Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

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General *Superintendent*

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January 23, 2007

Mr. Toby Frevert, Manager
Division of Water Pollution Control
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Mr. Frevert:

Subject: Evaluation of Management Alternatives for the Chicago Area Waterways: Investigation of Technologies for Supplemental Aeration of the North and South Branches of the Chicago River, Flow Augmentation of the Upper North Shore Channel, and Flow Augmentation and Supplemental Aeration of the South Fork of the South Branch of the Chicago River

The Metropolitan Water Reclamation District of Greater Chicago, at the request of the Illinois Environmental Protection Agency (IEPA), hereby submits the enclosed reports entitled "Technical Memorandum 4WQ: Supplemental Aeration of the North and South Branches of the Chicago River", "Technical Memorandum 5WQ: Flow Augmentation of the Upper North Shore Channel", and "Technical Memorandum 6WQ: Flow Augmentation and Supplemental Aeration of the South Fork of the South Branch of the Chicago River."

Using the services of Consoer Townsend Envirodyne Engineers, Inc., these reports have been developed to evaluate technologies and costs for Supplemental Aeration of the North and South Branches of the Chicago River, Flow Augmentation of the Upper North Shore Channel, and Flow Augmentation and Supplemental Aeration of the South Fork of the South Branch of the Chicago River.

If you have any questions, please contact Mr. Lou Kollias at (312) 751-5190.

Very truly yours,

R Lan VNI--

Richard Lanyon U
General Superintendent

JS:TK
Attachments
cc: L. Kollias, MWRD
R. Sulski, IEPA

FINAL 01/12/07

TECHNICAL MEMORANDUM 6WQ

FLOW AUGMENTATION AND SUPPLEMENTAL AERATION OF THE SOUTH FORK OF THE SOUTH BRANCH OF THE CHICAGO RIVER (BUBBLY CREEK)

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

NORTH SIDE WATER RECLAMATION PLANT AND SURROUNDING CHICAGO WATERWAYS

Submitted by:

CTE | AECOM

Revision 4– January 12, 2007

MWRDGC Project No. 04-014-2P
CTE Project No. 40779

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FLOW AUGMENTATION AND SUPPLEMENTAL AERATION OF THE SOUTH FORK OF THE SOUTH BRANCH OF THE CHICAGO RIVER (BUBBLY CREEK) TM-6WQ

INTRODUCTION

Background

Consoer Townsend Envirodyne Engineers, Inc. (CTE) was retained in 2005 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) to provide engineering services to prepare a comprehensive Infrastructure and Process Needs Feasibility Study (Feasibility Study) for the North Side Water Reclamation Plant (WRP). As part of the scope of work for the Feasibility Study, CTE was directed to determine the technologies and costs of water quality management options which originated from the on-going Use Attainability Analysis (UAA) being conducted by the Illinois Environmental Protection Agency (IEPA) of the Chicago Area Waterways (CAWs). The CAWs are shown in Figure 6.1.

This report presents the results of a study of one of the water quality management options that originated from the UAA, namely flow augmentation and supplemental aeration of the South Fork of the South Branch of the Chicago River commonly known as Bubbly Creek. Flow augmentation and supplemental aeration of Bubbly Creek is among several water quality management options studied by CTE. Other water quality management options are discussed in separate reports. These reports are not designed to determine which (if any) of the water quality management options should be implemented. Such a determination can only be made by conducting a comparison of the costs and benefits of all the management options and then developing a water quality management plan which combines the most cost effective option into an integrated strategy for improving the water quality of the CAWs. Such an integrated strategy has not been developed at this time.

UAA Process

The Clean Water Act requires the states to periodically review the uses of waterways to determine if changes to the existing water quality standards are needed to support a change in use. Based upon a study of the CAWs, the IEPA had decided that a change may be required in the dissolved oxygen (DO) standards for these waterways.

As part of the UAA the IEPA suggested several water quality management options for improving the DO of the CAWs and asked that the MWRDGC determine the technologies and costs for these options. One of the options that was suggested by the IEPA was flow augmentation and supplemental aeration of Bubbly Creek.

Flow Augmentation and Supplemental Aeration

Figure 6.1 shows the entire CAWs. Bubbly Creek consists of the section of the CAWs from the MWRDGC's Racine Avenue Pumping Station to the junction with the South Branch of the Chicago River (SBCR). Figure 6.2 shows an aerial photograph of Bubbly Creek.

Bringing flow from the SBCR to the headwaters of Bubbly Creek near the Racine Avenue Pumping Station could have the following benefits:

1. Increasing the DO of the Bubbly Creek.
2. Eliminating stagnant conditions during dry weather flow to improve aesthetics.

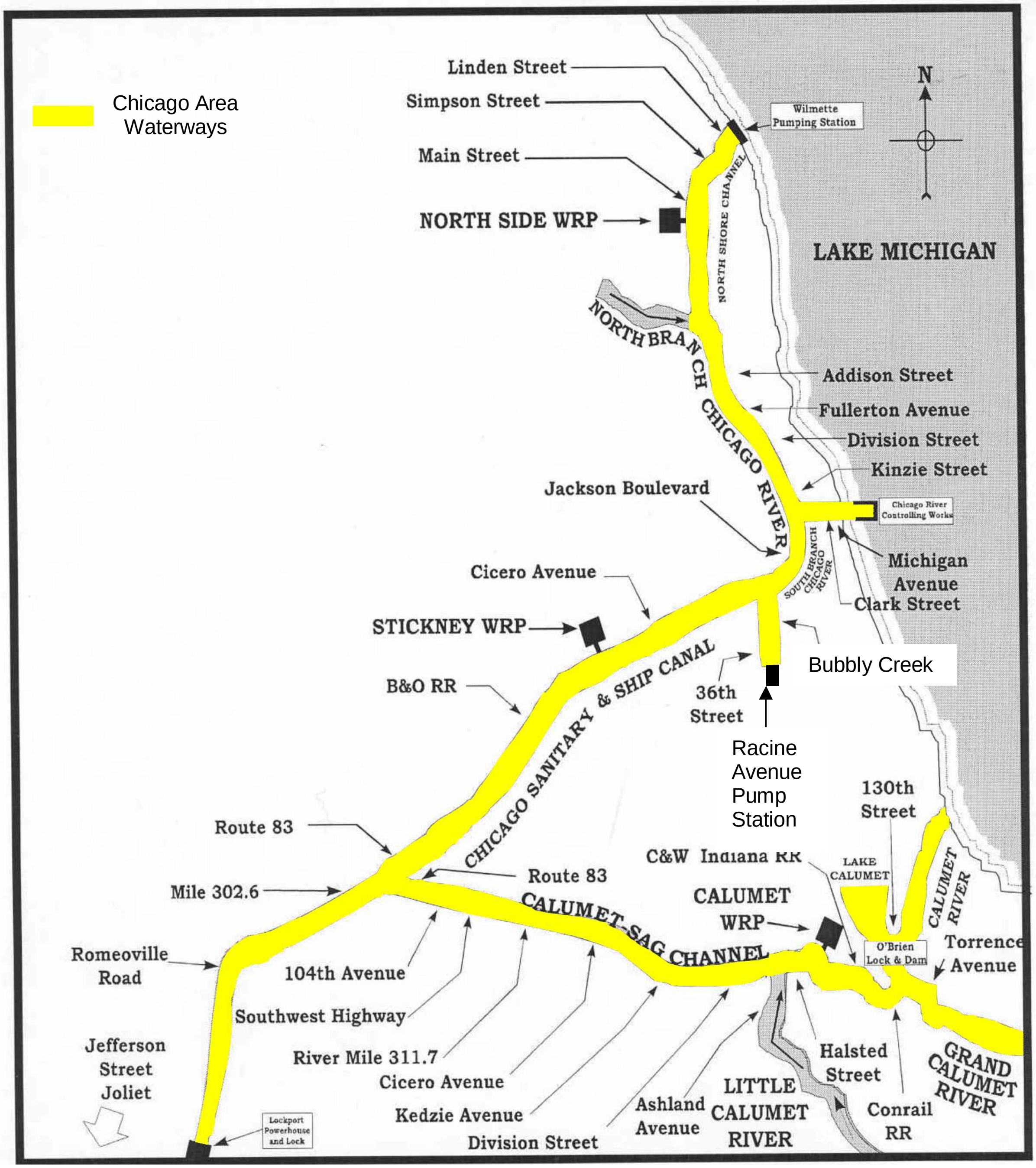


Figure 6.1 – The Chicago Area Waterways

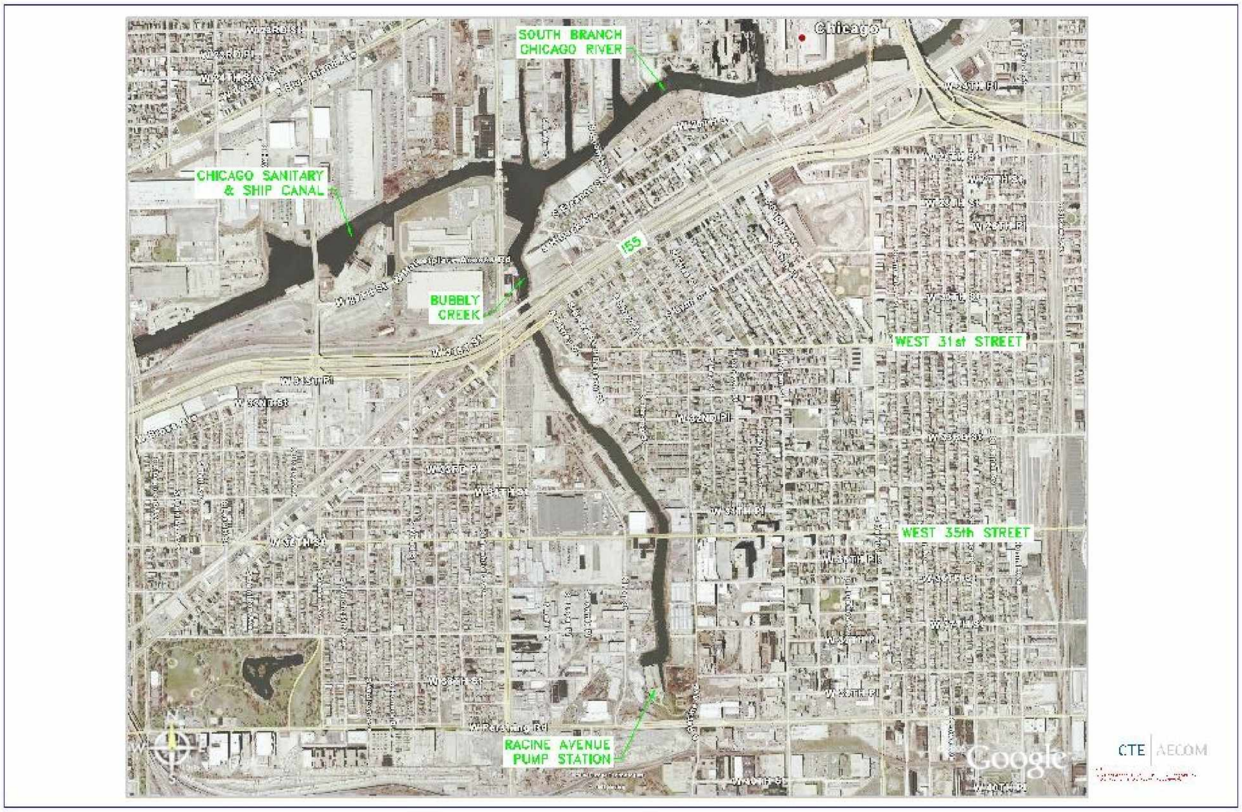


Figure 6.2 – Aerial Photograph of Bubbly Creek

Supplemental aeration is another water quality management option which has the potential for improving the DO of Bubbly Creek. This option was also studied in this report.

Supplemental aeration is already being practiced in the CAWs by the MWRDGC. Two supplemental aeration stations exist on the North Shore Cannel (NSC) and the North Branch of the Chicago River (NBCR) at Devon and Webster Avenues, respectively. These stations provide aeration by means of porous ceramic diffusers at the bottom of the waterway. The diffusers are supplied with air from an on-shore blower facility at each station. Along the Little Calumet River, Calumet River and Cal-Sag Channel waterways, the MWRDGC has five supplemental aeration stations utilizing sidestream aeration where low lift pumps remove a portion of the flow from the waterway and aerate this flow using a free-fall weir system which subsequently returns the flow back to the waterway.

Objective and Scope of Study

The objective of the study was to determine the technology and cost to transfer flow from the SBCR to the headwaters of Bubble Creek and investigate the possibility of supplemental aeration in conjunction with flow augmentation.

The District directed that CTE investigate two alternatives for flow augmentation of Bubbly Creek.

1. Transfer the flow from the SBCR to the Bubbly Creek without providing any artificial aeration of the transferred flow. In other words, the inherent DO of the SBCR would not be increased before discharge at the headwaters of Bubbly Creek.
2. Aerate the SBCR Flow to saturation before discharge at the headwaters of Bubbly Creek.

Supplemental aeration was also studied as a possible water quality management option for Bubbly Creek. For this option, it was necessary to include the combination of supplemental aeration with flow augmentation since there is virtually no flow in Bubbly Creek during dry weather. The main discharge to the waterway is the MWRDGC's Racine Avenue Pump Station which only discharges to Bubbly Creek during wet weather.

Therefore, this report contains a study of three water quality management options for Bubbly Creek:

1. Flow Augmentation without aeration of the transferred flow
2. Flow Augmentation with aeration of the transferred flow
3. Supplemental Aeration in combination with flow augmentation without aeration of the transferred flow

This report makes no attempt to determine whether flow augmentation and supplemental aeration is a cost-effective method to improve the water quality of Bubbly Creek. To reach such a conclusion, all of the water quality management options that have been suggested by the IEPA in the UAA process would have to be studied in an integrated fashion to determine which (if any) of the alternatives or combination of alternatives, would be the most cost-effective for meeting the future water quality standards for the entire CAWs as determined by the UAA. Such an analysis is beyond the scope of this study and would require significant input from the various stakeholders in the UAA process. Through the UAA process, the IEPA and the stakeholders will examine the technologies and costs of the various individual options, review their water quality benefits and ultimately determine which of the alternatives should be seriously considered for possible implementation.

Water Quality Dissolved Oxygen Standards for Bubbly Creek

Currently under existing Illinois Pollution Control Board (IPCB) Secondary Contact water quality regulations, Bubbly Creek is required to have a minimum of 4 mg/l of DO at all times. So far, the IEPA through the UAA process has not reached a final decision as to the future DO water quality standards for Bubbly Creek. They have suggested that current IPCB General Use water quality DO standards might be applied to Bubbly Creek (6 mg/l for 16 out of 24 hours and not less than 5 mg/l at any time) or minimum DO levels of 4, 5 or 6 mg/l may be required in the future for Bubbly Creek.

Target Waterway DO Levels for this Study

It is necessary in this study to select a dissolved oxygen target in order to determine process sizing and thus determine the cost for a flow augmentation and supplemental aeration system for Bubbly Creek. After discussions with the MWRDGC, it was decided that the dissolved oxygen target would be 5 mg/l. This level is within the range of potential DO standards suggested in the UAA. However, recognizing that a rigid DO standard is difficult to meet under all waterway conditions, it was decided that the target would be 5 mg/l and that achieving this level 90% of the time at all locations in a waterway would be acceptable. It is hoped that the IEPA will adopt a similar approach to a waterway DO standard and recognize that 100% compliance is not possible or necessary. The use of this target for this study in no way represents a recommendation from the MWRDGC.

Flow Augmentation Modeling

In order to determine the capacity of a flow augmentation and supplemental aeration system including the amount of transferred flow, the need for aeration of this flow and the size and location of the supplemental aeration stations, an existing water quality model of the CAWs was used. This model was developed by Marquette University for the MWRDGC.

This model is described in the report entitled, “Preliminary Calibration of a Model for Simulation of Water Quality During Unsteady Flow in the Chicago Waterway System and Proposed Application to Proposed Changes to Navigation make-Up Diversion Procedures”, dated August, 2004. This report was produced by Dr. Charles Melching from the Institute for Urban Environmental Risk Management at Marquette University (Milwaukee, Wisconsin) for the MWRDGC.

The Marquette Model was used to simulate the two flow augmentation alternatives described previously:

1. Transfer of unaerated SBCR flow to the headwaters of Bubbly Creek
2. Transfer of aerated SBCR flow to the headwaters of Bubbly Creek

The model was also used to determine the size of supplemental aeration stations used in conjunction with flow augmentation. The model allowed CTE to determine effects of various versions of these alternatives on the DO levels of Bubbly Creek. The model can simulate the

DO in the waterway as a result of a simulated amount of flow augmentation with a certain simulated dissolved oxygen concentration and simulate the effect of supplemental aeration.

For the unaerated flow augmentation alternative, simulated SBCR flows and DO levels in the SBCR from the Marquette Model were used. For an aerated flow augmentation simulation run, the model simulated the flow of the SBCR raised to saturated DO levels. Of course, saturated DO concentrations are dependent upon temperature but typically the saturated DO is about 8 to 10 mg/l.

The time periods simulated in the Marquette Model were:

Year	Time Period
2001	July 12 to September 14
2001	September 1 to November 10
2002	May 1 to August 11
2002	August 10 to September 23

Model simulations in the Marquette Model include overlapping time periods. It is inappropriate to use overlapping time periods for the evaluation of water quality management options. Therefore, percent compliance in this report does not include overlapping periods. For this report, all the results for the July 12 to September 14, 2001 and May 1 to August 11, 2002 times periods were used; those parts of the time periods of September 1 to November 10, 2001 and August 10 to September 23, 2002 which overlapped with these periods were not used.

These time periods were chosen by Marquette as inputs to the model since the data base was the most complete of any available.

Percentage compliance was based upon determining the percent of time that model simulated hourly DO stream DO levels were at or above 5 mg/l.

The Marquette Model runs conducted for this study had the following general assumptions.

1. Tunnel and Reservoir Plan (TARP) Tunnels are fully operational
2. TARP Reservoirs are not on-line.
3. Other water quality management options requested by IEPA in the UAA are not on-line.

Evaluation of the Alternatives contained in the report is based upon hourly results from all Marquette model simulation periods since there is considerable variation in the water quality conditions between the simulation periods in the Marquette Model.

The Racine Avenue Pump Station (RAPs) has a significant effect upon the DO levels in Bubbly Creek during wet weather events. Any significant change in the RAPs discharge concentrations of oxygen demanding substances or the RAPs discharge volume would significantly affect the size and the cost of the various water quality management alternatives studied.

Modeling Runs for Flow Augmentation of Bubby Creek Without Aeration

Modeling runs were conducted by Marquette University to determine if flow augmentation alone without aeration of the transferred flow would be sufficient to meet the DO target level for Bubbly

Creek. A report of these model runs authored by Marquette University can be found in Appendix B.

The withdrawal point for flow augmentation of Bubbly Creek is the intersection of Throop Street and the SBCR. This point is slightly upstream of the intersection of Bubbly Creek and the SBCR.

Six different unaerated flows of 50, 100, 200, 400, 450 and 550 mgd were evaluated. A maximum transfer rate of 550 mgd was selected since this was the approximate maximum amount of available flow in the SBCR for transfer to Bubbly Creek. Since for certain time periods, the model sometimes showed flows in the SBCR at Throop Street to be less than the transferred amount, the amount of flow was still transferred and the flow in the SBCR was set to zero. This approach did not result in hydraulic problems in the model computations. In the actual design of a flow augmentation scheme, more precise flow transfers should be used in the model. In such a design a time series of analysis of transferred flows would be constructed for the periods when the simulated SBCR discharge was less than the transferred amount. This time series analysis would be used to calculate the percent compliance with the DO standard. Such an analysis is beyond the scope of the existing Marquette Model project. For this report, percent compliance was calculated assuming that the transferred amount was available and thus the percent compliance is optimistic, especially for the higher transferred amounts.

Even though Marquette completed simulations for unaerated flow augmentation for 6 different transfer values varying from 50 to 550 mgd, results of only the 50 and 400 mgd transfer simulation results are shown in this report. These model runs show that flow augmentation without aeration does not significantly affect the DO of Bubbly Creek at I-55 near its discharge to SBCR. Table 6.1 shows the percentage of time that DO levels in Bubbly Creek at I-55 are above 5 mg/l for both wet and dry periods for transfer rates of 50 and 400 mgd. As can be seen in Table 6.1, there is no significant difference in the percent compliance for the two flows. Thus unaerated flow augmentation by itself will not significantly improve the DO of Bubbly Creek.

TABLE 6.1
PERCENTAGE OF TIME THAT DISSOLVED OXYGEN CONCENTRATIONS ARE GREATER THAN 5 MG/L AT I-55 AND BUBBLY CREEK FOR JULY 12-NOVEMBER 10, 2001 FOR DIFFERENT TRANSFER RATES FOR UNAERATED FLOW AUGMENTATION

Unaerated Flow Augmentation	% of Time	
	Wet	Dry
50 mgd	41.9	31.6
400 mgd	42.0	31.9

This result is not surprising since the Marquette Model generally shows low DO in the SBCR during summer conditions. Dissolved oxygen levels in the SBCR at Throop Street during the summer often are 1 mg/l or less.

Modeling Runs for Flow Augmentation with Aeration of the Transferred Flow

The Marquette model was used to simulate dissolved oxygen levels in Bubbly Creek where saturation DO concentrations were assigned to the transferred flow. A written report authored by Marquette University of these run can be found in Appendix B. Transfer volumes of 50, 100, 200, 400, 450 and 550 mgd were simulated. A transfer rate of 550 mgd was found necessary to approach 5 mg/l of DO more than 90% of the time at the intersection of Bubbly Creek and I-55. It should be again stated that a approximately 550 mgd of flow in the SBCR is available for flow augmentation. Figure 6.3 shows the percent compliance at various locations on Bubbly Creek with the 5 mg/l target water quality standard based upon the Marquette Simulations with 550 mgd of aerated transferred flow. The river miles on the x-axis of Figure 6.3 represent the mid-point of the model segments from the mouth of Bubbly Creek (confluence with the South Branch of the Chicago River). I-55 is the dividing line between the 2nd and 3rd segments in the model and is located at River Mile 0.32. As can be seen, the target DO water quality target is not achieved at all locations on Bubbly Creek even with aeration of 550 mgd of transferred flow. Over 90% compliance with 5 mg/l was only achieved in the upper reaches of Bubbly Creek and not at the mouth (the I-55 bridge).

Marquette model simulations showed a very high oxygen demand at the mouth of Bubbly Creek near the junction with the SBCR. This demand was so high that even pumping 550 mgd of aerated SBCR flow to the headwaters of Bubbly Creek was not sufficient to raise the percent compliance with 5 mg/l of DO to 90% at end of Bubbly Creek near the junction with the SBCR. The reasons for this high oxygen demand was not fully investigated but it is believed to be caused by the influence of the SBCR at the junction. The SBCR has a relatively low DO at this location and this low DO water may be impacting the DO of Bubbly Creek near the junction with the SBCR.

Figure 6.4 shows a map with the location of the 550 mgd flow augmentation pumping station and force main aeration system. The pumping station and force main aeration system would be located on land adjacent to the SBCR and the force main would be located on land adjacent to the SBCR and Bubbly Creek. There is sufficient vacant land adjacent to Throop Street on the SBCR to accommodate this pump station and force main aeration system.

For cost estimating purposes, compressed air U-Tubes will be used to provide force main aeration. Compressed air U-Tubes are routinely used for force main aeration to control odors from sewage pump stations. Thus, this is a proven technology for force main aeration. In addition, this aeration technology was among the four short-listed technologies selected for supplemental aeration in TM-4WQ. U-Tubes allow DO levels far above saturation, thus requiring less of the transferred flow to be aerated. If this Water Quality Management option should proceed to implementation, a more detailed study of force main aeration alternatives should be conducted to select a final candidate for design purposes.

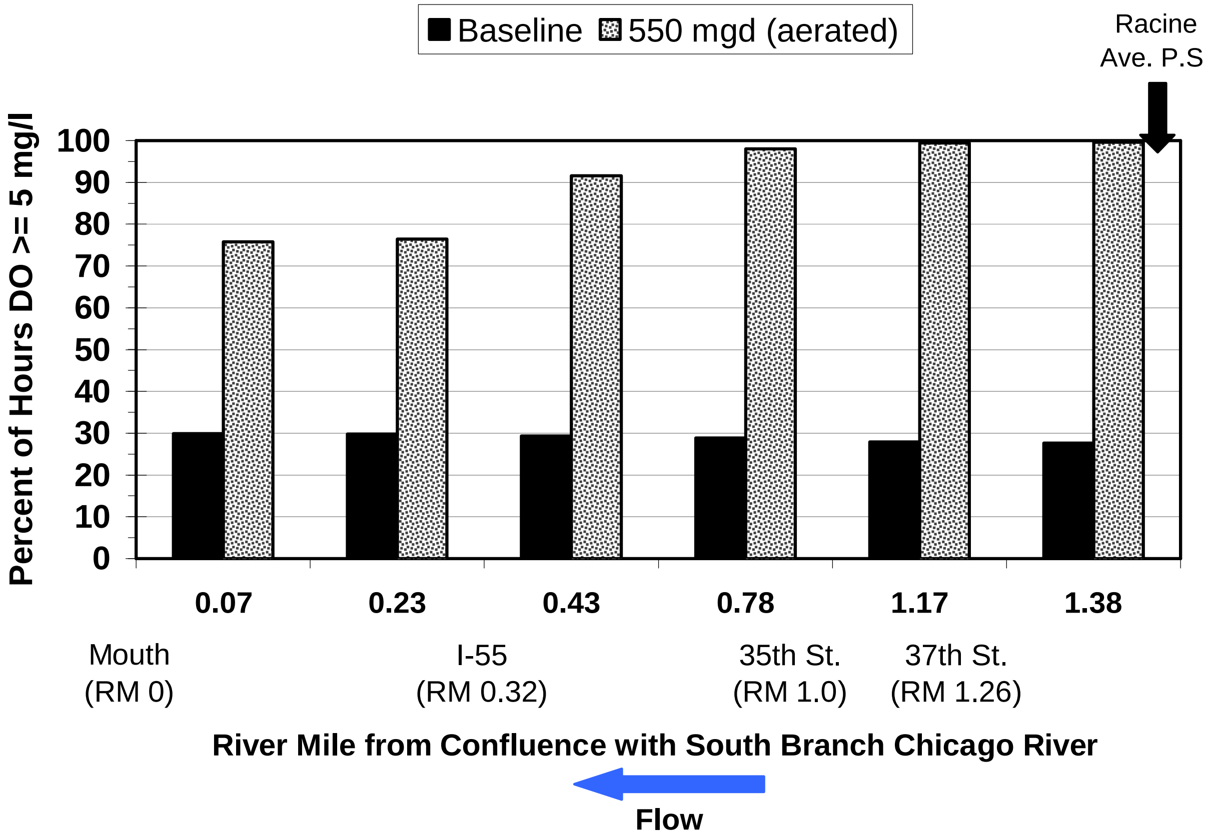


Figure 6.3 – Flow Augmentation with Aeration of Transferred Flow, % Compliance with 5 mg/l Minimum Dissolved Oxygen, For All Simulated Time Periods in the Marquette Model

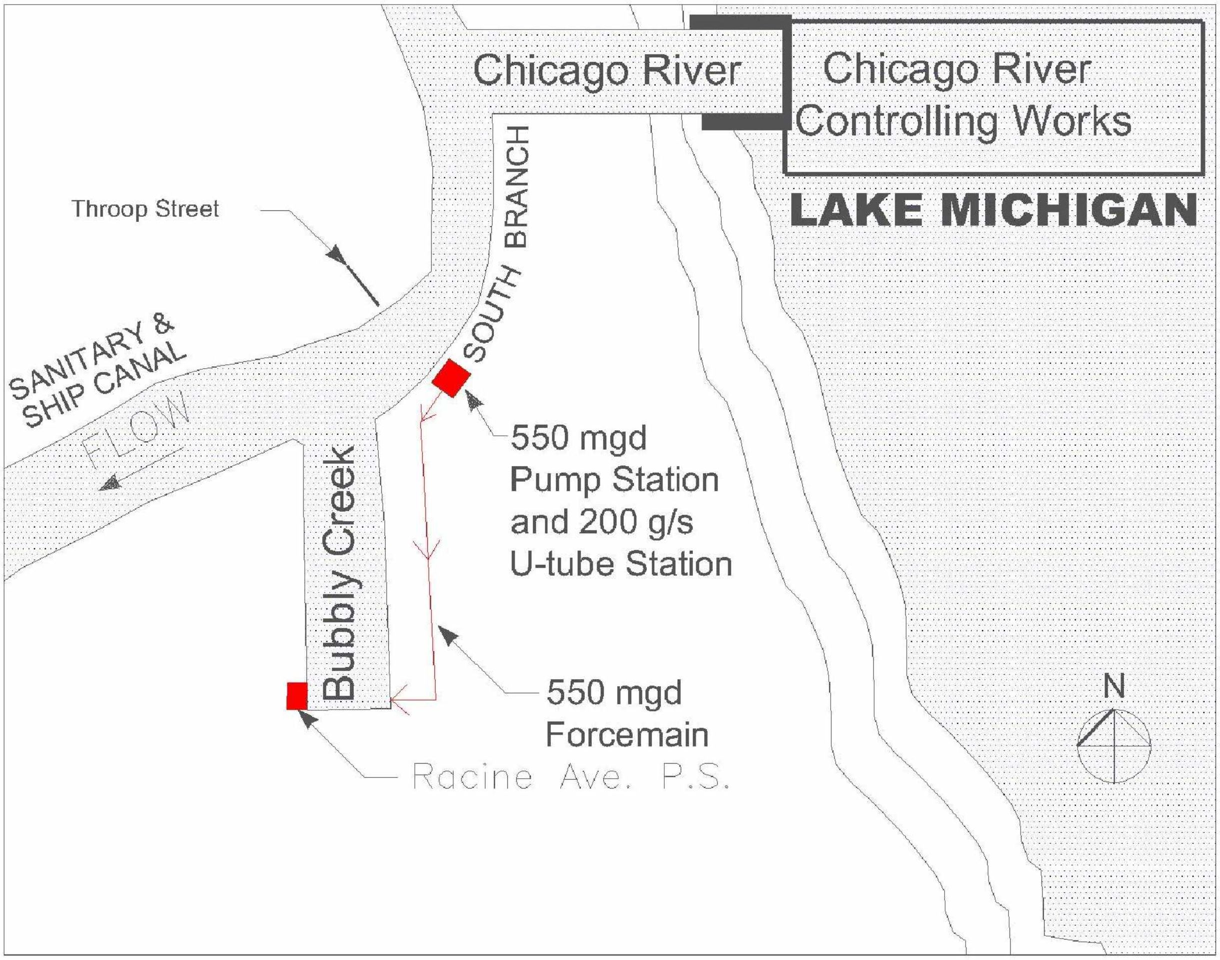


Figure 6.4 – Flow Augmentation of Bubbly Creek with Aeration Of Transferred Flow

Modeling Runs for Flow Augmentation without Aeration of the Transferred Flow in Combination with Supplemental Aeration

Marquette Modeling runs were conducted by the MWRDGC's Research and Development Department utilizing a combination of flow augmentation without aeration of the transferred flow and supplemental aeration of Bubbly Creek. A number of modeling runs were conducted utilizing different supplemental aeration station capacities and locations in combination with various amounts of flow augmentation. Ultimately, it was determined that a combination of these technologies would meet the quality objective of 5 mg/l of dissolved oxygen, 90% of the time. The chosen scenario was as follows:

- Three Supplemental Aeration Stations

Station #	Oxygen Delivery Capacity	Location
1.	80 g/sec (15,200 lbs/day)	Mouth of Bubbly Creek
2.	50 g/sec (9,500 lbs/day)	Approximated Mid-point of Bubbly Creek
3.	10 g/sec. (1, 900 lbs/day)	Headwater of Bubby Creek

- 50 MGD Flow Augmentation Pump Station
    - 50 MGD Pump Station on SBCR at Throop Street
    - 2 Mile Force Main to Headwaters of Bubbly Creek
    - Force Main Aeration is not Practiced

For the above chosen scenario, Figure 6.5 shows the percent compliance (at various locations on Bubbly Creek) with the 5 mg/l target water quality standard. As can be seen, the combination of 50 mgd of flow augmentation and 3 supplemental aeration stations is sufficient to maintain dissolved oxygen at 5 mg/l more than 90% of the time. The river miles on the x-axis of Figure 6.5 represent the mid-point of the model segments from the mouth of Bubbly Creek (confluence with the South Branch of the Chicago River). I-55 is the dividing line between the 2^{nd} and 3^{rd} segments in the model and is located at River Mile 0.32.

It should again be noted that the Marquette Model shows a very high oxygen demand at the mouth of Bubbly Creek near the junction with the SBCR. This demand results in a relatively large supplemental aeration station at this location. Model simulation runs demonstrated that aeration stations even twice as large as the 80 g/sec station could not raise the percent compliance much above 90%.

If low DO flow from the SBCR is the cause of the high oxygen demand at the mouth of Bubbly Creek, then providing supplemental aeration, flow augmentation or other water quality management options on the SBCR may eliminate the need for this aeration station on Bubbly Creek. The elimination of the aeration station at the mouth of Bubbly Creek should be justified based upon a detailed analysis of the Marquette Model followed by additional runs with perhaps a modified version of the model. Such an exercise is outside the scope of this study.

Figure 6.6 shows a map with the locations of the 50 mgd flow augmentation pump station and force main and the three supplemental aeration stations. The force main would be located on land adjacent to and along the SBCR and Bubbly Creek. There is sufficient vacant land area at Throop Street adjacent to the SBCR to accommodate this pump station.

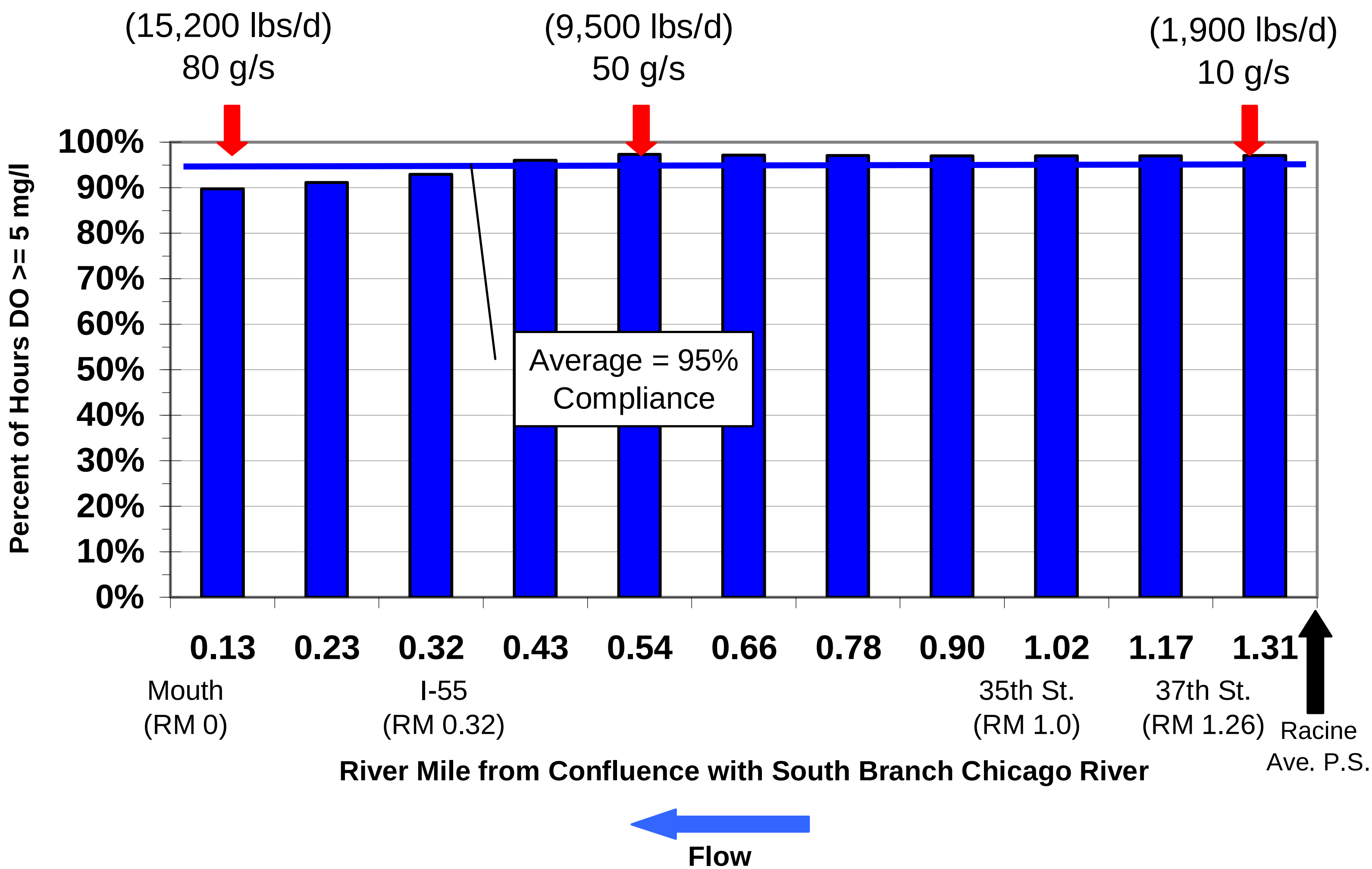


Figure 6.5 – Flow Augmentation (50 mgd) and Supplemental Aeration of Bubbly Creek at 3 locations, Percent of Hours Complying with 5 mg/l Dissolved Oxygen Criterion, For All Simulated Time Periods in the Marquette Model

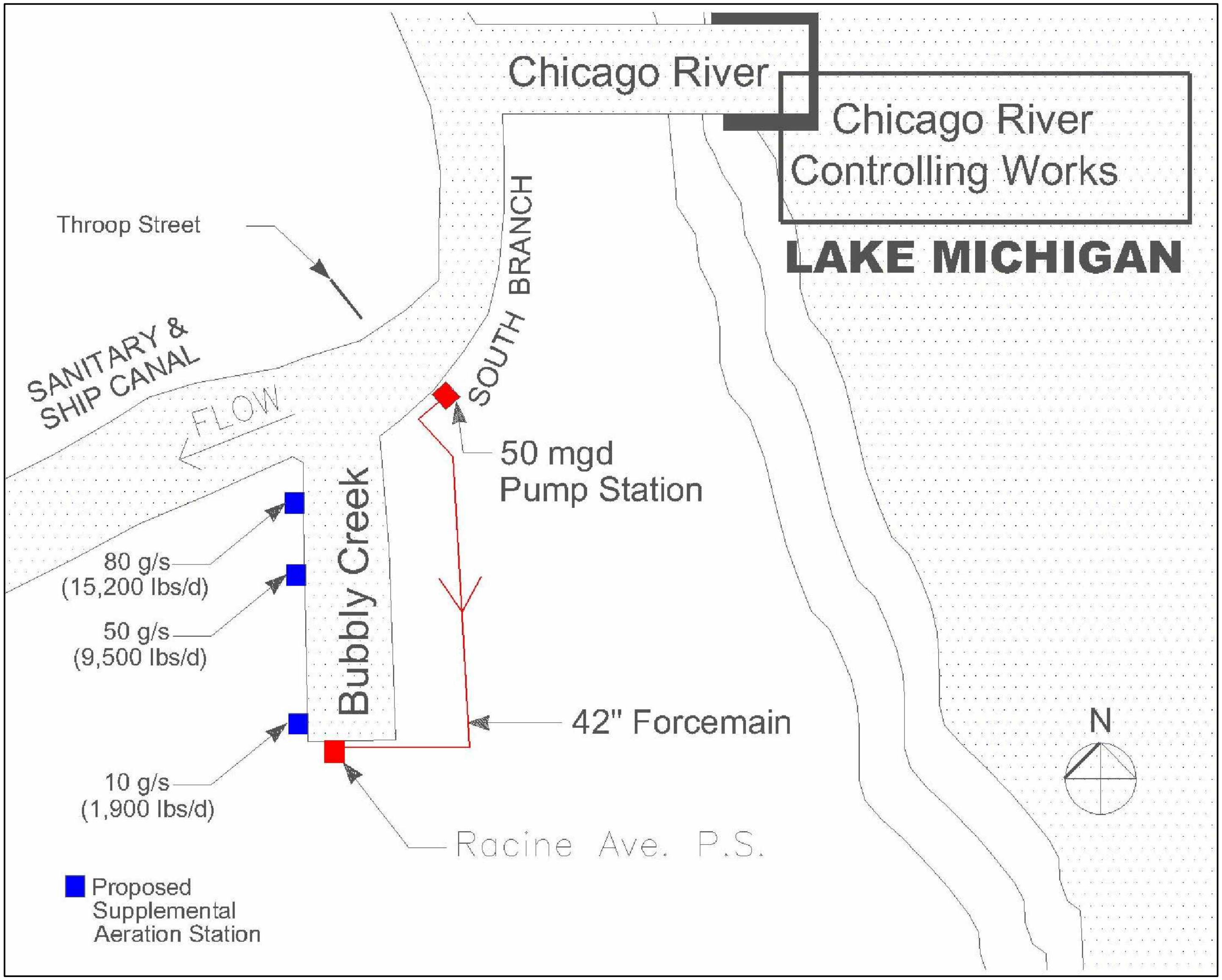


Figure 6.6 – Flow Augmentation & Supplemental Aeration of Bubbly Creek

LAND AVAILABILITY FOR SUPPLEMENTAL AERATION

Figure 6.7 shows a conceptual layout for an 80 g/s sidestream elevated pool aeration (SEPA) supplemental aeration station. This layout was taken from TM-4WQ. The land requirement for the 80 g/s station is approximately 1 acre. The land requirement for the 50 g/s and 10 g/s stations would be approximately ½ acre. As noted in TM-4WQ, the SEPA supplemental aeration technology requires the largest land area of the four short-listed technologies. Thus the land requirement for SEPA technology was used to determine if sufficient vacant land was available at the three supplemental aeration sites on Bubbly Creek.

Appendix C contains aerial photographs of each of the three supplemental aeration sites with an overlay showing the land requirements for the SEPA supplemental aeration technology. As can be seen, there is sufficient vacant land for SEPA technology at each site and therefore any of the four technologies could be located at each of the three sites without the need for building demolition. As was done for TM-4WQ, land costs for supplemental aeration were assumed to be $1.2 Million per acre and it was further assumed that all sites would have to be purchased by the MWRDGC.

The 80 g/s aeration station at the mouth of Bubbly Creek had a simulated location at river mile 0.13, 233 yards from the junction with the SBCR. However, this part of Bubbly Creek has many elevated roadways including I-55. Thus, the best available vacant land location for this aeration station is at river mile 0.32 which is about 560 yards from the mouth.

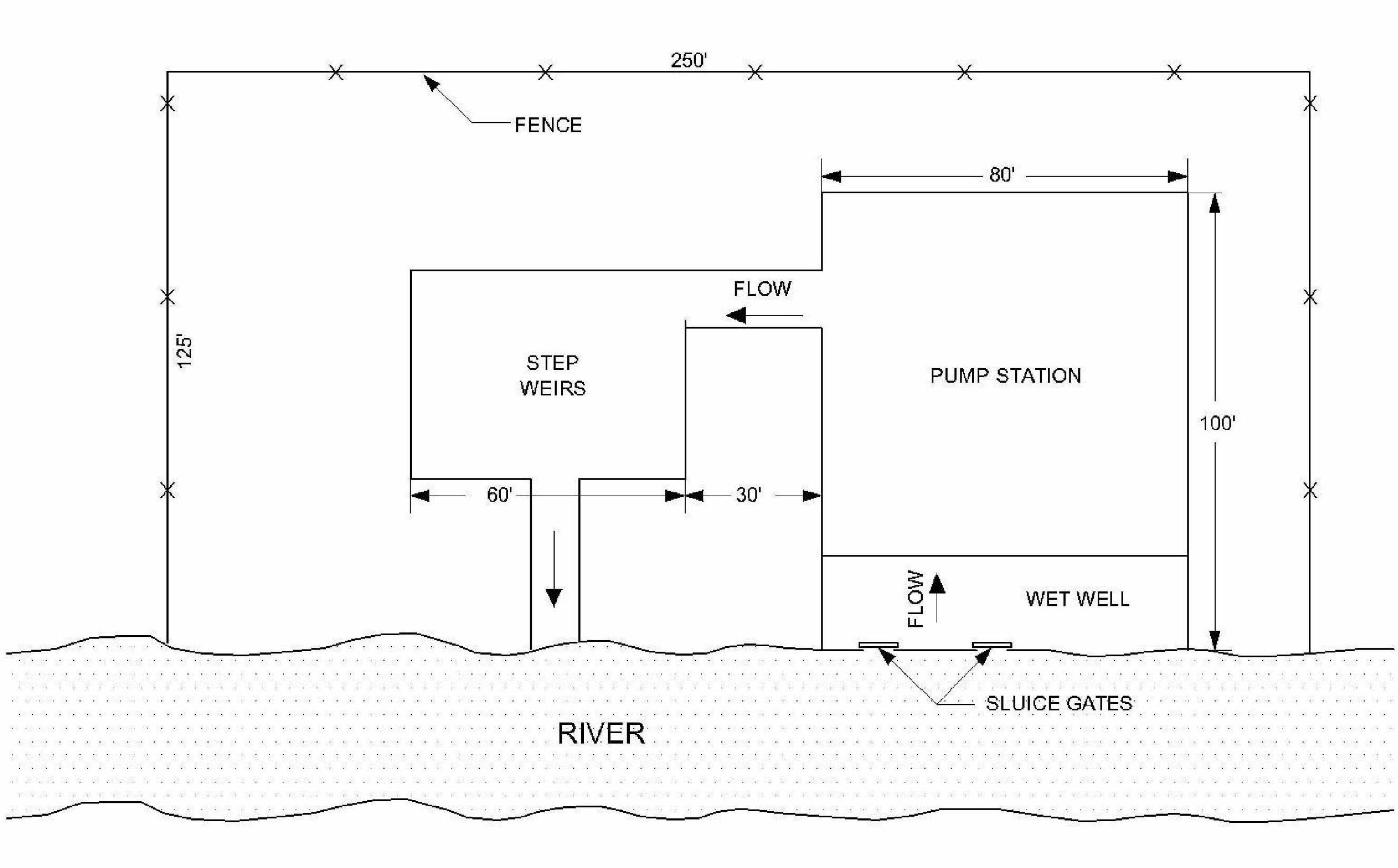


Figure 6.7 – Conceptual Layout for 80 g/s (Oxygen) SEPA Technology

COSTS FOR FLOW AUGMENTATION WITH AERATION OF THE TRANSFERRED FLOW

Appendix A contains the unit costs for this technical memorandum.

Appendix D contains the detailed spreadsheet for the capital costs for the approximate 2 mile flow augmentation pipeline and the 550 mgd pump station.

Appendix E contains the detailed cost estimate for the force main aeration system. The system chosen for cost estimation purposes was U-tube aeration using compressed air

Compressed air U-Tubes are routinely used for force main aeration to control odors from sewage pump stations. Thus, this is a proven technology for force main aeration. In addition, this aeration technology was among the four short-listed technologies selected for supplemental aeration in TM-4WQ. U-Tubes allow DO levels far above saturation, thus requiring less of the transferred flow to be aerated. If this Water Quality Management option should proceed to implementation, a more detailed study of force main aeration alternatives should be conducted to select a final candidate for design purposes.

Table 6.2 contains a summary of the Capital and Maintenance and Operation Costs for Flow Augmentation with aeration of the transferred flow. These costs were developed for the flow augmentation scenario shown in Figure 6.4.

TABLE 6.2
SUMMARY OF COSTS FOR FLOW AUGMENTATION (WITH AERATION) OF THE TRANSFERRED FLOW

Item	Capital Costs	Annual Costs	Total Present Worth
FORCE MAIN AERATION using U-Tubes (compressed air)	$39,000,000	$685,000	$53,000,000
FLOW AUGMENTATION (PUMP STATION AND FORCE-MAIN)	$229,000,000	$2,200,000	$273,000,000
TOTAL	$268,000,000	$2,885,000	$326,000,000

COSTS FOR FLOW AUGMENTATION (WITHOUT AERATION) AND SUPPLEMENTAL AERATION

In TM-4WQ (Supplemental Aeration), CTE developed a long list of supplemental aeration technologies. Based upon a matrix evaluation of the long list, CTE determined that the following supplemental aeration technologies would constitute the short list:

1. Free Fall Step Weirs (Similar to the MWRDGC's Sidestream Elevated Pool Aeration (SEPA) Stations)
2. Jet Aerators
3. Ceramic Fine Bubble Diffusers
4. Compressed Air U-Tube

Therefore the above four short-listed supplemental aeration technologies will be used for this study of Bubbly Creek.

Appendix F contains the detailed spreadsheets showing the capital cost for the four short-listed supplemental aeration technologies. It should be noted that the costs for the SEPA aeration station at the headwaters of Bubbly Creek does not include a pump station. This is because it is assumed that the 50 mgd of flow from the SBCR was directed to the weir system of this station. Thus no pump station was needed for this supplemental aeration alternative.

Appendix G contains the detailed spreadsheets for annual operation and maintenance costs for the four supplemental aeration short-listed technologies.

Appendix H contains the detailed spreadsheets for the capital cost for the approximately 2 mile flow augmentation pipeline and the 50 mgd flow augmentation pumping station.

Appendix I contains the annual operation and maintenance costs for the flow augmentation pump station and force main.

Table 6.2 contains a summary of the capital and maintenance and operation costs for flow augmentation and supplemental aeration of Bubbly Creek. These costs were developed for the flow augmentation and supplemental aeration scenario shown in Figure 6.3. As was done for TM-4WQ, costs are presented for each of the four short-listed supplemental aeration technologies. Again, it was felt that the scope of this study precluded a detailed evaluation of the many site specific factors necessary to make a final decision on a supplemental aeration technology. Also, pilot and/or laboratory scale testing is recommended to determine the design parameters for supplemental aeration stations. This information along with a site-specific analysis should be used to determine the most cost-effective supplemental aeration technology for each of the three sites.

TABLE 6.3
SUMMARY OF COSTS FOR SUPPLEMENTAL AERATION AND FLOW AUGMENTATION OF BUBBLY CREEK

Item	Capital Cost(1)	Total Annual	Total Present Worth
Supplemental Aeration			
U-Tubes	$31,000,000	$540,000	$41,800,000
SEPA	$73,000,000	$1,600,000	$105,000,000
Ceramic Diffusers	$30,400,000	$932,000	$49,000,000
Jet Aeration	$46,000,000	$2,300,000	$92,000,000
Flow Augmentation	$29,966,000	$509,000	$40,146,000

(1) Includes land acquisition cost – 3 x $1,200,000 = $3,600,000.

In summary the cost for flow augmentation and supplemental aeration of Bubby Creek would be approximately:

Capital Cost:
$60.4 Million - $102.9 Million

Total Annual Costs:
$1.0 Million - $2.8 Million

Total Present Worth
$81.9 Million - $145 Million

This Technical Memorandum is to include an examination of the Environmental and Human Health Impacts of: The energy required to operate the facilities; the energy required for processing and production of process chemicals; and the conversion and degradation of process chemicals. TM-6WQ, at the District's direction, does not make any technology recommendations but rather prepares cost estimates (capital and operation and maintenance) for the short listed technologies. There are no chemicals used in these technologies and therefore the impact of chemicals is non-existent. The energy requirements and costs for the shortlisted alternatives have been calculated and are presented in this report. Since the report only concludes with a shortlist of technologies, it is appropriate to evaluate the environmental and public health impacts of the energy for these technologies in any future studies of the water quality management options in TM-6WQ.

SUMMARY AND CONCLUSIONS

A study was conducted to determine the technology and costs for flow augmentation and supplemental aeration of Bubbly Creek. This study was conducted at the request of the IEPA who is currently exploring methods to improve the DO of the CAWs as part of their UAA.

Simulations were undertaken using a water quality model developed for the MWRDGC by Marquette University to determine the amount of flow augmentation and supplemental aeration to achieve a DO target of 5 mg/l in Bubbly Creek, 90% of the time. This target was a consensus decision with the MWRDGC and may not represent the target chosen by IEPA for the CAWs. The IEPA has not as yet chosen a water quality DO target for the CAWs. Thus, it was necessary to choose a target so that a cost estimate for flow augmentation and supplemental aeration could be prepared.

Three water quality management options were studied:

1) Flow Augmentation without aeration of the transferred amount
2) Flow Augmentation with aeration of the transferred amount
3) Supplemental aeration in combination with flow augmentation without aeration of the transferred amount

Based upon simulations conducted by Marquette University (shown in Appendix B), it was found that bringing up to 550 mgd of unaerated flow from the SBCR to Bubbly Creek would not significantly raise the DO of Bubbly Creek. This is mainly due to the relatively low levels of DO present in the SBCR at Throop Street during summer conditions.

Based upon Marquette Model simulations (See Appendix B) bringing 550 mgd of aerated flow from SBCR to the headwaters for Bubbly Creek will improve the DO of Bubbly Creek but will not achieve the DO target level at the end of this waterway near the mouth of its junction with the SBCR. It is not practical to bring more than 550 mgd from the SBCR since flows in the SBCR are generally lower than this amount during the summer months.

A cost estimate was prepared for flow augmentation using compressed air U-tubes for aeration. This method of force-main aeration was chosen for cost estimation purposes since it is commonly used for controlling odors at sewage pump stations. The capital cost for this alternative was $268 million and the annual O & M costs were $2.9 million. If this alternative is found to have merit in the future, a study of other methods of force main aeration should be undertaken before proceeding to final design.

Since flow augmentation did not achieve the DO target chosen for this study, a combination of flow augmentation (no aeration of the augmented flow) and supplemental aeration was studied.

The MWRDGC's R&D Department conducted various model runs testing various combinations of flow augmentation and supplemental aeration to achieve the DO target. It was found that flow augmentation of 50 mgd from the SBCR and the following locations and sizes of supplemental aeration stations would achieve the DO target for Bubbly Creek:

Station	Oxygen Delivery Capacity	Location
1	80 g/sec (15,200 lbs/day)	Mouth of Bubbly Creek
2	50 g/sec (9,500 lbs/day)	Approximate midpoint of Bubbly Creek
3	10 g/sec (1,900 lbs/day)	Headwaters of Bubbly Creek

The total capital cost for the 4 supplemental aeration technologies chosen for this cost estimate (U-Tubes, SEPA, Ceramic Diffusers and Jet Aeration) in combination with flow augmentation ranged from $60.4 Million to $102.9 Million. The total annual O&M costs ranged from $1.0 Million to $2.8 Million. A final decision as to the supplemental aeration technology that is most appropriate for implementation in Bubbly Creek would require additional study.

The study did show that the combination of flow augmentation (50 mgd) and three supplemental aeration stations achieved the DO target while aerated flow augmentation alone did not. Also the combination of flow augmentation and supplemental aeration was considerably lower in cost than aerated flow augmentation. Thus it would appear that the combination of flow augmentation and supplementation aeration would be the most cost effective for the DO control alternatives studied here for Bubbly Creek. However, it should be stated that it is not possible to determine whether any water quality management options suggested by the IEPA in the UAA should be implemented until all these alternatives are studied in an integrated analysis to compare and analyze their relative benefits and cost.

Table 6.4 shows a summary of the costs for flow augmentation with aeration and supplemental aeration in combination with flow augmentation without aeration.

TABLE 6.4
SUMMARY OF COSTS FOR FLOW AUGMENTATION WITH AERATION OF TRANSFERRED FLOW AND SUPPLEMENTAL AERATION AND FLOW AUGMENTATION WITHOUT AERATION OF BUBBLY CREEK

Option	Capital Cost	Annual Costs	Total Present Worth
Flow Augmentation with Aeration	$ 268,000,000	$ 2,900,000	$ 326,000,000
Supplemental Aeration with Flow Augmentation without Aeration	$ 60,400,000 – $ 102,900,000	$ 1,000,000 – $ 2,800,000	$ 81,900,000 – $ 145,000,000

APPENDIX A
Unit Costs for Cost Estimates

UNIT COSTS FOR COST ESTIMATES

Life cycle cost (LCC) analysis requires the development of certain constants that will be used throughout the evaluation of alternatives. Values used for constants are presented below. These values have been developed in consultation with District staff and represent actual values or agreed upon assumptions.

1.	Present Worth Factors for Life-Cycle Costs	
	• Years	20
	• Annual interest rate	3%
	• Annual inflation rate	3%
	• Annuity Present Worth Factor (with inflation)	19.42
2.	Design Life	
	• Structural Facilities	20
	• Mechanical Facilities	20
3.	Electrical Cost	$0.075/kW-hr
4.	Labor Rates Per Hour Including Benefits (1)	
	• Electrician	$159.50/hr
	• Operations	$90.00/hr
	• Maintenance	$90.00/hr
5.	Parts and Supplies	5 percent
6.	Contractor Overhead and Profit (2)	15%
7.	Planning Level Contingency (3)	30%
8.	Engineering Fees including Construction Management (4)	20%

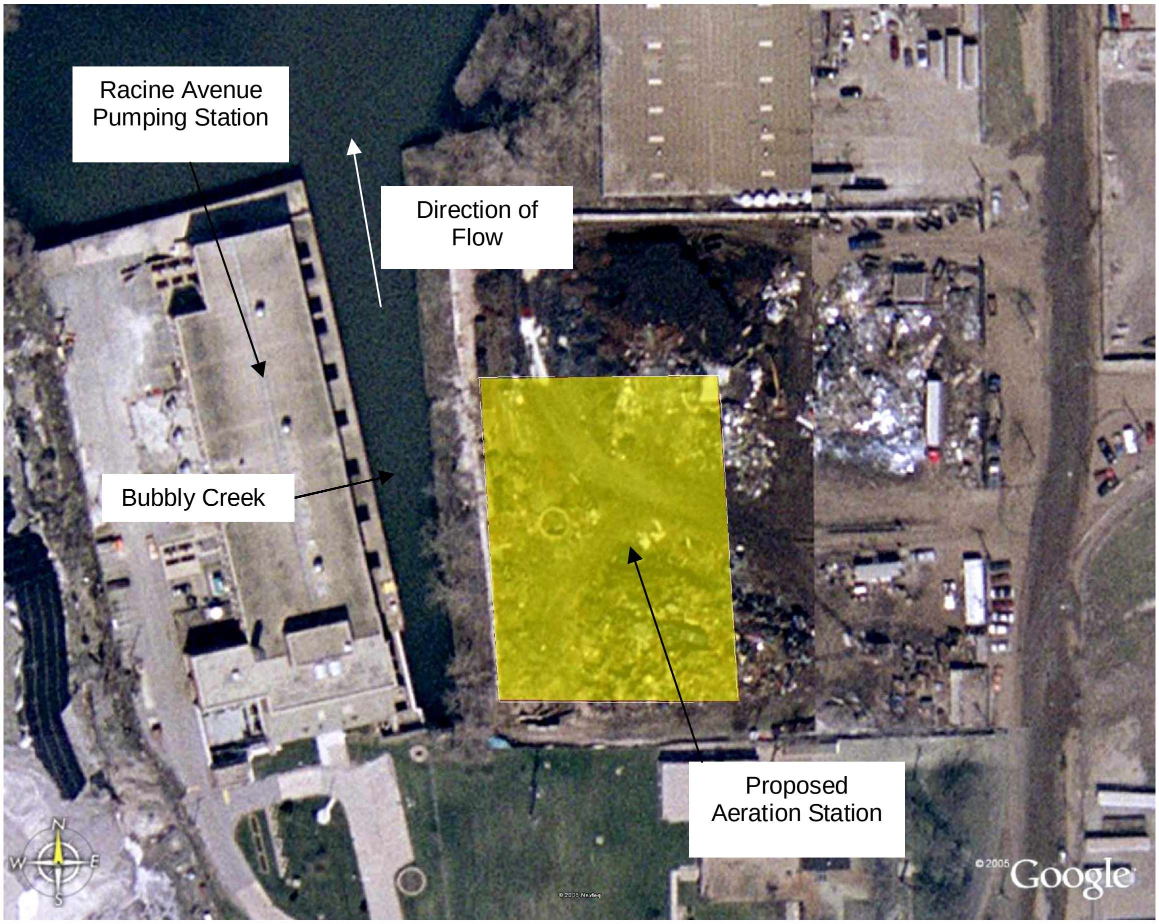
(1) A multiplier of 2.9 was used to reflect benefits as provided by the District.
(2) Percent of Total Construction Cost
(3) Percent of Total Construction Cost plus Contractor Overhead and Profit
(4) Percent of Total Construction Cost, Contractor Overhead and Profit plus Contingency

APPENDIX B
Report Authored by Marquette University "Progress on Flow Augmentation Simulations for Bubbly Creek"

APPENDIX C
Land Availability for Three Supplemental Aeration Stations on Bubbly Creek

Land Availability for 80 g/s Station at I-55 and Bubbly CreekLand Availability for 80 g/s Station at I-55 and

Land Availability for 50 g/s station at S. Throop Street and Bubbly Creek



Land Availability for 10 g/s Station near Racine Ave. P.S. and Bubbly Creek

APPENDIX D
Capital Costs for Flow Augmentation with Aeration of the Transferred Flow

APPENDIX E
Operation and Maintenance Costs for Flow Augmentation with Aeration of the Transferred Flow

APPENDIX F
Capital Costs for Supplemental Aeration Technologies

APPENDIX G
Operation and Maintenance Costs for Supplemental Aeration Technologies

APPENDIX H
Capital Costs for Flow Augmentation – No Aeration
(In Combination with Supplemental Aeration)

APPENDIX I

Operation & Maintenance Costs for Flow Augmentation – No Aeration (In Combination with Supplemental Aeration)

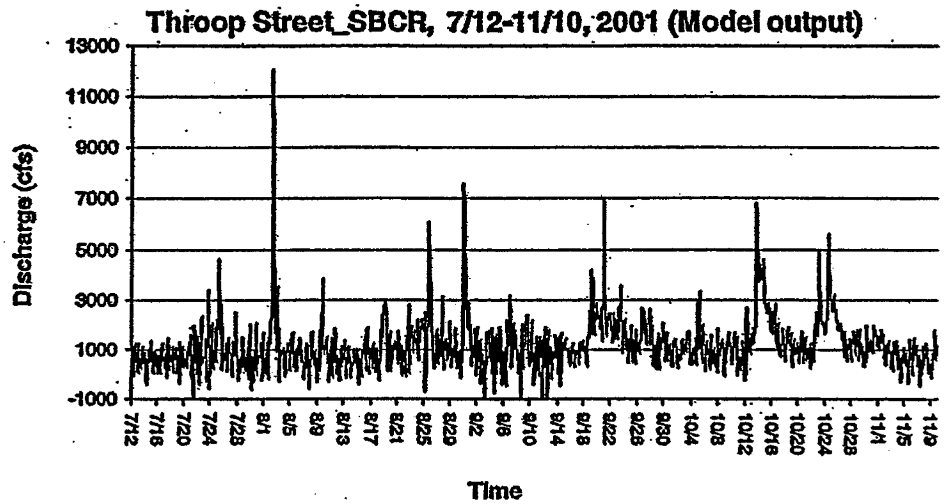
APPENDIX B
Report Authored by Marquette University "Progress on Flow Augmentation Simulations for Bubbly Creek"

PROGRESS ON FLOW AUGMENTATION SIMULATIONS FOR BUBBLY CREEK

Two sets of simulations considering diverting a portion of the South Branch Chicago River (SBCR) flow to the upstream end of the Bubbly Creek have been completed. The first set of simulations considers transferred flow without aeration and the second set of simulations considers aerated transferred flow. Six different (50, 100, 200, 400, 450, and 550 mgd) fixed amounts of flow transfer have been evaluated for the periods July 12 – September 14, 2001, September 15 – November 10, 2001, May 1-August 11, 2002 and August 12-September 23, 2002. The withdrawal point for flow augmentation for Bubbly Creek is the intersection of the SBCR and Throop Street. This point is slightly upstream (~0.4 mile) of the intersection of Bubbly Creek and the SBCR.

Plots of simulated (baseline) discharges at Throop Street are given in Figure 1. Average discharges for July 12 to November 10, 2001 and May 1 to September 23, 2002 are 1,186 cfs (767 mgd) and 984 cfs (636 mgd), respectively. Six different augmentation flow transfer values (50, 100, 200, 400, 450, and 550 mgd) have been evaluated and the maximum transferred flow was kept around the average discharge at Throop Street. For periods when the simulated discharge was less than the transfer amount, the flow in the SBCR was set to zero and the fixed amounts of flow still was transferred even though the available flow was not sufficient. This approach did not result in hydraulic problems in the computations. In the actual design of the augmentation scheme, more precise flow transfers (i.e. time series of flow for the periods when the simulated discharge is less than transfer amount and the total simulated discharge is transferred) should be used in the simulation to calculate percentage compliances especially if the desired transferred flow is much larger than the average simulated discharge at Throop Street at a specific time.

The percentage of hours that target dissolved oxygen (DO) concentrations of 3, 4, 5, and 6 mg/L are equaled or exceeded for the total period of July 12 – November 10, 2001 are listed in Tables 1-3 for Jackson Boulevard (SBCR), I-55 (Bubbly Creek), and Cicero Avenue (Chicago Sanitary and Ship Canal, CSSC), respectively. The wet periods listed in these tables correspond to times when flows at Romeoville were higher than typical dry weather flows (i.e. typically greater than 100 m^3/s = 3530 cfs for sustained periods).



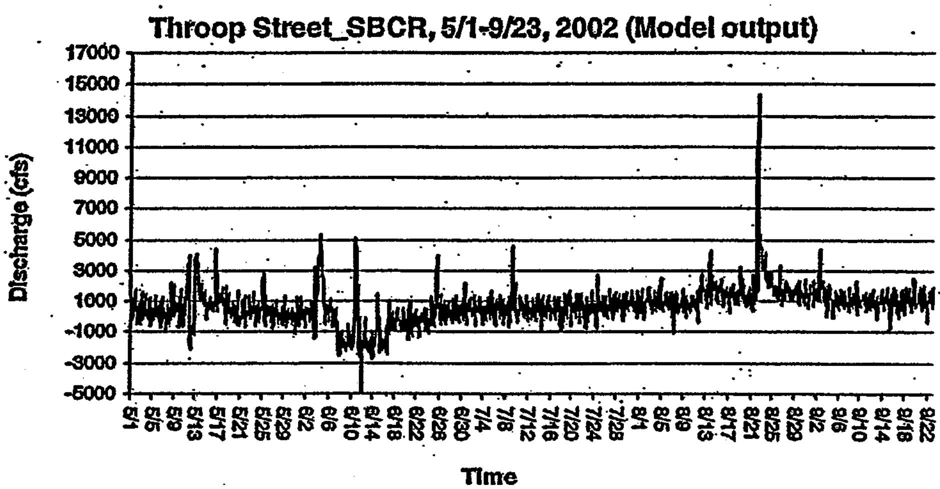


Figure 1. Simulated discharges at Throop Street for July 12 to November 10, 2001 and May 1 to September 23, 2002

Table 1. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Jackson Boulevard (South Branch Chicago River) for July 12 – November 10, 2001 for different withdrawal values for flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Jackson-SBCR	dry	wet	dry	wet	Dry	wet	Dry	wet
Measured	98.2	92.9	91.4	82.5	67.6	54.0	41.9	16.9
Calibrated	91.3	94.3	78.6	87.0	64.7	72.1	43.1	36.2
50 mgd	91.3	94.3	78.6	87.0	64.7	72.1	43.1	36.3
400 mgd	91.3	94.3	78.7	87.0	64.8	72.1	43.2	36.3

Table 2. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at I-55 (Bubbly Creek) for July 12 – November 10, 2001 for different withdrawal values for flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
I-55-Bubbly Creek	dry	wet	dry	wet	dry	wet	Dry	wet
Measured	-*	-	-	-	-	-	-	-
Calibrated	71.2	66.1	56.6	41.0	41.8	31.6	25.9	20.3
50 mgd	71.3	66.2	56.6	41.0	41.9	31.6	25.9	20.4
400 mgd	71.8	66.4	56.6	41.4	42.0	31.9	26.0	20.5

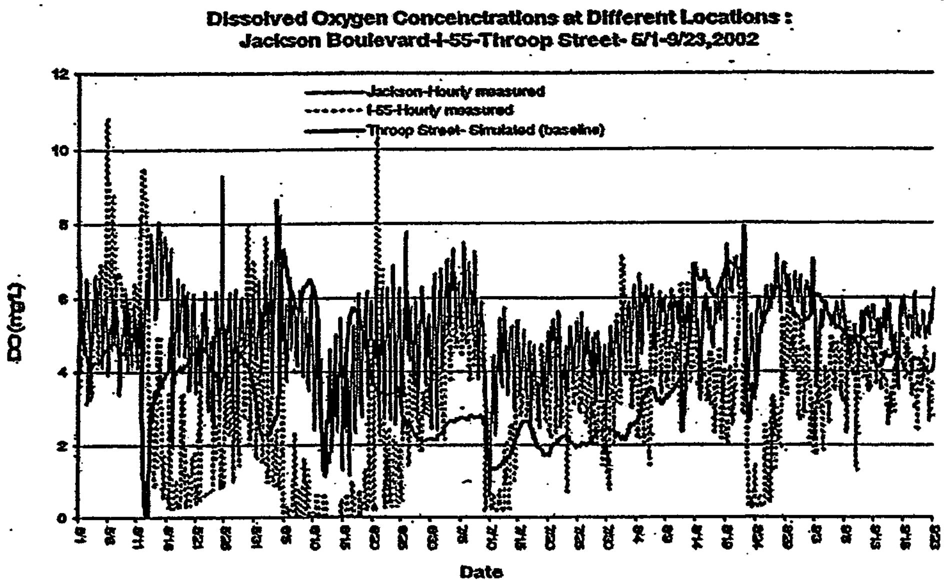
* No measured dissolved oxygen data available for 2001

Table 3. Percentage of time that dissolved oxygen concentrations are higher than the target concentrations at Cicero Avenue (Chicago Sanitary and Ship Canal) for July 12 – November 10, 2001 for different withdrawal values for flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Cicero_CSSC	dry	wet	dry	wet	Dry	wet	dry	Wet
Measured	83.8	71.5	54.9	46.8	27.6	15.9	22.8	0.1
Calibrated	85.4	70.4	58.7	40.0	43.6	28.9	27.6	19.4
50 mgd	85.4	70.4	58.7	40.0	43.6	28.9	27.7	19.4
400 mgd	85.5	70.7	58.7	40.5	43.6	28.9	27.8	19.6

Even though simulations have been completed for all 6 different flow transfer values for 2001 and 2002, results of only 50 and 400 mgd flow transfer simulations for 2001 are presented here since simulation results show that different levels of augmentation without aeration do not affect the DO concentration at I-55.

Measured DO concentrations at Jackson Boulevard can get as low as 1.1 mg/L and mostly fluctuate between 4 and 6 mg/L (Figure 2). Measured DO concentrations at I-55 (Bubbly Creek) are always lower than Jackson Boulevard DO concentrations and get as low as 0 mg/L at certain periods. Simulated DO concentrations at Throop Street are usually lower than Jackson Boulevard DO concentrations.



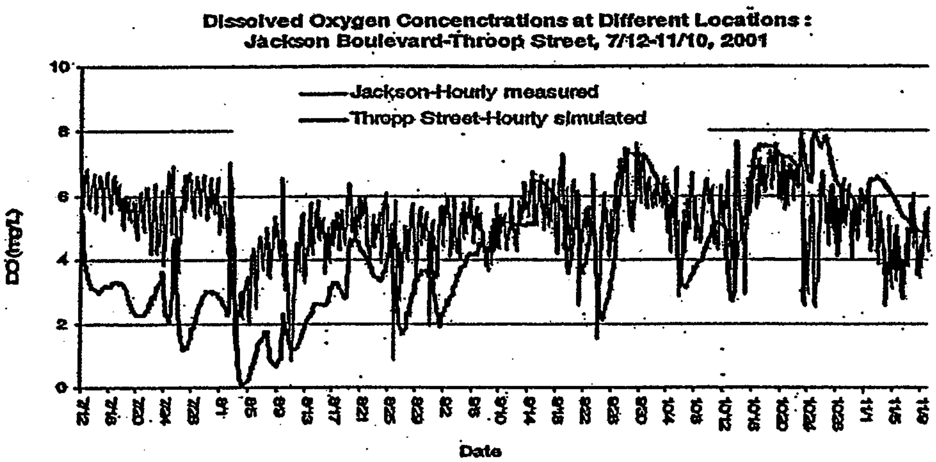


Figure 2. Dissolved oxygen (DO) concentrations measured at Jackson Boulevard on the South Branch Chicago River and I-55 on Bubbly Creek and simulated at Throop Street on the South Branch Chicago River for July 12 to November 10, 2001 and May 1 to September 23, 2002 (no measured DO available for the 2001 period at I-55 (Bubbly Creek))

Figure 2.(cont). Dissolved oxygen (DO) concentrations measured at Jackson Boulevard on the South Branch Chicago River and I-55 on Bubbly Creek and simulated at Throop Street on the South Branch Chicago River for July 12 to November 10, 2001 and May 1 to September 23, 2002 (no measured DO available for the 2001 period at I-55 (Bubbly Creek))

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Comparison of measured hourly DO concentration plots for Jackson Boulevard and Cicero Avenue for 2001 and 2002 simulation periods are given in Figure 3. Comparison of the simulated (baseline) DO concentration at Throop Street and I-55 for the 2001 and 2002 simulation periods are given in Figure 4. Figures 3 and 4 show that DO concentrations at Cicero Avenue are always lower than Jackson Boulevard DO concentrations and simulated DO concentrations at Throop Street and I-55 are almost identical. The agreement between Throop Street and I-55 results because during periods of no flow in Bubbly Creek the ambient water quality in the SBCR and CSSC dominates the downstream reaches of Bubbly Creek, whereas when the Racine Avenue Pumping Station is operating water quality at the downstream end of Bubbly Creek has a large effect on water quality in the nearby portions of the SBCR and CSSC. Figures 3 and 4 also show that simulated DO concentrations at Throop Street show a very similar trend with Cicero Avenue DO concentrations. Since simulated DO concentrations just at the upstream and downstream of the junction of the SBCR and Bubbly Creek are very similar to Bubbly Creek DO concentrations, Bubbly Creek augmentation without aeration did not improve DO concentrations in Bubbly Creek.

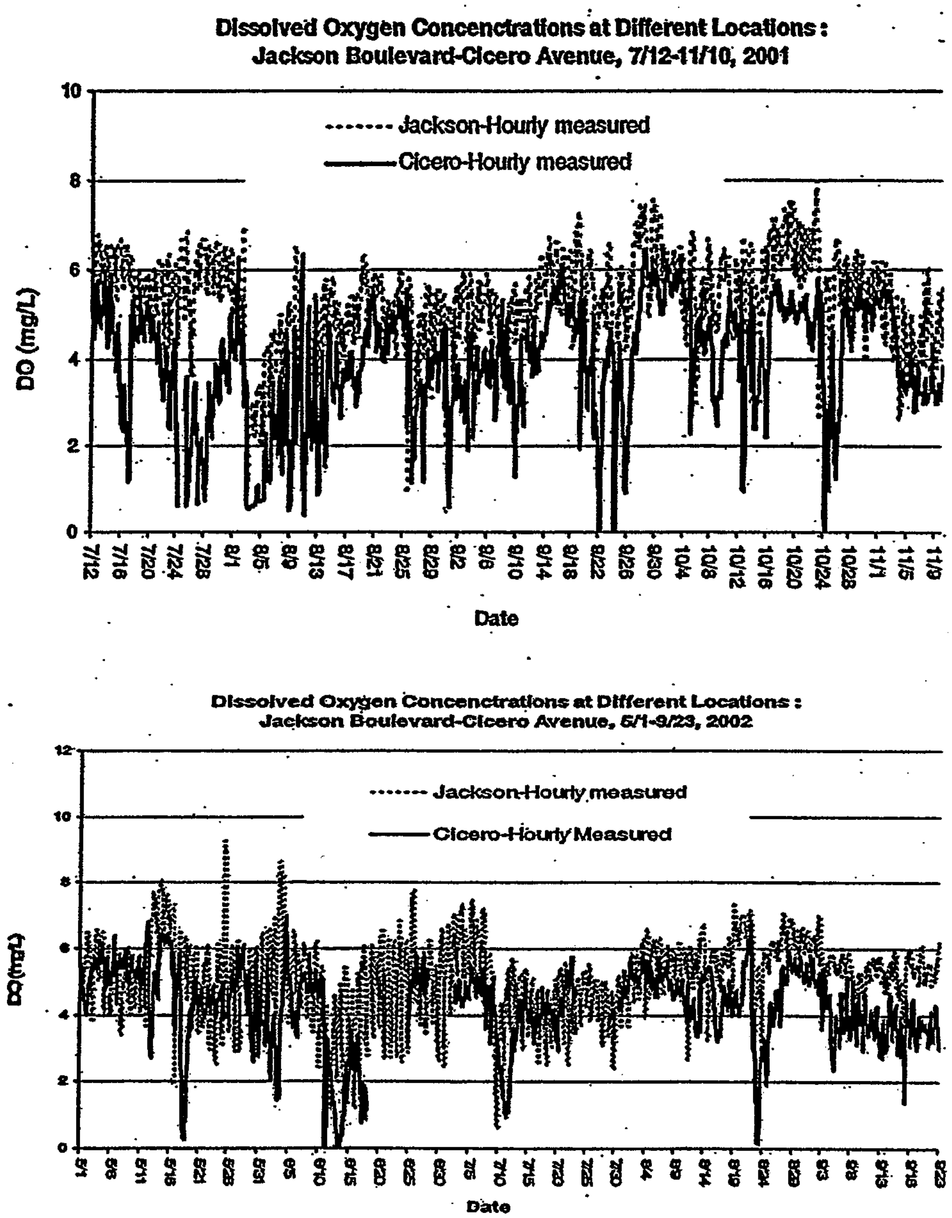
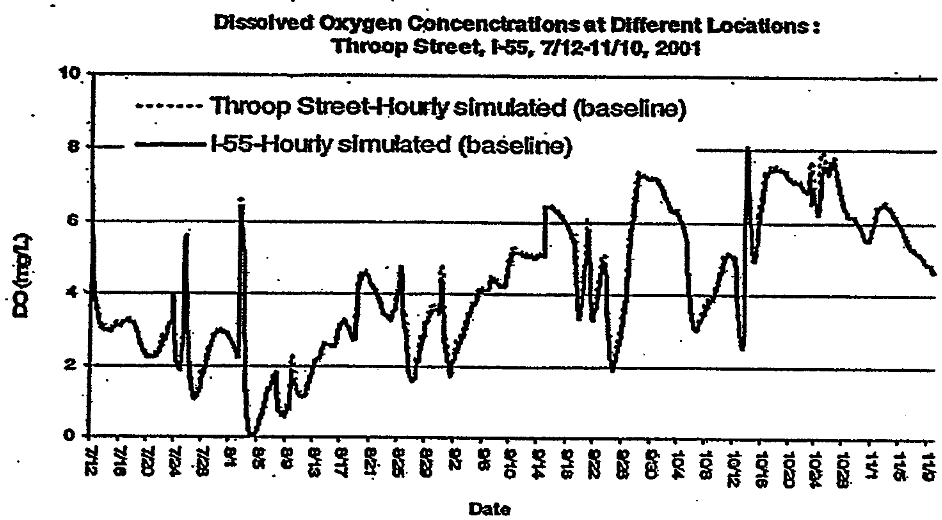


Figure 3. Comparison of measured DO concentrations at Jackson Boulevard and Cicero Avenue for July 12 to November 10, 2001 and May 1 to September 23, 2002



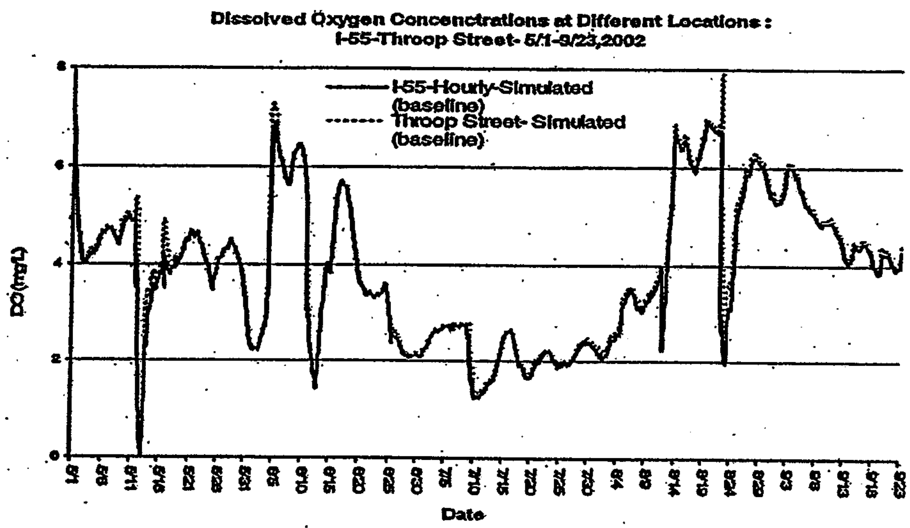


Figure 4. Comparison of simulated DO concentrations at I-55 and Throop Street for baseline conditions (no transfer) for July 12 to November 10, 2001 and May 1 to September 23, 2002

FLOW AUGMENTATION WITH AERATION FOR BUBBLY CREEK

In this section, results of simulations of scenarios of Bubbly Creek flow augmentation with aeration are presented. In these simulations, saturation DO concentrations were assigned to the augmented flow. The rest of the water quality variables were kept the same as the simulated Throop Street concentrations. Jackson Boulevard water temperatures were used to calculate saturation concentrations (Figures 5 and 6). This makes the following simulation results somewhat optimistic because the Midwest Generation Fisk Power Plant sits between Jackson Boulevard and Throop Street and comparison of monthly sample data at Madison Street and Damen Avenue indicate about a 1°C temperature increase primarily due to the Fisk Power Plant. Because only monthly data are available to estimate the temperature increase and this is a preliminary, planning level analysis no attempt was made to account for the temperature increase. In the actual design of a flow transfer scheme, the temperature increase resulting from the Fisk Power Plant should be considered.

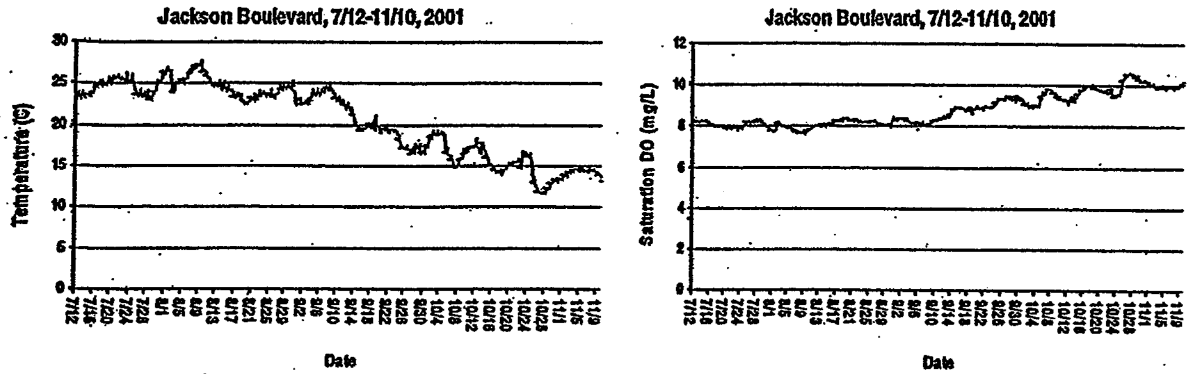


Figure 5. Temperature (°C) and calculated saturation dissolved oxygen (DO) concentrations at Jackson Boulevard for July 12 to November 10, 2001

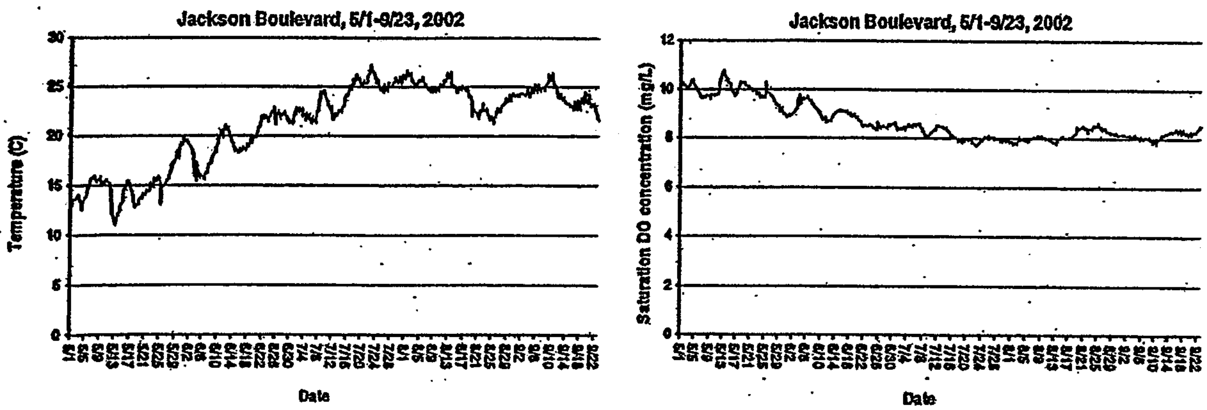


Figure 6. Temperature (°C) and calculated saturation dissolved oxygen (DO) concentrations at Jackson Boulevard for May 1 to September 23, 2002

RESULTS OF THE AERATED AUGMENTATION SIMULATIONS

The percentage of hours that target DO concentrations of 3, 4, 5, and 6 mg/L are equaled or exceeded for July 12 – November 10, 2001 are listed in Tables 4-6 for Jackson Boulevard (SBCR), I-55 (Bubbly Creek), and Cicero Avenue (CSSC), respectively.

Table 4. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Jackson Boulevard (South Branch Chicago River) for July 12 – November 10, 2001 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Jackson-2001	dry	wet	dry	wet	dry	wet	dry	Wet
Measured	98.2	92.9	91.4	82.5	67.6	54.0	41.9	16.9
Calibrated	91.3	94.3	78.6	87.0	64.7	72.1	43.1	36.2
50 mgd	91.5	94.4	79.0	87.6	65.9	72.4	43.5	36.4
100 mgd	92.0	94.7	79.3	87.9	66.4	72.5	44.1	36.5
200 mgd	93.2	95.2	79.7	88.5	67.7	72.9	45.3	36.7
400 mgd	95.1	95.9	81.6	89.2	68.6	73.6	46.9	37.3
450 mgd	95.4	96.1	82.0	89.4	68.7	74.0	47.1	37.4
550 mgd	96.2	96.1	82.2	89.4	68.9	74.7	47.2	37.7

Table 5. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at I-55 (Bubbly Creek) for July 12 – November 10, 2001 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
I-55-2001	dry	wet	dry	wet	dry	wet	dry	wet
Measured	-	-	-	-	-	-	-	-
Calibrated	71.2	66.1	56.6	41.0	41.8	31.6	25.9	20.3
50 mgd	83.0	73.0	60.4	44.6	45.5	33.7	29.7	22.7
100 mgd	87.3	81.4	65.5	55.9	48.2	35.6	33.0	24.0
200 mgd	91.5	91.5	84.3	72.8	60.1	40.9	44.5	28.7
400 mgd	100.0	96.2	92.9	91.2	86.2	72.8	56.0	36.3
450 mgd	100.0	97.0	96.6	93.1	87.8	75.8	60.6	39.6
550 mgd	100.0	100.0	99.7	95.4	90.5	81.9	70.2	49.5

Table 6. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Cicero Avenue (Chicago Sanitary and Ship Canal) for July 12 – November 10, 2001 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Cicero-2001	dry	wet	dry	wet	dry	wet	dry	wet
Measured	83.8	71.5	54.9	46.8	27.6	15.9	22.8	0.1
Calibrated	85.4	70.4	58.7	40.0	43.6	28.9	27.6	19.4
50 mgd	88.4	75.3	60.8	45.7	45.2	29.4	30.2	21.0
100 mgd	89.5	79.7	67.9	50.8	47.0	29.8	32.6	21.8
200 mgd	91.3	82.4	81.8	60.6	55.1	30.6	36.4	25.0
400 mgd	96.0	90.9	89.0	72.8	67.4	41.0	44.8	26.8
450 mgd	96.3	91.7	89.9	75.2	72.5	44.5	45.3	26.9
550 mgd	98.7	93.7	91.3	77.8	81.3	52.9	48.4	27.3

Results of the aerated flow augmentation simulations show that aeration of the transferred flow improves the DO conditions in Bubbly Creek. It can be seen that the transfer of 550 mgd of aerated flow results in attainment of DO concentrations in excess of 3 mg/L at I-55 during dry and wet weather 100 percent of the time. Whereas 3 mg/L DO concentrations are achieved 100 percent of the time during just dry weather for 400 and 450 mgd transfer simulations. More than 95% of the time the 4 mg/L DO target level is achieved with a transfer of 550 mgd both for wet and dry periods. Results also show that aerated flow augmentation influences the DO concentrations at locations downstream from the junction of Bubbly Creek and the SBCR (Table 6). At Cicero Avenue the percentage compliance with the 3 mg/L DO target level increased from 85.4 % and 70.4 % for wet and dry periods, respectively, during calibration to 98.7% and 93.7% for wet and dry periods, respectively, for a transfer of 550 mgd of aerated SBCR water. Even though aerated augmentation simulations have little effect on DO concentrations at Jackson Boulevard (Table 4) it is possible to see the effect of aerated augmentation operations along the CSSC until the downstream boundary (Romeoville) of the modeled section of the river system (Table 7).

The percentage of hours that target DO concentrations of 3, 4, 5, and 6 mg/L are equaled or exceeded for the total period of May 1-September 23, 2002 are listed in Tables 8-10 for Jackson Boulevard (SBCR), I-55 (Bubbly Creek), and Cicero Avenue (CSSC), respectively.

Table 7. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Romeoville (Chicago Sanitary and Ship Canal) for July 12 – November 10, 2001 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Romeoville-2001	dry	wet	dry	wet	Dry	wet	dry	wet
Measured	93.5	67.7	74.0	38.0	30.7	12.0	21.5	0.2
Calibrated	79.5	86.0	63.9	60.9	42.4	33.2	28.4	20.7
50 mgd	80.3	86.5	66.1	62.4	45.5	34.9	29.6	22.3
100 mgd	81.3	87.2	68.7	64.2	46.7	35.4	30.7	22.9
200 mgd	82.8	87.8	71.6	70.7	51.2	38.4	32.2	24.3
400 mgd	84.8	90.1	72.9	73.7	57.1	43.2	33.5	26.3
450 mgd	85.3	90.4	73.2	74.1	58.2	44.2	33.7	26.6
550 mgd	86.1	91.1	73.7	75.3	59.7	46.6	34.7	27.0

Table 8. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Jackson Boulevard (South Branch Chicago River) for May 1-September 23, 2002 for different withdrawal values for aerated flow augmentation.

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Jackson-2002	dry	wet	dry	wet	dry	wet	dry	Wet
Measured	97.3	92.2	85.9	81.5	59.6	60.7	15.8	23.9
Calibrated	97.2	92.4	59.3	81.9	45.9	73.0	20.2	54.3
50 mgd	99.3	93.5	60.7	82.0	46.9	73.3	21.0	55.0
100 mgd	99.5	93.6	64.4	82.6	47.4	74.4	21.9	56.2
200 mgd	99.8	94.3	69.1	84.2	48.7	75.3	23.8	58.6
400 mgd	100.0	95.4	74.5	87.2	50.8	78.4	26.7	61.6
450 mgd	100.0	95.7	76.6	87.7	52.0	79.0	27.5	61.7
550 mgd	100.0	96.2	79.1	89.1	54.8	79.5	28.0	61.9

Like the simulations for 2001, aerated transferred flow improved the DO concentrations in Bubbly Creek. The 3 mg/L DO target level is achieved for the 200, 400, 450, and 550 mgd augmentation scenarios at I-55 (Table 9) for dry periods. Whereas 3 mg/L target level cannot be achieved even with the transfer of 550 mgd of aerated flow for wet periods at I-55. The 400, 450, and 550 mgd simulations result in achievement of 4 mg/L 100 % of the time for dry periods. Effects of aerated flow augmentation extend until Romeoville (Table 11).

Table 9. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at I-55 (Bubbly Creek) for May 1-September 23, 2002 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
I-55-2002	dry	wet	dry	wet	dry	wet	dry	wet
Measured	62.2	37.8	31.8	29.0	9.8	17.9	2.8	7.8
Calibrated	62.5	71.1	44.8	52.5	18.6	30.6	5.9	19.5
50 mgd	72.2	79.2	53.0	62.8	25.8	44.2	8.2	24.5
100 mgd	90.6	83.2	60.2	66.4	36.4	49.5	11.0	26.6
200 mgd	100.0	90.7	81.8	78.0	55.7	62.8	22.6	44.4
400 mgd	100.0	97.6	100.0	92.6	85.4	76.9	49.9	62.2
450 mgd	100.0	98.1	100.0	94.0	97.1	79.2	54.2	65.6
550 mgd	100.0	98.8	100.0	95.0	100.0	85.7	69.8	73.2

Table 10. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Cicero Avenue (Chicago Sanitary and Ship Canal) for May 1-September 23, 2002 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Cicero-2002	dry	wet	dry	wet	dry	wet	dry	Wet
Measured	92.9	79.4	66.8	61.5	28.0	35.2	0.5	7.8
Calibrated	70.6	78.9	53.1	62.3	25.4	43.9	6.1	20.8
50 mgd	80.6	82.2	56.4	64.8	30.7	47.0	7.3	21.6
100 mgd	90.3	82.8	58.3	67.6	36.1	49.0	8.7	24.2
200 mgd	99.7	85.5	70.9	77.1	46.6	53.3	16.5	38.9
400 mgd	100.0	91.3	95.7	81.1	59.0	67.7	25.9	46.8
450 mgd	100.0	91.7	98.0	81.8	65.7	71.1	27.7	48.4
550 mgd	100.0	92.8	99.7	85.0	72.1	73.4	32.6	50.7

For each flow transfer amount the overall percentage compliance for 4, 5, and 6 mg/L at I-55 are given in Table 12 and Figure 7. It can be seen from Figure 7, 95 % compliance for 4 mg/L is achieved with a transfer of 400 mgd. A transfer of approximately 700 mgd (by extrapolation) is needed to attain 5 mg/L 95% of the time. Therefore, an increase in the transferred flow of 300 mgd is needed to increase 95 % compliance from 4 mg/L to 5 mg/L. Since the average daily simulated flow at Throop Street for 2002 was only 636 mgd, this is an impractical solution. Even though transfer of aerated flow can help to improve DO conditions in Bubbly Creek, it is still very hard to attain 6 mg/L 95 % of the time since Bubbly Creek water quality is still affected by the water quality of South Branch Chicago River (SBCR) and Chicago Sanitary Ship Canal (CSSC). Hence, it is possible to expect more improvement in DO in Bubbly Creek if the water quality of the South Branch Chicago River gets better.

Table 11. Percentage of time that dissolved oxygen concentrations are greater than the target concentrations at Romeoville (Chicago Sanitary and Ship Canal) for May 1-September 23, 2002 for different withdrawal values for aerated flow augmentation

Scenario	3 mg/L		4 mg/L		5 mg/L		6 mg/L	
Romeoville-2002	dry	wet	dry	wet	Dry	wet	dry	wet
Measured	85.7	82.5	54.2	64.5	20.7	34.5	3.7	10.9
Calibrated	98.6	85.8	64.6	73.3	37.2	57.0	16.7	29.3
50 mgd	99.3	86.5	68.1	74.1	40.2	59.5	17.0	31.5
100 mgd	99.6	86.9	71.2	74.6	41.7	60.9	17.2	34.0
200 mgd	99.8	87.6	77.4	77.3	43.3	62.6	18.0	38.8
400 mgd	100.0	88.5	88.7	79.3	48.1	65.8	20.0	42.8
450 mgd	100.0	88.8	89.8	79.7	49.3	66.4	20.2	43.5
550 mgd	100.0	89.8	93.2	80.0	53.1	68.2	21.5	44.8

Table 12. Percentage of time that dissolved oxygen (DO) concentrations are greater than the target concentrations at I-55 for all periods during July 12 – November 10, 2001 and May 1 – September 23, 2002 for different withdrawal values for aerated flow augmentation

Scenario	>4 mg/L	>5 mg/L	>6 mg/L
Calibrated	48.6	29.2	16.1
50 mgd	55.1	35.6	19.3
100 mgd	61.9	41.6	21.9
200 mgd	80.2	55.4	33.2
400 mgd	95.3	82.0	51.1
450 mgd	96.9	87.8	55.2
550 mgd	98.3	91.8	66.8

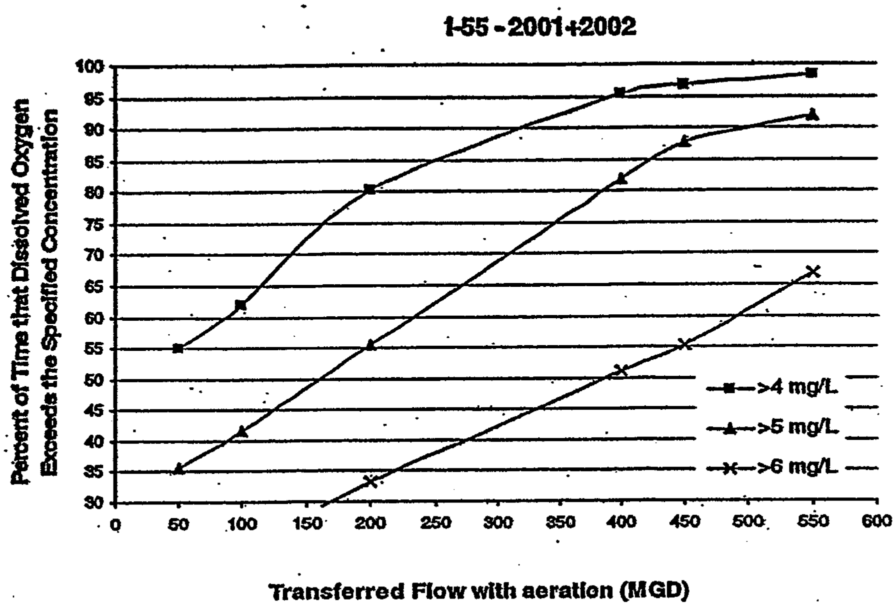


Figure 7. Relation between the amount of aerated transferred flow and percentage compliance with the dissolved oxygen concentration criteria for July 12 – November 10, 2001 and May 1 – September 23, 2002 at I-55 (Bubbly Creek).

APPENDIX D
Capital Costs for Flow Augmentation with Aeration of the Transferred Flow

TABLE D.1
CAPITAL COST ESTIMATION FOR 550 MGD FLOW AUGMENTATION BUBBLY CREEK
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST TOTAL
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	
1	GENERAL REQUIREMENTS								$5,410,311
2	SITEWORK								
	Site Restoration	LS	1	$150,000.00	$150,000				$150,000
	Site Utility Relocations and Extensions	LS	1	$150,000.00	$150,000				$150,000
	Trench Excavation	CY	185370	$15.00	$2,780,550				$2,780,550
	Bedding	CY	12833	$30.00	$384,990				$384,990
	Backfill	CY	129360	$20.00	$2,587,200				$2,587,200
	Structural Fill	CY	53603	$32.00	$1,715,280				$1,715,280
	7-60" DIP Forcemains	LF	73920	$650.00	$48,048,000	40%		$19,219,200	$67,267,200
	Diffuser Pipe into Bubbly Creek	LS	1	$90,000.00	$90,000				$90,000
	Dewatering	Day	90	$500.00	$45,000				$45,000
	Sheeting	SF	1800	$20.00	$36,000				$36,000
	SUBTOTAL								
2-16	PUMPING STATION	MGD	550	$60,000.00	$33,000,000				$33,000,000
	SUBTOTAL								**$113,616,531**
	Contractor OH&P @ 15%								**$17,042,480**
	Subtotal								**$130,659,011**
	Planning Level Contingency @ 30%								**$39,197,703**
	Subtotal								**$169,856,714**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$25,478,507**
	Engineering Fees including CM @ 20%								**$33,971,343**
	Subtotal								**$59,449,850**
	Project Total								**$229,306,564**

APPENDIX E
Operation and Maintenance Costs for Flow Augmentation with Aeration of the Transferred Flow

TABLE E.1
ANNUAL O&M COSTS FOR BUBBLY CREEK 550 MGD P.S. WITH AERATED FORCEMAIN

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	4094.44	24	98266.7	$7,370.00	$1,793,367	19.42	$34,827,181
SUBTOTAL					$1,793,367		$34,827,181

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
LABOR - OPERATOR	2	8	16	$90.00	$350,400	19.42	$6,804,768
ELECTRICIAN	0	0	0	$159.50	$0	19.42	$0
SUBTOTAL					$350,400		$6,804,768

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES (assume 1% of Total PS costs)	330,000	5%			$16,500	19.42	$320,430
SUBTOTAL					$16,500		$320,430

TOTAL ANNUAL O&M $2,160,267

TOTAL PRESENT WORTH O & M COST $41,952,379

APPENDIX F
Capital Costs for Supplemental Aeration Technologies

TABLE F.1
CAPITAL COST ESTIMATION FOR U-TUBE SUPPLEMENTAL AERATION (10 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$48,192
2	SITEWORK								
	Cut/Fill	CY	483	$5.00	$2,417				$2,417
	Removable Bollards	EA	4	$300.00	$1,200				$1,200
	Fencing	LS	1	$4,333.33	$4,333				$4,333
	Miscellaneous Sitework	CY	33	$36.00	$1,200				$1,200
	Miscellaneous Sitework	SF	1067	$5.00	$5,333				$5,333
3	CONCRETE								
	Slabs	CY	28	$500.00	$14,000				$14,000
	Wet Well	LS	1	$8,500.00	$8,500				$8,500
9	MASONRY								
	Split Block Masonry Building	SF	667	$100.00	$66,667				$66,667
10	FINISHES								
	Coatings	LS	1	$6,666.67	$6,667				$6,667
11	EQUIPMENT								
	Vertical turbine Pumps and Appurtenances	EA	3	$76,500.00	$204,000				$204,000
	Blower	EA	1	$8,200.00	$8,200	40%		$3,280	$11,480
	Drill & Prep U-Tube Shaft	FT	115	$580.67	$66,777				$66,777
	Casing Material (Welded Steel, 1")	LB	29100	$2.00	$58,200				$58,200
	Install U-Tube Casing	FT	115	$33.33	$3,833				$3,833
	Install Bottom Plug (Concrete and Mortar)	CY	25	$250.00	$6,250				$6,250
	Pump Water from Shaft and Prepare Casing	LS	1	$17,500.00	$17,500				$17,500
	Bubble Collector and Appurtenances	EA	1	$5,333.33	$5,333				$5,333
	Diffusers	LS	1	$4,000.00	$4,000				$4,000
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	2	$500.00	$1,000				$1,000
	Flow Meter	EA	2	$4,500.00	$9,000				$9,000
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	250	$4.00	$1,000				$1,000
	Control Valve	EA	8	$1,000.00	$8,000				$8,000
	20" Pump control Valve	EA	8	$9,333.33	$74,667				$74,667
	Isolation Valves	EA	10	$4,666.67	$46,667				$46,667
	20" DIP	LF	51	$180.00	$9,150				$9,150
	30" DIP	LF	17	$270.00	$4,500				$4,500
	20" Flexible Piping	LF	100	$180.00	$18,000				$18,000
	Inner Piping system	LF	50	$450.00	$22,500				$22,500
	HDPE Diffuser Pipe	LF	1,333	$15.00	$20,000				$20,000
	Pressure Regulating Station	EA	7	$5,000.00	$33,333				$33,333
	Diffuser Supports	EA	133	$150.00	$20,000				$20,000
	Lateral Installation (Within Water Column)	LF	1,333	$94.00	$125,333				$125,333
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$25,000.00	$25,000				$25,000
	Control systems and Instrumentation	LS	1	$16,666.67	$16,667				$16,667
	Control wiring	LS	1	$3,333.33	$3,333				$3,333
	SUBTOTAL								$970,032
	Contractor OH&P @ 15%								$145,505
	Subtotal								$1,115,537
	Planning Level Contingency @ 30%								$334,661
	Subtotal								$1,450,198
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								$217,530
	Engineering Fees including CM @ 20%								$290,040
	Subtotal								$507,569
	Project Total								$1,957,767

TABLE F.2
CAPITAL COST ESTIMATION FOR U-TUBE SUPPLEMENTAL AERATION (50 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$230,960
2	SITEWORK								
	Cut/Fill	CY	2417	$5.00	$12,083				$12,083
	Removable Bollards	EA	20	$300.00	$6,000				$6,000
	Fencing	LS	1	$21,666.67	$21,667				$21,667
	Miscellaneous Sitework	CY	167	$36.00	$6,000				$6,000
	Miscellaneous Sitework	SF	5333	$5.00	$26,667				$26,667
3	CONCRETE								
	Slabs	CY	140	$500.00	$70,000				$70,000
	Wet Well	LS	1	$32,500.00	$32,500				$32,500
9	MASONRY								
	Split Block Masonry Building	SF	3333	$100.00	$333,333				$333,333
10	FINISHES								
	Coatings	LS	1	$33,333.33	$33,333				$33,333
11	EQUIPMENT								
	Vertical turbine Pumps and Appurtenances	EA	13	$76,500.00	$1,020,000				$1,020,000
	Blower	EA	5	$8,200.00	$41,000	40%		$16,400	$57,400
	Drill & Prep U-Tube Shaft	FT	115	$2,903.33	$333,883				$333,883
	Casing Material (Welded Steel, 1")	LB	145500	$2.00	$291,000				$291,000
	Install U-Tube Casing	FT	115	$166.67	$19,167				$19,167
	Install Bottom Plug (Concrete and Mortar)	CY	25	$1,250.00	$31,250				$31,250
	Pump Water from Shaft and Prepare Casing	LS	1	$87,500.00	$87,500				$87,500
	Bubble Collector and Appurtenances	EA	1	$26,666.67	$26,667				$26,667
	Diffusers	LS	1	$20,000.00	$20,000				$20,000
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	2	$2,500.00	$5,000				$5,000
	Flow Meter	EA	2	$22,500.00	$45,000				$45,000
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	250	$20.00	$5,000				$5,000
	Control Valve	EA	8	$5,000.00	$40,000				$40,000
	20" Pump control Valve	EA	8	$46,666.67	$373,333				$373,333
	Isolation Valves	EA	10	$23,333.33	$233,333				$233,333
	20" DIP	LF	254	$180.00	$45,750				$45,750
	30" DIP	LF	83	$270.00	$22,500				$22,500
	20" Flexible Piping	LF	500	$180.00	$90,000				$90,000
	Inner Piping system	LF	250	$450.00	$112,500				$112,500
	HDPE Diffuser Pipe	LF	6,667	$15.00	$100,000				$100,000
	Pressure Regulating Station	EA	33	$5,000.00	$166,667				$166,667
	Diffuser Supports	EA	667	$150.00	$100,000				$100,000
	Lateral Installation (Within Water Column)	LF	6,667	$94.00	$626,667				$626,667
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$125,000.00	$125,000				$125,000
	Control systems and Instrumentation	LS	1	$83,333.33	$83,333				$83,333
	Control wiring	LS	1	$16,666.67	$16,667				$16,667
	SUBTOTAL								$4,850,160
	Contractor OH&P @ 15%								$727,524
	Subtotal								$5,577,684
	Planning Level Contingency @ 30%								$1,673,305
	Subtotal								$7,250,989
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								$1,087,648
	Engineering Fees Including CM @ 20%								$1,450,198
	Subtotal								$2,537,846
	Project Total								$9,788,835

TABLE F.3
CAPITAL COST ESTIMATION FOR U-TUBE SUPPLEMENTAL AERATION (80 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$369,536
2	SITEWORK								
	Cut/Fill	CY	3867	$5.00	$19,333				$19,333
	Removable Bollards	EA	32	$300.00	$9,600				$9,600
	Fencing	LS	1	$34,666.67	$34,667				$34,667
	Miscellaneous Sitework	CY	267	$36.00	$9,600				$9,600
	Miscellaneous Sitework	SF	8533	$5.00	$42,667				$42,667
3	CONCRETE								
	Slabs	CY	224	$500.00	$112,000				$112,000
	Wet Well	LS	1	$52,000.00	$52,000				$52,000
9	MASONRY								
	Split Block Masonry Building	SF	5333	$100.00	$533,333				$533,333
10	FINISHES								
	Coatings	LS	1	$53,333.33	$53,333				$53,333
11	EQUIPMENT								
	Vertical turbine Pumps and Appurtenances	EA	21	$76,500.00	$1,632,000				$1,632,000
	Blower	EA	8	$8,200.00	$65,600	40%		$26,240	$91,840
	Drill & Prep U-Tube Shaft	FT	115	$4,645.33	$534,213				$534,213
	Casing Material (Welded Steel, 1")	LB	232800	$2.00	$465,600				$465,600
	Install U-Tube Casing	FT	115	$266.67	$30,667				$30,667
	Install Bottom Plug (Concrete and Mortar)	CY	25	$2,000.00	$50,000				$50,000
	Pump Water from Shaft and Prepare Casing	LS	1	$140,000.00	$140,000				$140,000
	Bubble Collector and Appurtenances	EA	1	$42,666.67	$42,667				$42,667
	Diffusers	LS	1	$32,000.00	$32,000				$32,000
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	2	$4,000.00	$8,000				$8,000
	Flow Meter	EA	2	$36,000.00	$72,000				$72,000
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	250	$32.00	$8,000				$8,000
	Control Valve	EA	8	$8,000.00	$64,000				$64,000
	20" Pump control Valve	EA	8	$74,666.67	$597,333				$597,333
	Isolation Valves	EA	10	$37,333.33	$373,333				$373,333
	20" DIP	LF	407	$180.00	$73,200				$73,200
	30" DIP	LF	133	$270.00	$36,000				$36,000
	20" Flexible Piping	LF	800	$180.00	$144,000				$144,000
	Inner Piping system	LF	400	$450.00	$180,000				$180,000
	HDPE Diffuser Pipe	LF	10,667	$15.00	$160,000				$160,000
	Pressure Regulating Station	EA	53	$5,000.00	$266,667				$266,667
	Diffuser Supports	EA	1,067	$150.00	$160,000				$160,000
	Lateral Installation (Within Water Column)	LF	10,667	$94.00	$1,002,667				$1,002,667
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$200,000.00	$200,000				$200,000
	Control systems and Instrumentation	LS	1	$133,333.33	$133,333				$133,333
	Control wiring	LS	1	$26,666.67	$26,667				$26,667
	SUBTOTAL								$7,760,256
	Contractor OH&P @ 15%								$1,164,038
	Subtotal								$8,924,294
	Planning Level Contingency @ 30%								$2,677,288
	Subtotal								$11,601,583
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								$1,740,237
	Engineering Fees Including CM @ 20%								$2,320,317
	Subtotal								$4,060,554
	Project Total								$15,662,137

TABLE F.4
CAPITAL COST ESTIMATION FOR JET AERATION (10 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$70,984
2	SITEWORK								
	Mobilization for dredging	LS	1	$18,833.33	$18,833				$18,833
	River Dredging	CY	2778	$20.00	$55,556				$55,556
	Sheet Piling	SF	5000	$30.00	$150,000				$150,000
	Coffer Dam	SF	6667	$52.50	$350,000				$350,000
	Diversion Pumping	DAY	7	$3,600.00	$24,000				$24,000
	Blower & Pump Bldg. Excavation	CY	2722	$7.00	$19,056				$19,056
	Backfill	CY	1735	$8.00	$13,877				$13,877
3	CONCRETE								
	Wetwell	LS	1	$6,666.67	$6,667				$6,667
9	MASONRY								
	Pump and Blower Building	SF	1667	$100.00	$166,667				$166,667
10	FINISHES								
	Coatings	LS	1	$6,666.67	$6,667				$6,667
11	EQUIPMENT								
	Pumps, Blowers, Manifolds	LS	1	$316,666.67	$316,667	40%		$126,667	$443,333
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	1	$500.00	$500				$500
	Flow Meter	EA	1	$4,500.00	$4,500				$4,500
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	267	$12.00	$3,200				$3,200
	Control Valve	EA	2	$3,000.00	$7,000				$7,000
	20" Pump control Valve	EA	2	$28,000.00	$65,333				$65,333
	Isolation Valves	EA	2	$14,000.00	$32,667				$32,667
	20" DIP	LF	33	$180.00	$6,000				$6,000
	30" DIP	LF	17	$270.00	$4,500				$4,500
	Priming System	EA	1	$1,666.67	$1,667				$1,667
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$16,666.67	$16,667	40%		$6,667	$23,333
	Control systems and Instrumentation	LS	1	$10,000.00	$10,000	40%		$4,000	$14,000
	Control wiring	LS	1	$1,666.67	$1,667	40%		$667	$2,333
	SUBTOTAL								**$1,490,672**
	Contractor OH&P @ 15%								**$223,601**
	Subtotal								**$1,714,273**
	Planning Level Contingency @ 30%								**$514,282**
	Subtotal								**$2,228,555**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$334,283**
	Engineering Fees Including CM @ 20%								**$445,711**
	Subtotal								**$779,994**
	Project Total								**$3,008,549**

TABLE F.5
CAPITAL COST ESTIMATION FOR JET AERATION (50 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	TOTAL
1	GENERAL REQUIREMENTS								$354,922
2	SITEWORK								
	Mobilization for dredging	LS	1	$94,166.67	$94,167				$94,167
	River Dredging	CY	13889	$20.00	$277,778				$277,778
	Sheet Piling	SF	25000	$30.00	$750,000				$750,000
	Coffer Dam	SF	33333	$52.50	$1,750,000				$1,750,000
	Diversion Pumping	DAY	33	$3,600.00	$120,000				$120,000
	Blower & Pump Bldg. Excavation	CY	13611	$7.00	$95,278				$95,278
	Backfill	CY	8673	$8.00	$69,383				$69,383
3	CONCRETE								
	Wetwell	LS	1	$33,333.33	$33,333				$33,333
9	MASONRY								
	Pump and Blower Building	SF	8333	$100.00	$833,333				$833,333
10	FINISHES								
	Coatings	LS	1	$33,333.33	$33,333				$33,333
11	EQUIPMENT								
	Pumps, Blowers, Manifolds	LS	1	$1,583,333.33	$1,583,333	40%		$633,333	$2,216,667
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	1	$2,500.00	$2,500				$2,500
	Flow Meter	EA	1	$22,500.00	$22,500				$22,500
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	1333	$12.00	$16,000				$16,000
	Control Valve	EA	12	$3,000.00	$35,000				$35,000
	20" Pump control Valve	EA	12	$28,000.00	$326,667				$326,667
	Isolation Valves	EA	12	$14,000.00	$163,333				$163,333
	20" DIP	LF	167	$180.00	$30,000				$30,000
	30" DIP	LF	83	$270.00	$22,500				$22,500
	Priming System	EA	1	$8,333.33	$8,333				$8,333
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$83,333.33	$83,333	40%		$33,333	$116,667
	Control systems and Instrumentation	LS	1	$50,000.00	$50,000	40%		$20,000	$70,000
	Control wiring	LS	1	$8,333.33	$8,333	40%		$3,333	$11,667
	SUBTOTAL								$7,453,360
	Contractor OH&P @ 15%								$1,118,004
	Subtotal								$8,571,364
	Planning Level Contingency @ 30%								$2,571,409
	Subtotal								$11,142,773
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								$1,671,416
	Engineering Fees including CM @ 20%								$2,228,555
	Subtotal								$3,899,971
	Project Total								$15,042,744

TABLE F.6
CAPITAL COST ESTIMATION FOR JET AERATION (80 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$567,875
2	SITEWORK								
	Mobilization for dredging	LS	1	$150,666.67	$150,667				$150,667
	River Dredging	CY	22222	$20.00	$444,444				$444,444
	Sheet Piling	SF	40000	$30.00	$1,200,000				$1,200,000
	Coffer Dam	SF	53333	$52.50	$2,800,000				$2,800,000
	Diversion Pumping	DAY	53	$3,600.00	$192,000				$192,000
	Blower & Pump Bldg. Excavation	CY	21778	$7.00	$152,444				$152,444
	Backfill	CY	13877	$8.00	$111,012				$111,012
3	CONCRETE								
	Wetwell	LS	1	$53,333.33	$53,333				$53,333
9	MASONRY								
	Pump and Blower Building	SF	13333	$100.00	$1,333,333				$1,333,333
10	FINISHES								
	Coatings	LS	1	$53,333.33	$53,333				$53,333
11	EQUIPMENT								
	Pumps, Blowers, Manifolds	LS	1	$2,533,333.33	$2,533,333	40%		$1,013,333	$3,546,667
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	1	$4,000.00	$4,000				$4,000
	Flow Meter	EA	1	$36,000.00	$36,000				$36,000
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	2133	$12.00	$25,600				$25,600
	Control Valve	EA	19	$3,000.00	$56,000				$56,000
	20" Pump control Valve	EA	19	$28,000.00	$522,667				$522,667
	Isolation Valves	EA	19	$14,000.00	$261,333				$261,333
	20" DIP	LF	267	$180.00	$48,000				$48,000
	30" DIP	LF	133	$270.00	$36,000				$36,000
	Priming System	EA	1	$13,333.33	$13,333				$13,333
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$133,333.33	$133,333	40%		$53,333	$186,667
	Control systems and Instrumentation	LS	1	$80,000.00	$80,000	40%		$32,000	$112,000
	Control wiring	LS	1	$13,333.33	$13,333	40%		$5,333	$18,667
	SUBTOTAL								**$11,925,376**
	Contractor OH&P @ 15%								**$1,788,806**
	Subtotal								**$13,714,183**
	Planning Level Contingency @ 30%								**$4,114,255**
	Subtotal								**$17,828,438**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$2,674,266**
	Engineering Fees Including CM @ 20%								**$3,565,688**
	Subtotal								**$6,239,953**
	Project Total								**$24,068,391**

TABLE F.7
CAPITAL COST ESTIMATION FOR SEPA 10 g/s STATION (No Pump Station)[1]
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST TOTAL
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	
1	GENERAL REQUIREMENTS								$57,139
11	EQUIPMENT								
	SEPA Station (1)	$/gpm	133333	$25.71	$3,428,325				$1,142,775
	SUBTOTAL								**$1,199,914**
	Contractor OH&P @ 15%								**$179,987**
	Subtotal								**$1,379,901**
	Planning Level Contingency @ 30%								**$413,970**
	Subtotal								**$1,793,871**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$269,081**
	Engineering Fees Including CM @ 20%								**$358,774**
	Subtotal								**$627,855**
	Project Total								**$2,421,726**

(1) Costs are to be used for 10 g/s station for Bubbly Creek only. This SEPA station does not require its own pump station.

TABLE F.8
CAPITAL COST ESTIMATION FOR SEPA 50 g/s STATION
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST TOTAL
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	
1	GENERAL REQUIREMENTS								$603,310
11	EQUIPMENT								
	SEPA Station (1)	$/gpm	133333	$54.30	$7,239,715				$12,066,192
	SUBTOTAL								**$12,669,502**
	Contractor OH&P @ 15%								**$1,900,425**
	Subtotal								**$14,569,927**
	Planning Level Contingency @ 30%								**$4,370,978**
	Subtotal								**$18,940,905**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$2,841,136**
	Engineering Fees Including CM @ 20%								**$3,788,181**
	Subtotal								**$6,629,317**
	Project Total								**$25,570,222**

(1) Costs were obtained from existing SEPA station construction costs, updated to 2006 rates using ENR index of 7660.

TABLE F.9
CAPITAL COST ESTIMATION FOR SEPA 80 g/s STATION
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	TOTAL
1	GENERAL REQUIREMENTS								$965,295
11	EQUIPMENT								
	SEPA Station (1)	$/gpm	133333	$54.30	$7,239,715				$19,305,907
	SUBTOTAL								**$20,271,203**
	Contractor OH&P @ 15%								**$3,040,680**
	Subtotal								**$23,311,883**
	Planning Level Contingency @ 30%								**$6,993,565**
	Subtotal								**$30,305,448**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$4,545,817**
	Engineering Fees Including CM @ 20%								**$6,061,090**
	Subtotal								**$10,606,907**
	Project Total								**$40,912,355**

(1) Costs were obtained from existing SEPA station construction costs, updated to 2006 rates using ENR index of 7660.

TABLE F.10
CAPITAL COST ESTIMATION FOR CERAMIC DIFFUSER SYSTEM (10 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	TOTAL
1	GENERAL REQUIREMENTS								$45,131
2	SITEWORK								
	Mobilization for dredging	LS	1	$18,833.33	$18,833				$18,833
	River Dredging	CY	2778	$20.00	$55,556				$55,556
	Sheet Piling	SF	5000	$30.00	$150,000				$150,000
	Coffer Dam	SF	6667	$52.50	$350,000				$350,000
	Diversion Pumping	DAY	7	$3,600.00	$24,000				$24,000
	Blower Bldg. Excavation	CY	222	$7.00	$1,556				$1,556
	Backfill	CY	160	$8.00	$1,284				$1,284
3	CONCRETE								
9	MASONRY								
	Blower Building	SF	833	$100.00	$83,333				$83,333
10	FINISHES								
	Coatings	LS	1	$6,666.67	$6,667				$6,667
11	EQUIPMENT								
	Diffusers	LS	1	$30,000.00	$30,000	40%		$12,000	$42,000
	Blower	EA	3	$8,333.33	$25,000	40%		$10,000	$35,000
	Local Inlet Filter	LS	1	$6,666.67	$6,667				$6,667
	Spray Pump	LS	1	$5,000.00	$5,000				$5,000
	Blower Actuator	LS	1	$6,333.33	$6,333				$6,333
	PLC	EA	1	$33,333.33	$33,333				$33,333
13	SPECIAL CONSTRUCTION								
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	333	$29.00	$9,667	40%		$3,867	$13,533
	Control Valve	EA	3	$1,000.00	$3,000	40%		$1,200	$4,200
	HDPE Diffuser Pipe	LF	333	$15.00	$5,000	40%		$2,000	$7,000
	Diffuser Supports	EA	27	$150.00	$4,000	40%		$1,600	$5,600
	AC Unit	EA	1	$1,666.67	$1,667	40%		$667	$2,333
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$20,000.00	$20,000	40%		$8,000	$28,000
	Control systems and instrumentation	LS	1	$13,333.33	$13,333	40%		$5,333	$18,667
	Control wiring	LS	1	$2,666.67	$2,667	40%		$1,067	$3,733
	SUBTOTAL								**$947,760**
	Contractor OH&P @ 15%								**$142,164**
	Subtotal								**$1,089,924**
	Planning Level Contingency @ 30%								**$326,977**
	Subtotal								**$1,416,901**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$212,535**
	Engineering Fees including CM @ 20%								**$283,380**
	Subtotal								**$495,915**
	Project Total								**$1,912,816**

TABLE F.11
CAPITAL COST ESTIMATION FOR CERAMIC DIFFUSER SYSTEM (50 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$225,657
2	SITEWORK								
	Mobilization for dredging	LS	1	$94,166.67	$94,167				$94,167
	River Dredging	CY	13889	$20.00	$277,778				$277,778
	Sheet Piling	SF	25000	$30.00	$750,000				$750,000
	Coffer Dam	SF	33333	$52.50	$1,750,000				$1,750,000
	Diversion Pumping	DAY	33	$3,600.00	$120,000				$120,000
	Blower Bldg. Excavation	CY	1111	$7.00	$7,778				$7,778
	Backfill	CY	802	$8.00	$6,420				$6,420
3	CONCRETE								
9	MASONRY								
	Blower Building	SF	4167	$100.00	$416,667				$416,667
10	FINISHES								
	Coatings	LS	1	$33,333.33	$33,333				$33,333
11	EQUIPMENT								
	Diffusers	LS	1	$150,000.00	$150,000	40%		$60,000	$210,000
	Blower	EA	3	$41,666.67	$125,000	40%		$50,000	$175,000
	Local Inlet Filter	LS	1	$33,333.33	$33,333				$33,333
	Spray Pump	LS	1	$25,000.00	$25,000				$25,000
	Blower Actuator	LS	1	$31,666.67	$31,667				$31,667
	PLC	EA	1	$166,666.67	$166,667				$166,667
13	SPECIAL CONSTRUCTION								
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	1667	$29.00	$48,333	40%		$19,333	$67,667
	Control Valve	EA	3	$5,000.00	$15,000	40%		$6,000	$21,000
	HDPE Diffuser Pipe	LF	1667	$15.00	$25,000	40%		$10,000	$35,000
	Diffuser Supports	EA	133	$150.00	$20,000	40%		$8,000	$28,000
	AC Unit	EA	1	$8,333.33	$8,333	40%		$3,333	$11,667
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$100,000.00	$100,000	40%		$40,000	$140,000
	Control systems and Instrumentation	LS	1	$66,666.67	$66,667	40%		$26,667	$93,333
	Control wiring	LS	1	$13,333.33	$13,333	40%		$5,333	$18,667
	SUBTOTAL								**$4,738,799**
	Contractor OH&P @ 15%								**$710,820**
	Subtotal								**$5,449,619**
	Planning Level Contingency @ 30%								**$1,634,886**
	Subtotal								**$7,084,505**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$1,062,676**
	Engineering Fees Including CM @ 20%								**$1,416,901**
	Subtotal								**$2,479,577**
	Project Total								**$9,564,081**

TABLE F.12
CAPITAL COST ESTIMATION FOR CERAMIC DIFFUSER SYSTEM (80 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$361,051
2	SITEWORK								
	Mobilization for dredging	LS	1	$150,666.67	$150,667				$150,667
	River Dredging	CY	22222	$20.00	$444,444				$444,444
	Sheet Piling	SF	40000	$30.00	$1,200,000				$1,200,000
	Coffer Dam	SF	53333	$52.50	$2,800,000				$2,800,000
	Diversion Pumping	DAY	53	$3,600.00	$192,000				$192,000
	Blower Bldg. Excavation	CY	1778	$7.00	$12,444				$12,444
	Backfill	CY	1284	$8.00	$10,272				$10,272
3	CONCRETE								
9	MASONRY								
	Blower Building	SF	6667	$100.00	$666,667				$666,667
10	FINISHES								
	Coatings	LS	1	$53,333.33	$53,333				$53,333
11	EQUIPMENT								
	Diffusers	LS	1	$240,000.00	$240,000	40%		$96,000	$336,000
	Blower	EA	3	$66,666.67	$200,000	40%		$80,000	$280,000
	Local Inlet Filter	LS	1	$53,333.33	$53,333				$53,333
	Spray Pump	LS	1	$40,000.00	$40,000				$40,000
	Blower Actuator	LS	1	$50,666.67	$50,667				$50,667
	PLC	EA	1	$266,666.67	$266,667				$266,667
13	SPECIAL CONSTRUCTION								
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	2667	$29.00	$77,333	40%		$30,933	$108,267
	Control Valve	EA	3	$8,000.00	$24,000	40%		$9,600	$33,600
	HDPE Diffuser Pipe	LF	2667	$15.00	$40,000	40%		$16,000	$56,000
	Diffuser Supports	EA	213	$150.00	$32,000	40%		$12,800	$44,800
	AC Unit	EA	1	$13,333.33	$13,333	40%		$5,333	$18,667
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$160,000.00	$160,000	40%		$64,000	$224,000
	Control systems and Instrumentation	LS	1	$106,666.67	$106,667	40%		$42,667	$149,333
	Control wiring	LS	1	$21,333.33	$21,333	40%		$8,533	$29,867
	SUBTOTAL								**$7,582,079**
	Contractor OH&P @ 15%								**$1,137,312**
	Subtotal								**$8,719,390**
	Planning Level Contingency @ 30%								**$2,615,817**
	Subtotal								**$11,335,207**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$1,700,281**
	Engineering Fees Including CM @ 20%								**$2,267,041**
	Subtotal								**$3,967,323**
	Project Total								**$15,302,530**

APPENDIX G
Operation and Maintenance Costs for Supplemental Aeration Technologies

TABLE G.1
ANNUAL O&M COSTS FOR U-TUBE 10 g/s AERATION SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	11.15	24	267.6	$20.07	$4,885	19.42	$94,858
SUBTOTAL					$4,885		$94,858

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Blowers	1	0.1	0.1	$90.00	$3,285	19.42	$63,795
Pumps	1	0.1	0.1	$90.00	$3,285	19.42	$63,795
LABOR - OPERATOR							
Blowers & Pumps	1	0.2	0.2	$90.00	$4,380	19.42	$85,060
ELECTRICIAN	1	0.05	0.05	$159.50	$2,911	19.42	$56,529
SUBTOTAL					$13,861		$269,178

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	479,350	5%			$23,968	19.42	$465,449
SUBTOTAL					$23,968		$465,449

TOTAL ANNUAL O&M $42,713

TOTAL PRESENT WORTH O & M COST $829,486

TABLE G.2
ANNUAL O&M COSTS FOR U-TUBE 50 g/s AERATION SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, J	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	56	24	1338.2	$100.37	$24,423	19.42	$474,292
SUBTOTAL					$24,423		$474,292

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Blowers	1	0.6	0.6	$90.00	$19,710	19.42	$382,768
Pumps	1	0.6	0.6	$90.00	$19,710	19.42	$382,768
LABOR - OPERATOR							
Blowers & Pumps	1	0.4	0.4	$90.00	$8,760	19.42	$170,119
ELECTRICIAN	1	0.1	0.1	$159.50	$5,822	19.42	$113,058
SUBTOTAL					$54,002		$1,048,714

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	2,396,750	5%			$119,838	19.42	$2,327,244
SUBTOTAL					$119,838		$2,327,244

TOTAL ANNUAL O&M $198,262

TOTAL PRESENT WORTH O & M COST $3,850,251

TABLE G.3
ANNUAL O&M COSTS FOR U-TUBE 80 g/s AERATION SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	89	24	2141.2	$160.59	$39,077	19.42	$758,868
SUBTOTAL					$39,077		$758,868

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Blowers	1	0.6	0.6	$90.00	$19,710	19.42	$382,768
Pumps	1	0.6	0.6	$90.00	$19,710	19.42	$382,768
LABOR - OPERATOR							
Blowers & Pumps	1	0.8	0.8	$90.00	$17,520	19.42	$340,238
ELECTRICIAN	1	0.2	0.2	$159.50	$11,644	19.42	$226,117
SUBTOTAL					$68,584		$1,331,892

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	3,834,800	5%			$191,740	19.42	$3,723,591
SUBTOTAL					$191,740		$3,723,591

TOTAL ANNUAL O&M	$299,400	
TOTAL PRESENT WORTH O & M COST		$5,814,350

TABLE G.4
ANNUAL O&M COSTS FOR JET AERATION 10 g/s SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	288	24	6900.0	$517.50	$125,925	19.42	$2,445,464
SUBTOTAL					$125,925		$2,445,464

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Pumps	2	0.1	0.2	$90.00	$6,570	19.42	$127,589
Blowers	2	0.1	0.2	$90.00	$6,570	19.42	$127,589
LABOR - OPERATOR							
Blowers & Pumps	2	0.1	0.2	$90.00	$4,380	19.42	$85,060
ELECTRICIAN	1	0.05	0.05	$159.50	$2,911	19.42	$56,529
SUBTOTAL					$20,431		$396,768

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	437,033	5%			$21,852	19.42	$424,359
SUBTOTAL					$21,852		$424,359

TOTAL ANNUAL O&M $168,208

TOTAL PRESENT WORTH O & M COST $3,266,590

TABLE G.5
ANNUAL O&M COSTS FOR JET AERATION 50 g/s SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	1438	24	34500.0	$2,587.50	$629,625	19.42	$12,227,318
SUBTOTAL					$629,625		$12,227,318

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Pumps	2	0.6	1.2	$90.00	$39,420	19.42	$765,536
Blowers	2	0.6	1.2	$90.00	$39,420	19.42	$765,536
LABOR - OPERATOR							
Blowers & Pumps	2	0.4	0.8	$90.00	$17,520	19.42	$340,238
ELECTRICIAN	1	0.1	0.1	$159.50	$5,822	19.42	$113,058
SUBTOTAL					$102,182		$1,984,370

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	2,185,167	5%			$109,258	19.42	$2,121,797
SUBTOTAL					$109,258		$2,121,797

TOTAL ANNUAL O&M	$841,065	
TOTAL PRESENT WORTH O & M COST		$16,333,484

TABLE G.6
ANNUAL O&M COSTS FOR JET AERATION 80 g/s SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	2300	24	55200.0	$4,140.00	$1,007,400	19.42	$19,563,708
SUBTOTAL					$1,007,400		$19,563,708

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Pumps	2	0.6	1.2	$90.00	$39,420	19.42	$765,536
Blowers	2	0.6	1.2	$90.00	$39,420	19.42	$765,536
LABOR - OPERATOR							
Blowers & Pumps	2	1	2	$90.00	$43,800	19.42	$850,596
ELECTRICIAN	1	0.25	0.25	$159.50	$14,554	19.42	$282,646
SUBTOTAL					$137,194		$2,664,315

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	3,496,267	5%			$174,813	19.42	$3,394,875
SUBTOTAL					$174,813		$3,394,875

TOTAL ANNUAL O&M $1,319,408

TOTAL PRESENT WORTH O & M COST $25,622,898

TABLE G.7
ANNUAL O&M COSTS FOR 10 g/s SEPA STATION

NOTE: The 10 g/s SEPA station for Bubbly Creek utilizes the existing Racine Avenue Pump Station. Therefore, no additional O&M costs are incurred.

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	0	24	0.0	$0.00	$0	19.42	$0
SUBTOTAL					$0		$0

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Cut & Landscape	0	0.4	0	$90.00	$0	19.42	$0
Pump Maintenance	0	0.1	0	$90.00	$0	19.42	$0
LABOR - OPERATOR	0	2	0	$90.00	$0	19.42	$0
ELECTRICIAN	0	0.05	0	$159.50	$0	19.42	$0
SUBTOTAL					$0		$0

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	0	5%			$0	19.42	$0
SUBTOTAL					$0		$0

TOTAL ANNUAL O&M	$0	
TOTAL PRESENT WORTH O & M COST		$0

TABLE G.8
ANNUAL O&M COSTS FOR 50 g/s SEPA STATION

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	1243	24	29824.0	$2,236.80	$544,288	19.42	$10,570,073
SUBTOTAL					$544,288		$10,570,073

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Cut & Landscape	2	0.6	1.2	$90.00	$26,280	19.42	$510,358
Pump Maintenance	1	0.4	0.4	$90.00	$13,140	19.42	$255,179
LABOR - OPERATOR	1	0.75	0.75	$90.00	$16,425	19.42	$318,974
ELECTRICIAN	1	0.2	0.2	$159.50	$11,644	19.42	$226,117
SUBTOTAL					$67,489		$1,310,627

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	120,662	5%			$6,033	19.42	$117,163
SUBTOTAL					$6,033		$117,163

TOTAL ANNUAL O&M $617,810

TOTAL PRESENT WORTH O & M COST $11,997,862

TABLE G.9
ANNUAL O&M COSTS FOR 80 g/s SEPA STATION

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	1988	24	47718.4	$3,578.88	$870,861	19.42	$16,912,117
SUBTOTAL					$870,861		$16,912,117

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Cut & Landscape	2	0.6	1.2	$90.00	$26,280	19.42	$510,358
Pump Maintenance	1	0.75	0.75	$90.00	$24,638	19.42	$478,460
LABOR - OPERATOR	1	1	1	$90.00	$21,900	19.42	$425,298
ELECTRICIAN	1	0.2	0.2	$159.50	$11,644	19.42	$226,117
SUBTOTAL					$84,461		$1,640,233

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	193,059	5%			$9,653	19.42	$187,460
SUBTOTAL					$9,653		$187,460

TOTAL ANNUAL O&M $964,975

TOTAL PRESENT WORTH O & M COST $18,739,810

TABLE G.10
ANNUAL O&M COSTS FOR CERAMIC DIFFUSER SYSTEM 10 g/s SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	125	24	3000.0	$225.00	$54,750	19.42	$1,063,245
SUBTOTAL					$54,750		$1,063,245

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE	1	0.1	0.1	$90.00	$3,285	19.42	$63,795
LABOR - OPERATOR	1	0.1	0.1	$90.00	$2,190	19.42	$42,530
ELECTRICIAN	1	0.05	0.05	$159.50	$2,911	19.42	$56,529
SUBTOTAL					$8,386		$162,854

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	129,667	5%			$6,483	19.42	$125,906
SUBTOTAL					$6,483		$125,906

TOTAL ANNUAL O&M	$69,619	
TOTAL PRESENT WORTH O & M COST		$1,352,005

TABLE G.11
ANNUAL O&M COSTS FOR CERAMIC DIFFUSER SYSTEM 50 g/s SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, J	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	625	24	15000.0	$1,125.00	$273,750	19.42	$5,316,225
SUBTOTAL					$273,750		$5,316,225

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE	1	0.6	0.6	$90.00	$19,710	19.42	$382,768
LABOR - OPERATOR	1	0.2	0.2	$90.00	$4,380	19.42	$85,060
ELECTRICIAN	1	0.1	0.1	$159.50	$5,822	19.42	$113,058
SUBTOTAL					$29,912		$580,886

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	648,333	5%			$32,417	19.42	$629,532
SUBTOTAL					$32,417		$629,532

TOTAL ANNUAL O&M	$336,078	
TOTAL PRESENT WORTH O & M COST		$6,526,643

TABLE G.12
ANNUAL O&M COSTS FOR CERAMIC DIFFUSER SYSTEM 80 g/s SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	1000	24	24000.0	$1,800.00	$438,000	19.42	$8,505,960
SUBTOTAL					$438,000		$8,505,960

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE	1	0.6	0.6	$90.00	$19,710	19.42	$382,768
LABOR - OPERATOR	1	0.25	0.25	$90.00	$5,475	19.42	$106,325
ELECTRICIAN	1	0.2	0.2	$159.50	$11,644	19.42	$226,117
SUBTOTAL					$36,829		$715,209

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	1,037,333	5%			$51,867	19.42	$1,007,251
SUBTOTAL					$51,867		$1,007,251

TOTAL ANNUAL O&M $526,695

TOTAL PRESENT WORTH O & M COST $10,228,420

APPENDIX H
Capital Costs for Flow Augmentation – No Aeration
(In Combination with Supplemental Aeration)

TABLE H.1
COST ESTIMATE FOR BUBBLY CREEK 50 MGD PUMP STATION AND FORCEMAIN
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL		LABOR			INSTALLED COST
				UNIT COST	TOTAL COST	% MAT COST	UNIT COST	TOTAL COST	TOTAL
1	GENERAL REQUIREMENTS								$707,016
2	SITEWORK								
	Site Restoration	LS	1	$50,000.00	$50,000				$50,000
	Site Utility Relocations and Extensions	LS	1	$50,000.00	$50,000				$50,000
	Trench Excavation	CY	26481	$15.00	$397,215				$397,215
	Bedding	CY	1425	$30.00	$42,750				$42,750
	Backfill	CY	6518	$20.00	$130,360				$130,360
	Structural Fill	CY	12000	$32.00	$384,000				$384,000
	60" DIP Forcemain	LF	11000	$650.00	$7,150,000	40%		$2,860,000	$10,010,000
	Diffuser Pipe into Bubbly Creek	LS	1	$10,000.00	$10,000				$10,000
	Dewatering	Day	60	$500.00	$30,000				$30,000
	Sheeting	SF	1800	$20.00	$36,000				$36,000
	SUBTOTAL								
2-16	PUMPING STATION	MGD	50	$60,000.00	$3,000,000				$3,000,000
	SUBTOTAL								**$14,847,341**
	Contractor OH&P @ 15%								**$2,227,101**
	Subtotal								**$17,074,442**
	Planning Level Contingency @ 30%								**$5,122,333**
	Subtotal								**$22,196,775**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$3,329,516**
	Engineering Fees Including CM @ 20%								**$4,439,355**
	Subtotal								**$7,768,871**
	Project Total								**$29,965,646**

APPENDIX I

Operation & Maintenance Costs
for Flow Augmentation – No Aeration
(In Combination with Supplemental Aeration)

TABLE I.1
ANNUAL O&M COSTS FOR BUBBLY CREEK 50 MGD P.S.

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	372.22	24	8933.3	$670.00	$244,550	19.42	$4,749,161
SUBTOTAL					$244,550		$4,749,161

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
LABOR - OPERATOR	1	8	8	$90.00	$262,800	19.42	$5,103,576
ELECTRICIAN	0	0	0	$159.50	$0	19.42	$0
SUBTOTAL					$262,800		$5,103,576

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	30,000	5%			$1,500	19.42	$29,130
SUBTOTAL					$1,500		$29,130

TOTAL ANNUAL O&M $508,850

TOTAL PRESENT WORTH O & M COST $9,881,867