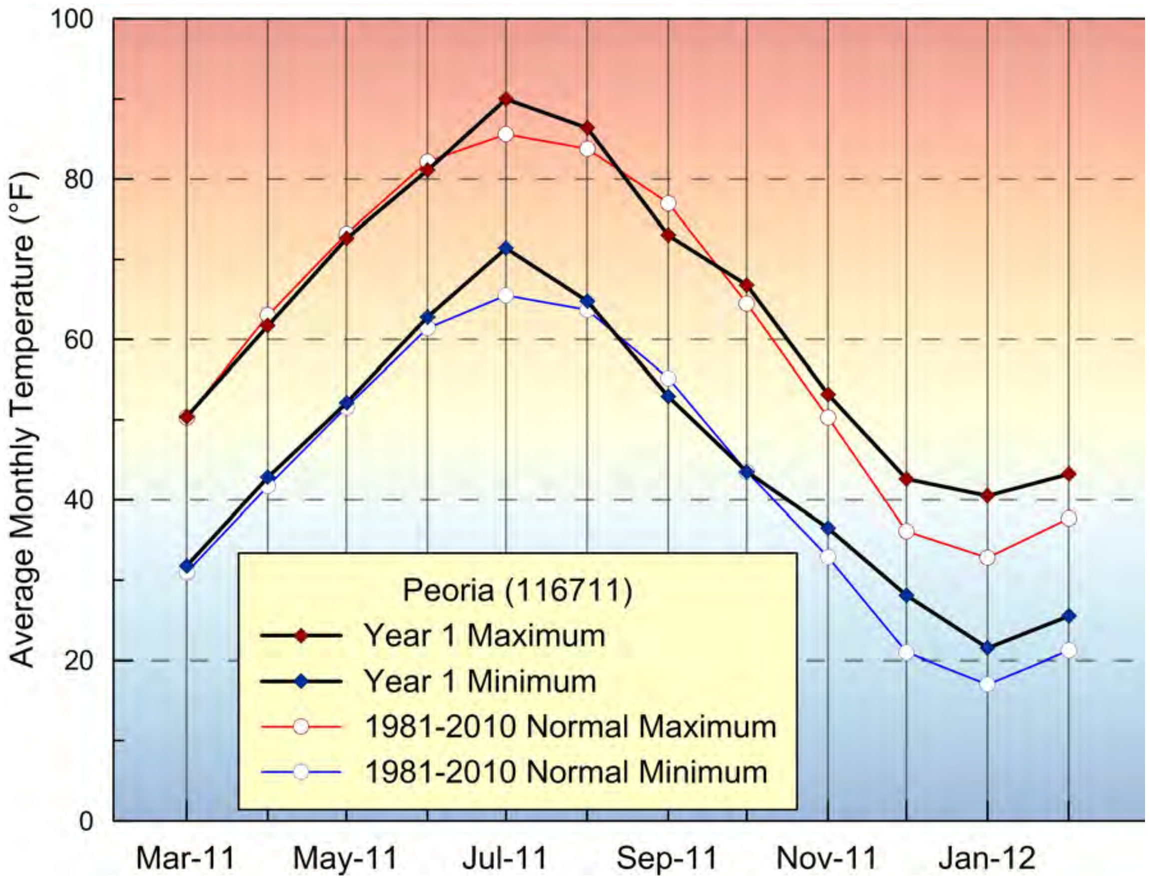

Figure 5-9. Monthly temperatures at Peoria, IL during study period (March 2011-February 2012), as compared to normal conditions (1981-2010)

5.2.2 Gaging Stations

To understand the hydrology of a watershed it is important to have long-term streamgage records. Unfortunately, there are no active or discontinued USGS streamgages in the Canton Lake watershed. Active USGS streamgages near the Canton Lake watershed are listed in Table 5-8 and presented in Figure 2-16.

Table 5-8. Active USGS streamgages near the Canton Lake watershed

USGS ID	Station Name	Drainage Area (mi^2)	Period of Record
05568800	Indian Creek near Wyoming, IL	62.7	1960-Present
05569500	Spoon River at London Mills, IL	1072.0	1943-Present
05570000	Spoon River at Seville, IL	1636.0	1914-Present
05584500	La Moine River at Colmar, IL	655.0	1945-Present
05585000	La Moine River at Ripley, IL	1293.0	1921-Present

As part of the monitoring conducted for this study, three streamgages (Table 5-9) were installed in the Canton Lake watershed. Because there can be significant variation in streamflows both within a year and from year to year, it is critical to understand how the short-term project streamflow records compare to long-term annual and seasonal streamflows for the region.

Table 5-9. ISWS project streamgages installed in the Canton Lake watershed

Station ID	Station Description	Drainage Area (mi^2)	Start of Record
RDD-T1	Canton Lake Spillway	14.7	3/24/2011
RDD-T2	W Br Copperas Creek at Cypress Road	6.7	3/23/2011
RDD-T4	South Unnamed Tributary at field road on W edge of Canton Lake	1.7	3/23/2011

Depending on the methodology selected for Phase II TMDL calculations, the ISWS project streamgages may be used for calibration and validation of watershed loading models. If determination of flow statistics for tributaries to Canton Lake is necessary, then the long-term USGS streamgage records such as those listed in Table 5-8 would be used to provide additional information for these calculations. One of two approaches will be used to compute tributary flow statistics: application of regional regression equations previously developed for the Illinois Streamflow Assessment Model (ILSAM) or application of a record-extension method to adjust the project flow duration curves using an appropriate index station.

5.2.3 Annual Flow Variability

Annual flows at the three ISWS gages are summarized in Table 5-10. Data from the USGS gages for the same time period will be used to characterize the first year's flows. Annual flows at the selected USGS gages are summarized in Table 5-11.

Table 5-10. Annual flow statistics for ISWS gages, Project Year 1 (March 2011* - February 2012)

Station ID	Total Flow (cfs)	Mean Flow (cfs)	Total Runoff (in)
RDD-T1	3,016	8.8	7.6
RDD-T2	1,721	5.0	9.6
RDD-T4	395	1.2	8.6

*Note: March 2011 is only a partial month.

Table 5-11. Annual flow statistics for USGS gages, Project Year 1 (March 2011 - February 2012)

Station ID	Total Flow (cfs)	Mean Flow (cfs)	Total Runoff (in)
05568800	24,150	66	14.3
05569500	362,193	990	12.6
05570000	539,319	1,474	12.3
05584500	245,555	671	13.9
05585000	430,340	1,176	12.4

Figure 5-10 presents the annual flows at the USGS stations within the bordering Spoon River watershed as compared to each gage's long-term average flow, computed using the common period 1960-2011. Water Year 2011 is defined as the period October 1, 2010 to September 30, 2011, so this represents only a portion of the project's first year of data collection. Water Year 2011 was the third consecutive year of above average annual flows. Annual flows in Water

Years 2009 and 2010 were more than twice the long-term average. This two-year wet period followed a more than six-year stretch of below average flows.

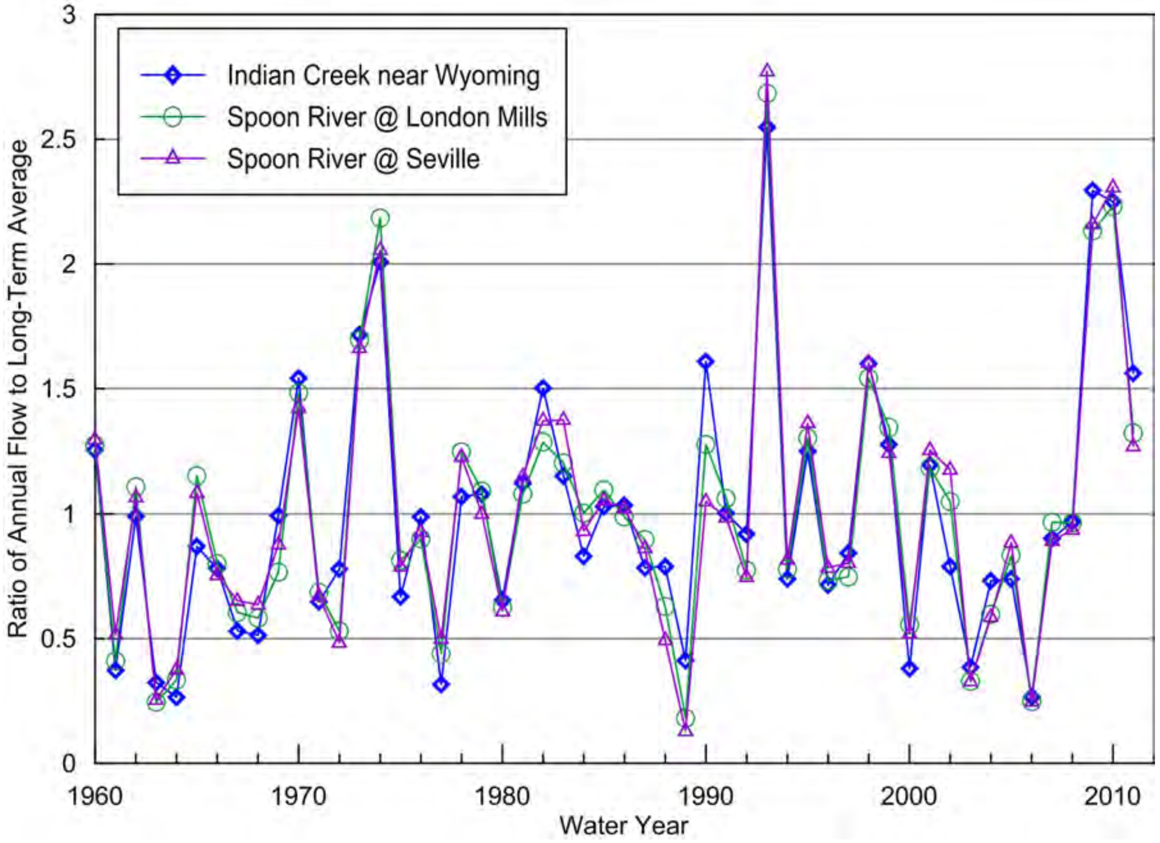

Figure 5-10. Annual flows at selected USGS stations as compared to each gage's long-term (1960-2011) average

5.2.4 Seasonal Flow Variability

While overall flows in 2011 were above average, there can be considerable variation in the monthly and seasonal flows. To explore this variability, monthly streamflows at Indian Creek from March 2011 to February 2012 are compared to its monthly streamflow statistics in Figure 5-11. Similar to the precipitation fluctuations, Indian Creek's flows in March-July 2011 were higher than median monthly flows (50th percentile), while August 2011-February 2012 flows were much closer to median streamflows. To determine how far above or below normal these 2011-2012 flows were, monthly flow values for each USGS gage's period of record were sorted, ranked, and assigned a flow percentile. These monthly streamflow percentiles are presented in Figure 5-12. Differences between the Spoon gages' and the La Moine gages' monthly flow percentiles reflect the spatial variation in rainfall and runoff events. At Spoon watershed streamgages, summer flows, while less than median flows (50th percentile), were still mostly in the range of normal flows. La Moine River streamgages dipped into the below normal range of flows August-October 2011 and again in February 2012. At the Colmar and Ripley gages on the La Moine River, it was the second and third wettest Junes on record, respectively.

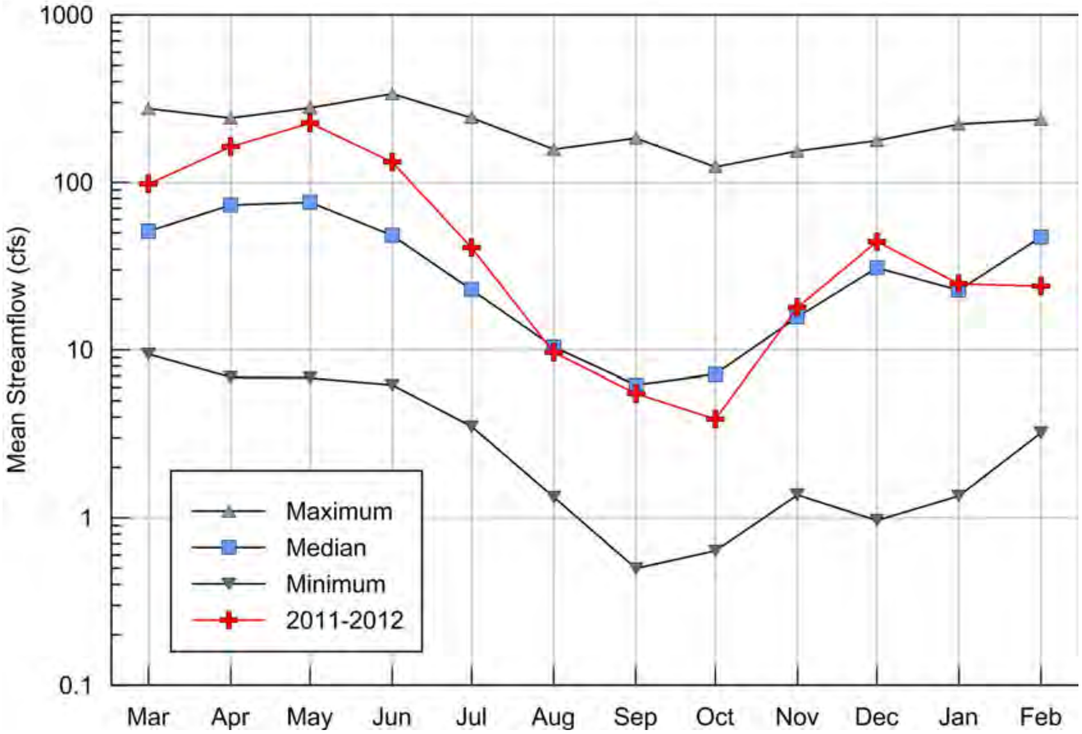

Figure 5-11. Monthly average streamflow during study period for Indian Creek near Wyoming, IL (USGS Gage 05568800) as compared to long-term monthly streamflow statistics (1960-2010)

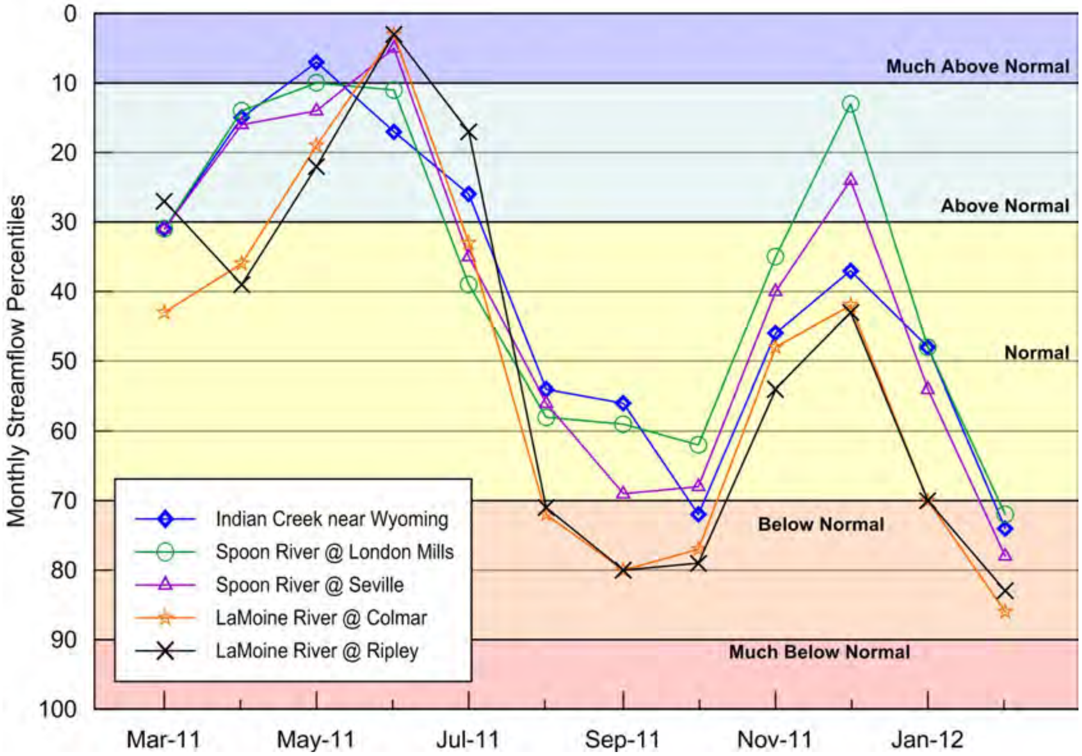

Figure 5-12. Monthly streamflow percentiles during study period (March 2011-February 2012) for selected USGS streamgages

5.2.5 Stream Flashiness

Stream flashiness refers to the rate of change in streamflow and the frequency of these changes. Differences in stream flashiness can be attributed to soils, geology, land use, drainage area, and presence of point sources. An index developed by Baker et al. (2004) quantifies the flashiness of a stream by summing the absolute values of changes in streamflow and then dividing by the total of all mean daily discharges during the period of interest. This index is most commonly computed using mean daily streamflow records, but can be used with records of any regular time-step. The Richards-Baker Index (RBI) of flashiness was computed for ISWS gaging stations using mean daily, hourly, and 15-minute records of streamflow (Table 5-12). On streams of this size, using mean daily flow to characterize flashiness or stream response does not capture the rapidity of changes in the stream hydrographs. The streamflow response at RDD-T4 was the flashiest of all study sites. Many of the runoff events at this site were measured in hours.

Table 5-12. Stream flashiness at ISWS stations during study period (unitless)

Station ID	**Drainage Area (mi^2)**	**RBI Based on Mean Daily Flows**	**RBI Based on Hourly Flows**	**RBI Based on 15-minute Flows**	**Ratio of 15-min/Hourly**	**Ratio of 15-min/Daily**
RDD-T1	14.7	0.687	1.963	2.388	1.22	3.48
RDD-T2	6.7	0.677	2.419	2.599	1.07	3.84
RDD-T4	1.7	0.781	4.613	5.645	1.22	7.23

Typically the larger watersheds have much slower responses to storm events. For comparison, RBI values were computed for USGS gaging stations in the Spoon River watershed for the first year of project monitoring (Table 5-13).

Table 5-13. Stream flashiness at USGS stations during study period (unitless)

Station ID	**Drainage Area (mi^2)**	**RBI Based on Mean Daily Flows**	**RBI Based on 15-minute Flows**	**Ratio of 15-min/Daily**
05568800	62.7	0.271	0.665	2.46
05569500	1072	0.193	0.382	1.98
05570000	1636	0.177	0.267	1.51

Stream flashiness is an important flow characteristic to take into consideration because many water quality constituents experience rapid changes in concentration during these periods of rapid changes in streamflow, specifically during the rising limb of an event. For many small rural streams, the loadings of particulate constituents during these large flow events of short duration can comprise a majority of the annual load. In *A Study of Measurement and Analysis of Sediment Loads in Streams*, the Federal Interagency Sedimentation Project (FISP, 1940) investigated the suspended sediment loading characteristics of small streams and found that for 11 small streams in the Midwest the one-day maximum load experienced during a 15-month monitoring period represented 8-36% of the total load. While conservation tillage has increased and fertilizer usage has decreased since this early study, more recent studies still support the finding that a few high flow events can account for the overwhelming majority of non-point source loadings of particulate constituents such as TSS and TP (Markus and Demissie, 2006; Royer et al., 2006; Haggard et al., 2003; Richards et al., 2001).

5.2.6 High Flows

Instantaneous peak discharges and high flow statistics for the three ISWS gages are summarized in Table 5-14. The high flow statistics presented are the largest average flows experienced for the duration indicated during the study period. High flow statistics for the USGS gages are presented in Table 5-15, and their corresponding flow percentiles are presented in Figure 5-13.

The peak discharges and one-day high flows experienced at the Spoon watershed gages during the first year of study were normal. However, the longer duration high flows were above normal for these gages. The La Moine River at Colmar gage experienced much above normal high flows during the study year. In general, the high flows experienced during individual storm events were normal, but the average flows sustained for two to three months were unusually high for these gages.

Table 5-14. High flows at ISWS stations during study period, March 2011*-February 2012 (cfs)

Station	Peak Discharge	1-day	7-day	15-day	31-day	61-day	91-day
RDD-T2	332	143	64	42	24	18	17
RDD-T4	177	48	17	10	5.9	4.0	3.4
RDD-T1	717	278	144	89	49	36	33

*Note: March 2011 is only a partial month.

Table 5-15. High flows at USGS stations during study period, March 2011-February 2012 (cfs)

Station	Peak Discharge	1-day	7-day	15-day	31-day	61-day	91-day
05568800	1710	1400	597	358	246	216	175
05569500	8940	8820	7544	4937	3493	3119	2575
05570000	12600	12200	11167	7598	5675	4666	3991
05584500	20700	19300	9521	7040	4267	2868	2271
05585000	12100	11800	9420	9205	6474	4539	3742

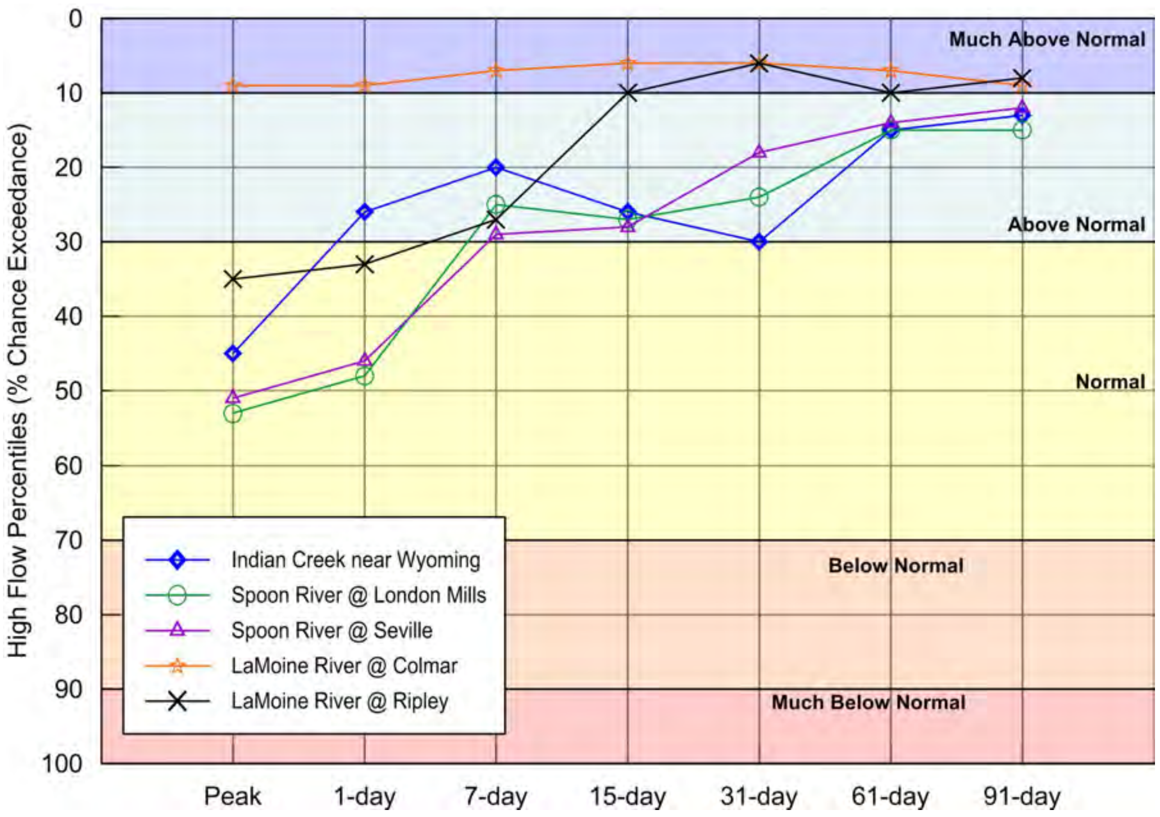

Figure 5-13. High flow percentiles during study period (March 2011-February 2012) for selected USGS streamgages

5.2.7 Low Flows

Low flow statistics for the three ISWS gages are summarized in Table 5-16. The low flow statistics presented are the smallest average flows experienced for the duration indicated during the study period. Low flow statistics for the USGS gages are presented in Table 5-17, and their corresponding flow percentiles are presented in Figure 5-14.

The low flows experienced at the USGS gages during the first year of study were mostly normal. All of the ISWS gages went dry during the study period, which is expected at gages of this size in this region of the state during most summers and extended dry periods. The USGS gages have much larger drainage areas and would not be expected to reach zero flow even during extended dry periods. Their low flows were all above normal or normal during the first year of monitoring, with the exception of the Colmar gage's 91-day low flow, which was slightly below normal.

Table 5-16. Low flows at ISWS stations during study period, March 2011*-February 2012 (cfs)

Station	1-day	7-day	15-day	31-day	61-day	91-day
RDD-T2	0	0	0	0	0.01	0.01
RDD-T4	0	0	0	0.01	0.06	0.06
RDD-T1	0	0	0	0	0	0

*Note: March 2011 is only a partial month.

Table 5-17. Low flows at USGS stations during study period, March 2011-February 2012 (cfs)

Station	1-day	7-day	15-day	31-day	61-day	91-day
05568800	3.4	3.7	3.7	3.9	4.6	5.9
05569500	59	65	67	74	81	98
05570000	87	89	98	101	115	142
05584500	8.1	9.0	11	13	15	19
05585000	25	29	30	33	37	45

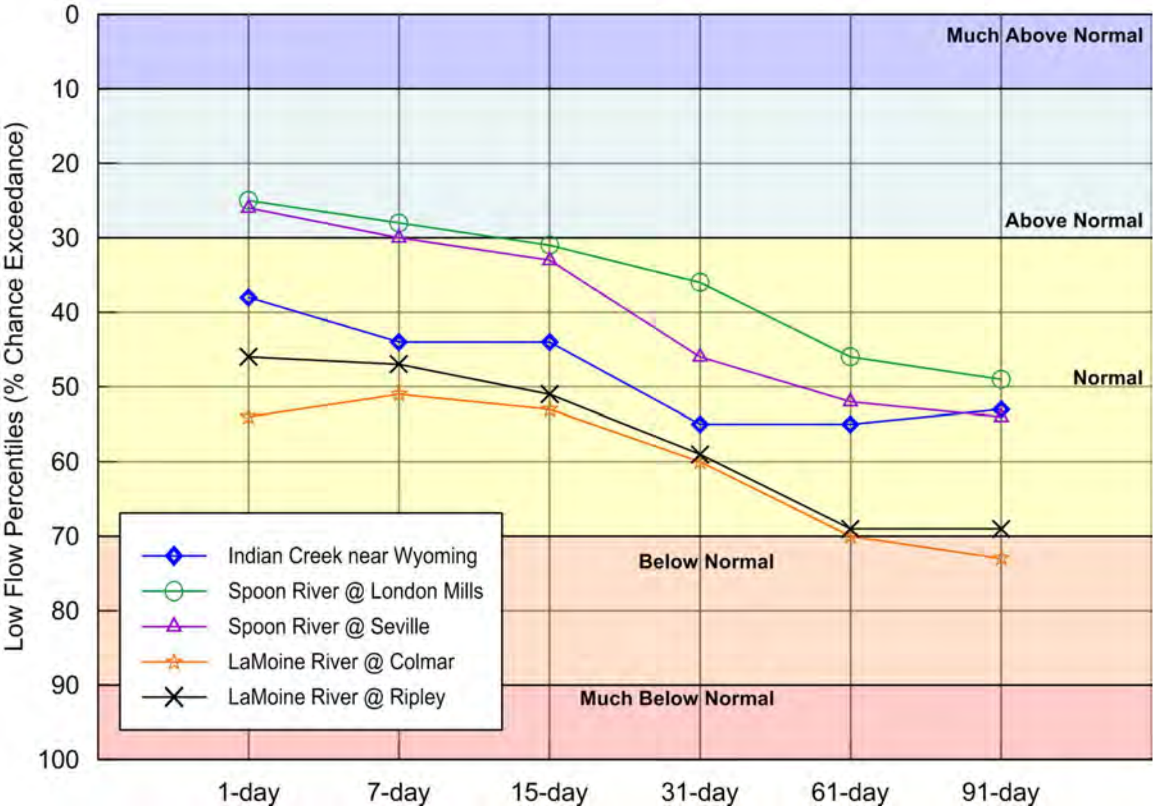

Figure 5-14. Low flow percentiles during study period (March 2011-February 2012) for selected USGS streamgages

5.2.8 Historical Reservoir Levels

Month-end reservoir levels as reported to the Illinois State Water Survey as part of its monthly Illinois Water and Climate Summary (http://www.isws.illinois.edu/warm/climate.asp) are presented in Figure 5-15. The Illinois State Water Survey began requesting this information from the City of Canton during the 1988-1989 drought and has continued making monthly inquiries regarding lake levels and pumping for more than 20 years.

At the end of the first TMDL monitoring year, the lake level was approximately 5 feet below the spillway. This is a common occurrence at Canton Lake as evidenced by its average month-end lake levels (Figure 5-16); the level has dropped at least 4 feet below normal pool approximately a dozen times in the 23-year record. The magnitude of the largest drop has increased from

1994 to 2008. The following two years the lake remained close to capacity due to the two consecutive years of above average streamflow (Figure 5-10) before once again returning below normal pool for a minimum of six months in 2010 and2011.

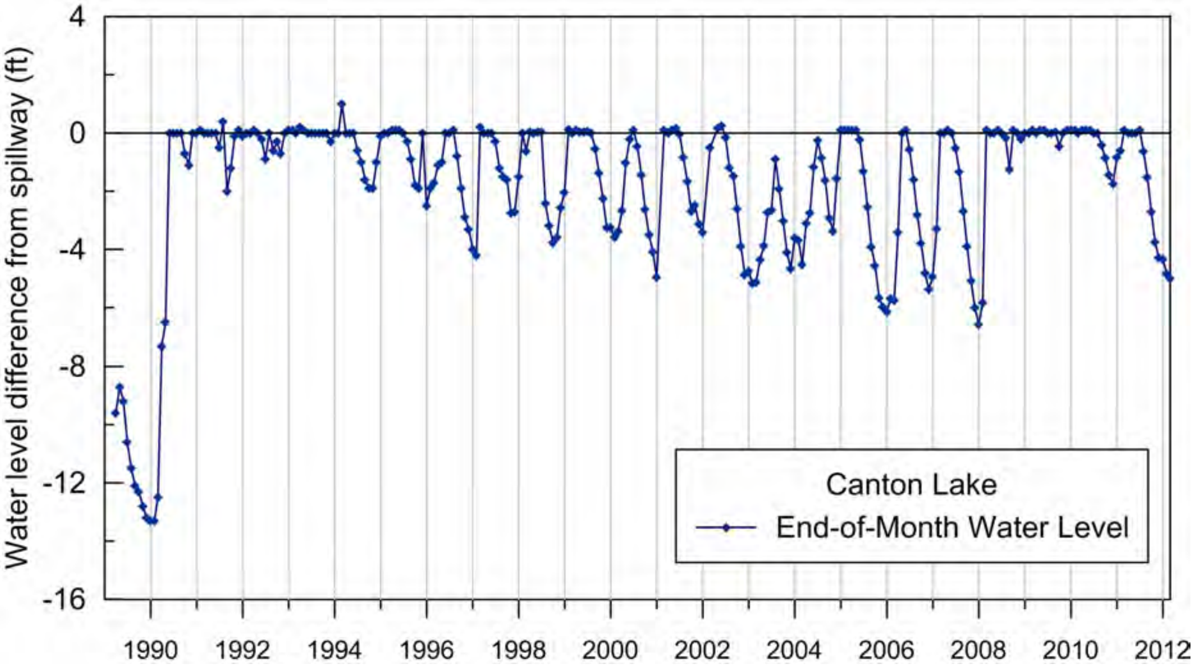

Figure 5-15. Canton Lake month-end reservoir levels as reported to the ISWS

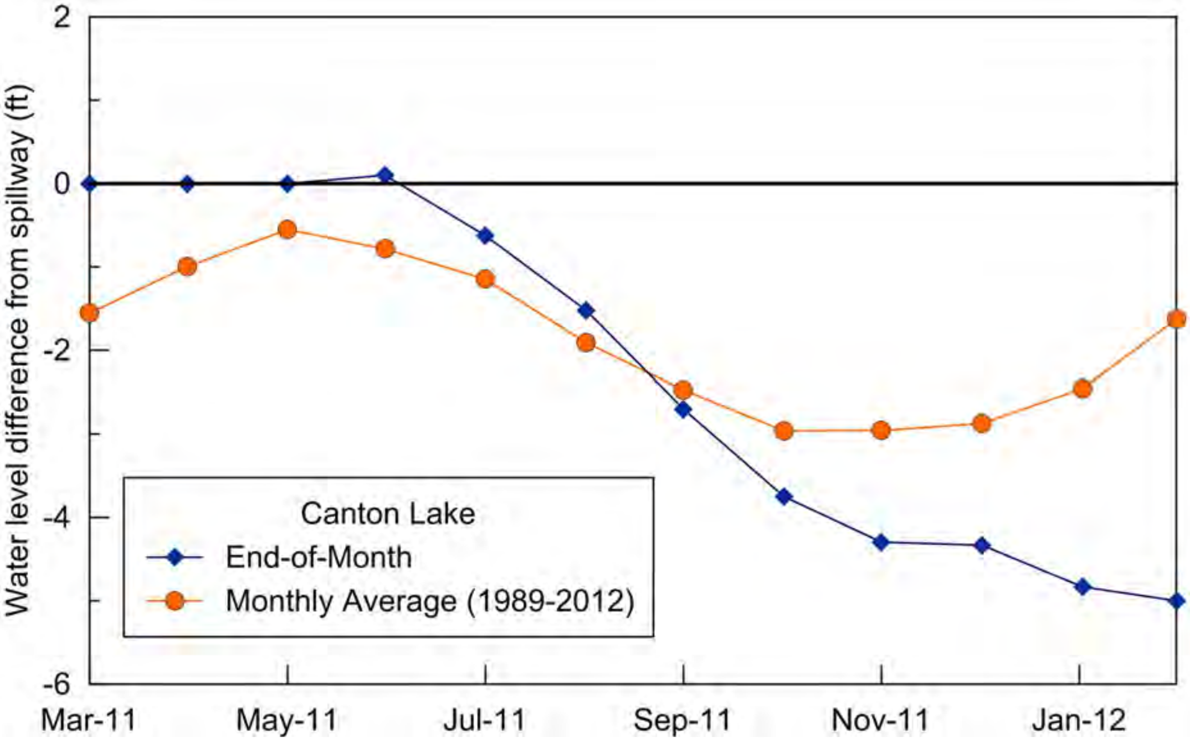

Figure 5-16. Month-end lake levels during study period (March 2011-February 2012) as compared to average month-end lake levels (1989-2012)

5.2.9 Reservoir Water Budget Analysis

The water budget analysis performed for the first year of monitoring estimates the gains and losses in Canton Lake's capacity from March 2011 to February 2012. The equation used for this analysis can be summarized as simply:

Storage Change = Inflow – Outflow

The main sources of inflow are tributary inflows and direct precipitation on the lake surface. The main sources of outflow are flow over the spillway, evaporation from the surface of the lake, and direct withdrawals from the lake by Canton Water Treatment Plant (WTP). In Illinois, measures of seepage from the dam and groundwater inflows are typically considered to balance out, so they were not accounted for in this analysis.

The water budget is presented in Table 5-18 with monthly values presented for all of the inputs.

- Lake storage
- Tributary inflows
- Direct precipitation on the lake
- Evaporation
- Outflow from the lake as spillage
- Withdrawals by the Canton WTP

A detailed explanation of the inputs and assumptions follows.

Lake storage was determined from the continuous monitoring of lake levels at ISWS station RDD-T1. In order to determine the volume of lake storage this level represents, the relationship between level and volume (stage-storage curve) is needed. The most recent sedimentation survey of Canton Lake was conducted in 1992 to determine the total lake volume as well as its sedimentation rate. The survey report, provided as an appendix in the Clean Lakes Report (CMT, 1995), does not include a stage-storage curve. In order to estimate storage, a quadratic equation was developed relating relative depth to relative volume for Waverly Lake, another water supply reservoir in a predominantly agricultural watershed in western Illinois. In addition to having similar land use and topography, this lake was also selected because the ISWS conducted a detailed bathymetric survey of this reservoir in 2009 which produced a stage-storage curve at 1-foot intervals. This quadratic equation was applied to Canton Lake after all lake levels were converted to relative depths (using a total depth of 29 feet) to determine a corresponding relative volume. This was then converted to an estimated volume using Canton Lake's 2010 estimated capacity of 2815 acre-feet (ac-ft) (http://www.isws.illinois.edu/data/ilcws/drought.asp?id=05790250).

Tributary inflows were directly measured at ISWS gages RDD-T2 and RDD-T4, which represent 6.7 and 1.7 square miles (sq mi), respectively, of the 14.7 sq mi total lake drainage area. This leaves 6.3 sq mi of ungaged tributary inflows to the lake. These inflows were estimated as a ratio of the total gaged contributions at RDD-T2. The area drained by RDD-T4 is approximately 50% urban. Because flows at RDD-T4 are significantly impacted by combined sewer overflow and urban storm water runoff from the City of Canton, flows at this gage were not considered representative of the ungaged portion of Canton Lake.

Precipitation values used in the analysis are those measured at St. David. They were converted to a volume by multiplying the rainfall depth by the surface area of the lake (230 ac). Pan evaporation data for the first year of monitoring was not yet available on the ISWS website. Monthly evaporation estimates for Peoria, IL were obtained from *Lake Evaporation in Illinois* (Roberts and Stall, 1967). Evaporation estimates were also converted to a volume by multiplying by the surface area of the lake.

Outflow from the lake was directly measured at ISWS RDD-T1. Direct withdrawals from the lake are reported each month by the City of Canton to the ISWS as part of the Illinois Water and Climate Summary. Pumpage information was not available for August 2011, so this value was estimated by averaging all other August pumpage information for the period of record (1996-2011). This approach was selected due to the seasonal variation in monthly withdrawals. Peak pumpage typically occurred in July and August, while pumpage was the least in late winter/early spring.

The last column in Table 5-18 represents the residual or unaccounted for volume in the water budget. The fact that the largest discrepancy occurs during a high flow month would suggest an error in the inflow estimates. It is possible that a May storm affected the most upstream portion of the watershed more than the area in the immediate vicinity of the lake. If that was the case, applying the drainage-area ratio to the ungaged area of the watershed would overestimate their streamflow contributions. Additionally, the consistently positive residual amounts from July to February suggest that there is a consistent bias in the estimates of lake storage. It would appear that the actual storage change at lake levels below the spillway should be larger, causing drops in lake level to result in larger negative changes in storage.

A detailed bathymetric survey would greatly reduce the uncertainty in these water budget calculations and improve confidence in the results.

From March to July, the overwhelming majority (>90%) of inflow to the lake was in the form of tributary streamflow (Table 5-19). From August to November, most of the inflow was in the form of direct precipitation. The small amount of tributary inflow was predominantly from RDD-T4 whose high percentage of impermeable surfaces and storm water overflow resulted in responses to several small precipitation events not seen in other areas of the watershed. During the winter, the primary inflow source was once again tributary streamflow.

The lake was at capacity when monitoring began on 3/24/2011, so the majority of outflow for the first three full months of record (Apr-Jun) was discharge over the spillway (Table 5-20). Once the lake stopped spilling in July, the majority of outflow shifted to direct withdrawals by the WTP. Evaporation represented roughly one-third of the outflows during July-September, but during the fall and winter, the overwhelming majority of outflow from the lake was direct pumpage.

Table 5-18. Water budget for Canton Lake, March 2011* - February 2012

	Lake Storage ac-ft	RDD-T2 Discharge ac-ft	RDD-T4 Discharge ac-ft	Gaged Inflow ac-ft	Ungaged Inflow ac-ft	Direct Precip. ac-ft	**Total Inflow ac-ft**	RDD-T1 Discharge ac-ft	WTP Pumpage ac-ft	Lake Evap. ac-ft	**Total Outflow ac-ft**	**Residual ac-ft**
Mar-11*	**-2.0**	*57.7*	*13.3*	71.0	53.8	0.2	**125.0**	28.4	50.3	8.8	**87.4**	**-39.6**
Apr-11	**28.1**	*1367.6*	*337.0*	1704.6	1273.7	177.3	**3155.6**	2915.7	185.5	63.1	**3164.3**	**36.8**
May-11	**6.0**	*771.2*	*136.8*	908.0	718.2	87.4	**1713.6**	1206.0	202.0	92.4	**1500.3**	**-207.2**
Jun-11	**-2.0**	*890.2*	*142.5*	1032.7	829.1	124.6	**1986.3**	1695.9	195.1	109.4	**2000.4**	**12.1**
Jul-11	**-91.8**	*160.3*	*23.9*	184.2	149.3	30.7	**364.2**	136.0	209.3	122.9	**468.1**	**12.2**
Aug-11	**-250.6**	*2.5*	*1.2*	3.7	2.3	6.1	**12.1**	0.0	209.2	99.5	**308.7**	**46.0**
Sep-11	**-177.2**	*0.7*	*7.7*	8.4	0.6	66.5	**75.6**	0.0	197.0	68.8	**265.8**	**13.0**
Oct-11	**-204.5**	*0.3*	*2.5*	2.8	0.3	8.1	**11.1**	0.0	205.2	43.5	**248.7**	**33.1**
Nov-11	**-42.8**	*9.2*	*43.3*	52.5	8.6	98.1	**159.2**	0.0	195.5	19.7	**215.3**	**13.3**
Dec-11	**11.9**	*61.6*	*45.9*	107.5	57.3	57.7	**222.5**	0.0	209.4	8.6	**218.1**	**7.4**
Jan-12	**-104.3**	*40.8*	*15.3*	56.1	38.0	14.8	**108.8**	0.0	213.4	8.4	**221.8**	**8.7**
Feb-12	**-29.8**	*50.9*	*14.9*	65.8	47.4	22.2	**135.5**	0.0	190.1	13.8	**203.9**	**38.7**
Annual	**-858.9**	3413.0	784.2	4197.2	3178.7	693.6	**8069.5**	5981.9	2262.0	658.9	**8902.9**	**-25.5**

*Note: Partial month. Analysis began on 3/24/2011

Table 5-19. Monthly distribution of Canton Lake inflows, March 2011* - February 2012

	Gaged Inflow	**Ungaged Inflow**	**Direct Precipitation**
Mar-11 *	57%	43%	0%
Apr-11	54%	40%	6%
May-11	53%	42%	5%
Jun-11	52%	42%	6%
Jul-11	51%	41%	8%
Aug-11	30%	19%	51%
Sep-11	11%	1%	88%
Oct-11	25%	2%	72%
Nov-11	33%	5%	62%
Dec-11	48%	26%	26%
Jan-12	52%	35%	14%
Feb-12	49%	35%	16%
Average Annual	43%	28%	30%

*Note: Partial month. Analysis began on 3/24/2011

Table 5-20. Monthly distribution of Canton Lake outflows, March 2011* - February 2012

	Spillway Discharge	**WTP Withdrawals**	**Lake Evaporation**
Mar-11 *	32%	57%	10%
Apr-11	92%	6%	2%
May-11	80%	13%	6%
Jun-11	85%	10%	5%
Jul-11	29%	45%	26%
Aug-11	0%	68%	32%
Sep-11	0%	74%	26%
Oct-11	0%	83%	17%
Nov-11	0%	91%	9%
Dec-11	0%	96%	4%
Jan-12	0%	96%	4%
Feb-12	0%	93%	7%
Average Annual	27%	61%	12%

*Note: Partial month. Analysis began on 3/24/2011

5.2.10 Reservoir Retention Time

The average residence time of a reservoir is the volume of the water body divided by the annual inflow. The mean annual inflow to Canton Lake was estimated following the approach utilized by the Illinois Streamflow Assessment Model (ILSAM) for ungaged streams unimpacted by effluent discharges. The ILSAM was initially developed in 1985 (Knapp et al., 1985) and has continued to be updated and expanded to 11 watersheds throughout Illinois (http://www.isws.illinois.edu/data/ilsam/). The following equation was most recently presented in Knapp and Russell (2004a):

$$Q_{mean}=0.0738\ DA\ (P–ET)$$

Where Q_{mean} (cfs) is the annual mean flow at the location of interest; DA (mi^2) is the drainage area of the watershed; P is the average annual precipitation (inches); and ET is the average annual evapotranspiration (inches). The term (P-ET) is termed the average annual net precipitation, and was determined by Knapp and Russell (2004b) to be 9.4 inches for streams in the Galesburg Plain region of Illinois for the base period of 1940-2002.

Using this approach, the annual mean flow into Canton Lake is 10.2 cfs (7385 ac-ft/yr), and the average residence time for Canton Lake is 0.38 years, or more than 4.5 months.

5.3 Water Quality Data Analysis

5.3.1 Total Phosphorus

A summary of historical and project data for total phosphorus data collected in Canton Lake watershed and its tributaries is presented in Table 5-21 and Table 5-22, respectively. The water quality standard for total phosphorus applicable to lakes with a surface area 20 acres or greater is 0.05 mg/l. Only samples taken at 1 foot of depth are considered by the IEPA for water body assessments and assignment of impairment causes. However, water quality samples collected at all depths were analyzed in this section in order to provide a comprehensive discussion of lake water quality. The water quality standard was exceeded in 62%-80% of historical samples collected in Canton Lake depending on the station where the samples were collected. The current project data collected in Canton Lake (station RDD-T1) confirm the impairment with 91% samples exceeding the standard.

While the water quality standard does not apply to Canton Lake tributaries, it is useful to evaluate exceedances of the standard value to compare individual tributaries and their contribution to the overall concentrations found in the lake. The value 0.05 mg/l is often exceeded in Canton Lake tributaries (73-100% samples, Table 5-22). Note that the total phosphorus concentrations at tributary sites are generally higher than concentrations measured at Canton Lake sites.

Table 5-21. Total phosphorus data summary, lake data (mg/l)

Station Code	Start Date	End Date	Number Samples	Minimum	Average	Maximum	Number Exceedances
Historical data							
RDD-1	6/27/1977	10/14/2011	124	ND	0.075*	0.38	83 (67%)
RDD-2	6/27/1977	10/14/2011	55	ND	0.061*	0.171	34 (62%)
RDD-3	6/27/1977	10/14/2011	54	0.002	0.075	0.214	43 (80%)
CL	4/17/1978	10/16/1978	81	0.02	0.14	0.78	52 (64%)
Project data							
RDD-T1	3/1/2011	2/29/2012	69	ND	0.085*	0.201	63 (91%)

Notes: ND = analyte not detected, value below detection limit
* value is affected by a presence of values below detection limit (ND)

Table 5-22. Total phosphorus data summary, tributary data (mg/l)

Station Code	Start Date	End Date	Number Samples	Minimum	Average	Maximum	Number Exceedances$^{\$}$
Historical data							
RDD 01	4/16/1992	12/31/1992	16	0.035	0.769	6.28	15 (94%)$^{\$}$
RDD 02	4/16/1992	12/31/1992	17	0.043	1.92	7.43	16 (94%)$^{\$}$
RDD 03	4/16/1992	12/31/1992	15	0.055	0.730	8.13	15 (100%)$^{\$}$
Project data							
RDD-T2	3/1/2011	2/29/2012	79	ND	0.439*	3.35	60 (76%)$^{\$}$
RDD-T4	3/1/2011	2/29/2012	79	0.0568	0.562	4.94	79 (100%)$^{\$}$
RDD-T5	3/8/2011	2/22/2012	22	ND	0.157*	0.745	16 (73%)$^{\$}$
RDD-T6	3/8/2011	2/22/2012	27	ND	0.152*	1.03	20 (74%)$^{\$}$
RDD-T7	3/8/2011	2/22/2012	27	ND	0.412*	2.75	24 (89%)$^{\$}$

Notes: ND = analyte not detected, value below detection limit
* value is affected by a presence of values below detection limit (ND)
$^{\$}$ = water quality standard is not directly applicable, exceedances shown only for comparison purposes

The ISWS lake study (Roseboom et al., 1979) reported total phosphorus concentrations at three depth categories: surface, mid-depth, and near bottom. The IEPA lake data were also sampled at several different depths. Table 5-23 shows statistics for data separated by sampling depth. Total phosphorus concentrations for surface and mid-depth samples collected during the historical ISWS lake study are comparable and 44% samples exceed the water quality standard. Near bottom concentrations are significantly higher with all samples above the water quality standard (100%). The IEPA data also show an increase in total phosphorus concentrations with depth. Site RDD-1 had enough data collected at different depths for this evaluation with statistics shown in Table 5-23. Data for both sites are plotted in Figure 5-17.

Table 5-23. Total phosphorus data by depth, historical data (mg/l)

Depth Category	Start Date	End Date	Number Samples	Minimum	Average	Maximum	Number Exceedances
CL							
Surface	4/17/1978	10/16/1978	27	0.02	0.047	0.14	12 (44%)
Mid-depth	4/17/1978	10/16/1978	27	0.02	0.051	0.14	13 (44%)
Near bottom	4/17/1978	10/16/1978	27	0.06	0.324	0.78	27 (100%)
RDD-1							
Surface	6/27/1977	10/14/2011	53	0.005	0.058	0.146	31 (57%)
Mid-depth	4/28/1999	8/18/2011	28	0.005	0.067	0.157	20 (71%)
Near bottom	6/6/1979	10/14/2011	43	0.005	0.102	0.38	32 (74%)

Figure 5-18 shows total phosphorus concentrations plotted in time for historical data; time-series plots of total phosphorus concentrations for current project data are provided in Figure 5-19. Discharge for the three gaged project sites is also shown. The gaps in the discharge plot show dry periods of zero flow (i.e., there are no missing streamflow data from the gage installations). For the lake sites with historical data, the occurrence of high total phosphorus concentrations is more frequent in recent years. Historical data on stream sites are only available for 1992. The ISWS lake study (site CL) shows total phosphorus concentrations for the near bottom samples increased during the season starting late May.

Figure 5-20 shows a relationship between the observed total phosphorus concentrations and instantaneous discharge for the current project data. Concentrations measured at zero discharge conditions are plotted against a discharge on the y-axis for each site. No discharge data were available for historical data set. The highest total phosphorus concentrations were measured at the highest flows for all but the Canton Lake spillway site (RDD-T1). This is because phosphorus is typically adsorbed to fine sediment particles. At tributary stream sites the sediment is suspended within the streamflow, and suspended sediment concentrations are highest when streamflow and stream velocities are greatest. The Canton Lake spillway (site RDD-T1) shows no significant relationship between total phosphorus concentration and discharge due to sediment having settled out as a result of the low velocities prevalent within the impoundment.

Figure 5-21 compares distributions of total phosphorus concentrations at the project monitoring sites. The Canton Lake spillway (site RDD-T1) shows the smallest variation and the lowest mean. Sites RDD-T2 and RDD-T7 have the largest variation in observed concentrations. Site RDD-T4 has the highest mean.

Statistical comparison of means[1] was carried out using samples collected at non-zero discharges during dates common across the sites, i.e., storm samples and every other set of weekly samples were removed for the base sites to create a subset that would correspond to bi-weekly sampling at supplemental sites. This was necessary because of the relationship between total phosphorus concentrations and discharge and the lower number of samples collected during high flows at supplemental sites. The difference in mean total phosphorus concentrations cannot be statistically confirmed among the sites with the exception of site RDD-T4 that has a mean higher than the remaining sites.

Instantaneous loadings were calculated as a product of observed concentration, discharge, and appropriate conversion factor. In spite of the lowest concentrations, the Canton Lake spillway site (RDD-T1) carried the highest mean total phosphorus loadings (Figure 5-22). The difference in mean total phosphorus loadings cannot be statistically confirmed among the sites with the exception of site RDD-T1 that has a mean higher than the remaining sites.

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[1] Statistical significance was determined using 95% confidence level.

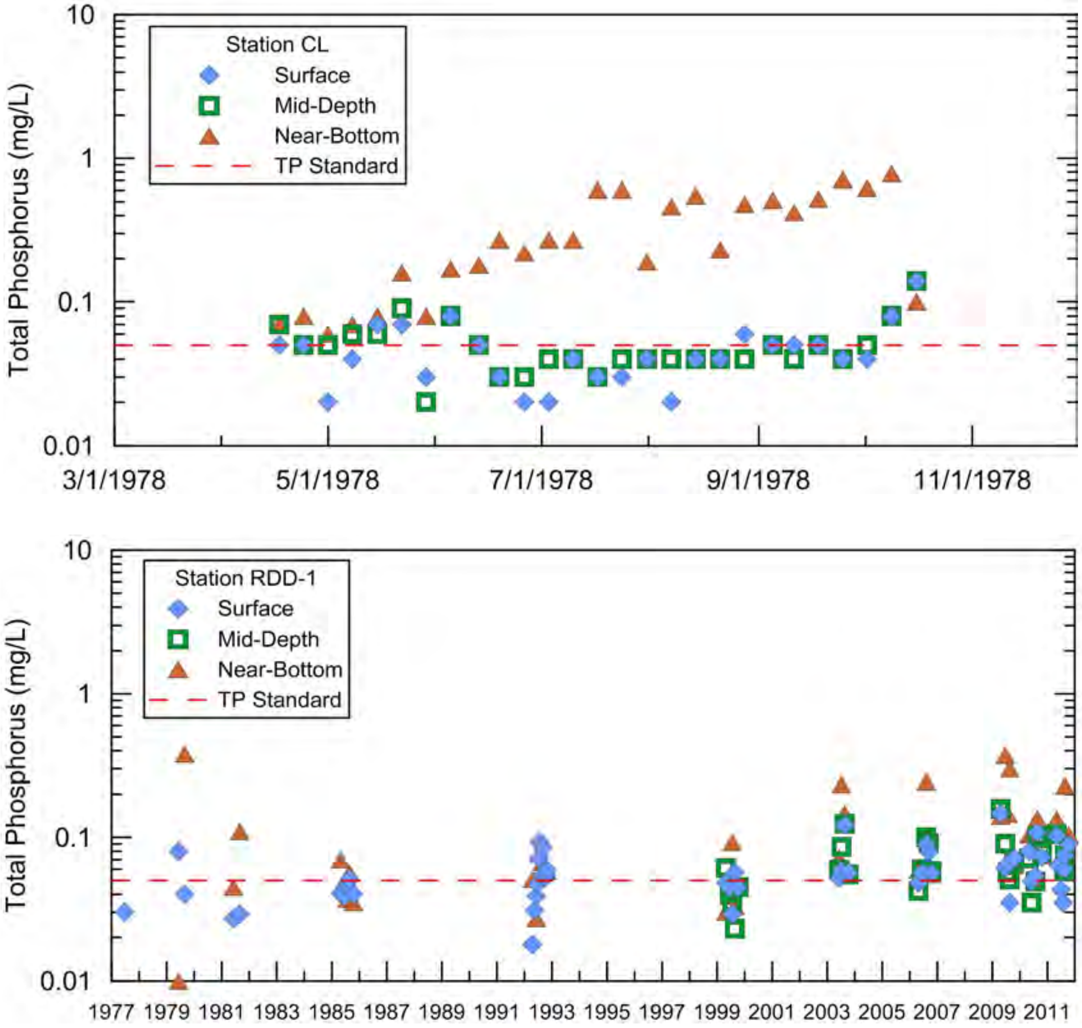

Figure 5-17. Total phosphorus concentrations for different sampling depths, historical data

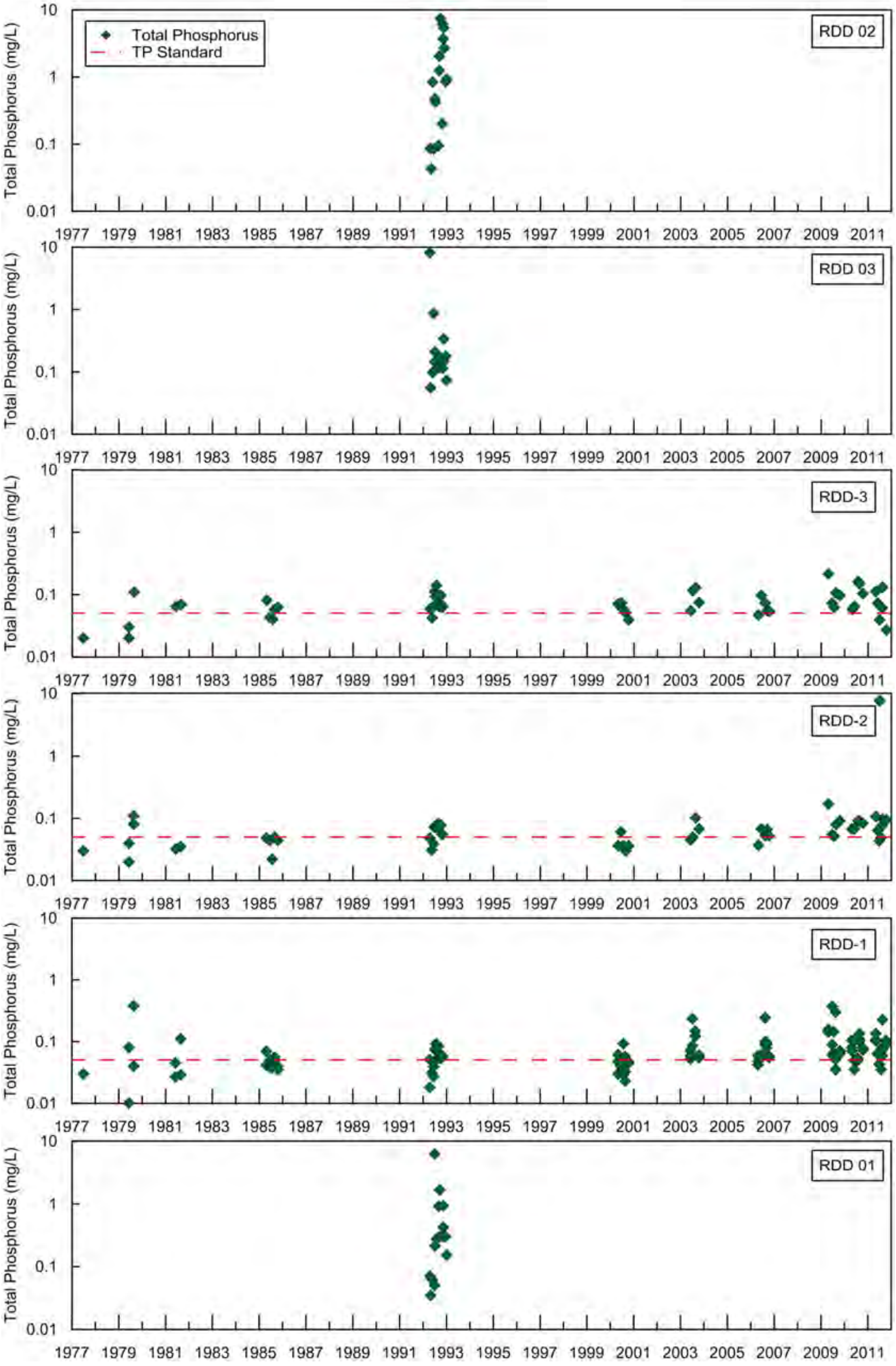

Figure 5-18. Total phosphorus concentrations, historical data

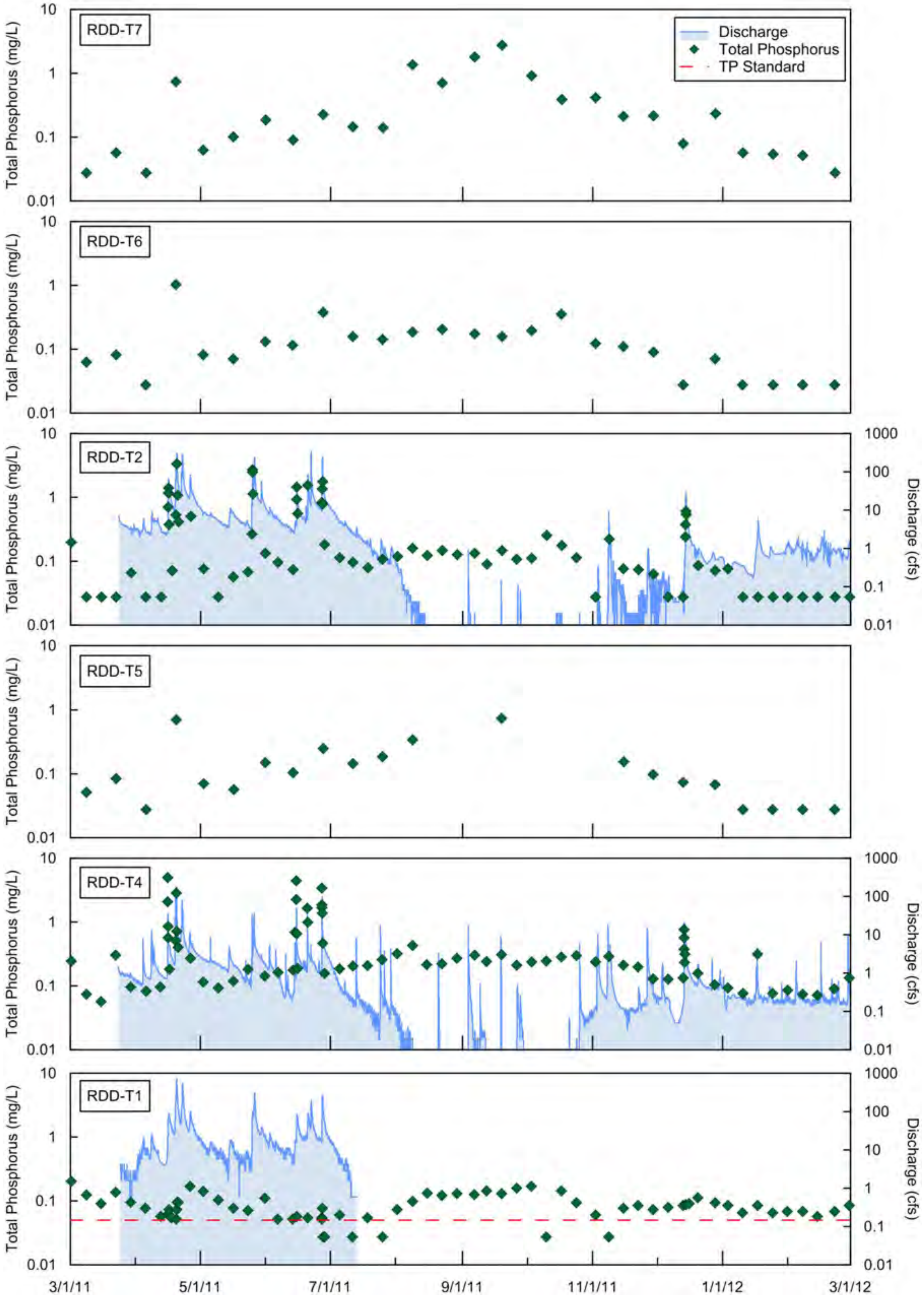

Figure 5-19. Total phosphorus concentrations, project data

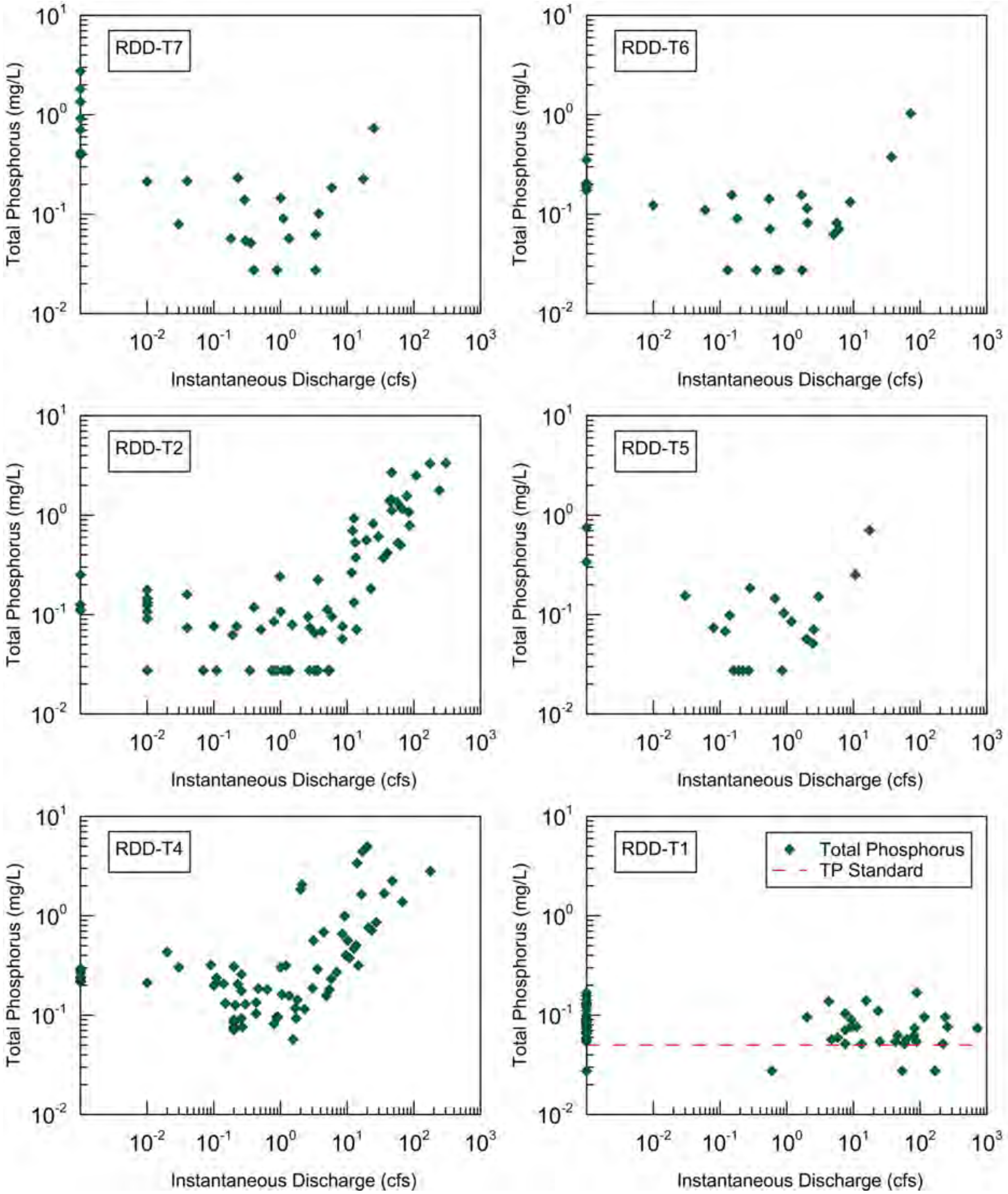

Figure 5-20. Relationship between total phosphorus concentration and discharge, project data

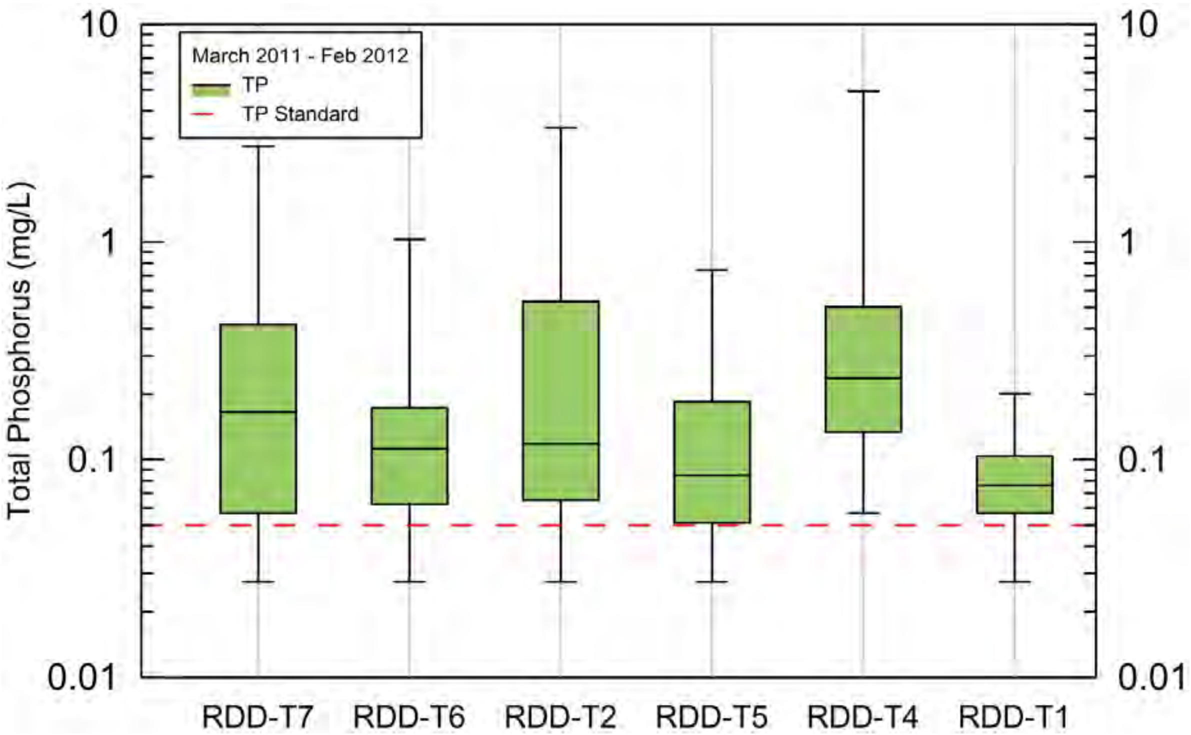

Figure 5-21. Box-whisker plots of total phosphorus concentrations, project data

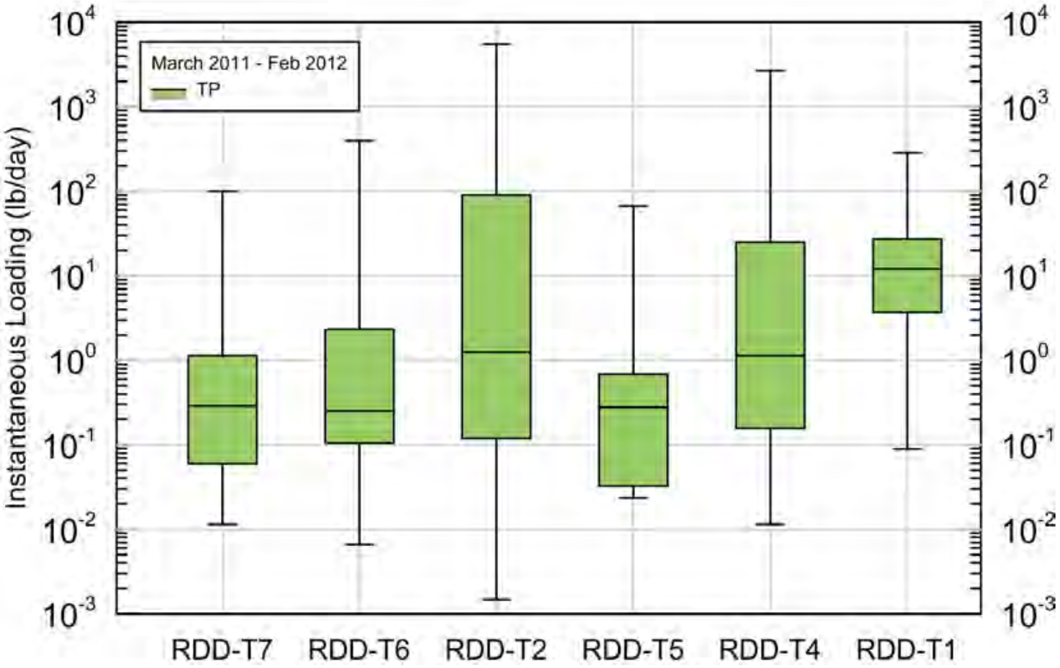

Figure 5-22. Box-whisker plots of total phosphorus instantaneous loadings, project data

Table 5-24 shows annual total phosphorus loads calculated from the project monitoring data for the three base sites. The outflow at the spillway site (RDD-T1) represents only a small fraction of the total load incoming to the reservoir. The two sampled tributaries (RDD-T2 and RDD-T4) represent 57% of the drainage area contributing to Canton Lake. Annual total phosphorus load from the ungaged area was estimated using an area-weighted average annual yield (Table 5-24) to get a rough estimate of the total loading that entered the lake between March 2011 and February 2012. The load withdrawn through the Water Treatment Plant (WTP) intake was estimated from monthly pumped volumes and average monthly concentrations at RDD-T1. These numbers represent only preliminary estimates for the sampled time period and should not be interpreted as final or average loads. This preliminary estimate indicates that a majority (90%) of the total phosphorus load that entered Canton Lake between March 2011 and February 2012 remained in the lake storage.

Table 5-24. Annual total phosphorus loads, project data

Station Code	Type	Annual Load	Annual Yield
		lbs	lbs/ac
RDD-T2	Inflow	10,400	2.43
RDD-T4	Inflow	1,310	1.18
Ungaged area	Inflow	8,130*	2.17**
Total estimated inflow		*19,840*	
RDD-T1	Outflow	1,370	
WTP Pumpage***	Outflow	525	
Total estimated outflow		*1,895*	*0.21*

Notes: * Estimated from average annual yield

** Area-weighted average from gaged inflows

*** Estimated from average monthly concentrations at RDD-T1

Dissolved phosphorus data were available for historical water quality sites. Table 5-25 shows summary information for the ratio of dissolved phosphorus to total phosphorus. Only some samples were analyzed for both dissolved and total phosphorus concentrations, as shown by the number of samples. The average ratio of dissolved phosphorus to total phosphorus at two stream sites (RDD 02 and RDD 03) is higher than at the lake sites. Only 1 sample was available for site RDD 01 (stream). For the lake sites, the near-bottom samples at site CL show the highest ratios. The lowest ratios are found at sites RDD-2 and RDD-3.

Table 5-26 summarizes historical data for total phosphorus in sediments. Short (1997) analyzed sediment data for Illinois between 1982 and 1995 and determined concentrations at or above 1,000 milligrams per kilogram (mg/kg) were “elevated” and concentrations at or above 2,800 mg/kg were “highly elevated.” “Elevated” and “highly elevated” refer to those concentrations of a particular constituent that equal or exceed the 85th and 98th percentiles, respectively, (along the normal distribution curve) for the samples included in the study by Short (1997). Four samples at site RDD-1 are found above the elevated value, and one sample is considered highly elevated. Data collected during the last 10 years at station RDD-1 are higher than previous data (Figure 5-23).

Table 5-25. Ratio of dissolved phosphorus to total phosphorus, historical data (unitless)

Station Code	Start Date	End Date	Number Samples	Minimum	Average	Maximum
RDD-1	6/6/1979	10/14/2011	95	0.0125*	0.294*	0.940*
RDD-2	6/6/1979	10/14/2011	38	0.056*	0.221*	0.643*
RDD-3	6/6/1979	10/14/2011	38	0.058	0.222	0.613
RDD 01	4/16/1992	4/16/1992	1	0.271	0.271	0.271
RDD 02	4/16/1992	10/23/1992	5	0.282	0.673	0.941
RDD 03	4/16/1992	6/11/1992	2	0.515	0.534	0.552
CL surface	4/17/1978	10/16/1978	26	0.125*	0.380*	0.667*
CL mid	4/17/1978	10/16/1978	27	0.167	0.375	0.800
CL bottom	4/17/1978	10/16/1978	27	0.167	0.518	1.000

Notes: * Concentrations below detection limit (ND) were removed to calculate the ratio

Table 5-26. Total phosphorus data in sediment, historical data (mg/kg)

Station Code	Start Date	End Date	Number Samples	Minimum	Average	Maximum
RDD-1	8/23/1979	7/28/2010	7	590	1690	4999
RDD-3	7/8/2003	7/28/2010	4	302	631	1172

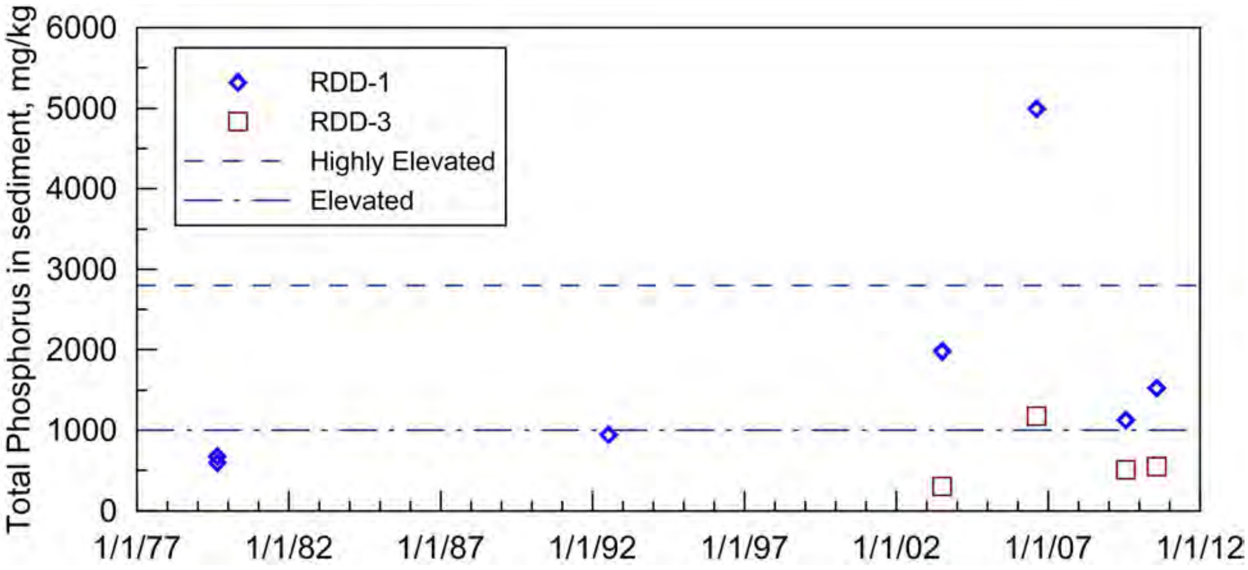

Figure 5-23. Total phosphorus concentration in sediment, historical data

Phosphate data (PO_4 as P) were collected in two wells in the Canton Lake watershed from 1974 to 1979. All analyzed samples were below 0.05 mg/l. A summary of groundwater total phosphate concentrations from the two Canton Lake watershed wells contained in ISWS groundwater database is in Table 5-27 and Figure 5-24.

Table 5-27. Total phosphate data summary, groundwater data (mg/l as P)

TRS	Start Date	End Date	Number Samples	Minimum	Average	Maximum	Number Exceedances$
07N04E11	8/14/1979	8/14/1979	1	ND	*	ND	0 (0%)$
08N04E34	7/31/1974	6/12/1976	2	ND	*	0.01	0 (0%)$

Notes: TRS = Township, Range, Section; ND = analyte not detected, value below detection limit
* = value could not be calculated due to a presence of values below detection limit (ND)
$ = water quality standard is not directly applicable, exceedances shown only for comparison purposes

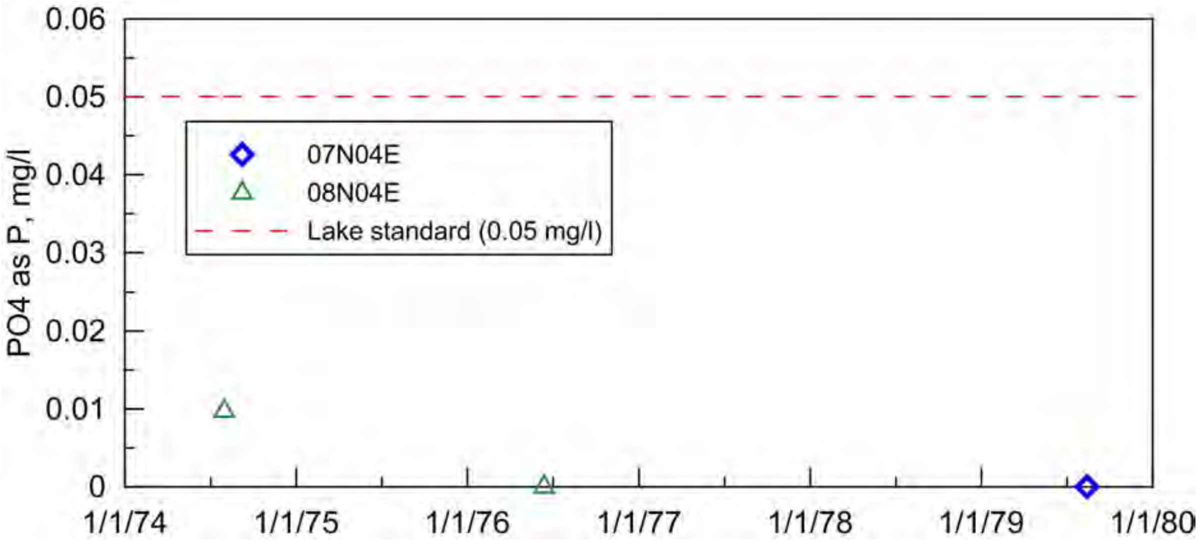

Figure 5-24. Total phosphate concentration as P in groundwater by township and range

5.3.2 Total Suspended Solids

A summary of the historical and current project total suspended solids data collected from Canton Lake and its tributaries can be found in Table 5-28 and Table 5-29, respectively. There is no water quality standard for total suspended solids. However, total phosphorus is largely associated with sediment and carried to receiving waters via soil erosion. Total suspended solids data are thus relevant to TMDL development for total phosphorus.

Average and maximum total suspended solids concentrations observed in the lake are generally smaller than those in its tributaries. Slower velocities in the lake allow for significant settling of suspended particles. Average and maximum total suspended solids concentrations reported by the CRDC are generally much smaller than those sampled during this project. However, the CRDC samples were collected at lower flows; the highest reported flow at site NC-6 was 10 cfs. This site is approximately at the same location as the current project site RDD-T2 where the currently highest sampled flow is 305 cfs (Table 5-5). Typically, high total suspended solids concentrations are found during runoff events in streams.

Table 5-28. Total suspended solids data summary, lake data (mg/l)

Station Code	Start Date	End Date	Number Samples	Minimum	Average	Maximum
Historical data						
RDD-1	6/27/1977	10/14/2011	125	ND	14.1*	86
RDD-2	6/27/1977	10/14/2011	56	3	11.6	25
RDD-3	6/27/1977	10/14/2011	55	3	21.0	62
Project data						
RDD-T1	3/1/2011	2/29/2012	67	ND	11*	48

Table 5-29. Total suspended solids data summary, tributary data (mg/l)

Station Code	Start Date	End Date	Number Samples	Minimum	Average	Maximum
Historical data						
RDD 01	4/16/1992	12/31/1992	16	6	153	640
RDD 02	4/16/1992	12/31/1992	17	13	207	1236
RDD 03	4/16/1992	12/31/1992	15	2	84	284
NC-1	4/20/2004	5/10/2006	10	6	21.4	56
NC-4	4/9/2006	5/10/2006	2	6	6	6
NC-5	5/20/2004	5/10/2006	4	9	12	17
NC-6	5/14/2004	5/10/2006	8	6	15.9	42
NC-9	7/2/2004	5/10/2006	3	9	15	24
Project data						
RDD-T2	3/1/2011	2/29/2012	77	ND	448*	5060
RDD-T4	3/1/2011	2/29/2012	77	ND	499*	9880
RDD-T5	3/8/2011	2/22/2012	21	ND	44*	474
RDD-T6	3/8/2011	2/22/2012	26	ND	87*	1540
RDD-T7	3/8/2011	2/22/2012	26	ND	51*	396

Notes: ND = analyte not detected, value below detection limit
* value is affected by a presence of values below detection limit (ND)

Figure 5-25 and Figure 5-26 show total suspended solids concentrations plotted in time for historical and current project data, respectively. Discharge for the three base sites from the current project is also shown. The gaps in the discharge plot show dry periods of zero flow (i.e., there were no missing streamflow data from the gage record). Historical data on stream sites are only available for 1992. Figure 5-26 also shows volatile suspended solids concentrations analyzed for the same samples.

Figure 5-27 shows the relationship between the observed total suspended solids concentrations and instantaneous discharge for the current project data. Concentrations measured at zero discharge conditions are plotted at the y-axis for each site. No discharge data were available for the historical data set. The highest total suspended solids concentrations were measured at the highest flows for all but the Canton Lake spillway site (RDD-T1). The Canton Lake spillway (site RDD-T1) shows no significant relationship between total suspended solids concentration and discharge.

Figure 5-28 compares distributions of total suspended solids concentrations at the project monitoring sites. The Canton Lake spillway (site RDD-T1) shows the smallest variation in observed concentrations. Sites RDD-T2, RDD-4, and RDD-T7 have the largest variation in observed concentrations. Site RDD-T4 has the highest mean, closely followed by site RDD-T2.

A statistical comparison of means[2] was carried out using samples collected at non-zero discharges during dates common across the sites (i.e., storm samples and every other set of weekly samples were removed for the base sites to create a subset that would correspond to bi-weekly sampling at supplemental sites). This was necessary because of the relationship between total phosphorus concentrations and discharge and the lower number of samples collected during high flow regime at supplemental sites. Any difference in mean total suspended solids concentration cannot be statistically confirmed among the sites.

Instantaneous loadings were calculated as a product of observed concentration, discharge, and appropriate conversion factor. In spite of the lowest concentrations, the Canton Lake spillway site (RDD-T1) carried the highest total suspended solids loadings (Figure 5-29). Any difference in mean total suspended solids loadings cannot be statistically confirmed among the sites with the exception of site RDD-T1 which has a mean higher than all remaining sites. Mean total suspended solids loadings at site RDD-T2 cannot be confirmed as statistically different from site RDD-T1 nor from the remaining stream sites (i.e., confidence levels for mean loadings at site RDD-T2 overlap confidence levels for mean loadings at all remaining sites).

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[2] Statistical significance was determined using 95% confidence level.

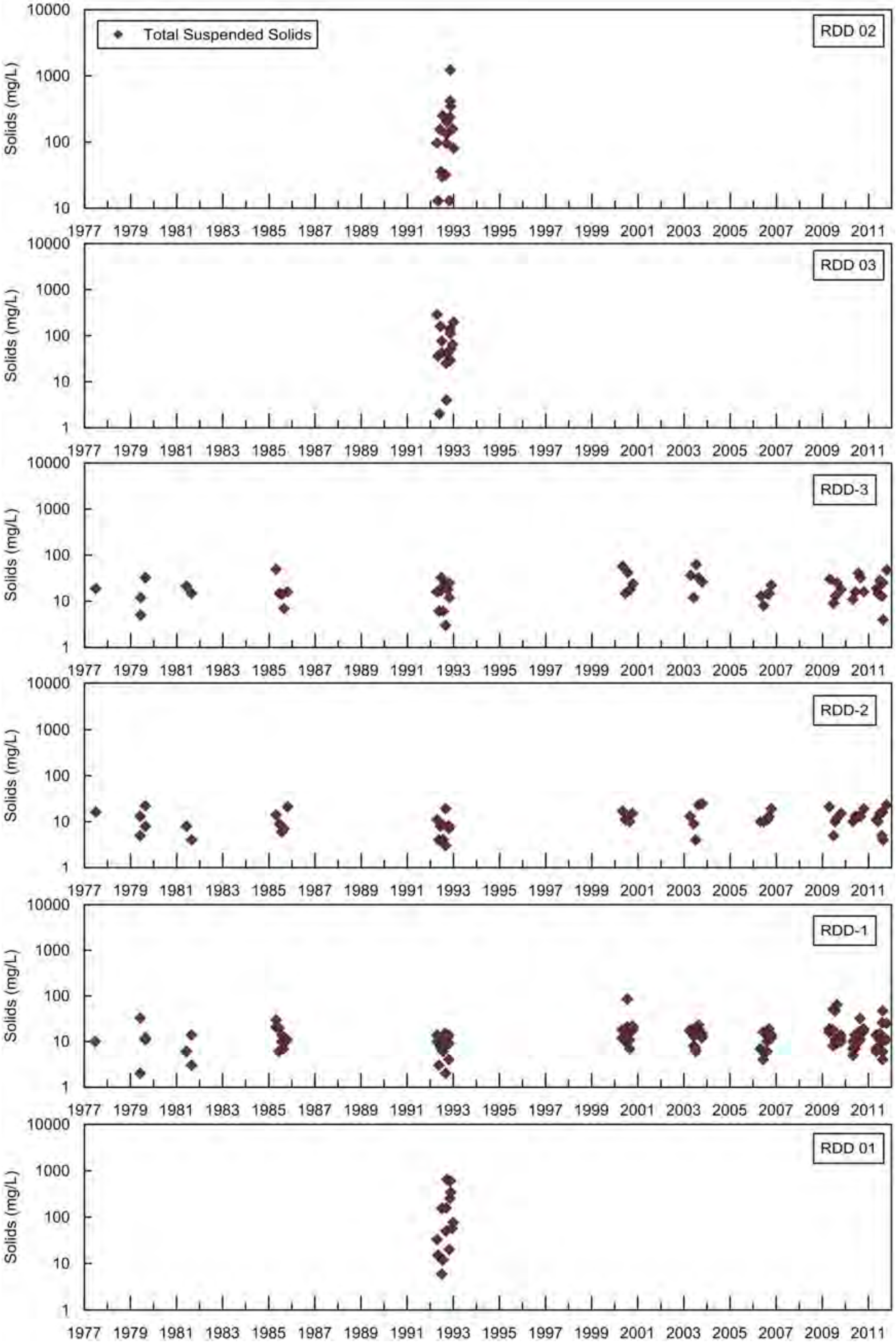

Figure 5-25. Total suspended solids concentrations, historical data

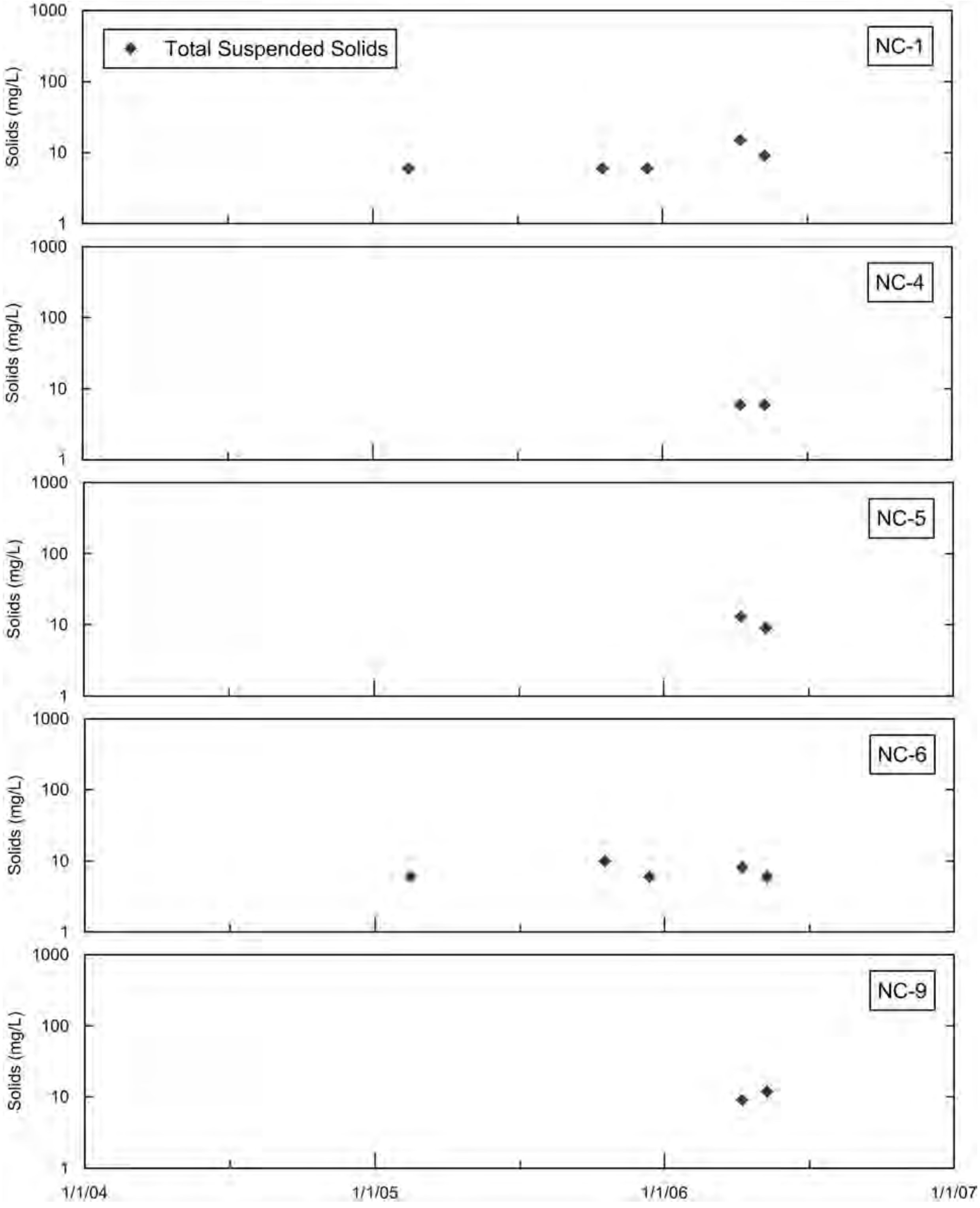

Figure 5-25. (concluded)

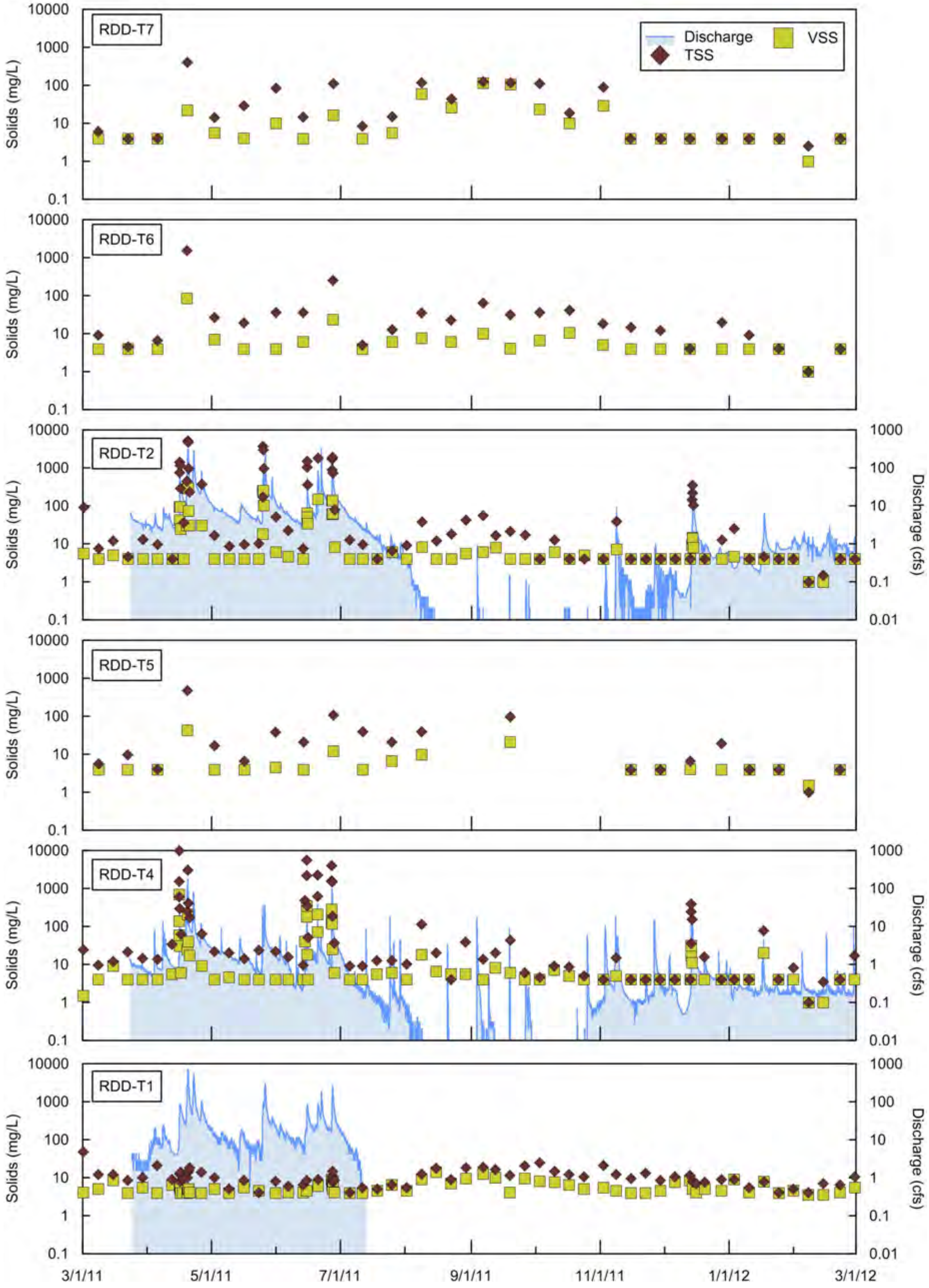

Figure 5-26. Total suspended solids concentrations, project data

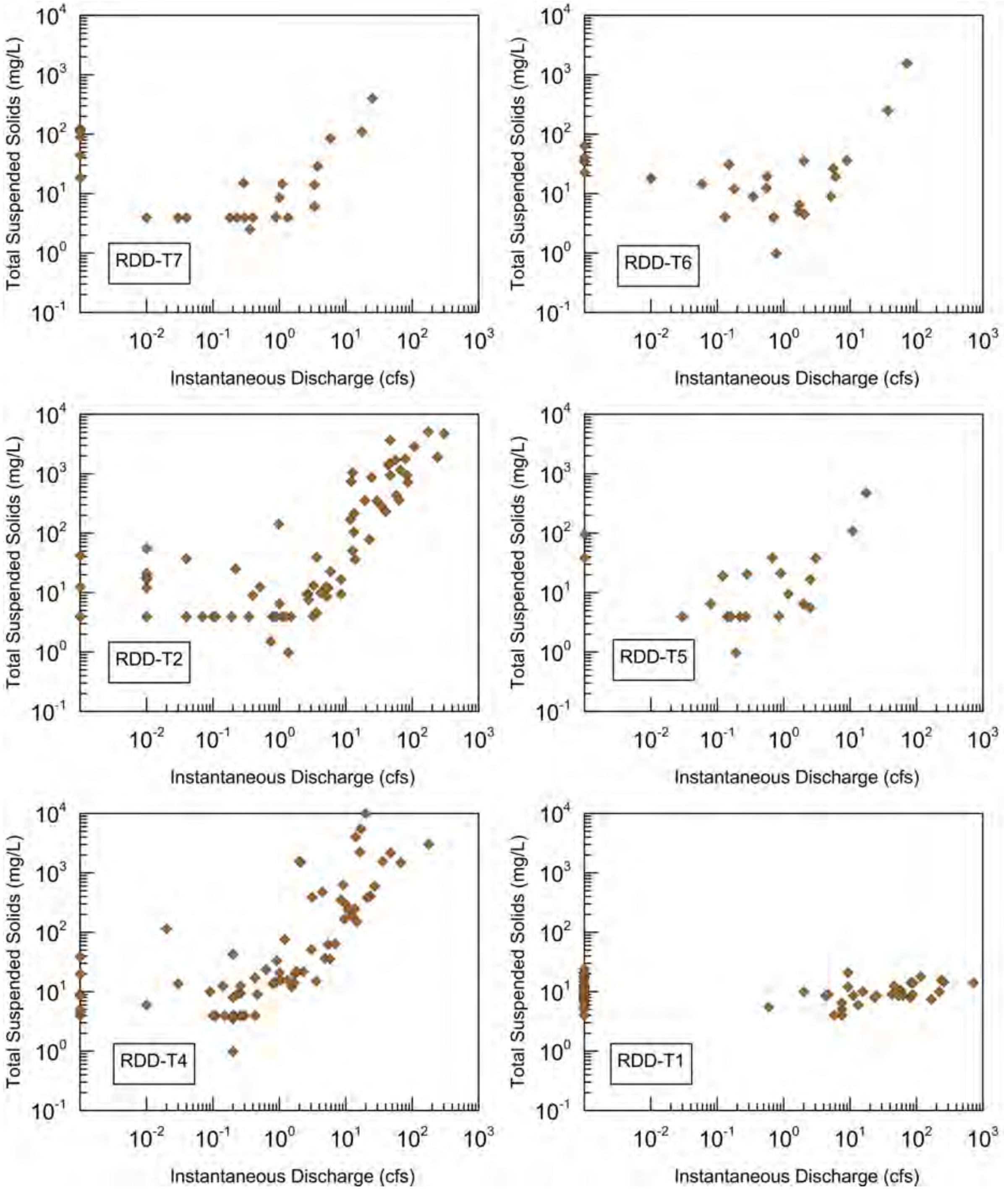

Figure 5-27. Relationship between total suspended solids concentration and discharge, project data

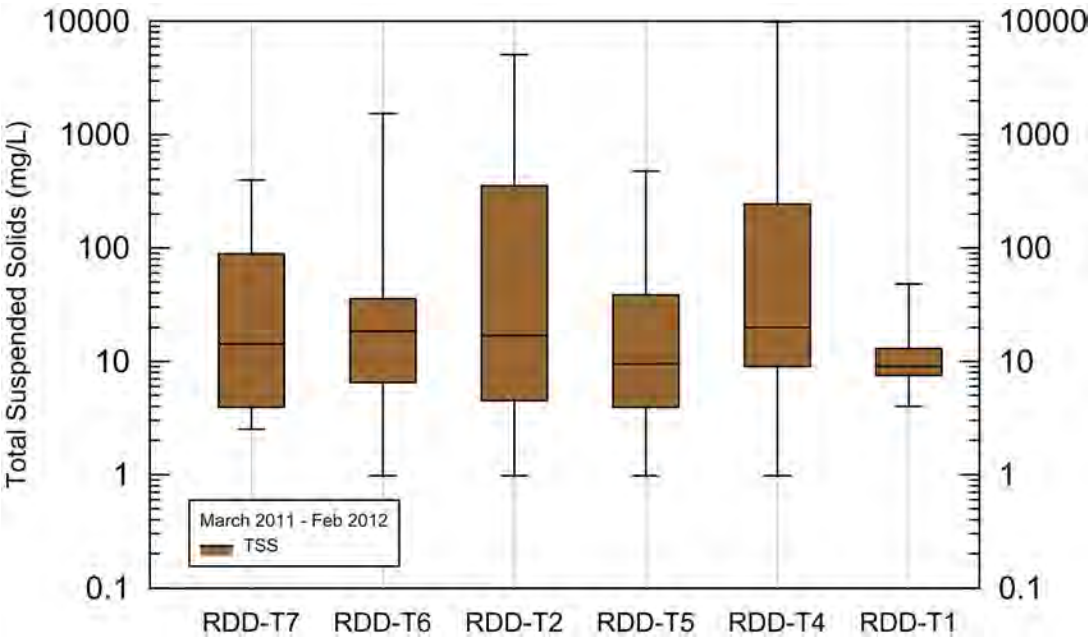

Figure 5-28. Box-whisker plots of total suspended solids concentrations, project data

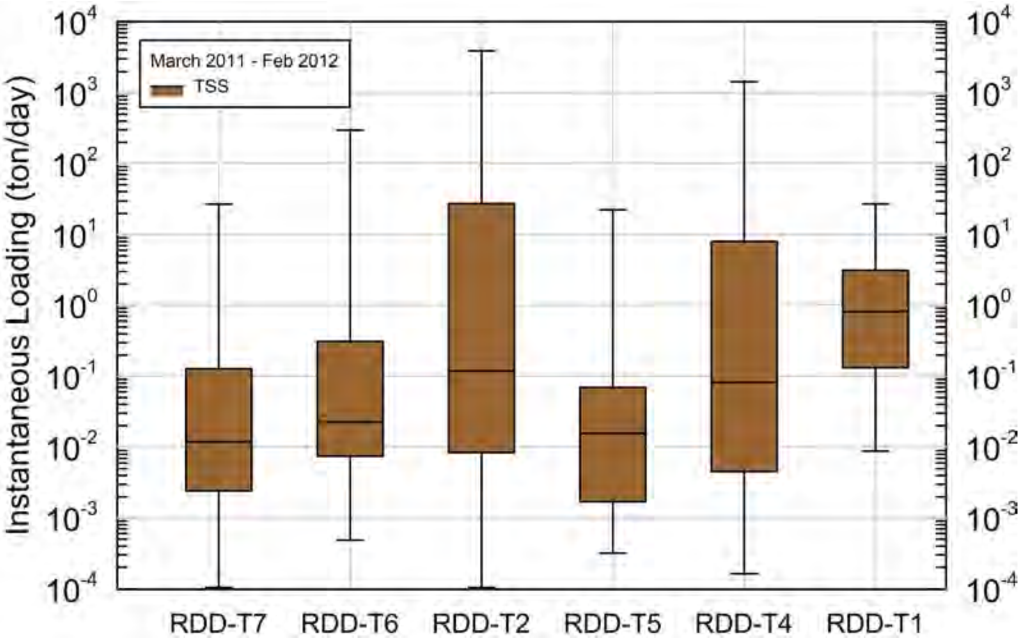

Figure 5-29. Box-whisker plots of total suspended solids instantaneous loadings, project data

Table 5-30 shows the annual total suspended solids loads calculated from the project monitoring data for the three base sites. The outflow at the spillway site (RDD-T1) represents only a small fraction of the total load delivered to the reservoir. The two sampled tributaries (RDD-T2 and RDD-T4) represent 57% of the drainage area contributing to Canton Lake. Annual total suspended solids loads from the ungaged area were estimated using an area-weighted average annual yield to get an estimate of the total loading that entered the lake between March 2011 and February 2012. The load withdrawn through the WTP intake was estimated from monthly pumped volumes and average monthly concentrations at RDD-T1. These numbers represent only preliminary estimates for the sampled time period and should not be interpreted as final or average loads. This preliminary estimate indicates that a majority (99%) of the total suspended solids load that entered Canton Lake between March 2011 and February 2012 was retained within the lake.

Table 5-30. Annual total suspended solids loads, project data

Station Code	Type	Annual Load tons	Annual Yield tons/ac
RDD-T2	Inflow	8,990	2.10
RDD-T4	Inflow	610	0.55
Ungaged area	Inflow	6,960*	1.78**
Total estimated inflow		*16,560*	
RDD-T1	Outflow	93	
WTP Pumpage***	Outflow	32	
Total estimated outflow		*125*	*0.01*

Notes: * Estimated from average annual yield
** Area-weighted average from gaged inflows
*** Estimated from average monthly concentrations at RDD-T1

5.4 Potential Sources of Impairment

This section addresses potential sources of impairment as they relate to the constituents of concern (causes of impairment) for Canton Lake. The potential sources listed in the IEPA Integrated Water Quality Reports are listed in Table 5-31 for years 2014 and 2016. The list of potential sources is based on best professional judgment and is not exclusive of other potential causes of impairment. In addition to the potential sources listed in Table 5-31, other sources are also discussed based on watershed characteristics. The individual sources relevant to the causes of impairment in Canton Lake are discussed below in more detail, including any permitted discharges present in the watershed.

Table 5-31.Potential sources of impairment (from IEPA, 2014, 2016)

Potential Source of Impairment	**2014**	**2016**
Atmospheric deposition – Toxics*	Y	Y
Internal Nutrient Recycling	Y	Y
Runoff from forest/grassland/parkland	Y	Y
Unknown sources	Y	Y

Notes:
* Identified as potential source for mercury; mercury is not addressed in this study

5.4.1 Point Sources

Information on National Pollutant Discharge Elimination System (NPDES) permit holders in the vicinity of the Canton Lake watershed was obtained from the Environmental Protection Agency Permit Compliance System (US EPA, 2011). Only one permit holder is actually located within the Canton Lake watershed: the City of Canton Water Treatment Plant (WTP). The main outfall for a second permit holder, the City of Canton West STP, is located outside of the Canton Lake watershed; however, there is one combined sewer overflow (CSO) for the West plant that discharges within the Canton Lake watershed. CSOs carry organic matter, nutrients, pathogens, suspended solids, and potentially other pollutants. Discharge monitoring report (DMR) data for relevant NPDES permits were obtained online from the Illinois Environmental Protection Agency historic DMR search page (IEPA, 2010a). Table 5-32 provides a summary of available information from these facilities. It is also important to note that Canton is not an MS4 community.

The Canton WTP is permitted to discharge into the West Branch Copperas Creek, and the parameters currently monitored are pH, TSS, chlorine, and flow. However, it has been verified that the discharge point for the Canton WTP NPDES permitted discharges is downstream of the Canton Lake spillway. The CSO at Eleventh & Myrtle was permitted to discharge into a ditch to Canton Lake and the number of flow events per month was reported.

Table 5-32. NPDES permit holders and/or dischargers within the Canton Lake watershed

NPDES permit holder	NPDES ID	Constituents Monitored	Period
CANTON WTP, CITY OF	ILG640037	pH, TSS, flow, chlorine	2000-2002, 2007-2012
CANTON WEST STP, CITY OF 11th & Myrtle CSO	IL0027839	Number of flow events	2000-2012

Figure 5-30 shows the number of CSO discharges reported for the CSO at 11th and Myrtle. There is a significant change in the reported numbers starting in May 2006. Prior to May 2006, one event per month was reported for 5 out of 58 months from August 2000 to April 2006. On the contrary, an average of 5.1 events per month was reported for 56 out of 70 months from May 2006 to February 2012. Table 5-33 summarizes the number of discharges from the CSO at 11th and Myrtle by year. However, the number of CSO events cannot be directly correlated to volume of water or the pollutant load discharged through CSOs.

The outfall at 11th and Myrtle is no longer functional as a CSO. The City of Canton completed a separation of storm water and sanitary waste at this location. The last reported CSO event occurred in September 2011, when the City of Canton issued a Public Notice of CSO Discharge listing three separate events (City of Canton, 2011):

- September 25th, 2011, 12:20 am, lasting for 20 minutes,
- September 26th, 2011, 4:20 pm, lasting for 15 minutes.
- September 26th, 2011, 8:10 pm, lasting for 15 minutes

However, it is important to note that while sanitary wastes are no longer being discharged at this point, the site serves as a storm water outfall. Storm water runoff from urban impervious areas is also known to carry high concentrations of organic matter, nutrients, suspended solids, and potentially other pollutants.

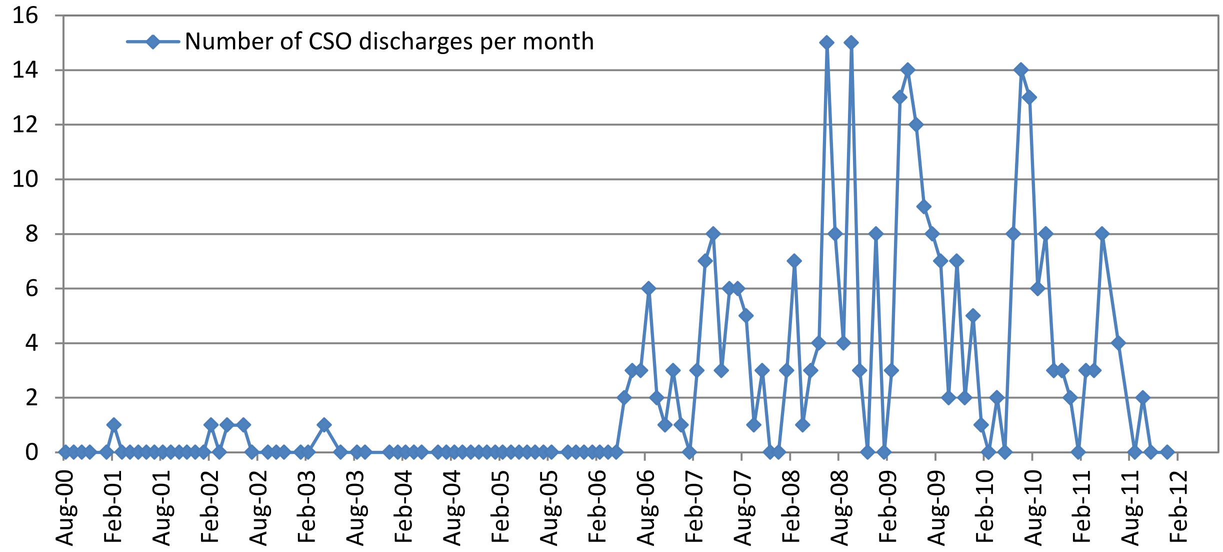

Figure 5-30. Monthly number of discharges from CSO at 11th and Myrtle

Table 5-33. Annual number of discharges from CSO at 11th and Myrtle

Year	Number of CSO Events
2000	0
2001	1
2002	3
2003	1
2004	0
2005	0
2006	21
2007	42
2008	71
2009	82
2010	60
2011	28

5.4.2 Non-Point Sources

Non-point sources discussed here are considered potential sources of impairment at this stage of TMDL development. It is also important to note that the adoption of recommended land use practices to help reduce pollutant loads from non-point sources is voluntary.

Canton Lake watershed is dominated by agriculture land uses. The 1999-2000 land cover dataset shows 65.54% of the watershed is classified as agriculture land (Table 2-1). Visual comparison of aerial photography from 1999 and 2009 does not confirm any significant development in the watershed. Existing urban development and agricultural practices can adversely impact water quality.

5.4.2.1 Row-Crop Agriculture

Nearly two-thirds of the Canton Lake watershed is in agricultural production. Agriculture practices impact water quality in the Canton Lake watershed. Tillage and residue management practices can affect erosion rates, and consequently, the transport of sediment and nutrients to receiving waters. Fertilizer application rates and timing affect nutrient storage and transport to receiving waters as well. Timing and intensity of rain events play a large role in runoff of nutrients from agriculture.

Information on fertilizer usage within Fulton County was obtained from the 2007 and 2012 USDA Census of Agriculture (USDA, 2009, 2014). Fertilizer use in Fulton County decreased overall from 2007 to 2012. Use of manure as fertilizer decreased 33% while use of commercial fertilizers, lime, and soil conditioners decreased by 8% (Table 5-34). Since both manure and commercial fertilizers contain phosphorus, the decrease in use of both in the watershed is likely resulting in less phosphorus transport to receiving waters from row-crop agriculture.

Data on tillage practices in Fulton County were obtained from the Illinois Department of Agriculture 2006 and 2011 Illinois Soil Conservation and Transect Survey Summary (IDOA, 2006, 2011). The transect survey tracks conservation tillage practices in Illinois for different crops. Results show the majority of soybean and small grain producers use no-till methods, which reduce soil erosion. The majority of corn producers use reduced-till methods (Table 5-35). A representative from the Fulton County Soil and Water Conservation District was contacted and confirmed that these county-wide estimates also reflected the practices currently implemented in the Canton Lake watershed (Andrew Karrick, personal communication).

Table 5-34. Fertilizer usage in Fulton County in 2007 and 2012

	Acres Treated		
	2007	**2012**	**Percent Change**
Commercial fertilizers, lime, soil conditioners	229,799	210,325	-8 %
Manure	10,834	7,287	-33 %
Total	240,633	217,612	-10 %

Table 5-35. Tillage practices in Fulton County in 2006 and 2011

	Corn		Soybeans		Small Grain	
	2006	2011	2006	2011	2006	2011
Conventional	10 %	28 %	1 %	8 %	0 %	0 %
Reduced-till	45 %	49 %	4 %	23 %	0 %	0 %
Mulch-till	30 %	18 %	24 %	22 %	0 %	0 %
No-till	15 %	5 %	71 %	47 %	100 %	100 %

5.4.2.2 Animal Operations

Confined animal facilities as well as livestock grazing can also contribute nutrients and sediment directly when animals are allowed to enter the stream or lake corridor, through runoff of facilities, or indirectly through land application of manure and increased erosion.

Data on animal populations within Fulton County were obtained from the 2007 and 2012 USDA Census of Agriculture (USDA, 2009, 2014). In 2012 hogs and pigs were the most common farm animal found within Fulton County, despite a 20% drop in their population between 2007 and 2012. Cattle and calves were also numerous within the county, and their population increased 3% between 2007 and 2012. The populations of poultry, sheep/lambs, and horses/ponies were small, less than 1,250 animals each. Use of poultry, horses/ponies, and sheep and lambs all decreased between 2007 and 2012 (Table 5-36). However, to more precisely determine the impact of animal operations on phosphorus transport within the Canton Lake watershed would require information of how the animals are distributed, as well as managed (access to tributaries, manure handling practices, etc.).

Table 5-36. Change in animal population in Fulton County from 2007 to 2012

	2007	2012	Percent Change
Cattle and Calves	25,431	26,135	3 %
Beef	10,421	12,200	17%
Dairy	31	108	349%
Hogs and Pigs	54,292	43,550	-20 %
Poultry	1,555	1,218	-22 %
Sheep and Lambs	1,086	980	-10 %
Horses and Ponies	1,058	625	-41 %

There is a single permitted Concentrated Animal Feeding Operation (CAFO) located within the Canton Lake watershed: Dare Farms. This operation (NPDES number ILA010083) is a cattle finishing facility located north of the City of Canton and approximately 1,200 feet southwest of West Branch Copperas Creek. According to the operation's 2010 CAFO permit application (http://www.epa.state.il.us/water/permits/cafo/), the facility housed 1,700 beef cattle in five livestock building and lots. Approximately 1,148 acres planted in continuous corn are available for waste utilization. The majority of this acreage is located within the Canton Lake watershed.

5.4.2.3 Urban Areas

Urban development can contribute to the deterioration of surface waters in ways other than the point source discharges and combined sewer overflows addressed in Section 5.4.1 Point Sources, page 88). Impervious surfaces present in the urban areas affect watershed hydrology by intercepting rain water and limiting infiltration. Urban streams typically have lower base flows and higher peak flow rates and volumes than natural streams.

Human activities in urban areas affect the type and amount of pollutants transported to receiving waters. Fertilizers applied on lawns and gardens are potential sources of nutrients. Materials used in construction and maintenance can also be sources of pollution. Pet waste represents an increased nutrient load. Road salts or sands used for winter road management can also impact surface waters. However, since the amount of urban area draining into to the lake is small, its contribution to phosphorus loading in Canton Lake is very likely small as well.

Construction itself can contribute to water quality impairments through increased erosion due to soil destabilization. However, construction activities probably have not recently impacted Canton Lake as no significant new development was found to have occurred in the Canton Lake watershed since 1999/2000.

5.4.2.4 Septic Systems

Failing or poorly functioning septic systems may contribute phosphorus and can provide a pathway for household chemicals to enter surface waters. The 1990 U.S. Census provides estimates of the number of septic systems by Public Land Survey System Townships. This census information on septic systems was obtained using the U.S. Census FactFinder website (U.S. Census Bureau, 2010a), with GIS data of 1990 Census township boundaries downloaded from the Census Bureau TIGER website (U.S. Census Bureau, 2010b). Densities of septic systems per township were calculated and used to compute an area-weighted estimate of septic systems in the Canton Lake watershed in 1990. GIS data of the areas served by the City of Canton’s sewer system were obtained from the city’s engineer, Maurer-Stutz, Inc., in order to exclude the City of Canton’s sewershed from the area-weighted calculation. In total, there are an estimated 151 septic systems located within the Canton Lake watershed, including 72 households on Canton Lake. However, more detailed information as to the type of septic systems or their state of repair and maintenance within the watershed was unavailable.

5.4.2.5 Internal Nutrient Loading

Canton Lake becomes stratified during the summer months and oxygen in hypolimnion gets depleted (Figure 5-26 and Figure 5-27). Under these conditions, phosphorus, manganese, and other constituents become more soluble and are released from the bottom sediments to the overlying waters of the hypolimnion. Data presented in previous sections pertaining to phosphorus support that this process is occurring in Canton Lake. Once these constituents become dissolved, they can be transported to other lake layers when mixing or partial mixing occurs. This typically occurs during fall turnover when air temperatures decline. As the top lake layer cools, water temperature and densities of the individual layers come closer, allowing the layers to mix more readily through wind, inflows, density currents, or other mechanisms. Oxygen, nutrients, and other dissolved constituents are then distributed through the water column more evenly. Partial mixing can sometimes occur in shallower lakes under certain conditions even in summer (high winds, passing of cold front, etc.). However, based the modeling analysis presented in the Phase II report, the internal loading of phosphorus is only a minor contributor of phosphorus to Canton Lake (2.6%) on an average annual basis at present.

While the frequency of the IEPA data collected at site RDD-1 is not sufficient to determine dissolved oxygen isopleths, these data do provide good insight into the current state of stratification in Canton Lake. Figure 5-28 shows dissolved oxygen data observed at site RDD-1 during years 2009, 2010, and 2011. Dissolved oxygen concentrations are shown relative to the size of the circle plotted in time at the observed depth. Very low dissolved oxygen values were found near the bottom during each year, although there is a significant variation in the extent of the hypoxic zone between years.

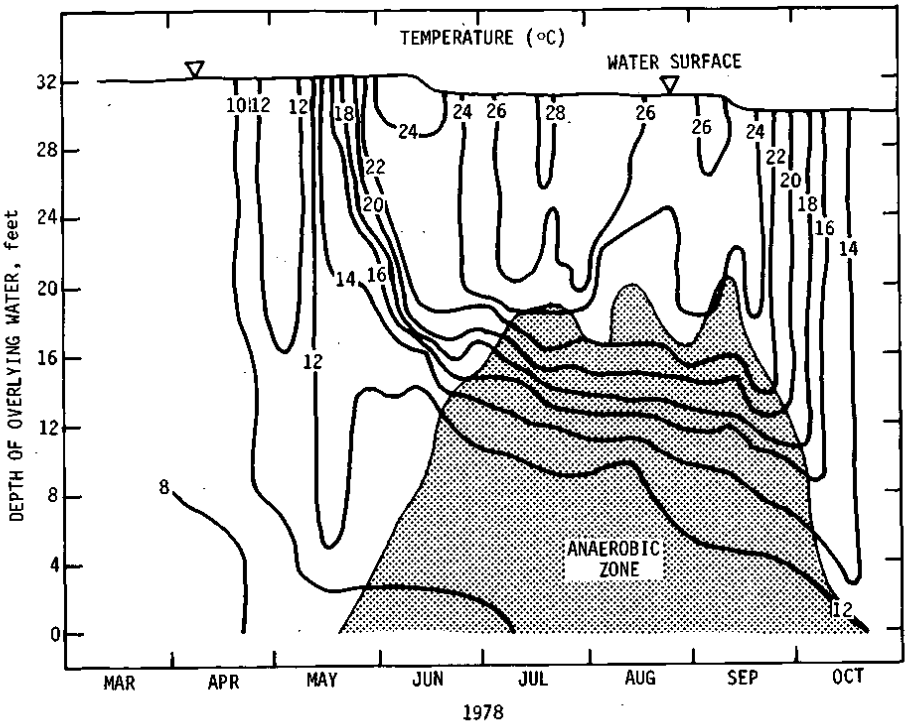

Figure 5-31. Isothermal plots for Canton Lake (Roseboom et al., 1979)

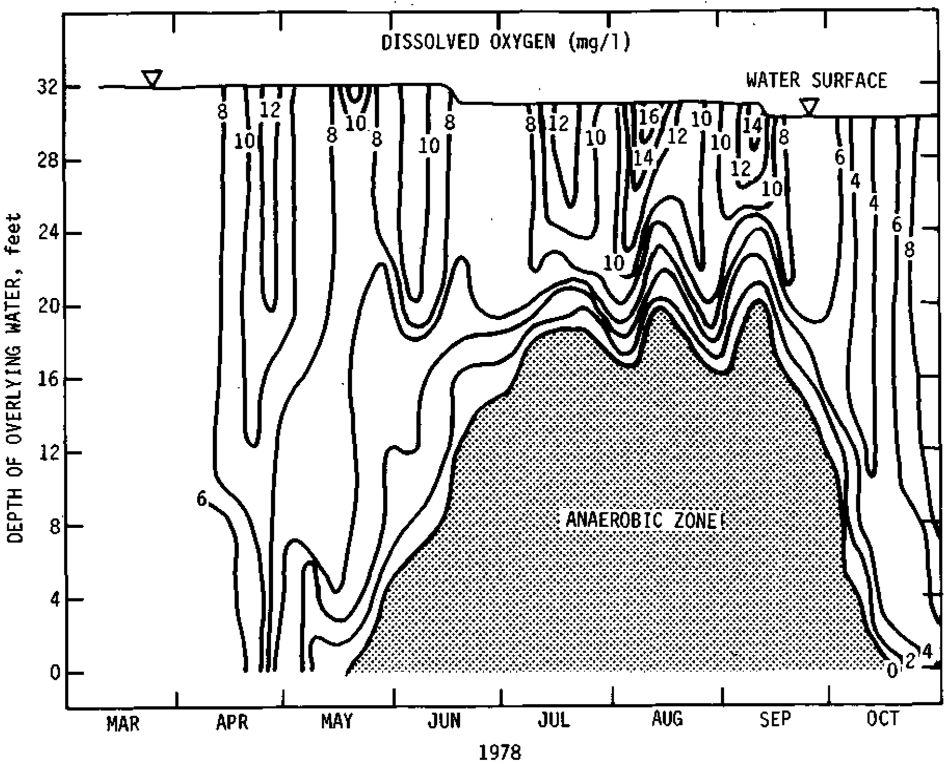

Figure 5-32. Dissolved oxygen isopleths for Canton Lake (Roseboom et al., 1979)

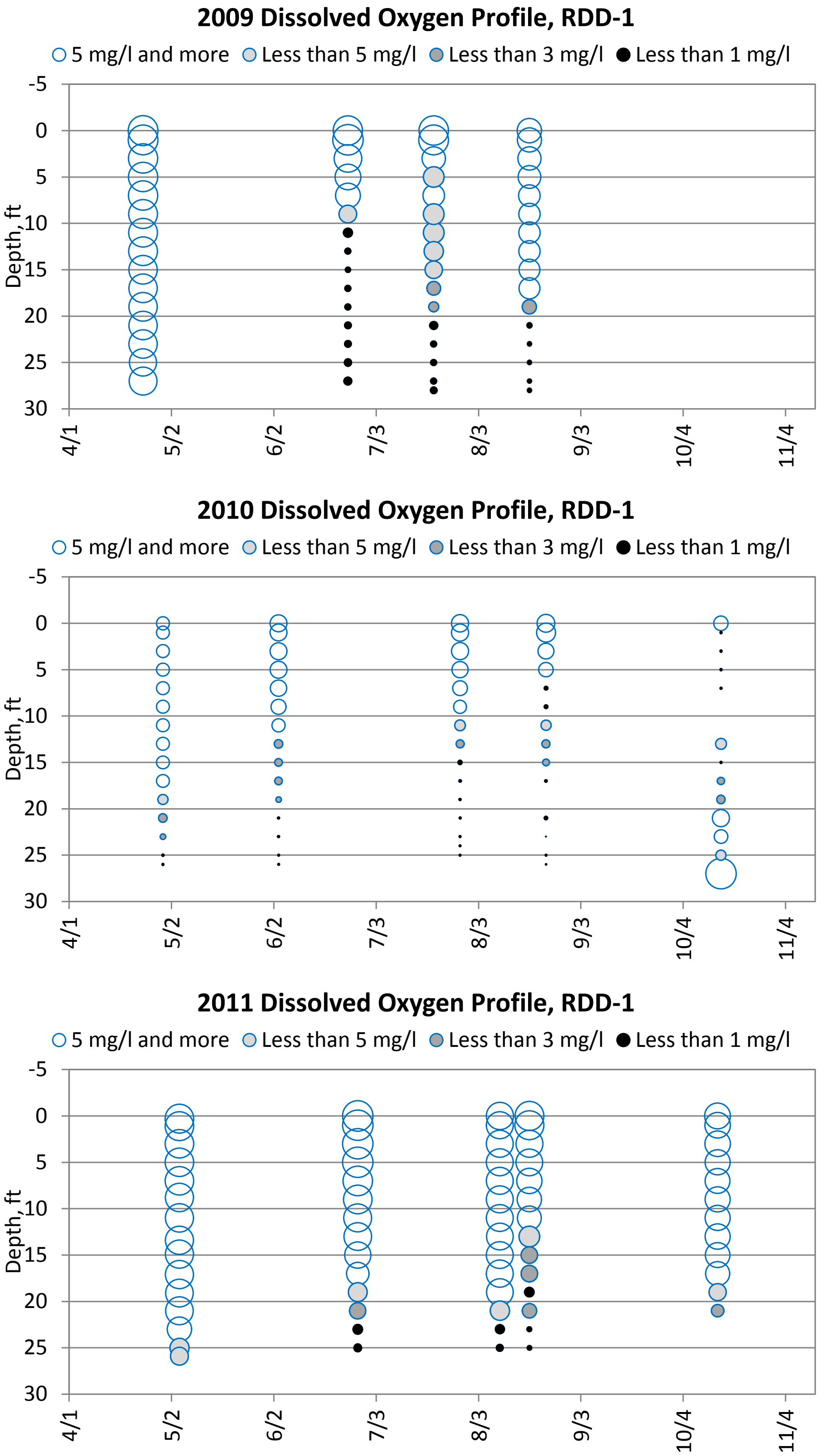

Figure 5-33. Dissolved oxygen profile at site RDD-1 during 2009-2011.
The size of the circle increases with increasing observed dissolved oxygen concentration.

5.4.2.6 Mining

The only mines within the watershed are inactive and underground. They are primarily located near West Branch Copperas Creek in the northern half of the study area (Figure 5-29). GIS shapefiles of coal mines within the Canton Lake watershed were obtained from the Illinois State Geological Survey (ISGS). The ISGS compiled geographic mining data from multiple public and private sources to create digital maps of resolution 1:500,000 in NAD 83 (ISGS, 2010). It is not known if there are discharges from these inactive and underground mines. Moreover, any future mining-related discharge may require reopening of the TMDL if pollutants are generated.

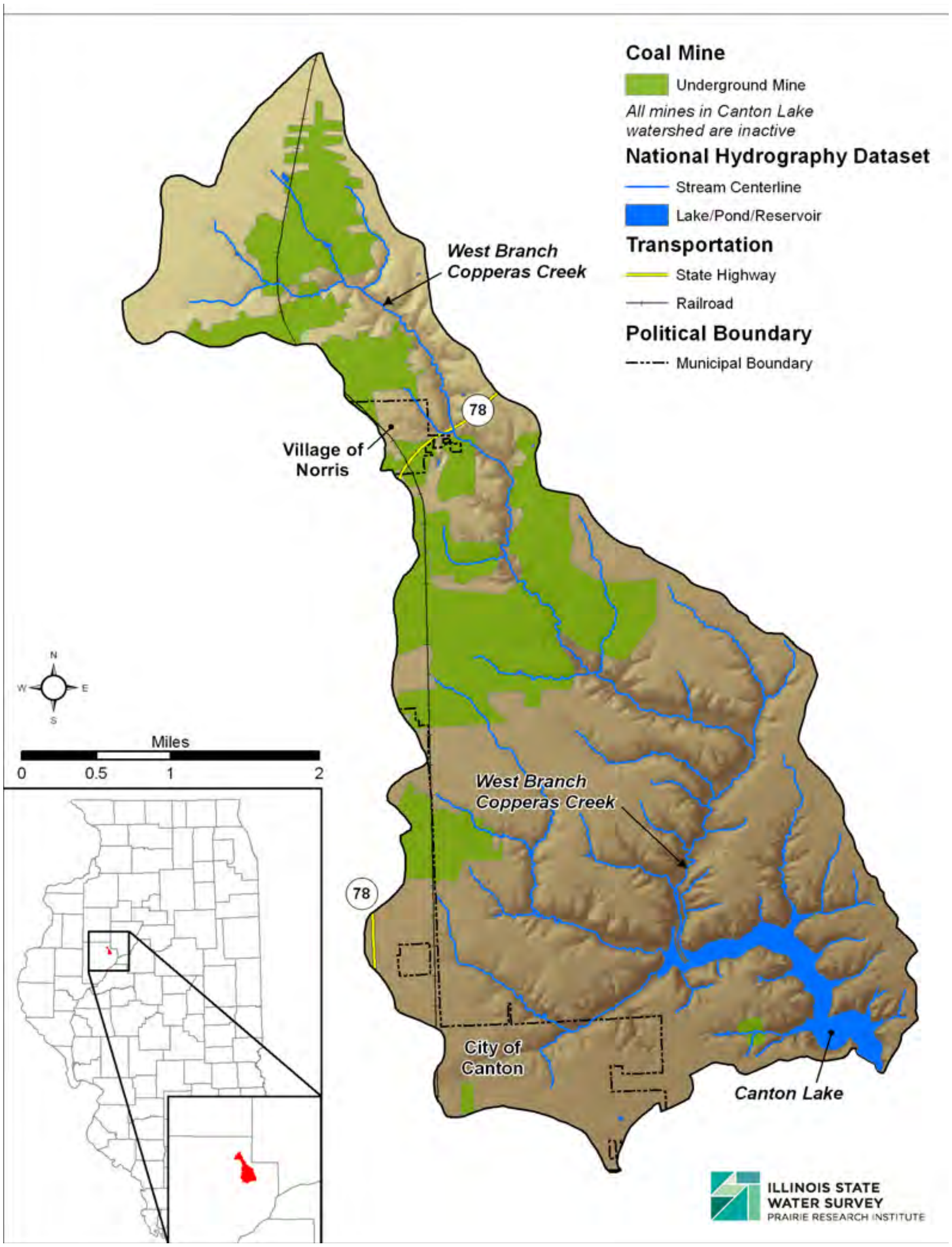

Figure 5-34. Mines in the Canton Lake watershed

5.4.2.7 Recreational Pollution Sources

Canton Lake is accessible to the public. The number of recreational user days was estimated at 50,000 in 1995 (CMT, 1995). Facilities for public use include a beach, campground, and boat access. Fishing is allowed in the lake. Figure 5-30 shows the location of existing facilities and those proposed by CMT (1995). The campground is open from April 15 to mid-November. The campground offers both electric and non-electric sites.

Motorized boats with an engine rated to 90HP are allowed on Canton Lake. During 1991-1992, 306 boating permits were issued with 60% of permits being issued to City of Canton residents (CMT, 1995). According to the City of Canton, approximately 400 boating permits were issued in fiscal year 2011 (Greg Pollitt, personal communication). Fueling and maintenance of boats can potentially introduce fuel, oil, paint, and other substances to water. The wake due to boating activity can damage shorelines and resuspend sediments from the lake bottom in shallow areas.

5.4.2.8 Runoff from Forest, Grassland, and Parkland

Forested lands and grasslands are generally considered beneficial for watershed health by serving as natural filters, retaining nutrients and sediment (TCF, 2006). However, poor grazing practices and lack of management of forested lands can be detrimental to water quality. Forested land is the second highest major land cover category (22%) in the Canton Lake watershed, and runoff from these areas can be a source of total suspended solids, total phosphorus, and potentially manganese associated with certain soils. As most of the forested areas within the watershed are found along stream corridors, streambank erosion can also be a significant source of TSS.

5.4.2.9 Littoral/Shore Area Modifications

Changing water levels and waves generated from winds or boating activities can contribute to increased bank erosion within a water body. Sediment delivered to the water body from these erosional processes contributes to increased loadings of total suspended solids, total phosphorus, and potentially manganese associated with certain soils. In 1989 it was estimated that 2,200 feet of Canton Lake's shoreline was in critical condition and needed stabilized, and as a result, some stabilization efforts were conducted in 1990. Previous studies have estimated shoreline erosion contributes approximately 122 tons of soil per year to Canton Lake (CMT, 1995). More recent assessments were not located and no field reconnaissance of shoreline erosion was conducted as part of this monitoring effort.

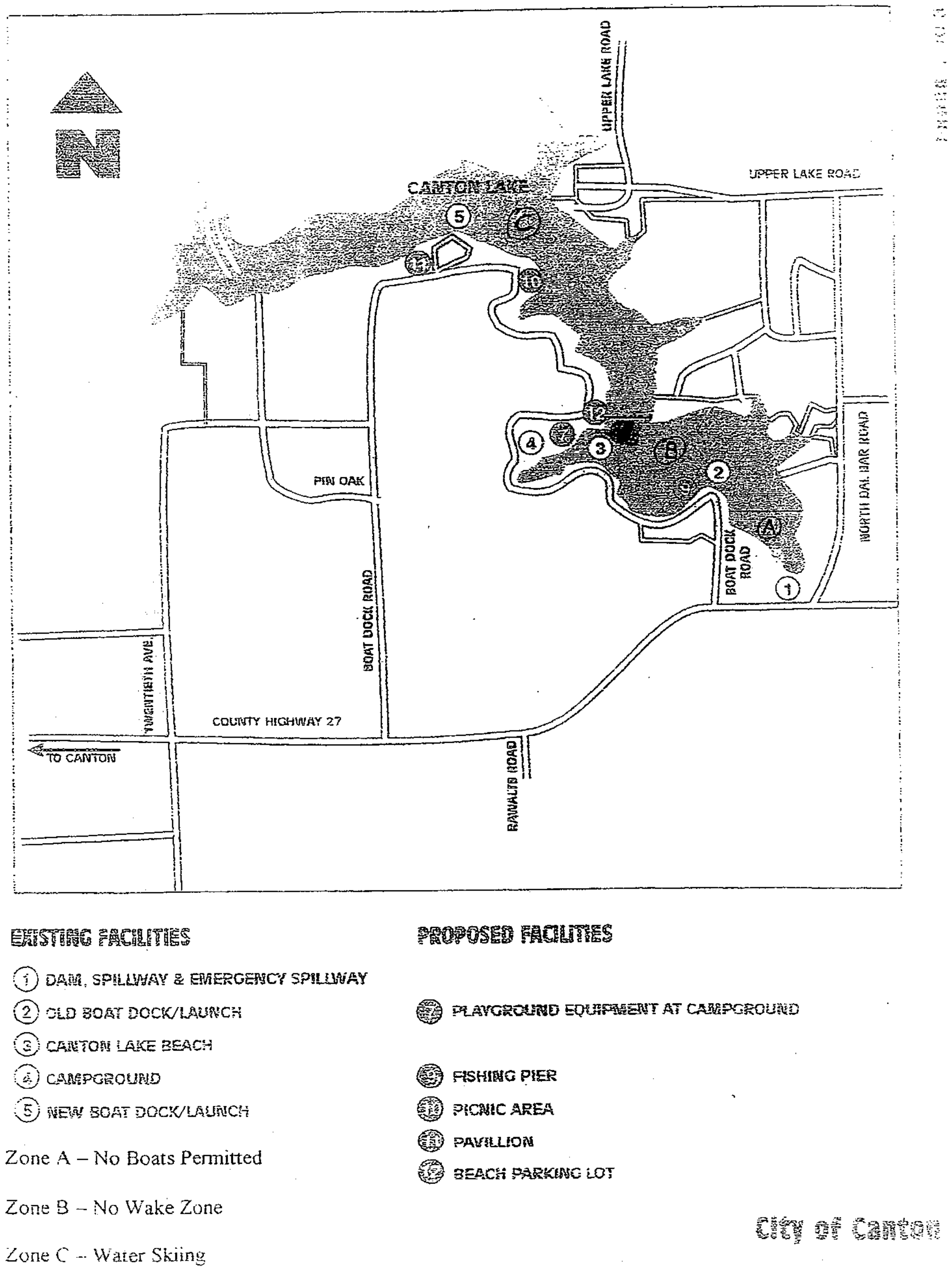

Figure 5-35. Existing and proposed recreational facilities at Canton Lake (City of Canton, 2011)

6. TMDL Approach

This section summarizes observations and conclusions for the total phosphorus and total suspended solids causes of impairment for Canton Lake.

A recommended approach for subsequent Phase II modeling efforts is also presented. In general, any proposed modeling approach must adequately address the following aspects of transport and transformation: generation of loads from point and non-point sources, transport and transformation of pollutants in tributaries, and transport and transformation of pollutants in Canton Lake. Data collected during this project has helped identify the essential processes affecting transport and transformation of monitored pollutants and will be an integral part of the TMDL development. Specific requirements are presented for each listed pollutant as the processes vary with pollutant characteristics.

6.1 Summary of Water Quality Analyses

6.1.1 Total Phosphorus

Total phosphorus concentrations in Canton Lake often exceed the Illinois water quality standard for lakes. Analysis of water quality data can be summarized as follows:

- Lake sediments have a high phosphorus content;
- The lake is stratified with respect to total phosphorus concentration (higher concentrations at the bottom layer);
- The bottom layer of the lake has a higher proportion of dissolved phosphorus than top layers;
- A significant portion of the total phosphorus loading entering Canton Lake remains trapped in the lake;
- High total phosphorus concentrations in tributaries are associated with storm events.

The inflow to the lake is characterized by higher flows in spring (storm runoff) and relatively lower flows during the summer and fall. Non-point sources dominate the phosphorus loading delivered to the lake through sampled tributaries. The phosphorus concentration at the bottom layer of the lake (hypolimnion) increasing throughout the summer season as well as other observations indicate the lake undergoes stratification in summer and oxygen in hypolimnion is depleted. When water levels in the lake fall below the spillway, as often happens, all tributary loadings stay within the lake at least until the reservoir is replenished.

Considering the above observations, the final TMDL approach needs to include the following processes affecting total phosphorus concentrations and loadings in Canton Lake:

- Lake stratification;
- Internal loading;
- Runoff primarily from agricultural areas, but also other areas including septic systems and urban and recreational areas.

6.1.2 Total Suspended Solids

Total suspended solids in tributary streams as well as in Canton Lake are important in TMDL development for total phosphorus because a significant portion of the total phosphorus load is associated with suspended sediments. Analysis of water quality data can be summarized as follows:

- Total suspended solids concentration above the IEPA guideline are found in tributaries but not in Canton Lake;
- High concentrations in tributaries are associated with storm events;
- Significant portion of the total suspended solids loading entering Canton Lake remains trapped in the lake;

The inflow to the lake is characterized by higher flows in spring (storm runoff) and lower flows during the summer and fall. Non-point sources dominate the total suspended solids loading delivered to the lake through sampled tributaries. Most total suspended solids transported by the local tributaries during storm runoff are inorganic. When water levels in the lake fall below the spillway, as often happens, all loadings stay within the lake at least until the reservoir is replenished.

Considering the above observations, the final modeling effort needs to include the following processes affecting total suspended solids concentrations and loadings in Canton Lake:

- Runoff from urban, agriculture, and other areas including abandoned mines and recreational areas;
- Stream bank and lake shore erosion;
- Re-suspension of lake sediments
- Sediment storage in stream channels.

6.2 Methodology

This section discussed methodologies used in TMDL development and their applicability to the Canton Lake TMDL. A variety of approaches have been used in Illinois and other states to develop TMDLs. The methodologies range from simple empirical relationships to sophisticated physically based computer models. However, all approaches are a simplification of the physical reality. Each approach has limitations and inherent assumptions that affect its application and predictive accuracies. Thus, it is critical to use a methodology appropriate for the modeled situation and to develop suitable applications. The methodologies or their application can also vary in time and spatial scales. The loads can be developed as a long-term average, on an annual or shorter time scale or even based on individual storm events. Data needs can increase substantially with smaller time steps and a higher spatial resolution. IEPA once relied on watershed models when developing TMDLs, but over the past several years has relied solely on water quality models. IEPA is considering using watershed models to help prioritize TMDL implementation.

6.2.1 Load Duration Curve

Load Duration Curve represents a simple approach to TMDL development (US EPA, 2007). An underlying assumption of this approach is a correlation of water quality impairments to flow conditions. The method compares the stream loading capacity obtained using a water quality standard and stream flow statistics with the observed loads measured across a range of flows. The method can account for seasonal variations.

Long-term flow and concentration data are needed for the impaired reach to properly develop the load duration curve and to account for all variations. The method is severely limited in its ability to track individual sources and link them with allocated loads. Generally, the application of this method is limited to streams and other water bodies where other processes beside flow are negligible. Long residence time and the need to address internal loadings in Canton Lake means this method is not appropriate to use for phosphorus or manganese. Its applicability for total suspended solids is severely limited in Canton Lake due to long residence time and prolonged periods of no outflow. The Load Duration Curve could possibly be used for the tributaries to Canton Lake for preliminary assessment of load reductions if reliable flow statistics can be obtained.

6.2.2 Loading Models

Watershed loading models provide a linkage between sources of pollution and loads generated in the contributing watershed and delivered to the impaired reach. Watershed loading models can be categorized as simple, mid-ranged, and detailed (US EPA, 1997). Simple methods provide rapid assessment with minimal effort and data requirements using empirical relationships between watershed characteristics and pollutant export. These methods provide a rough estimate of pollutant loads and have limited predictive capabilities. Loads are determined from export coefficients, as a function of sediment yield, or from statistical relationships developed from past monitoring information in similar watersheds. Mid-range models use simplified relationships for the generation and transport of pollutants while retaining responsiveness to management actions. They allow assessment of seasonal or inter-annual loads. Detailed models use storm events or continuous simulation to predict flows and pollutant concentrations for a range of conditions (US EPA, 1997) by simulating the physical processes of infiltration, runoff, pollutant accumulation, instream effects, etc.

6.2.2.1 Land-Use Based Export Coefficients

The premise of this method is that the amount of pollutants delivered to impaired water bodies is driven by land use. The method multiplies individual land use areas and “average expected” loading rates (yields or land-use based export coefficients) to obtain average annual load. The method is very simple. However, it doesn’t account for any temporal variation due to precipitation or impacts of different soil types and/or activities associated with land use practices such as fertilizer application rate. Caution must be exercised in selecting the loading rates to represent current conditions in the assessed watershed.

Long-term or annual estimates determined from this method may be sufficient to estimate loadings to water bodies with large residence time. Application is often limited to pre-planning or screening activities. Export coefficients could be tested and adjusted for Canton Lake against the loads documented through the current project monitoring. The relatively short-term availability of this detailed data could bias the estimates for conditions encountered during the 18 months of monitoring.

6.2.2.2 Sediment Yield-Based Models

This group of models uses the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978) or its modifications to predict erosion. Concentrations for dissolved and particulate pollutants are then associated with flow volumes and sediment loads, respectively. The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) and the Generalized Watershed Loading Functions (GWLF) models are two examples of the sediment-yield based mode (Haith and Shoemaker, 1987; Haith et al., 1992).

STEPL calculates annual sediment, nutrients, and organic matter loads from different land uses and load reductions that would result from the implementation of various Best Management Practices (Tetra-Tech, 2011). For each watershed, average annual nutrient loadings are calculated from the runoff volume and pollutant concentrations in the runoff that can vary with land use and management practices. The annual sediment load is calculated based on the USLE and the sediment delivery ratio. Streambank and gully erosion can be estimated also from their size. The sediment and pollutant load reductions are computed using the known BMP efficiencies.

GWLF is a daily time-step model used to predict runoff, sediment, and nutrients from watersheds with mixed land uses. GWLF can be used for both sediment and phosphorus TMDLs. The runoff is simulated using the runoff curve number and antecedent moisture. The sediment load is estimated with USLE. Dissolved nutrients are simulated using event mean concentrations. The loads generated by individual sources are simply aggregated to produce total load. While the model is simulated at a daily time step, the outputs should be evaluated on a monthly or longer time step due to methods implemented in the model. This simple model has been used in several TMDLs. It requires a relatively small amount of input data. It does not require calibration, although calibration is helpful where monitored data are available. GWLF assumes no re-deposition within the watershed; all the sediment generated within a given year flows out of the watershed during the same year (Borah et al., 2006). The model could be calibrated and validated using the current project monitoring data and then used to estimate total suspended solids and total phosphorus loads to Canton Lake.

6.2.2.3 Watershed Models

There are several watershed models that simulate detailed hydrology together with pollutant generation and transport. The implementation of in-stream transport and processes varies within the models but usually it is simpler than in a receiving stream water quality model. These models are flexible and can be used in TMDL development. However, due to the large data requirements, they are best suited for watersheds with long-term flow and water quality data for model calibration and validation.

The Agricultural NonPoint Source (AGNPS) model is a single-storm event model (Young et al., 1987). It simulates surface runoff, soil erosion, and transport of sediment, N, P, chemical oxygen demand (COD), and pesticides from nonpoint and point sources resulting from a single rainfall event. The simulated watershed is divided into uniform square areas (grid cells). The model generates total or average responses for a storm event considering the storm duration as one time step. AGNPS computes runoff volume using the runoff curve number method. Computation of soil erosion due to rainfall is based on USLE. It is considered a mid-range model by the U.S. EPA (1997).

The Hydrological Simulation Program FORTRAN version 12 (HSPF) simulates watershed loading and the generation and transport of loads from point and nonpoint sources of pollution from a watershed (Bicknell et al., 2001). HSPF is well suited for watersheds with mixed urban and agriculture land uses. HSPF uses a comprehensive, physically based water budgeting algorithm with interaction among the various storages and processes. Erosion and transport of pollutants from pervious and impervious surfaces are modeled using empirical relationships for soil detachment, detached sediment wash-off, and gully erosion. The simulated watershed is divided into homogeneous areas with respect to runoff and pollutant generation. HSPF typically utilizes an hourly time step with results summarized at a daily or longer time step. It is intended for long-term impact analyses as well as storm event analyses. The HSPF model can simulate the following constituents: streamflow (as a sum of surface runoff, interflow, and baseflow) sediment loading, inorganic suspended sediment, pathogens, organic matter, DO, pH, pesticide chemicals, inorganic nitrogen, nitrite, ammonia, nitrate, orthophosphate, phosphorus, phosphate, inorganic phosphorus, tracers (chloride, bromide, dyes, etc.), carbon dioxide, inorganic carbon, zooplankton, phytoplankton, benthic algae, organic carbon, fecal coliform bacteria, pH, and alkalinity (Bicknell et al., 2001).

The SWAT model was developed for agricultural watersheds. It predicts the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land-use, and management conditions over long periods of time. The SWAT model is ideally suited to rural areas dominated by agriculture and requires a great amount of data for vegetative changes and agricultural practices. The simulated watershed is typically divided into homogeneous areas with respect to runoff and pollutant generation. The SWAT model uses a daily time step for simulations with results presented at a daily or longer time step. It is intended for long-term impact analyses (Neitsch et al., 2002). The following constituents can be simulated: water flow, sediment loading, organic nitrogen, organic phosphorus, nitrate, mineral (soluble) phosphorous, ammonium, nitrite, algae as chlorophyll a, conservative metals (aluminum, antimony, arsenic, cadmium, etc.), bacteria, organic matter, dissolved oxygen, and pesticides (Neitsch et al., 2002). SWAT uses runoff curve numbers to calculate surface runoff. Erosion and sediment yield are estimated with the Modified Universal Soil Loss Equation (MUSLE) (Williams, 1975).

6.2.3 Receiving Water Quality Models

Receiving water quality models simulate the impacts of pollutant loadings on stream or lake water quality. The watershed loading models described in the previous section provide inputs to the receiving water quality models. As with watershed loading models, receiving water quality models range in complexities and details. Receiving water quality models discussed in this section are limited to those that can simulate (i) vertical distribution of water quality constituents (stratification) and (ii) release of pollutants from sediment when anoxic hypolimnion occurs.

6.2.3.1 BATHTUB

The BATHTUB model performs steady-state water and pollutant balance calculations in a spatially segmented hydraulic network. The model relies on empirical relationships to predict lake trophic conditions and subsequent DO conditions as functions of total phosphorus and nitrogen loads, residence time, and mean depth (US EPA, 1997). Empirical relationships have been calibrated and tested for reservoir applications (Walker, 1985, 1986). The basic simulated constituents are total phosphorus, total nitrogen, chlorophyll a, Secchi depth (transparency), organic nitrogen, and dissolved reactive phosphorus. Total suspended solids or sediment are not simulated. BATHTUB can simulate 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.

6.2.3.2 CE-QUAL-W2

CE-QUAL-W2 (Cole and Wells, 2003) is a laterally averaged, two-dimensional (longitudinal and vertical) hydrodynamic and water quality model. It is best suited for relatively long and narrow water bodies. The hydrodynamic component of the model predicts water surface elevations, velocities, and temperatures, while the water quality component simulates 21 constituents, including nutrients, phytoplankton, and DO interactions during anoxic conditions. CE-QUAL-W2 models basic eutrophication processes such as relationships among temperature, nutrients, algae, dissolved oxygen, organic matter, and sediment in stratified or non-stratified systems. A predominant feature of the model is its ability to compute the two-dimensional velocity field for narrow systems that stratify. In contrast with many reservoir models that are zero-dimensional with regards to hydrodynamics, the ability to accurately simulate transport can be as important as the water column kinetics in accurately simulating water quality.

6.2.3.3 WASP

WASP is a detailed and versatile state-of-the-art receiving water quality model with dynamic one-, two-, or three-dimensional spatial simulation capabilities simulating both eutrophication, nutrient, and dissolved oxygen, as well as metals, toxics, and sediment. When run in other than the one-dimensional state, the hydraulics component needs to be simulated by an outside multi-dimensional hydraulic model such as EFDC. WASP has been greatly improved in the past several years. A body of water is represented in WASP as a series of discrete computational elements or segments. Environmental properties and chemical concentrations are modeled as spatially constant within segments. Each variable is advected and dispersed among water segments, and exchanged with surficial benthic segments by diffusive mixing. Sorbed or particulate fractions may settle through water column segments and deposit to or erode from surficial benthic segments. Within the bed, dissolved variables may migrate downward or upward through net sedimentation or erosion.

6.2.3.4 AQUATOX Release 3

The AQUATOX model is a general ecological risk assessment model that represents combined environmental fate and effects of conventional pollutants, such as nutrients and sediments, and toxic chemicals in aquatic ecosystems (US EPA, 2009). AQUATOX can simulate stratification and sediment diagenesis in a single-segment lake as well as in linked segments. It considers several trophic levels, including attached and planktonic algae and submerged aquatic vegetation, invertebrates, and forage, bottom-feeding, and game fish; it also represents associated organic toxicants. It can be implemented as a simple model (indeed, it has been used to simulate an abiotic flask) or as a truly complex food-web model. The ecosystem model AQUATOX is one of the few general ecological risk models that represents the combined environmental fate and effects of toxic chemicals. The model also represents conventional pollutants, such as nutrients and sediments. Uncertainty analyses built into the model can be used to assess sources of uncertainty, including sensitivity to key parameters (US EPA, 2009).

AQUATOX is also one of the few models capable of simulating macrophytes, one of the newly listed causes of impairments. AQUATOX can be applied as a screening level model with readily available data, but it can also be used for more detailed analyses when calibrated to site specific conditions. AQUATOX does not simulate hydrodynamic conditions, although it can be coupled with a hydrodynamic model if necessary. AQUATOX is one of the models included in BASINS. It can be linked directly to a SWAT or HSPF model that would provide loadings to the water body.

6.3 Recommendations

The recommended approach includes two steps. First, a method to estimate pollutant loads from the watershed will be developed using a loading model. Second, the impact of estimated loads will be simulated with a receiving stream model. The final methodology will be determined with consultation with the IEPA based on the requirements of a defensible and approvable TMDL, data and fund availability, stakeholders interest and public acceptance, the ability of the models to evaluate BMPs, and the complexity of the transport and transformation processes. The level of detail implemented in the model impacts the study complexity, accuracy of the results, and the time and funds necessary to complete the study. Simpler methods are faster, less expensive, require less data, but also provide less accurate results and often do not provide direct linkages between the individual sources of pollution and a water quality response. More sophisticated modeling approaches require more time and higher funding but also provide direct linkages disregarded by simpler methods.

Inherent characteristics of the Canton Lake watershed will affect the choice of the modeling approach. There is a discrepancy in the temporal resolution needed at the tributary level where flows and pollutant concentrations change rapidly on a sub-hourly scale and at the lake level where flows (or stages) and pollutant concentrations change more slowly (daily or longer time scale). The lake typically falls below the spillway level for a substantial time period each year. Preliminary analyses show lake sediments could be important in total phosphorus cycling. It is critical that the final approach that is chosen will evaluate their impacts on Canton Lake impairment.

Total suspended solids do not exceed the IEPA guideline in the lake itself, only in the tributaries, although the methodology of evaluating total suspended solids as a possible cause of impairment of Aesthetic Use has recently changed. Additional analyses may be needed to determine if developing a receiving stream model to characterize total suspended solids in Canton Lake would be required. However, the incoming load of total suspended solids contributes to lake sedimentation, decreasing the capacity of the reservoir, affects the habitat, and brings associated nutrients and other pollutants. A bathymetric survey is recommended to determine current depths and the current capacity of Canton Lake as well as the extent of sedimentation. A survey of stream bank and lake shore erosion would help to quantify potential contribution of pollutants from these sources.

Total phosphorus should be evaluated within the context of lake sediments and anoxic hypolimnion. A simple approach could use land-use based export coefficients or one of the sediment yield based models to generate average annual pollutant loads and the BATHTUB model to simulate impacts on total phosphorus concentration in Canton Lake. A more detailed approach could use GWLF, SWAT, or HSPF to simulate temporal variability in incoming pollutant loads. CE-QUAL-W2 could then be used to simulate the impacts of loads on total phosphorus and sediment, concentrations in Canton Lake. AQUATOX can be used to simulate water quality in Canton Lake in either a simple approach or on a more detailed level. More frequent dissolved oxygen and temperature profiles would help to establish the current extent of the anoxic zone.

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Canton Lake TMDL Development
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7. Methodology Development for the Canton Lake Watershed

7.1 Methodology Overview

The modeling approach used in this project included two steps. First, the pollutant load from the watershed was estimated using the GWLF loading model. Second, the impact of estimated loads on Canton Lake water quality was simulated with the CE-QUAL-W2 lake model. This combination of models was chosen to take advantage of the strengths of each, and the model selection process is discussed in the Phase I Report.

7.1.1 GWLF Overview

GWLF is a monthly time-step model used to predict runoff, sediment, and nutrients from watersheds with mixed land uses. GWLF can be used for both sediment and phosphorus TMDLs. The runoff is simulated using daily precipitation, the runoff curve number and antecedent moisture. The sediment load is estimated with the USLE. Dissolved nutrients are simulated using event mean concentrations. The loads generated by individual sources are simply aggregated to produce total load (Haith and Shoemaker, 1987; Haith et al., 1992).

GWLF also produces flows, loads, and concentrations at a daily time step. However, daily loads and concentrations in the current model version produce erroneous results, inconsistent with monthly loads and concentrations. Thus, only daily flows were used in the calibration. Loads and concentrations were calibrated using monthly data. This is described in more detail in section7.2.2.3 titled “Inflows and Boundary Conditions” on page 15.

The GWLF model was calibrated and validated using the current project monitoring data and then used to estimate total suspended solids and total phosphorus loads to Canton Lake.

7.1.2 CE-QUAL-W2 Overview

CE-QUAL-W2 (Cole and Wells, 2003) is a laterally averaged, two-dimensional (longitudinal and vertical) hydrodynamic and water quality model. It is best suited for relatively long and narrow water bodies. The hydrodynamic component of the model predicts water surface elevations, velocities, and temperatures, while the water quality component simulates 21 constituents, including nutrients, phytoplankton, and DO interactions. CE-QUAL-W2 models basic eutrophication processes such as relationships among temperature, nutrients, algae, dissolved oxygen, organic matter, and sediment in stratified or non-stratified systems. A predominant feature of the model is its ability to compute the two-dimensional velocity field for narrow systems that stratify. In contrast with many reservoir models that are zero-dimensional with regards to hydrodynamics, the ability to accurately simulate transport can be as important as the water column kinetics in accurately simulating water quality.

The CE-QUAL-W2 model used inputs from the GWLF modeling to simulate the impacts of loads on total phosphorus and sediment in Canton Lake. The use of these two separate models plays to the strengths of each. That is, GWLF is better suited to simulate watershed loading processes, and CE-QUAL-W2 is better suited to simulate water quality processes within lakes and reservoirs.

7.2 Model Development

7.2.1 GWLF Development

GWLF requires geo-spatial data characterizing the watershed and meteorological data. Geo-spatial data were processed in MapShed, geospatial software that is a part of GWLF. MapShed creates text files with land use, soils, and stream characteristics for the watershed that can be directly used as GWLF input files. Individual inputs are described in the following sections.

The GWLF outputs were compared with the observed flows and loads. The model parameters were adjusted during the calibration process until a sufficient agreement between the simulated and observed data was achieved.

7.2.1.1 Input Files

GWLF model input consists of a set of Geographic Information System (GIS) files and a set of 2 or more weather data files. The inputs are: watershed delineations, elevation, land use, soils, streams, weather, and flow lines.

Land Use

Land use data were downloaded from the Illinois Gap Analysis Project (IL-GAP) (http://www.agr.state.il.us/gis/pass/gapdata/), clipped to the extent of the watershed, and reclassified to the categories required by the GWLF model. For example, IL-GAP classifies corn, soybeans, and winter wheat as 11, 12, and 13, respectively. GWLF classifies all three of these crops as 5 for row crops.

Soils

Soils input data were downloaded from the SSURGO Soil Survey Geographic Database available from the USDA NRCS Soil Data Mart (http://soildatamart.nrcs.usda.gov). Next, the soils data were clipped to the extent of the watershed and intersected with the watershed delineation sub-basins. Water holding capacity, soil erodibility (K factor), and the dominant soil groups were then determined for each map unit.

Streams

The streams input file contains the location and length of stream segments in the watershed. Canton streams GIS data were downloaded from the National Hydrography Dataset (NHD) (http://nhd.usgs.gov/). The high-resolution data were then clipped to the watershed boundary.

Weather

Climate data input consists of daily data for only three parameters: precipitation, maximum temperature, and minimum temperature. There are no active or historical climate stations located within the Canton watershed, so climate data were estimated using four nearby stations: Peoria (east), Yates City (north), Prairie City (west) and Canton/St. David (south). Data at these four stations were downloaded from the Midwest Regional Climate Center (MRCC) cli-MATE data portal (http://mrcc.isws.illinois.edu/CLIMATE/). Daily precipitation data were calculated as the average precipitation from all four stations. Daily minimum and maximum temperatures were calculated as the average of Prairie City and Peoria only, since temperature was not measured at Yates City or Canton/St. David. The resulting data set was associated with a faux weather station created in GIS and located in the geographic centroid of the Canton watershed.

Flow Lines

The flow line layer in GWLF depicts pathways a stream particle might take as it moves from a sub-area to the outlet of a larger watershed. Flow lines are used by the GWLF model to estimate travel distance to the outlet of each sub-area and thus to attenuate nutrient and sediment loads based on travel time.

The Canton watershed flow line shapefile was created by following established stream lines from the high resolution NHD when available. In areas where NHD streams were not available, the flowlines were digitized along downhill paths using the 30-meter DEM.

Elevation

The elevation input file was created by clipping a 30-meter USGS digital elevation model (DEM) to the rectangular extent of the watershed. While 2012 Fulton County LiDAR data are available, the 30-meter DEM has sufficient accuracy to determine watershed delineation and is more time-efficient to process. LiDAR data were only used during the lake model development where higher accuracy was needed.

Watershed delineations

GWLF allows modeling to be performed on a single basin or a selected subset of adjoining basins. The watershed delineation file sets the location and shape of the watershed and its sub-basins and therefore determines which areas of the watershed may be modeled separately or together.

The Canton Lake watershed was divided into 35 sub-basins based on the digital elevation model and locations of tributaries using the Better Assessment Science Integrating point & Non-point Sources (BASINS) framework. The outside boundary was then adjusted to match HUC12 boundaries in the undeveloped areas. Additional revisions were made to the watershed boundaries near the City of Canton to adjust for areas where the city storm sewer system drains toward or away from the Canton Lake watershed. The revised sub-basin delineations are shown in red in Fig. 1.

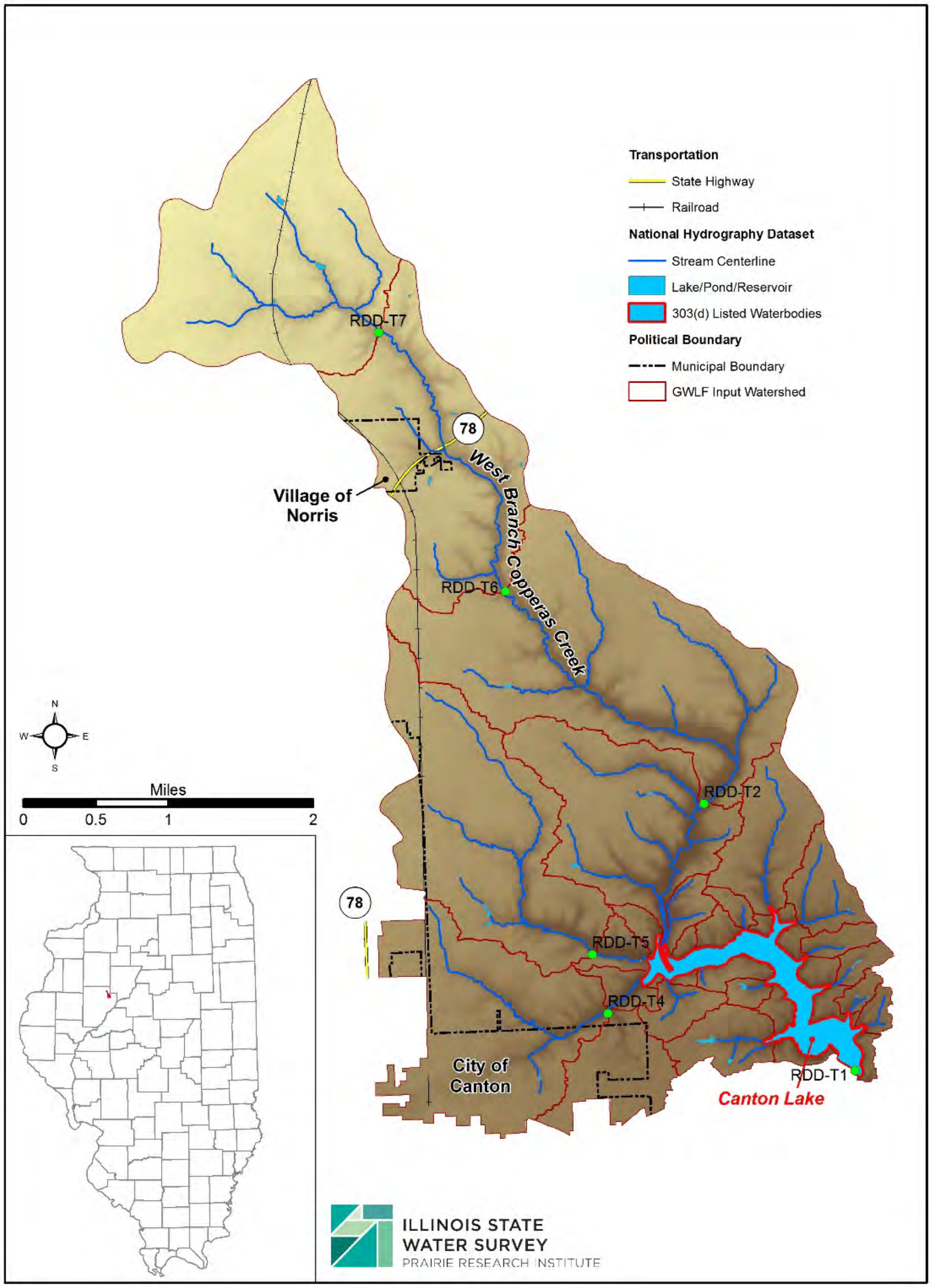

Figure 1. Subwatershed delineation for the Canton Lake watershed

7.2.1.2 Flow Calibration

Daily discharge data collected at RDD-T2 and RDD-T4 during the Year 1 monitoring were used to calibrate the flow parameters. Groundwater parameters were adjusted first to achieve the best match with the observed rate of recession. Then, Curve Numbers were adjusted to achieve the best match with the observed peak flows.

Additional corrections to precipitation records that affected the flow calibration were applied during the sediment load calibration due to the unrealistically low sediment loads in April 2011 as simulated with the original precipitation amounts recorded at the rain gages. NEXRAD data for each precipitation event during the ISWS monitoring period were analyzed to identify a ratio between the precipitation recorded in the rain gages and the precipitation over the calibration watersheds. These ratios were generally greater than one in April 2011 which resulted in increased precipitation amounts and consequently higher and more realistic sediment loads for that month.

Table 1 shows how model performance was determined based on the goodness-of-fit statistics. For the RDD-T4 site, the GWLF model performed well during the calibration period (Table 2) when evaluated on weekly or monthly steps. Goodness-of-fit statistics indicate a statistically reliable fit. Weekly and monthly statistics show very good fit in all indicators except volume difference. The volume difference indicates a good fit. The overestimation of total volume can potentially be attributed to two causes: overestimated April flows as discussed above and overestimated flows during high precipitation events that occur during extended dry periods when the simulated flow is zero.

Volume difference indicates a satisfactory fit for the full simulation period (Table 2). When simulated flows are adjusted for outliers identified during dry periods, model performance increases significantly to very good. The Nash-Sutcliffe Efficiency (NSE) and Root Mean Square Error – Observations Standard Deviation Ratio (RSR) statistics indicate a very good fit for weekly and monthly flows regardless of whether the outliers were removed. However, the flows adjusted for outliers show a significantly better fit, especially for weekly flows.

Table 1. Goodness-of-fit statistics as indicators of the model performance (after Moriasi et al, 2007)

	Volume/load difference				
Model performance	Streamflow	Sediment	Phosphorus	NSE	RSR
Very good	<±10%	<±15%	<±25%	>0.75	<0.50
Good	±10 - ±15%	±15 - ±30%	±25 - ±40%	0.65 - 0.75	0.50 - 0.60
Satisfactory	±15 - ±25%	±30 - ±55%	±40 - ±70%	0.50 - 0.65	0.60 - 0.70
Unsatisfactory	>±25%	>±55%	>±70%	<0.50	>0.70

Table 2. Canton Lake watershed flow calibration statistics

Site	Period	Volume difference, %	Time step	NSE	RSR	R^2
RDD-T4	3/2011-7/2011	11%	Daily	0.52	0.67	0.78
			Weekly	0.80	0.43	0.99
			Monthly	0.81	0.37	0.99
	3/2011-2/2012	13%	Daily	0.35	0.80	0.72
			Weekly	0.76	0.49	0.93
			Monthly	0.87	0.34	0.95
	3/2011-11/2012	23%	Daily	-0.19	1.09	0.62
			Weekly	0.42	0.76	0.80
			Monthly	0.79	0.44	0.90
	3/2011-11/2012*	-3%	Daily	0.58	0.65	0.78
			Weekly	0.84	0.40	0.95
			Monthly	0.90	0.31	0.97
RDD-T2	3/2011-7/2011	5%	Daily	0.24	0.86	0.44
			Weekly	0.91	0.29	0.92
			Monthly	0.86	0.33	0.94
	3/2011-2/2012	15%	Daily	0.23	0.88	0.46
			Weekly	0.87	0.35	0.89
			Monthly	0.91	0.29	0.93
	3/2011-11/2012	32%	Daily	-0.25	1.11	0.36
			Weekly	0.60	0.63	0.72
			Monthly	0.85	0.38	0.89
	3/2011-11/2012*	-0.2%	Daily	0.44	0.75	0.56
			Weekly	0.91	0.30	0.92
			Monthly	0.96	0.19	0.97

Notes: NSE ranges from 1 (perfect fit) to minus infinity, RSR ranges from 0 (perfect fit) to 1, and R^2 ranges from 1 (perfect fit) to 0.
* Statistics calculated for the simulated flow adjusted for outliers identified during dry periods

7.2.1.3 TSS Calibration

Daily loads determined from observed daily flows and TSS concentrations were summarized to calculate monthly loads during the Year 1 monitoring. Monthly TSS loads were used to calibrate GWLF. Daily outputs from GWLF were determined to unreliable due to an internal model error.

Monthly goodness-of-fit statistics are listed in Table 3. Due to the errors in the model’s daily output files, daily and weekly goodness-of-fit statistics cannot be calculated. The model simulates monthly sediment loads during wet period very well. The overall model performance is affected by the model’s inability to accurately simulate low flows during dry periods. When the model output is adjusted for the outliers during dry periods, the overall model performance can be classified as very good.

Almost in its entirety, the relatively high load difference for RDD-T4 can be attributed to differences between the observed and simulated sediment loads for the month of April. The final calibration for flow and sediment is a compromise between overestimating flows in April 2011 and underestimating sediment load that same month. Any adjustment of the calibration parameters leads to an overall increase in sediment loads throughout the year.

Table 3. Statistics for sediment calibration at Canton Lake watershed sites.

Site	Period	Load difference, %	Time step	NSE	RSR	R^2
RDD-T4	3/2011-7/2011	-16%	Monthly	0.73	0.45	0.85
	3/2011-2/2012	76%	Monthly	-0.02	0.96	0.26
	3/2011-2/2012*	23%	Monthly	0.64	0.58	0.66
RDD-T2	3/2011-7/2011	3%	Monthly	0.72	0.46	0.73
	3/2011-2/2012	107%	Monthly	-1.41	1.48	0.16
	3/2011-2/2012*	11%	Monthly	0.69	0.53	0.74

Notes: NSE ranges from 1 (perfect fit) to minus infinity, RSR ranges from 0 (perfect fit) to 1, and R^2 ranges from 1 (perfect fit) to 0.

* Statistics calculated for the simulated flow adjusted for outliers identified during dry periods

7.2.1.4 TP Calibration

Monthly TP loads were also calculated from the concentrations and stream flows observed during Year 1 monitoring. This observed monthly load was used to calibrate the GWLF model.

Monthly goodness-of-fit statistics are listed in Table 4. The overall model performance is affected by the model's inability to accurately simulate low flows during dry periods. When the model output is adjusted for the outliers during dry periods, the overall model performance can be classified as very good.

Table 4. Statistics for TP calibration at Canton Lake watershed sites.

Site	Period	Load difference, %	Time step	NSE	RSR	R^2
RDD-T4	3/2011-7/2011	-13%	Monthly	0.80	0.38	0.93
	3/2011-2/2012	42%	Monthly	0.45	0.71	0.51
	3/2011-2/2012*	5%	Monthly	0.81	0.42	0.85
RDD-T2	3/2011-7/2011	-2%	Monthly	0.67	0.50	0.68
	3/2011-2/2012	88%	Monthly	-0.90	1.32	0.18
	3/2011-2/2012*	4%	Monthly	0.87	0.34	0.87

Notes: NSE ranges from 1 (perfect fit) to minus infinity, RSR ranges from 0 (perfect fit) to 1, and R^2 ranges from 1 (perfect fit) to 0.

* Statistics calculated for the simulated flow adjusted for outliers identified during dry periods

Similarly to TSS loads, the relatively high TP load difference for RDD-T4 can be attributed to differences between the observed and simulated sediment loads for the month of April. The final calibration for flow and sediment is a compromise between overestimating flows in April 2011 and underestimating sediment load that same month. Any adjustment of the calibration parameters leads to an overall increase in TP loads throughout the year.

7.2.2 CE-QUAL-W2 Development

The CE-QUAL-W2 lake model inputs are in the form of a series of fixed format text files which define model inflows and withdrawals, meteorological data, and reservoir bathymetry. These input text files are referenced by an input "control file" which also specifies all input variables and runtime settings, such as the date range of the simulation and which water quality parameters are modelled.

7.2.2.1 Bathymetry

Bathymetric surveying was conducted by ISWS staff on June 4th and 5th 2013 using a combination of acoustic depth sounding of the reservoir bottom surface and physical depth measurements. An Odom EchoTrac DF3200 MKII Precision Survey Echo Sounder mounted on an 18 foot pontoon boat was used to perform the acoustic depth soundings. These bathymetric survey data were processed, in conjunction with 2012 Fulton County LiDAR data, into model input data and evaluated to identify the optimum vertical layer thickness to be modeled.

7.2.2.2 Model Segmentation

The model allows for segmentation into multiple waterbodies, branches, tributaries, and distributed tributaries. Planimetric model segmentation of the lake was evaluated to identify an appropriate balance between accurate hydrodynamics and computational efficiency. The segmentation scenario adopted is a 1-branch, 32-segment model with 8 tributaries (Figure 2 and Figure 3). Note that segment 1 is actually empty boundary cell which is required for the CE-QUAL-W2 model. Hence, it is not visible in Figure 2, but is visible in the gridded representation (Figure 3).

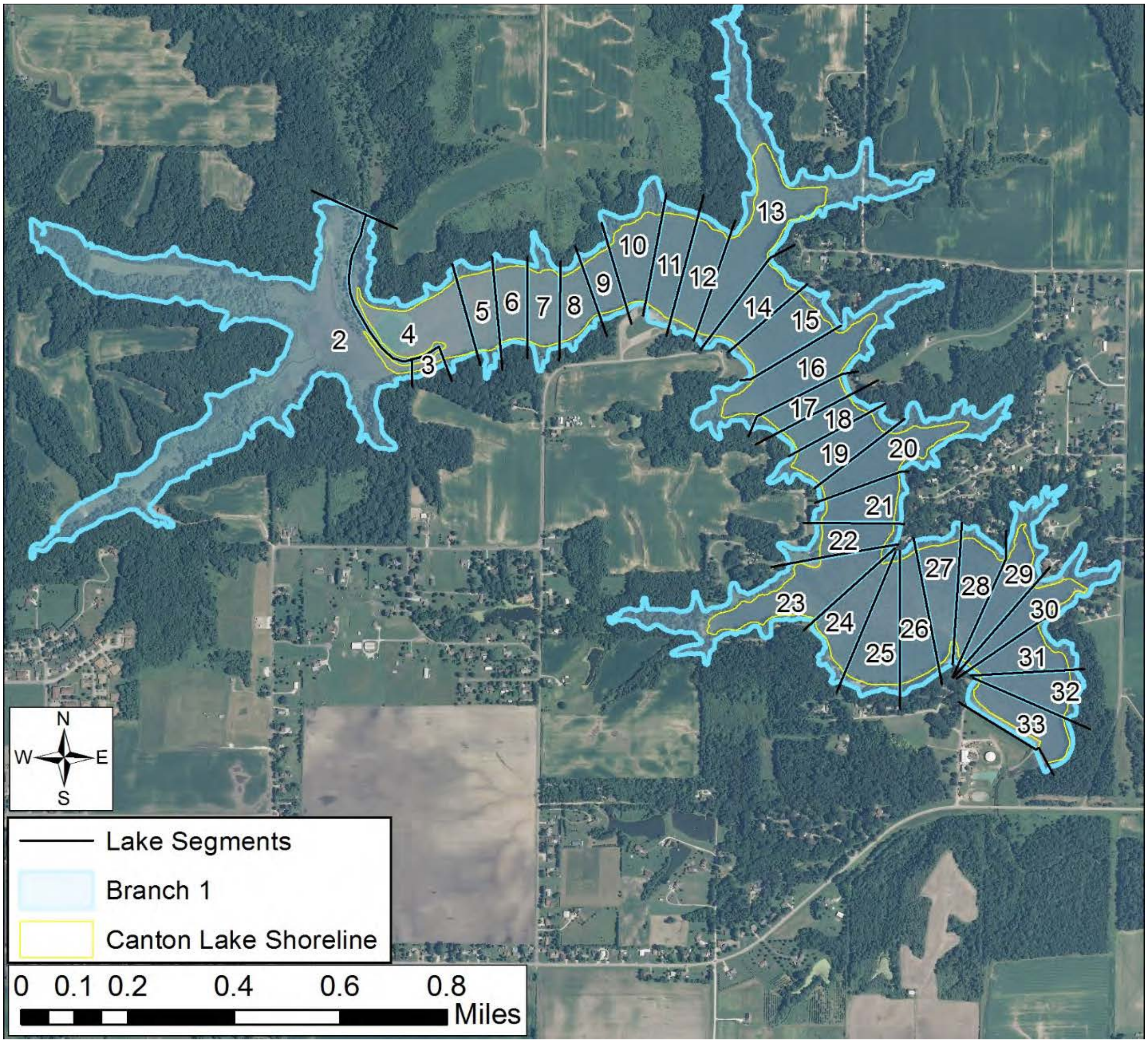

Figure 2. Segmentation for a 1-branch, 32-segment CE-QUAL-W2 model of Canton Lake.

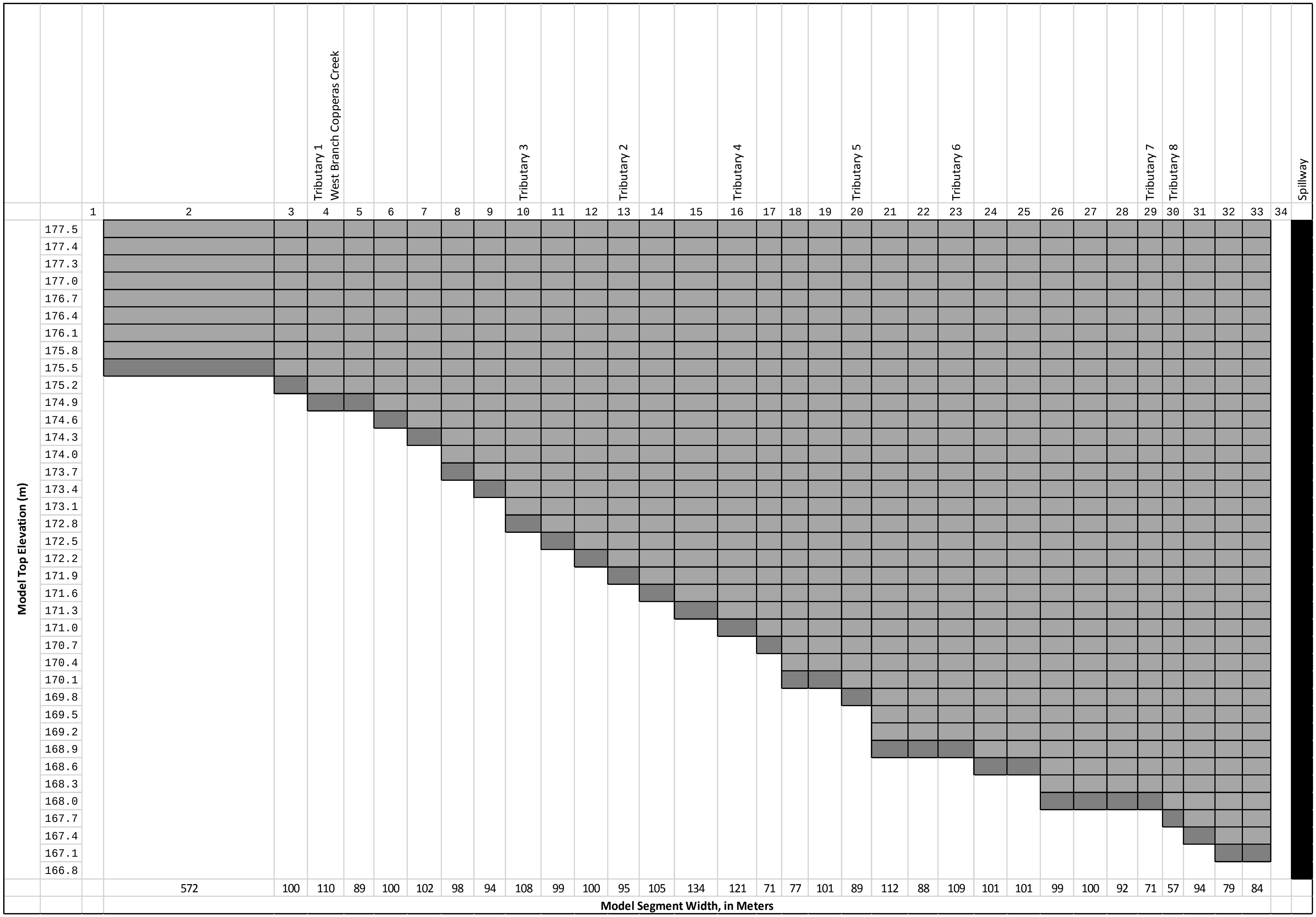

Figure 3. Cross-section view of the model grid used to represent Canton Lake showing where tributaries enter the lake

7.2.2.3 Inflows and Boundary Conditions

Inflow data for the lake model includes not only flow volumes, but temperature and constituent concentrations for the inflows as well. While ISWS gage data was used during pre-calibration evaluations, the calibrated GWLF flows were used as the inflows to the lake model. GWLF simulates flows and loads (from which concentrations are derived) for each modeled sub-basin. Due to the confirmed inaccuracies of GWLF daily outputs, monthly data was used to derive daily concentrations for the inflows to the lake model. Subwatersheds simulated with the calibrated GWLF model as tributary inputs to Canton Lake are shown in Figure 4.

Simulated flows from the GWLF model required additional processing prior to being input to the CE-QUAL-W2 model. This processing corrects known issues with GWLF results and includes identification and removal of outliers that occur during dry periods, as well as adjustment of simulated zero flow values that are known to be greater than zero based on observed data at nearby locations. The method selected replaces outliers with a linear adjustment developed from the observed data during the calibration period. Periods of zero flows are evaluated based on flow similarities with the ISWS Conservation Reserve Enhancement Program (CREP) sites. The CREP monitoring program collects hydrologic, sediment, and nutrient data for selected watersheds within the Illinois River watershed to assist in the evaluation of the effectiveness of the CREP program. The CREP sites used consist of 5 stations located in the Court and Panther Creek watersheds in West-central Illinois. These five stations have been continuously operated since 2000. Routine streamgaging as well as weekly sampling for sediments and nutrients is done at all 5 sites. In addition, these sites are also sampled during storm events. A constant value was substituted for periods where the method identified non-zero flow should be simulated.

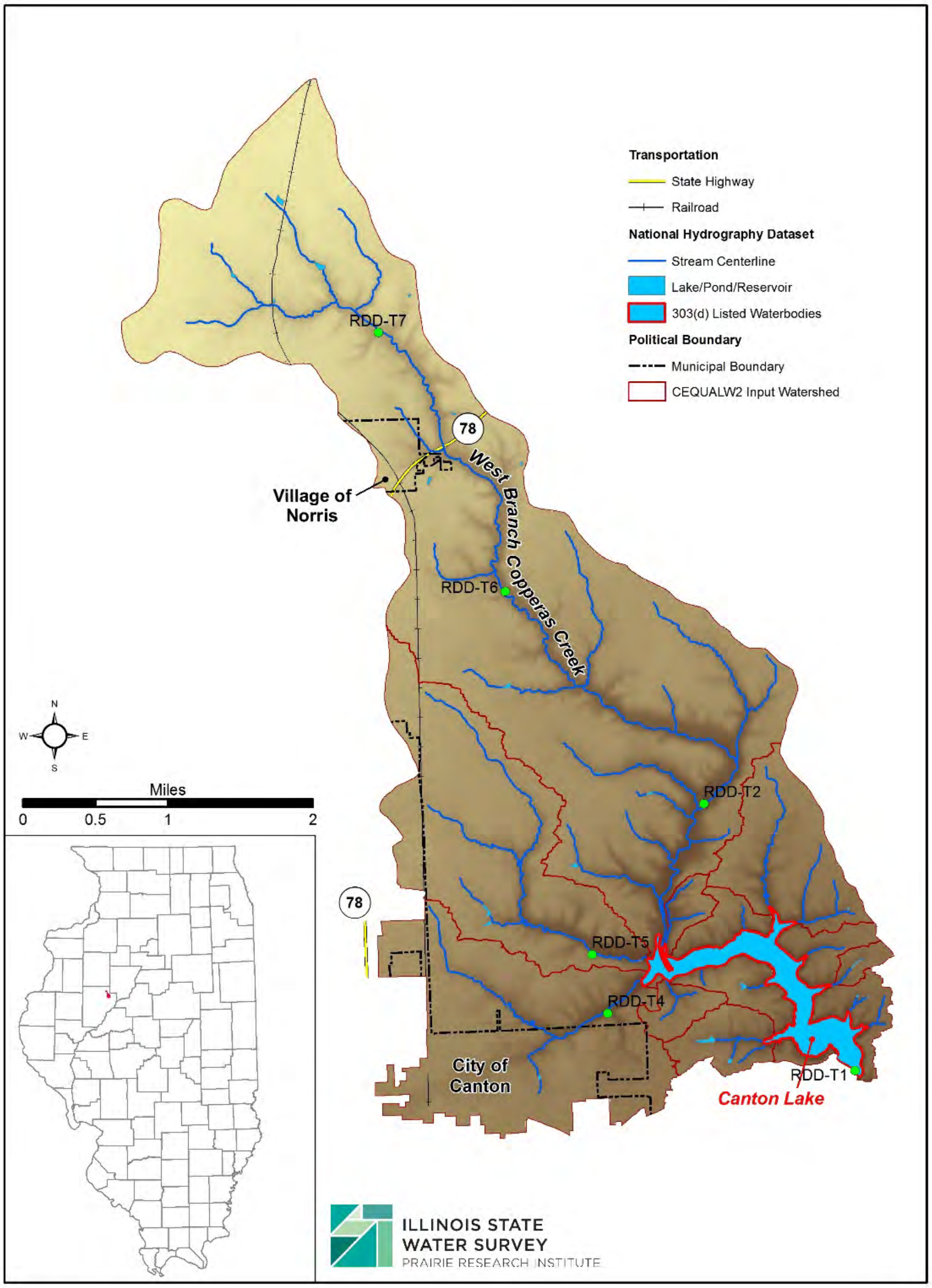

Figure 4. Tributary watersheds used as inflows to Canton Lake

To estimate the temperature of these inflows, stream temperatures from CREP were evaluated against the spot measurements taken during the Canton Lake watershed monitoring period. The ISWS CREP gaging station on North Creek was the most highly correlated to West Branch Copperas Creek's observed stream temperatures and was thus selected as a surrogate record.

The same ISWS stations were also analyzed to determine the relationships between the monthly loads, daily loads, and daily flows for sediment and TP. A method to convert the GWLF-simulated monthly loads to daily loads needed for the CE-QUAL-W2 input files was developed and tested. First, daily concentrations were calculated from daily stream flows adjusted for outliers and non-zero flows and a daily load was calculated. Then, monthly loads from these estimated concentrations were compared to the monthly loads simulated by the GWLF model (also adjusted for outliers and non-zero flows). The daily concentrations were then proportionately adjusted, resulting in daily concentrations that when summed, matched the simulated monthly loads from the calibrated GWLF model.

The CE-QUAL-W2 model requires numerical values for additional constituents to simulate the full nutrient cycle with algae and dissolved oxygen, including nitrogen forms and organic matter. The GWLF model was developed only for constituents where data were available for calibration: flow, total suspended solids, and total phosphorus. Daily concentrations for the remaining constituents were derived either from the ISWS CREP stations, the ISWS and IEPA monitoring in the Canton Lake watershed, ISWS gaging stations in western Illinois, estimated from literature values, or set to values expected for similar streams. The impact of selecting the numerical values for these constituents was evaluated with sensitivity analyses on the preliminary model. The final selected methods are listed in Appendix A.

7.2.2.4 Precipitation

The precipitation input files include three components: rainfall amounts, rainfall temperature, and constituent concentrations in the rainfall. The precipitation input files are used only to compute the amount of precipitation falling directly onto the lake. Rainfall data consistent with the GWLF model inputs have been prepared.

Wet bulb temperature data were used as a surrogate for precipitation temperature. The equations used for calculation of wet bulb temperature were derived using best fit polynomials of dry bulb vs. wet bulb temperatures at Peoria from 2005-2013. The temperature data at Peoria were downloaded from the QCLCD website (http://cdo.ncdc.noaa.gov/qclcd/QCLCD?prior=N). Wet bulb data for the period of simulation were then calculated as a function of the mean daily dry bulb temperature record used in the GWLF modeling effort.

7.2.2.5 Meteorological

The CE-QUAL-W2 model uses multiple meteorological parameters for input including: air temperature, dew point temperature, wind speed, wind direction, and cloud cover. The weather station in Peoria, Illinois was selected as the best representative station near the watershed which had all the needed parameters available. Peoria climate data were available from two NCDC websites: Unedited Local Climatological Data (http://cdo.ncdc.noaa.gov/ulcd/ULCD) for data from 2000-2004 and Quality Controlled Local Climatological Data (QCLCD) (http://cdo.ncdc.noaa.gov/qclcd/QCLCD?prior=N) for data from 2005-2013.

All gaps in wind speed, wind direction, and cloud cover data were linearly interpolated. Gaps in air temperature and dew point temperature were linearly interpolated if they were less than 2 hours in length; otherwise, the data were estimated using Galesburg climate data downloaded from the same sources.

Additionally, further processing was needed to reduce the density of available data. The original data set contained a variable time step with some measurements as little as 1 or 2 minutes apart. Data this dense caused extremely slow run times in the lake model; therefore, the data were thinned to a minimum time-step of 15 minutes.

7.2.2.6 Withdrawals and Spillway Information

Daily raw water withdrawals and historical outlet works construction documents were provided by the City of Canton. Additional information was provided by the City's consulting firm (Maurer-Stutz) regarding modifications to the outlet works that have been completed since the original construction which were processed for inclusion in the model.

7.2.2.7 Initial Concentrations

Initial concentrations must be provided for all simulated constituents for the first day of simulation, June 1, 2000. Initial concentrations were determined from several sources (in the listed order of preference): intake analyses provided by the City of Canton, historical data collected in Canton Lake, and literature values for similar lakes. The selected concentrations are listed in Appendix B.

Uniform in-lake concentrations were assumed at the beginning of the simulation. This is a rough approximation because concentrations of most water quality constituents would rarely be uniform throughout Canton Lake. Therefore, to eliminate the impact of this assumption, the first 4 months of simulation results were excluded from further analysis.

7.2.2.8 Water Level Calibration

Figure 5 and Table 5 show results for water level calibration at Canton Lake. Both Canton self-reported lake levels and ISWS monitored levels are shown. Note the data reported by the City of Canton do not include actual observations above the spillway, only a comment that the lake is full. Simulated water levels match the observed data well.

The CE-QUAL-W2 model tended to under predict lake water levels during periods when the observed lake level stabilizes following the seasonal decline and prior to the seasonal increase. With GWLF inflows to the lake being in general agreement with observed discharges during periods of ISWS monitoring, the source of this volume discrepancy was not thought to originate from watershed contributions.

Bedrock topography within the Canton Lake Watershed suggests groundwater divides are similar to the surficial watershed divides for this location. In general, from the northern extent of the surficial watershed divide, bedrock elevations slope toward Canton Lake at approximately 35 feet per mile before continuing to decrease in elevation toward the Illinois River. Differences between the bedrock elevation and surficial elevations in the 2012 Fulton County DEM are typically on the order of 20-30 feet, with only small areas approaching 50 feet. Some portion of the initial abstractions from precipitation events are expected to contribute to shallow groundwater flow. Given the shallow depth of the confining bedrock, the slope of the bedrock surface, and relative depth of Canton Lake, it is reasonable to assume that Canton Lake intercepts some portion of the shallow subsurface flow. This flow was incorporated into the calibrated model using distributed tributary inflow within CE-QUAL-W2 which allows for non-point additions of flow. The volume of water was determined using Water Balance Utility that is provided within the CE-QUAL-W2 modeling package.

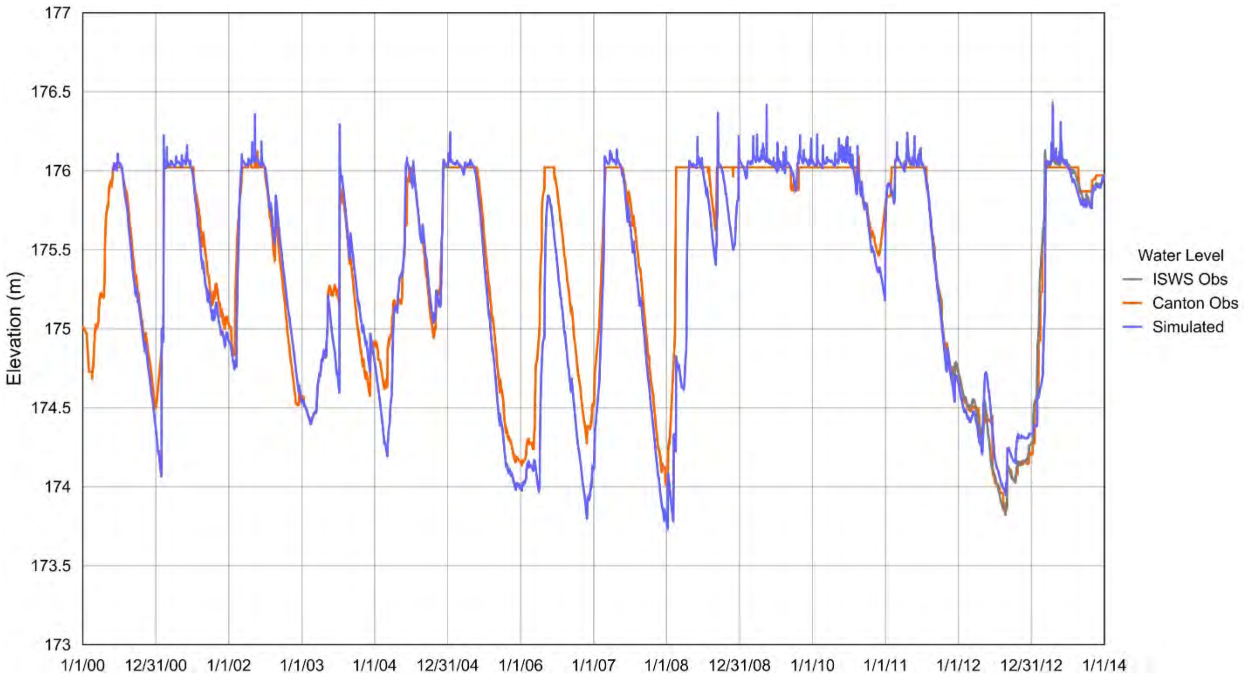

Figure 5. Water level simulated for Canton Lake

Table 5. Statistics for water level calibration at Canton Lake

	Canton reported data*				ISWS observed data			
Statistics	Daily	Weekly	Monthly	Yearly	Daily	Weekly	Monthly	Yearly
R^2 [a]	0.89	0.89	0.90	0.89	0.96	0.96	0.97	1.00
NSE	0.85	0.85	0.86	0.82	0.96	0.96	0.96	0.99
PBIAS [b]	0.05	0.05	0.06	0.05	0.01	0.01	0.01	0.01
RSR	0.38	0.38	0.37	0.41	0.21	0.20	0.18	0.09

Note: *Canton statistics exclude observed values at or above spillway (actual values were not reported, only a lake full state). [a] R^2 = Pearson's coefficient of determination. [b] PBIAS = Percent bias.

7.2.2.9 Water Quality Calibration

Water quality calibration was completed for the same time period as the hydrodynamic calibration. The model coefficients were adjusted in an iterative process where the simulated values were compared to the observed concentrations collected at the water supply intake, the ISWS monitoring site RDD-T1 by the spillway, and several lake sampling sites with concentrations collected at several different depths (Figure 6).

The ISWS monitoring data collected at RDD-T1 and the ISWS and IEPA lake sites with profile data were the primary calibration focus. Water supply intake data were used to evaluate long-term trends only. The intake data were found to show larger discrepancy than the primary data sources, possibly due to the water samples being collected at the treatment plant rather than in the lake itself.

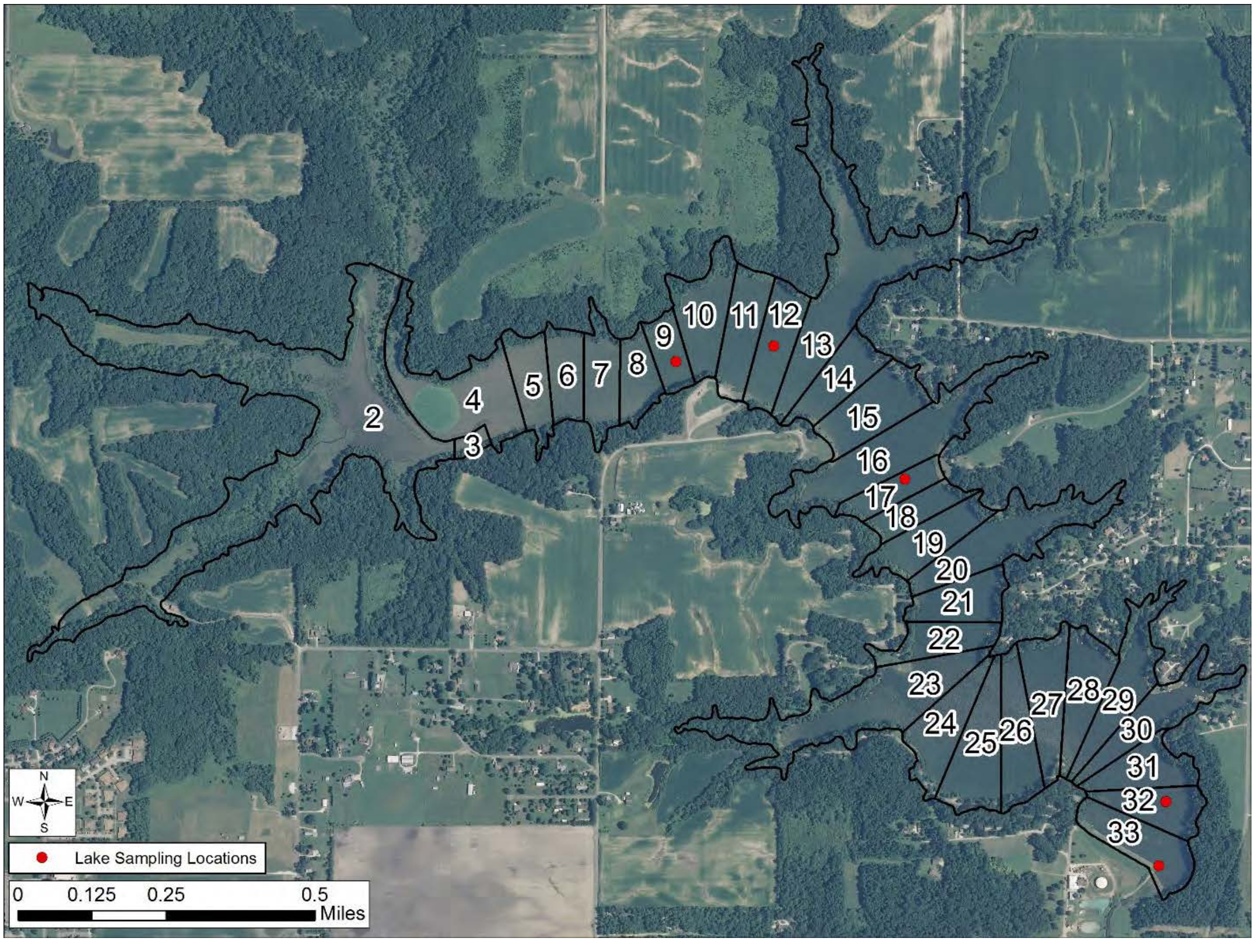

Figure 6. Canton Lake water quality sampling locations

The model calibration progressed from water level to temperature first, and then to other water quality constituents. While the calibration focused on total phosphorus concentrations in Canton Lake, full nutrient cycling, including algae and dissolved oxygen were simulated and evaluated. Appendix C shows final values of the model kinetic coefficients as calibrated.

The observed and simulated temperatures at RDD-T1 and at the Canton Lake intake match rather well (Table 6 and Figure 7). Samples collected by the ISWS during April through June 2012 show a larger discrepancy from the simulated data than samples collected during the rest of the monitoring period. A comparison of these data with data collected by ISWS at other sites in Central Illinois during the 3/2011-11/2012 period indicate a possible bias in the RDD-T1 data for spring 2012.

The temperature observed at the intake in general matches the simulated temperature. The simulated temperatures tend to be slightly colder during the winter months and slightly warmer during the summer months. This may be due to the temperature readings taking place within the treatment plant rather than at the intake location in the lake itself.

The model simulates total phosphorus concentrations fairly well (Table 6) with average differences in simulated and observed concentrations at -0.02 mg/l and -0.03 mg/l for RDD-T1 (2011-2012) and RDD-1 (2001-2012). Goodness-of-fit statistics are also shown for dissolved oxygen, dissolved phosphorus, and chlorophyll a (Table 6). Figure 8 shows individual depth profiles of total phosphorus concentrations collected between October 2010 and September 2013. Full set of results for all profiles and constituents are attached in Appendix D.

While for most days the model describes the observed data adequately, there are several days where the model either overestimates or underestimates total phosphorus concentrations. Figure 9 shows observed and simulated total phosphorus data at RDD-T1. The trend is generally simulated well with the exception of an increase in total phosphorus concentrations during the dry period of July-August 2011. This behavior was not replicated in the model. The model underestimates measured total phosphorus concentrations during this time.

Considering the computer time required to execute the model (2-3 hours for one simulation) and the time required to process and analyze the results, additional resources would be needed to improve the model calibration. In addition, the calibration process was affected (1) by the uncertainty in estimating daily concentrations of TP and TSS from the simulated monthly loads, (2) by the uncertainty in estimating input concentrations from the lake tributaries for constituents other than TSS and total phosphorus, and (3) by the uncertainty in simulating 13 years of total phosphorus loads with a model calibrated and validated with 1.5 years of data collected during years with low precipitation totals. These model inaccuracies were considered during the selection of the Margin of Safety (MOS) value chosen for the TMDL determination (Section 8.3.3).

Table 6. Goodness-of-fit statistics for Canton Lake water quality calibration

Statistics	Temperature, °C		TP, mg/l		DO, mg/l	DP, mg/l	Chlorophyll a, µg/l
	RDD-T1	Intake	RDD-T1	RDD-1	RDD-1	RDD-1	RDD-1
R2	0.91	0.97	0.004	-	-	-	-
NSE	0.84	0.90	-3.066	-	-	-	-
PBIAS	-13.42	7.51	35.847	-	-	-	-
RSR	0.39	0.32	2.004	-	-	-	-
S-O	1.86	-1.15	-0.031	-0.020	0.004	1.64	16.1

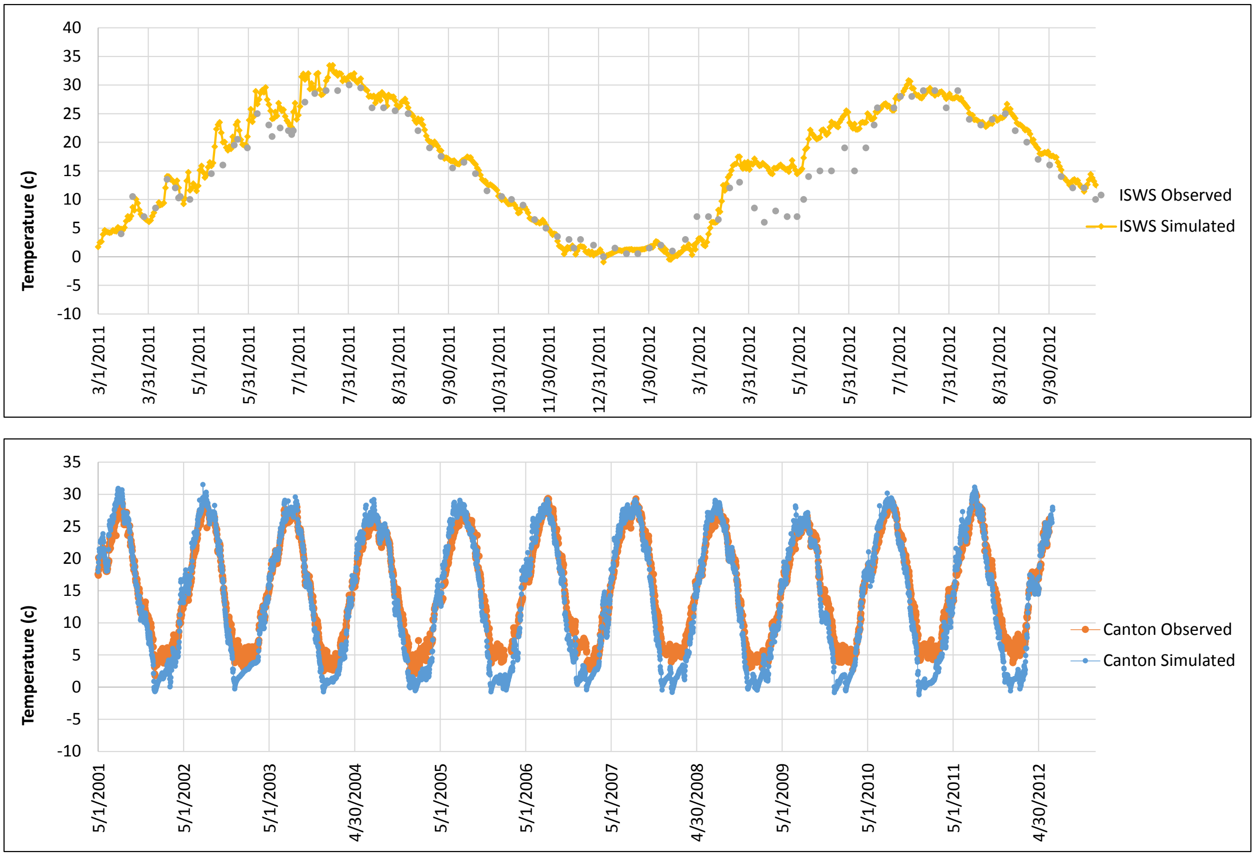

Figure 7. Observed and simulated temperatures at RDD-T1(upper plot) and Canton Lake intake (lower plot)

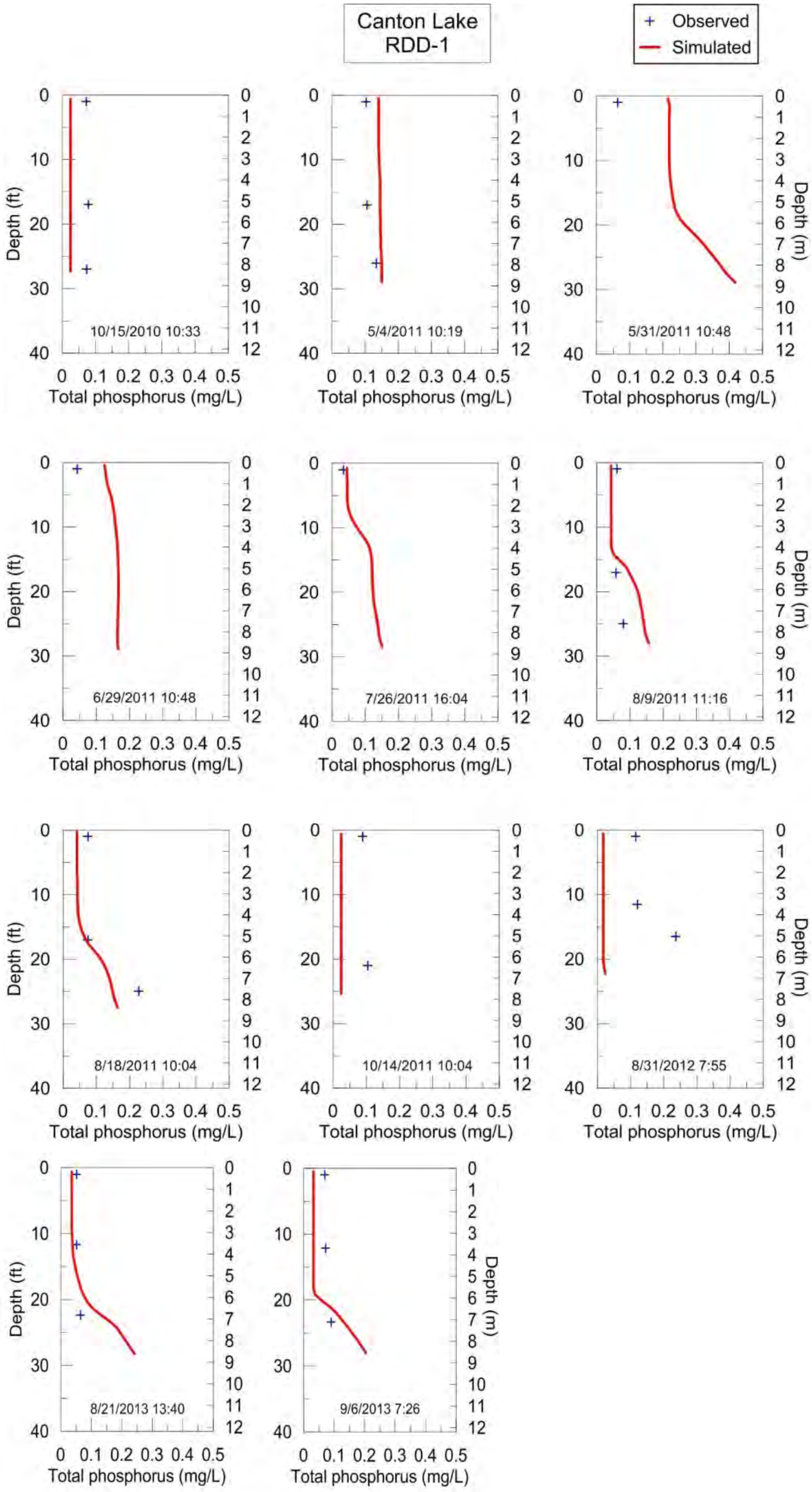

Figure 8. Observed and simulated total phosphorus collected at RDD-1 in 2011-2013; depth profiles

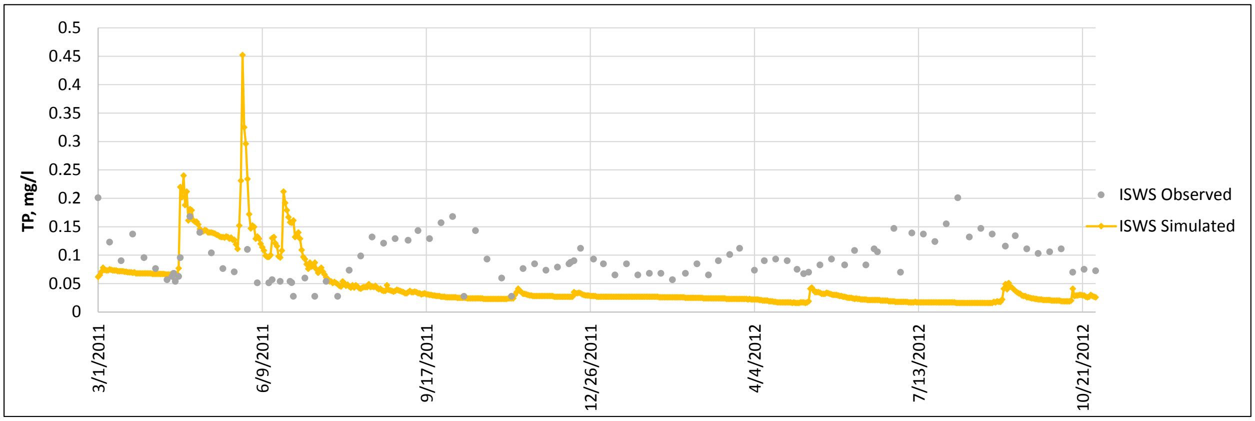

Figure 9. Observed and simulated total phosphorus at RDD-T1

8. Total Maximum Daily Loads for the Canton Lake Watershed

8.1 TMDL Endpoints for the Canton Lake Watershed

The desired water quality for water supply reservoirs in Illinois is set forth in Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards. Total phosphorus concentration for lakes and reservoirs with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake shall not exceed 0.05 mg/l.

Total phosphorus concentrations in water samples collected during the monitoring period often exceeded the water quality standard for phosphorus in Canton Lake as shown in the Phase I Report. Phosphorus contributes to excessive algae growth in the lake potentially leading to anaerobic conditions in the deeper portions of the lake. The total phosphorus water quality standard aims to solve these issues by limiting the total phosphorus available to support algal growth.

8.2 Pollutant Source and Linkages

Pollutant sources and linkages were described in the Phase I Report. There are no active municipal or industrial treatment plants discharging into the Canton Lake watershed. The Combined Sewer Overflow (CSO) at 11th and Myrtle is no longer functional. The City of Canton completed a sewer separation, replacing the contribution from a combined sewer with separated storm water. Moreover, it is not an MS4 community. Storm water typically has much lower TP concentrations than CSOs.

Canton Lake watershed is dominated by agriculture, particularly row crops. There is a single permitted Concentrated Animal Feeding Operation (CAFO) located within the Canton Lake watershed: Dare Farms which is a beef cattle operation. There are also several septic systems in the watershed. A fully functioning septic should not contribute TP to surface waters. However, a failing or ponded system can result in TP leaking to the receiving water body, especially for septic systems located in the vicinity of water bodies.

8.3 Allocation

The TMDL for Canton Lake was established using the CE-QUAL-W2 model. The existing load to the lake was reduced in 10% increments. For each incremental reduction, the CE-QUAL-W2 model was executed and the TP concentrations in the lake were analyzed. Then, the reduction needed to achieve water quality standards was determined.

As explained in Section 1, a TMDL is allocated as

$$TMDL = WLA + LA + MOS + RC$$

where WLA is Waste Load Allocation and refers to a load discharged to a water body by point sources; LA is Load Allocation and refers to a load that enters the water body from non-point sources and natural background; MOS is Margin of Safety that accounts for uncertainty; and RC is Reserve Capacity that allows for future growth.

8.3.1 Existing Total Phosphorus Loads

8.3.1.1 Watershed P loading

TP loads during the project monitoring period were calculated directly from the observed flows and concentrations. The calibrated GWLF model was used to produce a long-term series of TP loads generated in the Canton Lake watershed. These annual watershed TP loads are shown in Figure 10 and given in Table 7. Weather conditions during the monitoring period affected the magnitude of the loads. After a relatively normal spring in 2011 when monitoring was initiated, dry conditions occurred from July 2011 to the end of the monitoring period in October 2012 resulting in lower loads being observed when compared to those periods where average run off occurs. Over the course of the calibration period, the annual average TP load in lbs/day was 52.1 lbs/day, ranging from 5.8 lbs/day (2012) to 180.2 lbs/day (2009) depending on the weather conditions.

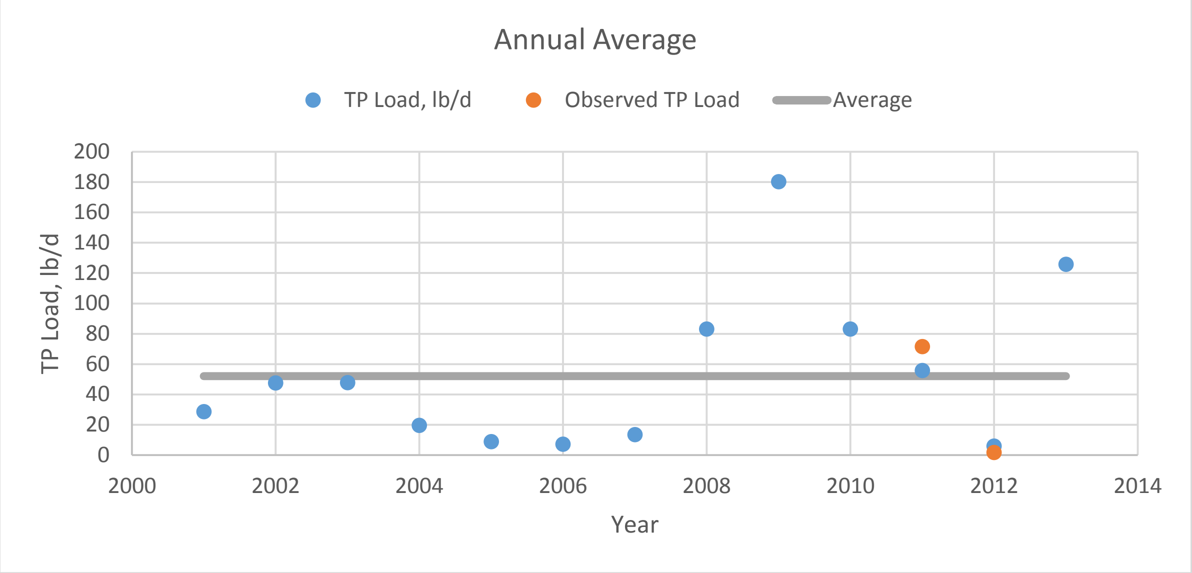

Figure 10. Annual average TP load in lbs/day

Table 7. Annual average watershed TP load during 2001-2013

Year	RDD-T2 Simulated TP Load, lbs/Day	RDD-T4 Simulated TP Load, lbs/Day	Total Simulated TP Load, lbs/Day	Average Observed TP Load, lbs/day
2000	20.0	2.8	22.8	-
2001	24.7	3.9	28.6	-
2002	41.5	5.9	47.4	-
2003	43.0	4.6	47.7	-
2004	13.8	5.7	19.6	-
2005	6.5	2.4	8.9	-
2006	4.7	2.4	7	-
2007	10.1	3.4	13.4	-
2008	77.7	5.4	83.1	-
2009	169.4	10.8	180.2	-
2010	75.2	7.9	83.1	-
2011	50.8 (70.3†)	4.9 (4.7†)	55.7	71.6**
2012	3.3 (1.0†)	2.5 (0.9†)	5.8	1.6
2013	117.2	8.6	125.8	-
Average	**47.9**	**5.1**	**52.1**	-

Notes: **TP was not monitored during January-March 2011. Daily average load was assumed to be equal to the average observed daily load during April-December 2011.

†Observed value

8.3.1.2 Internal P loading

Internal loading of P can also be an important nonpoint source, especially during drier summer periods in the deeper portions of Canton Lake. As noted in Section 5.4.2.5 of the Phase I Report, the deeper portions of Canton Lake can stratify during the summer months, with the result that dissolved oxygen is depleted, which then enhances the release of dissolved phosphorus from the bottom sediments. This can been seen in the historical data summarized in the Phase I Report, which show increased dissolved phosphorus conditions near the bottom under oxygen-depleted conditions.

Our CE-QUAL-W2 model runs simulated P release from bottom sediments under oxygen-depleted conditions, and this effect is especially noticeable at the deepest Canton Lake water quality sampling station RDD-1. During the summer months, many of the simulated TP and dissolved P profiles presented in Appendix D noticeably increase near the bottom at RDD-1. Additionally, the corresponding dissolved oxygen profiles show that dissolved oxygen has been depleted.

Our CE-QUAL-W2 model simulations also allowed us to estimate the areal extent and duration of oxygen depleted conditions in Canton Lake over the 13 year simulation period. As might be expected, drier summer periods resulted in both greater areal extents and durations of dissolved oxygen depletion. Simulated depleted oxygen conditions occurred during every summer season of the simulation period, and ranged from 120 days in 2003 to 30 days in 2007. Similarly, the areal extent of simulated depleted oxygen conditions was also variable, from the bottom 15 ft of Canton Lake in 2011 and 2012, to only the deepest 5 ft in 2006 and 2007.

The P release rate from sediments overlain by oxygen depleted water is set by adjusting the variable “PO4R” in the model, and for our simulations that value was set to 0.001 (Appendix C, below) which equates to a sediment release rate of 1 mg P/m^2/day. That value, combined with the duration and areal extent of oxygen depleted conditions, can be used to estimate the internal P loading, which can then be compared to the external loading from tributaries. In relation to the annual tributary P loading over the simulation period, the internal load ranges from a high of 18% of the tributary load in 2012, to a low of 0.1% in 2007. The mean value is 2.6%, indicating that internal P loading is usually only a small fraction of the external loading from tributaries. Thus, it does not need a separate Load Allocation.

8.3.2 Loading Capacity

Loading capacity was determined from a series of simulations where the TP load from tributaries was reduced in 10 percent increments from the original TP load and the corresponding in-lake concentration was determined for each load reduction scenario by conducting simulations with the calibrated CE-Qual-W2 model. Figure 11 shows how Canton Lake TP concentrations are expected to decrease for the different percent reductions simulated. The load reduction curve shows that a 55% reduction is needed to achieve 0.05 mg/l TP in Canton Lake. The corresponding loading capacity (LC) was determined to be 23.4 lbs/day on annual average.

Figure 12 shows percent time the simulated TP concentrations were exceeded in Canton Lake during 2001-2013. The lake water quality standard (0.05 mg/l) was exceeded 40% of the time when current TP loading from tributaries was assumed. The recommended 55% reduction will lead to the water quality standard being exceeded approximately 25% of the time. Note that it would be unreasonable to expect 0% time exceedance when evaluating model results with a daily time-step. The high TP concentrations associated with high-precipitation storm events will cause temporary increases in lake TP concentrations even with the highest reductions. However, these higher concentrations would occur only temporarily during and immediately following high flow events.

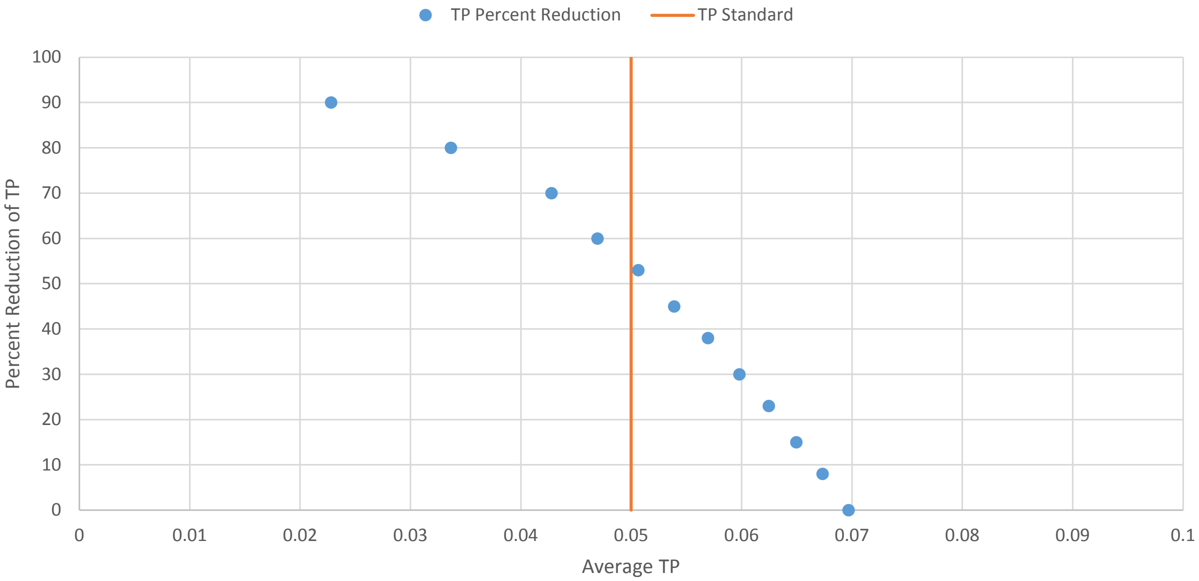

Figure 11. Effect of percent reduction in TP load on TP concentration in Canton Lake

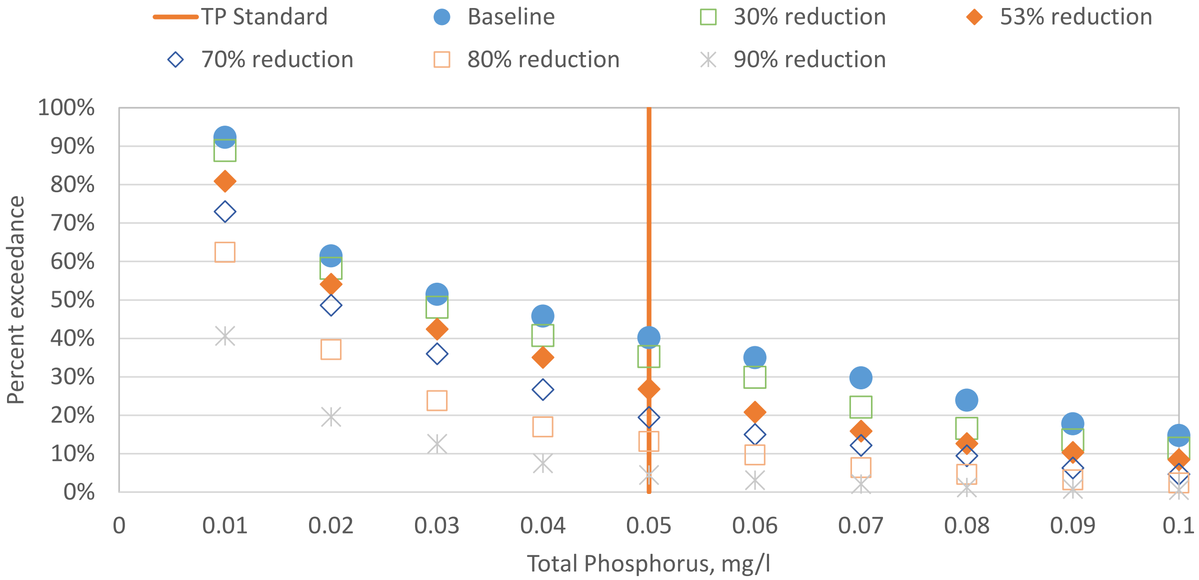

Figure 12. Percent time TP concentration is exceeded in Canton Lake, 2001-2013

8.3.3 Margin of Safety

MOS can be incorporated into TMDL in two ways: it can be implicitly included in the analyses through the use of conservative assumptions or it can be explicitly defined as a portion of loadings. MOS was defined explicitly in this study as 25% of the Loading Capacity. The selected percentage reflects the uncertainty associated with the model calibration and the differences between the observed and calibrated values. The average TP concentration from the TP data collected in Canton Lake is 0.087 mg/l. The average TP concentration simulated by the CE-QUAL-W2 model is 0.070 mg/l. This corresponds to a 25% difference between the observed and simulated TP concentrations.

MOS = 0.25 LC = 0.25 x 23.4 lbs/day = 5.8 lbs/day

8.3.4 Reserve Capacity

There has only been a limited development in the Canton Lake watershed from 2000 to 2009, and little additional development is expected for the foreseeable future. Therefore, the Reserve Capacity for this TMDL has been set to zero.

RC = 0 lbs/day

8.3.5 Wasteload Allocation

The only point source in the watershed is the Dare Farms CAFO. However, its WLA is zero in accordance with its permit. Therefore, WLA for the entire watershed is set to zero.

WLA = 0 lbs/day

8.3.6 Load Allocation

Load allocation was determined from Loading Capacity, Margin of Safety, Reserve Capacity, and Wasteload Allocation:

LA = LC – MOS – RC – WLA = 17.6 lbs/day

8.3.7 Pollutant Load Reductions

Current average daily TP load to Canton Lake is 52.1 lbs/day. The recommended Loading Capacity is 23.4 lbs/day, which represents an effective 55% reduction in total phosphorus load from the watershed to Canton Lake. This is summarized in Table 9.

Table 8. TMDL Summary for Canton Lake-Total Phosphorus

LC (lb/day)	WLA (lb/day)	LA (lb/day)	MOS (lb/day)	Current Load (lb/day)	Reduction (lb/day)	Percent Reduction
23.4	0	17.6	5.8	52.1	28.7	55%

8.3.8 Seasonal Variation

Seasonal variation is explicitly included in this TMDL because conditions were modeled over an annual basis for a 13 year period which included substantial seasonal variations. In addition, the observed data upon which both the watershed GWLF and in-lake CE-QUAL-W2 models were calibrated were collected throughout multiple years. Hence, seasonal variation, including the most critical growing season period is adequately represented in this TMDL.

9. Implementation Plan for the Canton Lake Watershed

9.1 Adaptive Management

An adaptive management or phased approach is recommended for the TMDLs developed for the Canton Lake watershed due to the limited amount of data available for the TMDL analysis. Adaptive management is a systematic process for continually improving management policies and practices through learning from the outcomes of operational programs. Some of the beneficial characteristics of adaptive management are:

- Acknowledgement of uncertainty about what policy or practice is "best" for the particular management issue
- Thoughtful selection of the policies or practices to be applied (the assessment and design stages of the cycle)
- Careful implementation of a plan of action designed to reveal the critical knowledge that is currently lacking
- Monitoring of key response indicators
- Analysis of the management outcomes in consideration of the original objectives and incorporation of the results into future decisions (British Columbia Ministry of Forests 2000)

Implementation actions, point source controls, management measures, or BMPs are used to control the generation or distribution of pollutants. BMPs are either structural, such as wetlands, sediment basins, fencing, or filter strips; or managerial, such as conservation tillage, nutrient management plans, or crop rotation. Both types require good management to be effective in reducing pollutant loading to water resources (Osmond et al. 1995).

It is generally more effective to install a combination of point source controls and BMPs or a BMP system. A BMP system is a combination of two or more individual BMPs that are used to control a pollutant from the same critical source. In other words, if the watershed has more than one identified pollutant, but the transport mechanism is the same, then a BMP system that establishes controls for the transport mechanism can be employed (Osmond et al. 1995).

To assist in adaptive management, implementation actions, management measures, available assistance programs, and recommended continued monitoring are all discussed throughout the remainder of this section.

9.2 Implementation Actions and Management Measures for TP in the Canton Lake Watershed

Total phosphorus concentrations in Canton Lake often exceed the Illinois water quality standard for lakes (0.05 mg/L). Analysis of water quality data can be summarized as follows:

- Lake sediments have a high phosphorus content;
- The lake is often stratified with respect to total phosphorus concentration (higher concentrations near the bottom);
- The bottom layer of the lake often has a higher proportion of dissolved phosphorus than top layers;

- A significant portion of the total phosphorus loading entering Canton Lake remains trapped in the lake (internal loading);
- High total phosphorus concentrations in tributaries are associated with storm events.

The inflow to the lake is characterized by higher flows in spring (storm runoff) and relatively lower flows during the summer and fall. Non-point sources dominate the phosphorus loading delivered to the lake through sampled tributaries. The phosphorus concentration near the bottom of the lake increasing during the summer season as well as other observations and the modeling results indicate the deeper portions of the lake often undergo stratification in summer and oxygen in the hypolimnion is depleted. Also, when water levels in the lake fall below the spillway, as often happens, all tributary loadings stay within the lake at least until the reservoir is replenished.

Considering the above observations, the final TMDL approach needs to include the following processes affecting total phosphorus concentrations and loadings in Canton Lake:

- Internal Loading and lake stratification;
- Runoff from urban, agriculture, and other areas, including septic systems and recreational areas.

9.2.1 Point Sources of TP

There are no significant point sources of TP in the Canton Lake watershed, and the associated WLA is therefore set to zero.

9.2.2 Nonpoint Sources of TP

Potential sources of nonpoint source phosphorus pollution to Canton Lake are dominated by runoff from upland agricultural areas, with more minor contributions from other runoff sources including urban areas, abandoned mines, septic systems, and recreational areas. Therefore, BMPs should focus on those that reduce TP entering Canton Lake from upland agricultural areas. These are discussed in Section 9.3.1 below.

9.3 Reasonable Assurance

Reasonable assurance means that a demonstration is given that nonpoint source reductions in the Canton Lake watershed will be implemented. It should be noted that all programs discussed in this section are voluntary and some may currently be in practice in the watershed. The discussion in Section 9.3.1 below provides information on available BMPs for reducing phosphorus loads from nonpoint sources. Then, Section 9.3.2 below presents an estimate of costs for implementing nonpoint source management practices, and programs available to assist with funding those BMPs.

9.3.1 Available BMPs for Nonpoint Source Management

9.3.1.1 Conservation Tillage

Conservation tillage is any method of soil cultivation that leaves the previous year's crop residue (such as corn stalks) on fields before and after planting the next crop, to reduce soil erosion and runoff. To provide these conservation benefits, at least 30% of the soil surface must be covered with residue after planting the next crop. Some conservation tillage methods forego traditional tillage entirely and leave 70% residue or more. Conservation tillage is especially suitable for erosion-prone cropland.

Conservation tillage methods include no-till, strip-till, ridge-till and mulch-till. Each method requires different types of specialized or modified equipment and adaptations in management. No-till and strip-till involve planting crops directly into residue that either hasn't been tilled at all (no-till) or has been tilled only in narrow strips with the rest of the field left untilled (strip-till). Ridge-till involves planting row crops on permanent ridges about 4-6 inches high. The previous crop's residue is cleared off ridge-tops into adjacent furrows to make way for the new crop being planted on ridges. Maintaining the ridges is essential and requires modified or specialized equipment. Mulch-till is any other reduced tillage system that leaves at least one third of the soil surface covered with crop residue.

When tillage is reduced or eliminated, particulate phosphorus loss in surface runoff usually declines, but dissolved P losses may increase if phosphorus becomes more concentrated near the soil surface unless P fertilizers or manure are injected or incorporated into the soil (Czapar et al. 2008). However, it should be kept in mind that TP reductions from conservation tillage or other BMP measures have been highly variable in published studies. For conservation tillage in particular, a recent review of the literature found particulate P reductions from -33 to 96%, and dissolved P reductions from -308 to -40 %, meaning dissolved P runoff has been observed to increase under conservation tillage alone, compared to conventional tillage (Dodd and Sharpley, 2016). In Illinois, it is estimated that converting from conventional to conservation tillage practices on soils eroding at greater than the soil tolerance rate (T) will reduce total P runoff from those soils 50% (IEPA, 2015). And, fewer trips across the fields save time and money (lowers fuel, labor and machinery maintenance costs) and reduces soil compaction that can interfere with plant growth.

To achieve TMDL load allocations, conservation tillage practices already in place should be continued, and practices should be assessed and improved upon for all agricultural areas in the watershed. According to the 2015 Transect Survey Report for Fulton County from the Illinois Dept. of Agriculture (https://www.agr.state.il.us/illinois-soil-conservation-transect-survey-reports), no-till practices were used on 12.4% of the corn and 59.5% of the soybean acreage, mulch-till practices on 22.9 % of the corn and 22.3 % of the soybean acreage, reduced till practices on 46.8% of the corn and 14.2% of the soybean acreage, and conventional tillage practices on 17.8 % of the corn and 4.0% of the soybean acreage. These percentages are similar to those for 2006 and 2011 given in Table 5-35 of the Phase I report. To increase the effectiveness of conservation tillage practices, more acreage should be converted to no-till (especially for corn), and targeted toward highly erodible land (HEL) areas of the watershed.

The known HEL areas of the Canton Lake watershed are shown in Figure 13, along with cropland and other land uses. This Figure indicates that known HEL areas are primarily located near stream corridors, and that a significant portion of the HEL areas are also cropland. In fact, of the 496 watershed acres which have been classified as HEL, 110 of those acres or 22.4% are also in cropland. However, as discussed in the stage 1 final report, only 5% of the land in the Canton Lake watershed has been classified as HEL, and 15% has been classified as non-HEL which means 80% remains unclassified. Consequently, there is likely much more HEL in the watershed. Assuming that the percentage of HEL in the entire watershed remains at the 1:3 ratio as those acres that have been classified would mean that 25% of the Canton Lake watershed, or about 2400 acres is HEL. As similar estimate comes from the 2015 soil transect survey for Fulton County which found that 16.0% of the surveyed croplands were eroding at between 1 and two times the soil tolerance rate, and 5.3% at greater than two times the soil tolerance rate. Thus, 21.3% of the cropland in the County is eroding at greater than the soil tolerance rate. In addition, ephemeral gully erosion was noted in 37% of the cropland surveyed. In any case, since

HEL areas are typically nearer stream channels and/or on greater slopes, these areas should be the focus of conservation tillage and other BMP practices in the watershed.

9.3.1.2 Filter Strips

Filter strips can be used as a structural control to reduce pollutant loads, including nutrients and sediment to Canton Lake. Filter strips implemented along stream segments and around waterbodies slow and filter nutrients and sediment out of runoff and provide bank stabilization decreasing erosion and deposition. Strictly speaking, however, filter strips can be placed between crop or grazing land and any environmentally sensitive land, and not necessarily only adjacent to stream segments and waterbodies (IL-NRCS, 2003).

Grass and riparian filter strips filter out nutrients and organic matter associated with sediment loads to a water body. Filter strips reduce nutrient and sediment loads to lakes by establishing ground depressions and roughness that settle sediment out of runoff and providing vegetation to filter nutrients out of overland flow. For the purposes of filtering contaminants, permanent filter strip vegetative plantings shall be harvested as appropriate to encourage dense growth, maintain an upright growth habit and remove nutrients and other contaminants that are contained in the plant tissue (NRCS, 2013).

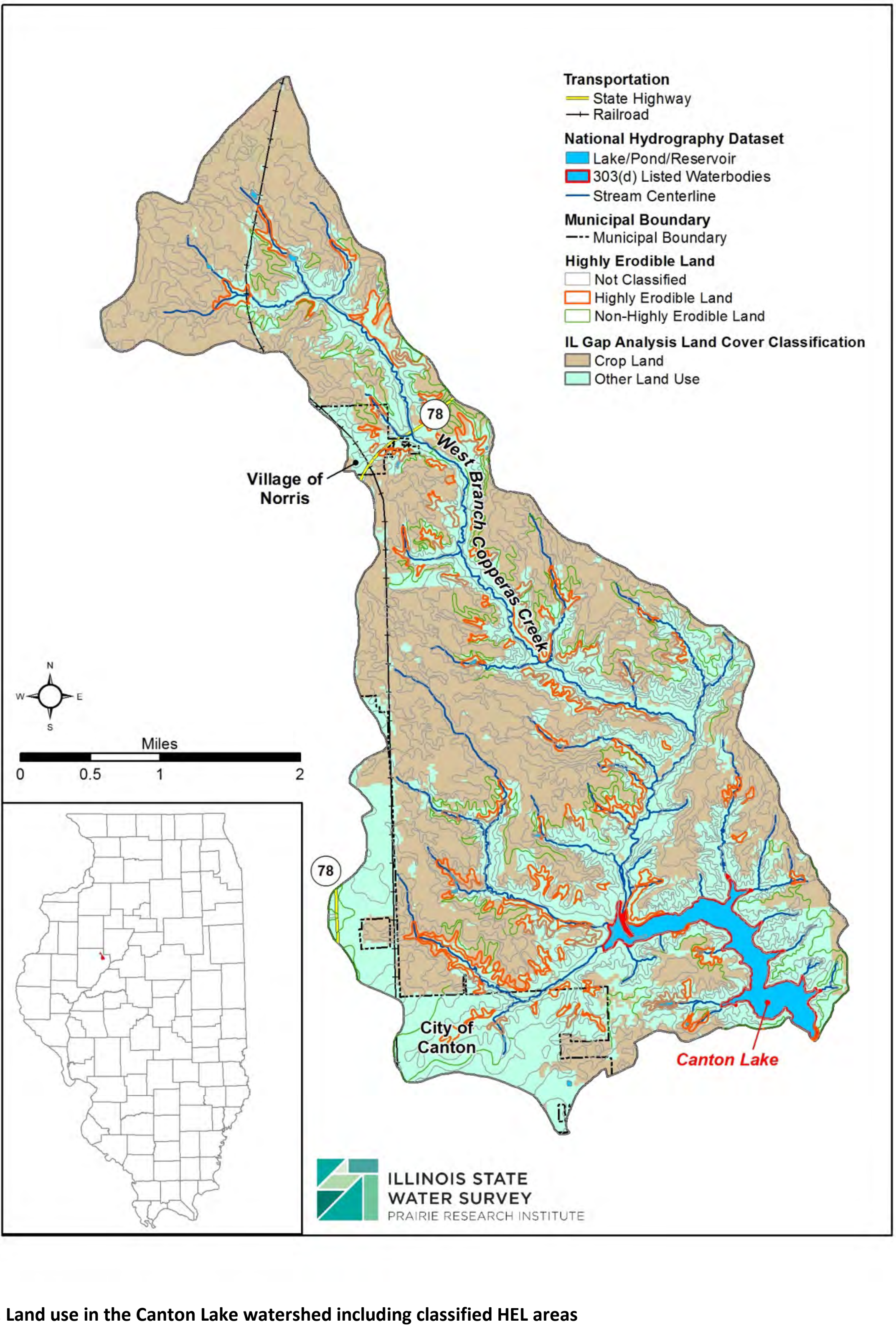

Figure 13. Land use in the Canton Lake watershed including classified HEL areas

Additionally, filter strip areas should be periodically re-graded and re-established when sediment deposition at the filter strip-field interface jeopardizes its function.

According to guidance published by the Illinois NRCS, the minimum and maximum flow through times for filter strips should be increased with slope (IL-NRCS, 2003). Recommended minimum flow through times (for a ½ inch depth flow) range from 36 minutes for 0.5% slope source areas, to 117 minutes for 5.0% (or greater) slope source areas. Similarly, maximum flow through times (above which filter strip effectiveness will likely not increase) range from 72 to 234 minutes for 0.5% and 5.0 % (or greater) slope source areas, respectively. Filter strip widths greater than that needed to achieve a 30 minute flow through time at 1/2 inch depth will not likely improve the effectiveness of the strip in addressing most water quality concerns, whereas a minimum of 15 minute flow through times are necessary for substantial water quality benefits (IL-NRCS,2003). Flow into filter strips should be primarily sheet flow, and concentrated flow should be dispersed.

From the land use coverage given in Figure 2-3 of the Phase I final report, roughly the upper 1/3 of most mapped tributaries appear to be bordered by crop land. Over the entire watershed, this corresponds to about 3200 acres that could benefit from filter strip BMPs, especially bordering the stream channels.

9.3.1.3 Riparian Buffers

A riparian buffer is a newly established area along a stream, of either grass or trees, which is managed to maintain the integrity of stream channels and shorelines and reduce the impacts of upstream land uses such as nutrient and sediment runoff. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow "sheet;" concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants. Similarly, riparian buffers are ineffective in tile-drained areas. Even more important than the filtering capacity of the buffers is the protection they provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion.

Minimum buffer widths are required for water quality benefits. These minimum widths are different for forest and herbaceous riparian buffers, as described in Illinois NRCS publications (IL-NRCS, 2013; IL-NCRS, 2014). For herbaceous cover buffers, minimum widths should be 2.5 times the bank-full width for streams, and 35 feet for other water bodies. Minimum forest buffer widths vary according to stream order, and should consist of at least 2 zones. For first- and second-order streams the minimum zone 1 and zone 2 widths are both 25 feet, while for third-order and higher streams the minimum zone 1 and zone 2 widths are 25 and 75 feet, respectively. Most of the streams in the Canton Lake watershed that would benefit from riparian buffers are first-order, meaning a minimum width of 50 feet would apply for riparian forest buffers.

From the land use data provided in Table 2-1 of the Canton Lake Phase I report, subtracting the surface area of Canton Lake (230 acres), leaves about 30 acres of stream course acreage within the watershed. Of that amount, about 10 acres are directly bordered by cropland (roughly the upper 1/3 of most mapped tributaries). Assuming an adequate riparian buffer width of 50 feet on both sides of those 10 acres (on average), and a stream width average of 10 feet, results in about 100 acres of cropland being suitable for conversion to riparian buffers within the Canton Lake watershed.

Phosphorus removal rates of approximately 25 to 30 percent for 30 ft wide buffers and 70 to 80 percent for 60 to 90 ft wide buffers have been documented (NCSU, 2002). Within Illinois, a TP runoff reduction from crop land of 25 to 50% can be expected from riparian buffers according to the Illinois Nutrient Loss Reduction Strategy (IEPA, 2015). However, the effectiveness of riparian buffers can be even more highly variable, ranging from -258 to 88% for dissolved P, and 35-96% for particulate P in published studies (Dodd and Sharpley, 2016). One factor reducing riparian buffer effectiveness are concentrated flow paths, and in one field survey in Southern Illinois, 82.5-100% of the drainage leaving agricultural fields was along concentrated flow paths (Pankau, et. al, 2012). Minimizing concentrated flow paths requires up gradient control measures such as regrading.

9.3.1.4 Sediment Control Basins

A sediment control basin is a basin constructed with an engineered outlet formed by an excavation or embankment or a combination of the two, to capture sediment laden runoff and trap it in the basin (IL-NRCS 2012a). Sediment basins should be located so that they intercept as much of the runoff as possible from disturbed areas of watersheds. Locations should be chosen that minimize the number of entry points for runoff into the basin and interference with construction or farming activities. Sediment basins should not be located in perennial streams. Vegetation should be established on the embankment and side slopes of the basin immediately after construction. Because the sediment storage capacity of a basin is finite, locations should be chosen that allow access for sediment removal when the storage capacity is full.

Sediment control basins should be designed to hold a minimum of 900 ft^3 of sediment per acre of disturbed area, and 3600 ft^3 of total storage per acre of drainage area. Given that there are roughly 2400 acres of HEL within the Canton Lake watershed, and that few sediment control basins exist in the watershed according to aerial photographs, means there are ample opportunities for their establishment. According to the Illinois Nutrient Reduction Strategy sediment control basins have been shown to trap about 90 % of the entering sediment (IEPA, 2015).

9.3.1.5 Cover Crops

Cover crops can be grasses, legumes, or forbs planted for seasonal vegetative cover (IL-NRCS, 2015a). Water quality benefits of cover crops come from three processes. The first is the literal cover that the crop provides to the soil, reducing erosion from raindrop impact. The second is the potential for the cover crop to take up nutrients that would otherwise be lost from the field through surface or drainage water and the third is increasing soil infiltration.

Cover crops should be established as soon as practical prior to or after harvest of the production crop. (i.e. before or after harvest). Cover crop species should be selected for their ability to effectively utilize nutrients. Terminate the cover crop as late as practical to maximize plant biomass production and nutrient uptake. Practical considerations for the termination date may include crop insurance criteria, the amount of time needed to prepare the field for planting the next crop, weather conditions, and cover crop effects on soil moisture and nutrient availability to the following crop. If the cover crop will be harvested for feed (hay/balage/etc.), choose species that are suitable for the planned livestock, and capable of removing the excess nutrients present.

Total phosphorus runoff can be reduced 50% with cover crops planted on highly erodible Illinois soils currently in reduced mulch or no-till according to the Illinois Nutrient Reduction Strategy (IEPA, 2015).

The Midwest Cover Crop Council (http://www.mccc.msu.edu/index.htm) maintains a decision support tool to help select cover crops according to crop, soil drainage characteristics, and desired goals. For Fulton County, representative cover crops rated as excellent for minimizing erosion on moderately well drained soils include winter rye and wheat, ryegrass, and a 50:50 mixture of hairy vetch and oats.

9.3.1.6 Nutrient Management

Nutrient management is defined as managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments (IL-NRCS, 2015b). The Illinois Fertilizer and Chemical Associations (http://www.ifca.com/) 4R nutrient stewardship program (http://www.keepit4rcrop.org/) promulgates nutrient management education and outreach under the slogan, "Right Source, Right Rate, Right Time, and Right Place". The right source refers to matching the type of fertilizer to crop needs, the right rate to matching the amount applied to crop needs, the right time to making nutrients available when crops need them, and right place to keeping nutrients where plants can use them.

Chapter 8 of the Illinois Agronomy Handbook (http://extension.cropsci.illinois.edu/handbook) provides guidelines for fertilizer application rates based on the inherent properties of the soil (typical regional soil phosphorus concentrations, root penetration, pH, etc.), the starting soil test phosphorus concentration for the field, and the crop type and expected yield. Fulton County lies in the "high sub-soil phosphorus supplying power region of Illinois, which means that less P fertilizer is required for optimal crop yields than elsewhere in the State. Near-maximal corn and soybean yields are obtained if available phosphorous levels are maintained at 40 lbs/acre, while considerably higher levels, about 60 lbs/acre, are required for maximum wheat and oat yields. If available phosphorus levels are above 60 lbs/acre then there is no agronomic advantage to applying phosphorus fertilizer. In fact, Illinois studies have shown that if available P is at 60 lbs/acre or greater, yields are maintained for at least 4 years without any phosphorus application. If available phosphorus levels are between 40 and 60 lbs/acre, phosphorus fertilizer should be applied only in amounts necessary to replace amounts removed by the crop, which are 0.43, and 0.85 lbs/bushel (as P_2O_5) for corn and soybeans, respectively. This is termed maintenance fertilization. If available phosphorus levels are below 40 lbs/acre, then levels must be built back up to the desired level, and to replace what the crop will remove.

Available phosphorus levels can also vary spatially within a given field in which case variable rate application can be used to place more or less phosphorus as needed to build-up or maintain adequate levels. Studies have also shown that subsurface placement of phosphorus fertilizer reduces phosphorus runoff, and can increase crop yields, as compared to surface broadcast treatment. In one recent Illinois study, phosphorus uptake rates for corn were 24% greater with strip-till subsurface phosphorus application, relative to no-till broadcast application (Fernandez and White, 2012).

The overall goal of phosphorus reduction from agriculture should increase the efficiency of phosphorus use by balancing phosphorus inputs in feed and fertilizer with outputs in crops and grasslands as well as managing the level of phosphorus in the soil. Reducing phosphorus loss in runoff may be brought about by source and transport control measures, such as filter strips or riparian buffers (discussed above).

Nutrient management plans account for all inputs and outputs of phosphorus to determine reductions. Included is a statement that the plan was developed based on requirements of the current standard and any applicable Federal, state, or local regulations, policies, or programs, which may include the implementation of other practices and/or management activities. Changes in any of these requirements may necessitate a revision of the plan. The following components shall be included in the nutrient management plan:

- Review of aerial photography and soil maps
- Regular soil testing (the IAH recommends soil testing every four years)
- Review of current and/or planned crop rotation practices
- Yield goals and associated nutrient application rates
- Nutrient budgets with the right rate, place, time and source of application
- Identification of sensitive areas and restrictions on application when land is snow covered, frozen or saturated

9.3.1.7 Streambank and Shoreline Erosion

Since much of the classified HEL acreage in the Canton Lake watershed is located near stream corridors (Figure 13), streambank erosion is likely a significant contributor of TSS and TP to Canton Lake. Hence, BMP efforts should address this source as well. These efforts can be broadly defined as treatments to stabilize and protect banks of streams or constructed channels and shorelines of lakes, reservoirs or estuaries (IL-NRCS, 2012b). Streambank erosion is a natural process. However, in agricultural areas increased runoff from croplands and/or channelization result in increased flows and correspondingly increased sediment loads, resulting in severe erosion. Such severely eroding streambanks can contribute 30-50 per cent of the sediment entering waterbodies from all sources (IEPA, 2015).

Before selecting a specific BMP it is first necessary to identify the cause of the erosion problem. Otherwise, a given BMP could actually increase erosion. Additionally, consideration must be given to the velocity of the stream, depth of the stream at the BMP placement site, slope and height of the bank, and the soils contained in the bank (Iowa DNR, 2006). The channel evolution model of Schumm, Harvey, and Watson (1984) can be used to help determine the most appropriate BMPs for streambank erosion. In this model there are 5 stages of evolution a stream channel will go through if it is disturbed. Stage I is the initial channel condition, stage II is deepening of the channel through increased bed erosion, stage III is widening of the channel through increased bank erosion, stage IV is the building of a new floodplain and the onset of stabilization, and stage V is the return to a new stable condition. If a channel is in a stage I or V condition, minimally invasive BMPs such as planting of willow posts or other types of vegetation along with erosion netting may be sufficient. Effective stage II BMPs to mitigate channel bed erosion includes the placement of rock riffles to slow water velocity and “stair step” water down steeper grades. Effective stage III channel BMPs include bendway weirs, which are in stream low rock structures placed at angles upstream of outside bends. A well placed series of bendway weirs direct water away from eroding streambanks. Stream barbs are another type of low rock structures which act to direct flow away from erodible streambanks. Stage IV channel BMPs should be directed toward the establishment of vegetation to prevent excessive widening of the floodplain. One such practice is stone toe protection which involves the placement of stone structures which are peaked toward the bank thus stabilizing the bank and aiding the establishment of bankside vegetation.

A study cited in the Phase I report estimated shoreline erosion contributes about 122 tons of sediment per year to Canton Lake. This is a very small contribution compared to the TSS load delivered by tributaries which ranged from about 5,000 to 20,000 tons annually between 2000 and 2013. Still, many of the BMPs effective for dealing with streambank erosion are also effective against shoreline erosion and should be established where shoreline erosion problems exist.

9.3.1.8 Septic Systems

According to the Phase I report, there are an estimated 151 septic systems in the Canton Lake watershed and 72 households on Canton Lake itself. An unknown number of the systems may be failing or are otherwise improperly maintained and consequently may be contributing phosphorus and other household chemicals to Canton Lake. To address this possibility, a regular inspection and maintenance plan should be followed which includes regular pumping of the septic system tank, typically at 3 to 5 year intervals. If the tank is not pumped regularly, sludge can accumulate and become deep enough to enter the drain field. Regular pumping prolongs the life of septic systems by protecting the drain field from sludge that may cause clogs and system backups. Pumping costs range from about $300 to $500 dollars depending on the gallons pumped and the disposal fee for the area.

Best management practices for septic systems include using water efficiently such as with low flow toilets, faucets and showerheads. A homeowner should also avoid disposing of substances such as cigarette butts, cat litter, cooking oil or grease, coffee grounds, and pharmaceuticals or household chemicals. Finally, it is important to protect the drain field from physical damage from, for example, parked vehicles, tree roots, and excessive rainwater drainage from rooftops and sump pumps.

9.3.2 BMP Cost Estimates

Table 10 lists the FY 2016 Environmental Quality Incentives Program (EQIP) payment rates applicable to Illinois for the BMP practices listed in Section 9.3.1 above. These rates are deemed to represent up-to-date BMP implementation cost estimates. The full list of payment rates is available at, (http://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/). More information on EQUIP is given in Section 9.3.4.1 below. Note that a range of rates is given for most of the listed BMPs. Total watershed costs will depend on the combination of BMPs selected to target nonpoint sources within the Canton Lake watershed. Regular monitoring will support adaptive management of implementation activities to most efficiently reach the TMDL goals.

Table 9. Selected BMP Payment Rates

BMP	FY 2016 EQUIP Payment Rates
Conservation Tillage (no till)	$4-$30/acre
Filter Strip (seeded)	$520-$640/acre
Grass Riparian Buffer (seeded)	$662/acre
Tree Riparian Buffer (seeded)	$741/acre
Water & Sediment Control Basins	$2.20-$3.10/cubic yard
Cover Crops	$46-$132/acre
Nutrient Management	$13-$45/acre

9.3.3 State BMP Cost Share Programs

Most of the State (Section 9.3.3) and Federal (Section 9.3.4) BMP program information given below is taken from the Illinois Nutrient Loss Reduction Strategy Document (IEPA, 2015), which is available at, (http://www.epa.illinois.gov/topics/water-quality/watershed-management/excess-nutrients/nutrient-loss-reduction-strategy/index).

9.3.3.1 Section 319

Section 319 is a grant program under the Clean Water Act (33 U.S.C. 1329) that disburses funds to states with approved non-point source management plans. States in turn can competitively award grants to qualified applicants to support non-point source pollution control.

Through technical and financial assistance, and to facilitate the planning process, the Illinois Environmental Protection Agency encourages the development of watershed-based plans consistent with current watershed planning principles. Plan development and monitoring is tracked through the Resource Management Mapping Service. Visit their website, (http://www.rmms.illinois.edu/RMMS-JSAPI/) for more information.

The long-term goals of the Program as listed in the latest State of Illinois Section 319 Biannual Report (IEPA, 2016) are: 1) The restoration and protection of all beneficial uses of Illinois' surface and groundwater resources from non-point source pollution. This goal will be achieved through watershed based assessment, planning, implementation, and education activities carried out as part of an effective and efficient process that employs both regulatory and non-regulatory programs, agencies, authorities, and stakeholders, 2) The prioritization and targeting of impaired waterbodies for the selection and implementations of non-point pollution control measures so as to efficiently and expeditiously restore and protect the full support of their designated uses, 3) Effective communication, coordination, collaboration, and education among all partners and stakeholders involved in NPS pollution control, 4) The refinement and development of monitoring and assessment tools to better determine NPS pollution impairments, including nutrient impacts on Illinois waters.

9.3.3.2 State Revolving Fund

Funding for non-point source pollution control projects, including agricultural sources, is available through the State Revolving Fund loan program as a result of recent eligibility expansions under the Clean Water Initiative (Public Act 98-0782) designed to address stormwater runoff, which can contribute to nutrient loading in Illinois waters.

9.3.3.3 Conservation Reserve Enhancement Program

The Illinois Conservation Reserve Enhancement Program (CREP) is a state incentive program tied to the U.S. Department of Agriculture (USDA) Federal Conservation Reserve Program (CRP). CREP achieves long-term environmental benefits by allowing 232,000 acres of eligible environmentally-sensitive land within the Illinois and Kaskaskia River watersheds to be restored, enhanced, and protected over periods ranging from 15 years to perpetuity. The Canton Lake watershed lies within the Illinois River watershed and hence watershed landowners are eligible for this program. CREP is driven by locally-led conservation efforts, as evidenced by increased landowner support, and employs a variety of BMPs to protect and restore riparian corridors. This program is a prime example of how partnerships between landowners, governmental entities, and non-governmental organizations can work to address watershed quality concerns.

CREP is one of many tools used by the Illinois Department of Natural Resources (INDR) and its conservation partners to implement the Illinois Comprehensive Wildlife Action Plan, which provides a framework for restoring critical habitats, increasing plant diversity, and expanding habitats for species in greatest need of conservation in a predominately agricultural landscape.

Since CREP's inception in 1998, 135,517 acres have been enrolled in federal CREP contracts at an average rental rate of $188.6/acre. The state has also successfully executed 1,316 CREP easements, protecting 83,273 acres. These easements have prevented approximately 150,000 lbs of nitrate-nitrogen at an average of 3.15 lbs/acre, 42,263 lbs of total phosphorus at an average of 0.87 lbs/acre, and 34,084 tons of sediment at an average of 0.7 tons/acre from entering the Illinois and Kaskaskia rivers each year.

9.3.3.4 Partners for Conservation Cost-Share

The Illinois Department of Agriculture (IDOA) administers several initiatives promoting advanced nutrient management, conservation tillage, and the use of cover crops. These programs reduce soil erosion, sedimentation, and nutrient runoff, leading to improved water quality. IDOA's Partners for Conservation (PFC) cost-share program provides funding for the implementation of cultural (e.g., no-till and cover crops) and structural (e.g., grassed waterways and terraces) conservation practices. PFC funds are allocated annually to local soil and water conservation districts (SWCDs) for distribution to eligible landowners for carrying out BMPs that will benefit the environment.

The 97 local SWCDs throughout Illinois play a key role in fostering locally-led conservation work in rural and urban areas. They conduct outreach to increase public awareness of the importance of natural resource conservation. In addition, they hold landowner signups to build conservation projects and prioritize project proposals for funding based on the environmental benefits. Their technical staff provides landowners conservation practice design and construction oversight. The SWCDs are a very important asset in the delivery of IDOA's soil and water conservation programs to rural and urban customers. They also assist the USDA Natural Resources Conservation Service (NRCS) in the construction of conservation projects through various programs authorized by the U.S. Farm Bill.

Conservation practices 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. A total of 6,733 PFC projects were completed by landowners from 2006-2012. Although the state's portion of the cost of these projects totaled almost $17 million, this amounts to approximately 50 percent of the cost of construction, with a little less than half of the cost contributed by landowners. To date, these projects reduced soil erosion on 68,088 acres of cropland.

9.3.3.5 Streambank Stabilization and Restoration Program

In an effort to stabilize and restore severely eroding stream banks that would otherwise contribute sediment to the state's rivers and tributaries, IDOA with, assistance from SWCDs, administers the Streambank Stabilization and Restoration Program (SSRP). This cost-share program provides up to 75% of the construction cost for eligible and approved projects. The program has 3 primary objectives:

1) Provide funding to construct effective, low-cost practices, such as rock riffles, stream barbs or stone toe protection at suitable locations.
2) Provide technical assistance to landowners interested in stabilizing an eroding streambank.
3) Distribute education materials on the effects of streambank erosion along with the practices available to stabilize the erosion through SSRP.

Severely eroding stream banks can contribute as much as 30-50 percent of the sediment entering waterways from all sources. The SSRP, funded under PFC, provides funds to construct low-cost techniques to stabilize eroding stream banks. During 2004-2012, 58 miles of eroding stream banks were stabilized, resulting in a 61,389 ton reduction in sediment delivery. Loading of nitrate-nitrogen was also reduced by 107,214 lb and total phosphorus by 57,308 lb (IEPA, 2015). The IDOA summarizes the SSRP projects completed in a given year in their Illinois Conservation Partnership Annual Report series, which are available at, (https://www.agr.state.il.us/land-water-resources).

9.3.4 Federal Cost Share BMP Programs

9.3.4.1 Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is a voluntary cost share program originally authorized under the 1996 Farm Bill (Pub. L. 104-127) and re-authorized in the 2014 Farm Bill (Pub. L. 113- 79). Sixty per cent of EQIP funds must be used for livestock practices. Eligible program participants receive financial and technical assistance to implement conservation practices or activities such as conservation planning that address natural resource concerns on their land. NRCS staff works with applicants to develop an EQIP plan of operations that identifies the appropriate conservation practices needed to address identified natural resource concerns. The following national priorities, consistent with statutory resources concerns that include soil, water, wildlife, air quality, and related natural resource concerns, may be used in EQIP implementation:

1. Reductions of nonpoint source pollution, such as nutrients, sediment, pesticides, or excess salinity in impaired watersheds consistent with total maximum daily loads (TMDL) where available; the reduction of surface and groundwater contamination; and the reduction of contamination from agricultural sources, such as animal feeding operations
2. Conservation of ground and surface water resources
3. Reduction of emissions, such as particulate matter, nitrogen oxides, volatile organic compounds, and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards
4. Reduction in soil erosion and sedimentation from unacceptable levels on agricultural land
5. Promotion of at-risk species habitat conservation including development and improvement of wildlife habitat
6. Energy conservation to help save fuel, improve efficiency of water use, maintain production, and protect soil and water resources by more efficiently using fertilizers and pesticides and
7. Biological carbon storage and sequestration

In addition, Illinois has identified the following priorities:

1. Improve soil health by adding organic matter, reducing compaction, and promoting soil organisms.
2. Reduce soil erosion by managing water runoff and increasing plant residue.
3. Improve water quality by reducing the sediments, nutrients and other contaminates from entering Illinois waterways.

Applications for EQIP are accepted on a continuous basis, and NRCS establishes submission deadlines for evaluation and ranking of eligible applications. Applications are ranked based on a number of factors, including the environmental benefits and cost effectiveness of the proposal. Payments are made to participants after the conservation practices and activities identified in the plan are implemented. Contracts can last up to 10 years. Information on practices available for funding in Illinois can be found at, http://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/

9.3.4.2 Conservation Reserve Program

The Conservation Reserve Program (CRP) is a land conservation program administered by the Farm Service Agency (FSA). 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. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. Enrollment is continuous and information about the CRP program is available at, (https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index).

A particularly relevant initiative for the Canton Lake watershed within the CRP program concerns HELs. Participating farmers and landowners will receive 10 years of annual rental payments, and 50% cost share for establishing grass or tree cover on HELs. As estimated in Section 9.3.1.1 above, approximately 2400 acres of cropland within the Canton Lake watershed is HEL and may qualify for this initiative.

9.3.4.3 Conservation Stewardship Program

The Conservation Stewardship Program (CSP) helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.

The types of practices eligible for payments which enhance water quality or minimize soil erosion include: applying phosphorus fertilizer below the soil surface, applying fertilizer no more than 30 days prior to planting, variable rate application of fertilizers, applying enhanced efficiency fertilizers, intensive no-till practices, use of cover crop mixes, and intensive cover cropping.

Through CSP, participants can take additional steps to improve soil health, air and habitat quality, water quality and quantity, and energy conservation on their land. CSP provides two types of payments through five-year contracts: annual payments for installing new conservation activities and maintaining existing practices and supplemental payments for adopting a resource-conserving crop rotation. Producers may be able to renew a contract if they have successfully fulfilled the initial contract and agree to achieve additional conservation objectives. A person or legal entity may not receive more than $200,000 during fiscal years 2014 through 2018.

9.3.4.4 Easement Programs

NRCS offers voluntary easement programs to landowners who want to maintain or enhance their land in ways that are beneficial to the environment. The 2014 Farm Bill authorized the Agricultural Conservation Easement Program (ACEP) and the Healthy Forests Reserve Program (HFRP). ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. ACEP consolidates programs authorized by previous Farm Bills, including the Wetlands Reserve Program (WRP), Grassland Reserve Program, and Farm and Ranch Lands Protection Program. Under ACEP, NRCS helps Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the easement component of WRP, NRCS helps restore, protect, and enhance enrolled wetlands. HFRP helps landowners restore, enhance, and protect forestland resources on private lands through easements and financial assistance. Through HRFP, landowners can promote the recovery of endangered or threatened species, improve plant and animal biodiversity, and enhance carbon sequestration.

9.3.4.5 Regional Conservation Partnership Program

This program, which competitively awards funds to conservation projects designed by local partners specifically for their region, was authorized in the 2014 Farm Bill. The Regional Conservation Partnership Program (RCPP) provides assistance to producers through partnership agreements and program contracts or easements. RCPP encourages partners to join in conservation efforts by leveraging RCPP funding for conservation activities in select project areas. Illinois has set priorities for water quality, soil health, and soil erosion for funding proposals. Additional RCPP information is available at, http://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/farmbill/rcpp/

9.3.4.6 Local Program Information

Specific information related to the BMP programs available in Fulton County may be obtained from the contacts given in Table 11 below.

Table 10. Fulton County Contacts

Contact	Address	Phone
Local SWCD Office		
Andrew Karrick	13118 North US Highway 24 Lewistown, IL 61542	(309)547-2215
Local NRCS office		
Kim Smail	13118 North US Highway 24 Lewistown, IL 61542	(309)547-2215

9.4 Monitoring Plan

The purpose of the monitoring plan for Canton Lake is to assess the overall effectiveness of implementing the BMPs outlined in this chapter. This can be accomplished by the continued monitoring of Canton Lake and its tributaries. Continued monitoring of the inflow tributaries is critical for following total phosphorus loading to Canton Lake as BMP measures are implemented. As discussed in the stage one report, the ISWS established several stations along the tributaries to Canton Lake, which were monitored for discharge, total phosphorus, and total suspended solids. These constituents were monitored on a weekly basis at two base tributary stations, and biweekly at three supplemental stations, but only between March, 2012 and October, 2012. In addition, sampling was conducted during high flow storm events. These are the only data available with which to directly calculate total phosphorus loading to Canton Lake. Additional discharge and water quality sampling should be conducted at these stations as BMP measures are implemented to document their effectiveness. At a minimum, routine samples should be collected quarterly, and 2 or more high flow events should sampled per year.

Estimating the effectiveness of the BMPs implemented in the watershed could be accomplished by monitoring before and after the BMP is incorporated into the watershed. For example, additional monitoring could be conducted on specific structural systems such as sediment control basins or riparian buffers. Inflow and outflow measurements could be conducted to determine site-specific TP removal efficiency.

The IEPA should also continue to monitor water quality at their three stations within Canton Lake. This should include measurements total and dissolved phosphorus, dissolved oxygen, and chlorophyll a, especially between April and October at a frequency of at least every few weeks. Additionally, at the deeper mid-lake (RDD-2), and near dam stations (RDD-1), both near-surface and near bottom samples should be analyzed, and profiles of dissolved oxygen and temperature collected, since both historical data and modeling simulations indicate that anoxic conditions can develop within Canton Lake under favorable conditions at depths greater than about 12 feet. Anoxic conditions promote internal phosphorus generation, which can help fuel algal production even as BMP measures are implemented and thus could mask their effectiveness.

Tracking the implementation of BMPs through these monitoring efforts can be used to address the following goals:

- Determine the extent to which management measures and practices have been implemented compared to action needed to meet TMDL endpoints
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts
- Measure the extent of voluntary implementation efforts
- Support work-load and costing analysis for assistance or regulatory programs
- Determine the extent to which management measures are properly maintained and operated

9.5 Implementation Time Line

Implementing the actions outlined in this section for the Canton Lake watershed should occur in phases and the effectiveness of the management actions should be continually assessed as improvements are made. However, BMPs should begin to be implemented as soon as willing landowners are identified. Moreover, for many of the specific programs outlined above, enrollment is on a continuous basis, so interested landowners can begin implementation immediately.

Even if TP loading to Canton Lake was reduced by the TMDL endpoint of 55% instantaneously through effective BMP measures, it could take several decades for their full effect to be realized. This is because legacy phosphorus stores in the soils and stream courses of the watershed and bottom sediments of Canton Lake itself can continue as phosphorus sources and hence delay water quality improvements (Sharpley et. al., 2013). Consequently, it will be important to document reductions in total phosphorus loading from tributaries, which should be more immediately observable as more BMP practices are implemented and maintained in the watershed, and distinguish those from in-lake water quality improvements, which may be slower to achieve.

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Appendix A: Methods to determine water quality concentrations for Canton Lake tributaries

Constituent Name	Concentration	Source or Method
TDS or Salinity	TDS = sqrt(66507.5 - 11180.3*ln(Qdaily_cm))	Relationship developed from CREP site 302
Suspended solids	TSS-VSS	Constituent/chemical balance
Phosphate	TP<1: 0.2199*TP^0.727 TP>1: 0.2111*TP^(-0.724)	Relationship developed from CREP site 302
Ammonium	0.06	median for 202 (mg/l
Nitrate-Nitrite	43.5799 + 4.14261*ln(flow in cfs per ha)	Relationship developed from CREP site 302
Dissolved silica	dis silica = 2.75 + 2.5 exp (-flow in cm/day /1.1)	Estimate from literature values/other similar lakes
Particulate silica	25% TSS	Estimate from literature values/other similar lakes
Labile DOM	25% DOM	Estimate from literature values/other similar lakes
Refractory DOM	75% DOM	Estimate from literature values/other similar lakes
Labile POM	25% POM	Estimate from literature values/other similar lakes
Refractory POM	75% POM	Estimate from literature values/other similar lakes
Algae Group 1	2	Estimate from literature values/other similar lakes
Algae Group 2	2	Estimate from literature values/other similar lakes
Algae Group 3	2	Estimate from literature values/other similar lakes
Dissolved oxygen		100% saturation concentration at daily temperature
Inorganic Carbon	alkalinity * 12 / 50	Constituent/chemical balance
Alkalinity	intake data	Daily intake concentrations
Labile DOM-P	50% DOM-P	Estimate from literature values/other similar lakes
Refractory DOM-P	50% DOM-P	Estimate from literature values/other similar lakes
Labile POM-P	30% POM-P	Estimate from literature values/other similar lakes
Refractory POM-P	70% POM-P	Estimate from literature values/other similar lakes
Labile DOM-N	50% DOM-N	Estimate from literature values/other similar lakes
Refractory DOM-N	50% DOM-N	Estimate from literature values/other similar lakes

Labile POM-N	30% POM-N	Estimate from literature values/other similar lakes
Refractory POM-N	70% POM-N	Estimate from literature values/other similar lakes
POM	VSS - algae biomass	Constituent/chemical balance
DOM	2*POM	Constituent/chemical balance
temperature		Values developed from CREP site 302
TP		GWLF TP (monthly loads converted to daily)
TN	21.1848 + 1.81115*ln(flow in cfs per ha)	relationship developed for 202
TSS		GWLF TSS (monthly loads converted to daily)
VSS	0.5*TSS*MIN(IF(TSS>30,(0.280369 + 3.6829/TSS)^2,1/(0.271932 + 0.209574*TSS)),1)	Relationship developed from RDD-T2 site
OM-P	TP - Phosphate - P in algae	Constituent/chemical balance
DOM-P	0.016 * TP^(-0.935)	Relationship developed from CREP site 302
POM-P	OM-P - DOM-P	Constituent/chemical balance
OM-N	TN - NH4 - NO23 - N in algae	Constituent/chemical balance
DOM-N	Assume DOM-N/OM-N = DOM-P/OM-P	Constituent/chemical balance
POM-N	OM-N - DOM-N	Constituent/chemical balance

Appendix B: Methods to determine initial water quality concentrations in Canton Lake on 6/1/2000

Constituent Name	Initial Concentration	Data Source or Method
TDS or Salinity	257	Average of June 2000 intake concentrations
Suspended solids	6	Median of June lake concentrations, IEPA data
Phosphate	0.013	Median of June lake concentrations, IEPA data
Ammonium	0.218	Median of June lake concentrations, IEPA data
Nitrate-Nitrite	2.326	Median of June lake concentrations, IEPA data
Dissolved silica	5	Estimate from literature values/other similar lakes
Particulate silica	3.5	Estimate from literature values/other similar lakes
Labile DOM	5.25	25% DOM
Refractory DOM	15.75	75% DOM
Labile POM	3.5	50% POM
Refractory POM	3.5	50% POM
Algae Group 1	5	Estimate from literature values/other similar lakes, as chlorophyll a
Algae Group 2	10	Estimate from literature values/other similar lakes, as chlorophyll a
Algae Group 3	5	Estimate from literature values/other similar lakes, as chlorophyll a
Dissolved oxygen	8.72	100% saturation concentration at 22C
Inorganic Carbon	44.4	
Alkalinity	185	Average of June 2000 intake concentrations
Labile DOM-P	0.010440216	50% DOM-P
Refractory DOM-P	0.010440216	50% DOM-P
Labile POM-P	0.000635871	30% POM-P
Refractory POM-P	0.001483698	70% POM-P
Labile DOM-N	0.310482935	50% DOM-N
Refractory DOM-N	0.310482935	50% DOM-N
Labile POM-N	0.018910239	30% POM-N
Refractory POM-N	0.044123891	70% POM-N
POM	7	Median of June lake concentrations, IEPA data
DOM	21	3 x POM
temperature	22	Average of June 2000 intake temperatures
TP	0.058	Median of June lake concentrations, IEPA data
TN	3.58	Median of June lake concentrations, IEPA data
OM-P	0.023	TP-Phosphate-P in algae
DOM-P	0.020880431	Relationship developed from CREP site 302: 0.016 * TP^(-0.935)
POM-P	0.002119569	OM-P - DOM-P
OM-N	0.684	TN - NH4 - NO23 - N in algae

DOM-N	0.62096587	Assume DOM-N/OM-N = DOM-P/OM-P
POM-N	0.06303413	OM-N - DOM-N

Appendix C: Major Coefficients and Constants Used in the CE-QUAL-W2 Model of Canton Lake

Default values and/or representative example values provided by Cole and Wells (2002) are listed for comparison. NA= Not Applicable.

MODEL GRID SETUP; INFLOW/OUTFLOW STRUCTURES

Model Symbol	Description	Value	Default Value
NWB	Number of water bodies	1	NA
NBR	Number of branches	1	NA
IMX	Number of segments in the computational grid	34	NA
KMX	Number of layers in the computational grid	38	NA
NTR	Number of tributaries (minor tributaries are treated as distributed	7	NA
NSTR	Number structures (a single discharge structure at the dam)	0	NA
NWD	Number of withdrawals (a single drinking water withdrawal)	1	NA

TIME FACTORS

Model Symbol	Description	Value	Default Value
TMSTRT	Start time (1 Jun 2000)	153	NA
TMEND	End time (31 Dec 2013)	5144	NA
DLTMAX	Maximum time step (seconds)	3600	NA

HEAT EXCHANGE/ICE COVER

Model Symbol	Description	Value	Default Value
SLHTC	Equilibrium temperature computation (ET) for surface exchange	ET	NA
AFW	Intercept for wind-driven heat exchange function	9.2	9.2
BFW	Slope for wind-driven heat exchange function	0.46	0.46
CFW	Exponent of wind-driven heat exchange function	2.0	2.0
WINDH	Height of wind speed measurement (m)	10.0	NA
SLTRC	Transport solution scheme; ULTIMATE algorithm eliminates physically unrealistic over/undershoots due to longitudinal transport	ULTIMATE	ULTIMATE
THETA	Time-weighting for vertical advection	0.5	0.55
ICEC	Ice Cover Algorithm	ON	NA
ALBEDO	Albedo (Reflection/Incident)	0.25	0.25
HWICE	Coefficient of water-ice heat exchange	10.0	10.0
BICE	Fraction radiation absorbed by ice	0.6	0.6
GICE	Solar radiation extinction coefficient (m^{-1})	0.07	0.07
ICEMIN	Minimum ice thickness before ice formation (m)	0.05	0.03
ICET2	Temperature above which ice does not form (^{o}C)	3	3

HYDRAULICS

Model Symbol	Description	Value	Default Value
AX	Longitudinal Eddy Viscosity (m^2 sec^{-1})	1	1
DX	Longitudinal Eddy Diffusivity (m^2 sec^{-1})	1	1
CBHE	Coefficient of bottom heat exchange (W m^{-2} sec^{-1})	0.3	0.3
TSED	Temperature of the sediment (^oC)	11.2	10.0
FI	Interfacial friction factor	0.015	0.015
TSEDF	Heat from sediments added back to water	0	0-1
FRICC	Bottom friction	CHEZY	MANN
AZC	Form of vertical turbulence closure algorithm	W2	W2
AZSLC	Implicit (IMP) or Explicit (EXP) treatment of vertical eddy Viscosity	EXP	N/A
AZMAX	Maximum value for vertical eddy viscosity, (m^2 sec^{-1})	1E-4	1E-3/1.0

HYDRAULIC STRUCTURE CHARACTERISTICS

Model Symbol	Description	Value	Default Value
KTSTR	Top water layer above which selective withdrawal will not occur through the intake structure of the power house draft tubes	NA	NA
KBSTR	Bottom layer below which selective withdrawal will not occur through the intake structure of the power house draft tubes	NA	NA
SINKC	Selective withdrawal algorithm for the intake structure of the power house draft tubes	NA	NA
ESTR	Centerline elevation of intake structure for the power house draft tubes (m)	NA	NA
IWD	Drinking water withdrawal structure; lake segment number	33	NA
EWD	Drinking water withdrawal structure centerline elevation (m)	173.27	NA
KTWD	Top water layer above which withdrawal will not occur through the drinking water intake structure	2	NA
KBWD	Bottom water layer below withdrawal will not occur through the drinking water intake structure	36	NA

LIGHT EXTINCTION and SUSPENDED SOLIDS

Model Symbol	Description	Value	Default Value
EXH2O	Extinction for pure water (m^{-1})	0.25	0.25 or 0.45
EXSS	Extinction due to inorganic suspended solids, (m^{-1} /gm^{-3})	0.1	0.1
EXOM	Extinction due to organic suspended solids, (m^{-1} /gm^{-3})	0.1	0.1
BETA	Fraction of solar radiation absorbed at water surface	0.45	0.45
EXA1	Extinction due to algal biomass#1, (m^{-1} /gm^{-3})	0.2	0.2
EXA2	Extinction due to algal biomass#2, (m^{-1} /gm^{-3})	0.2	0.2
EXA3	Extinction due to algal biomass#3, (m^{-1} /gm^{-3})	0.2	0.2
SSS	Suspended Solids Settling rate (m d^{-1})	2	1.0
SEDRC	Sediment resuspension control	OFF	OFF

ALGAL METABOLISM

Model Symbol	Description	Group 1 Diatoms	Group 2 Greens	Group 3 Cyano-bact.	Default Value
AG	Maximum Growth Rate (d^{-1})	1.75	1.9	1.9	2.0
AR	Respiration (d^{-1})	0.04	0.04	0.04	0.04
AE	Excretion (d^{-1})	0.04	0.04	0.04	0.04
AM	Mortality (d^{-1})	0.1	0.1	0.1	0.1
AS	Sinking Rate ($m\ d^{-1}$)	0.3	0.1	0.05	0.1
AHSP	Half-saturation constant for P (mg/L)	0.002	0.002	0.002	0.003
AHSN	Half-saturation constant for N (mg/L)	0.014	0.035	0.001	0.014
AHSSI	Half-saturation constant for Si (mg/L)	0.002	0.002	0.002	0
ASAT	Light Saturation ($W\ m^{-2}$)	150	125	145	75
Temperature					
AT1	Min temperature for growth (^{o}C)	5	10	15	5
AT2	Lower temp for max growth (^{o}C)	15	20	28	25
AT3	Upper temp for max growth (^{o}C)	20	26	35	35
AT4	Max temp for growth (^{o}C)	30	35	40	40
AK1	Fraction of algal growth rate at AT1	0.1	0.1	0.1	0.1
AK2	Fraction of max. algal growth rate at AT2	0.5	0.8	0.99	0.99
AK3	Fraction of max. algal growth rate at AT3	0.99	0.99	0.99	0.99
AK4	Fraction of algal growth rate at AT4	0.1	0.1	0.1	0.1
Stoichiometry					
ALGP	Algal P: Biomass ratio	0.005	0.005	0.005	0.005
ALGN	Algal N: Biomass ratio	0.08	0.07	0.08	0.08
ALGC	Algal C: Biomass ratio	0.45	0.50	0.45	0.45
ALGSI	Algal Si: Biomass ratio	0.18	0	0	0.18
ACHLA	Algal Biomass: Chlorophyll ratio	0.05	0.05	0.05	0.05
ALPOM	Fraction of biomass mortality converted to particulate organic matters	0.8	0.8	0.8	0.8
ANEQN	Ammonium preference factor**	2	2	2	2
ANPR	Half-saturation preference for Ammonia-Nitrate	0.001	0.001	0.001	0.001

ORGANIC MATTER PROCESSING

Model Symbol	Description	Value	Default Value
LDOMDK	Labile dissolved organic matter decay rate (d^{-1})	0.1	0.1
RDOMDK	Refractory dissolved organic matter decay rate(d^{-1})	0.001	0.001
LRDDK	Labile to refractory DOM decay rate (d^{-1})	0.005	0.01
LPOMDK	Labile particulate organic matter decay rate (d^{-1})	0.08	0.08
RPOMDK	Refractory particulate organic matter decay rate (d^{-1})	0.01	0.001
LRPDK	Labile to refractory POM decay rate (d^{-1})	0.001	0.01
POMS	Particulate organic matter settling rate ($m\ d^{-1}$)	1	0.1
ORGP	P:OrgMatt ratio for labile organic matter	0.005	0.005
ORGN	N:OrgMatt ratio for labile organic matter	0.08	0.08
ORGC	C:OrgMatt ratio for dissolved and particulate organic matter	0.45	0.45
ORGSI	Si:OrgMatt ratio for dissolved and particulate organic matter	0.18	0.18
OMT1	Lower temperature for organic matter decay (^{o}C)	4	4
OMT2	Upper temperature for organic matter decay (^{o}C)	30	25
OMK1	Fraction of organic matter decay rate at OMT1	0.1	0.1
OMK2	Fraction of organic matter decay rate at OMT2	0.99	0.99

NUTRIENT CYCLING

Model Symbol	Description	Value	Default Value
PO4R	Phosphorus release from anaerobic sediments (fraction of SOD)	0.001	0.001
NH4R	Ammonium release from anaerobic sediments (fraction of SOD)	0.001	0.001
NH4DK	Ammonium decay rate (d^{-1})	0.12	0.12
NH4T1	Lower temperature for ammonia decay (^oC)	5.0	5.0
NH4T2	Lower temperature for maximum ammonia decay (^oC)	20.0	25.0
NH4K1	Fraction of nitrification rate at NH4T1	0.1	0.1
NH4K2	Fraction of nitrification rate at NH4T2	0.99	0.99
NO3DK	Nitrate decay rate	0.03	0.03
NO3S	Nitrate loss to sediments due to sediment denitrification ($m\ d^{-1}$)	0.001	1.0
NO3T1	Lower temperature for nitrate decay (^oC)	5.0	5.0
NO3T2	Lower temperature for maximum nitrate decay (^oC)	25.0	25.0
NO3K1	Fraction of denitrification rate at NO3T1	0.1	0.1
NO3K2	Fraction of denitrification rate at NO3T2	0.99	0.99
DSIR	Dissolved silica sediment release rate, fraction of SOD	0.1	0.1
PSIS	Particulate Si settling rate ($m\ d^{-1}$)	1.0	1.0
PSIDK	Particulate Si decay rate	0.3	0.3
PARTSI	Dissolved Si partitioning coefficient	0.0	0.0
FER	Fe release from anaerobic sediments (fraction of SOD)	NA	0.5
FES	Fe settling velocity ($m\ d^{-1}$)	NA	2.0

CARBON DIOXIDE AND OXYGEN

Model Symbol	Description	Value	Default Value
CO2R	CO2 release from sediments (fraction of SOD)	1.2	0.1
O2NH4	Oxygen stoichiometry for nitrification	4.57	4.57
O2OM	Oxygen stoichiometry organic matter decay	1.4	1.4
O2AR	Oxygen stoichiometry for algal respiration	1.1	1.1
O2AG	Oxygen stoichiometry for algal primary production	1.6	1.4
O2LIM	O2 concentration below which anaerobic processes begin	0.1	0.1

SEDIMENT DYNAMICS

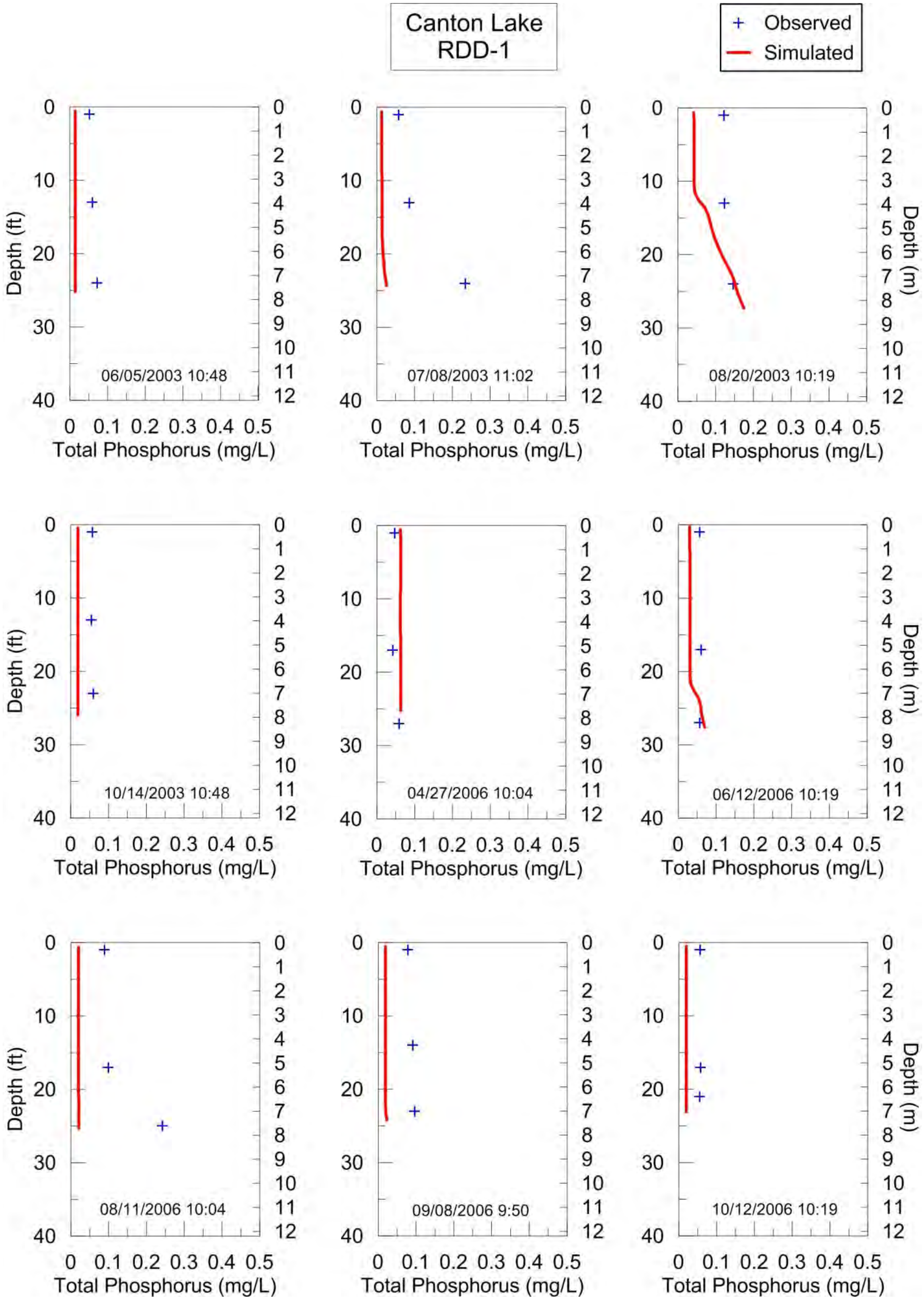
Model Symbol	Description	Value	Default Value
SEDC	Implements 1st-order sediment organic matter decay	OFF	
SEDCI	Initial sediment organic matter concentration ($g\ m^{-2}$)	0.0	0.0
SEDS	Sediment settling or focusing velocity ($m\ d^{-1}$)	0.1	0.1
SEDK	Sediment organic matter decay rate (d^{-1})	0.05	0.1
FSOD	Fraction of the zero-order SOD rate used	1.0	1.0
FSED	Fraction of the first-order sediment rate used	1.0	1.0
SODT1	Lower temperature for sediment organic matter decay (^oC)	4.0	4.0
SODT2	Upper temperature for sediment organic matter decay (^oC)	25.0	25.0
SODK1	Fraction of sediment organic matter decay rate at SODT1	0.1	0.1
SODK2	Fraction of sediment organic matter decay rate at SODT2	0.99	0.99
SEDBR	Sediment burial rate (d-1)	0.01	0.01
DYNSEDK	Dynamic sediment K	OFF	OFF

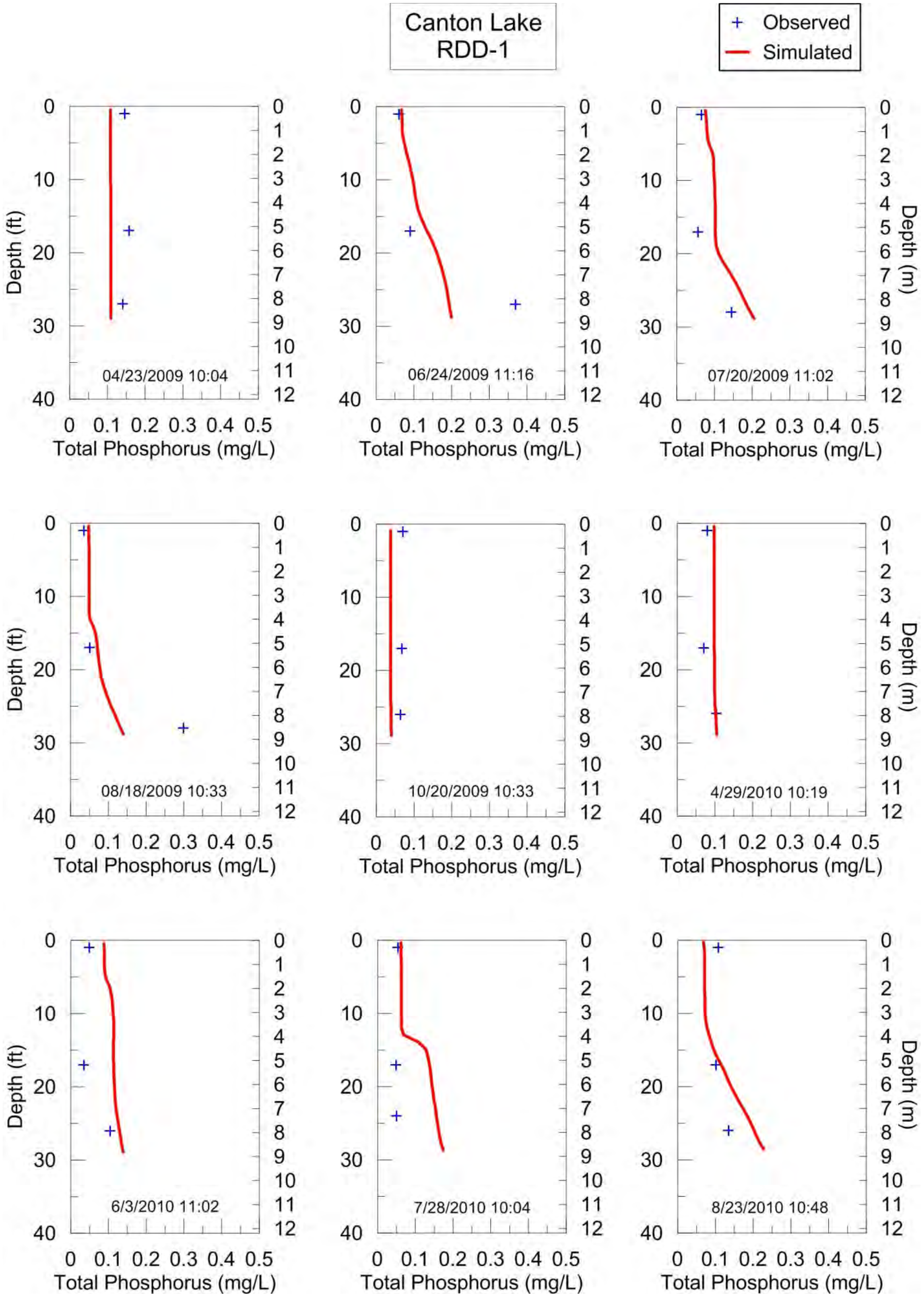
REAERATION

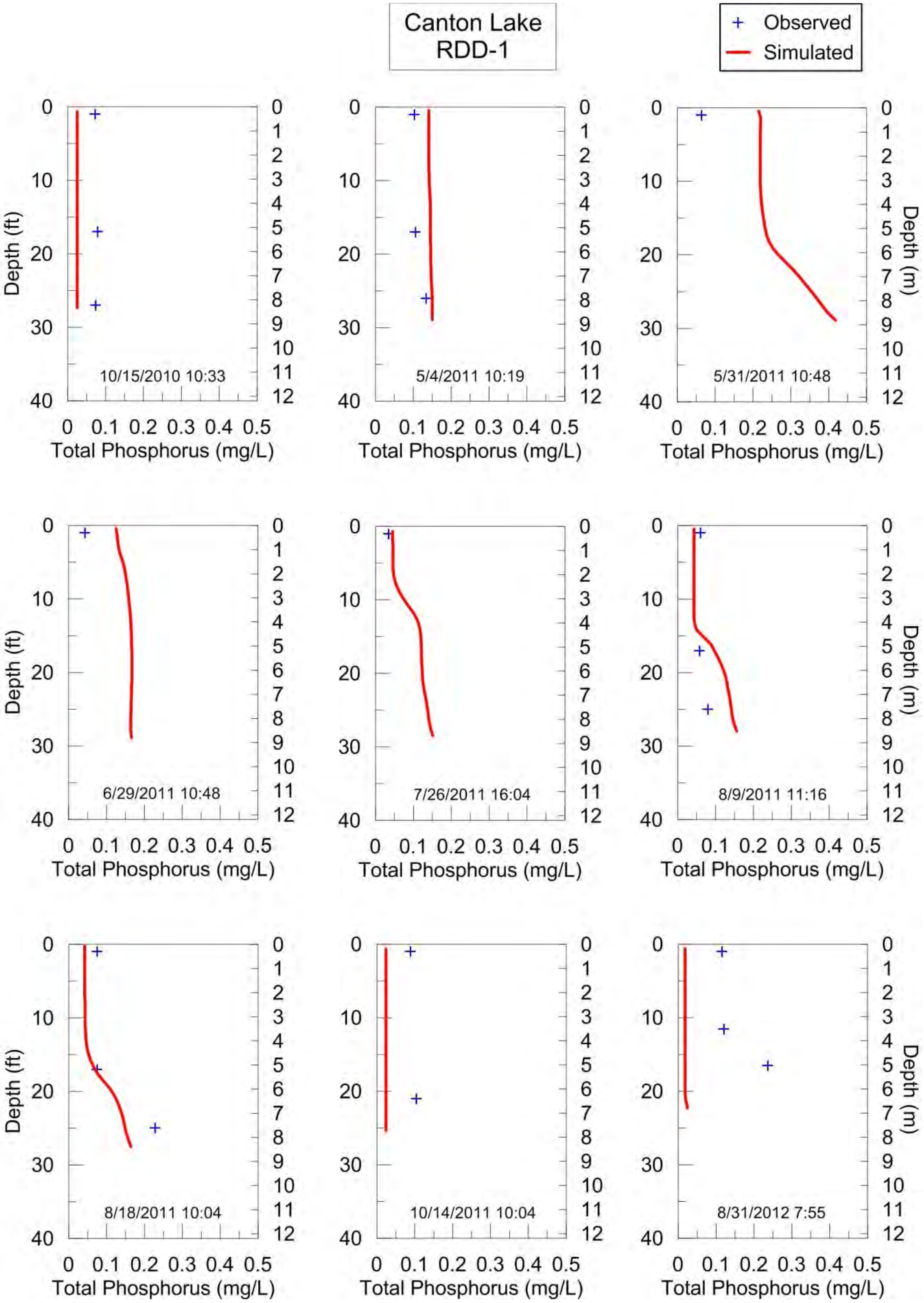
Model Symbol	Description	Value	Default Value
TYPE	RIVER, LAKE, OR ESTUARY	LAKE	NA
EQN#	$Ka = 7.62U/H^{1.33}$ (Langbien and Durum 1967)	6	NA

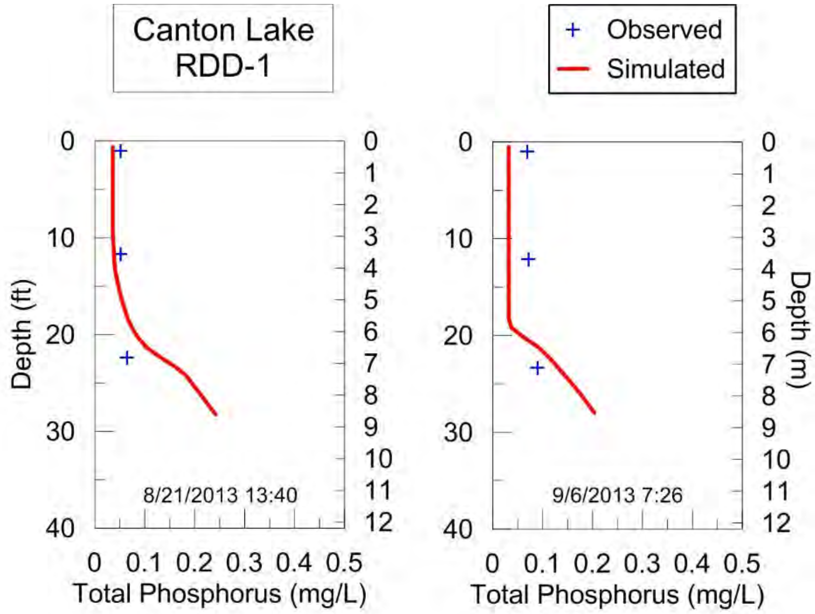
Appendix D: CE-QUAL-W2 Model Results

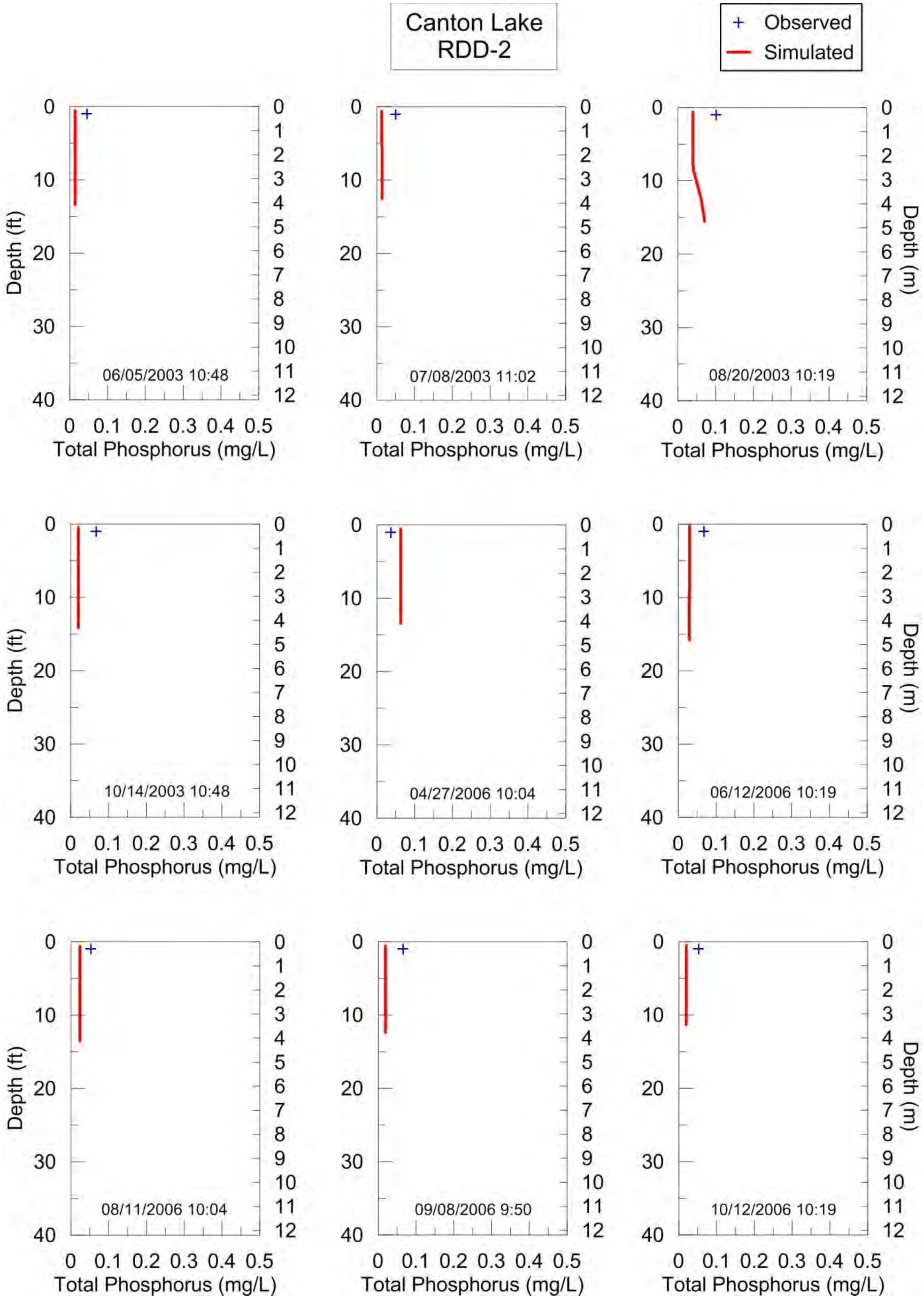
Total Phosphorus

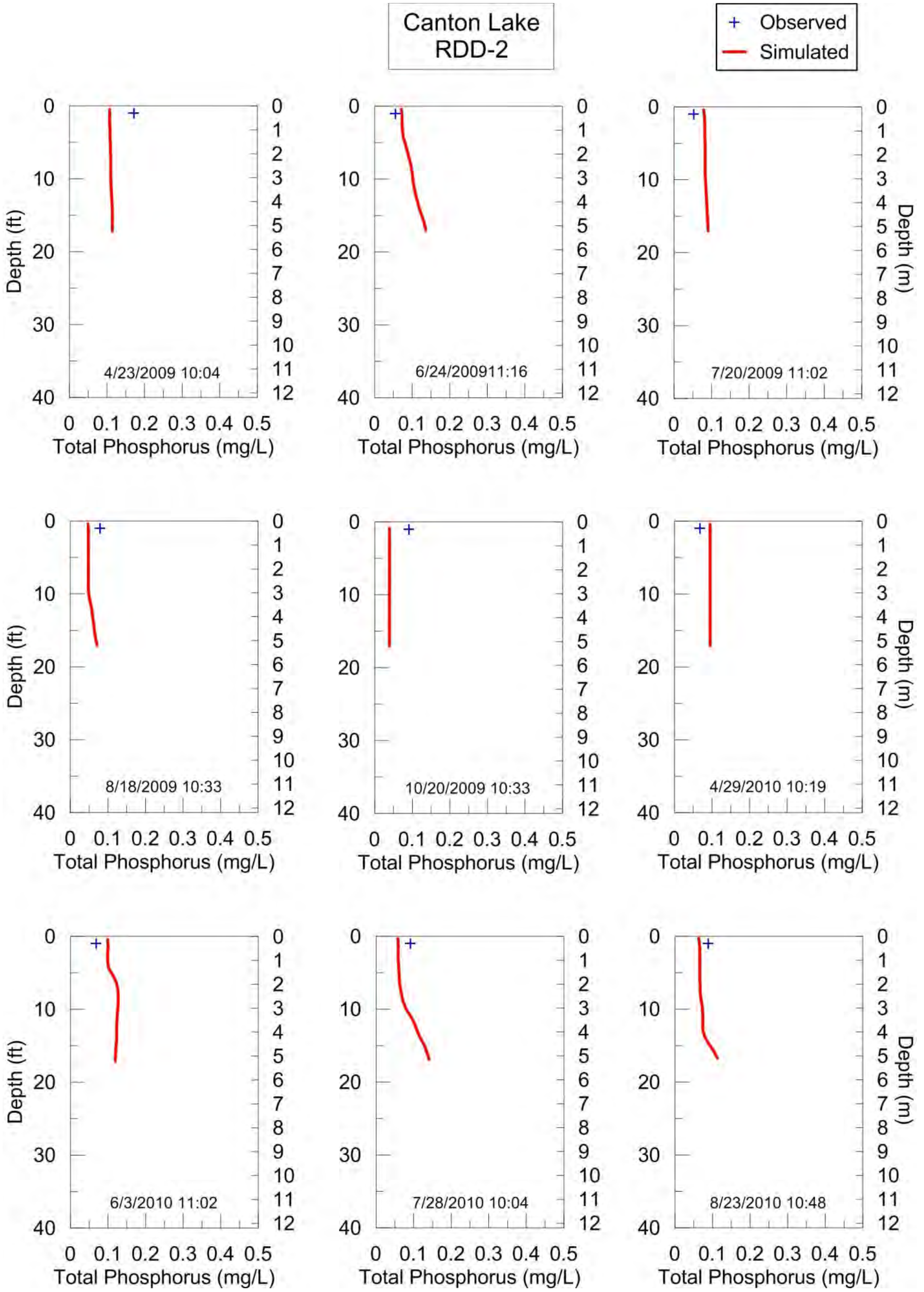

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
0.4
0.5
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
10/12/2006 10:19

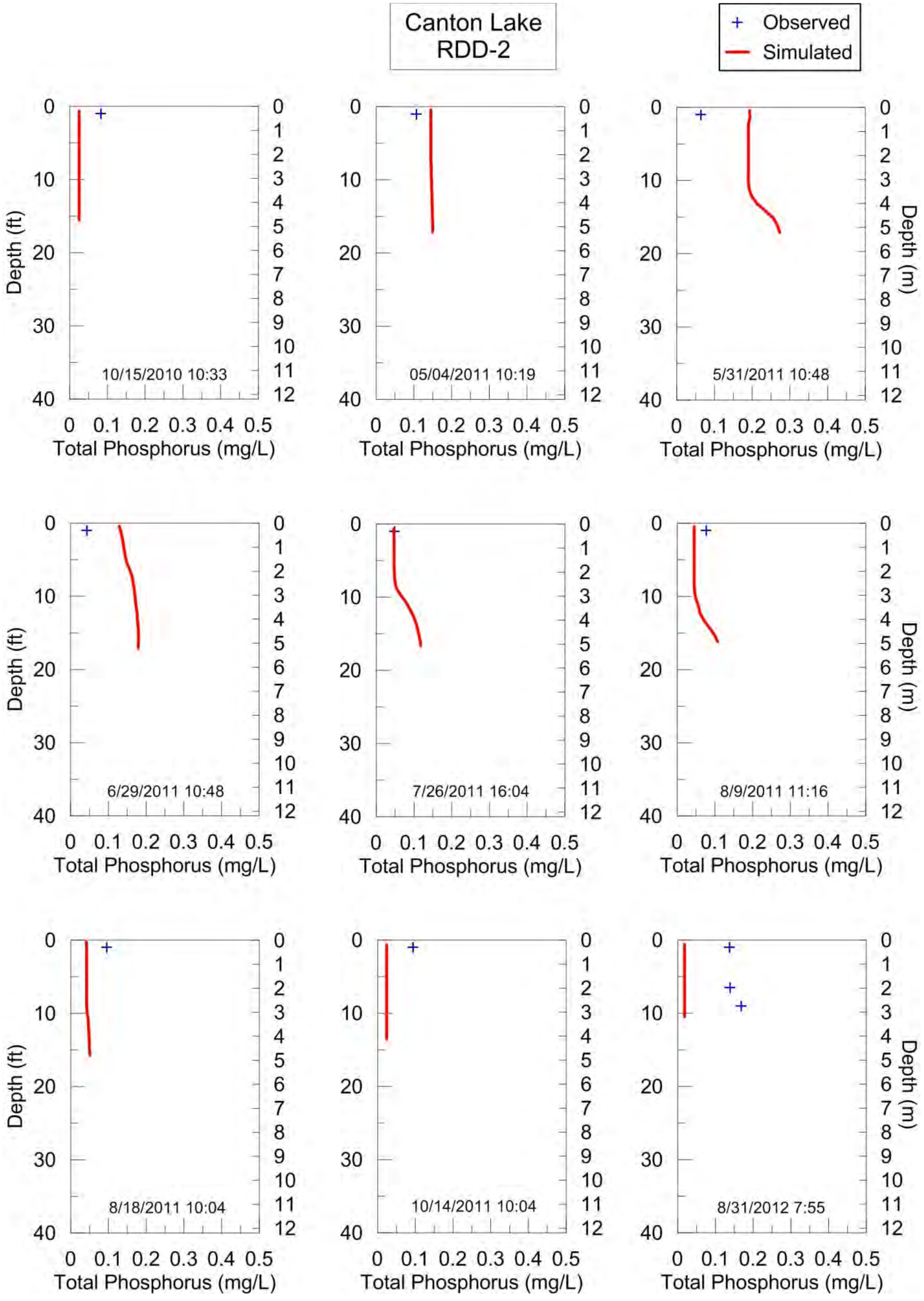

Canton Lake
RDD-1
Observed
Simulated
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
10/20/2009 10:33
4/29/2010 10:19
6/3/2010 11:02
7/28/2010 10:04
8/23/2010 10:48
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Total Phosphorus (mg/L)
0
0.1
0.2
0.3
0.4
0.5

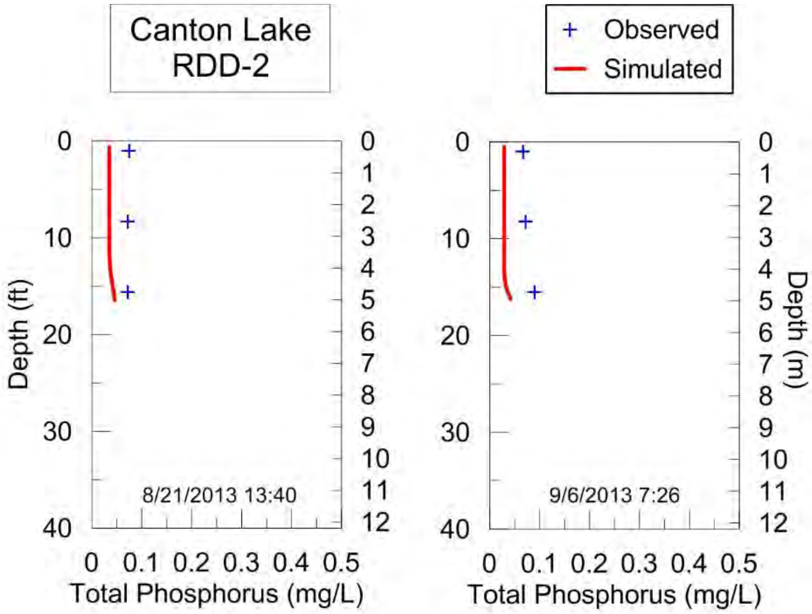

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
10/15/2010 10:33
5/4/2011 10:19
5/31/2011 10:48
6/29/2011 10:48
7/26/2011 16:04
8/9/2011 11:16
8/18/2011 10:04
10/14/2011 10:04
8/31/2012 7:55
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 0.1 0.2 0.3 0.4 0.5

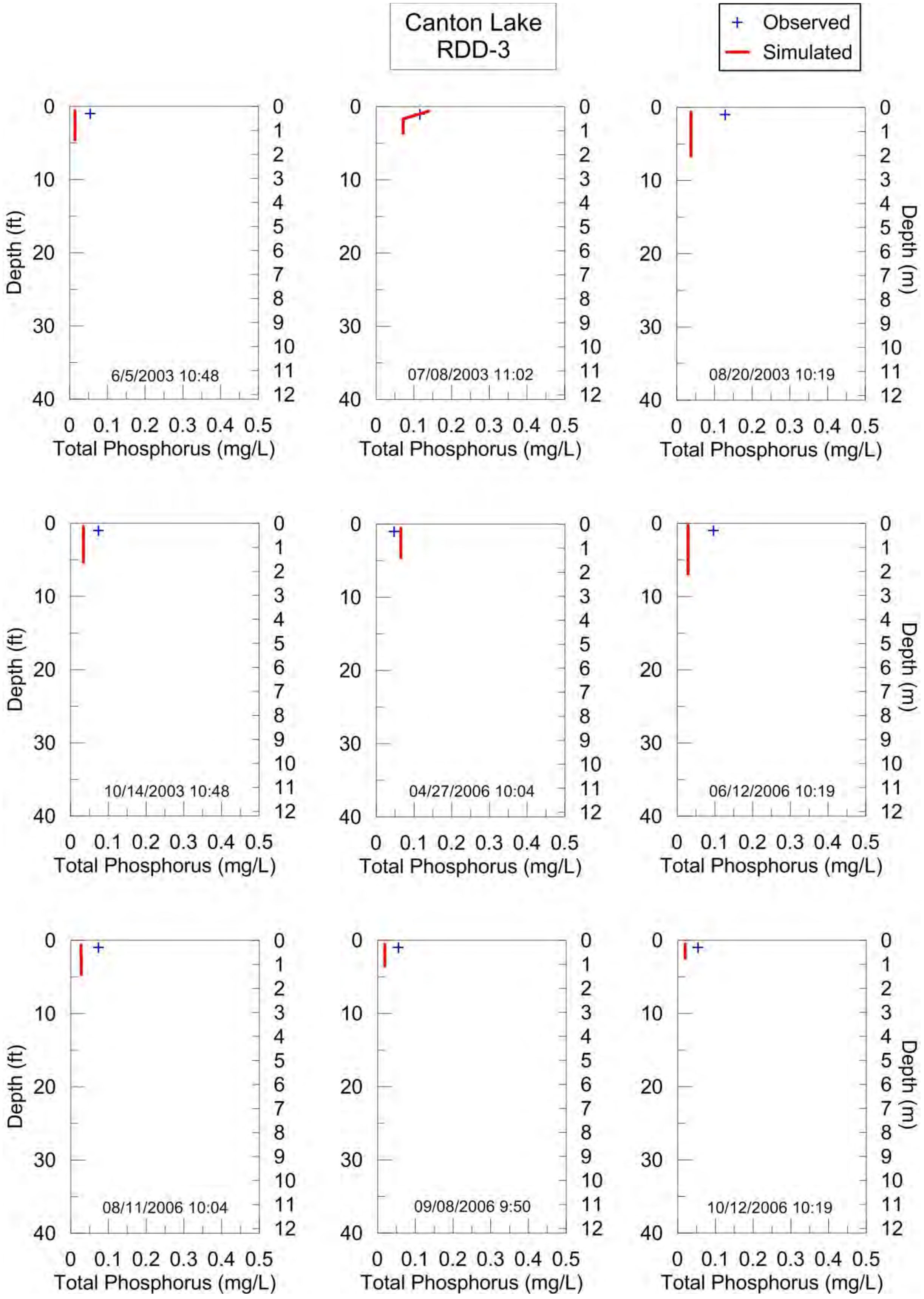

Canton Lake
RDD-1
+ Observed
Simulated
Depth (ft)
Depth (m)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
8/21/2013 13:40
9/6/2013 7:26
0
0.1
0.2
0.3
0.4
0.5
Total Phosphorus (mg/L)

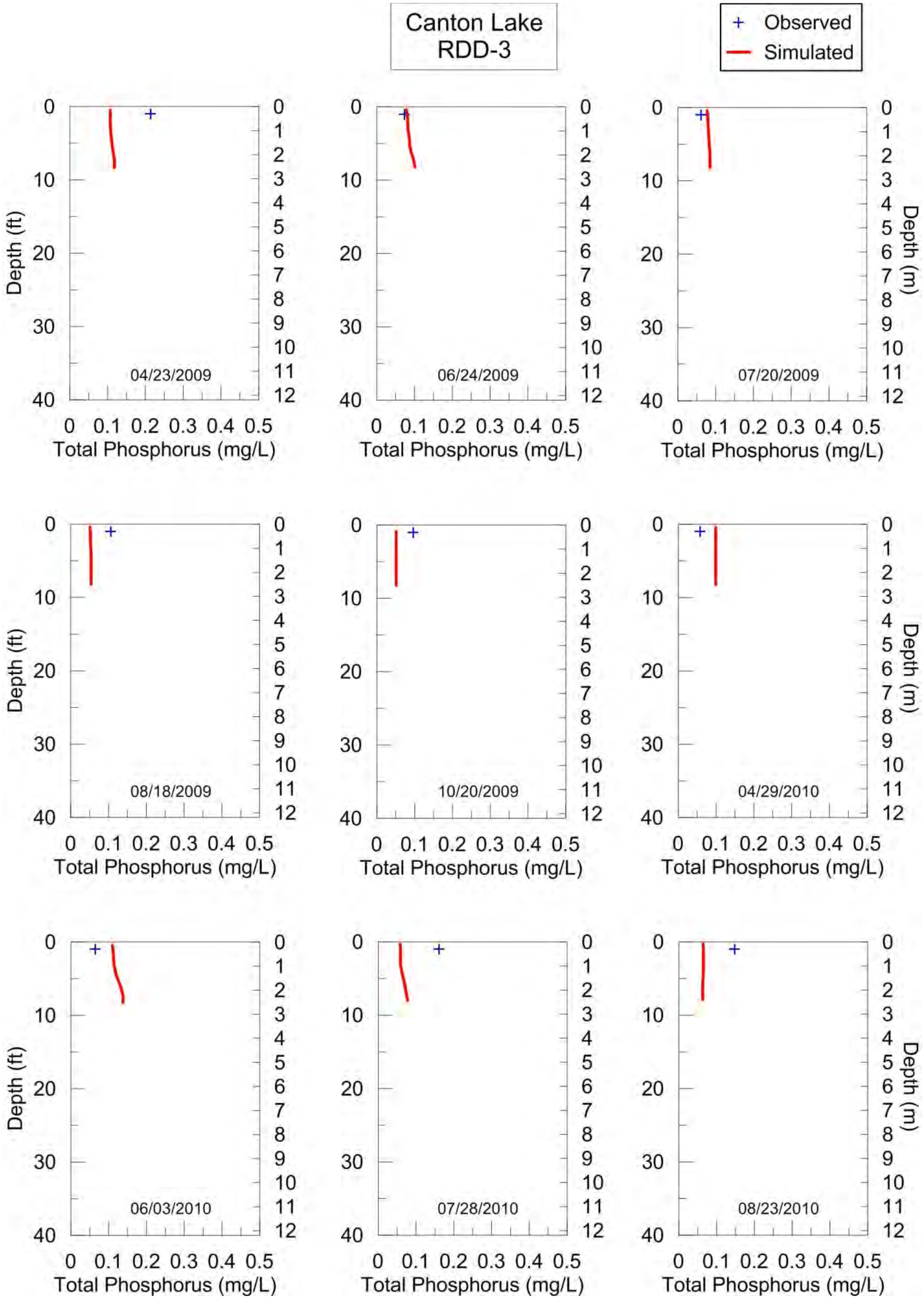

Canton Lake
RDD-2
Observed
Simulated
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
10/12/2006 10:19
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0
10
20
30
40
0 1 2 3 4 5 6 7 8 9 10 11 12
0 0.1 0.2 0.3 0.4 0.5

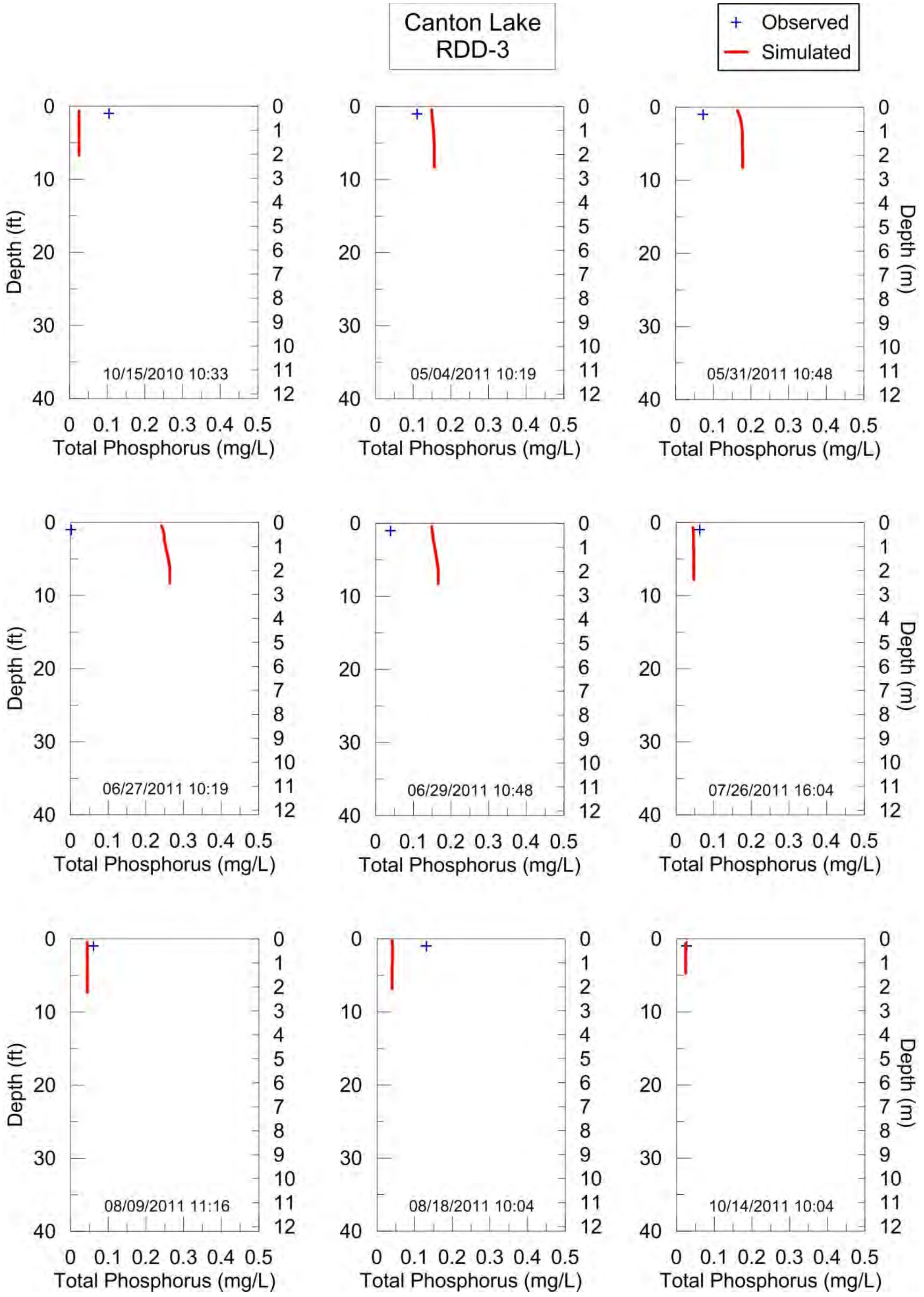

Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
0 0.1 0.2 0.3 0.4 0.5
4/23/2009 10:04
6/24/200911:16
7/20/2009 11:02
8/18/2009 10:33
10/20/2009 10:33
4/29/2010 10:19
6/3/2010 11:02
7/28/2010 10:04
8/23/2010 10:48

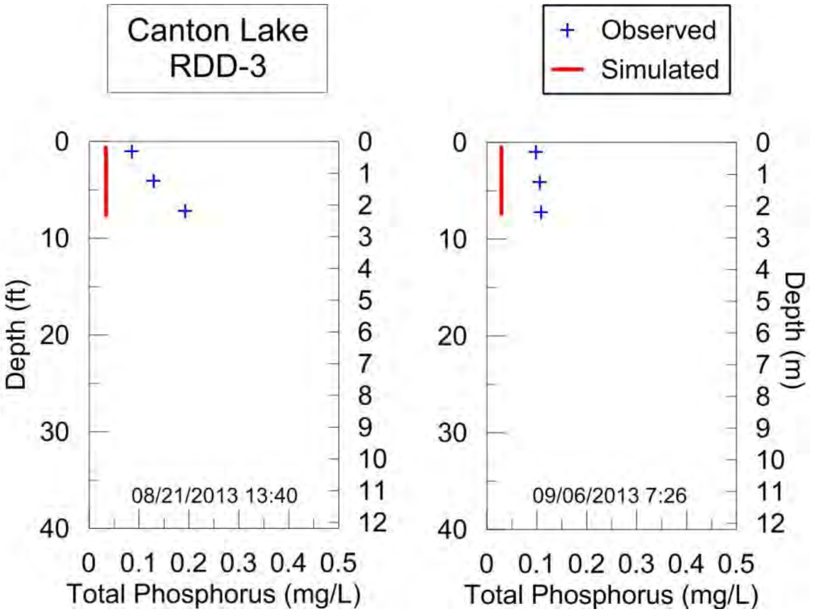

Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
0.4
0.5
10/15/2010 10:33
05/04/2011 10:19
5/31/2011 10:48
6/29/2011 10:48
7/26/2011 16:04
8/9/2011 11:16
8/18/2011 10:04
10/14/2011 10:04
8/31/2012 7:55


Canton Lake
RDD-2
+ Observed
Simulated
Depth (ft)
Depth (m)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
8/21/2013 13:40
9/6/2013 7:26
0
0.1
0.2
0.3
0.4
0.5
Total Phosphorus (mg/L)

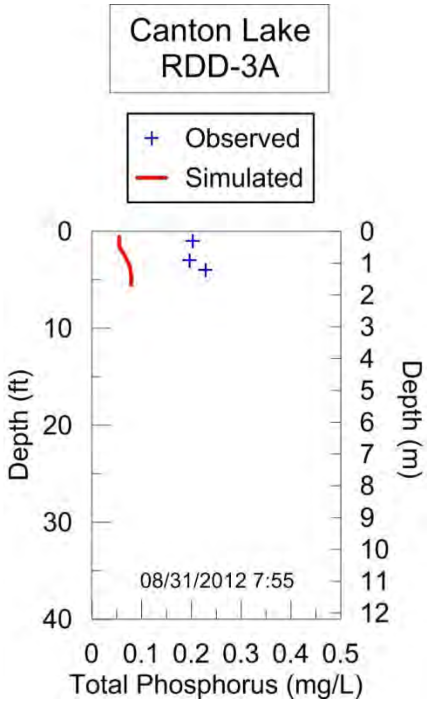

Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
0.4
0.5
6/5/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
10/12/2006 10:19

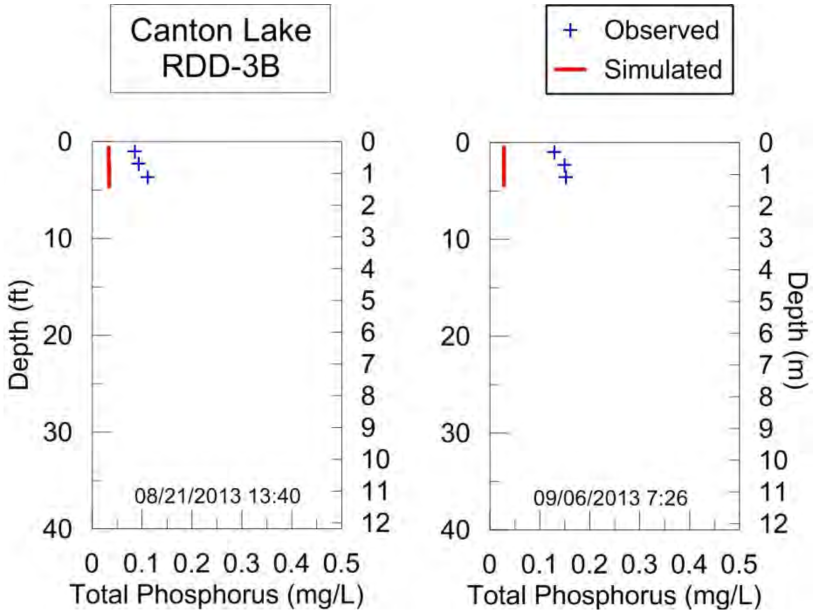

Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 0.1 0.2 0.3 0.4 0.5
04/23/2009
06/24/2009
07/20/2009
08/18/2009
10/20/2009
04/29/2010
06/03/2010
07/28/2010
08/23/2010


Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
Total Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 0.1 0.2 0.3 0.4 0.5
10/15/2010 10:33
05/04/2011 10:19
05/31/2011 10:48
06/27/2011 10:19
06/29/2011 10:48
07/26/2011 16:04
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04

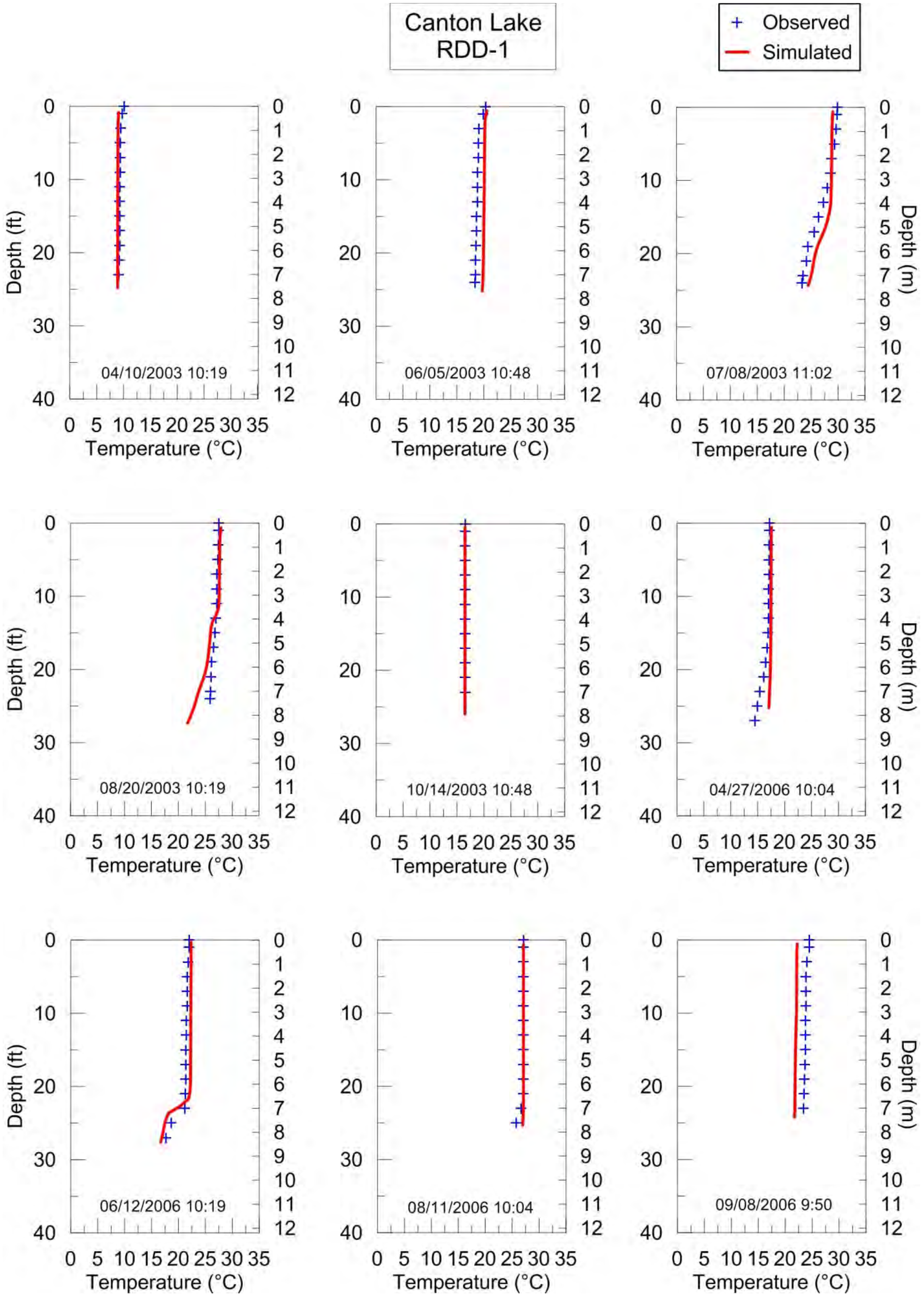


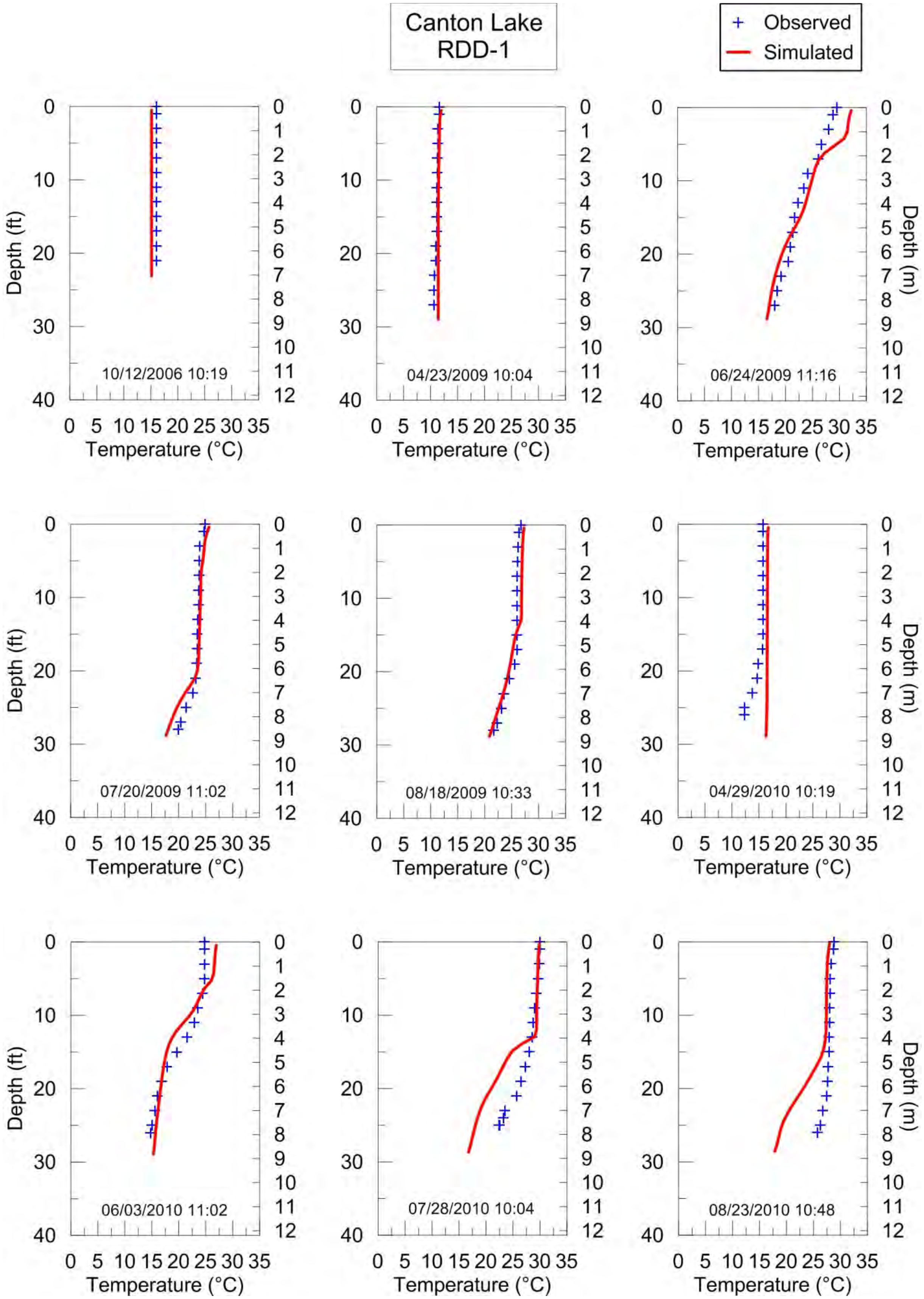
Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
08/21/2013 13:40
09/06/2013 7:26
0
0.1
0.2
0.3
0.4
0.5
Total Phosphorus (mg/L)

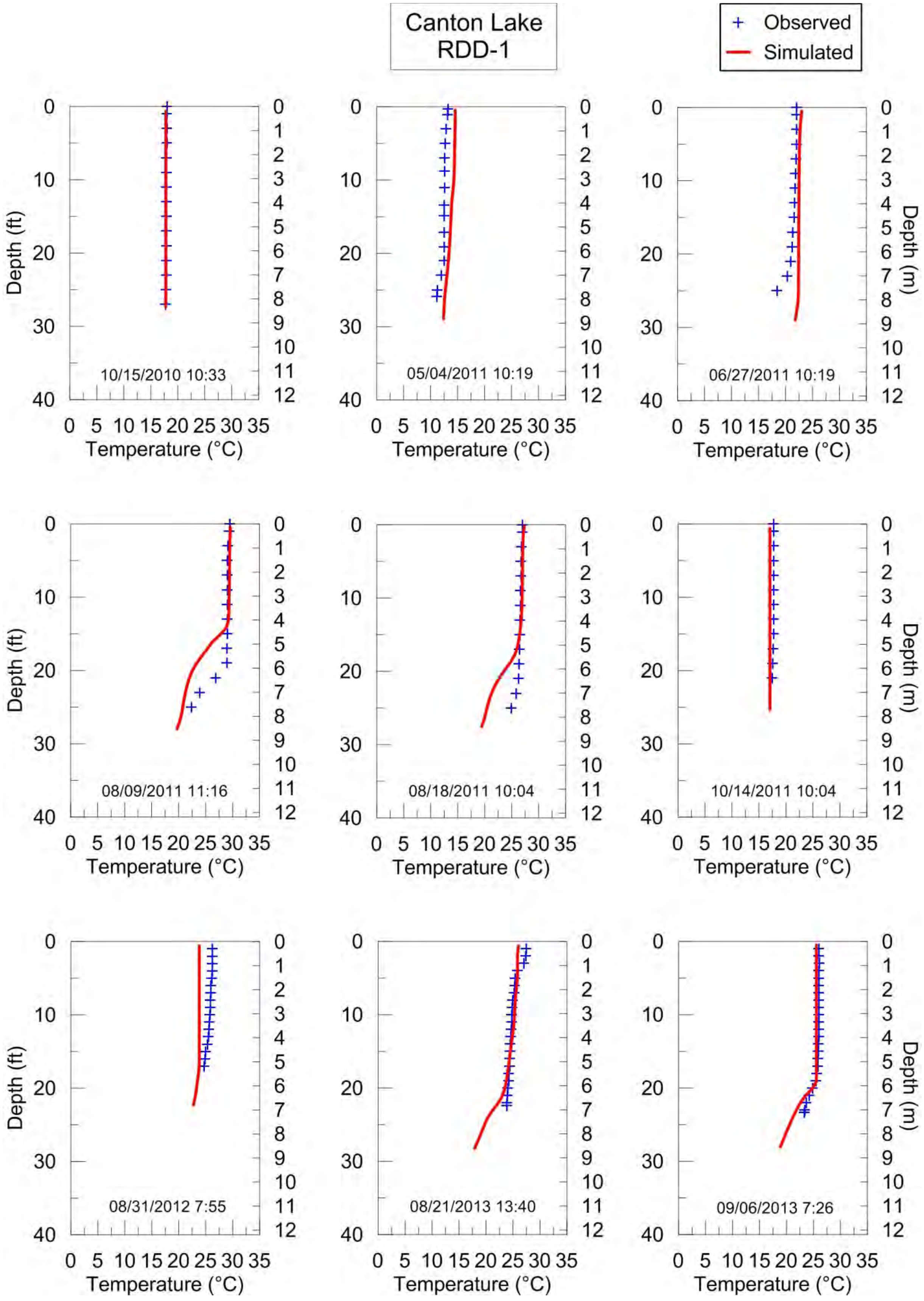

Canton Lake
RDD-3A
+ Observed
Simulated
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
08/31/2012 7:55
0
0.1
0.2
0.3
0.4
0.5
Total Phosphorus (mg/L)

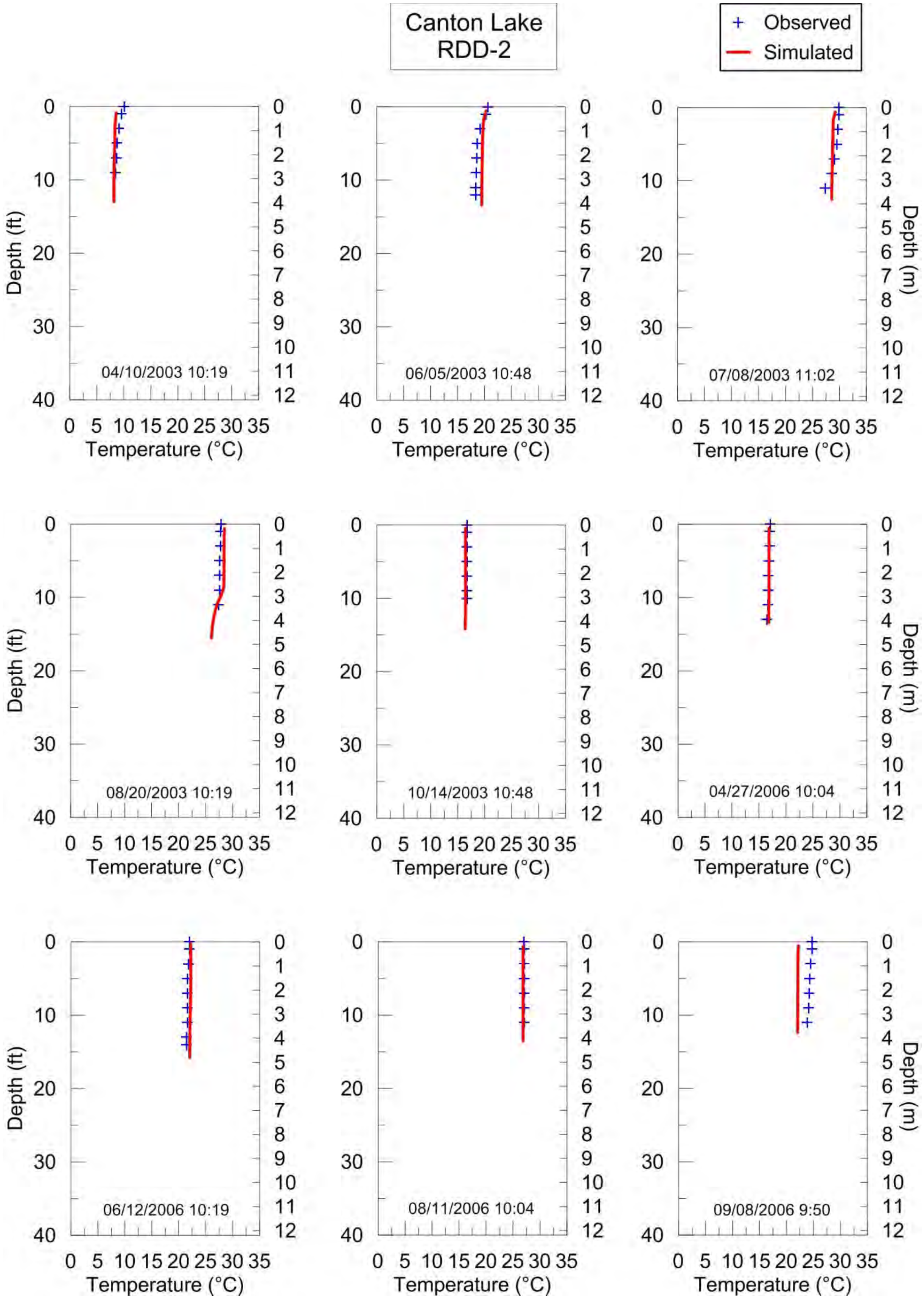

Canton Lake
RDD-3B
+ Observed
Simulated
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
08/21/2013 13:40
09/06/2013 7:26
0
0.1
0.2
0.3
0.4
0.5
Total Phosphorus (mg/L)
Total Phosphorus (mg/L)

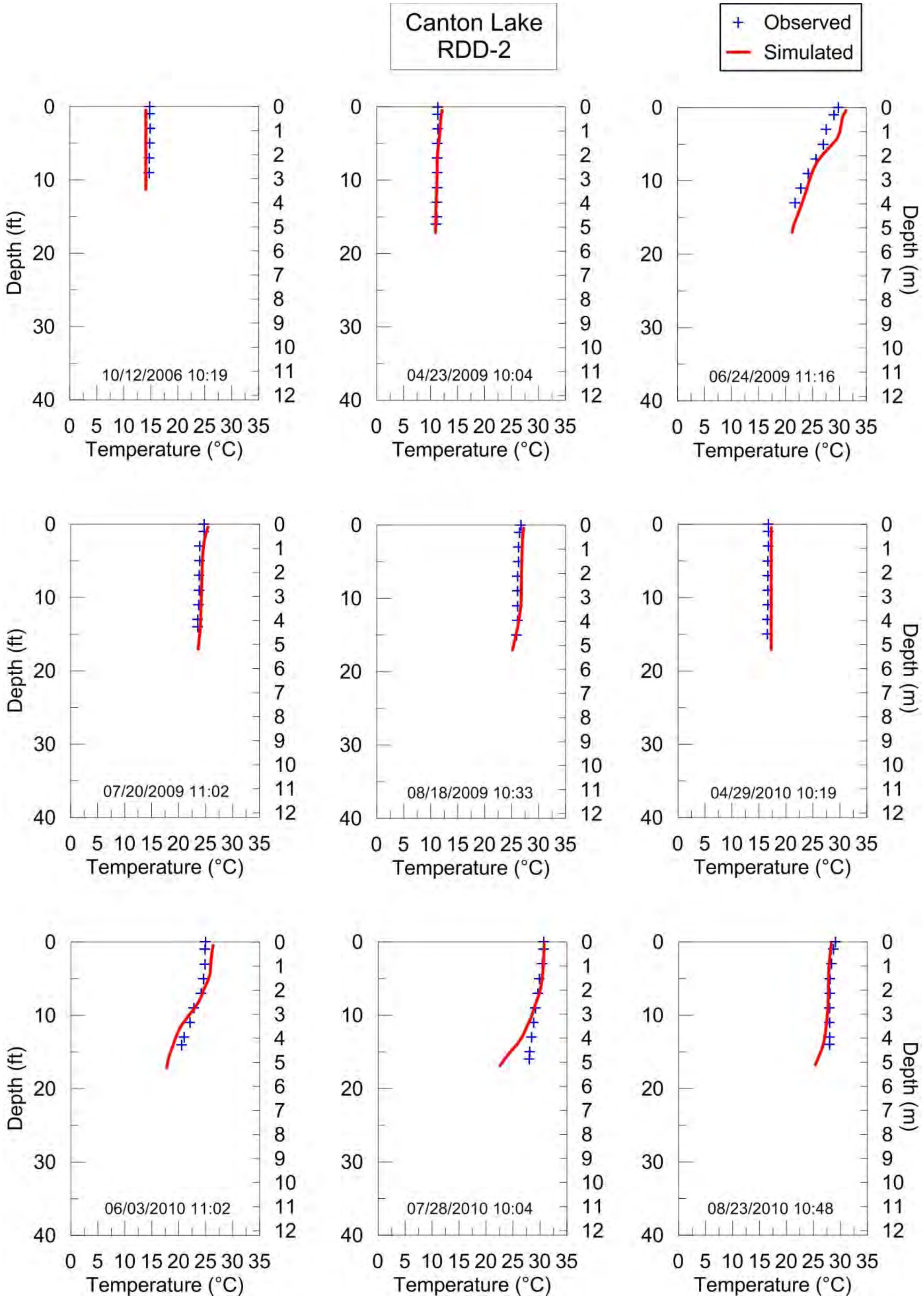
Temperature

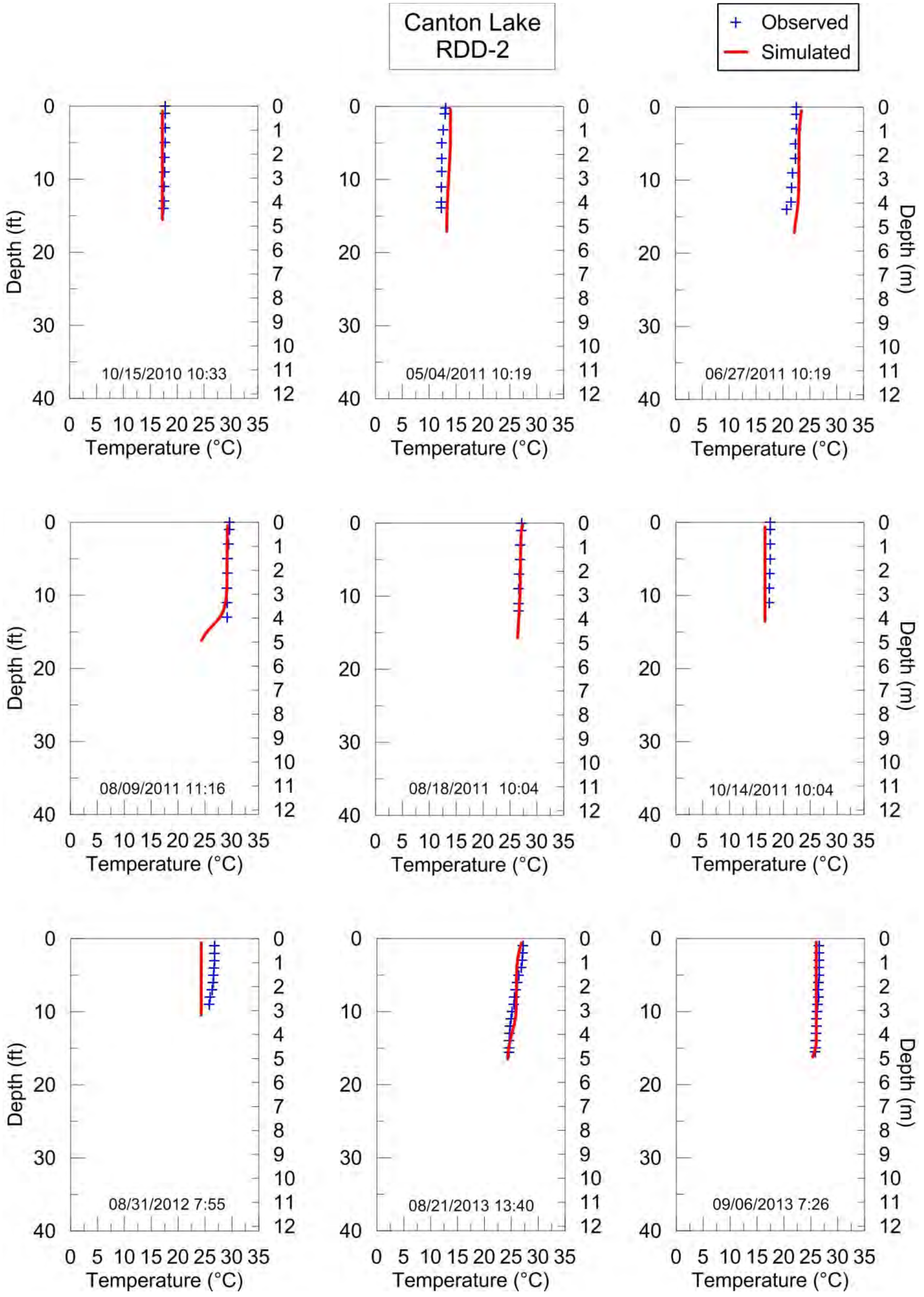

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0 5 10 15 20 25 30 35
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50

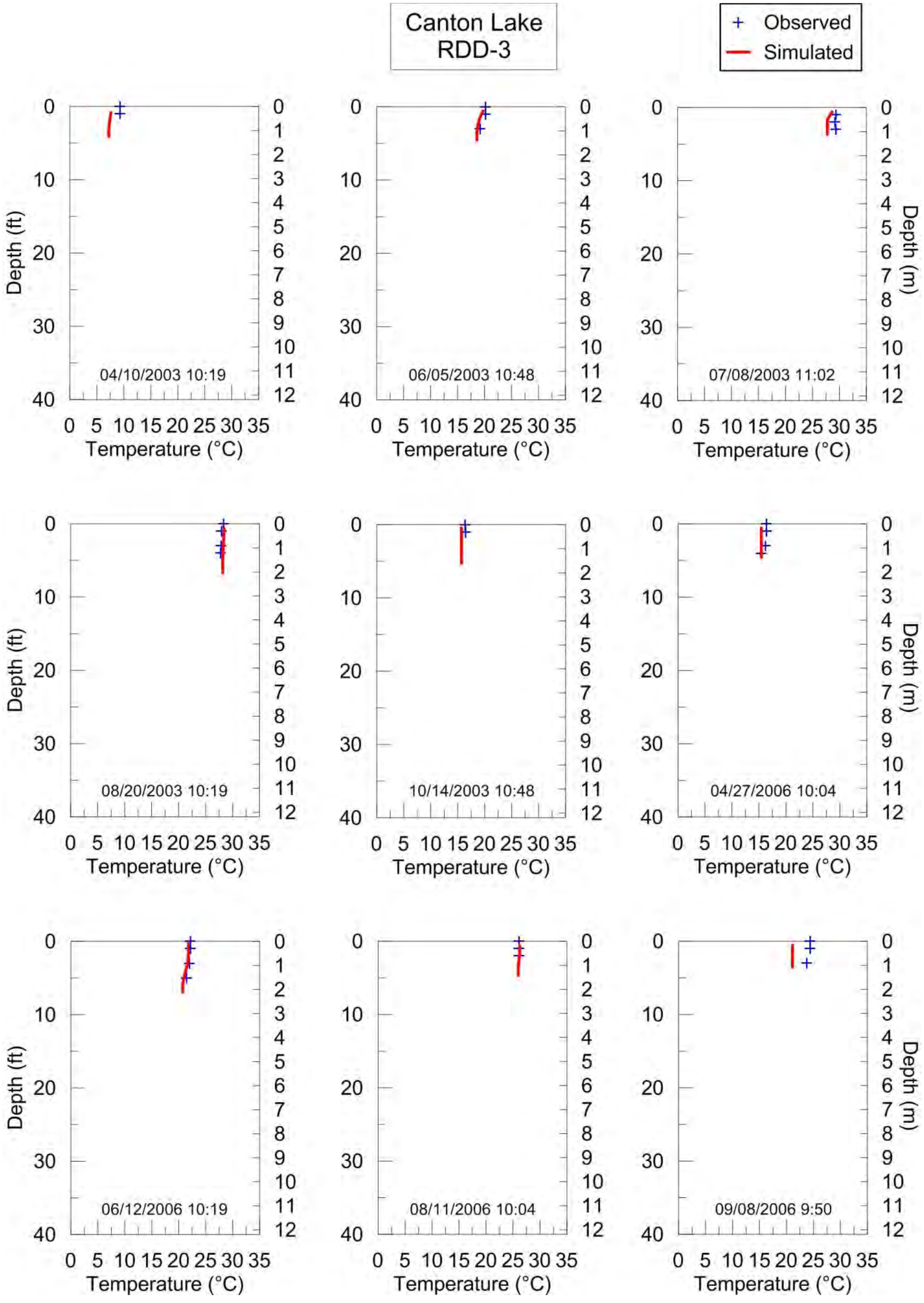

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0 5 10 15 20 25 30 35
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48

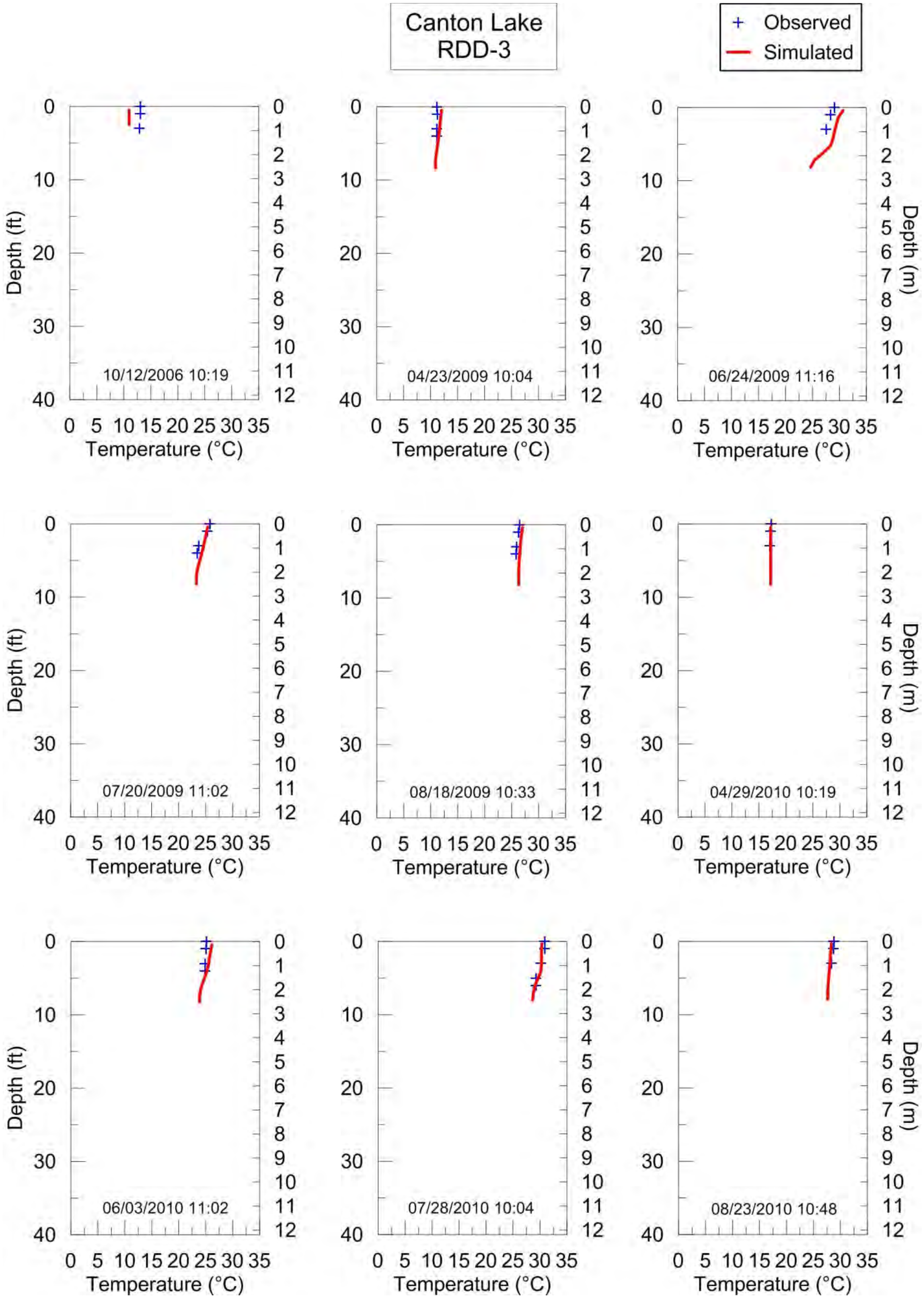

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0 5 10 15 20 25 30 35
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
10/15/2010 10:33
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04
08/31/2012 7:55
08/21/2013 13:40
09/06/2013 7:26

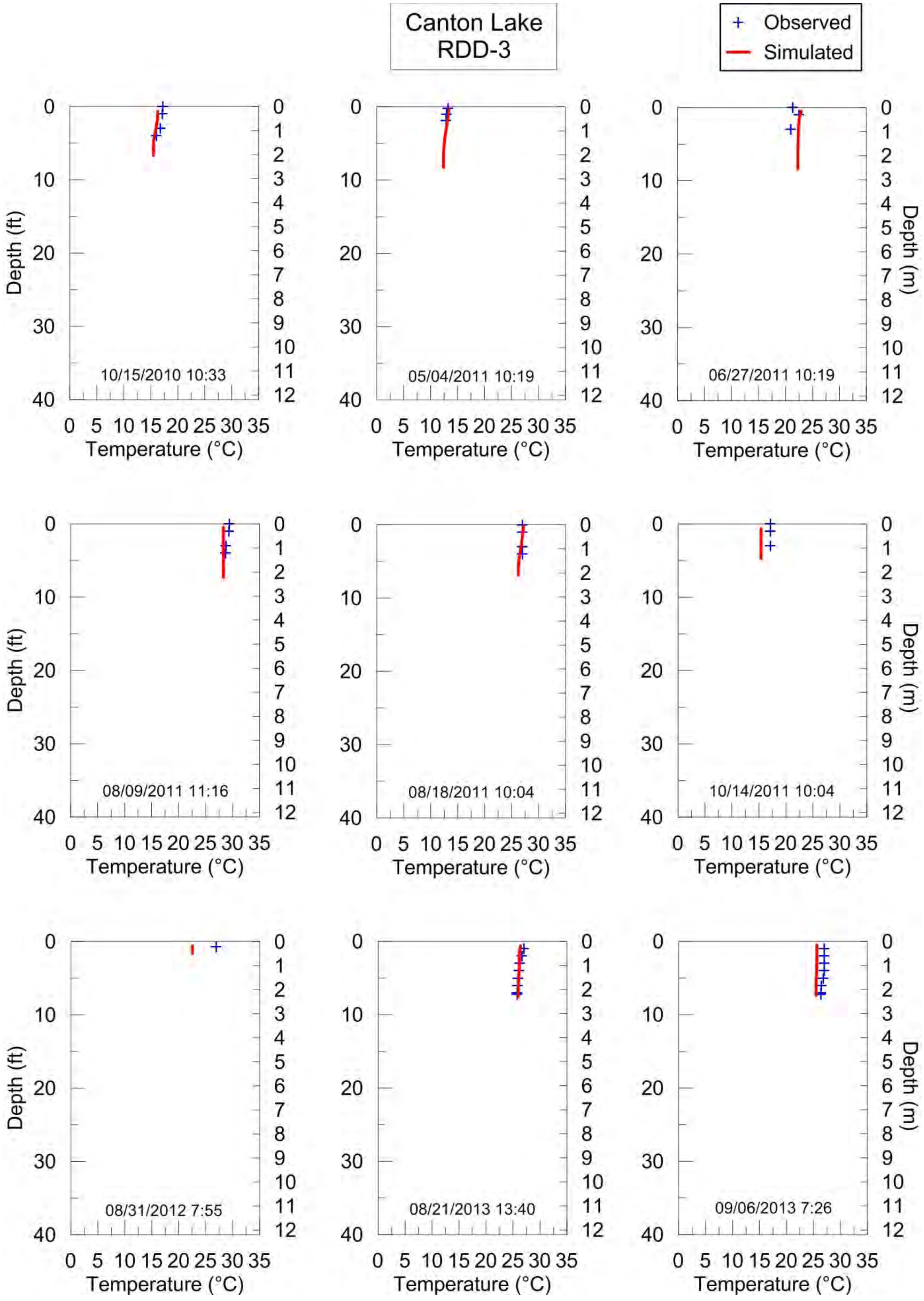

Canton Lake
RDD-2
+ Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0 5 10 15 20 25 30 35
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50

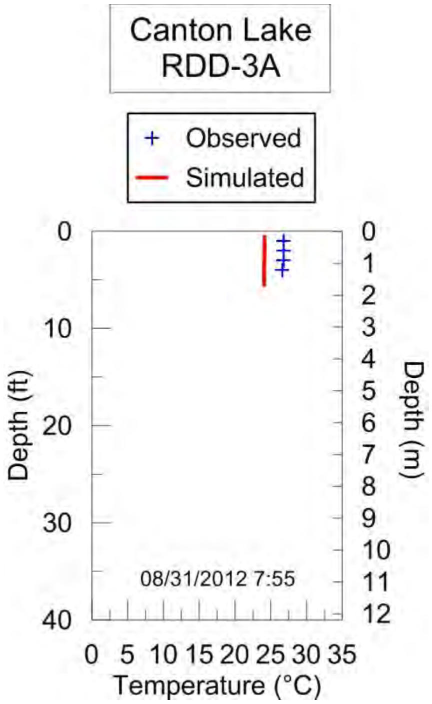

Canton Lake
RDD-2
+ Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 5 10 15 20 25 30 35
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48

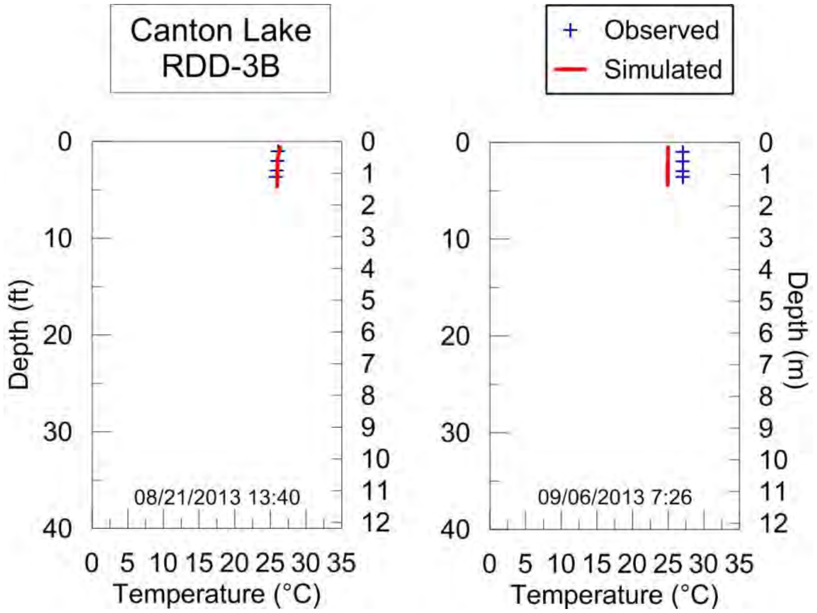

Canton Lake
RDD-2
+ Observed
Simulated
10/15/2010 10:33
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04
08/31/2012 7:55
08/21/2013 13:40
09/06/2013 7:26
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Temperature (°C)
0
5
10
15
20
25
30
35


Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Temperature (°C)
0 5 10 15 20 25 30 35
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50

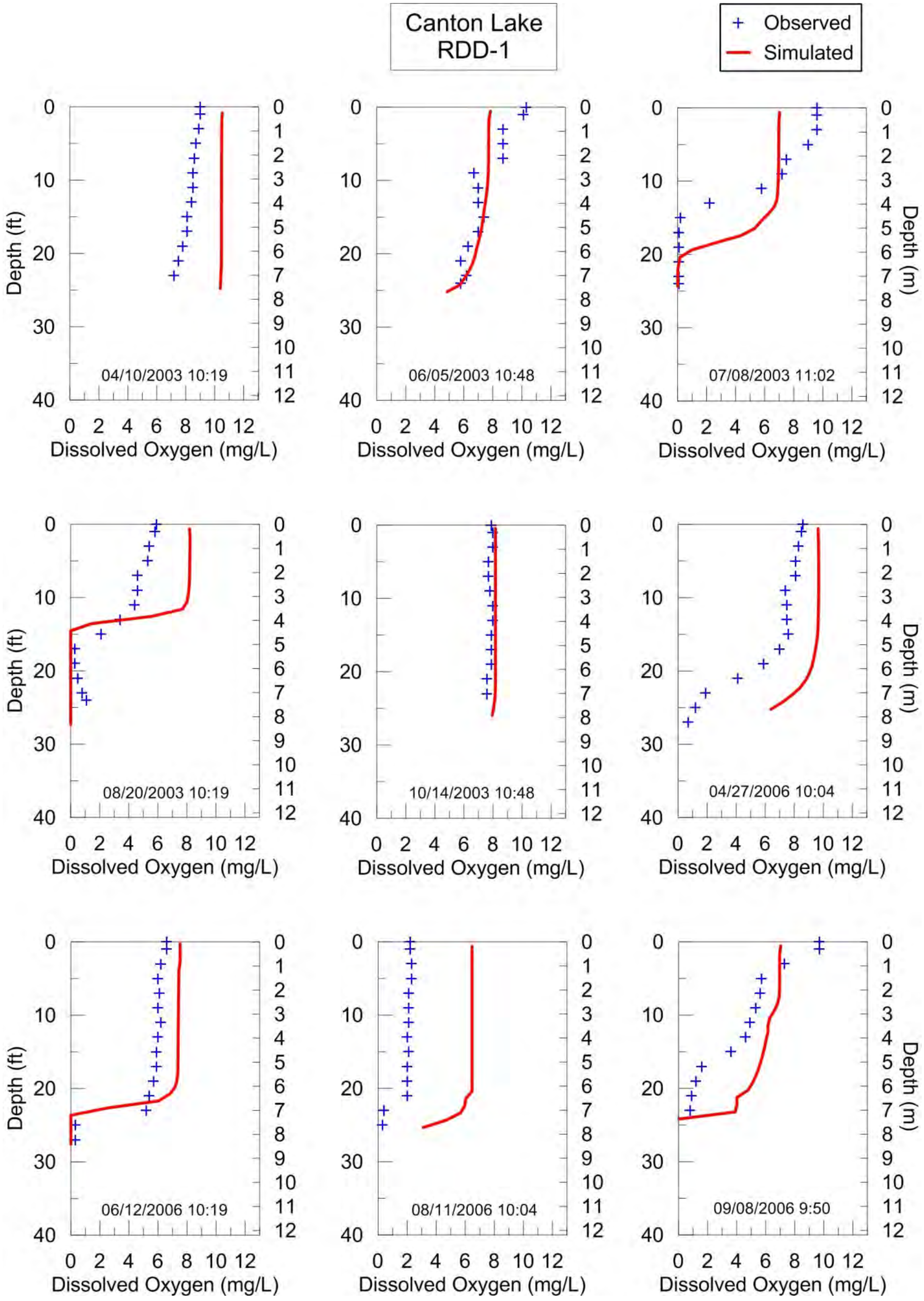

Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 5 10 15 20 25 30 35
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48

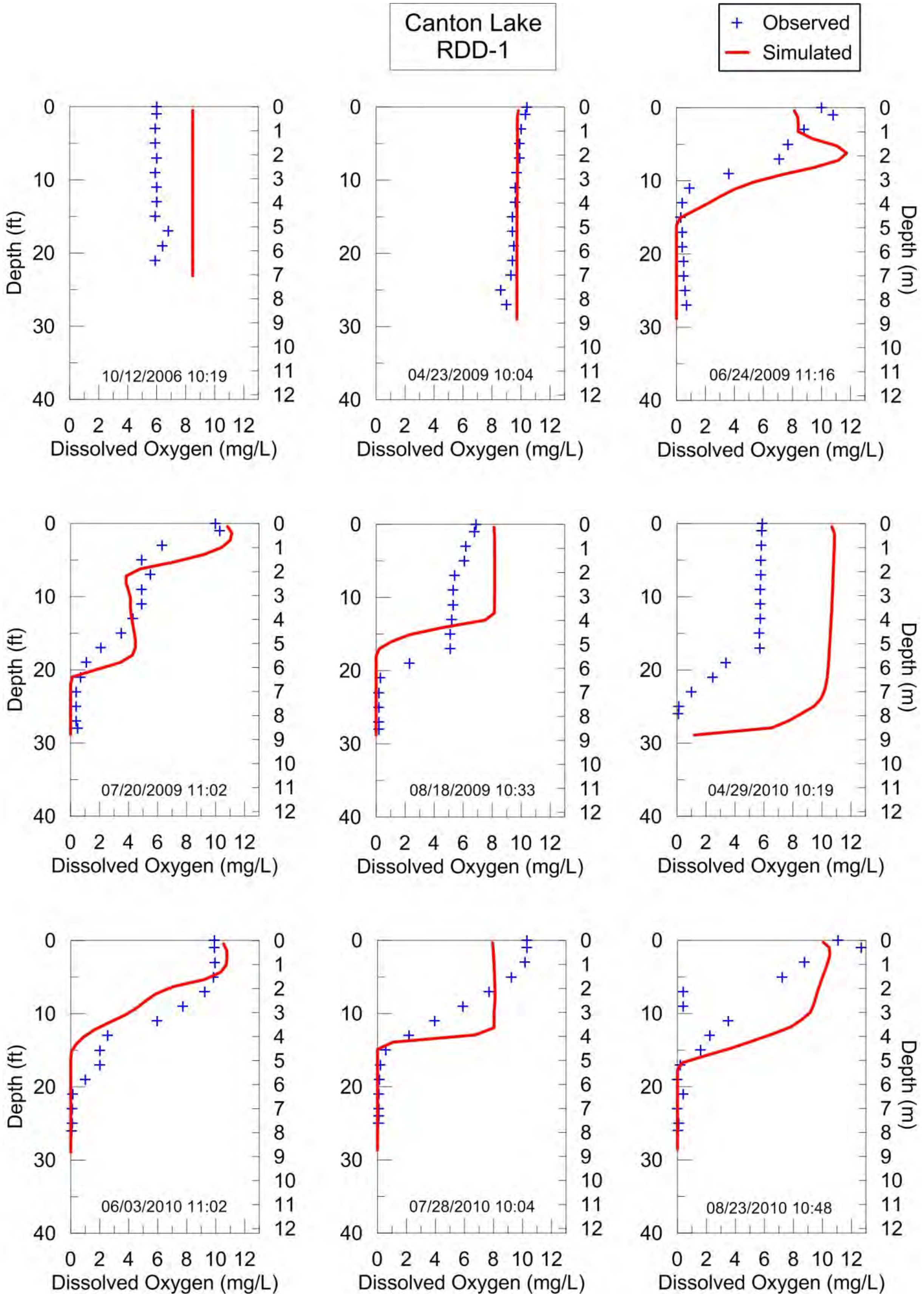

Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
Temperature (°C)
0 5 10 15 20 25 30 35
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
10/15/2010 10:33
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04
08/31/2012 7:55
08/21/2013 13:40
09/06/2013 7:26

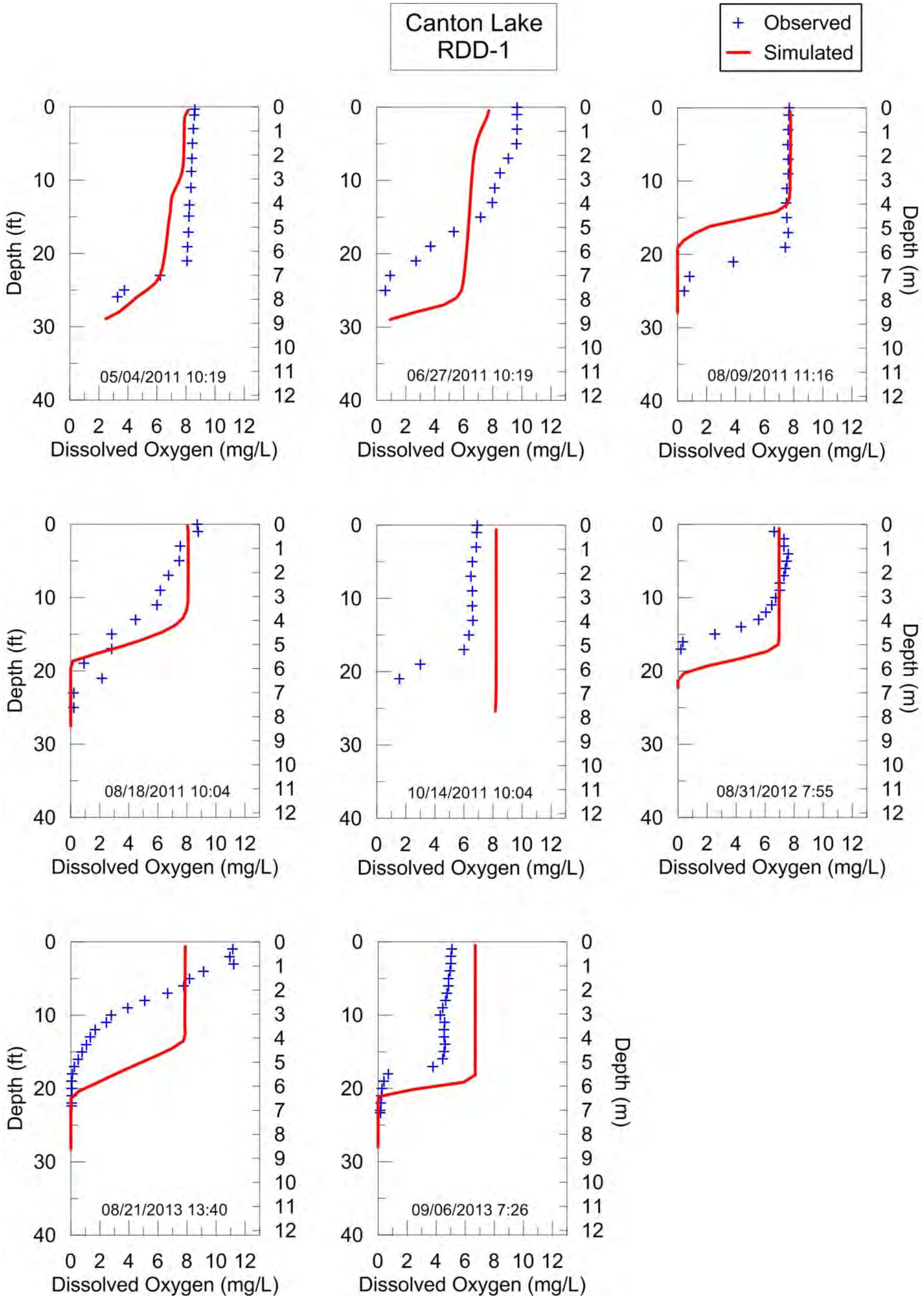

Canton Lake
RDD-3A
+ Observed
Simulated
0
10
20
30
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
Depth (m)
08/31/2012 7:55
0 5 10 15 20 25 30 35
Temperature (°C)

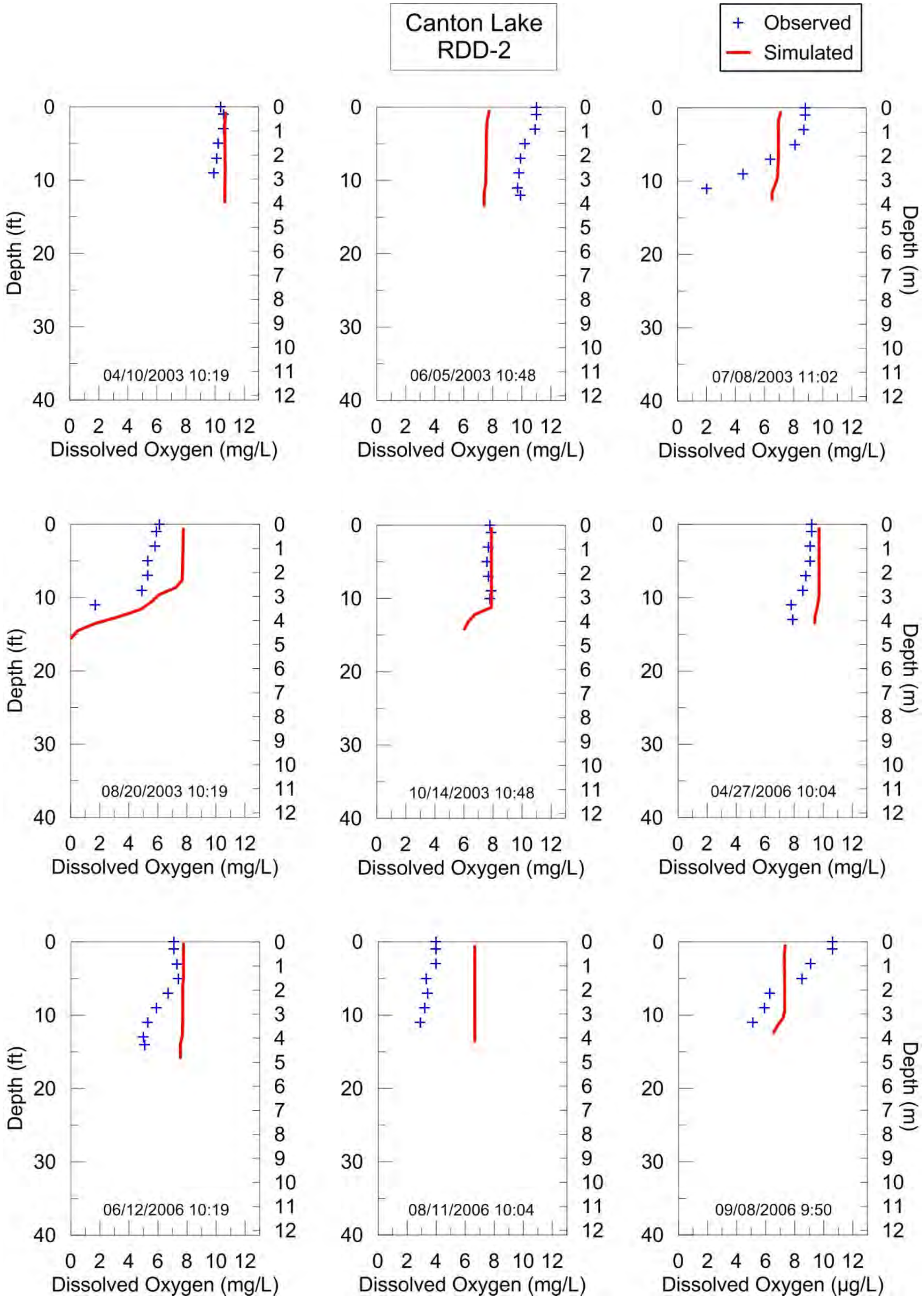

Canton Lake
RDD-3B
+ Observed
Simulated
0
10
20
30
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
Depth (m)
08/21/2013 13:40
09/06/2013 7:26
0 5 10 15 20 25 30 35
Temperature (°C)

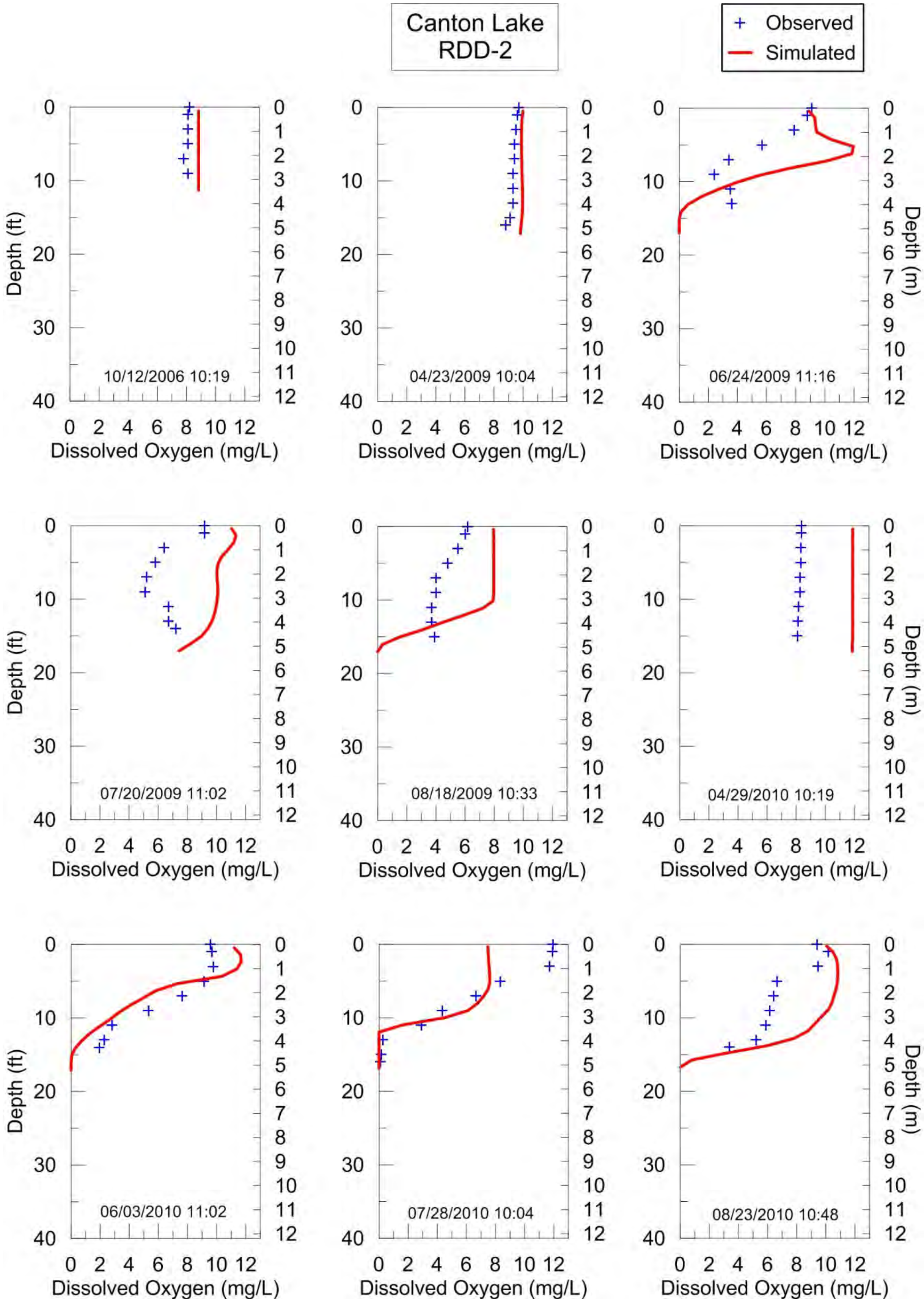
Dissolved Oxygen

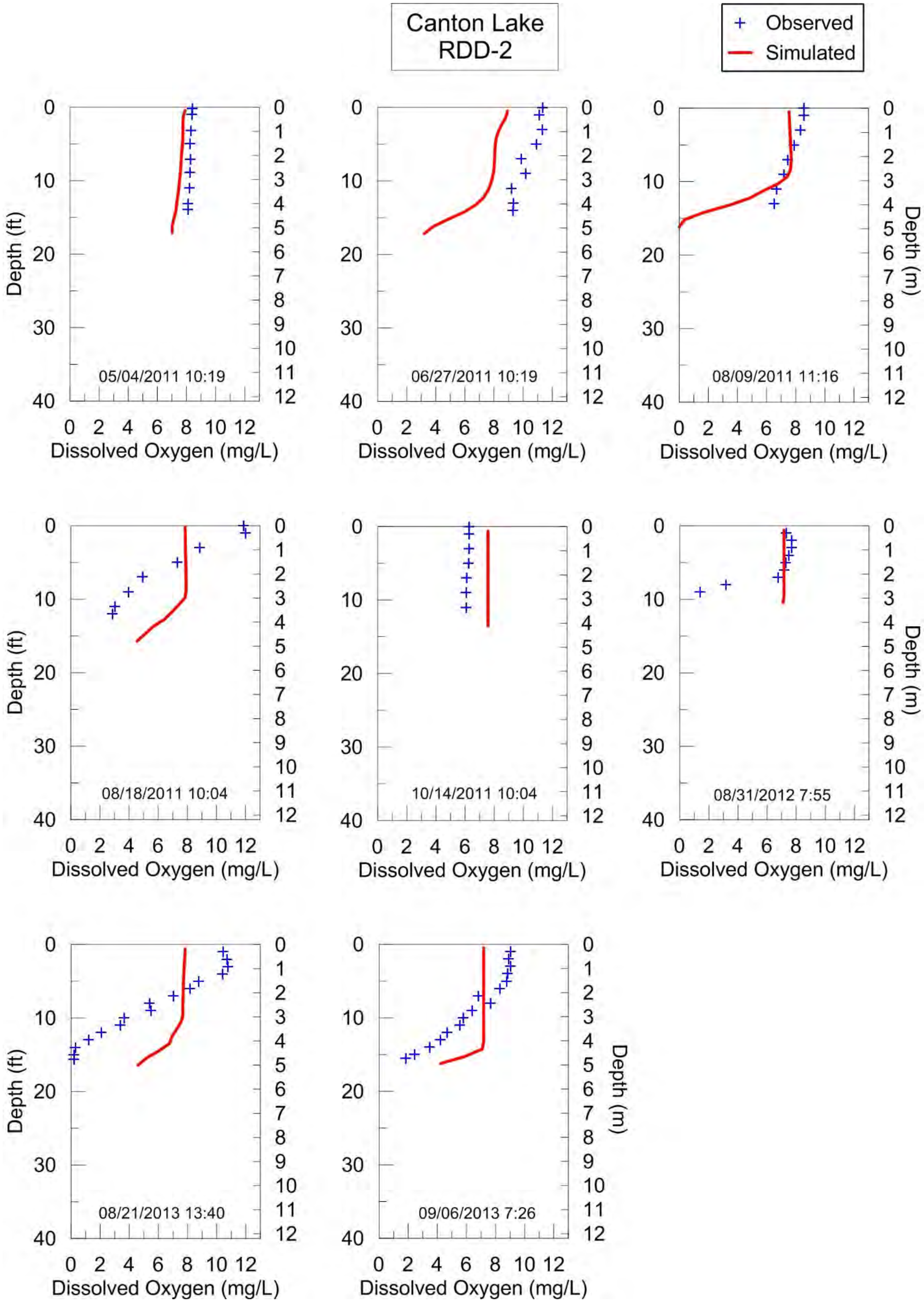

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 2 4 6 8 10 12

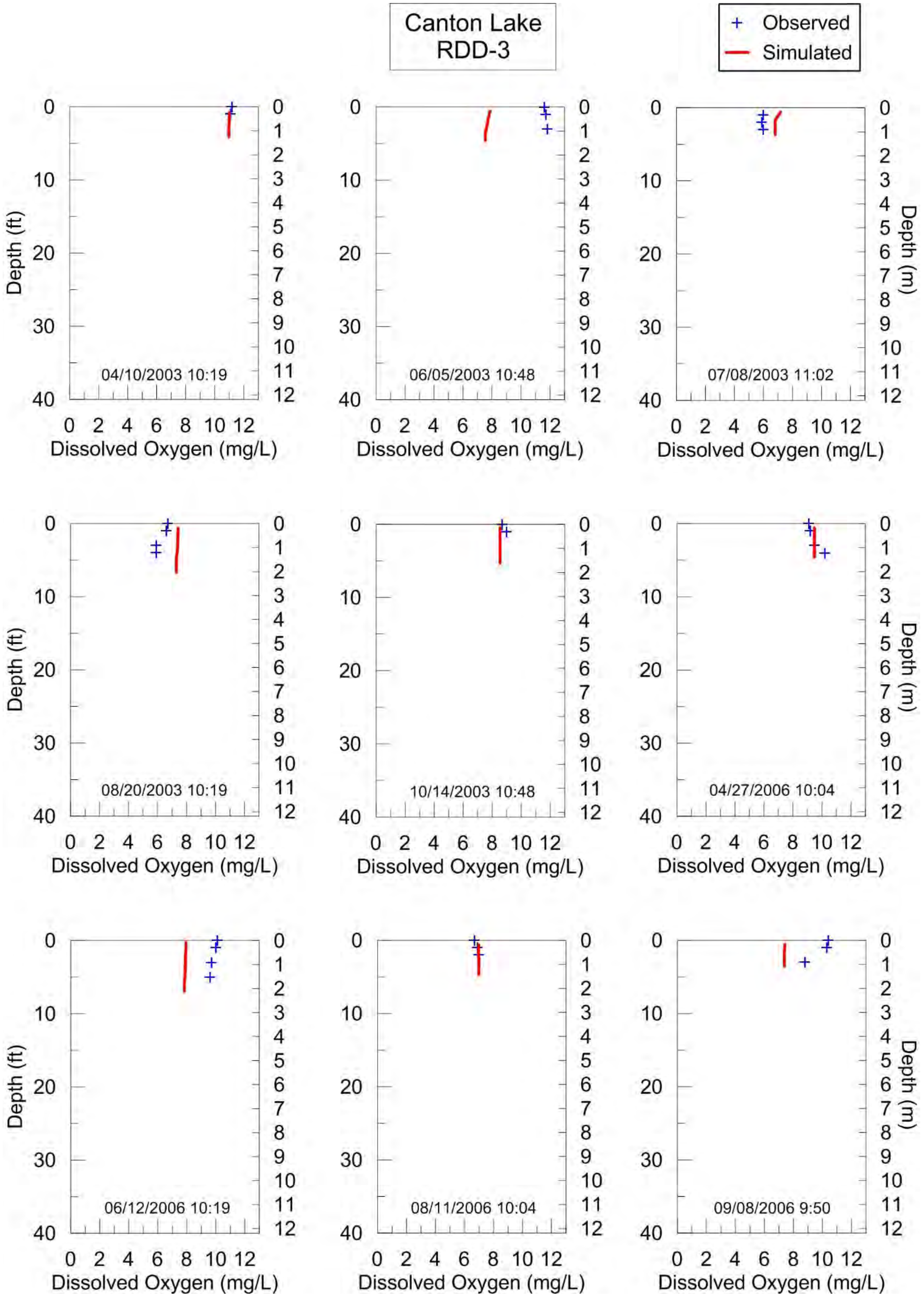

Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
0 2 4 6 8 10 12
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48


Canton Lake
RDD-1
Observed
Simulated
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04
08/31/2012 7:55
08/21/2013 13:40
09/06/2013 7:26
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 2 4 6 8 10 12


Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
Dissolved Oxygen (µg/L)
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 2 4 6 8 10 12


Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
0 2 4 6 8 10 12
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48


Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
0
10
20
30
40
0 1 2 3 4 5 6 7 8 9 10 11 12
0 2 4 6 8 10 12
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04
08/31/2012 7:55
08/21/2013 13:40
09/06/2013 7:26


Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
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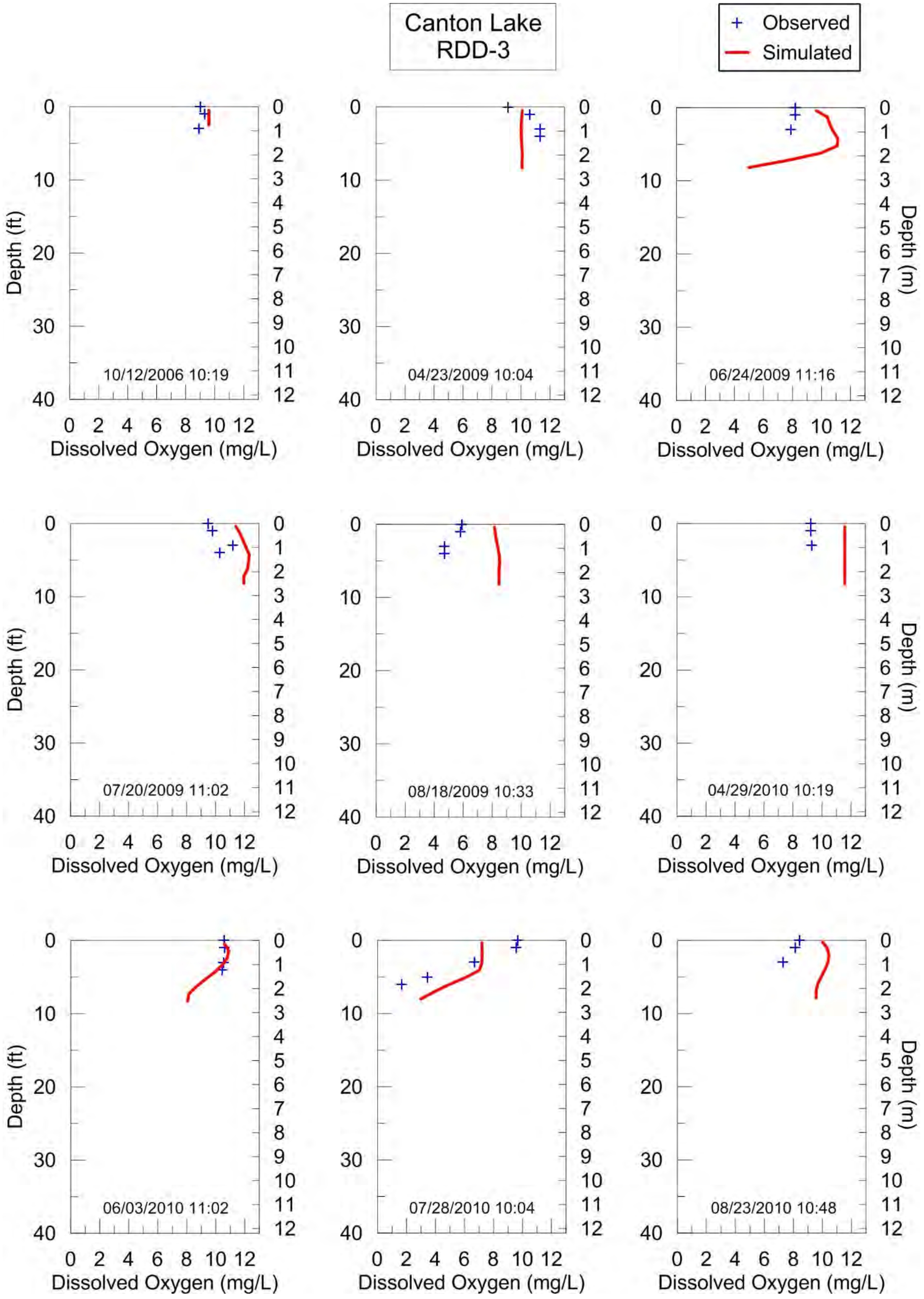
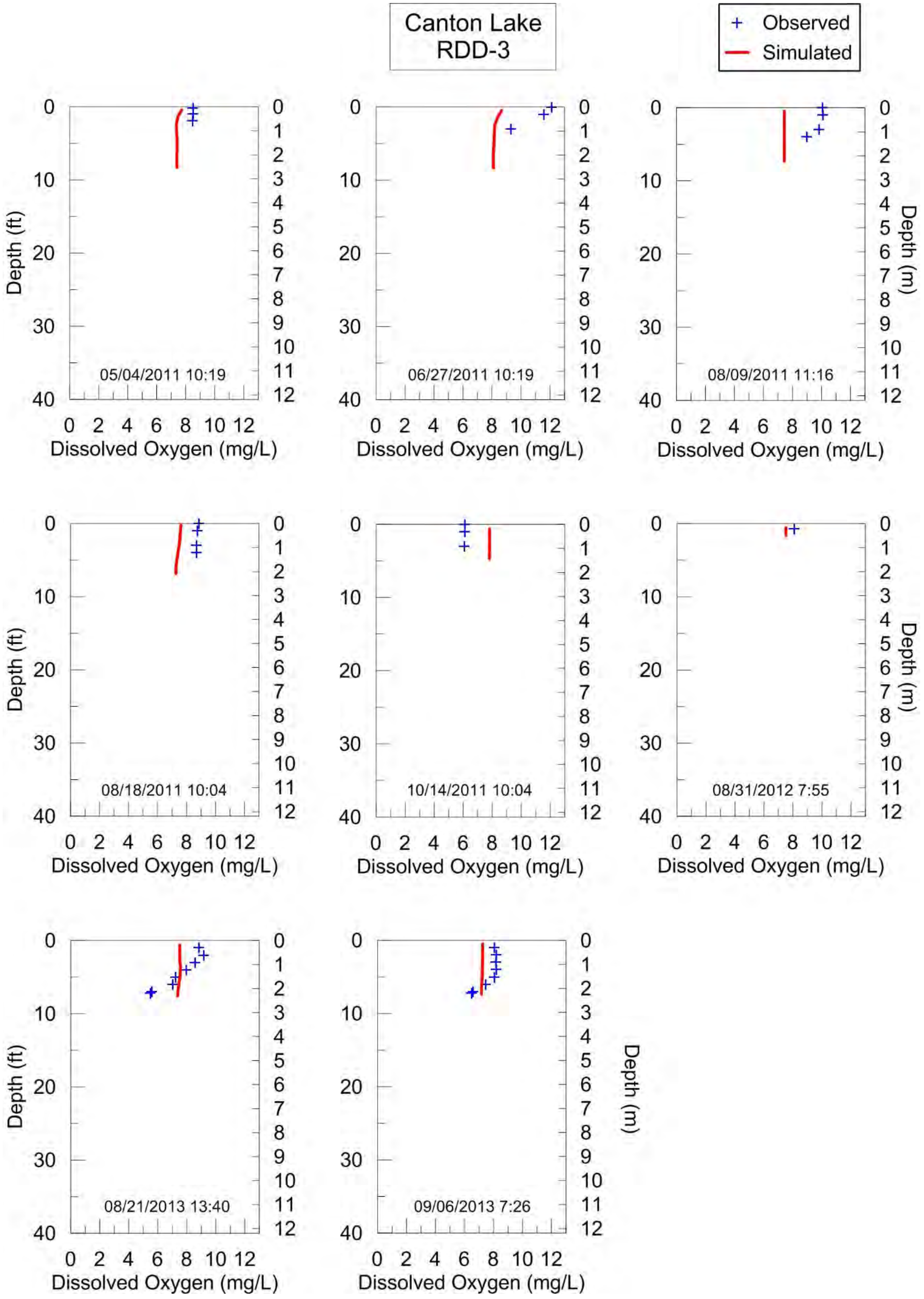
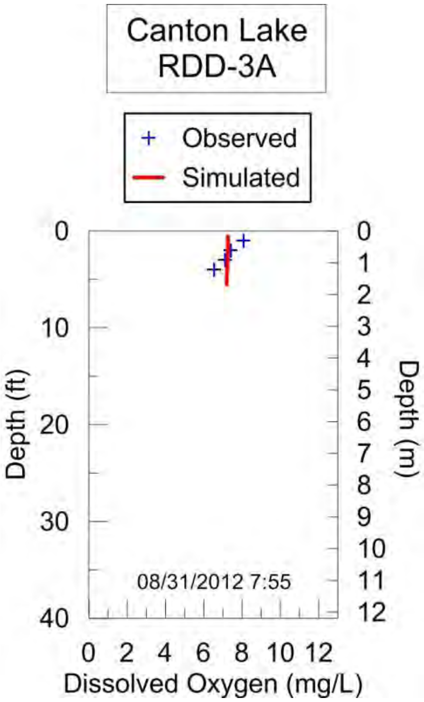
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 2 4 6 8 10 12
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50


Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 2 4 6 8 10 12
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48


Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Oxygen (mg/L)
0 2 4 6 8 10 12
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04
08/31/2012 7:55
08/21/2013 13:40
09/06/2013 7:26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RDD-3A
Observed
Simulated
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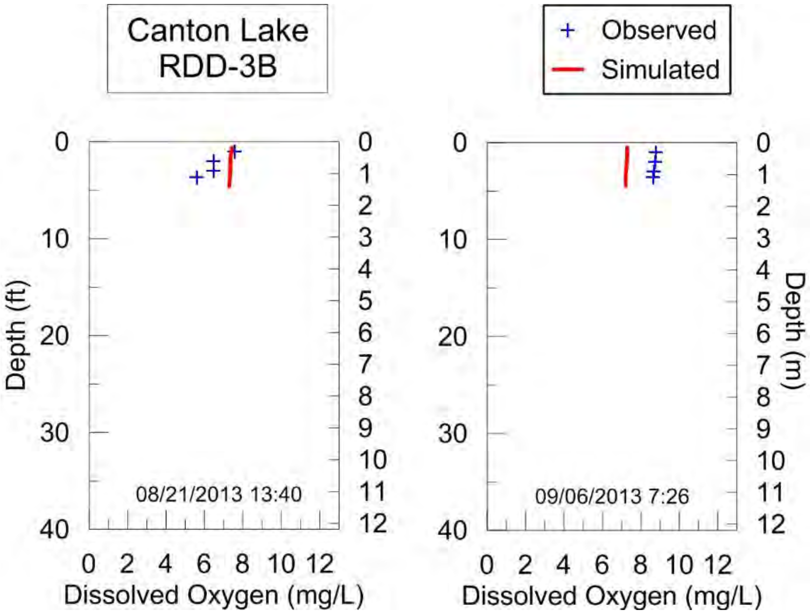
10
20
30
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
Depth (m)
08/31/2012 7:55
0 2 4 6 8 10 12
Dissolved Oxygen (mg/L)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Observed
Simulated
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20
30
40
Depth (ft)
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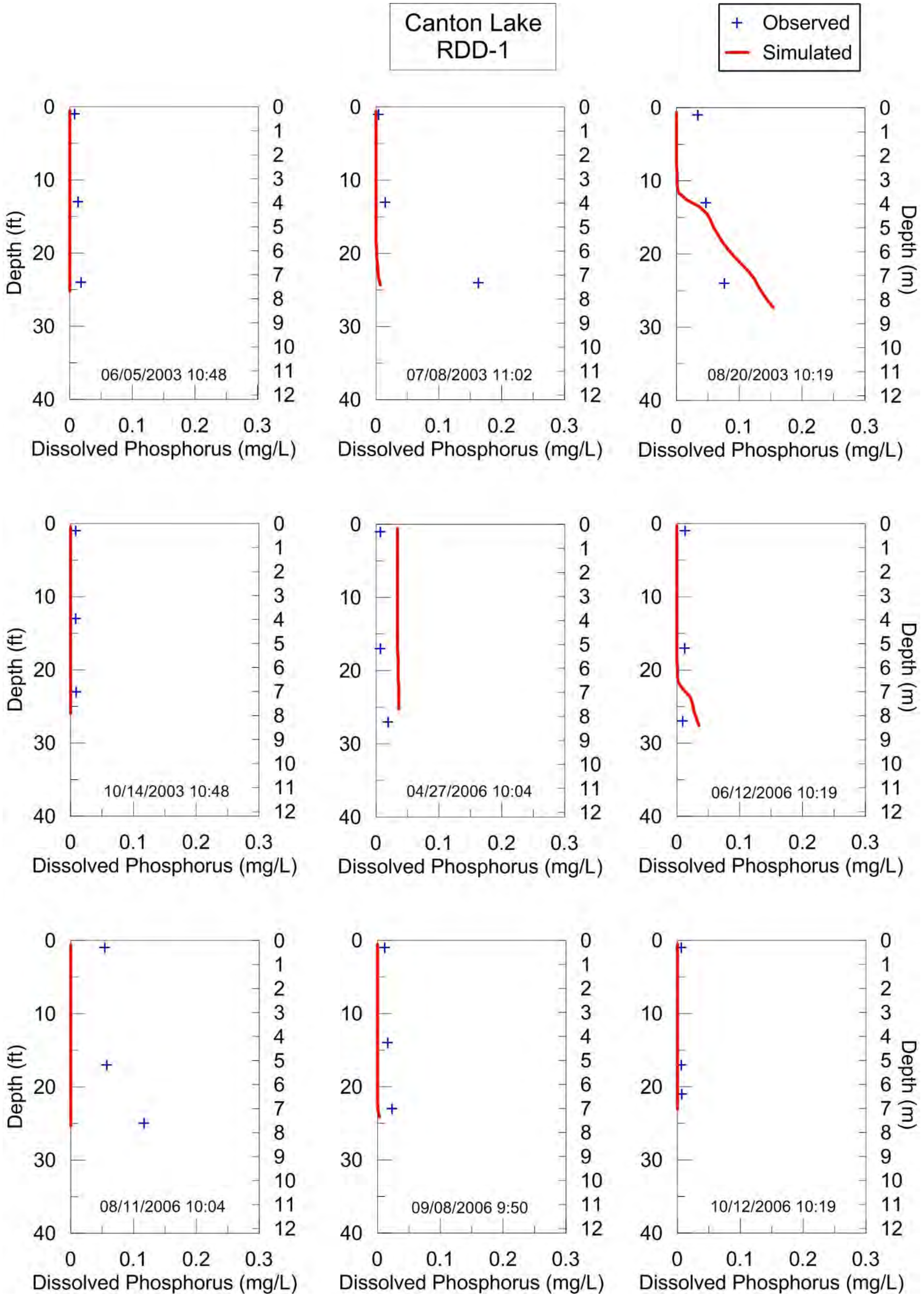
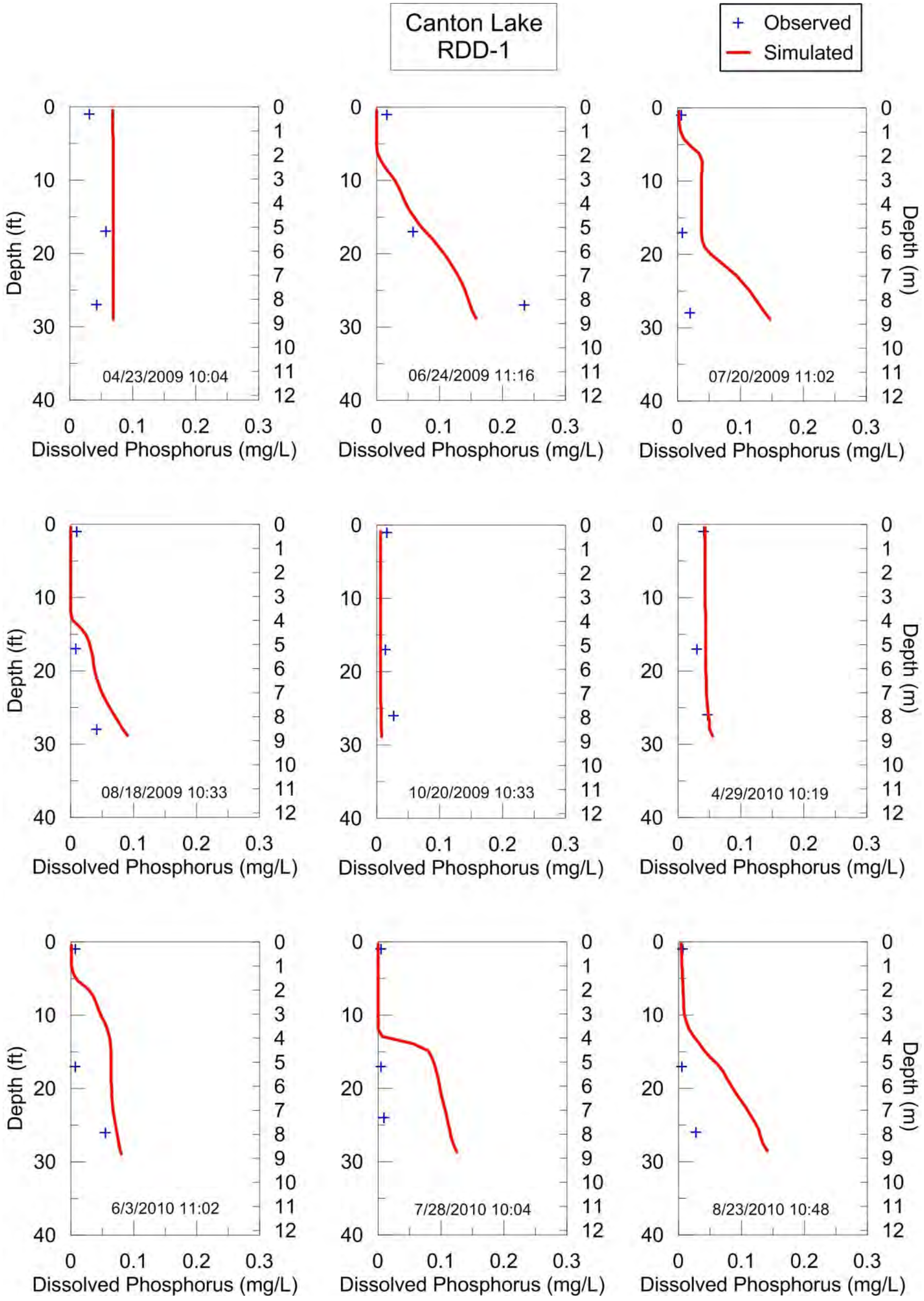
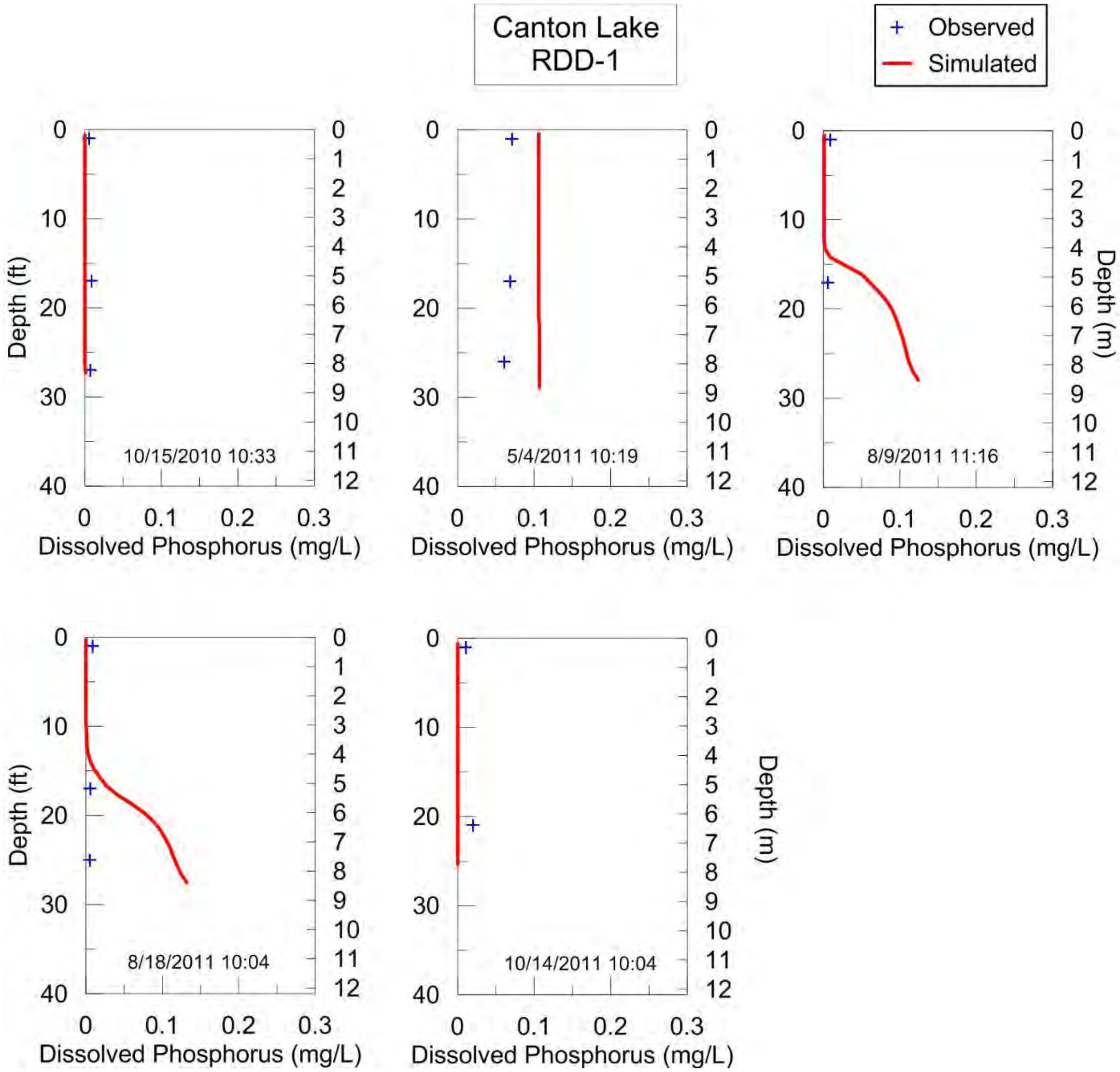
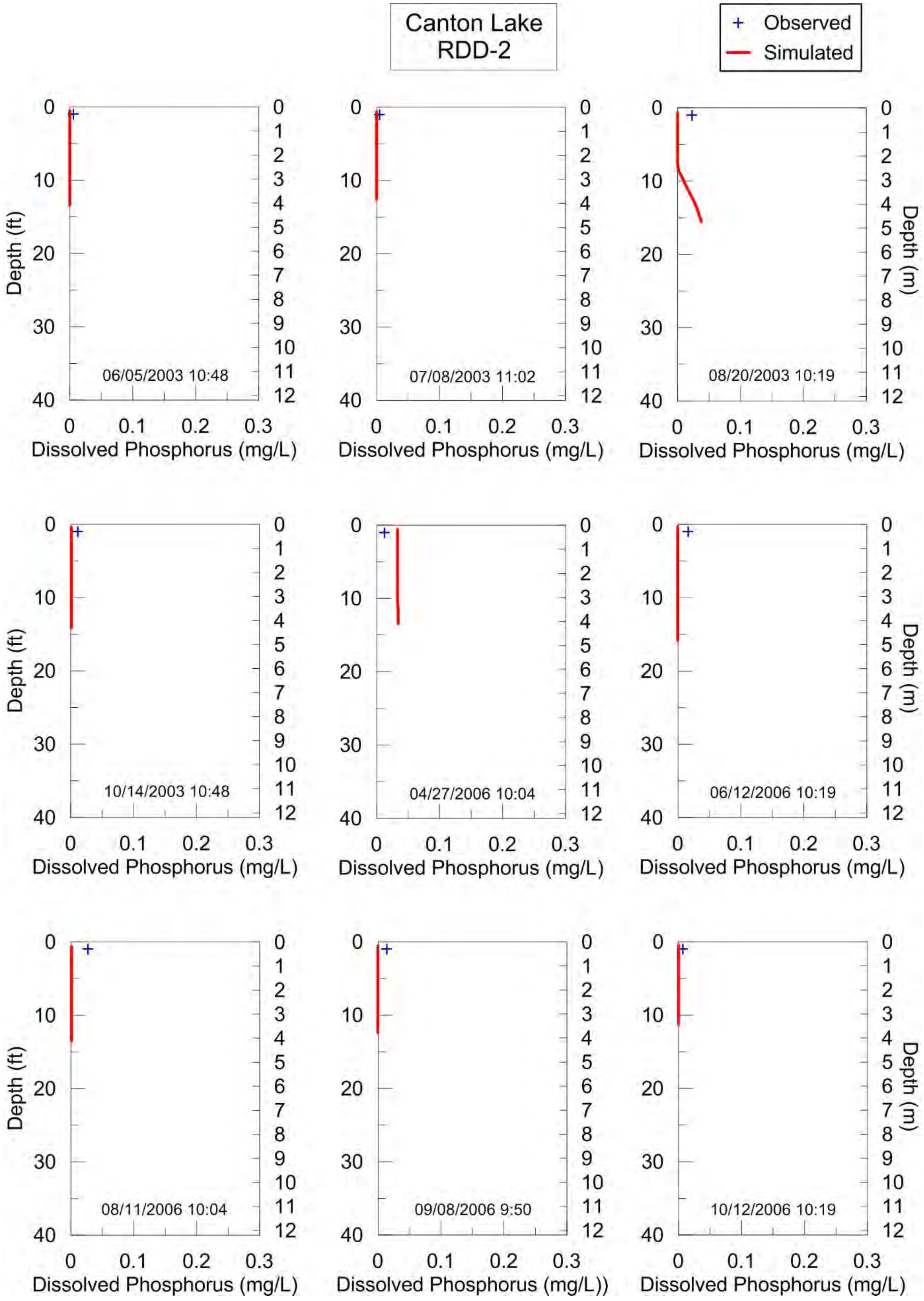
1
2
3
4
5
6
7
8
9
10
11
12
08/21/2013 13:40
0 2 4 6 8 10 12
Dissolved Oxygen (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
Depth (m)
09/06/2013 7:26
0 2 4 6 8 10 12
Dissolved Oxygen (mg/L)

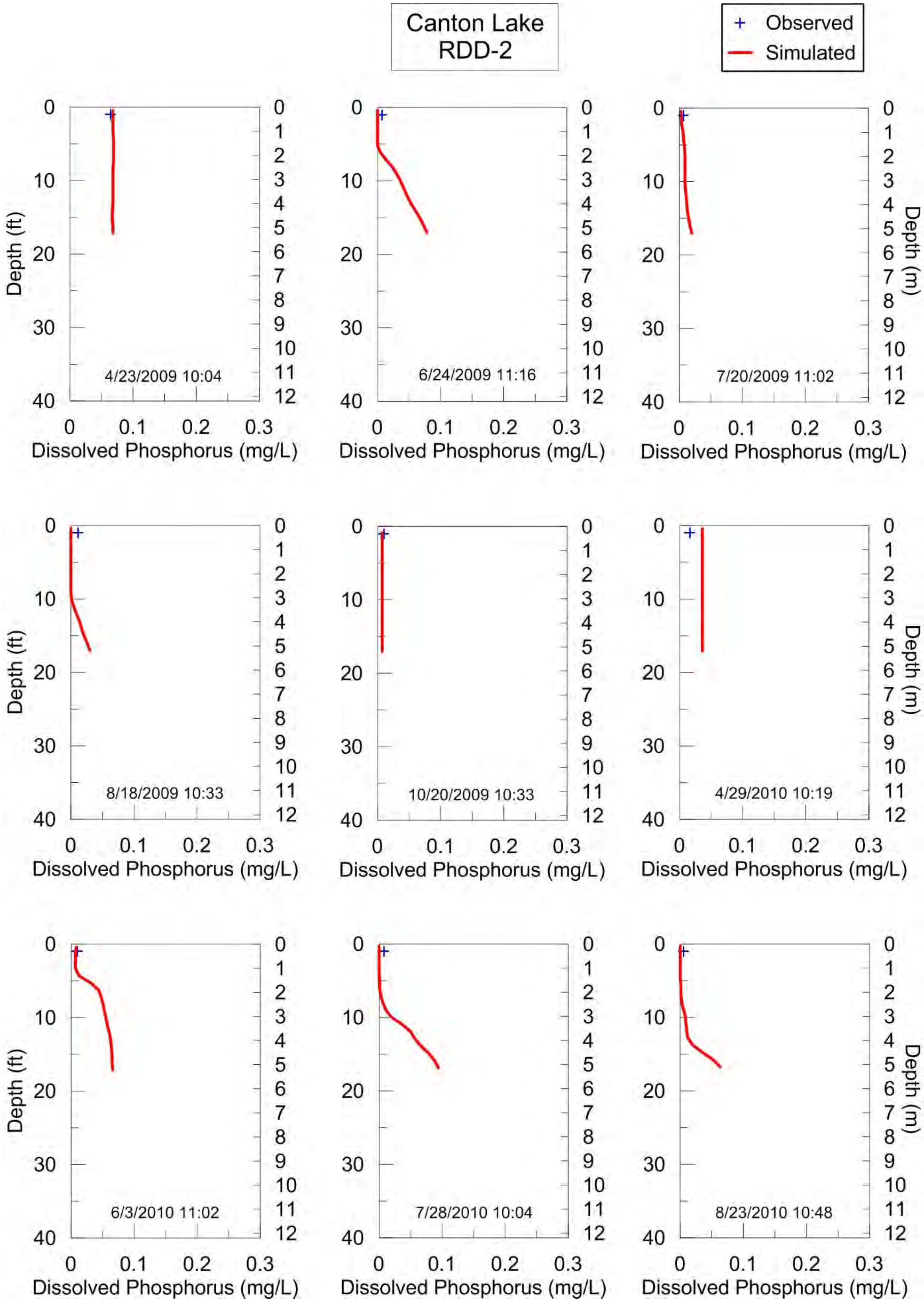
Dissolved Phosphorus

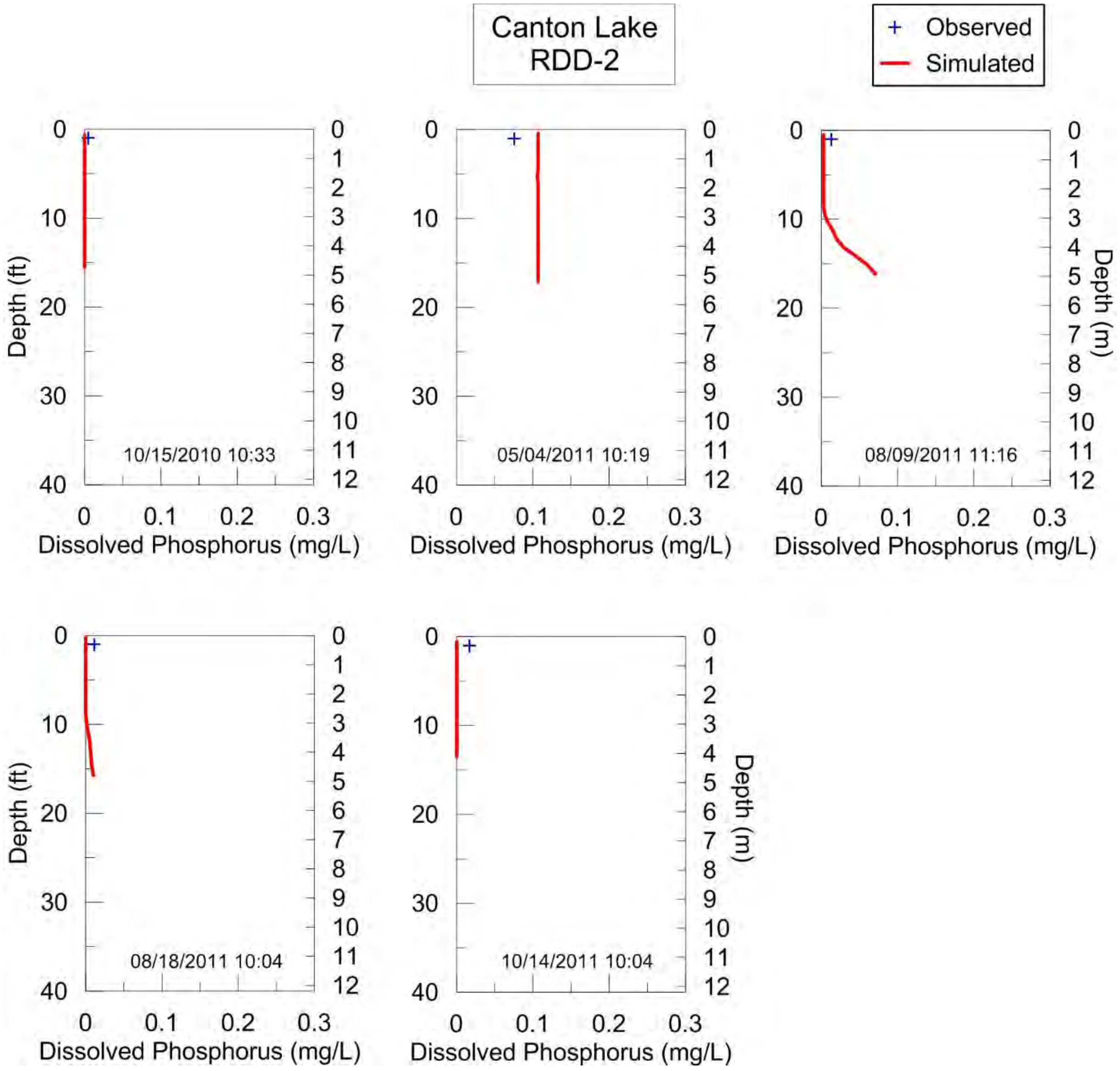

Canton Lake
RDD-1
Observed
Simulated
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
10/12/2006 10:19
Depth (ft)
Depth (m)
Dissolved Phosphorus (mg/L)
0
0.1
0.2
0.3
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12

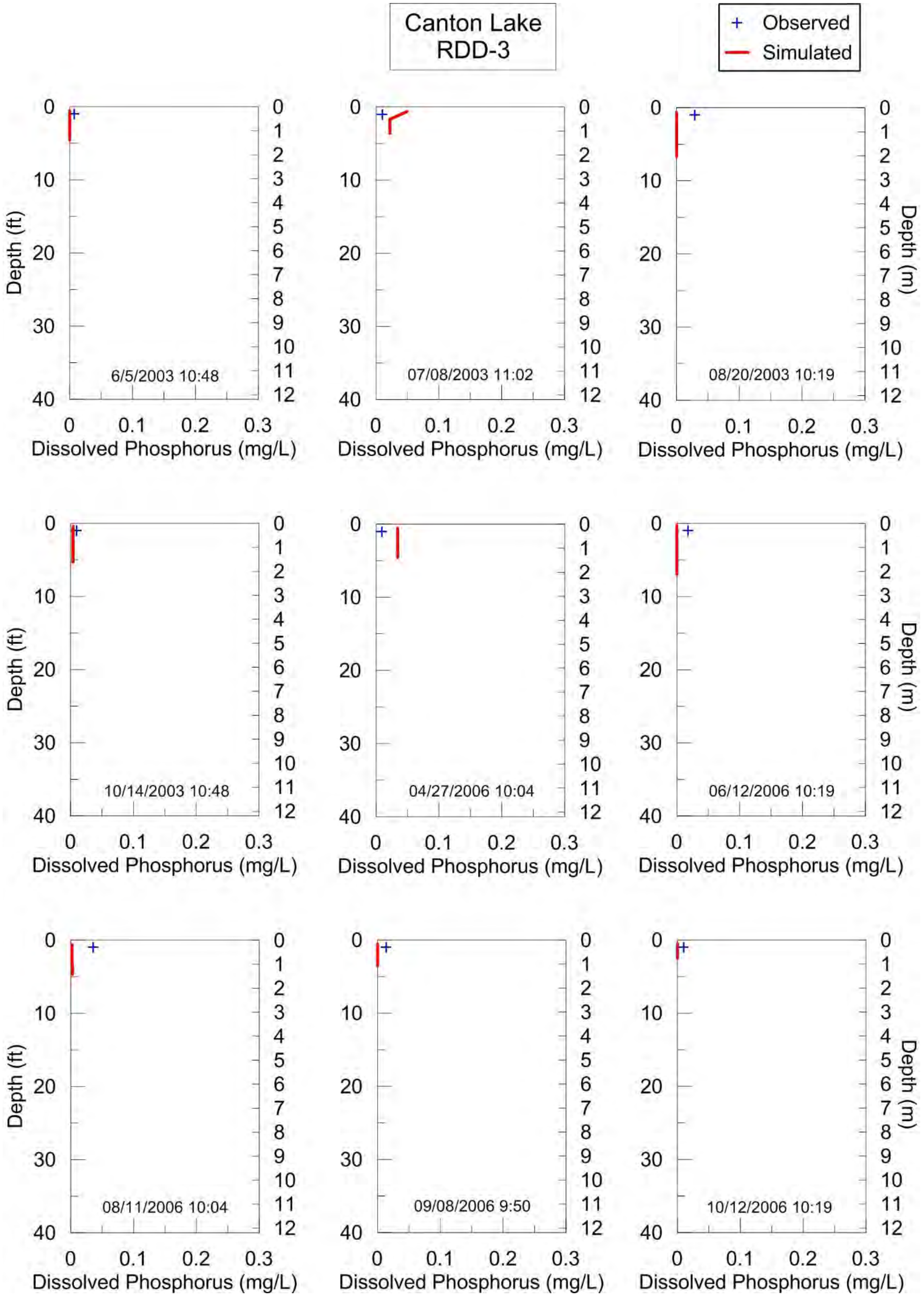

Canton Lake
RDD-1
+ Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0.1
0.2
0.3
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
10/20/2009 10:33
4/29/2010 10:19
6/3/2010 11:02
7/28/2010 10:04
8/23/2010 10:48


Canton Lake
RDD-1
+ Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
10/15/2010 10:33
5/4/2011 10:19
8/9/2011 11:16
8/18/2011 10:04
10/14/2011 10:04


Canton Lake
RDD-2
Observed
Simulated
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
10/12/2006 10:19
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Dissolved Phosphorus (mg/L)
Dissolved Phosphorus (mg/L))
0
0.1
0.2
0.3


Canton Lake
RDD-2
+ Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Phosphorus (mg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
4/23/2009 10:04
6/24/2009 11:16
7/20/2009 11:02
8/18/2009 10:33
10/20/2009 10:33
4/29/2010 10:19
6/3/2010 11:02
7/28/2010 10:04
8/23/2010 10:48


Canton Lake
RDD-2
+ Observed
Simulated
Depth (ft)
Depth (m)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
Dissolved Phosphorus (mg/L)
10/15/2010 10:33
05/04/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04


Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
Dissolved Phosphorus (mg/L)
0
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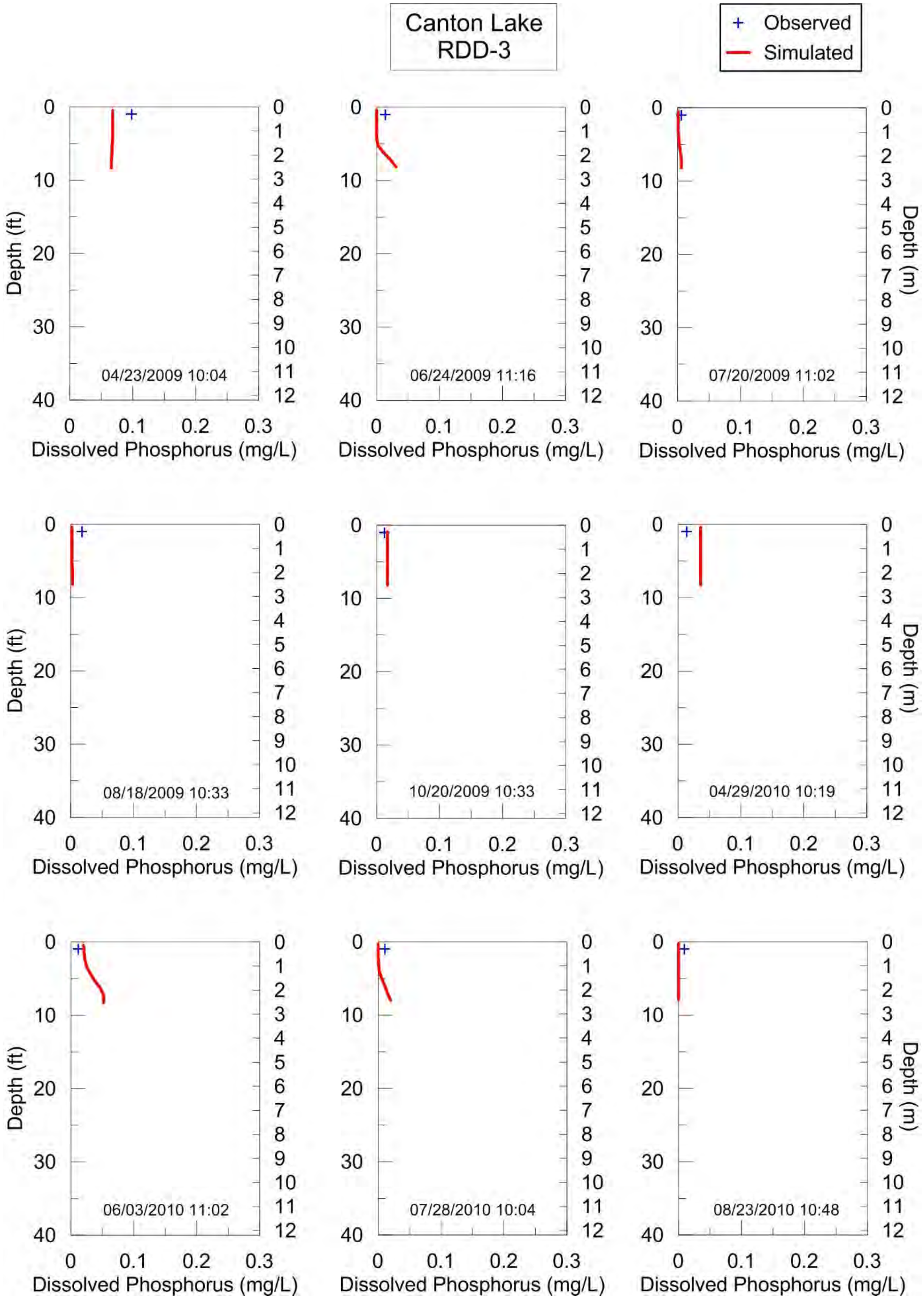
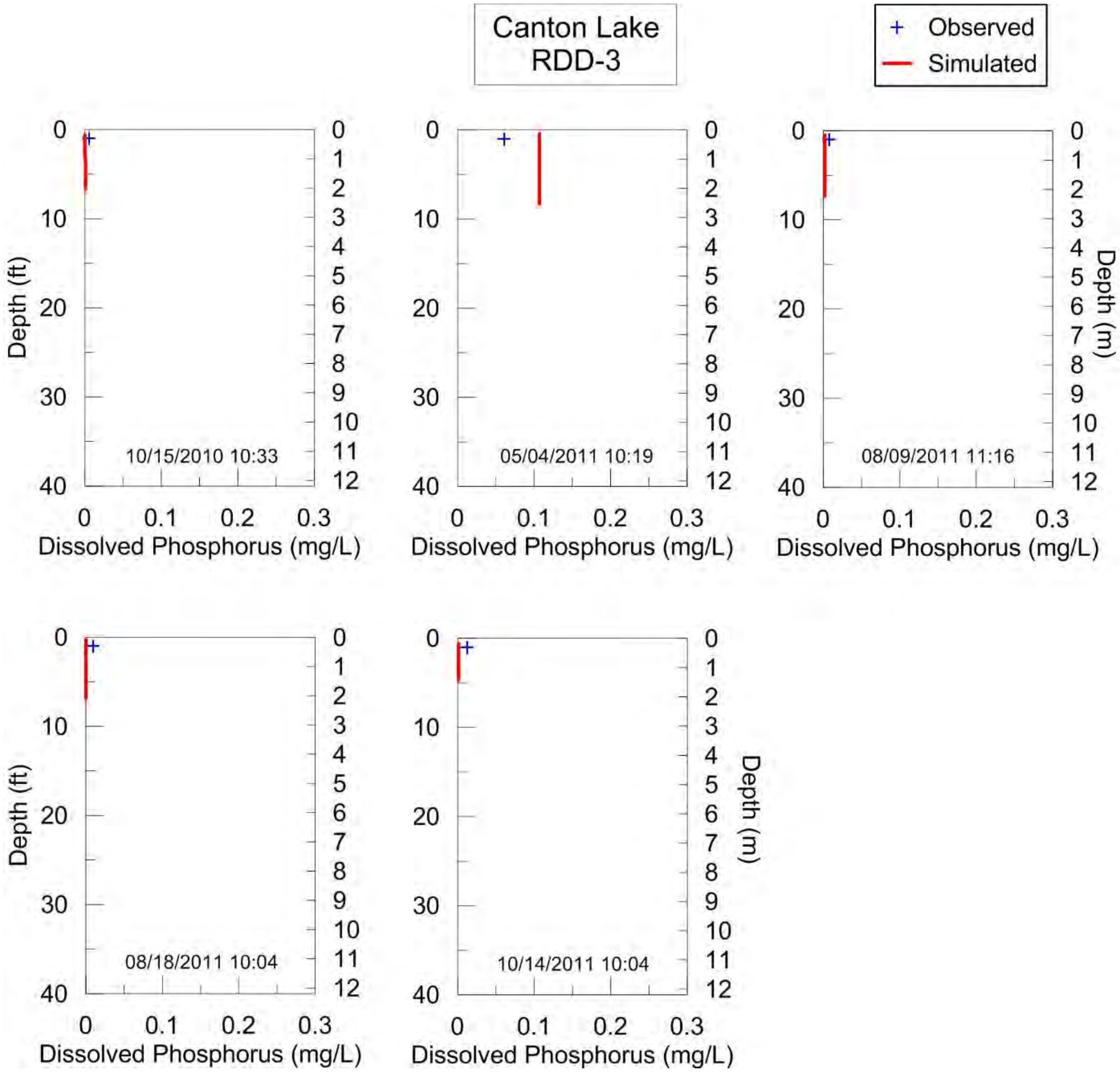
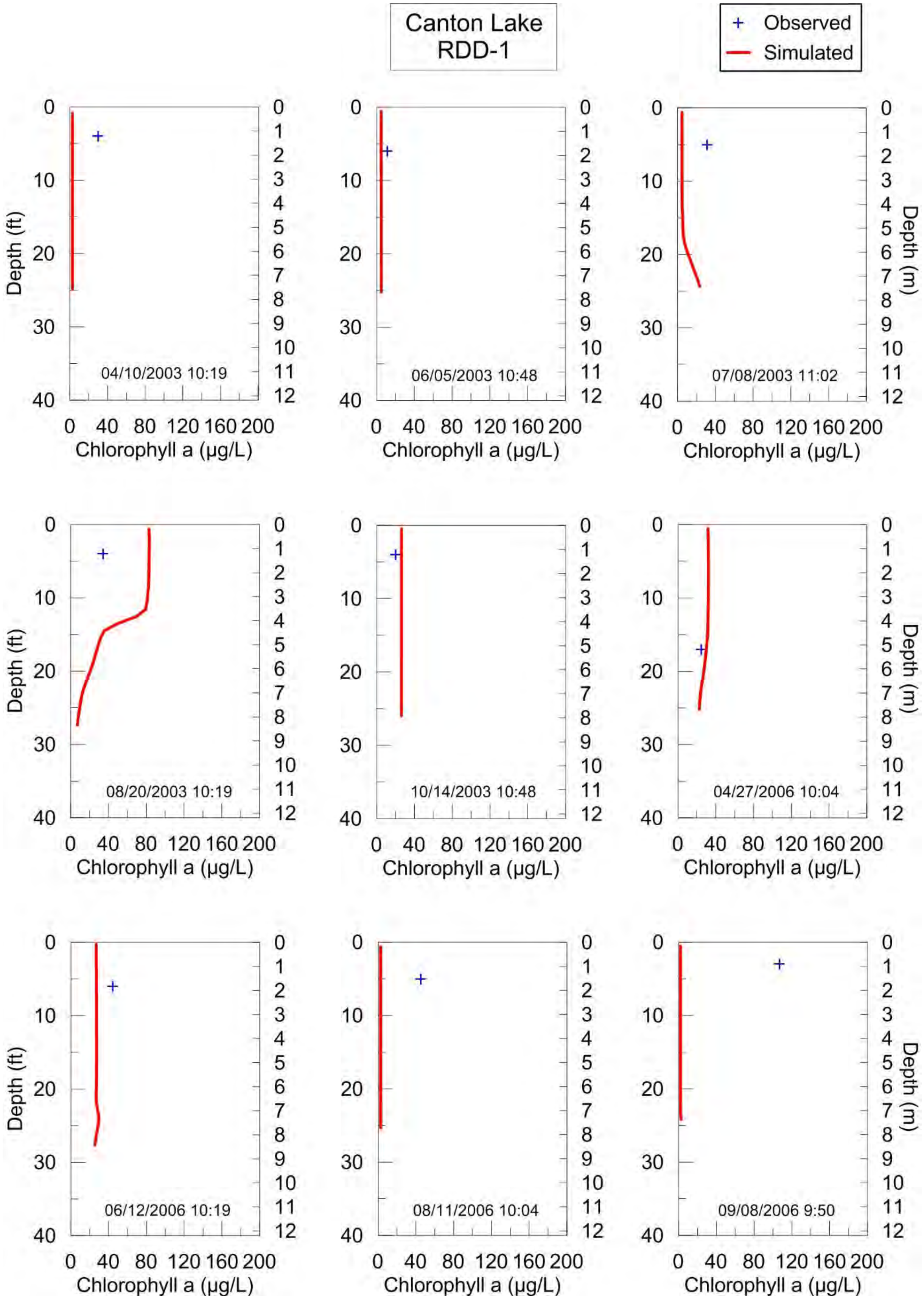
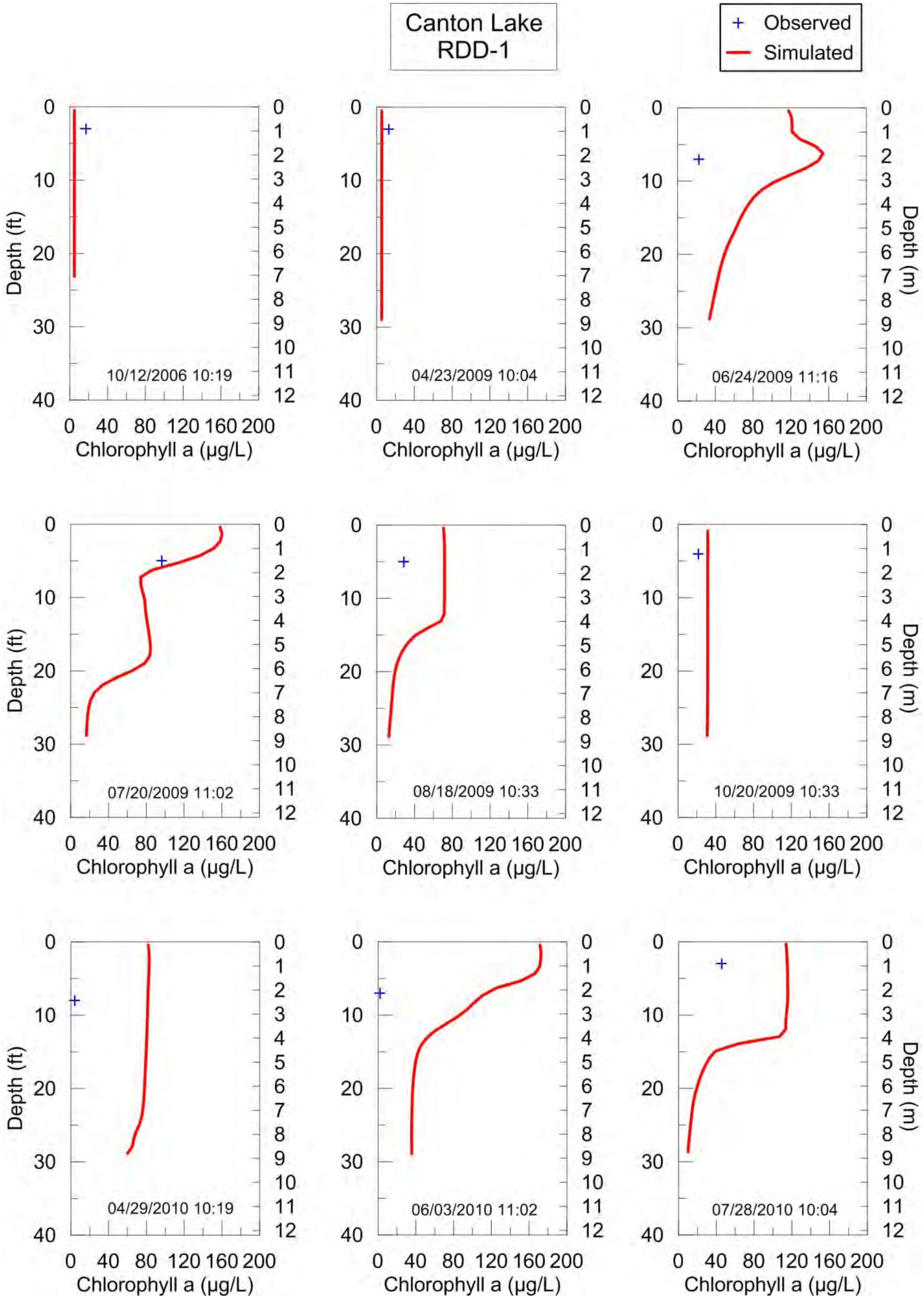
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
6/5/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50
10/12/2006 10:19


Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
0
10
20
30
40
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Dissolved Phosphorus (mg/L)
0
0.1
0.2
0.3
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
10/20/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04
08/23/2010 10:48


Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.1
0.2
0.3
Dissolved Phosphorus (mg/L)
10/15/2010 10:33
05/04/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04

Chlorophyll *a*


Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
40
80
120
160
200
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50


Canton Lake
RDD-1
+ Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0 40 80 120 160 200
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
10/20/2009 10:33
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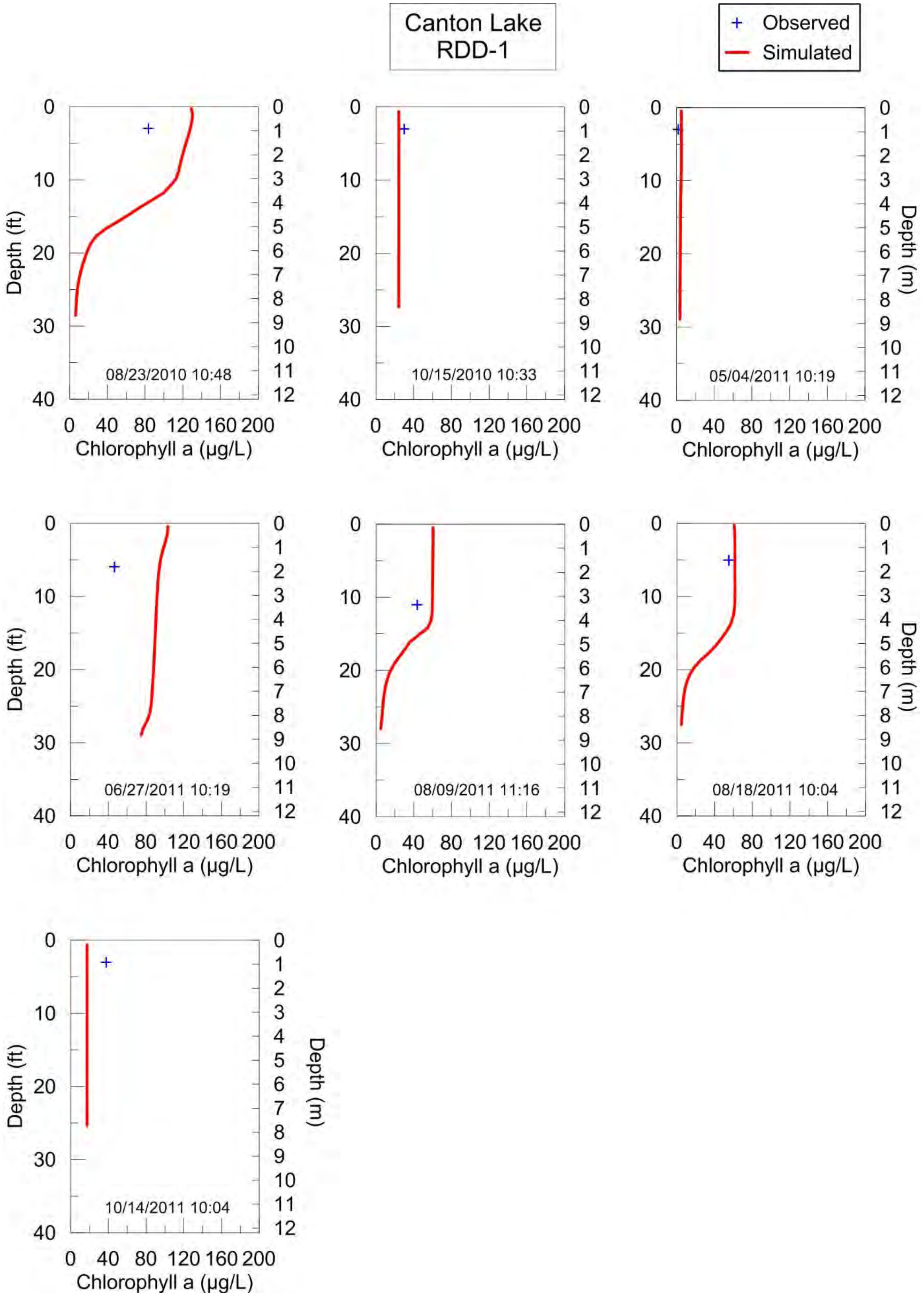
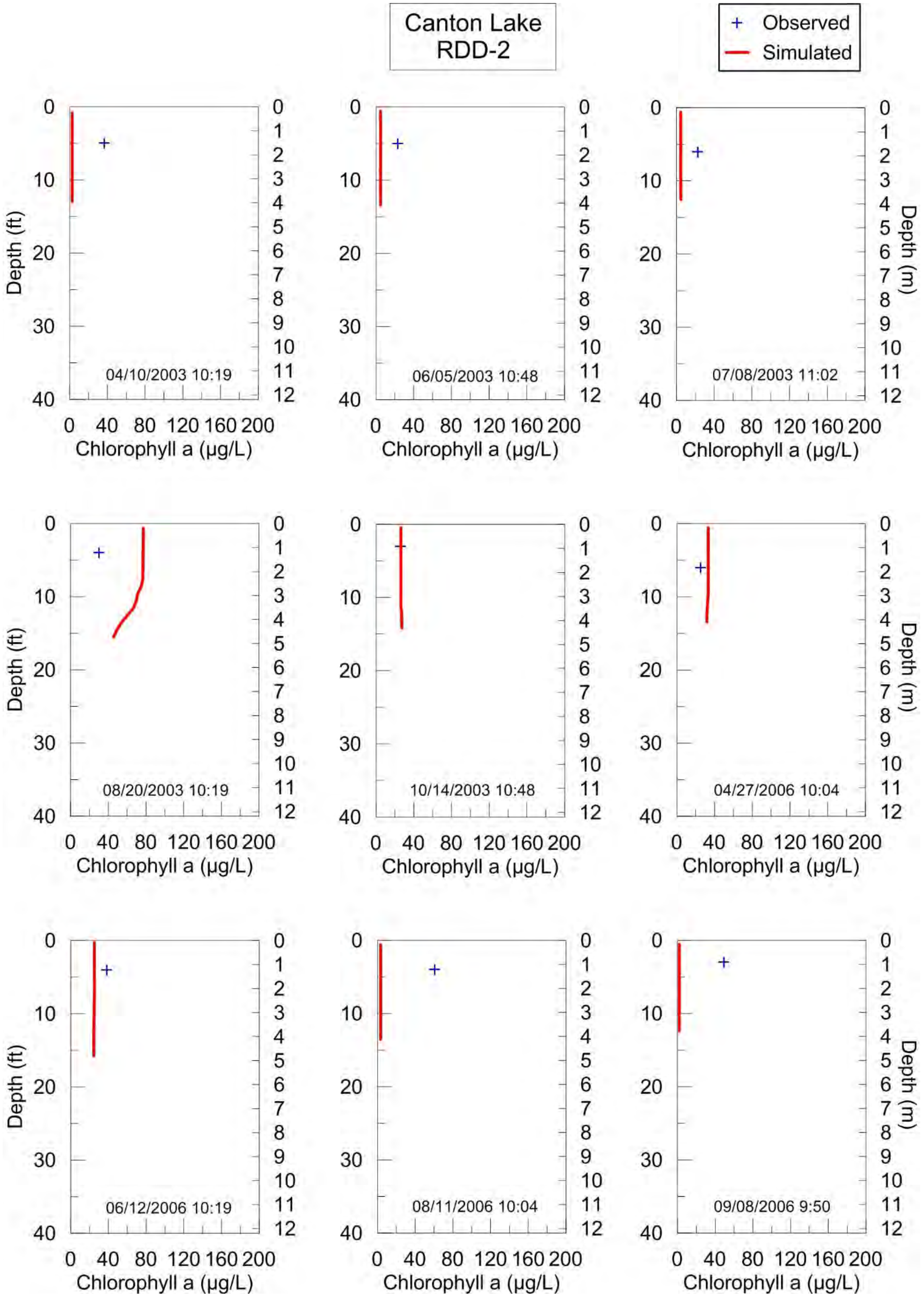
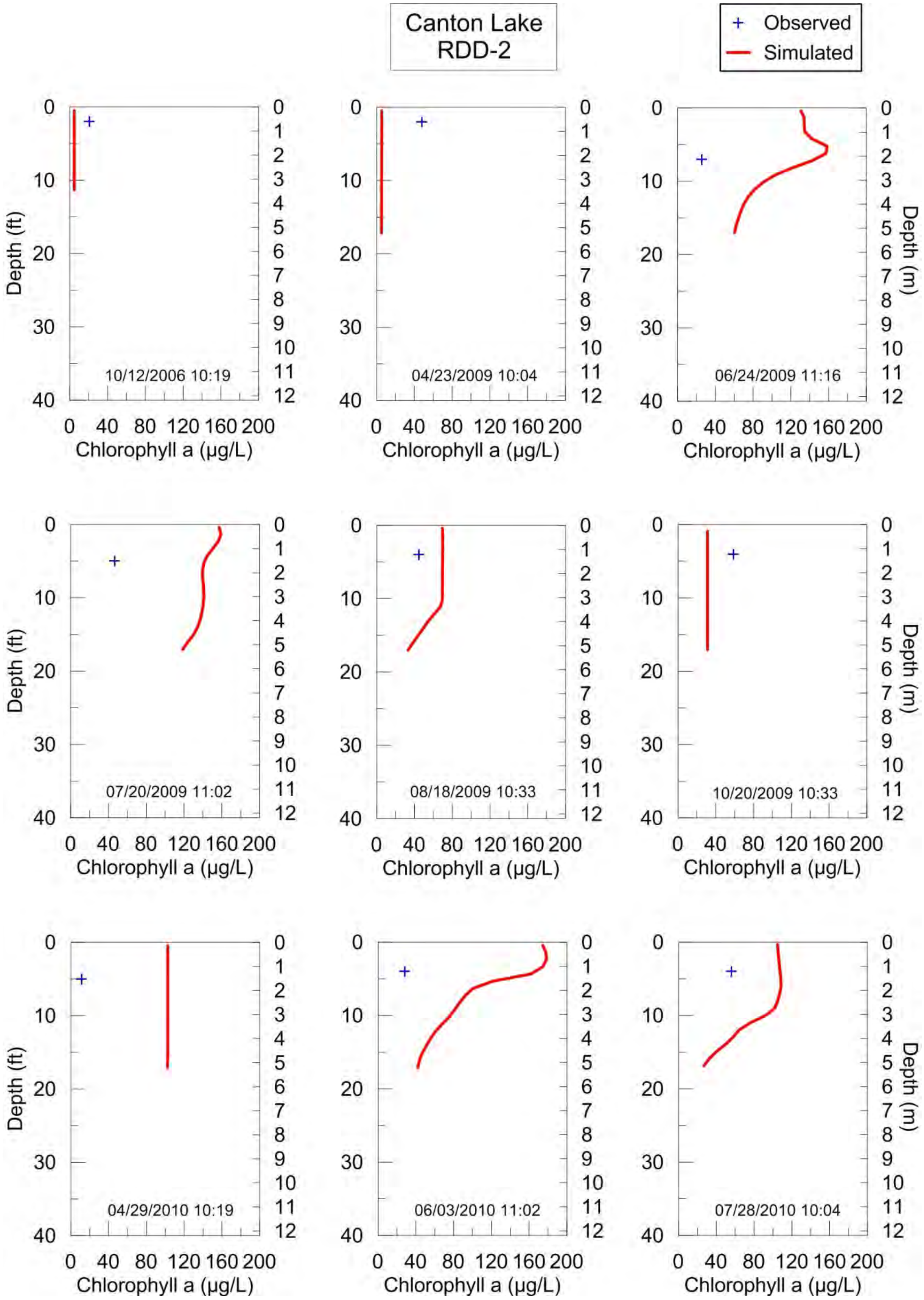
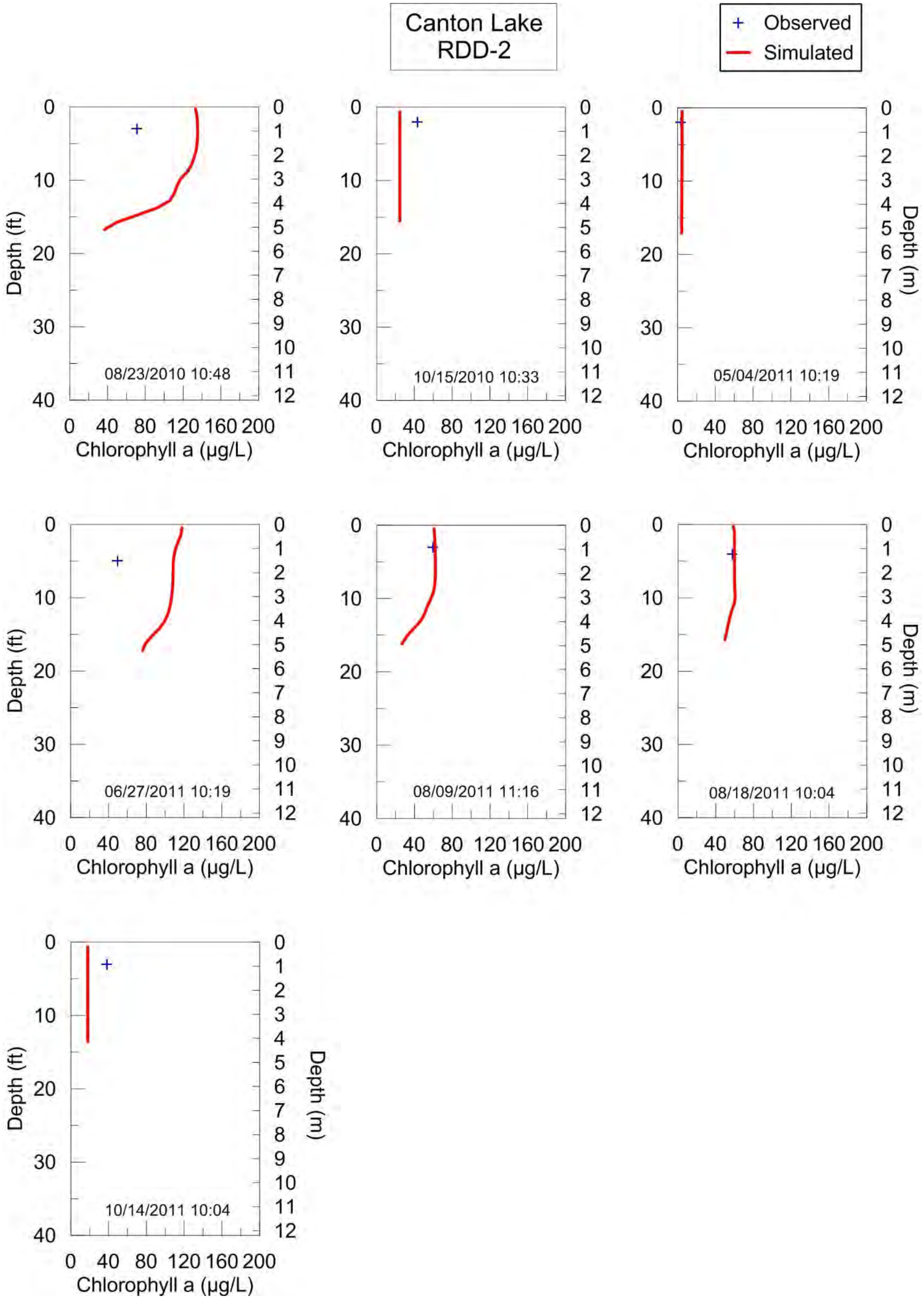
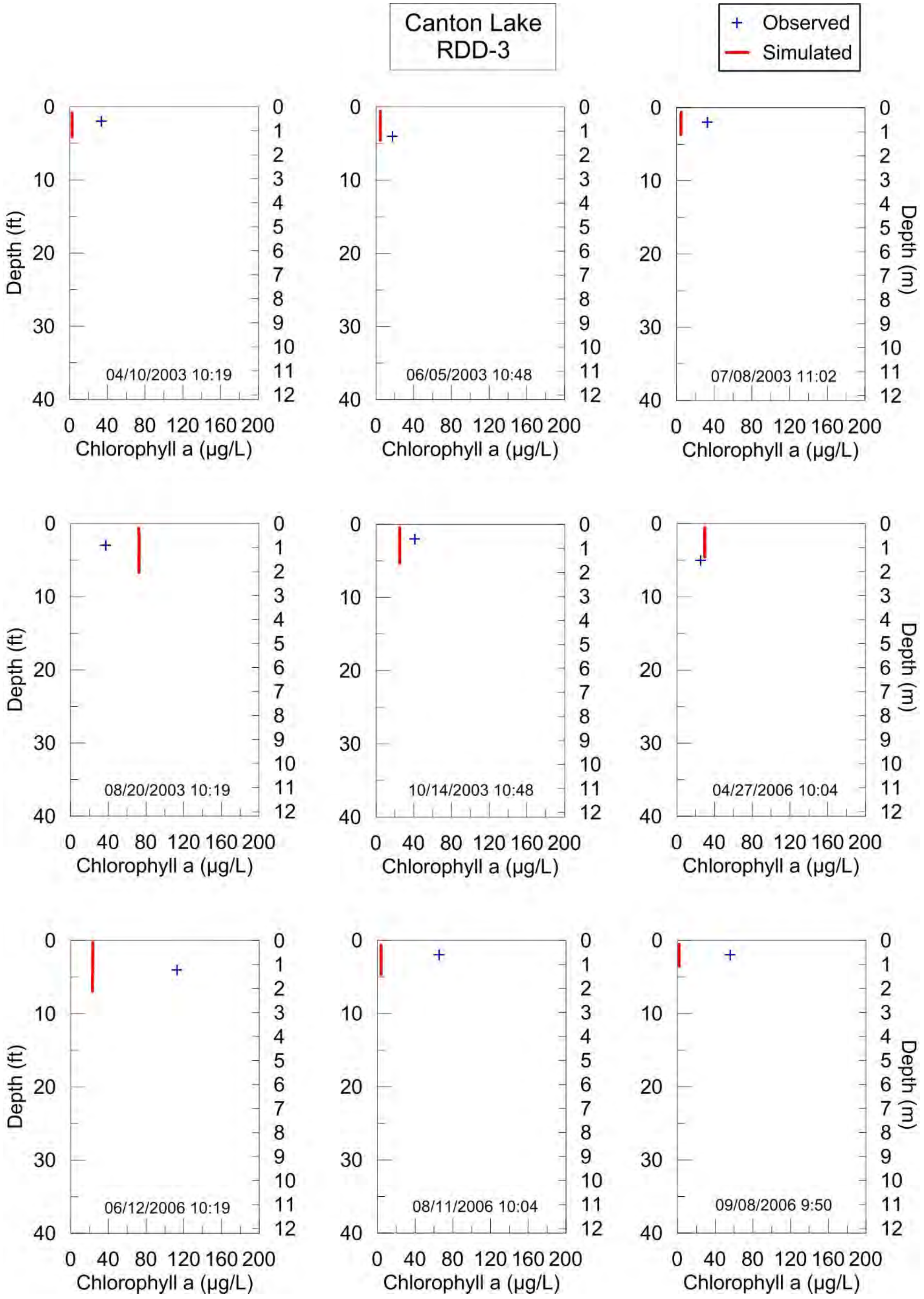
06/03/2010 11:02
07/28/2010 10:04


Canton Lake
RDD-1
Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
40
80
120
160
200
08/23/2010 10:48
10/15/2010 10:33
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04


Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
40
80
120
160
200
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50


Canton Lake
RDD-2
+ Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0
40
80
120
160
200
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
07/20/2009 11:02
08/18/2009 10:33
10/20/2009 10:33
04/29/2010 10:19
06/03/2010 11:02
07/28/2010 10:04


Canton Lake
RDD-2
Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 40 80 120 160 200
08/23/2010 10:48
10/15/2010 10:33
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04


Canton Lake
RDD-3
Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
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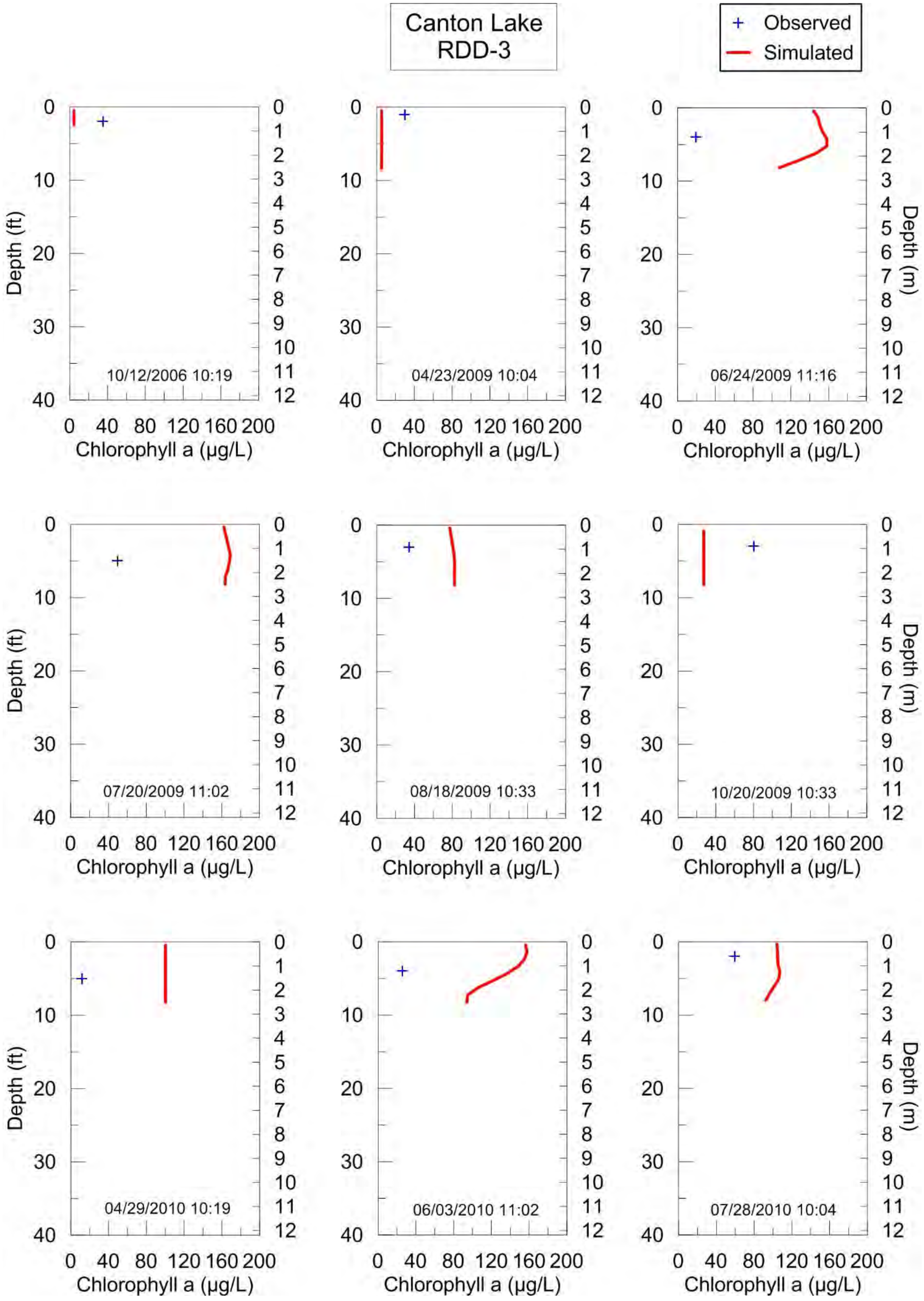
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 40 80 120 160 200
04/10/2003 10:19
06/05/2003 10:48
07/08/2003 11:02
08/20/2003 10:19
10/14/2003 10:48
04/27/2006 10:04
06/12/2006 10:19
08/11/2006 10:04
09/08/2006 9:50


Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
Chlorophyll a (µg/L)
0
10
20
30
40
0
1
2
3
4
5
6
7
8
9
10
11
12
0 40 80 120 160 200
10/12/2006 10:19
04/23/2009 10:04
06/24/2009 11:16
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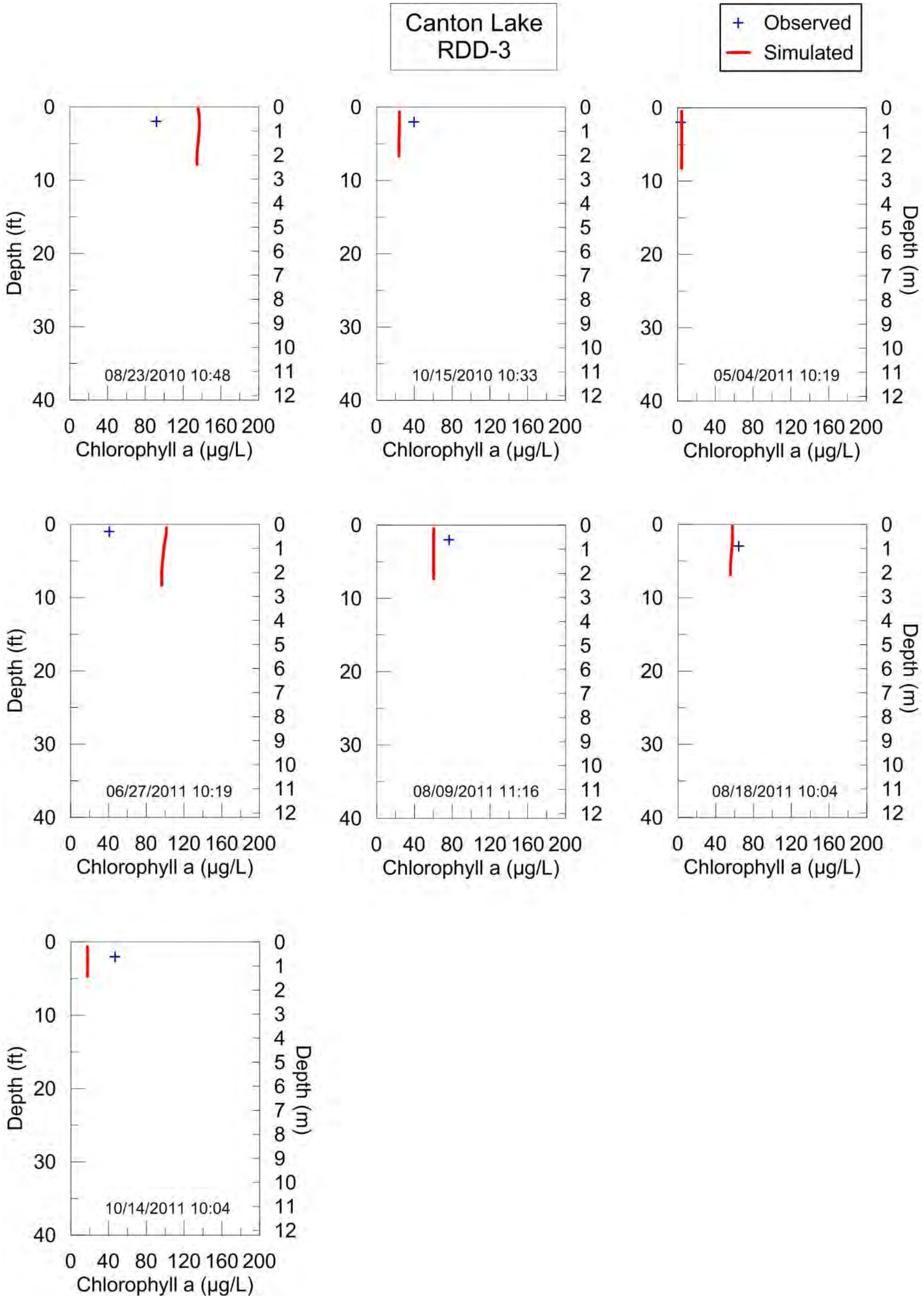
06/03/2010 11:02
07/28/2010 10:04


Canton Lake
RDD-3
+ Observed
Simulated
Depth (ft)
Depth (m)
0
10
20
30
40
0 1 2 3 4 5 6 7 8 9 10 11 12
0 40 80 120 160 200
Chlorophyll a (µg/L)
08/23/2010 10:48
10/15/2010 10:33
05/04/2011 10:19
06/27/2011 10:19
08/09/2011 11:16
08/18/2011 10:04
10/14/2011 10:04

Appendix E: Acronyms

Modeling

BASINS	Better Assessment Science Integrating point & Non-point Sources
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operations
CSO	Combined Sewer Overflow
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DOM	Dissolved Organic Matter
DOM-N	Dissolved Organic Matter - Nitrogen
DOM-P	Dissolved Organic Matter - Phosphorus
DP	Dissolved Phosphorus
GWLF	Generalized Watershed Loading Function
HUC	Hydrologic Unit Code
LA	Load Allocation
LC	Loading Capacity
LiDAR	Light Detection and Ranging
MOS	Margin of Safety
OM	Organic Matter
OM-N	Organic Matter - Nitrogen
OM-P	Organic Matter - Phosphorus
POM	Particulate Organic Matter
POM-N	Particulate Organic Matter - Nitrogen
POM-P	Particulate Organic Matter - Phosphorus
RC	Reserve Capacity
S-O	Simulated minus Observed
TDS	Total Dissolved Solid
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USLE	Universal Soil Loss Equation
VSS	Volatile Suspended Solid
WLA	Waste Load Allocation

Statistics

NSE	Nash-Sutcliffe efficiency
PBIAS	Percent bias
R^2	Pearson's coefficient of determination
RMSE	Root mean square error
RSR	RMSE-Observations standard deviation ratio

Data Source

CREP	Conservation Reserve Enhancement Program
IL-GAP	Illinois Gap Analysis Project
NEXRAD	Next Generation Weather Radar
NHD	National Hydrography Dataset
QCLCD	Quality Controlled Local Climatological Data
SSURGO	Soil Survey Geographic Database
ULDC	Unedited Local Climatological Data

State and Federal Agency

IEPA	Illinois Environmental Protection Agency
ISWS	Illinois State Water Survey
MRCC	Midwest Regional Climate Center
NCDC	National Climatic Data Center
NRCS	National Resource Conservation Service
SWCD	Soil and Water Conservation District
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Appendix F: Responsiveness Summary

Canton Lake Watershed Total Maximum Daily Load

The responsiveness summary responds to any questions and comments received during the public comment period from March 2, 2017, through April 5, 2017.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a pollutant that a water body can receive from all contributing sources and still meet water quality standards or designated uses. The Waverly Lake 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 Canton Lake (IL_RDD) in Fulton County. The Canton Lake watershed encompasses an area of approximately 9,600 acres (15 square miles). Land use in the watershed is predominately agriculture.

Canton Lake consists of 230 acres and is used as a water source for the City of Canton. The waterbody is listed on the Illinois EPA 2016 Section 303(d) List as being impaired for total phosphorus, total suspended solids, and mercury. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Therefore, a TMDL was developed for total phosphorus. Illinois EPA contracted with the Illinois State Water Survey to prepare a TMDL report for the Canton Lake Watershed.

Public Meetings

A public meeting was held on December 6, 2012 at the Donaldson Community Center and on March 22, 2017 at the Baker Recreation Center in Canton, Illinois. Illinois EPA provided public notice for both meetings by placing display ads in the Canton Daily Ledger newspaper. In addition, a direct mailing was sent to approximately 78 individuals in the watershed. These notices gave the date, time, location, and purpose of the meeting. The notice also provided references to obtain additional information about this specific site, the TMDL program and other related information. The draft TMDL report was available for review at the Parlin-Ingersoll Public Library and Canton City Hall, and also on the Agency's webpage at www.epa.state.il.us/public-notices.

A public meeting started at 3:00 p.m. on Wednesday, March 22, 2017. It was attended by approximately 14 people and concluded at 4:30 p.m. with the meeting record remaining open until midnight, April 5, 2017.

Questions & Comments

No Comments Received.