DUPAGE RIVER SALT CREEK WORK GROUP

STREAM DISSOLVED OXYGEN IMPROVEMENT FEASIBILITY STUDY FOR THE EAST BRANCH OF THE DUPAGE RIVER

FINAL REPORT

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1 EXECUTIVE SUMMARY

The East Branch of the DuPage River (East Branch) is listed as an impaired waterway in the 303(d) list. Dissolved oxygen (DO) is listed as one of the causes of impairment. This study was undertaken to address alternative approaches for improving the DO levels on the East Branch during lower flow periods.

As an initial step, a DO model was developed. Model development was supported by a DO monitoring program undertaken by the DuPage River Salt Creek Work Group (DRSCW) and by sediment oxygen demand measurement collected along the waterway.

The East Branch is an urban stream with low hydraulic gradients and extensive channelization. Eight municipal wastewater treatment plants discharge to the East Branch, and during low flow periods comprise a significant portion of the overall flow. In addition, two dams of significance, the Churchill Woods Dam and Prentiss Creek Dam, are located along the East Branch. The DO monitoring efforts indicated the Churchill Woods Dam was causing DO levels below 2.0 mg/L above the dam, while at the Prentiss Creek Dam did not have a significant effect on DO levels.

A QUAL2K model was developed using available data. The model was calibrated using DO data collected between August 13 and 17, 2006. A validation run was then completed for August 20, 2006, that showed overall good agreement between modeled and observed. For the baseline model, the highest stream temperatures recorded over the past decade were utilized at the 7-day, 10-year low flows. BOD_5 loading from the municipal treatment plants was based on the actual monthly average levels reported by the individual plants, as opposed to the maximum permitted concentrations. This approach provided a model that more closely matched actual stream conditions.

Options for partial and complete dam removal were explored. Options for stream aeration were also explored. These options included air-based and oxygen-based systems, both instream and side stream. Oxygen-based systems have a distinct advantage of requiring fewer installations, as the stream DO can readily be increased to 150 percent of saturation. The shallow conditions that exist throughout much of the East Branch limits the use of instream air-based technologies to the deeper pools.

From both the modeling and DO monitoring completed, Churchill Woods was identified as the most significant cause of low DO levels. The model predicted that with the Churchill Woods Dam removed, minimum DO levels throughout the East Branch would approach 5 mg/L under low flow conditions. Continuous DO monitoring further downstream at Hidden Lake in 2006 revealed minimum DO levels between 5 and 6 mg/L, consistent with the model. However, in 2007, minimum DO levels in Hidden Lake fell consistently below 4.0 mg/L. The maximum DO levels during these same periods were near 14 mg/L, versus 10 to 12 mg/L in 2006, suggesting more plant/algal activity in 2007. This higher DO flux suggests the calibrated model for the Hidden Lake reach may understate the photosynthesis /respiration rates for some years.

Based on the modeling and monitoring, removal of the Churchill Woods Dam is the project that will have the greatest benefit in providing higher DO levels to the East Branch. Sediment management is a critical component to dam and is likely to be the most costly part of such a project. Complete sediment removal is estimated to have a total projected cost between $5 and

$8 million, depending on how the sediment is managed. If only 50% of the sediment is removed, the cost would decline by approximately half, or $2.5 to $4.0 million. Sediment characterization is on-going by the EB/SCWG that will allow for a more definitive cost estimate.

Based on the modeling and monitoring, there will likely be at least one area (Hidden Lake), where DO levels of 5.0 mg/L may not be achieved every year. It is recommended that the Churchill Woods Dam removal be completed, and subsequent monitoring be completed before proceeding with any additional project to address low flow DO levels. The location of the minimum DO may shift somewhat once Churchill Woods Dam is removed.

2 PROJECT BACKGROUND AND GOALS

Between 1992 and 1998, the East Branch of the DuPage River (East Branch) was listed on the Section 303(d) List of Impaired Waters by the Illinois Environmental Protection Agency (IEPA) as impaired for a number of water-borne pollutants including nutrients, low dissolved oxygen, and chlorides. In October 2004, Total Maximum Daily Loadings (TMDLs) for this stream were completed by the Illinois Environmental Protection Agency and approved by the United States Environmental Protection Agency (EPA). The TMDL report developed for the East Branch includes a discussion of the potential for improving stream dissolved oxygen (DO) by removing existing dams and/or by constructing and operating an in-stream aeration program. Two principle dams exist on the East Branch of the DuPage River. One dam is at Crescent Boulevard, known as Churchill Woods Dam, and the second structure is located at the confluence of Prentiss Creek and the East Branch.

Since the publication of the TMDL reports, a group of communities, publicly owned treatment works (POTWs), and environmental organizations formed the DuPage River Salt Creek Workgroup (DRSCW) to better understand the causes of degraded water quality and, in particular, to find ways to improve DO levels in the East Branch.

2.1 Project Goal

The goal of this study is to evaluate alternatives available to meet the dissolved oxygen water quality standard on the East Branch of the DuPage River. Preferred alternatives will be those that will have the greatest stream benefit and can be readily implemented.

This study was initiated to identify:

1. Criteria for selecting technologies appropriate for various sites where stream aeration could be used to improve DO levels during low flow conditions.
2. The impact the two dams are having on DO, and where significant, identify appropriate project(s) for specific dam sites, i.e., complete removal, ‘bridging,’ or some other modification that meets project goals while addressing applicable concerns.
3. Potential sites where stream aeration equipment would provide an opportunity to raise stream DO to levels where water quality standards would be achieved during low flow periods.
4. Applicability of alternative technologies available to provide stream aeration, such as mechanical, diffused air, side-stream elevated pool aeration (SEPA), and high purity oxygen injection (either in-stream or side-stream).
5. Permitting authorities, required permits, and regulatory issues.
6. Environmental impact on water quality and stream habitat, in addition to secondary impacts and other community issues such as adjacent land use.
7. Financial impacts, including project capital costs (including sediment removal and disposal costs), operation and maintenance needs, and costs associated with stream improvement projects (life cycle depreciation costs).
8. Dam owners and nearby landowners affected by stream improvement projects, along with their interest in accommodating such a project, and a description of the social impacts of stream improvement projects.

9. Adjacent associated construction needed as part of stream improvement projects (e.g., upstream and downstream stream bank improvements that would be necessary due to altered water levels, adjacent equipment, electrical feed, and equipment access for maintenance).
10. Potential sources of funding for projects, including federal, state, local and private entities.
11. Other aspects of stream improvement projects that may impact the feasibility of such a project.

2.2 Water Quality Standards

On January 24, 2008, the Illinois Pollution Control Board (IPCB) adopted a revised DO water quality standard for general use waterways. This standard is summarized in Table 2-1.

Low DO levels occur in the East Branch during prolonged hot, dry low-flow periods.[1] As the water temperature rises, the minimum daily DO values typically fall. From a practical perspective, any solution must take into account the prolonged hot, dry periods that can occur in June and July when more restrictive (higher) water quality DO standards apply. Based on in-stream monitoring, the minimum DO of 5.0 mg/L, as set by the IPCB, will be more difficult to achieve than the 6.0 mg/L daily mean, as photosynthesis will increase DO levels during the daylight hours well above 6.0 mg/L. Therefore, for the purposes of this report, the minimum DO of 5.0 mg/L will be the basis for evaluating alternative approaches of dissolved oxygen improvements on the East Branch.

Table 2-1 - IPCB DO Standards

Measurement Interval	**DO Water Quality Standard**	
	August – February	March – July
At any time	3.5 mg/L	5.0 mg/L
7 day average	4.0 mg/L Daily Min Average	6.0 mg/L Daily Mean
30 day average	5.5 mg/L Daily Mean	n/a

[1] This study is limited to low flow periods. Low DO levels have also been noted during high flow periods.

3 EXISTING CONDITIONS

Before evaluating alternatives for improving the DO on the East Branch of the DuPage River, it is important to understand the existing stream characteristics. Factors such as stream depth, canopy cover, sediment accumulation, stream bank erosion, riparian zone composition, wetlands, stream slope, bank heights, point source inputs, and flow data are all important during the alternative development and evaluation process, and are defined in this section.

3.1 Geomorphic Assessments

Streams are in constant dynamic equilibrium. Although it can be imperceptible over years or even decades, a stream in equilibrium moves within its floodplain both laterally and vertically over long periods of time. A channel can be in balance with the hydrologic and sediment influences or can be in rapid transition as a result of changes in the watershed or within the stream corridor.

Urban river systems are often in various states of disequilibrium. The development of Chicago area watersheds has significantly increased the intensity of land use. The impact of urbanization on stream systems is well documented and includes changes in the hydrology, water quality, sediment supply, and ecology. Other impacts include isolation from and reduction of, available floodplain capacity, and installation of road crossings and other lateral and vertical controls. Urbanization can significantly increase stream instability, as shown in Table 3-1.

Table 3-1 - Impacts of Urbanization on Channel Stability

Instability Description	Probable Cause
Increase in erosive energy of stream	Channel Straightening – sinuous and low gradient streams become straight and steeper
Increase in velocity	Larger discharge rates due to impervious cover, culverts, drain tiles, and storm sewers
Decrease in in-stream channel roughness	Removal of riparian vegetation and in-stream woody debris
Decrease in amount and character of incoming bed load	There is more energy to move bed material than there is available bed material due to impervious cover and channel armoring
Change in geotechnical loading characteristics of the banks	Alteration of baseflow, as well as periods, levels, and timing of saturation
Change in riparian management	Deforestation and turf grass changes

3.1.1 Channel Evolution

Schumm (1984) describes the evolution of degraded channels in arid and central plains streams, and these basic principles apply to urban channels as well. The Schumm system classifies streams by their place along a continuum of channel evolution, typically initiated by channel incision (Figure 3-1), a process commonly occurring in urban and agricultural areas following channelization. As a stream's slope is increased through straightening (Stage II), the increased shear forces cause bed material to displace and a small nickpoint or waterfall develops at the downstream end of the reach. This nickpoint travels upstream until a stable, lower grade is reached. This process is followed by lateral bank erosion and formation of a new, inset floodplain (Stages III-IV). The former floodplain is abandoned during runoff events and flow is confined to the new channel and floodplain. The old floodplain surface becomes an upland terrace. The stream achieves ultimate stability at a new channel elevation (Stage V).

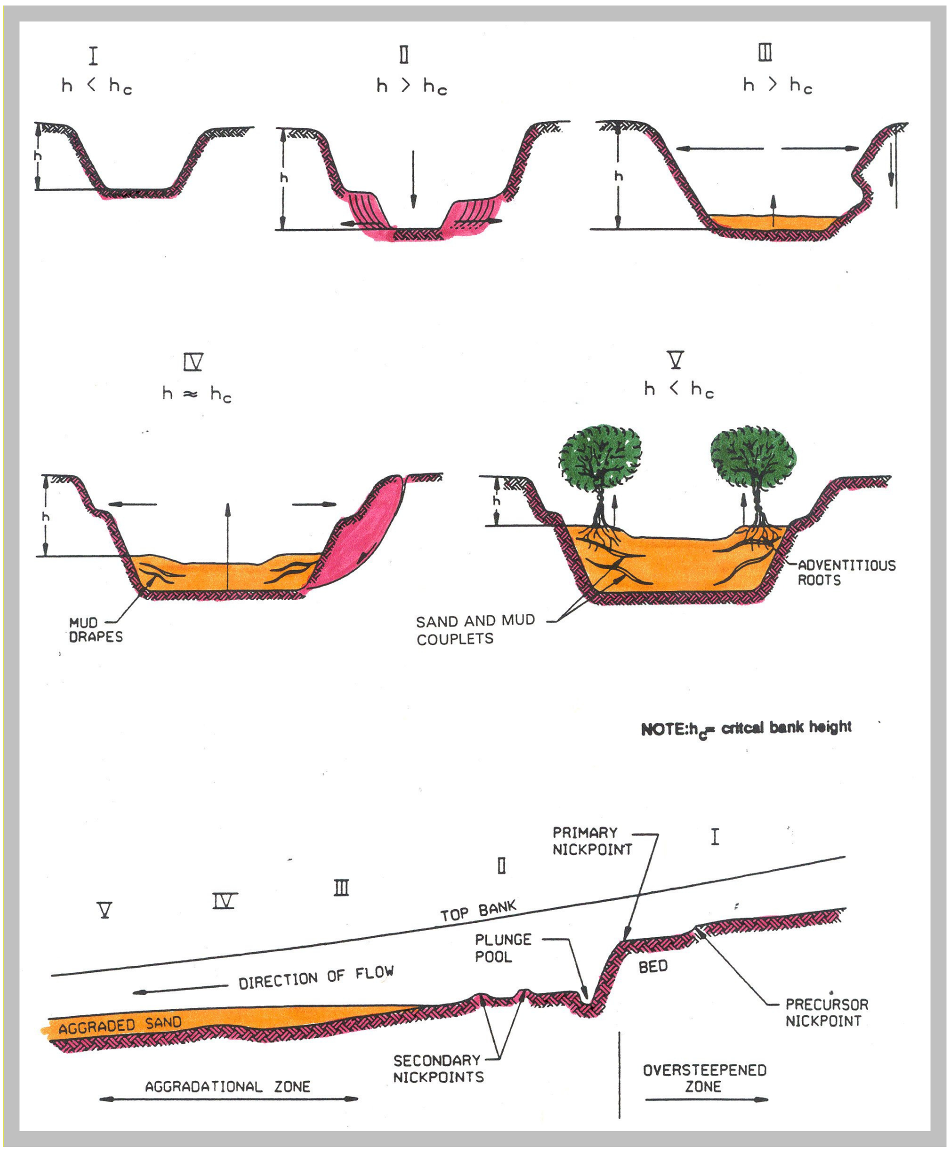

Figure 3-1 - Channel Evolution Model (Schumm 1984)

3.1.2 Bank Erosion

Bank erosion is part of the natural processes within a stable stream and is balanced by deposition of sediment on floodplains and bars. Erosion provides the needed bed material, allows recruitment of large woody debris, and encourages channel variability. However, 'excess' bank failure associated with unstable riverine systems and massive failures that threaten existing infrastructure can cause unacceptable environmental impacts and consequences to private and public resources. Bank failure can generally be attributed to three basic processes: subarial wasting, hydraulic scour, and mass failure. (Thorne, et al., 1997). Subarial wasting is not considered to be the major driving force for Midwestern urban streambank instability and is not discussed further.

The common result of urbanization is a significant increase in bank erosion due to hydraulic scour of the channel bed and toe of the bank. When changes in land use result in increased water velocity, streams begin to erode their bed and banks beyond the point of equilibrium. Excess hydraulic scour generally can be addressed in two ways, either by reducing channel velocity and thereby reducing erosive force, or by armoring the channel to resist the erosive force. Reduction of channel velocity can be accomplished either by increasing the cross-sectional area of the channel, increasing the capacity of the channel and/or floodplain, decreasing flow rates, or modifying slope through the use of grade controls. Following incision, as noted in the Schumm (1984) model above, hydraulic scour combined with mass failure can lead to extreme bank erosion.

Mass failure of the streambank is often the result of increased hydraulic scour, and/or a change in riparian vegetation management associated with urbanization. There are numerous bank failure mechanisms due to various loading and resistant conditions, including differences in soil characteristics and vegetative reinforcement. Streambank soils can vary both vertically and horizontally, and can generally be classified as cohesive, non-cohesive, and composite (banks with layers of soil that have significantly different characteristics). Each of these types of streambank soils presents different engineering challenges and different solutions. The equilibrium processes of scouring and deposition of soil layers within an alluvial valley can provide significant variability in the soil conditions within the valley. Hence, the type of bank material can change significantly along a stream length as the stream passes through different depositional eras.

Common measures to address mass failure of streambanks include decreasing the load by reducing bank height, reducing bank slope, providing subsurface drainage or planting stabilizing vegetation (to reduce pore pressure), and/or increasing the resistance to failure by geosynthetic reinforcement with revegetation.

3.1.3 Sediment Transport

Understanding sediment transport characteristics of a stream is very important in understanding stream stability and characteristics. Alluvial streams within urbanizing watersheds frequently experience rapid channel enlargement. Channel response to urbanization has been described by Leopold (1964), Hammer (1972), and numerous others. During the initial wave of construction in a basin, sediment loads reaching the stream from the watershed may increase 10 to 100 times, resulting in attendant destabilization, and sometimes flooding damages. Typically, high sediment yields during the construction phase are followed by reduced yields once infrastructure and storm sewer systems are fully constructed (Kondolf and Keller, 1991). However, as the percentage of the watershed covered by impervious materials increases, flow peaks become sharper, higher, and more frequent, while the sediment load reaching the channel declines.

In the absence of bed control (e.g. bedrock outcrops in natural channels or hardened stream crossings in urbanized areas), channels typically respond by incising. When bank heights exceed a critical threshold for geotechnical stability, mass failure ensues and explosive channel widening occurs. Sediment supply is altered by local and upstream bank failure, and upstream modifications. Transport capacity is altered by channel widening, meander cutoffs, and construction of additional crossings. These changes can make a reach aggrading, in equilibrium, and degrading over time.

Sediment transport continuity describes the ability of a stream reach to transport the sediment that it receives from upstream sources. A stream reach is considered to be in equilibrium if it can transport the sediment it receives within the reach and from upstream sources to downstream reaches. A reach is considered to be degrading if its transport capacity exceeds the sediment supply and aggrading if the supply exceeds the transport capacity.

3.1.4 Geomorphic Disturbances

Almost all geomorphic disturbances in urban streams can be attributed to human causes. The human-induced impacts to the East Branch include: tributary manipulation (piping, ditching), channelization, hard armoring, dams, road crossings, berms, direct discharge/hydrologic change, floodplain filling, riparian canopy removal, impervious surface coverage, and floodplain pond construction.

3.2 Stream Characterization

In general, the East Branch can be characterized as an urban stream with low gradients and extensive channelization. Canopy cover in the assessed stretches is limited due to development, resulting in higher summer stream temperatures and establishment of rooted vegetation within the stream bed. Contributions from point sources, including municipal wastewater treatment plant effluents are also significant, contributing phosphorus which may contribute to plant growth[2], but also provide higher flows during low flow and overall cooler temperatures.

The IEPA has assessed the East Branch as partial support (the water body is supporting some, but not all of its designated uses) for four of the five segments (GBL 05, GBL 10, GBL 08, and GBL 11) used to evaluate the East Branch (IEPA, 2004). Segment GBL 02 has been assessed as full support and is the last segment of the East Branch before the confluence with the West Branch. Identified causes of the less than full use support assessment include dissolved oxygen, chlorides, total nitrogen, habitat and flow alterations, suspended solids, phosphorous, sedimentation/siltation, algal growth, and fecal coliform. The sources contributing to impairment include municipal point sources, runoff and storm sewers, development, stream modifications, and upstream impoundments.

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[2] Even without the phosphorus contribution from the POTWs, phosphorus levels within the East Branch would be sufficient such that it would not be the limiting factor in plant growth. Additional phosphorus reductions would be necessary from other sources.

To describe the existing stream conditions, various data were collected, including point source discharges, stream flow data, stream habitat components, and reach characteristics.

3.3 Flow Data

The East Branch originates near Bloomingdale, Illinois. The East Branch flows approximately 25 miles through DuPage County and the north part of Will County before merging with the West Branch of the DuPage River (West Branch) (Healy, R. 1979). The stream becomes the DuPage River at the confluence in Bolingbrook, Illinois. The East Branch drainage area is approximately 79 square miles (CH2MHill, 2004).

Eight sewage treatment plants (STPs) and two industrial user discharges into the East Branch. These point source dischargers are presented in Table 3-2. Lombard maintains three combined sewer overflows (CSOs) within the watershed. Selected stream flows from the East Branch are listed in Table 3-3.

Table 3-2 - Point Source Discharges

Discharger	River Mile From Confluence with West Branch
Elmhurst Chicago Stone	Not Provided
Illinois-American #2 Sewage Treatment Plant	2.8
Quarry discharge	6.4
Bolingbrook Sewage Treatment Plant #1	5.5
DuPage County Woodridge Sewage Treatment Plant	7.5
Downers Grove Sanitary District Wastewater Treatment Plant	11.5
Glenbard Wastewater Authority - Glenbard	15.9
Glenbard Wastewater Authority - Lombard	18.8
Glendale Heights Sewage Treatment Plant (Armitage Creek)	21.2
Bloomingdale-Reeves Water Reclamation Facility	23.7

Table 3-3 - Published River Flows (Singh, and Ramanurthy, 1991)

Location	7-Day 10-Year Low Flow (cfs)	Harmonic Mean Flow (cfs)
Crescent Boulevard	4.0	13
Above Glenbard Wastewater Authority - Glenbard	3.6	33
Below Downers Grove Sanitary District	23.6	54
Above Woodridge	25.6	61
Before confluence	38.0	78

3.4 Reach Descriptions

To identify East Branch segments with DO impairment, results from previously conducted dissolved oxygen sampling were reviewed. Data collected from the Lisle sampling station during a DO study in June and September, 1997 indicated low DO beginning at approximately RM 8 and extending to RM 24. Based on this information, a field reconnaissance beginning at St. Charles Road (RM 19.9) and ending at RM 5.7, where a public boat access was available, was conducted on October 14, 2005.

The IEPA Qualitative Stream Habitat Assessment Procedure (SHAP) was utilized to describe each stream segment based on the observations collected during the reconnaissance. The SHAP index includes factors for bottom substrate, deposition, substrate stability, in-stream cover, pool substrate characterization, pool quality, pool variability, canopy cover, bank vegetation, top of bank land use, flow-related refugia, channel alteration and sinuosity, width/depth ratio, and hydrologic diversity. Table 3-4 presents the relative ratings of the possible SHAP scores.

Based on the subjective evaluation for the aforementioned factors, a SHAP score was determined.

Table 3-4 - SHAP Ratings (IEPA, 1994)

Rating	SHAP Score
Excellent	$\geq$ 142
Good	141 to 100
Fair	99 to 59
Poor	< 59

Channelization, lack of canopy cover, sediment oxygen demands, effluent dominated low flows, nutrient loading, and other factors can all contribute to the vegetative growth and subsequently lower early morning DO levels.

Generally, the East Branch has been highly channelized through developed areas of DuPage County. The stream banks are approximately three to six feet high for most of the stream length, with the exception of the few areas where the channel flows into a detention pond or wide stream reach. Stream flow velocity is generally slow moving with a few sections where the flow is restricted due to structures. A description of the stream reaches, specific information for the observed segments, and SHAP scores are presented below.

St. Charles Road (RM 19.9) to Crescent Boulevard (RM 18.8)

This 1.1-mile segment is located in Churchill Woods, an area owned and managed by the Forest Preserve District of DuPage County. The stream overbank areas are generally undeveloped with the exception of the picnic areas and parking within the forest preserve. The Churchill Woods Forest Preserve segment of the East Branch is an impoundment area created by the spillway of the Churchill Woods Dam at Crescent Boulevard.

The East Branch within the Churchill Woods Forest Preserve is approximately 500 feet wide and has created a series of islands within the center of the flow pattern. Water depths range from one to four feet with the deeper portions immediately upstream of the impoundment. The stream channel substrate leading to the open water habitat is silty sand which turns to soft sediment in the open water areas. The depth of the soft sediment is greater than two feet in most areas.

Streambank stabilization has been conducted in several areas along the banks in the Forest Preserve area. There is good riparian habitat in this area. The combined SHAP score for this segment and the next segment is 90 indicating a fair habitat quality. Mallards and shorebirds were observed in this area as were recreational fisherman.

Crescent Boulevard (RM 18.8) to Illinois Route 53 (RM 17.4)

This segment of the East Branch is immediately downstream of the impoundment area in the Churchill Woods Forest Preserve. Similar to most of the East Branch, this segment is channelized, with Interstate Route 355 on the east side and a golf course and residential development on the west side. There is poor streambank riparian habitat with little canopy cover. The SHAP score for this segment was developed with the previous 1.1 mile segment of the East Branch and is 89 indicating a fair habitat quality.

The water depth in this segment ranged from six inches to two feet. Two rock dams were observed near the upstream end of this segment with a riffle area downstream of the second rock dam. A second riffle area was observed at the downstream end of this segment near Illinois Route 53. The substrate was generally silty/sandy gravel with cobbles and boulders in the riffle areas.

The Glenbard Wastewater Authority Sewage Treatment Plant discharges to the East Branch at RM 18.8, just on the south side of Crescent Boulevard. Immediately downstream of the plant outfall is a concrete-lined channel which outlets to the East Branch from the east. Vegetation is growing through cracks in the concrete. A sewer outlet was also observed at RM 17.8 originating from under Roslyn Road on the west side of the East Branch.

Illinois Route 53 (RM 17.4) to Illinois Route 56 (RM 14.8)

This 2.6-mile segment of the East Branch has residential development on both the east and west side. Interstate Route 355 is east of and parallel to the stream at the north side of the segment. The Western Springs Golf Course is located north of Illinois Route 56 at the south end of the segment.

Five wet detention basins have been constructed along this segment of the East Branch. Due to the proximity of the ponds to the East Branch channel, the East Branch stream flow has created a direct hydraulic connection between the stream channel and some of the ponds. The main stream flow now travels through the detention pond immediately north of Illinois Route 38, as well as the detention pond between RM 16.3 and RM 16.5.

Water depth in this segment varies between less than 6 inches deep to 4 feet deep. The deeper portions are within the detention ponds and immediately downstream of the log jam located in the channel just north of Illinois Route 38 (RM 16.9). Beaver activity was noted along this segment. Water depths were shallow in the channel areas partially abandoned due to the flow alteration into the detention ponds. Substrate consisted of sand and gravel with some silt for most of the channel areas. The pond areas consisted of soft sediment up to 1.5 feet deep.

The SHAP score for this segment is 90 indicating fair quality. Poor canopy cover along the segment reduces the score as does the level of stream channelization. Beaver activity was observed along with mallards and a kingfisher.

A structure which blocks approximately half the stream channel was encountered at RM 16.6. The center portion of the structure had collapsed allowing the stream flow to continue. A riffle area was observed immediately downstream of the structure and near Illinois Route 56. The Glenbard Wastewater Authority – Glenbard Sewage Treatment Plant is located along this segment at RM 15.9.

Illinois Route 56 (RM 14.8) to Interstate Route 88 (RM 12.3)

This 2.5-mile segment of the East Branch includes residential development west of the East Branch and the undeveloped areas of the Morton Arboretum. Illinois Route 53 parallels the East Branch on the west from Illinois Route 56 (RM 14.8) to Illinois Route 53 (RM 13.0). The East Branch channel is within the Morton Arboretum property for most of this segment.

South of Illinois Route 56 the East Branch becomes wider as it passes through the Hidden Lake Forest Preserve. This stretch includes a poorly defined channel and is approximately 300 to 400 feet wide in some areas. Water depth is less than six inches in most places with up to eighteen inches of soft sediment. Mussels were observed in this area of the stream. Downstream, the stream has been channelized with fair canopy cover. Water depth varied between six inches and four feet with substrate consisting of sandy silt and gravel.

The SHAP score is 83 indicating fair habitat. Trash and debris were noted throughout the segment in proximity to Illinois Route 53. A large log jam was encountered at approximately

RM 13.8. Several riffles occurred just upstream of Interstate Route 88. A great blue heron was observed along this segment.

Interstate Route 88 (RM 12.3) to Maple Avenue (RM 10.8)

This 1.5-mile segment of the East Branch is a combination of residential areas and open space, mainly the Lisle Community Park. Downstream of Interstate Route 88 is a rock dam with water depths of three feet to four feet on either side of the dam. The remainder of the segment ranges in depth from six inches to two feet. The substrate is generally sand, gravel and cobble. An outfall pipe was observed on the downstream side of the railroad bridge at RM 11.4 on the east bank.

The SHAP score for this segment is 81 indicating fair habitat quality. There is poor canopy cover due to stream width and development along the stream banks.

Maple Avenue (RM 10.8) to Hobson Road (RM 8.7)

This 2.1-mile segment of the East Branch has been developed residentially and includes the River Bend Golf Course and the Seven Bridges Golf Course. Water depths range from six inches to four feet deep near the downstream end of the segment near where Prentiss Creek enters the East Branch. The Prentiss Creek dam is located on the East Branch and also spans the mouth of Prentiss Creek. Substrate is sand and gravel with silt. An old bridge structure is located on the upstream side of the Hobson Road bridge, which restricts flow in this area.

The SHAP score for this segment is 89 indicating fair habitat quality. Very little canopy was observed. Riffles had been created in the segment within the Seven Bridges Golf Course and several large boulders were placed within the stream. Mussels were observed downstream of the riffles.

Hobson Road (RM 8.7) to Access Point (RM 5.7)

This three mile segment of the East Branch is generally undeveloped and is within the Greene Valley Forest Preserve. A large amount of trash was observed in this segment, especially near the bridges. Water depths range from six inches to four feet with substrate consisting of fine sediment and gravel. A log jam was encountered at RM 7.2.

The DuPage County Woodridge STP is located at RM 7.5 and discharges to a side stream of the East Branch. A quarry operation is also located near the downstream end of this segment from approximately RM 6.7 to RM 4.1. Two outlet pipes with no flow and a submerged inlet pipe to the quarry were observed near RM 6.4.

The SHAP score for this segment is 96 indicating fair habitat quality. There is poor canopy cover along this segment of the East Branch and several areas of bank erosion were observed.

3.5 Habitat Summary

The SHAP scores and the habitat conditions for each segment are summarized in Table 3-5, beginning at St. Charles Road and proceeding south.

Table 3-5 - SHAP Scores

Stream Reach	Assessment Score SHAP	Limiting Habitat Conditions
St Charles Road to Crescent Boulevard RM 19.9 – RM 18.8	90 (Fair)	-
Crescent Boulevard to Illinois Route 53 RM 18.8 – RM 17.4	89 (Fair)	Lack of canopy (over channelized)
Illinois Route 53 to Illinois Route 56 RM 17.4 – RM 14.8	90 (Fair)	Poor riparian area/canopy (over channelized)
Illinois Route 56 to Interstate 88 RM 14.8 – RM 12.3	83 (Fair)	Channelized
Interstate 88 to Maple Avenue RM 12.3 – RM 10.8	81 (Fair)	Poor riparian area, canopy cover
Maple Avenue to Hobson Road RM 10.8 – RM 8.7	89 (Fair)	Poor canopy cover
Hobson Road to Access Point RM 8.7 – RM 5.7	96 (Fair)	Poor canopy cover/stream bank stabilization

In addition, the qualitative habitat evaluation index (QHEI) was determined at eight locations on the East Branch. The QHEI provides a quantitative assessment of physical characteristics of a stream and represents a measure of in-stream geography. The maximum total QHEI score is 100, and is broken down in Table 3-6. The East Branch QHEI scores by river mile are shown in Table 3-7.

Table 3-6 - Qualitative Habitat Evaluation Index (Rankin, 1989)

QHEI Component	Point Value
Substrate type and quality	20
In-stream cover type and amount	20
Channel morphology – sinuosity, development, channelization stability	20
Riparian zone – width, quality, bank erosion	10
Pool quality – maximum depth, morphology, current	12
Riffle quality – depth, substrate stability, substrate embeddedness	8
Map gradient	10

Table 3-7 - QHEI Scores by River Mile

River Mile	Location	QHEI Score
22.00	6385 ft downstream of Army Trail Road	43.0
20.50	1936 ft downstream of North Avenue	35.0
17.30	471 ft downstream of IL-53	48.0
11.85	119 ft upstream of Lacey Avenue	35.0
11.10	88 ft downstream of Short Street	39.0
8.46	1484 ft downstream of Hobson Road	46.0
5.15	3138 ft downstream of Royce Road (Will County)	43.0
2.60	4908 ft upstream of Naperville Road (Will County)	56.5

3.6 Dam Site Investigations

Removal or reconfiguration of dams has the potential to increase dissolved oxygen in waterways. The two dams were investigated to gain an understanding of their characteristics. The names, locations, and river miles (based on the GIS model) of the two dams on the East Branch are listed in Table 3-8.

Table 3-8 - River Dam Information

Name	Year Built	River Mile	Bounding Bridges		Nearest Town
			Upstream	Downstream	
Churchill Woods Dam	~1930	18.9	St. Charles Road	Crescent Boulevard	Lombard
Prentiss Creek / EB DuPage Dam(s)	1989	8.75	Summerhill Drive	Hobson Road	Woodridge

3.6.1 East Branch DuPage / Prentiss Creek Dams

The Prentiss Creek Dams are owned by the Village of Woodridge and were constructed in 1989 as stormwater storage and mitigation for the Seven Bridges Development. The system includes a dam across the East Branch, and another across the mouth of Prentiss Creek. Further up Prentiss Creek, three grade control weirs provide additional stormwater storage up to the intersection of Illinois Route 53. The dams are gravity structures consisting of rock-filled gabions covered by a concrete cap. The structure within the East Branch is 20 ft. wide at a weir elevation of 643.5 ft. while the Prentiss Creek structure is 10.1 ft. wide at an elevation of 646.0 ft. There is no upstream control mechanism for regulating upstream pool elevations.

There is little sediment being deposited within the East Branch DuPage River upstream of the dam: however, there is fair amount of fine material that has settled upstream of the Prentiss Creek structure. A total of seven cross sections were evaluated through the Prentiss Creek backwaters.

Hydraulic Impacts: The project was designed to provide regional stormwater storage and compensatory mitigation for the associated development. The impact at a range of flood events is unknown.

Figure 3-2 - Prentiss Creek Dam

3.6.2 Churchill Woods Dam

The Churchill Woods Dam is located just upstream of Crescent Avenue and is owned by the Forest Preserve District of DuPage County. Little historical documentation could be found relating to this dam. Residents in the area mentioned it was built during the Works Progress Administration (WPA) in the 1930's as a flood control project. Significant improvements were made to the structure as part of the Crescent Boulevard reconstruction in 1983.

The Churchill Woods Dam is a concrete gravity dam about 3.5 feet high with a 50-feet wide weir crest. The dam appears to be in good condition, as do the associated four box culvert structures that take water under Crescent Boulevard. The spillway and apron are in good condition and show signs of normal weathering and associated maintenance. There is a dewatering gate on the west end of the spillway. The dam is depicted in Figure 3-3.

The Churchill Woods Dam reservoir contains a large amount of sediment largely due to the low gradient and wide, shallow channel path. The profile shown in Figure 3-4 indicates nearly four feet of material consistently blanketing the bed of the reservoir. A number of areas have as much as eight feet of deposited material. The sediment is mostly composed of fine material (silts and clays) and is fairly consolidated in areas where it is greater than three feet in depth. Coarse (small gravel) depositional features were found approximately 1,000 feet upstream of the St. Charles Road Bridge, indicating this may be the extent of the delta formed as a result of the impoundment.

Figure 3-3 - Churchill Woods Dam

The hydraulic impact of the Churchill Woods structure is likely minimal, especially for larger flows. More interesting from a hydraulic perspective is the existing configuration of the dam, the four culverts under Crescent Boulevard, and the two stone arches under the railroad.

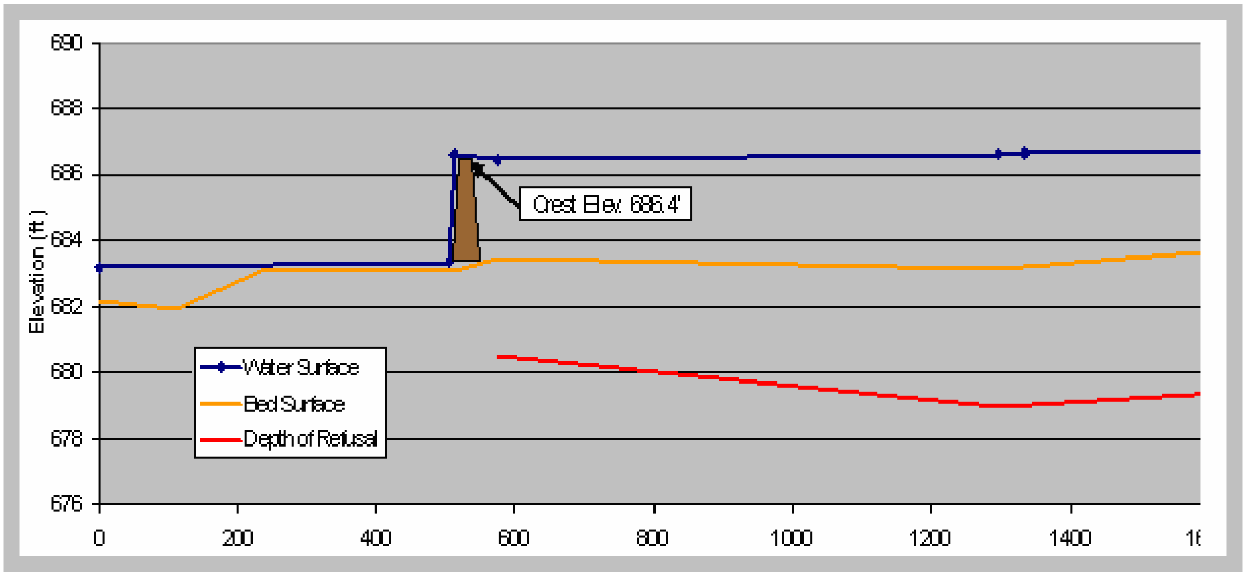

Figure 3-4 - Water Surface Profile at Churchill Woods Dam

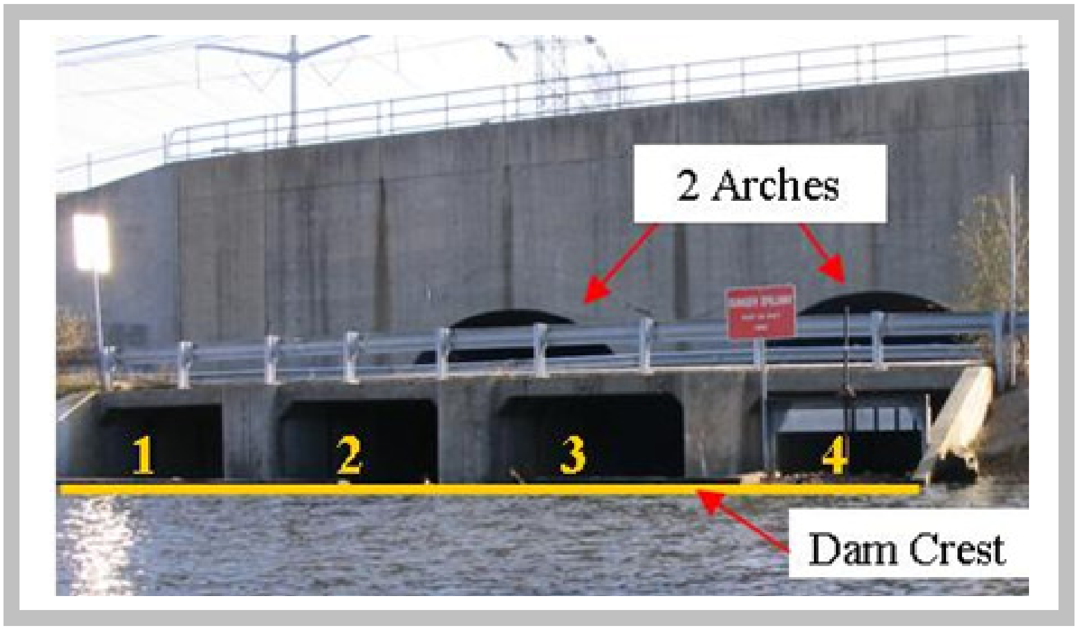

Figure 3-5 - Dam Outlet Structure

3.7 Sediment Oxygen Demand (SOD) Field Measurements

Field data were collected in the summer of 2006 to provide an estimate of the sediment oxygen demand (SOD) in the East Branch of the DuPage River. These data provided independent, empirical estimates of the SOD that were being modeled for dissolved oxygen as described in Section 4. It was concluded during the modeling analysis of stream DO improvement alternatives, that more SOD data in the vicinity of dams were needed to better understand the effects of potential dam removals. The survey was conducted at SOD stations at the locations described in Table 3-9. The field surveys were performed concurrently with the continuous DO monitoring. As water temperature affects SOD, the SOD survey period was completed during higher water temperatures to minimize temperature adjustments. The locations of the SOD sites and of the DO probes can be viewed in Figure 3-6.

Table 3-9 - SOD Survey Locations

Station ID	River Mile	Location
EB1	19.9	Upstream of St. Charles Road
EB2	19.1	Churchill Woods Dam
EB3	18.9	Churchill Woods at Crescent Boulevard
EB4	16.9	Just north of Route 38 (Roosevelt Road)
EB5	16.3	At outflow of detention pond, downstream of Route 38
EB6	14.8	300 feet upstream (north) of Butterfield Road (on east side of stream)
EB7	14.7	50 feet south of Butterfield Road
EB8	8.8	At Hobson Road

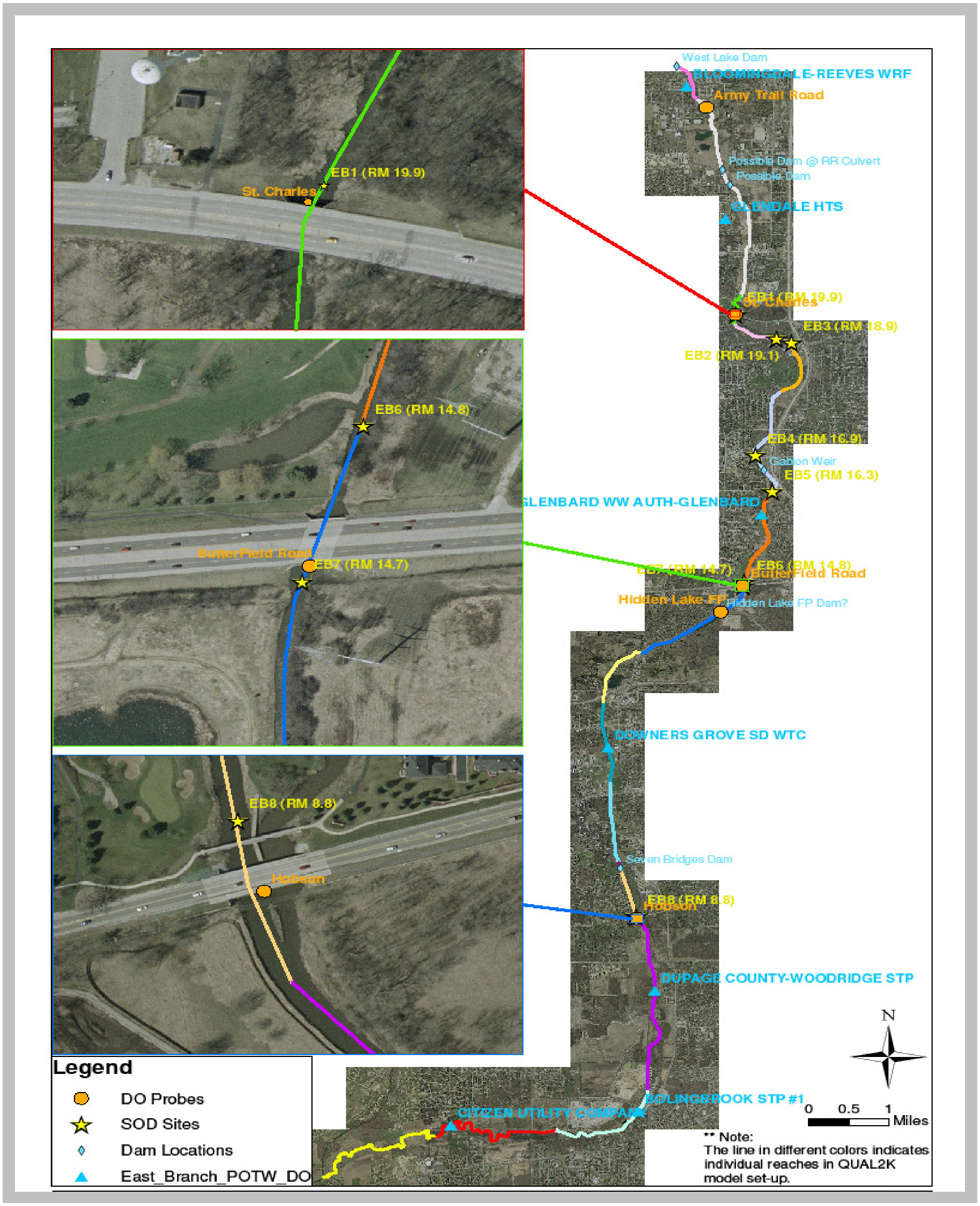

Figure 3-6 – SOD Location Map

3.7.1 FINDINGS

The SOD measured at ambient temperature in the East Branch ranged from a minimum of 0.67 $g/m^2/day$ to a maximum of 9.53 $g/m^2/day$. Station-averaged 20^oC-temperature adjusted SOD values were in the range of 1.13 to 3.61 $g/m^2/day$. The temperature standardized 20^oC SOD rates used in the preliminary QUAL2K modeling were in the range from 1.0 to 2.5 $g/m^2/day$.

The results of the SOD survey were used to examine the model calibration/verification particularly in the reaches adjacent to the dams. The refined model was then used to evaluate the DO improvement alternatives.

3.8 Continuous Dissolved Oxygen Monitoring

Continuous monitoring for dissolved oxygen values in the East Branch has been performed by the DRSCW and IEPA during 2006 and 2007. Stream monitoring data have been collected at six locations on the East Branch from April to October. Parameters included dissolved oxygen, temperature, pH, and conductivity.

All DO data was collected according to the Quality Assurance Project Plan (QAPP) agreed upon by the IEPA and the DRSCW. Calibration of the probes for the other parameters listed was carried out according to the manufacturerer's recommendations and the QAPP.

One site (EBSC) was abandoned in early 2007 after a build up of debris around the protective housing caused the sonde to be exposed to air. A new site (East Branch Churchill Woods (EBCW) was opened up just downstream of the abandoned site. The EBCW sampling location is within the impoundment of the Churchill Woods Dam just upstream of Crescent Boulevard. No data were produced meeting the outlined QAPP standards for the EBSC site. Table 3-10 catalogs the monitoring locations and Figure 3-7 displays the monitoring locations.

Appendix A includes a summary of the continuous DO data collected in 2006 and 2007. At the sites monitored both years, 2007 showed a greater DO flux (maximum minus minimum DO), suggesting more algal or rooted plant activity in that year. At Hidden Lake (RM 14.2), minimum DO in 2007 during a low flow period averaged 4.0 mg/L, compared to 5.9 mg/L the previous year.

Figure 3-7 - Continuous DO Monitoring Locations 2007

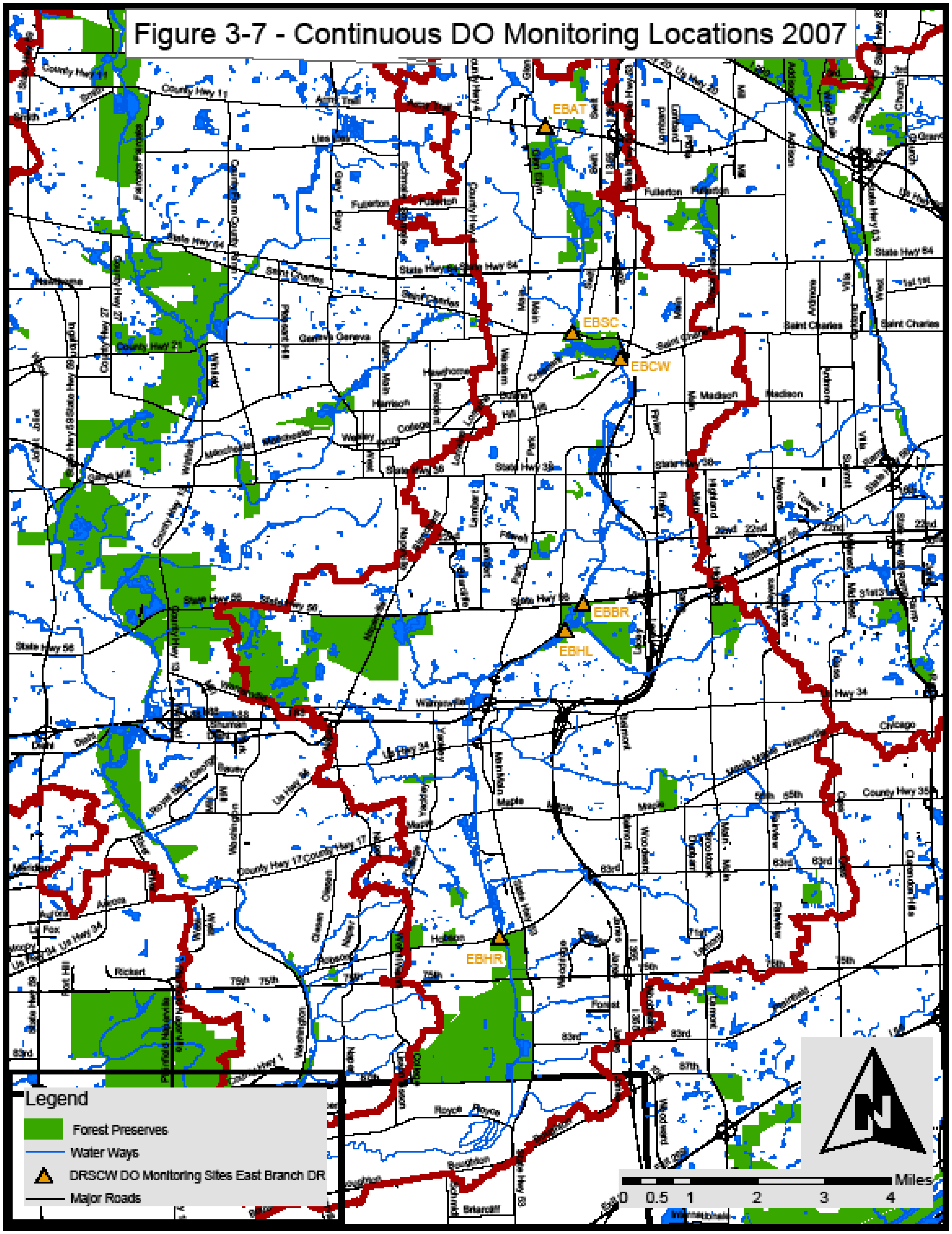

Table 3-10 - DO Monitoring Locations

Station	Location	Crossroad	Steward	Parameters
EBAT	Unincorporated Bloomingdale	Army Trail Road	Bloomingdale	DO, Temperature pH, Conductivity
EBCW	Glen Ellyn	Crescent Blvd	Glenbard WWA	DO Temperature, pH, Conductivity
EBBR	Unincorporated Downers Grove	Butterfield Road	Downers Grove Sanitary District	DO, Temperature, pH, Conductivity
EBHL	Unincorporated Downers Grove	Hidden Lake Forest Preserve	DuPage County Wastewater	DO, Temperature, pH, Conductivity
EBHR	Unincorporated Woodridge	Hobson Road	Downers Grove Sanitary District	DO, Temperature, pH, Conductivity

3.9 SUMMARY

The East Branch DuPage River is characterized in the upper reaches as being channelized and incised, having long stable ditched sections that are aggraded, having long reaches impounded by dams, having floodplains that are heavily encroached upon by residential development, golf courses, and detention pond storage. The channelization affects a large percentage of the East Branch. For example, the river is nearly completely straight from RM 7.0 to RM 14.0. Of the 25 miles assessed in this project, only the downstream 4.0 miles have any significant meanders remaining.

The East Branch of the DuPage River is a highly disturbed urban stream with low channel gradients and extensive channelization. Floodplains for the tributary stream and main channel were either filled in or separated from waterways by large berms that concentrate flood flows into a deep narrow channel. Floodplain and drainage surfaces are covered by pavement, and water is now directed into sewers and pipes that discharge directly into the creek. Point sources, including municipal wastewater treatment plant effluents, result in higher base flow during low flow periods and higher total phosphorus and total nitrogen. Canopy cover in general is limited, resulting in higher summer stream temperatures and promoting establishment of rooted vegetation. All of these attributes contribute to the low DO levels.

Downstream of RM 8.7, the river is channelized and bordered by either forest, reed canary grass wetland, or abandoned quarry pits. Excellent opportunities for channel restoration exist downstream of RM 8.7, and between RM 20 to RM 23. Remnant meanders exist throughout the Arboretum property, and restoration of a meandering channel could also be completed anywhere along portions between RM 12.0 to RM 19.0.

The continuous DO monitoring results from 2006 and 2007 (Appendix A) indicate that upstream of Churchill Woods (EBCW) DO levels drop to below 2.0 mg/L. This area has the lowest DO monitored on the East Branch of the DuPage River. At River Mile 14.2, Hidden Lake appears to also have DO levels below 4.0 mg/L during some dry weather periods (2007, but not observed in 2006).

4 WATER QUALITY MODELING

To develop the TMDLs for those constituents bound by water quality standards (i.e., DO and chlorides), IEPA used a regulatory water quality model called QUAL2E to analyze two stretches of the East Branch. The analyses were conducted to allocate allowable wasteloads for each pollutant discharger along the stream.

Since those analyses, the QUAL2E model has been updated with a more user-friendly interface and convenient post-processing tools. The updated version of QUAL2E is called QUAL2K and was developed for the USEPA by Steve Chapra, et al., at Tufts University (2005). Model theory, equations, and parameters are described completely in the QUAL2K Users Manual.

The goals of the water quality modeling for this study are to perform a model conversion from QUAL2E to QUAL2K, to validate the new modeling tool, to identify locations where low DO is expected or observed, and to quantitatively evaluate the effects of alternatives to potentially improve DO. These alternatives may include removal and/or bridging of dams, as well as aeration (mechanical, diffused air, side stream elevated pool, and pure oxygen).

Figure 4-1 shows the steps in developing and utilizing a water quality model to evaluate alternatives.

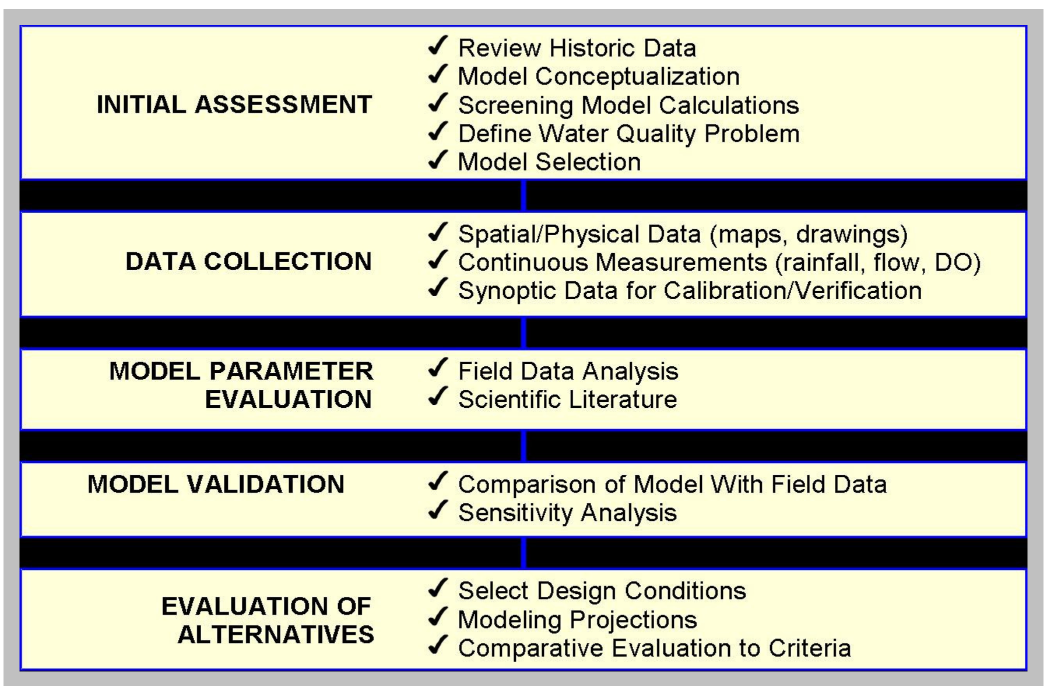

Figure 4-1 - Water Quality Model Development Steps

4.1 Conversion from QUAL2E to QUAL2K Model

Dissolved oxygen is a key indicator of water quality in streams and is of main interest to this project. As pollutant constituents in wastewater discharges demand oxygen through decay reactions, the DO concentration in the stream is consumed. Sediment oxygen demand and respiration of abundant algal life also consume oxygen. DO is restored through reaeration as well as plant photosynthesis during daylight hours. (For a full description of the mechanisms affecting DO, refer to Chapra 2005, Thomann and Mueller 1987, or Chapra 1997.)

The fundamental utility of QUAL2E and QUAL2K is essentially the same; they are one-dimensional, steady-state models to predict DO and associated water quality constituents in rivers and streams. However, QUAL2K has more refined features such as the capability of diurnally varying headwater/meteorological input data and a full sediment diagnosis model to compute SOD and nutrient fluxes from the bottom sediment to the water column. In addition, the QUAL2K model offers more options for decay functions of water quality constituents, reaeration rate equations, heat exchange, and photo-synthetically available solar-radiation calculations.

As the fundamental theoretical underpinnings of both models are similar, the objective of this subtask was to use the input data previously used in QUAL2E and produce QUAL2K outputs that are similar to the results found in the TMDL reports. Since QUAL2E input data files were not available, the listings of input data in the appendices of the TMDL reports were used to prepare the input to QUAL2K. The QUAL2E model set-up was closely followed to reproduce those results by applying QUAL2K instead of QUAL2E. The more refined features in the QUAL2K, described above, were not utilized, at least initially, to adhere to the QUAL2E modeling. Subsequently, independent evaluation of the selection of model formulations and functions and parameter evaluations for the East Branch was conducted.

4.1.1 Model Result Comparisons

The TMDL reports were reviewed to identify sets of input and output data that could be used for comparisons of QUAL2E and QUAL2K. QUAL2E model outputs of DO, CBOD5, and NH3-N were listed in the East Branch TMDL report. These QUAL2E results are compared against QUAL2K outputs. As presented in Figure 4-2, the QUAL2K model reproduced the general trend of DO profiles generated previously with QUAL2E. QUAL2K showed a jump in DO immediately downstream of each of the dams. QUAL2E, which has the same dam re-aeration equation as QUAL2K, did not show an increase in DO at the Churchill Woods dam; this does not appear to be an accurate depiction of what actually occurs, therefore, it was investigated further.

Differences between the two models were investigated to check that the relevant model equations were the same and the model parameter values were equal. A subtle difference between the QUAL2E and QUAL2K formulations of the SOD term in the DO equation was found, and input to the latter was adjusted to accommodate this difference. The values of SOD at $20^{o}C$ were input into QUAL2E and adjusted by the model calculations to ambient temperature based on a temperature correction factor. In contrast to this, the "prescribed SOD" input to QUAL2K is not temperature corrected internally, so the factor was applied external to the model to adjust the SOD input to the ambient temperature. The models differed slightly in the input relating to the height of water falling at a dam; QUAL2K input was adjusted to yield the same value as QUAL2E for the dams. The coefficients in the dam re-aeration equation in QUAL2K are set by the model developers whereas these coefficients can be specified as input in QUAL2E. Although there was a difference in the values of one of these two coefficients, it does not appear to substantially affect the calculated increase in DO at any of the dams being modeled.

The CBOD5 and nitrate results from QUAL2K show trends that are generally consistent with the QUAL2E results. Certain results from QUAL2E appeared to be anomalous, such as the minimal decrease in BOD at the Churchill Woods dam. In general, QUAL2K results appeared to conform more to expectations than the QUAL2E results. It should be noted that the computerized input files for QUAL2E were not made available for this project. As a result, the It has been assumed that the documentation of input data and output in the TMDL reports is completely correct, yet inconsistencies between the actual model and the TMDL report documentation cannot be eliminated as an explanation of the discrepancies between the two models.

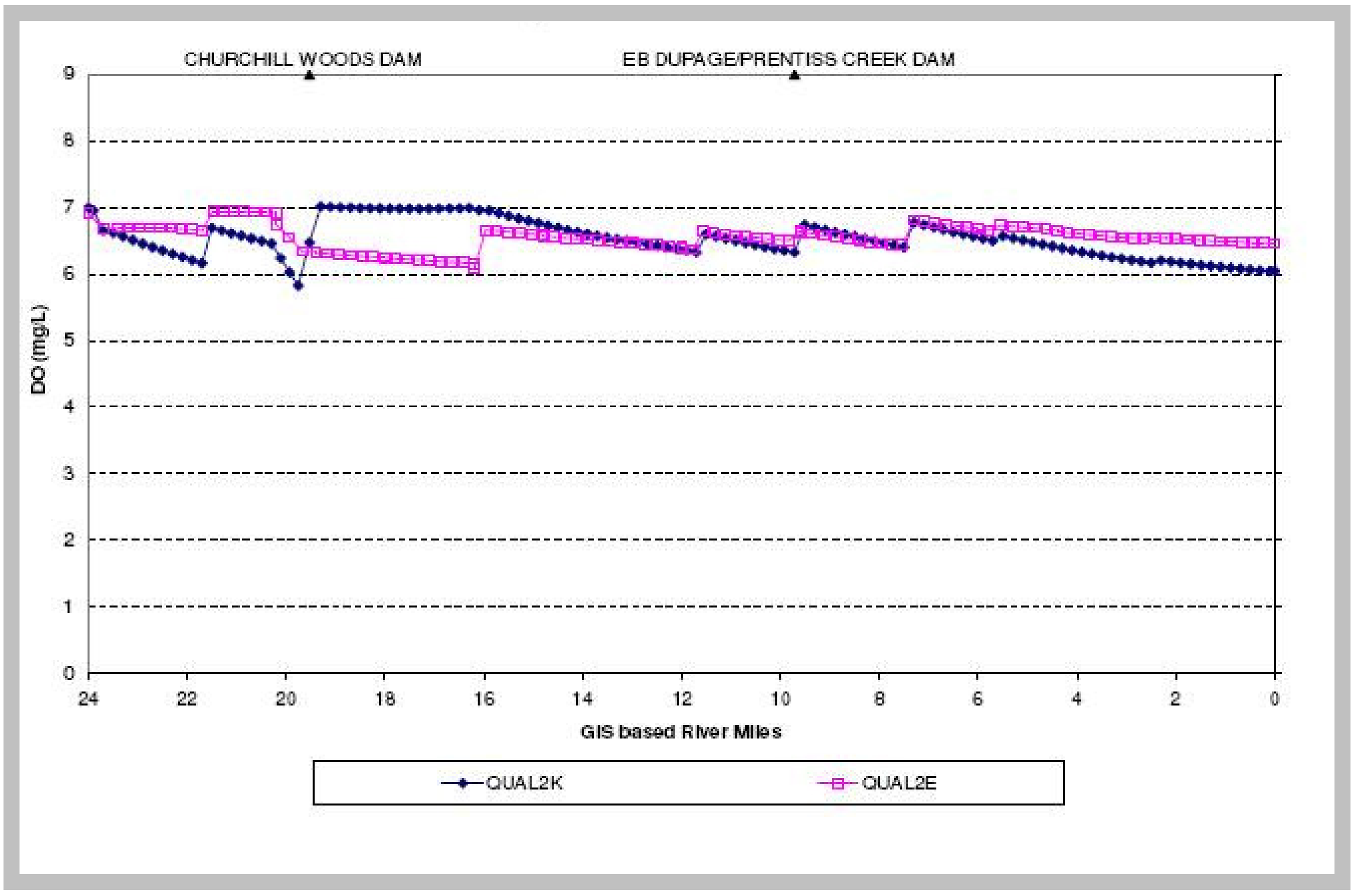

Figure 4-2 - Comparison of QUAL2K and QUAL2E DO Results

4.1.2 Conclusion

Overall, the QUAL2K model reproduced the general trends in water quality constituents with distance along the project study extents of the East Branch as reported in the TMDLs. Therefore, the next step was to validate the QUAL2K model with continuous DO measurements.

4.2 Validation of QUAL2K Model

After converting the QUAL2E model to QUAL2K, recent DO measurement data were used to validate the QUAL2K model. The DO in the East Branch was measured by DuPage County during several days starting on July 25, 2005 and ending on August 9, 2005. The field data consisted of date, time, station number, cross-section position (left, middle, right) sample depth and DO. It is important to note that these measurements were performed during daylight only so that the cyclically low DO due to respiration of phytoplankton during the night time was not captured.

There were also spreadsheets provided with DO data for a station on the East Branch downstream of the DuPage County WWTP (approximately RM 7.5). Hourly measurements for 24-hour periods during July 29-30, 2003 and August 14-15, 2003 were reviewed but not graphically compared to the model because the model validation period is in 2005.

River mile (RM) points of reaches were modified in QUAL2K based on more recent GIS data collected as part of this project as opposed to USGS RM information used in QUAL2E. Differences in RM between USGS and GIS data for East Branch were minimal.

All of the DO data were plotted against river mile to show the range in DO and provide an approximate basis for comparing QUAL2K results. As QUAL2K is a steady-state model, it assumes that stream conditions, such as flow, point source discharge, and loadings are constant in time. Sampling to collect data for comparison to a steady-state model is normally performed during periods when flow and other conditions are relatively constant. However, the DO data may not reflect steady-state conditions because of the variability in flow, meteorology, point source loadings, and headwater conditions during the 32 day sampling period. Since river flow data and point source data for July and August 2005 were not available, it was not possible to ascertain whether relatively constant conditions prevailed.

It should be noted that stormwater runoff and combined sewer overflow (CSO) discharges are assumed to be zero in the model and their effects, if any, would contribute to differences between the field measurements and the model. Daily precipitation recorded at Bensenville, IL for the sampling period was obtained and are presented on Figure 4-3 to provide an indication of potential stormwater/CSO discharges.

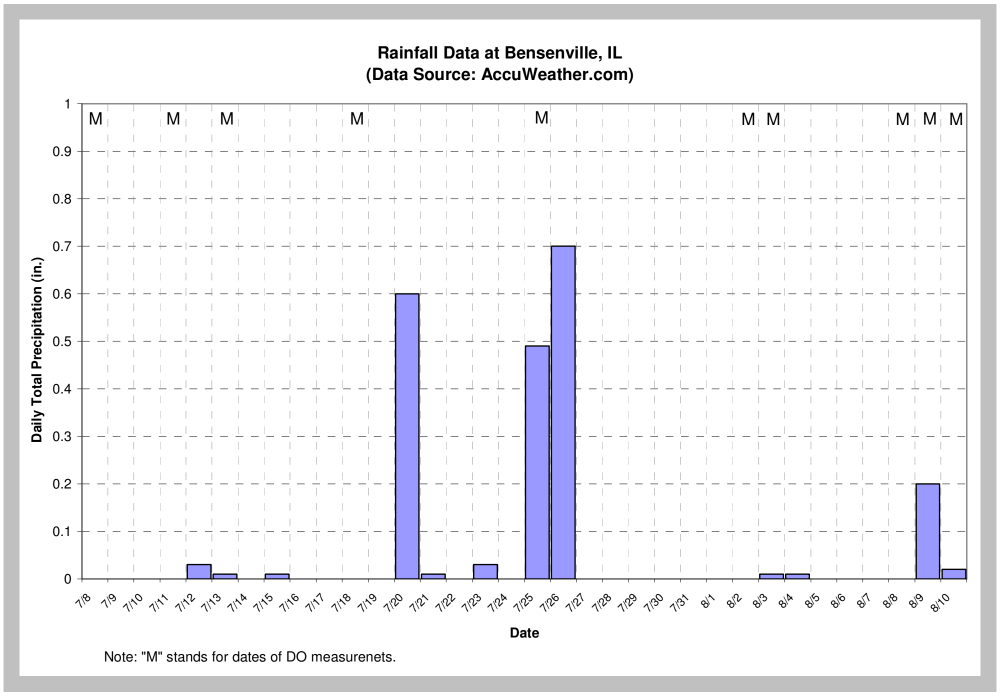

Figure 4-3 - Bensenville Rainfall Data for 2005 Period[15]

4.2.1 Changes in Model Input

This section describes the model input changes made to simulate the period of DO data collection (July - August 2005), as well as changes to the hydraulic characteristics (i.e., stream slope, depth and width data) necessary to reflect findings obtained during the field data collections (see Section 2.0, Existing Conditions for more details) and other recent sources of data. Reaction rate coefficients that depend on stream depth and velocity, such as the reaeration rate coefficient and the BOD oxidation coefficient, were also changed to reflect the changes in the hydraulic data. Other model parameter values from QUAL2E were also changed in QUAL2K in an attempt to improve its ability to simulate conditions in East Branch DuPage River as explained below.

Headwater flows were changed using historical USGS flow data for 20 years or more. Monthly average flows for July and August for the period of record were averaged. Flows from point sources were accounted for in calculating flows with distance upstream of the gaging stations. Water quality measurements at the headwaters during July - August, 2005 would have been ideal, but they were not available at this time. For the East Branch, a diurnal variation was used with an adjustment factor equal to the ratio of the average DO measured at the East Branch headwater to the average DO at JFK Boulevard. The DO, CBOD5, and ammonia concentrations of the tributaries were assumed to be the same as those in the QUAL2E model.

Main channel slopes were revised using the FEQ model input of the East Branch DuPage River developed by DuPage County. In addition, impoundment areas, where there are occurrences of hydraulic backup and sedimentation due to the presence of dams, were delineated as a refinement in QUAL2K. This was done by subdividing the appropriate QUAL2E model reach into two reaches for QUAL2K, a free-flowing reach and an impounded reach. Water depth information was taken from field reconnaissance. These changes of channel slope, depth, and velocity in impounded areas would potentially change re-aeration rates and BOD deoxygenation rates as explained under "decay rates" below.

Air and dew point temperatures were changed to represent a more reasonable local effect of weather for a period with which model validation was compared. Other meteorological inputs such as wind speed, cloud cover, and shades were set to 0m/s, 30%, and 0%, respectively. As the model does not simulate rainfall related inflows, precipitation data (shown previously) are not included as input.

As stated, changes to the stream geometry indicated that reaction rate coefficients would also change. CBOD, nitrification, and settling rates of various water quality constituents were changed using stream characteristics and a more reasonable range based on Chapra (1997) and Thomann and Mueller (1987). Velocity and depth are generally calculated by QUAL2K except for impounded reaches, where these data are taken from the Existing Conditions section and directly input to the model.

The model lacks absorption and back scatter of light by particulates because total suspended solids (TSS) was not simulated. This was accounted for by using a higher background light extinction rate compared to QUAL2E inputs.

Because DMR data for the period (July - August, 2005) were not available, monthly DMR data for July and August 2003, which is the last year of available data, were averaged to set discharge flows, CBOD5, and NH4 concentrations. Other effluent data, such as organic nitrogen, nitrate, phosphorus, and DO concentrations, were not available in the DMR data; therefore, the previous QUAL2E inputs were used. Thus, it should be recognized that this hypothetical set of point source data may not represent the period of model validation.

The SOD rates in the QUAL2E model input listings (0 for East Branch Scenario 1) were lower than expected for the existing conditions. (Note that no calibration data were reported for the East Branch DuPage River). SOD rates for the summer 2005 were set based on stream characteristics such as bottom sediment substrates, water depth, and impoundment as provided in Section 3.0, Existing Conditions. When a reach segment is characterized as "with silty/soft bottom" or "pool water depth greater than 5 ft", higher SOD rates (2.5 $g/m^2/d$ at 20^oC) were used because the reach was expected to have relatively heavy sedimentation with organic matter. Ammonia flux from the bottom sediments was set to zero because there was no information to support any other value.

4.2.2 Comparisons of Model and Observed Data

In the model, point source discharges in the East Branch account for the entire increase in flow between the headwaters and the model's downstream boundary. Hence, the East Branch is substantially influenced by effluent in this simulation of summer 2005 conditions.

As mentioned earlier, the 2005 DO measurements were performed during daylight hours only so that cyclically low DO due to respiration of phytoplankton (and the temporary cessation of photosynthesis) during night times were probably not measured. Therefore, the model may underestimate DO compared to the observed data because QUAL2K is a steady state model that simulates the diurnal variation in water quality as well as the daily average concentrations.

The model validation process was somewhat hampered by the absence of point source DMR information and stream flow data. Point source flows and effluent concentrations probably had a significant effect on DO, particularly during the relatively dry summer of 2005. Also, the model did not generate sharp fluctuations of DO compared to measurement data because average values of available data were used for diurnal variations, headwater flows, and point source parameters. Thus, the range of the model predicted DO would be narrow compared to the observed.

4.2.3 Sensitivity Analysis

Due to the interim status of the model validation, only one model sensitivity run was performed to date. The cloud cover was changed from 30% to 0% at all times in the East Branch DuPage River. This change resulted in model DO concentrations that were within 0.1 mg/L of the base case (30% cloud cover) DO. Increasing sunlight at the water surface tends to increase algal growth, which leads to higher photosynthesis and respiration. These mechanisms would partially offset each other and yield minimal change in DO.

4.3 Model Revisions

Model input changes were made to simulate the period of DO data collection in August 2006, to change the characteristics of the Churchill Woods impoundment based on the bathymetric survey performed in 2006, and to incorporate other data from recent sources. Updated data included flow and DMRs. Using the updated inputs and stream geometry a calibration and validation run of the model was carried out and the results compared with observed data gathered by the continuous DO monitoring program. The results are graphically represented in figures 4-4 and 4-5.

Figure 4-4 shows a validation run of the revised model with computed DO for August 20, 2006 plotted against the continuous DO measurements taken during field sampling for August 20, 2006. The diurnal range of the modeled DO is represented in Figure 4-4 with the minimum and maximum values being shown.

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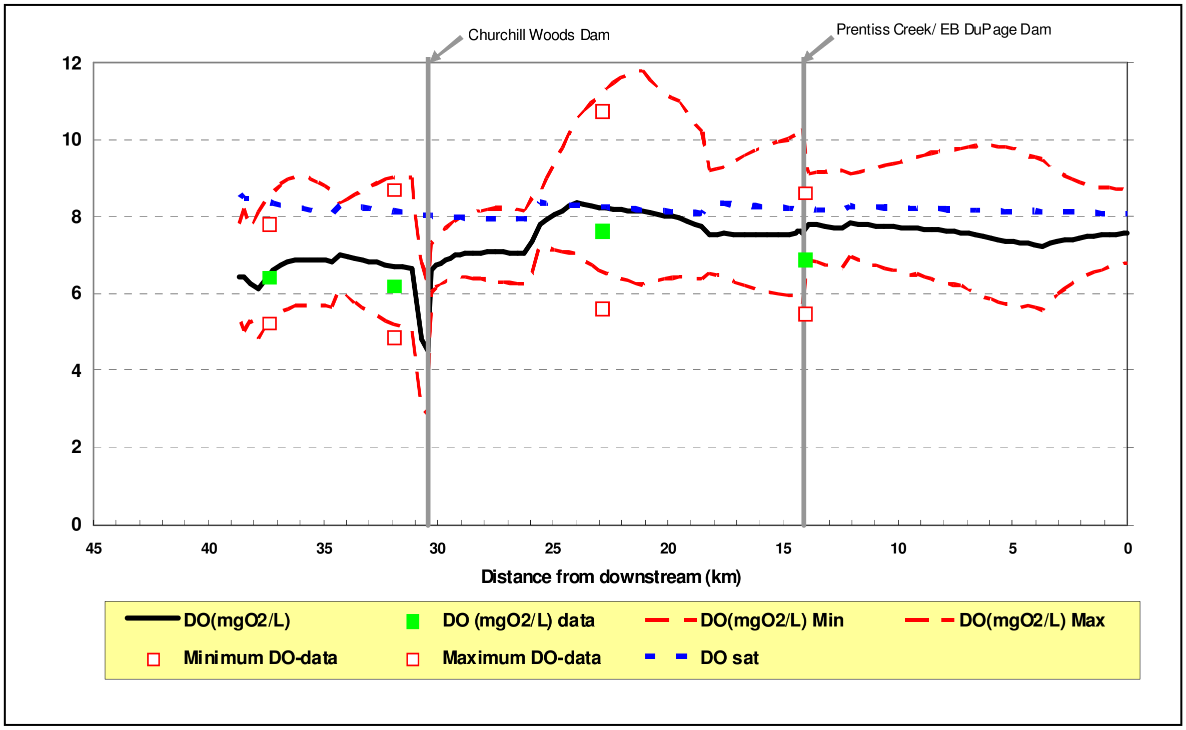


Figure 4-4 - Comparison of Observed and Predicted DO – Validation Run (8/20/06)

Figure 4-5 depicts the calibration run for August 13 to 17, 2006 versus the model. The diurnal pattern at Hidden Lake appears to be greater than then model predicted, but otherwise excellent agreement has been obtained. The green triangles shown along the top of figure 4-5 represent the locations of POTWs discharging to the East Branch. The relative size of each triangle is representative of the quantity of discharge supplied by the plant.

4.4 Modeling DO Impacts

Utilizing the average BOD5 and ammonia levels discharged during the summer months, the seven-day, ten-year low flow for the East Branch, and the maximum stream temperatures recorded over the past ten years, a baseline model was run. Figure 4-6 depicts the results of this model, which is intended to reflect worst case conditions low flow conditions. Upstream of the Churchill Woods Dam, DO minimum levels are predicted to drop to zero mg/L DO. The mean DO is predicted to decline to 1.5 mg/L. The computed values suggest that other DO deficits along the East Branch are minor compared to the DO impact from the Churchill Woods Dam. The green triangles shown along the top of figure 4-6 represent the locations of POTWs discharging to the East Branch. The relative size of each triangle is representative of the quantity of discharge supplied by the plant.

Figure 4-5
East Branch DuPage - Calibration Results

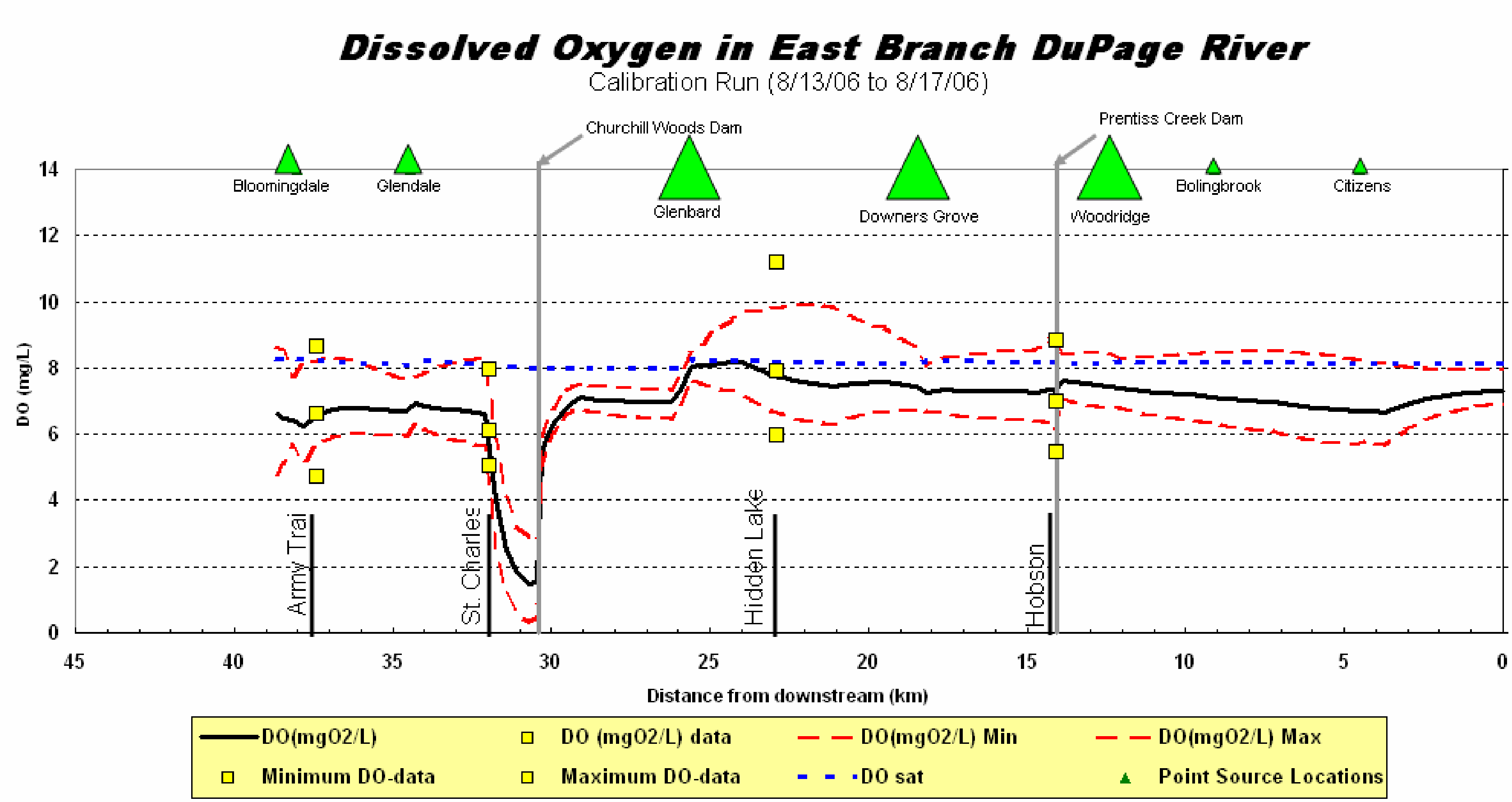
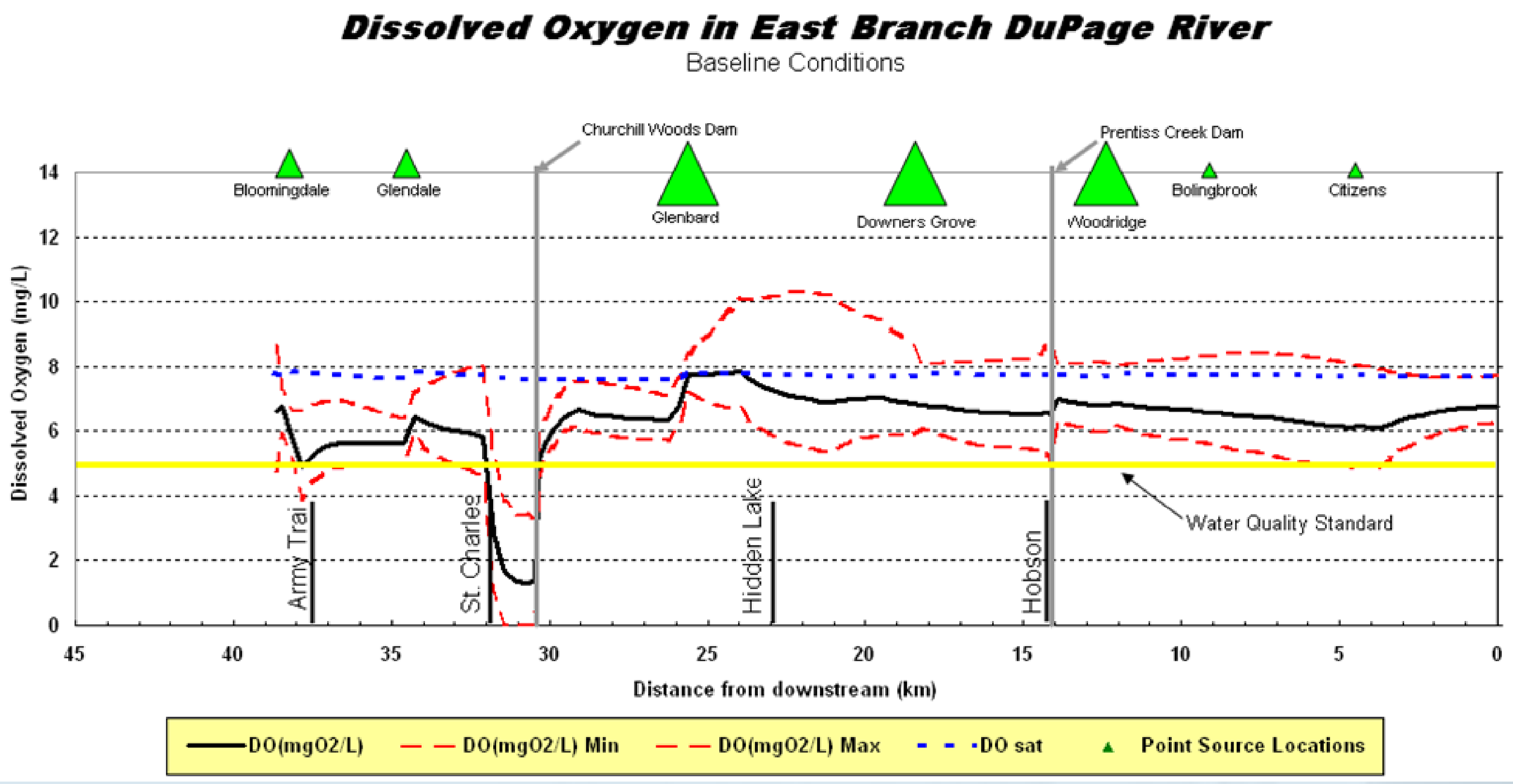


Figure 4-6
East Branch DuPage – Baseline DO



5 SCREENING FOR DAMS

Small, low-head dams have been noted to bring multiple problems to streams in the US due to the shear number that exist today. Dams inhibit the natural linear flow of energy in a stream, be it in the form of flowing water, sediment transport, fish migration, macroinvertabrate drift, or downstream nutrient spiraling. Specific to the impact on dissolved oxygen that is being studied on the East Branch DuPage River, dams create impoundments that concentrate sediment and organic material upstream which actively respires, removing dissolved oxygen from the water. In addition, dams slow the velocity of the water, allowing additional time for water to absorb solar energy and increase in temperature and consume the limited mass of oxygen with the longer retention time. These effects are further exacerbated when dams increase the width of the stream through the impoundment, which limits the extent of riparian shade that can counter the effect of solar heating, and increases surface area for algae

Complete removal or retrofitting of dams is becoming an increasingly utilized tool to eliminate the disruptive influence that dams create within the fluvial system. The impacts of dams on sediment, flood conveyance, and aquatic flora and fauna have been documented in the literature: however, there is little guidance that exists for implementing a dam removal or retrofit. Questions about the fate of impoundment sediment, mechanisms for de-watering, and short versus long term impacts to the health of the system dominate any dam removal project and usually default to the experience of a few individuals for solutions as opposed to documented methods.

Dam Modification projects like these will have an overall positive effect on the aquatic environment of the East Branch of the DuPage River. The effect of dams upon rivers and streams include changing flow regimes, altering physiochemical parameters, promoting increases in siltation upstream, and scouring substrates below the dams. Dams also can alter fish assemblages and block fish movement which affects mussel reproduction by limiting availability of host fish for larvae. Dams can reduce species richness and abundance and increase non-native species composition.

The proposed project includes the evaluation of dam modifications, restoration of natural flows, and removal of sediment which has built up behind the dam structure as a result of impoundment. Strict erosion control will mitigate construction-related impacts to the aquatic resources. These sort of projects include a Restoration Plan taking into account mitigation for wetlands, waters, and riparian impacts including vegetation restoration. The stabilization and improvement of the riparian area will have positive affects on the aquatic resources.

The restoration of a stable, normal flow regime coupled with dam/sediment removal will improve the aquatic environment. Normal fish movement will be enhanced within this portion of the East Branch of the DuPage River, and siltation will be minimized as a result of the project. The project will restore the natural ecological functions and processes of a free-flowing river segment, and eliminate barriers to fish migration and mussel dispersion upstream leading to an improved and functional aquatic habitat.

Although a myriad of options exist for any given dam site, the three basic options being investigated for this study are: complete removal; complete removal with riffles installed upstream to maintain a given pool elevation, and partial removal or bridging. These options are being driven by the primary design objective of improving the DO content of the stream. A secondary design objective is to re-establish biological connectivity, mainly in the form of faunal passage, at each site. The three alternatives are discussed in more detail below.

5.1 Complete Removal

Complete dam removal involves the removal of the entire dam structure. The most common case for removal is to eliminate the legal definition of a dam at a particular site, thereby removing liability and responsibility from the owner. Usually dams have exceeded their design life, and the cost of rehabilitation is greater than the cost of removal. Ecological benefits are significant, but are often a secondary consequence in the removal of the structure.

Complete removal can occur in a number of ways based on site conditions and budget. Dams with a substantial amount of sediment behind the structure are often drawn down in stages to minimize the downstream transport of sediment. Sediment in the dewatered impoundment can be excavated and/or stabilized in place, depending on the type and quality of material (i.e., silt vs. sand and contaminated vs. non-contaminated).

Depending on the size of the impoundment, varying levels of restoration of the new channel are required. In large impoundments the effort for restoration is great, while in narrow impoundments, only slightly wider than the natural channel, the restoration effort may be less extensive.

There is a broad range of effort that can be dedicated to restoration of the site based on funding, aesthetics, resource use, aquatic and terrestrial wildlife needs, hydrology, and sediment transport. A passive approach (minimal effort) to channel rehabilitation might include the excavation of a fairly straight, perhaps oversized channel through the impoundment. This would allow the stream to do most of the work of recovery, creating its own path and allowing flood and groundwater hydrology to dictate the riparian vegetation regime over a prolonged timescale. Timescales for the completion of this restoration can range from decades to centuries depending on site conditions. Alternatively, active channel restoration, requiring the largest effort, would involve the complete construction of a functioning floodplain and sinuous channel similar to what existed prior to dam construction. The geometry of this channel would emulate the historical channel but would be designed to function appropriately within the constraints of modern hydrology and sediment loading. This active restoration option could be constructed within a few months but for a greater cost. The costs and timescales for these approaches are drastically different to achieve the same ultimate outcome, the re-establishment of an intact fluvial system.

Figure 5-1 - Dam Removal Example

5.2 Removal with Constructed Riffles

Dam removal with constructed riffles to control the water surface elevation is an option that was not originally identified on the project. However, it has become obvious during the data collection phase of the project that development has occurred based on the rather constant water surface elevation provided by the dams. Along certain reaches of stream where the potential decrease in the pool elevation would have negative impacts, the use of constructed riffles in the stream can help maintain a constant pool elevation. Dam removal proceeds exactly as described above, followed by the construction of riffles at a spacing and elevation dictated by site conditions.

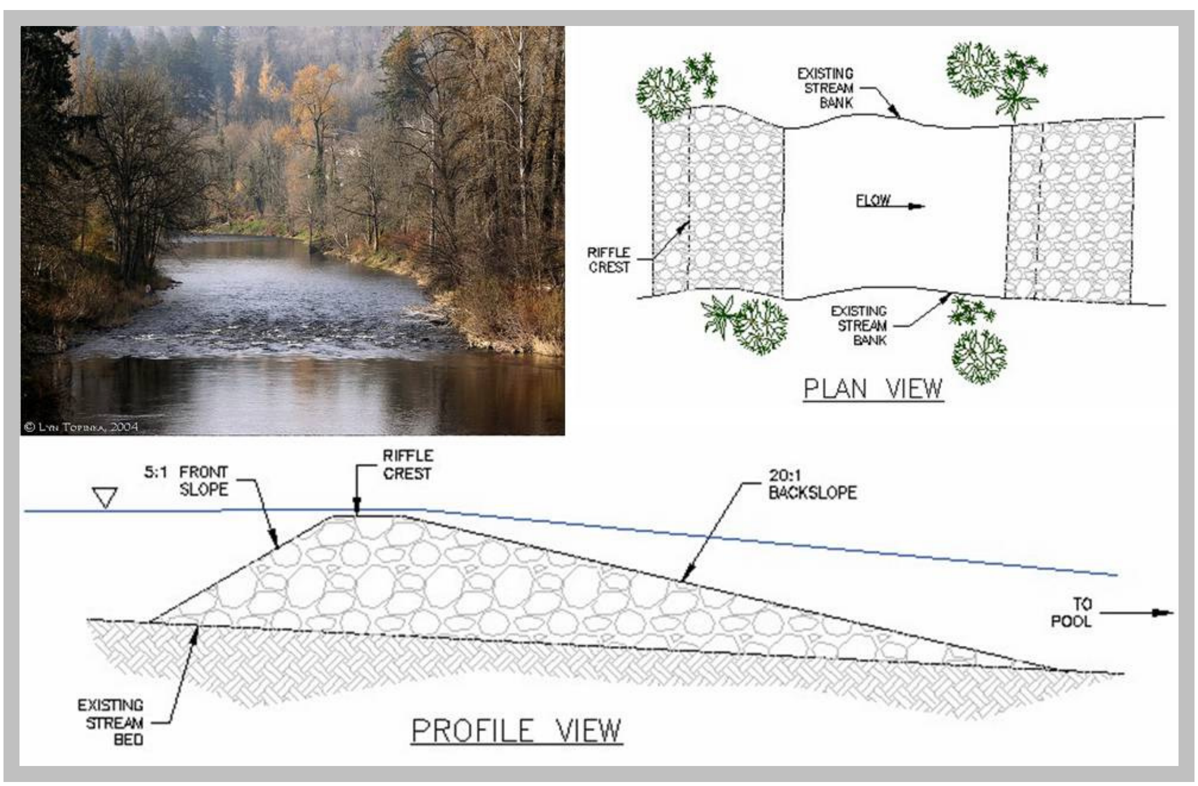


Figure 5-2 – Riffle Details

The construction of riffles requires careful planning and attention to their location along the profile of the stream. Due to the urban nature of the stream, little coarse sediment exists for replenishment, so riffles will need to remain intact in both their form and composition against a range of flows. Riffles occur naturally in streams at grade breaks along the profile. Constructed riffles consist of rock placed in the stream with the long tapering tail pointing downstream. The crest of the riffle is designed to maintain the water surface elevation required, while the long downstream slope ensures fish passage and provides the added benefit of aeration and interstitial habitats for macroinvertebrates.

Constructed riffles can be a great means of providing additional habitat and aesthetic value while maintaining pool elevations upstream. Though not confirmed in the model for the East Branch DuPage River, literature suggests that providing several areas of aeration along a stream in the form of riffles (example: four one-foot high riffles) is more advantageous to DO than providing a single, large riffle at one spot on the stream (example: one four-foot high riffle). The downside of riffles is the access required for their construction along the stream. In addition, since they are man-made structures, riffles would likely fall under the "dam" designation by IDNR, though their hazard classification is expected to be minimal.

Figure 5-3 – Examples of Riffle Usage

5.3 Partial Removal or Bridging

The final option is partial removal or bridging. The basic concept is to build a ramp of large rock leading up to the downstream face of the dam. The ramp effectively "bridges" the dam by providing upstream-downstream fish passage and/or canoe passage. Common variations to this include partially removing or lowering the dam crest in order to decrease the vertical elevation that must be made up downstream. In addition, notching the dam crest to concentrate flow in the center of the channel is also common.

Bridging provides fish passage and aeration as well as some interstitial habitat for macroinvertebrates. It also preserves existing water surface elevations upstream. Bridging does not eliminate the concentration of fine sediment and organic material that accumulates upstream of the dam. In fact, all negative impacts created by the upstream impoundment are still valid when using the bridging technique, though the extent of impoundment and sediment accumulation can be decreased if partial removal is done as well. Bridging does not remove the legal designation of a dam at the site. The State of Illinois' definition of a dam is "any structure built to impound or divert water." Thus the responsibility for maintaining and monitoring the structure will remain with the dam owner. There is a possibility for the hazard classification of the structure to be downgraded if partial removal diminishes the hydraulic impact of the structure.

5.4 Issues Common to All Dams

There are several issues that need to be addressed for project with modifications to existing dams. Permitting by federal, state, and local agencies, characterization and disposal of sediments removed from dam impoundments, and impacts of dam removal on flooding must be considered.

5.4.1 Permitting

The permitting climate for dam removal and bridging is somewhat uncertain. Because the technique, especially removal, is so new, most states, including Illinois, have had little guidance to craft efficient permitting processes to deal specifically with the technique. Instead, the current permitting environment that governs classic issues related to construction in and around streams and wetlands is applied. There are three levels of permitting that will be required for each project, with variations on each depending on the design method chosen. The Joint Permit Application Packet is designed to simplify the approval process for the applicant seeking project authorizations from the U.S. Army Corps of Engineers, the Illinois Department of Natural Resources Office of Water Resources, and the Illinois Environmental Protection Agency. The application portion sent to each individual agency should be tailored to that agency's area of responsibility, but otherwise provides a fairly seamless entry into the application process.

Federal Level – At the federal level, the Army Corps of Engineers has jurisdiction over any design that will impact wetlands or waterways. Because DuPage County's regulations are more stringent than the Federal Laws, a memorandum of understanding has been in place that allows much of the permit review for the Federal 401/404 permit to be accomplished by the County.

State Level – Permitting from the State of Illinois involves several agencies, including the IEPA and the Illinois Department of Natural Resources (IDNR). Within the Joint Permit Application process, there are several layers of review that require the approval of various agencies. The IDNR Office of Water Resources has established requirements for applications for permits to remove dams, detailed in Section 3702 of the State Administrative Code. The Office of Water Resources handles aspects mainly related to the construction (removal) process, such as the plan for dewatering and upstream restoration and the impacts to the flood profile. The IDNR Office of Realty and Environmental Planning will perform a review of the project to ensure no impacts to threatened or endangered species. A review will be done by the Illinois Historic Preservation Agency to ensure no impacts to state historic or archaeological resources.

Additional regulations that may apply depending on the project include Part 3708 – Floodway Construction in Northeastern Illinois.

The IEPA handles most of the sediment related questions concerning dam removal such as fate and transport of material and likelihood of contamination.

County Level - DuPage County permitting requirements are more stringent than most State or Federal requirements. As a result, once the county requirements are met for various items held in common among both state and federal regulations, the federal and state requirements are also met by default. It is important to note that this is only for certain items, such as wetland impacts, that are common among the three levels of permitting. Other items such as dam safety and the regulations associated therein are not common among the various permitting agencies and so the responsibility remains with the issuing agency, in this case, IDNR.

The county has a single permit application that covers all work in waterways that will be proposed on this project. The stormwater permit includes provisions for hydraulic/floodplain impacts, wetland impacts, and property impacts.

Hydraulic/Floodplain impacts are the most important category to identify prior to taking any project beyond conceptual design. It is premature to estimate what the impacts of the three alternatives would be at each of the dam locations. Removal of fixed elevation dams may increase or decrease the flood elevation depending on location along the profile, the nature of the impoundment, and the local hydraulics at the site for a range of flood events. Regardless of the alternative used at the site, it will likely require a Letter of Map Revision (LOMR) through the Federal Emergency Management Agency (FEMA). The LOMR is needed for both increases and decreases to the existing base flood elevations. If an increase in the base flood elevation is needed, easements will have to be secured from adjacent property owners who are affected.

Wetland impacts will be the next important parameter to characterize in the project. Wetland impacts associated with dam removal are evaluated on a case by case basis. Obviously wetlands that have been created as a result of dam construction would be impacted by removal. The quality of these wetlands and the impact to them is weighed against the potential ecological benefits of the dam removal/modification itself. Mitigation may be required if high quality or critical wetlands are impacted.

5.4.2 Reservoir Sediment

The correct characterization and understanding of reservoir sediments is the largest factor governing dam removal. Because dam bridging would have limited impact on upstream sediment transport, this discussion is mainly pertinent to full removal options. Reservoir sediments must first be evaluated for contamination. If material is deemed to be contaminated, the options for removal are likely limited to those that involve full removal of all contaminated material after drawdown or suction dredging material prior to dewatering the reservoir. This situation represents the most costly project scenario. If it is determined that the sediment is not contaminated, the next concern is transport of the material downstream.

There are no models currently available to accurately predict the movement and transport of reservoir material following a dam removal. The DREAM model developed by UC-Berkeley and Stillwater Sciences has made some inroads to model transport following dam removal, however it has been developed for non-cohesive silt, sand, and gravel situations, which do not often exist in Midwestern impoundments. HEC-6 has been used in the past to model transport, but it is incapable of accurately modeling the steep slope that results once the dam is removed and the nickpoint begins to move upstream (Cui, 2006.).

A decision must be made at this point based on limited information on how much material will be allowed to move down from the reservoir. This decision affects the cost of the project. A requirement of no material moving downstream means the sediment must be treated much like it was contaminated and removed mechanically or stabilized in place, if practicable. The other extreme is that the amount of material moving downstream is of little concern and the channel can be allowed to restore itself through a process of incising and widening. Most removals fall in the middle, where every attempt is made to stabilize material in place and excavate a volume of material for the new channel which will minimize the majority of transport associated with nickpoint migration and the ensuing channel widening.

5.4.3 Flood Impact

As mentioned above in the permitting section, quantifying the flood impact of any project on the dams being studied is of utmost importance. The impact may increase or decrease the floodplain boundaries as dictated by the Flood Insurance Rate Map (FIRM) from FEMA, and the recent revisions to the FEQ model done by the County.

6 SCREENING FOR STREAM AERATION

Numerous aeration technologies have been developed and utilized to increase dissolved oxygen (DO) in water. The purpose of this section is to introduce the readers to available aeration technologies and identify a group of technologies that may be feasible for implementation in the East Branch of the DuPage River. Other approaches for increasing DO concentration, such as in-stream improvements, may be feasible for this project but will be presented separately. Feasible technologies, constructability, and efficiencies of alternatives identified in this section will be further evaluated in Section 7.0 according to site-specific characteristics and project objectives. Thus, this section will provide general information regarding application, efficiencies, advantages, and disadvantages for each group of alternatives.

During this discussion, the term aeration will serve to designate the transfer of oxygen gas to the water column. For this study, aeration will be synonymous with the term reaeration. Additionally, this discussion designates low dissolved oxygen concentration as concentrations less than the state water quality standard of 5.0 mg/L minimum (March – July); moderate concentrations as concentrations from 5.0 mg/L to the point of saturation; and high concentrations as concentrations at the point of oxygen saturation and above. Operational effectiveness will be referenced as oxygen transfer efficiency (OTE) or the amount of oxygen that is absorbed by water during the aeration process divided by the amount of air or oxygen applied to the water. Efficiencies used in this section are generalized efficiency ranges for the technology applied to various conditions.

The following discussion incorporates information from scientific journals, government and state reports, independent research, project case studies, and manufacturer supplied specifications (where applicable). Available technologies are presented in three major categories: air-based alternatives, high-purity oxygen alternatives, and side-stream alternatives. Subsections 6.1, 6.2 and 6.3 briefly describe various technologies and subsection 6.4 provides an overview of the screening process. Table 6-1 provides a summary of the alternatives presented, and Table 6-2 lists the screening criteria and ranks alternatives in terms of general applicability.

6.1 Air-Based Alternatives

Approximately 21% of the earth's atmosphere is comprised of oxygen. In general, air-based alternatives are designed to expose as much water volume as possible to the atmosphere in order to increase dissolved oxygen in the water. As water is exposed to the atmosphere, oxygen absorbs into the water and dissolves until the pressure of oxygen in the atmosphere and the water are the same. When this point is reached, the water is at a "saturated state" and dissolved oxygen has reached the maximum theoretical concentration at ambient pressure and atmospheric conditions. This subsection outlines alternatives that have been developed to increase or maintain DO concentrations utilizing only the percentage and pressure of oxygen present in the atmosphere. The following air-based alternatives are grouped into simple aeration, mechanical aeration, and bubble aeration.

6.1.1 Simple Aeration

Often associated with stream elevation changes, simple aeration exposes water to the atmosphere as it drops and/or splashes into a lower pool. As a result, oxygen is entrained and the DO concentration is increased in the lower pool. Examples of simple aeration devices include weirs, inclined corrugated sheets, splashboards, cascade aerators, multiple-tray aerators, towers, and columns. The existing dams in the East Branch of the DuPage River are also examples of simple aeration.

Simple aeration devices are appropriate when sufficient changes in elevation are available, stream sediment loads are small, and low-to-moderate oxygen transfer efficiencies are adequate. If elevation changes are present, many of these alternatives can be implemented without a power source due to the force of gravity. If elevation changes are not present, these alternatives will require pumping to transfer water to the aeration device. In general, implementation may require site considerations for constructability, a power source if pumping is required, permitting, and maintenance access. The advantages to simple aeration alternatives include relatively low operation costs, ease of construction (in some cases), and limited moving parts to service. Disadvantages include the impediment for fish migration, and limitations due to navigational impacts. In addition, placement of some simple aeration alternatives, such as weirs, could extend the pooled conditions presently observed behind the dams on the East Branch of the DuPage River thus contributing to the upstream sediment accumulation, and lower dissolved oxygen levels upstream. Oxygen transfer efficiencies for these alternatives are low-to-moderate, excluding the negative impact from the pooled effects and sediment buildup on the upstream side of the device. Specific efficiencies are dependent on the height of the elevation drop or the height of the aeration device, water velocity, and the initial DO concentration.

6.1.2 Mechanical Aeration

Mechanical aeration is achieved with devices that create movement in the water, via splashing or agitation, or circulation between the top and bottom of the water column. Most mechanical aerators are designed to operate at or near the surface of the water column and draw water up into the air, but some aerators may be submerged and function by drawing the oxygenated surface water to the bottom of the water column. Common examples of mechanical aeration include paddlewheels, spray aerators, propeller-aspirator aerators, and jet aerators. Implementation of these devices may require site considerations for constructability, availability of an electrical source, permitting due to navigational impacts, placement of equipment and access for maintenance and operation. All mechanical aerators require electrical power and continuous maintenance on working parts.

Advantageous features of mechanical aeration devices include the ability to be placed in existing conditions and generally low cost for implementation. Disadvantages of mechanical aeration include the need for a continuous power source, operational costs for power consumption, generation of noise during operation, possible safety issues, potential for navigational impacts, and limitation of placement due to water depths. In general, oxygen transfer efficiencies for these devices are low-to-moderate and depend on the initial DO concentration and the water depth.

Figure 6-1 - Mechanical Aeration Display

6.1.3 Bubble Aeration

Bubble aeration consists of utilizing blowers or air compressors to introduce bubbles into the water column through air diffusers. The generated air stream is delivered via piping or tubing to air diffusers at the bottom of the water column. In general air is forced through the diffuser resulting in a release of small bubbles into the water. Examples of bubble aeration include aeration cones, and fine and coarse bubble diffusers. In order to install bubble aerators, site considerations may be required for constructability, availability of an electrical source, equipment, and periodic access for maintenance and operation, and sufficient depth for efficient oxygen transfer.

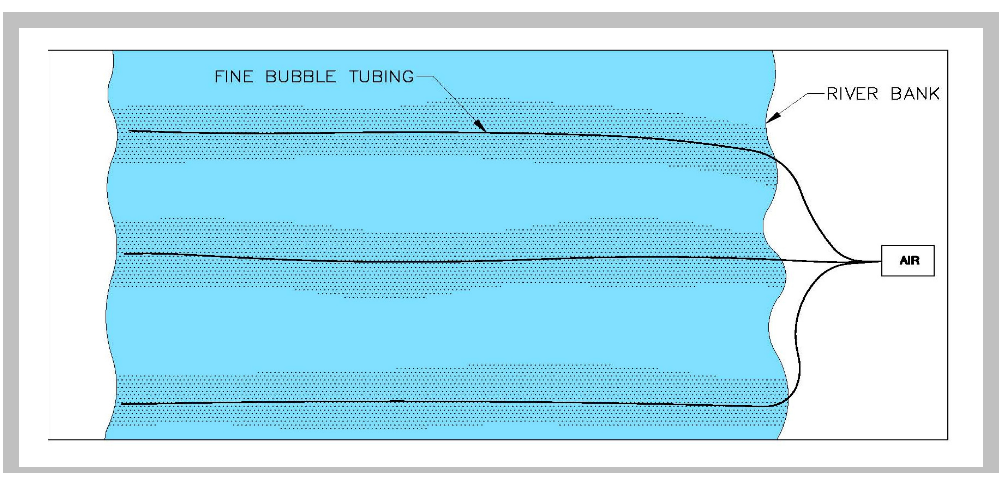


Figure 6-2 - Bubble Aeration

Advantages of bubble aeration include the ability to be placed in existing conditions with relative ease, minimal impacts from floating debris, widely serviceable components for repairs, and the ability to operate in series. Disadvantages of bubble aeration include the need for a continuous power supply, the need to place the piping/tubing level operational costs to generate an air source, housing for the generator, clogging, and potential noise associated with blower operation. Oxygen transfer efficiencies are low in shallow areas, but moderate efficiencies can be obtained when the water depth is greater than 5 feet. The efficiency of bubble aeration systems is dependent on the initial DO concentration, the size of bubbles generated, and the water depth.

6.2 High-Purity Oxygen Alternatives

High-purity oxygen alternatives for increasing dissolved oxygen are based on contacting the water column with a concentrated source of oxygen, with or without pressure above ambient atmospheric conditions. This concentrated or high-purity oxygen source is generally 90% to 99% oxygen versus the atmospheric percentage of around 21%. High-purity oxygen applications generally require onsite storage of oxygen in the liquid form or on-site oxygen generation. Specialized liquid oxygen vessels store the oxygen under pressure and utilize onsite vaporization to convert liquid oxygen to gaseous oxygen. As an alternative to liquid storage, on-site oxygen generators can be utilized to provide a source of high purity oxygen. However, there is more complexity associated with on-site oxygen generation and the seasonal requirement generally favors storage.

High-purity oxygen systems differ from atmospheric systems due to a larger pressure and concentration differential between the oxygen source and the water column. The pressure and concentration of oxygen in the air limits the mass transfer of oxygen in atmospheric systems. In high-purity oxygen systems with increased pressure and oxygen concentration, the water can reach DO concentrations up to 100 mg/L or more than ten-fold higher than with air systems. In other words, oxygen can be continuously transferred to the water regardless of initial dissolved oxygen content and partial pressure of the water. Thus, systems that utilize a source of high-purity oxygen rather than atmospheric oxygen have much higher oxygen transfer efficiencies. Supersaturated DO conditions in the water will dissipate with time as the water flows further from the aeration source or as agitation occurs. This subsection outlines alternatives that have been developed to increase dissolved oxygen concentrations utilizing high-purity oxygen. For this discussion, alternatives are grouped into simple oxygenation and bubble oxygenation. For high-purity oxygen, the term oxygenation will replace aeration as an indication of the high purity versus atmospheric source of oxygen.

6.2.1 Simple Oxygenation Using High-Purity Oxygen

Simple oxygenation devices increase DO concentrations by allowing oxygen-starved water to contact high-purity oxygen as it flows through a chamber. As water drops from the top of the chamber to the bottom, a gas/liquid interface is created by contact between the water and the oxygen source. Low head oxygenators (LHO) and sealed columns are two examples of devices that can be utilized with high-purity oxygen. These alternatives would typically be applied in a side-stream setting with pumping due to limitation of sufficient gradient change necessary to drive water through the devices, flow requirements, and navigational issues. Installation of these devices may require site considerations for constructability, maintenance and operation access, storage of supplies, and storage of liquid oxygen.

Advantages of these alternatives include high oxygen transfer efficiency, ease of construction, little navigational impact, and low maintenance due to a limited number of working parts. Disadvantages include potential for debris collection or clogging, placement of storage tanks, and possible transportation costs.

Figure 6-3 - Low Head Oxygenators with liquid oxygen cylinders

6.2.2 Bubble Oxygenation Using High-Purity Oxygen

Bubble oxygenation devices are similar to bubble aeration devices but differ in respect to the source of oxygen. Rather than an air stream traveling through an aeration cone or diffuser, high-purity oxygen is utilized to create small bubbles that float from the bottom to the top of the water column or oxygenation device. Bubble oxygenation systems include aeration cones, U-tubes, porous diffusers, and nonporous diffusers. Installation of these devices may require site considerations for constructability, maintenance and operation access, and storage of supplies and liquid oxygen.

Advantages to bubble oxygenation devices include low navigational impacts, moderate-to-high efficiencies due to the ability to supersaturate, adaptability to varying locations and water depths, and ability to operate in varying water flows. Disadvantages include clogging (in some cases), and high operational costs oxygen.

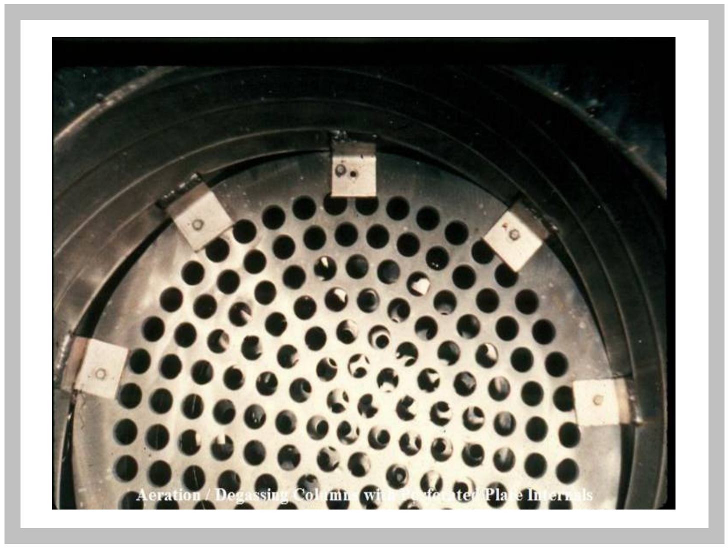


Figure 6-4 - Diffuser Used for Bubble Aeration

6.3 Side-Stream Alternatives

Aeration of side-streams is another technique that can be utilized to increase DO concentrations. Side stream applications involve partitioning a portion of the total river flow off and increasing the dissolved oxygen concentration in that portion. Both air-based and high purity based sources of oxygen can be utilized. The amount of water partitioned is site dependent but typically ranges from 5% to 40% of the total flow. Higher DO increases are associated with larger volumes of water contacted with the alternative, particularly with air-based alternatives. Specific side-stream applications include side-stream elevated pool aeration (SEPA), pressurized side-stream columns, side-stream channels, and bubble-free aeration; however, all alternatives outlined above can also be implemented as a side-stream alternative with the construction of a side-stream channel adjacent to the existing main riverbed. Advantages of the side-stream applications include potential for community amenity (SEPA has been implemented in the Chicago Metro area with positive results), a reduced column of water needed for direct addition of air or oxygen, control over flow conditions, and enhanced ability to supersaturate when utilizing high-purity oxygen (in some cases). Disadvantages include the need for elevation changes necessitating pumping (in some cases), fish impingement and entrainment as a result of pumping, and the required space adjacent to the main river channel. Advantages and disadvantages of specific air-based and high purity based alternatives listed above would also apply, if chosen for implementation.

Figure 6-5 - Side-Stream Aeration Facility

6.4 Overview of Feasible Alternatives

It is possible that multiple strategies could be utilized at varying locations throughout the project area. The ultimate efficiency and applicability of the technology selected to enhance dissolved oxygen is site and condition dependent. For this reason, it is important to consider the technologies that are most applicable for the general conditions in the East Branch DuPage River as outlined in Section 3.0. Further evaluation of the site specific criteria is necessary. The list of available alternatives must first be narrowed to those alternatives that have the greatest opportunity for meeting the project objectives without generating public opposition and without degrading local environmental conditions.

Using a similar matrix as Table 6-2, a numerical value has been assigned to each of the listed alternatives. A simple one to three (most desirable to least desirable) ranking system was implemented for categories classified as general, while a one to five (most desirable to least desirable) ranking was implemented for categories that are critical for meeting the project objective (see Table 6-1). Critical categories for this project were the ability to increase DO to the state standard of 5.0 mg/L, navigation impacts, and efficiency of transfer at shallow depths. The following descriptions outline ranking criteria for aeration technologies utilized in the initial screening process:

- **Ability to increase DO to the minimum state standard of 5.0 mg/L**

  Each alternative screened must be capable of increasing the DO to the standard under varying conditions. This criterion is critical in order to achieve the project objective. Alternatives that may be capable of meeting the objective but with significant effort and/or low transfer efficiencies are more likely to receive a high score (least desirable), while alternatives capable of quickly and efficiently meeting the standard are more capable of receiving a lower score (most desirable).

- **Navigational impacts**

  Navigational impacts reflect the likelihood that an alternative will impede progress or degrade the experience of individuals using the rivers for recreational purposes. This criterion is considered critical. Alternatives that block recreation or require significant effort to be avoided are more likely to receive a high score while alternatives that require no effort to avoid or that do not block navigation are more likely to receive a low score.

- **Efficiency of oxygen transfer in shallow water depths**

  This is critical criterion used to screen the ability of an alternative to meet the project objective with adequate oxygen transfer efficiencies in shallow water depths present in many areas of the East Branch of the DuPage River. Alternatives that will not operate or will operate at greatly reduced efficiencies in shallow water are more likely to receive a high score, while alternatives that are capable of operation and oxygen transfer in shallow depths are more likely to receive a low score.

- **Ability to increase dissolved oxygen concentration above saturation**

  This criterion is important for considering the ability of each alternative to create a positive impact over great horizontal distances, thereby necessitating fewer installations along the River. Alternatives that will have a localized impact on the DO concentrations are more likely to receive a high score, while alternatives that are capable of enhancing DO concentrations for greater horizontal distances are more capable of receiving a low score.

- **Constructability complexity and costs**

  Alternatives that do require major renovations, present engineering and construction challenges, or have an anticipated high investment cost are more likely to receive a high score, while alternatives that are easily implemented and generally cost less are more likely to receive a low score.

- **Operation and/or maintenance issues**

  Considerations are given for frequency of maintenance, required site personnel, and monthly operational costs. A high score reflects an alternative that is anticipated to be costly to operate on a monthly basis and/or may require a significant investment in maintenance dollars and man-hours. Lower scores are associated with alternatives that are relatively maintenance free or require fewer man-hours.

- **Public concerns**

  This criterion includes aesthetics, noise from equipment, and public safety issues that may be associated with alternatives. Public perception is an important aspect for a successful implementation of alternatives. Alternatives that are unsightly, obstruct views, and/or generate an intolerable noise level are more likely to receive a high score, while alternatives that remain less visible and are more aesthetically pleasing are more capable of a lower score.

- **Environmental impacts**

  This criterion screens alternatives that may through either construction or operation be responsible for a negative impact to the local environment. Considerations are given for alternatives that may cause species impingement or entrainment, alternatives that negatively impact any adjacent wildlife, and alternatives that severely disrupt the environment of the location where the alternative is implemented.

The general existing conditions on the East Branch of the DuPage River in addition to operational limitations of the alternatives were considered in the ranking. For the screening purposes of this study, the following scores were used to group items for further evaluation:

- <20 – Represents alternatives that are strong candidates for enhancing DO conditions and may be applicable to the conditions present in the East Branch of the DuPage River. These alternatives will be considered in the evaluation phase of this study.

  The following alternatives are strong candidates for meeting the project objective: fine bubble tubing, oxygen diffusers, U-tube, aeration cone (high purity oxygen based), low-head oxygenator, sealed column, and all side-stream alternatives.

- 21-25 – Represents alternatives that are moderate candidates for enhancing DO. These alternatives may be applicable only if very specific site and operational conditions are met. These conditions would include such things as space or elevation change or the need to apply alternatives in pools above dams.

  The following alternatives are moderate candidates for meeting the project objectives: cascade aerator, packed column, turbine aerators, spray aerators, paddlewheels, aeration cones and air diffusers.

- >25 – Represents alternatives that are weak candidates and would not provide sufficient opportunity to enhance DO. These alternatives will not be presented for consideration in the evaluation phase.

  The following alternatives are weak candidates for project objectives: any type of weir configuration, spray tower, multiple tray aerators, jet aerators (submersible), and aeration cones when using the atmosphere as a source of oxygen.

As previously outlined, the alternatives most suitable for meeting the project objective will be more closely evaluated in Section 7.0 on a site specific basis.

Table 6-1 - Aeration Alternatives

Aeration Alternative	Oxygen Source	Efficiency	Power Necessity	Navigational Impact	Operational and/or Maintenance Issues	Other Comments
Simple Aeration Weir, Inclined Corrugated Sheet, Splash Board, Cascade Aerator	Air	Low	No	Moderate if placed in main channel	Low maintenance and no operation required	Requires elevation change; may contribute to localized flooding and sediment accumulation
Simple Aeration Spray Tower, Multiple-tray Aerator, Packed Column	Air	Moderate	Likely	Minimal	May need periodic maintenance	Requires elevation change or pumping; large water volumes require multiple units; aerators may become clogged
Mechanical Aeration Paddlewheels, Turbine Aerators (Jet Aspirators), Pumps, Spray Aerators	Air	Moderate	Yes	Moderate if placed in main channel	Periodic maintenance is required	Sediment may accumulate in dead areas; good mixing capabilities; potentially noisy and disturbing to aquatic life
Mechanical Aeration Submersible Aspirators and Jet Aerators	Air	Moderate	Yes	Minimal	Periodic maintenance is required	Potentially disturbing to aquatic life; difficult to access for maintenance
Bubble Aeration Porous and Nonporous Diffusers, Aeration Cone	Air	Low to Moderate	Yes	None	Requires continuous maintenance	Subject to clogging ,chemical or biological fouling; requires good depth for high efficiency, adaptable to various stream conditions
Bubble Aeration using High-Purity Oxygen Paclked or Sealed Column, Low Head Oxygenator (LHO)	High Pure O_2	Moderate to High	Yes	None to minimal	May need periodic maintenance	May require pumping; large water volumes require multiple units; may become clogged or fouled by organics and particulates
Bubble Aeration using High-Purity Oxygen Aeration Cone, U-tube Porous& Nonporous Diffusers,	High Pure O_2	Moderate	Yes	None to minimal	Requires continuous maintenance	Subject to clogging and chemical or biological fouling; adaptable to various stream conditions
Side Stream Aeration	Air	Moderate	Yes	None	Low maintenance	Requires stream modification, elevation change and area adjacent to water body
Side-Stream Aeration using Air based Alternative	Air	Moderate	Yes	None	Depends on specific alternative	Requires stream modification and area adjacent to water body; see comments above
High-Purity Oxygen-Based Pressure Column, Bubbleless Aeration (see also	High Pure O_2	High	Yes	None	Depends on specific alternative	Requires stream modification and area adjacent to water body and/or requires pumping see also list above with high pure source

Table 6-2 - Aeration Alternative Rankings

Alternative Category	Type of Alternative	Ability to Increase DO to State Min 5.0 mg/L*	Navigation Impacts*	Efficiency of Transfer in Shallow Depths*	Ability to Increase DO to or Above Saturation	Construction and/or Implement. Complexity	Operational and/or Maint. Issues	Public Concerns Noise/ Aesthetics	Environ. Impacts	Total Rating Points
Air-Based	Simple Weir	5	5	5	3	3	3	2	2	28
	Inclined Corrugated Sheet	5	5	5	3	3	3	3	2	29
	Splash Board	5	5	5	3	3	3	3	2	29
	Cascade Aerator**	4	4	4	3	3	3	3	2	26
	Multiple Tray Aerator	4	4	5	3	3	3	3	3	28
	Spray Tower **	4	4	5	3	3	3	3	3	28
	Packed Column **	3	4	5	3	3	3	3	3	27
	Spray Aerators	3	5	5	3	2	2	3	2	25
	Paddlewheels	3	5	5	3	2	2	3	2	25
	Turbine Aerators	3	5	5	3	2	2	3	2	25
	Jet Aerators	3	5	5	3	3	3	3	3	28
	Aeration Cone **	3	4	5	3	2	3	3	3	26
	Fine Bubble Diffusing	3	1	4	3	2	2	3	1	19
	Air Diffusers	3	1	4	3	3	3	3	1	21
High-Purity Oxygen Based	Low Head Oxygenator**	1	4	2	1	3	3	3	3	20
	Sealed Column **	1	4	2	1	2	2	3	3	18
	Oxygen Diffusers	1	1	3	1	3	2	2	1	14
	U-tube	1	1	2	1	3	3	2	3	16
	Aeration Cone **	1	4	2	1	2	2	3	3	18
Side-Stream	SEPA **	3	1	3	3	3	3	1	3	20
	Pressure Column**	1	1	3	1	3	3	3	3	18
	Side-Stream Channel**	3	1	3	3	3	3	2	3	20
	Bubbleless Aeration**	1	1	2	1	3	3	2	3	16

Note: *Critical to project objectives, **Alternative uses pumped system, Standard Criteria is ranked 1 (best) to 3 (worst), Critical Criteria is ranked 1(best) to 5 (worst)

7 EVALUATION

Based on the data collected and with the insight from the screening phase, a detailed evaluation of alternatives for the dissolved oxygen problems on the East Branch was performed. Figure 7-1 presents the DO modeling results with the Churchill Woods Dam removed, under the same condition as described in Section 4. The model predicts much improved DO levels above the Churchill Woods Dam; however, minimum DO levels less than 5.0 mg/L are still predicted. The DO levels at the Prentiss Creek Dam are predicted to remain above 5.0 mg/L.

Based on the continuous stream DO monitoring, we know DO values less than 5.0 mg/L occur downstream the Churchill Woods Dam (at Hidden Lake). However, the sediment above the Churchill Woods dam is the largest DO sink, and efforts to improve the overall stream DO should initially focus at the Churchill Woods Dam. Once removed, then additional monitoring (and perhaps modeling) would be appropriate before proceeding with any additional projects designed to improve stream DO levels.

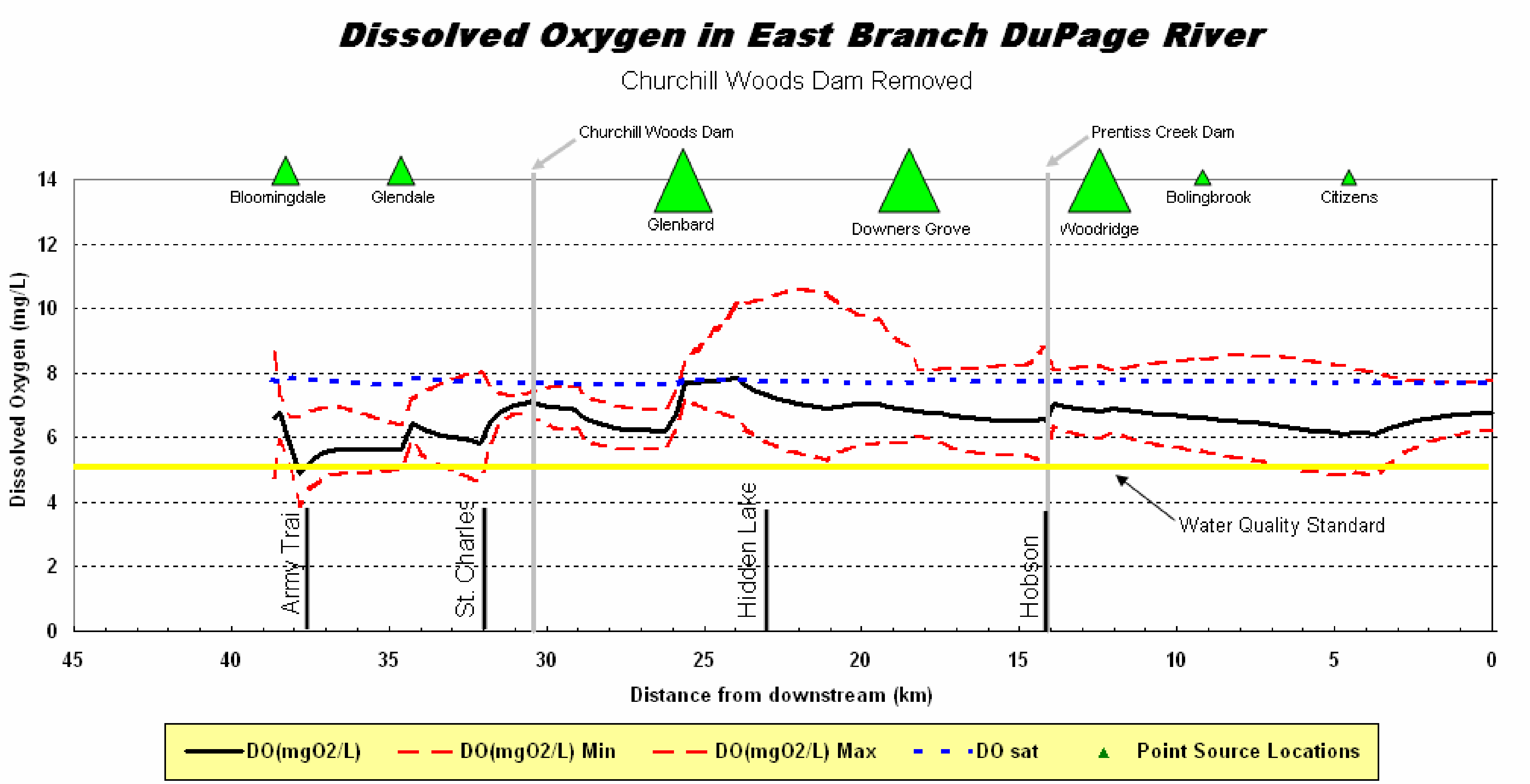
7.1 Evaluation Criteria

Criteria were developed to evaluate and compare the final set of alternatives on the basis of benefits, impacts, and costs. These evaluation criteria will guide the identification and selection of the preferred alternative. A set of evaluation criteria fact sheets were developed which included a description of the criteria, the target, and the evaluation methodology. These criteria are summarized in Table 7-1.

Table 7-1 - Alternative Evaluation Criteria

Ecological Evaluations	Impact on Wetlands Water quality	Impact on significant Habitat	Impact on local ecology & biological community
Physical Evaluations	Sediment and transport	Flood storage	
Engineering Evaluations	Site analysis Channel stability Permitting Utilities	Flooding implications Cost estimates Scheduling Implementation	Constructability Operation & maintenance Sediment characterization
Socio-economic Evaluations	Land ownership Land value Noise impacts	Historical context Community values Recreation impacts Change in Aesthetics	Safety issues related to dams and aeration equipment

Figure 7-1
East Branch DuPage – Future
Churchill Woods Dam Removal



7.2 Churchill Woods Dam

Churchill Woods' reservoir holds a significant amount of sediment. The reservoir also has some very wide lateral boundaries, being surrounded by Forest Preserve property along much of its perimeter. The wide area allows multiple possibilitites for channel restoration and the creation of adjacent wetlands or ponds in the event of a dam removal.

The hydraulic implications of any modifications to the dam will factor heavily in the decision for a preferred alternative as well. The location is complicated by three hydraulic structures packed into a narrow length of the stream, as shown in Figure 5. Water passing over the small dam and spillway flows under Crescent Boulevard through four concrete box culverts, after which it passes under the railroad viaduct through two large, brick arches. Tables 7-2 and 7-3 describe various conditions related to the dam which will affect the feasibility of dam modifications.

Table 7-2 - Churchill Dam Modification - Complicating Conditions

Flood Mitigation	The structure must be evaluated for its impact on flood elevations. Although the dam has a large storage effect, it is likely that the one of the other two hydraulic structures (the four box culverts under Crescent Boulevard., or the two arches under the railroad bridge) act as the hydraulic control, making the dam obsolete hydraulically at all but the smallest flood events.
Reservoir Sediment	There is a large amount of sediment accumulated in the upstream impoundment.
Crescent Blvd.	The proximity of Crescent Boulevard would require special attention to the design of a transition for removal and may prohibit the use of bridging at the site, assuming the road crossing will not be re-designed.
Permitting	The wetlands that have developed as a result of the water surface elevation controlled dam will be lost, and required mitigation However, there may be enough area on site to perform any required mitigation.

Table 7-3 - Churchill Dam Modification - Advantageous Conditions

Dewatering Gate	The presence of the dewatering gate allows for a drawdown to test the impact of upstream water surface elevation changes without removal. It also allows for a controlled drawdown to stabilize those sediments that have accumulated upstream should the dam be removed.
Construction Access	Access to the site for construction is excellent.
Upstream Water Levels	Water levels upstream will decrease from removal, but the majority of the riparian land upstream for quite a distance is undeveloped, and lower water levels would result in low aesthetic impact.
Lateral Work Area	There is a large amount of room to work in the reservoir area. The few homes located along the reservoir have lengthy buffers between any structures and the edge of the reservoir. This creates a number of possibilities for restoration of an intact stream and floodplain system, should removal be considered.

7.2.1 Churchill Woods Dam Alternatives

Dam removal, partial removal, or bridging, and removal with constructed riffles all provide a long list of benefits to the physical and biological nature of streams, each with its advantages over the other when looking at specific portions of the system. Quantifying their impact on the dissolved oxygen levels of the East Branch will be a major index by which the efficacy of each option is evaluated.

Based on the advantageous and complicating conditions defined above, feasibility of implementing each of the three dam modification alternatives, full removal, removal with constructed riffles, and bridging or partial removal, were evaluated.

Full removal of the Churchill Woods Dam is a viable option. The dam has a dewatering gate which could be used to slowly draw down the upstream impoundment that would allow for deliberate management of impounded sediments. The extensive lateral work area would allow for the restoration of a functioning stream and floodplain system through the old reservoir, as well as the development of fishing ponds or wetlands as needed.

Removal with riffles is unnecessary in this situation. Natural riffles built for maintaining any water surface elevation would not be required since lowering water surface levels upstream has minimal impacts. Riffles could be installed for habitat or other uses as needed.

Bridging would be difficult on the site, given the proximity of the Crescent Avenue bridge. The bridge contains four concrete box culverts to pass water under the road that would make it difficult to design a stable "bridge" of rock materials without using some kind of structural approach.

In general, removal of the dam would not have significant hydraulic impacts. Hydraulic analysis of the stream with the dam removal shows that, between St. Charles Road and the existing dam location, velocities and flows generally increase and water surface elevations generally decrease. For the same scenario downstream of the existing dam location, water surface elevations would increase up to 0.2 feet and flows would increase about 8 cfs for smaller storm events. The Crescent Avenue culverts restrict flows for larger storm events, so dam removal would not impact downstream conditions during those events.

Restoration alternatives were developed based on the full removal option. Figures 7-2 and 7-3 depict aerial views of two variations on the full removal option. Figure 7-4 shows the changes at the dam wall under the dam removal option.

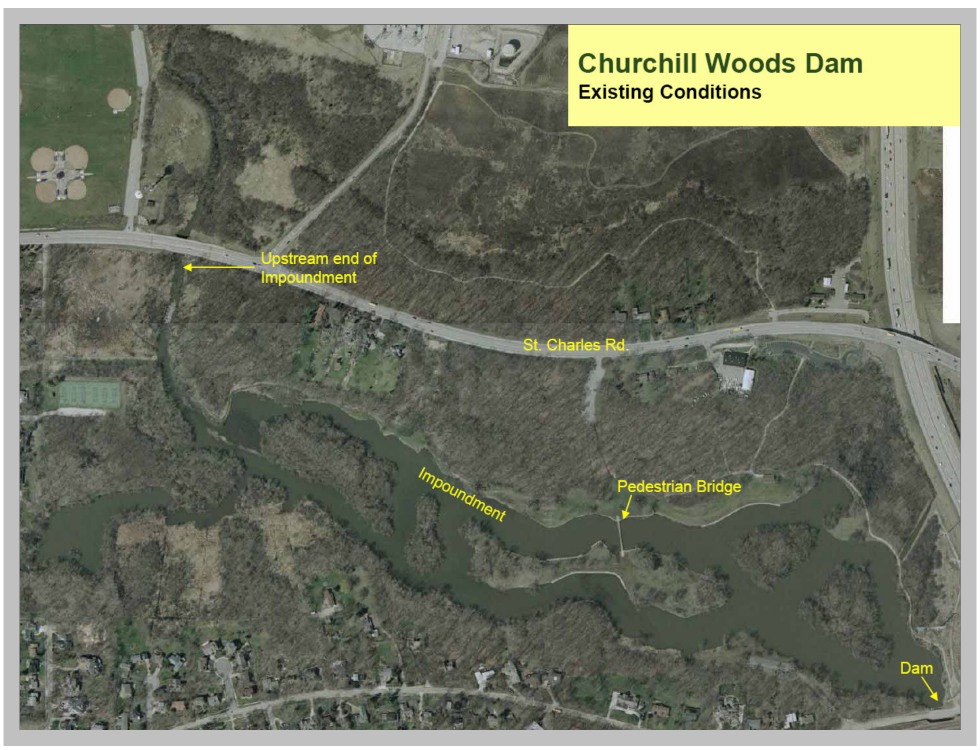


Figure 7-2 - Alternative 1
Restored Stream with Maintained Ponds

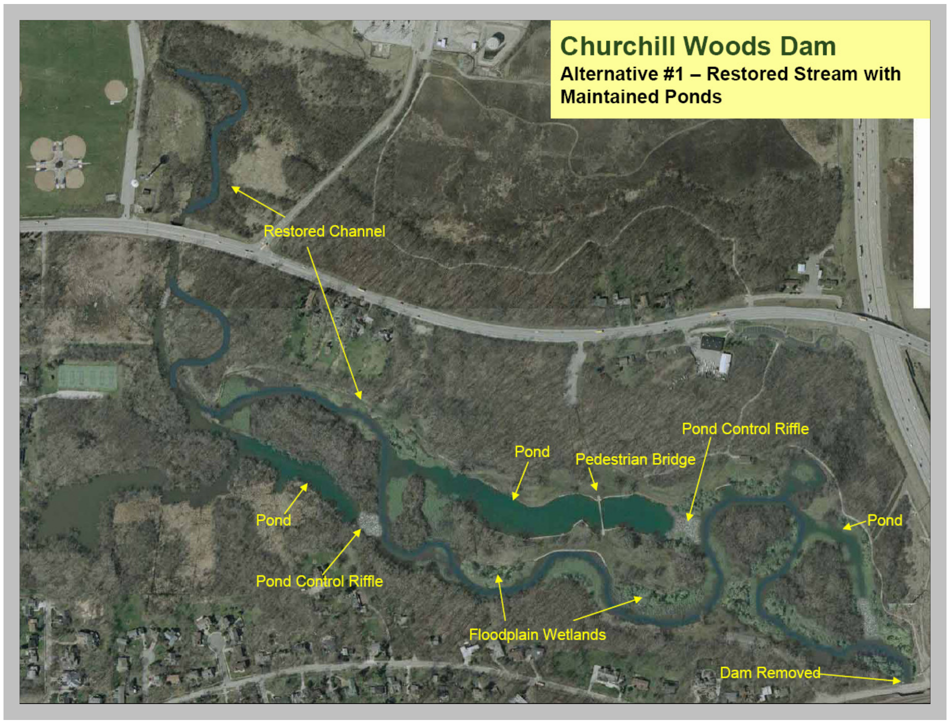


Figure 7-3 - Alternative 2
Restored Stream with Wetlands

Figure 7-4 - Churchill Woods
Outlet Before and After Dam Removal

These alternatives were evaluated in accordance with the criteria developed. Alternative 2 has positive impacts for water quality, hydraulic, ecological, socioeconomic, and maintenance issues. Alternative 1 has positive impacts on hydraulics and socioeconomic issues but DO levels would be negatively impacted by the ponded areas and sediment accumulation. The No Action alternative has continued negative impacts on water quality, and ecological issues.

8 IMPLEMENTATION PLAN

The evaluation of the potential projects to improve DO in the East Branch demonstrated that the full removal of the Churchill Woods Dam provides a feasible, cost-effective, and sustainable solution. DO modeling of the structure and reservoir has indicated a significant negative impact above the dam and has shown that removal will increase the minimum DO levels significantly. These findings are consistent with the findings from the on-going biological survey, which also has found the Churchill Woods Dam is a barrier to improving the biological quality above the Dam.

This section defines the plan for implementing the recommended project. Steps in the implementation plan as follows:

1. Concept plan definition,
2. Cost estimating and funding,
3. Design, permitting, and construction, and
4. Site operation, maintenance, and monitoring

This section also describes the steps in the implementation plan for the Churchill Woods Dam removal.

8.1 Concept Plan Definition

8.1.1 Project Concept Development

Dam removal and restoration alternatives were presented in Section 7. Components of the concept include dam removal, impoundment sediment handling, stream channel restoration, and wetland/pond development.

8.1.1.1 Dam Removal

The removal of the Churchill Woods dam includes the removal of the dam itself and its appurtenant structures such as concrete walls and gates. Due to the presence of impoundment sediments, a staged removal is recommended. The three stages of removal are dewatering, breaching, and complete removal. During each phase of the dam removal, upstream velocities can be controlled to reduce erosion and sediment transport. In addition, stabilizing the reconstructed channel during the dewatering stage followed by sediment removal will reduce transport of sediments downstream.

Dewatering of the impoundment allows for the saturated sediments to stabilize before complete dam removal. The existing dewatering gate will be used to gradually lower the water level in the impoundment. Controlling upstream flow velocities, installing grade control structures/systems, reconstructing the upstream channel to be stable and self-maintaining, and stabilizing areas where erosion may occur will reduce erosion and transport of the sediments downstream.

Once the water level is lowered by the gate, the dam will be breached to allow for drainage of the remaining impounded water. The concrete spillway and abutments will then be broken up and removed from the stream.

8.1.1.2 Impoundment Sediment Management

Impacts associated with quantity and quality of impounded sediment must be considered as part of the dam removal. Definition of the quantity and quality of the sediments is needed to address the issues related to sediment management.

Churchill Woods contains a significant amount of sediment. Additional investigation to quantify the amount of material was performed in August 2007. The density of cross sections in the impoundment was increased and a rod was used to probe for the depth of refusal, or the depth at which the assumed pre-impoundment bed was encountered, along each section. This exercise indicated that an average of 5.8 feet of material was deposited throughout the impoundment.

The data indicate that there may have been additional over-excavation that occurred upstream when the dam was built. The islands seen in the aerial photos may have been constructed of spoils excavated to create a deeper impoundment.

Project implementation can also be influenced considerably by the presence of contaminated sediment in the impoundment. To begin investigating this possibility, historic sediment analyses along the East Branch DuPage were obtained from the IEPA. The IEPA has conducted standard sediment analyses on the East Branch since 1974. These results, two of which were located within the Churchill Woods impoundment in 2001, showed an organic rich sediment. Table 8-1 compares these samples to Illinois streams for elevated and highly elevated levels.

Table 8-1 - Elevated Levels of Various Chemicals

Parameter (units)	Illinois Streams		Churchill Woods Samples	
	IL Streams 1997[1] Sieved (63u)		2001	
	Elevated	Highly Elevated	Sample # RGG-1	Sample # RGG-2
Arsenic (mg/kg)	7.2	18	8.6	-
Copper (mg/kg)	37	170	54	-
Iron (mg/kg)	26105	53000	33000	-
Kjeldahl Nitrogen (mg/kg)	2950	4680	4200	-
Nickel (mg/kg)	26	45	27	-
Phosphorus (mg/kg)	1000	2800	3650	-
Potassium (mg/kg)	1500	2200	2300	-
Silver (mg/kg)	-	5	180	-
Volatile Solids (%)	8.4	13	12.2	-
Zinc (mg/kg)	170	760	180	-
Aldrin (mg/kg)	-	1.0	0.0016	0.0012
Dieldrin (mg/kg)	1.0	15	-	0.0026
Dry Weight Basis				

Additional sediment sampling is being performed in 2008 by the DRSCW, in association with the USEPA. The results of this sampling are currently not available. These data will be invaluable in developing a sediment management plan.

Approaches for sediment management can include full or partial removal of impounded materials, staged dam removal to control sediment remobilization, and stabilizing sediment exposed through dam removal. Sediment stabilization can be accomplished using a variety of methods, including traditional, engineering-based methods, such as riprap armoring, as well as the installation of riparian vegetation and/or bio-engineering systems. Applicable methods are typically determined on a project-specific basis due to factors associated with the risk of soil and sediment erosion.

8.1.1.3 Stream Channel Restoration

The two restoration alternatives include restoration of the channel through the impoundment area and upstream of St. Charles Road within the preserve boundaries, with one alternative showing three ponds maintained for potential fishing access or other recreational use and another alternative including restoration of the stream with existing pond areas converted to wetlands. Hydraulic modeling will be used during the design phase to finalize the approach.

The channel is degraded along this entire reach through the forest preserve and shows signs of historic manipulation. The earliest known aerial photograph of the area from 1939 (Figure 8-1) indicates manipulations of this reach had already begun. The stream alignment from 1939 can be used as a basis for the channel relocation during restoration. This will result in lengthening the existing channel by over 30% to 8,700 feet.

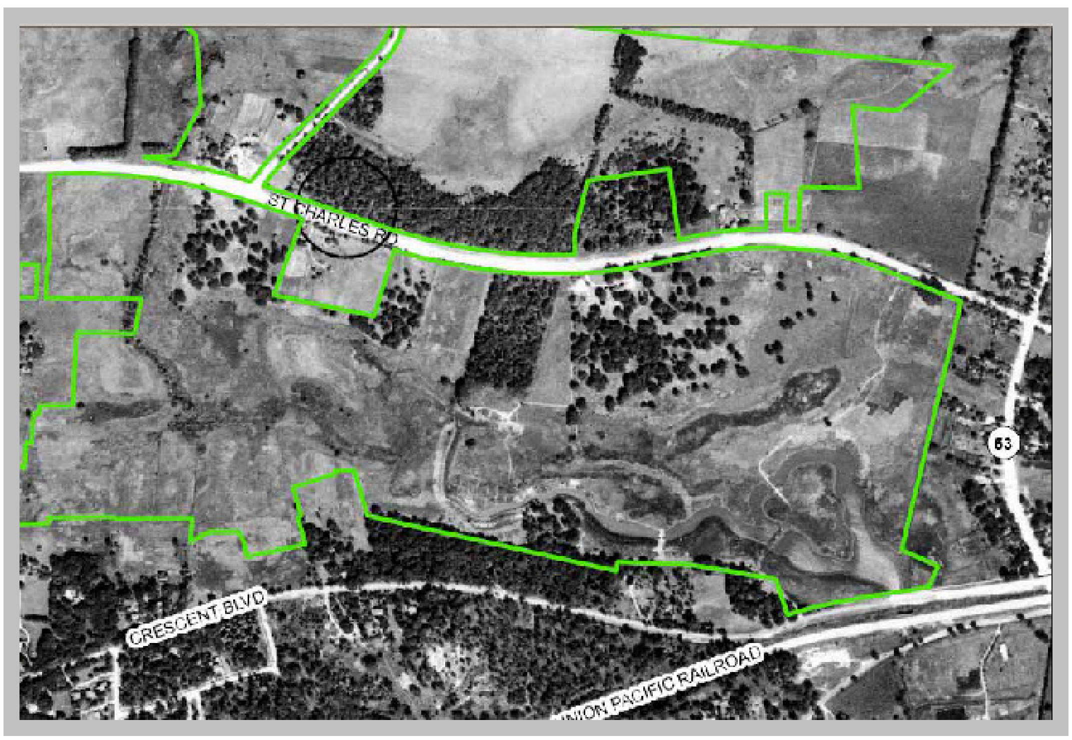


Figure 8-1 - Aerial Photograph of Site 1939

Plan views of the existing site conditions and the two alternatives are shown in Figure 8-2.

Invasion of undesirable, non-native species may also occur due to the level of disturbance in the area. Non-native plants thrive in the exposed sediments, and once established, can inhibit the establishment of native species. Because of this risk, a managed approach to vegetation establishment, following the removal of the dam, is recommended.

8.1.2 Agency and Stakeholder Coordination

The proposed alternative concepts have been presented to the property owner, the Forest Preserve District of DuPage County (FPDDC), and other stakeholders at several venues. Seeking and obtaining a consensus on the details of the recommended alternative is necessary to move forward with the project. Input given at the final public meeting will be reviewed and incorporated into the plan as appropriate.

This final concept plan will include the recommended components of the projects. Coordination with applicable agencies will continue to facilitate plan implementation.

8.2 Cost Estimating and Funding

To determine the magnitude of funding necessary to implement the finalized concept plan, preliminary cost estimates were prepared.

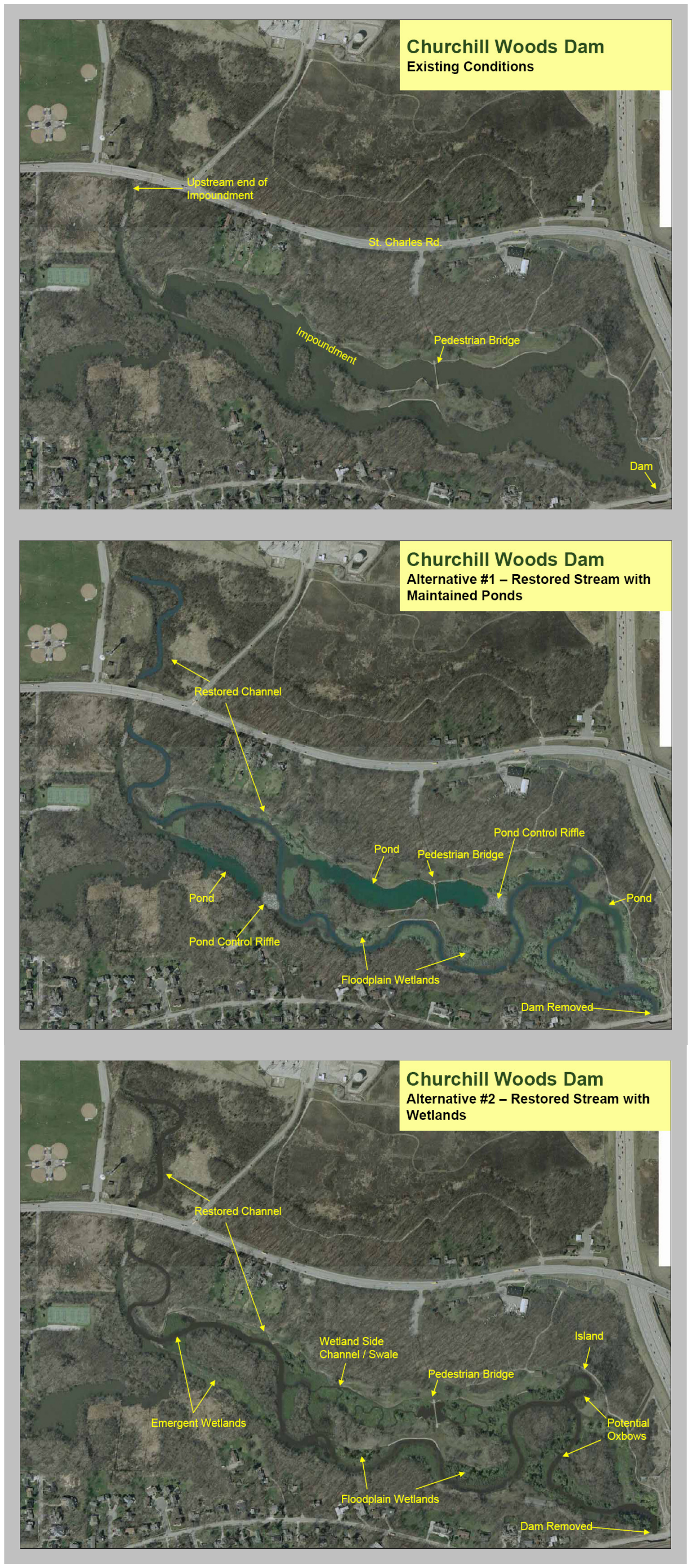


Figure 8-2 - Alternative Plan Views

8.2.1 Cost Estimates

Planning level cost estimates were prepared for three scenarios. Because the impoundment sediment characterization results are not yet available, the type of handling that will be required has not been determined. However, it is anticipated that the cost associated with sediment removal will be large compared to the cost of other project components and alternatives. Therefore, estimates were determined based on different types of excavation which may be anticipated. The estimates each consist of a 30% contingency for construction and a 15% contingency for design and permitting. As the concept plan becomes more defined during future stages of the project, the construction contingency percentage may be adjusted.

Table 8-2 - Planning Level Alternatives

SCENARIO	DESCRIPTION	PLANNING LEVEL COST ESTIMATE
Scenario #1 – Remove a majority of impoundment sediment	Nearly complete removal of all accumulated material behind the dam, with associated restoration of a meandering river channel and attendant riparian floodplain and wetlands	$5 million
Scenario #2 – Removal of 50% of the impoundment sediment	Partial removal of all accumulated material behind the dam, with associated restoration of a meandering river channel and attendant riparian floodplain and wetlands	$2.5 million
Scenario #3 – Remove a majority of impoundment sediment – contaminated	Assumes all sediment is contaminated. Nearly complete removal of all accumulated material behind the dam, with associated restoration of a meandering river channel and attendant riparian floodplain and wetlands	$8 million

It is important to note that these cost estimates do not incorporate the results of the additional sediment survey. The estimates above assumed an average sediment depth (after dry out) of approximately 2.5 feet over the entire impoundment, based on the preliminary screening investigation.

8.2.2 Funding

Based on historic experience with dam removal projects, there are two issues which tend to be significant in implementing a project. The first issue is related to the ownership of the dam and the upstream impoundment, and the second issue is funding for the project. Given that the dam and reservoir are owned by the FPDDC, this issue is manageable since only one owner is impacted.

Funding is likely available through a combination of project stakeholder organizations and grants. Several grant opportunities are described below, but the dynamic nature of grant funding cycles requires verification of existing sources and investigation of new sources if these are to be fully utilized.

8.2.2.1 State and Federal Programs

Illinois Environmental Protection Agency (IEPA)

Section 319(h) of the Federal Clean Water Act authorizes Congress to appropriate money to the states for the purposes of controlling non-point source pollution. The Illinois Environmental Protection Agency disburses Illinois' share of this money through the Non-point Source Pollution Control Grant Program, commonly known as the "319 Grant Program". Each year IEPA offers funding for projects designed to reduce water pollution through best management practices, educational projects, and, to a limited extent, research and monitoring. Further coordination with IEPA and the FPDDC will be required to determine the feasibility of this funding option. The work group has applied for a 319 Grant for the design phase of this project, which has been approved.

Illinois Department of Natural Resources (IDNR)

The purpose of the Ecosystems Program of IDNR is to integrate the interests and participation of local communities and private, public, and corporate landowners to enhance and protect watersheds through ecosystem-based management. The Ecosystems Program is funded through Conservation 2000 (C2000), a comprehensive long-term approach to protecting and managing Illinois' natural resources through partnerships with grass-roots stakeholders.

The C2000 Ecosystems Program is focused on non-state owned land, which encompasses about 95% of the state. The largest component of the C2000 program is the Ecosystem Project Grants. These grants are awarded annually in the following categories: Habitat, Land Acquisition, Research, Outreach, Planning, and Resource Economics.

Some components of this project may be funded by this program. Coordination with IDNR and the FPDDC will be required to determine the applicability of this funding option.

USDA Natural Resources Conservation Service

The Wildlife Habitat Incentives Program (WHIP) is a voluntary NRCS program for people who want to develop and improve wildlife habitat primarily on private land. Through WHIP, NRCS provides both technical assistance and up to 75% cost-share assistance to establish and improve fish and wildlife habitat. WHIP agreements between NRCS and the participant generally last from five to ten years from the date the agreement is signed.

WHIP funds can be used on a "Special Project" basis designation to remove low head dams that will improve fish habitat and water quality. Additional consideration is given to those projects that are endorsed locally. Coordination with NRCS will provide guidance on the requirements of this program.

US Fish and Wildlife Service

The Fish Passage Grant Program has been used to provide technical assistance and federal funds to remove, replace, or retrofit artificial barriers such as low head dams. The goal of the Fish Passage Program is to restore native fish and other aquatic species to self-sustaining levels by reconnecting habitats that have been fragmented by artificial barriers, where such reconnection results in a positive ecological effect. Coordination with USFWS is required to determine the possibility of funding from this program.

8.2.2.2 DuPage County Wetland Mitigation Banking

Development of a wetland bank as part of this project could provide funding for improvements. A wetland bank is a large wetland creation project (usually greater than 10 acres) that offers to sell created wetland acreage to satisfy permit requirements. In exchange for a fee, the banker takes the responsibility of maintaining and monitoring the mitigation site. Like onsite and offsite mitigation, creation of wetland must take place in the same watershed as the impact.

In DuPage County, mitigation is often required to replace or restore the benefits of a resource. When onsite or offsite mitigation for a project is not practicable, payment into an approved wetland bank is sometimes an option. Coordination with DuPage County and the FPDDC will be required to determine the feasibility of this funding option.

8.2.2.3 Private and Non-Profit Organizations

<u>American Rivers</u>

American Rivers is a national non-profit conservation organization dedicated to protecting and restoring healthy natural rivers and the variety of life they sustain for people, fish, and wildlife. The American Rivers organization provides reports, documents, and other resources relevant to dam removal financing.

<u>National Fish and Wildlife Foundation - General Matching Grant Program</u>

The National Fish and Wildlife Foundation funds projects to conserve and restore fish, wildlife, and native plants through matching grant programs. The Foundation awards matching grants to projects that address habitat conservation, while working proactively with community interests. Federal, state, and local governments, educational institutions, and non-profit organizations can apply for a general matching grant throughout the year.

Traditionally projects have tried to gain funding for both design and construction at the same time or have garnered funds for design only, pending a detailed construction cost estimate as a deliverable in the design phase to guide additional fund raising efforts. The differences between the two approaches are small, although the latter does afford a higher level of assurance on construction costs once final design has been completed.

8.3 Design, Permitting, and Construction

<u>Permitting</u>

Dam removal or modification requires permits from federal, state and local agencies. A federal 404 permit from the U.S. Army Corps of Engineers (USCOE) would be required for instream work related to dam modification or removal. A related 401 Water Quality Certification will also be required from the Illinois Environmental Protection Agency (IEPA).

The Illinois Department of Natural Resources Office of Water Resources (IDNR_OWR) regulated construction in streams, public waters and floodplains. Construction in the waterway for dam removal or modification would require IDNR-OWR permitting.

The DuPage County Department of Economic Development and Planning, Division of Environmental Concerns (DEC) has jurisdiction over wetlands and floodplains in DuPage County. Permits will also be required from DEC for modifications to the floodplain, dam removal/modification or wetland impacts.

Agency coordination will be part of the permitting process. Permitting applications for the USCOE or DEC will be submitted to the following agencies:

- US Fish & Wildlife Service (USF&WS)
- Illinois Department of Natural Resources (IDNR)
- Illinois Environmental Protection Agency (IEPA)
- Illinois Historic Preservation Agency (IHPA)

The IHPA may require a Phase I Archeological survey of the project area. Due to the historic nature of the dam, details about its removal may be required to be catalogued with the IHPA in the appropriate manner. To mitigate any adverse effects caused by dam modification or removal, a Historic American Building or Historic American Engineering Record survey (HABS) for the dam may also be required.

The timing of a dam repair or removal is critical for controlling sediment movement and performing restoration work, such as wetland restoration or revegetating the newly exposed land. Revegetation improves the appearance of the site, and it also helps control sedimentation, provide habitat, and protect native plant species. Dam removal will result in temporary impacts on water quality, habitat, and aesthetics, at any time of the year. Table 8-3 lists seasonal advantages and disadvantages for drawing down an impoundment and performing restoration work.

Table 8-3 - Seasonal Factors of Dam Removal

FACTOR	WINTER	SPRING	SUMMER	FALL
WEATHER	Weather can impact construction progress.	Weather is changeable.	Weather is favorable for construction activities.	Weather is favorable for construction activities.
FLOW	Low runoff reduces erosion of exposed sediments.	High snowmelt or rainstorm runoff may lead to increased erosion	High intensity rainstorms can cause high runoff and sediment erosion	Fall rainstorms may produce high runoff that erodes exposed sediments.
HABITAT	Amphibians and reptiles that have buried their eggs or are hibernating may be affected.	Most biological activity (fish spawning, migration, nesting, egg laying) occurs.	Panfish spawn may be affected by drawdown of the impoundment.	Drawdown of the impoundment may impact waterfowl migrations.
SITE	Frozen ground may improve accessibility to site.	Wet site conditions may impact progress.	Good site conditions for earthwork.	Good site conditions for earthwork.
CONTRACTING	Generally bids are lower	Generally bids are higher		
AESTHETICS	Winter snow may cover exposed sediments.	Exposed sediments are more visible	Exposed sediments are more visible & noise and dust are more evident.	Exposed sediments are more visible
VEGETATION	New vegetation will not appear until later in spring.	New vegetation quickly establishes in the spring..	New vegetation quickly establishes in the summer.	New vegetation establishes in early fall, but in late fall, will not appear until spring.

8.4 Operation and Monitoring

Proper operation and maintenance is critical to the success of the project. Attaining acceptable channel stability may take several years. During the establishment period, allowances for revegetation and adjustments to riffles and other features must be considered.

A thorough monitoring plan before, during, and after dam removal is not only necessary to determine attainment of mitigated stream function, but is also necessary as part of an adaptive management program that provides early indication of potential problems and direction for corrective actions.

Applicable monitoring methods for dam removal should be determined based upon specific monitoring goals and requirements as defined in project permits. Specific monitoring requirements may include evaluation of primary and secondary indicators of project success.

Guidelines for monitoring techniques should be determined based on monitoring requirements. General references for applicable ecological and biological monitoring protocols should be utilized. The referenced documents are commonly used by the regulatory community and are therefore applicable to the determination of mitigation benefits associated with dam removal. Specific regional guidelines should also be referenced as required.

Regional, state, and local guidelines should also be assessed to establish practical and meaningful monitoring strategies.

Table 8-4 defines potential monitoring parameters for dam removal.

Table 8-4 - Monitoring Parameters

PHYSICAL	CHEMICAL	BIOLOGICAL	ECONOMIC	SOCIAL
Changes to downstream hydrology	Dissolved oxygen	Change in algal biomass and species composition	Cost-benefit of dam O&M versus removal	Change in public attitudes to project over time
Sediment degradation within impounded area and upstream	Specific conductance	Change in benthic macroinvertebrate taxa	Value of services lost and services gained	Change in recreational patterns
Sediment degradation downstream of removal site	Temperature and pH	Change in fish community assemblage	Change in property values	Change in property ownership near project
Grain size and bedload analysis	Turbidity	Restored fish passage and distribution	Change in cost of O&M for infrastructure	Change in seasonal homeowners
Channel morphology (cross sectional and longitudinal)	Suspended particulate material and nutrients (C, N, P)	Change in populations and distributions of species	Change in local business revenue	Change in perceptions of public safety
Floodplain morphology	Redistributions of organic contaminants	Decrease in fish parasites	Groundwater recharge	Change in zoning or long-term municipal planning
Groundwater recharge	Redistribution of particulate organic matter	Change in riffle and deep pool habitat	-	-
Watershed fragmentation	Change in seasonal nutrients (e.g., due to fish migration)	Change in wetland type and acreage	-	-

9 SOURCES

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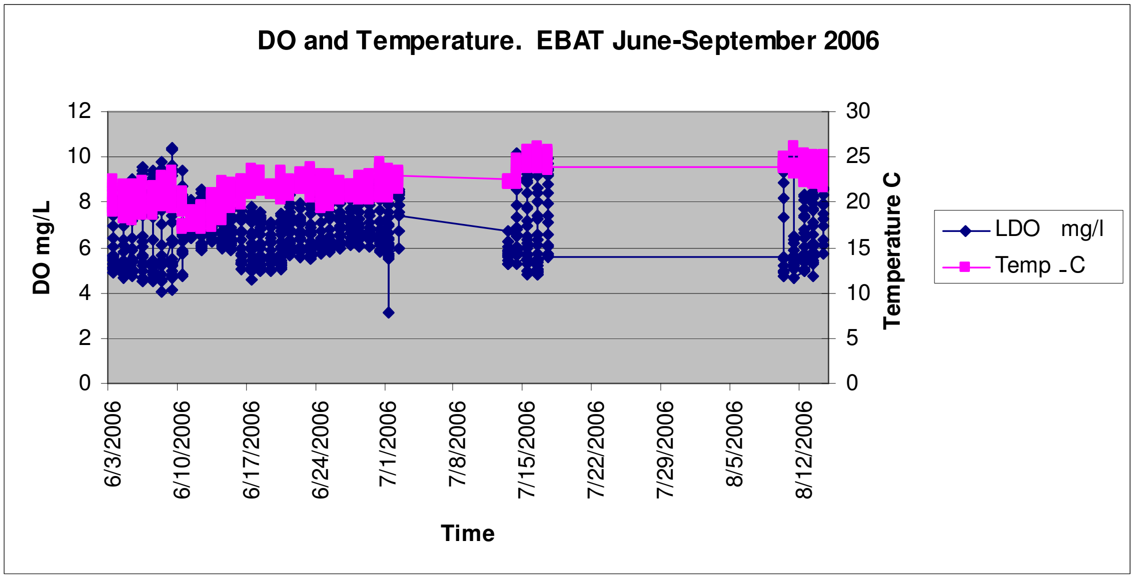
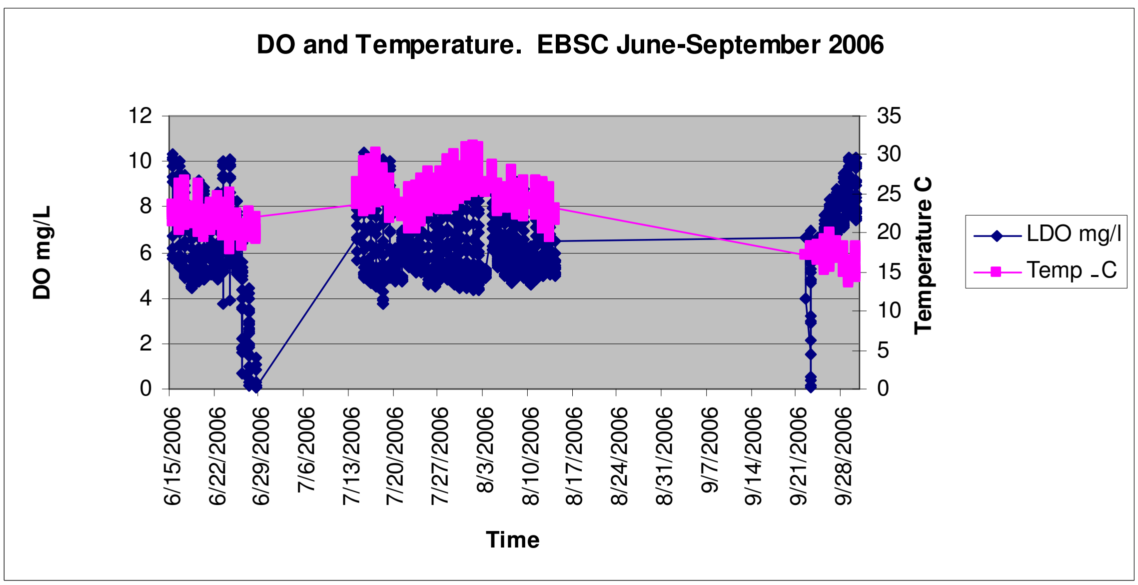
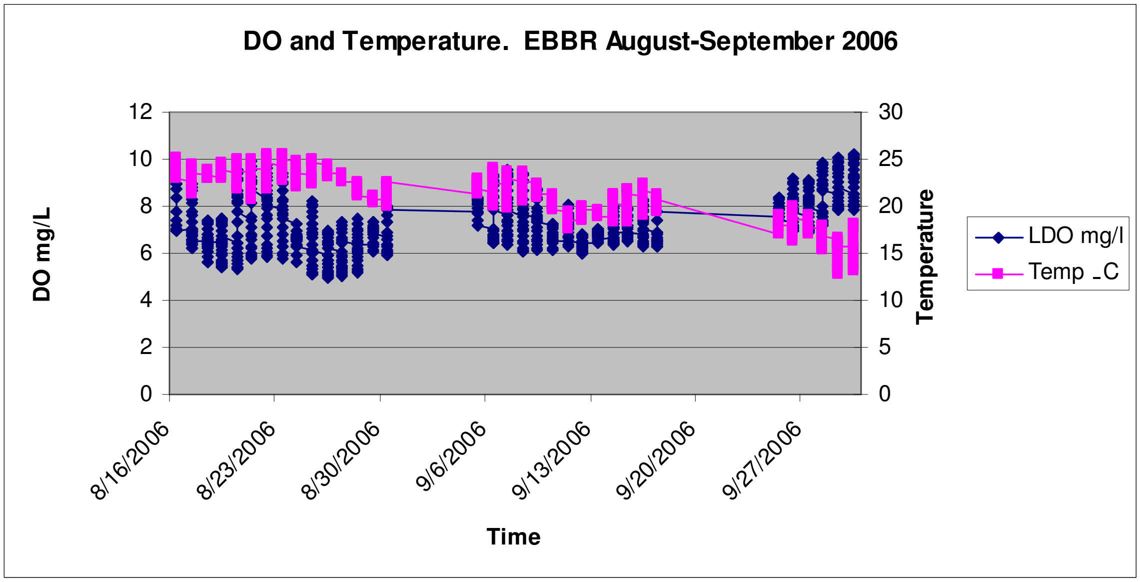
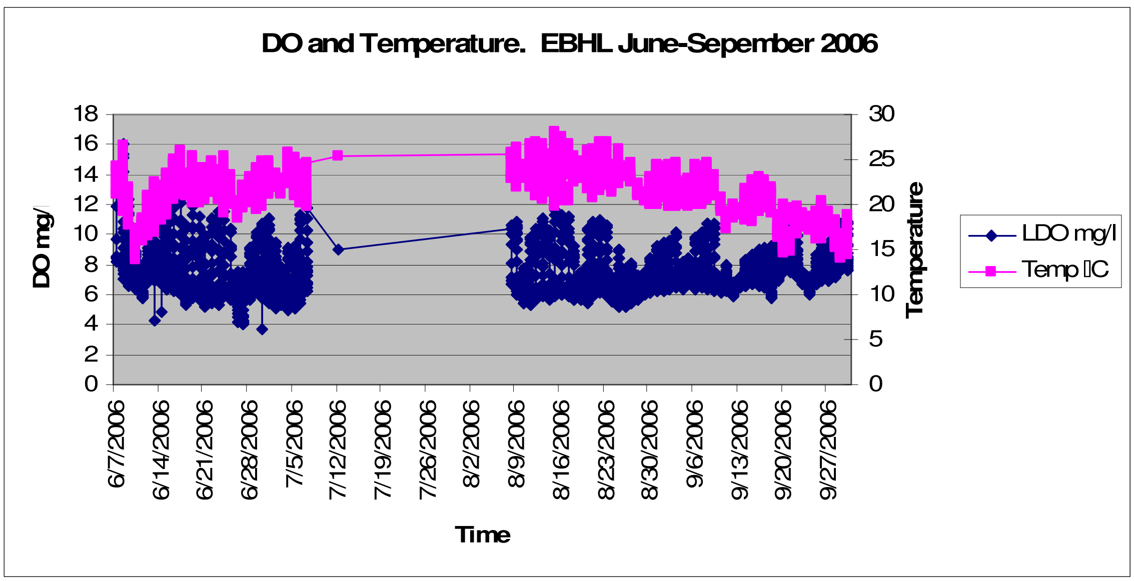
Annex 1. Summary of DO data





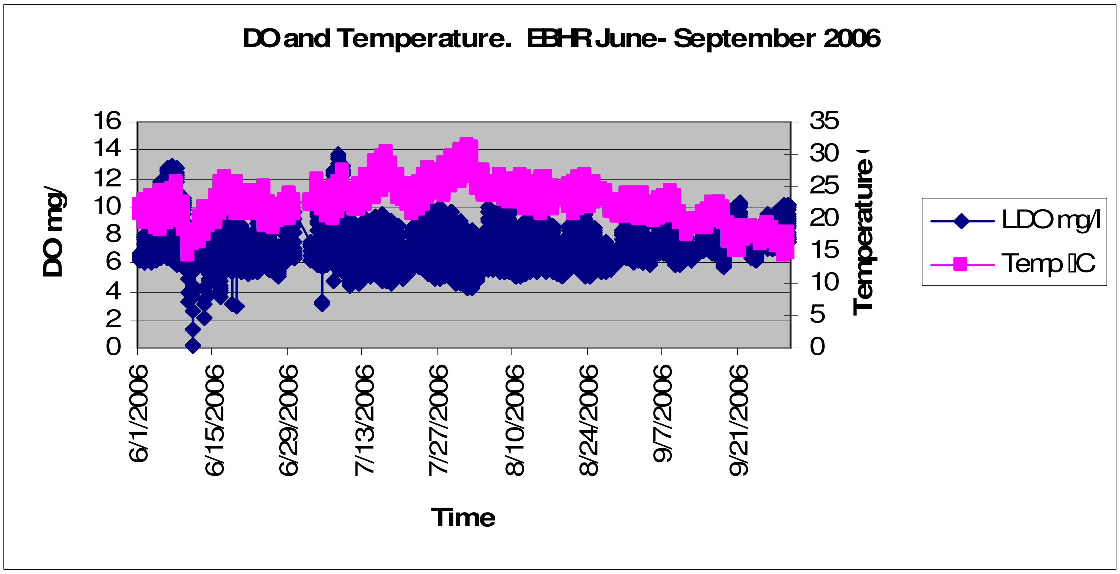
Annex 1. East Branch DO and temperature data for 2006, Army Trail Road (EBAT) and Saint Charles Road (EBSC)

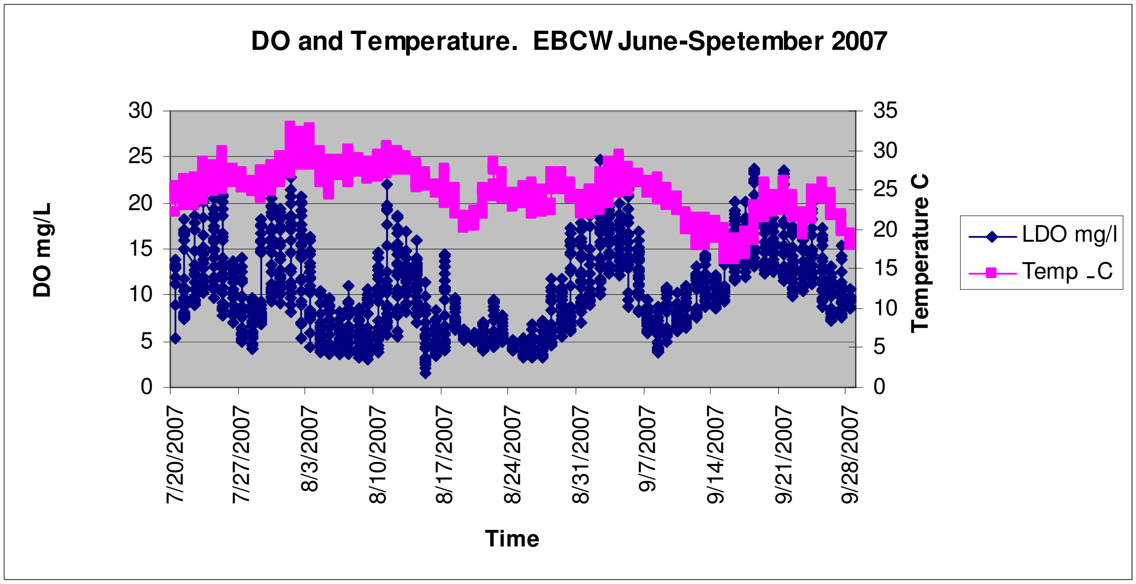


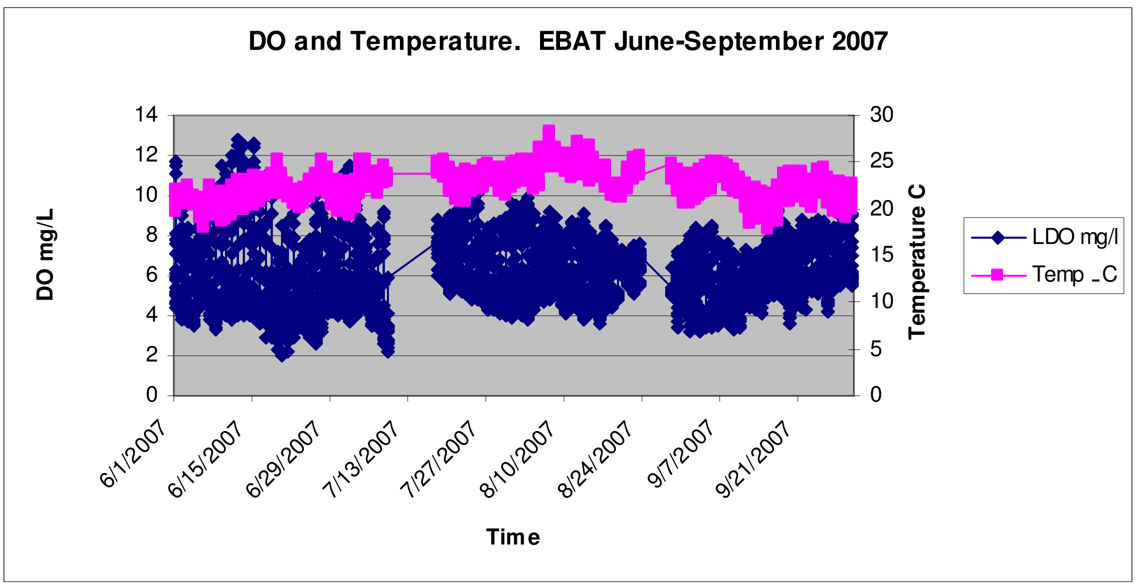


Annex 1. East Branch DO and temperature data for 2006, Butterfield Road (EBBR) and Hidden Lake (EBHL)

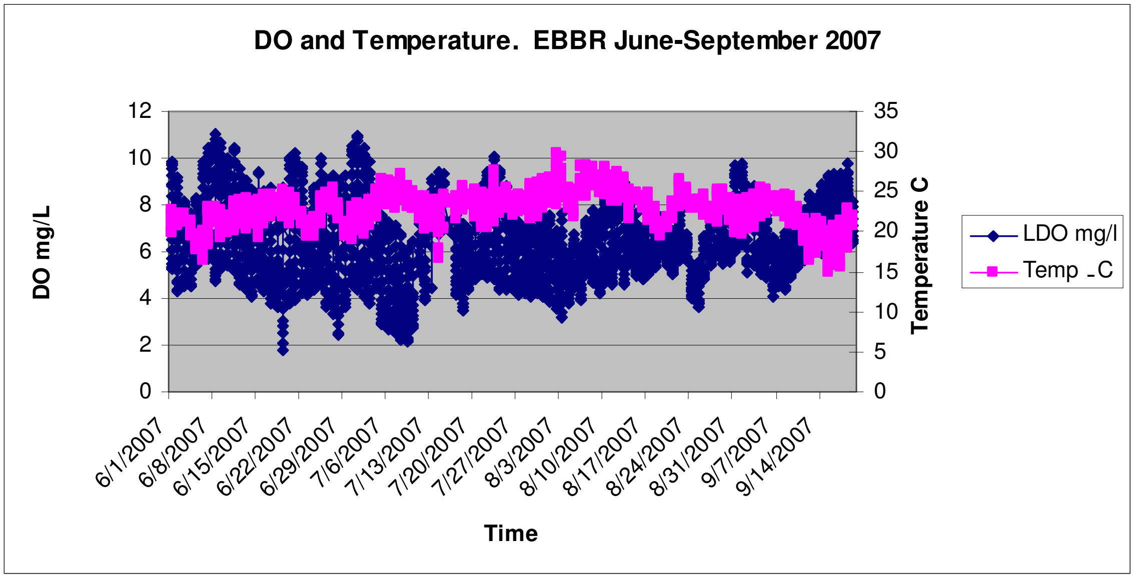
Annex 1. East Branch DO and temperature data for 2006, Hobson Road (EBHR)

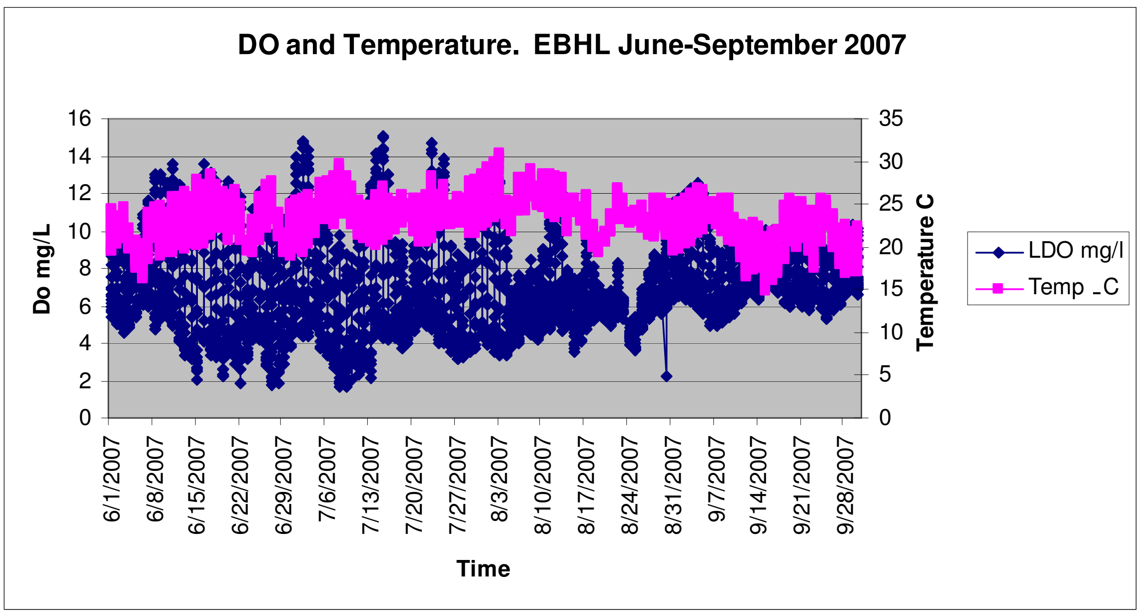




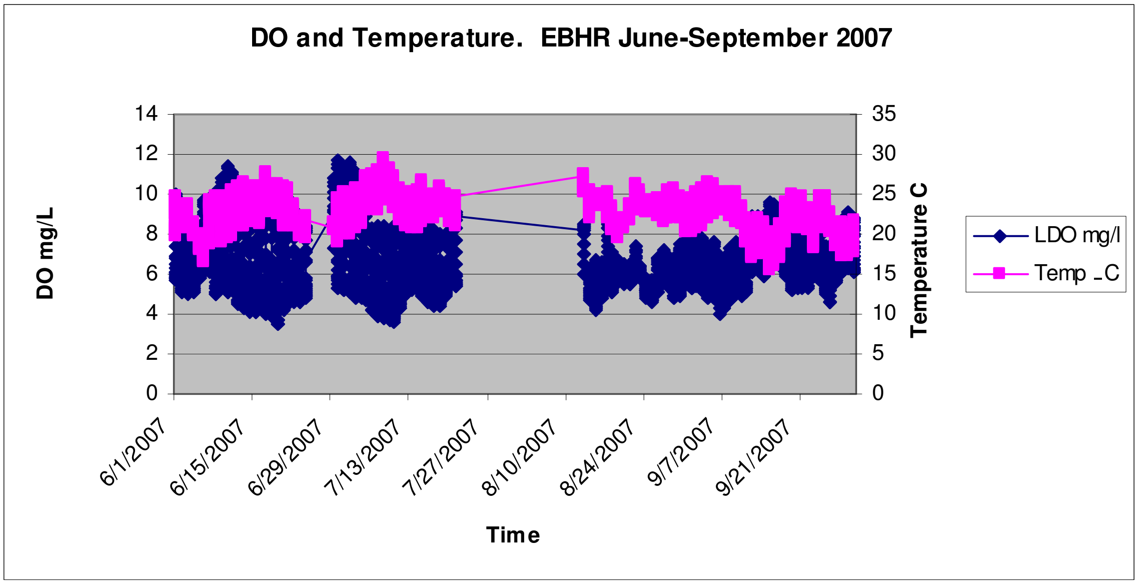


Annex 1. East Branch DO and temperature data for 2007, Churchill Woods (EBCW) and Army Trail Road (EBAT)





Annex 1. East Branch DO and temperature data for 2007, Butterfield Road (EBBR) and Hidden Lake (EBHL)



Annex 1. East Branch DO and temperature data for 2007, Hobson Road (EBHR)