CTE | AECOM

Evaluation of Cost and Benefits of CSO Treatment and Supplemental Aeration to Improve Water Quality in the Chicago Area Waterways

Metropolitan Water Reclamation District
of Greater Chicago
Research and Development Department
2006 Seminar Series

July 28, 2006

AECOM

Outline of Presentation

CSO Treatment

- Purpose of Initiating Study
- Objective of Study
- CSO's in Study Area
- Water Quality Standards
- End-of-Pipe Treatment Objectives
- Long List of Technologies
- Practicable Treatment Technologies
- Summary of Cost Estimation Procedure
- Layout of Typical CSO Treatment Facility
- Estimation of CSO Flows
- Study Area Land Availability
- Opinion of Probable Costs

Purpose For Initiating Study

– Use Attainability Analysis (UAA)

- Through UAA, IEPA is Reviewing Existing Use Classifications for Chicago Area Waterways (CAWs)
- Reclassifications Driven by Current and Potential Future Usage of CAWs
- District is a Stakeholder in UAA Process
- District Agreed to Perform Study of the Technologies and Cost of End-of-Pipe CSO Treatment on Designated Portions of CAWs

Objectives of Study

Determine the technologies, siting impacts and costs for end-of-pipe treatment of CSOs in the:

- Upper North Shore Channel
- Lower North Shore Channel
- North Branch of Chicago River (below confluence with North Shore Channel)
- Chicago River
- South Branch of Chicago River

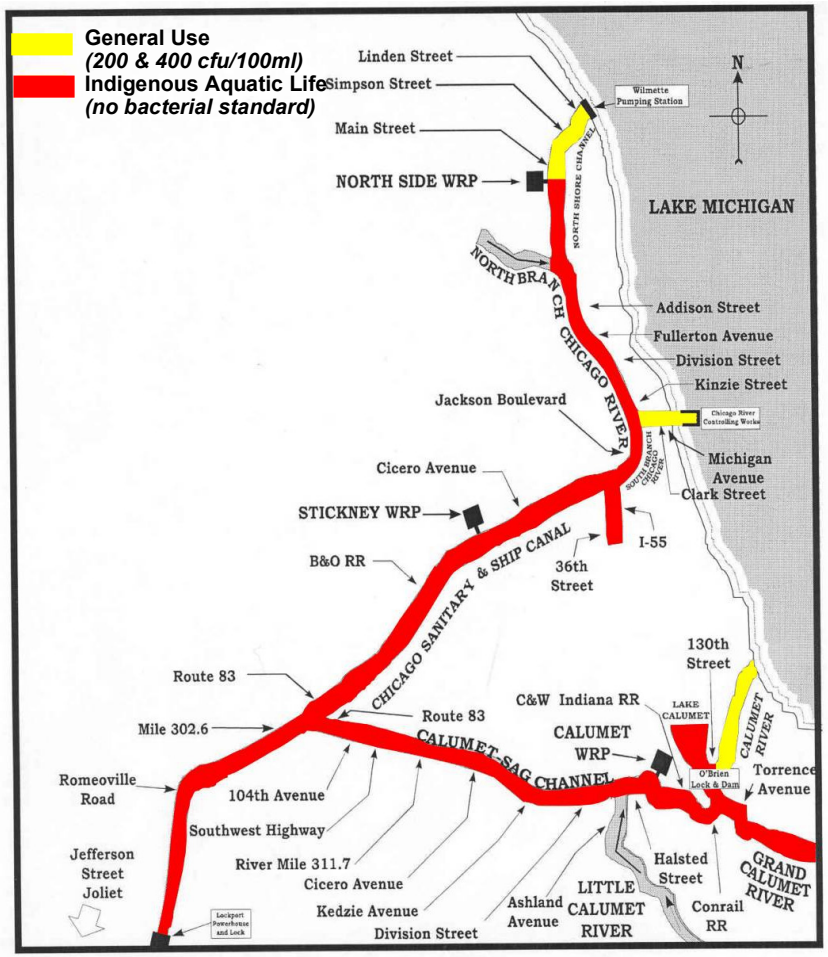
Combined Sewer Overflows in Study Area

AECOM

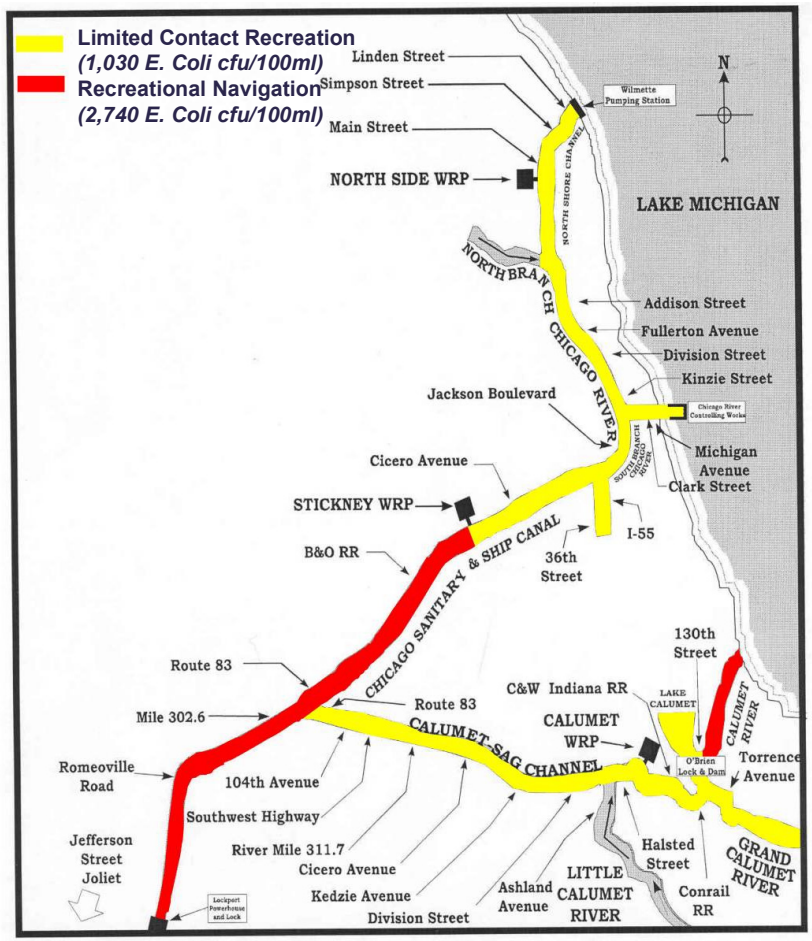
Summary of CSO Locations in Study Area

Water Way	Total Number of CSOs
UNSC	25
LNSC	20
NBCR	59
CR	18
SBCR	48
Total	170

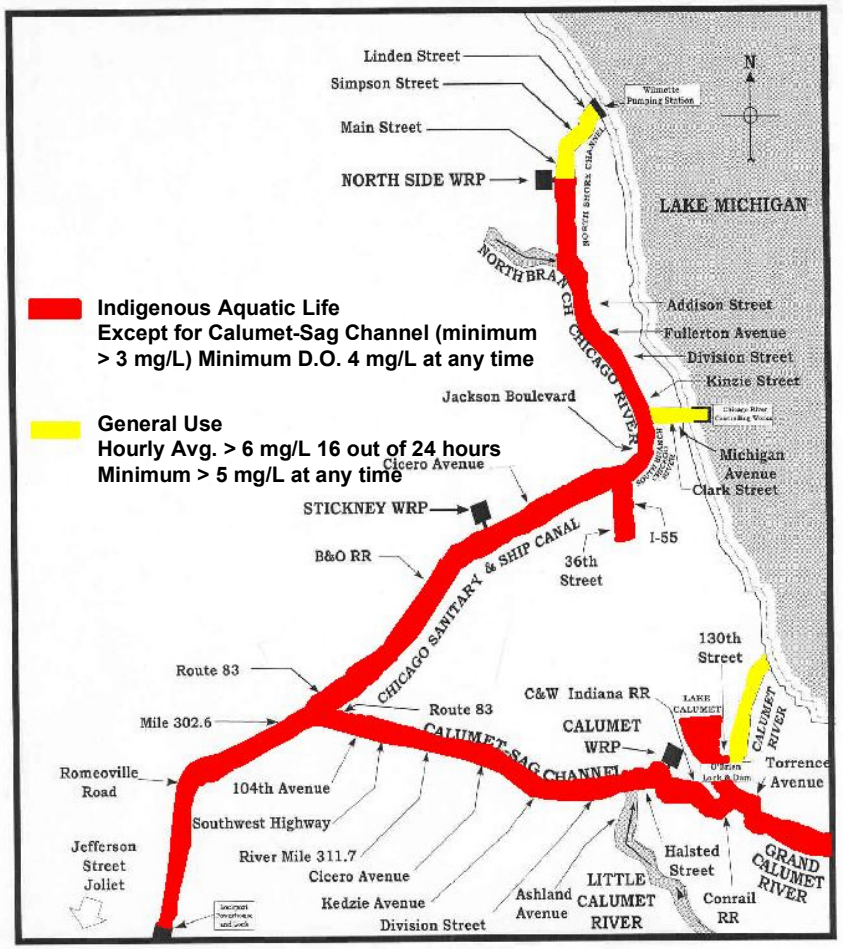
Water Quality Standards



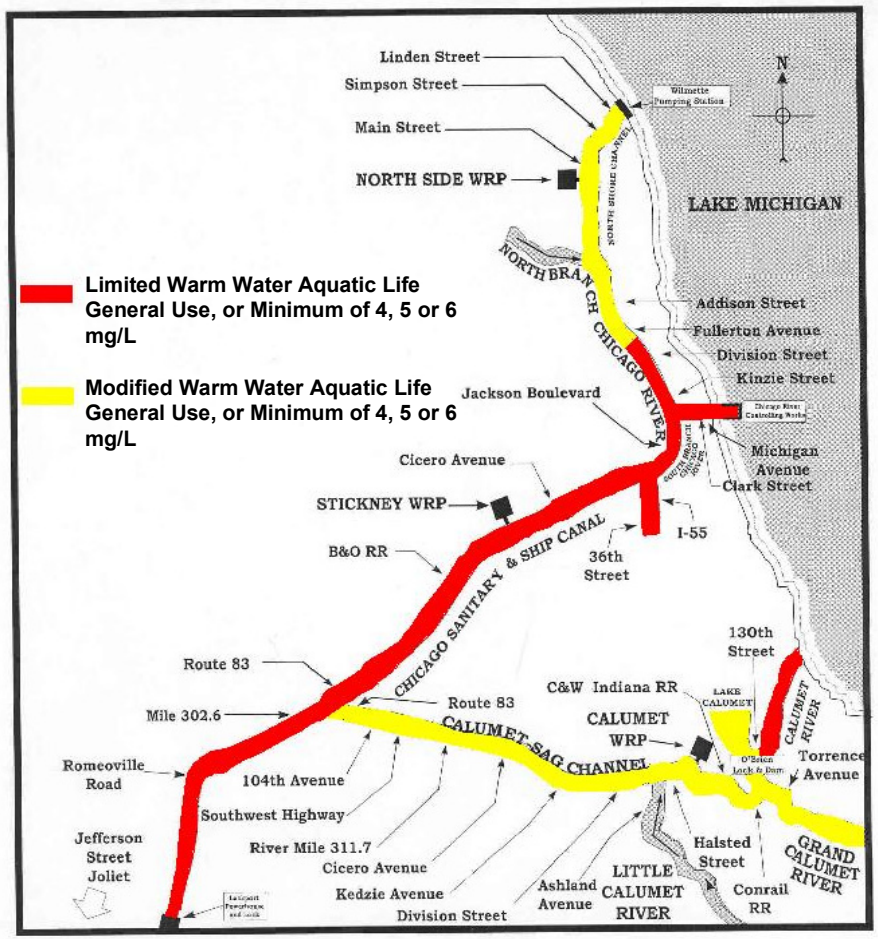
Current Bacterial Standards for Chicago Waterway System



Proposed Bacterial Standards for Chicago Waterway System



Current Chicago Waterway System Dissolved Oxygen Standards



Proposed Chicago Waterway System Dissolved Oxygen Standards

End of Pipe CSO Treatment Objectives

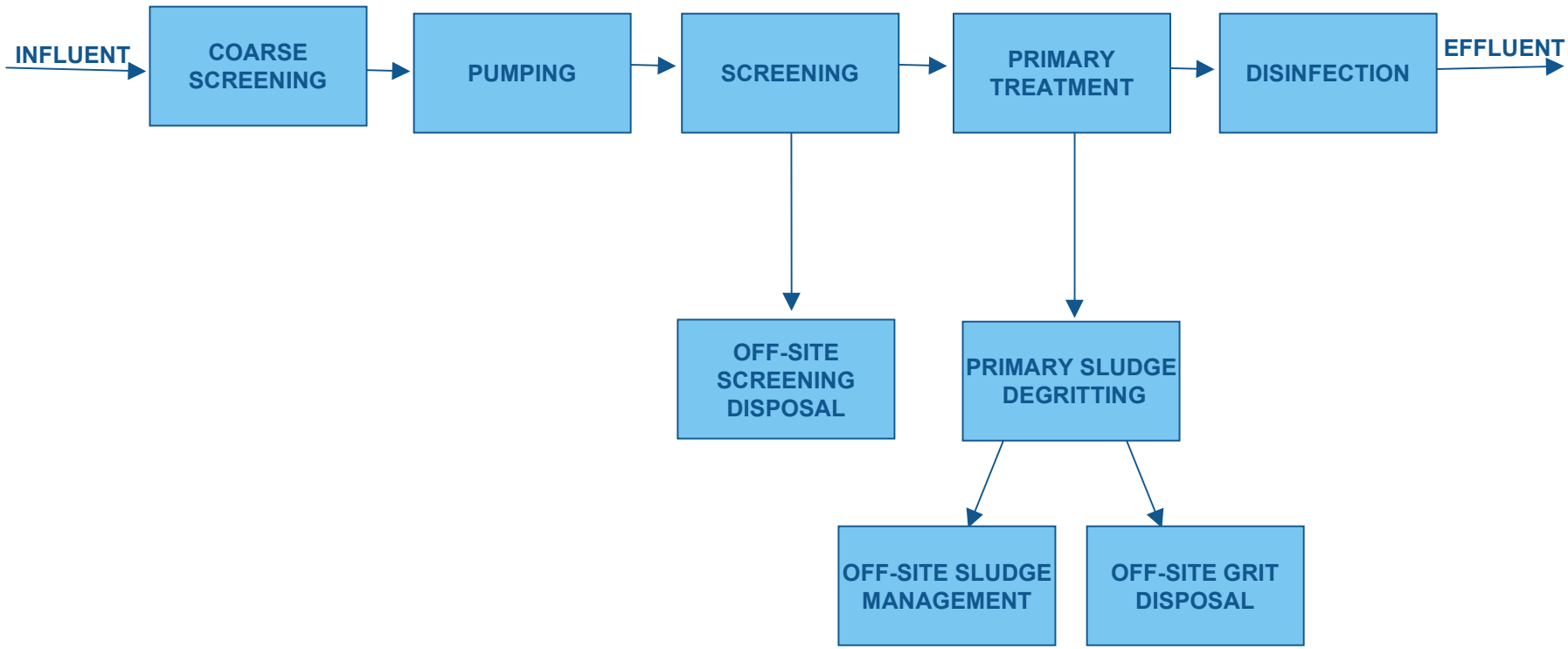
End-of-Pipe Treatment Objectives

– District Scope-of-Work
- Primary treatment plus disinfection

– CSO Treatment Assumptions
- Screening to remove floatables and large solids
- $CBOD_5$ Removal of 30%
- TSS removal of 50%
- Disinfection effluent target of 1,030 E.coli/100ml (limited contact recreation)

AECOM

Typical CSO Treatment Train



Long List of CSO Treatment Technologies

– Fine Screens

- Chain Driven Vertical Bars
- Climber Type Vertical Bars
- Catenary Screens
- Horizontal Overflow Screens
- Horizontal Brush Overflow Screens
- Rotary Drum Screens
- Net Bags

AECOM

Long List of CSO Treatment Technologies

– Primary Treatment

- Rectangular Primary Tanks
- Circular Primary Tanks
- Swirl and Vortex Concentrators
- Ballasted Flocculation
- Microscreens

Long List of CSO Treatment Technologies

– Effluent Disinfection Study has Yielded the Following Short List:

- Ultraviolet Disinfection
  - ✓ High Intensity
- Ozonation
  - ✓ Oxygen

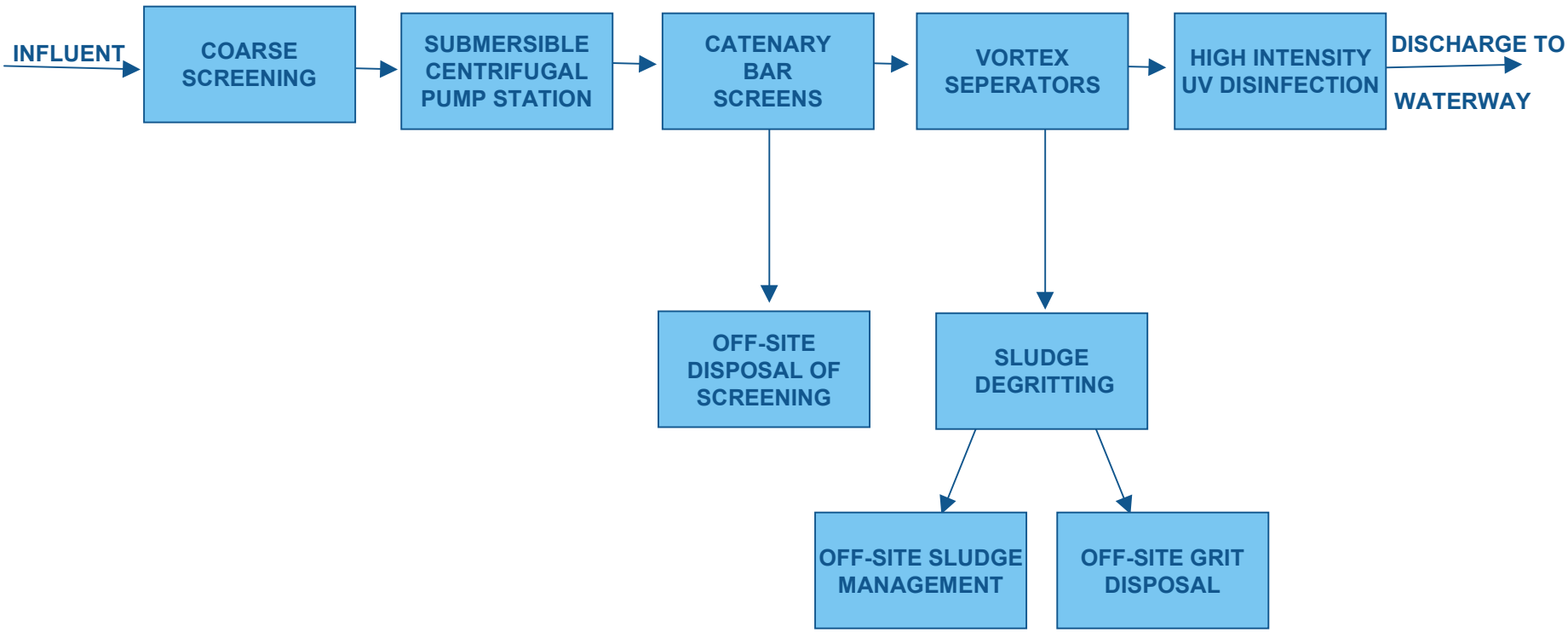
AECOM

Disinfection Alternative Evaluation

– High Intensity UV Disinfection was Selected for Cost Estimation Purposes:

- Over 100 End-of-Pipe CSO Treatment Plants in Study Area
- Less Complex Mechanical Equipment
- No On-site Storage of Oxygen
- Ease of Start-up

CSO Treatment Process Train for Cost Estimation Purposes



Cost Estimation Procedure

General Cost Estimation Issues

- Program Cost Estimate
  - Study Level
  - ± 30%
- CSO Flow Information Needed to:
  - Size Treatment Units
  - Determine Treatment Process Footprint
- Use Attainability Analysis Requires:
  - CSO Treatment Program Cost Estimate
  - Water Quality Impacts
- Water Quality Impacts to be Determined by Marquette Model

General Cost Estimation Issues

- Marquette Model Can Determine Water Quality Impacts for:
  - Various CSO Flows
  - Various CSO BOD Removals
  - Various CSO Effluent Disinfection Targets
- Cost Estimate Flows Tied to Marquette Model CSO Flows
- Screenings Disposal
  - Assume Off-site Disposal Using Private Contractor for Landfill Disposal
- Grit Disposal
  - After Primary Sludge Degritting, Resulting Grit is Disposed in a Landfill by Private Contractor
- Sludge Management
  - Degritted Sludge Management by MWRDGC: Convey Sludge to North Side WRP After Storm Ends via Dry Weather Interceptor
- North Branch and Racine Avenue Pump Stations were not included

General Cost Estimation Procedure

- Use Marquette Model to Determine CSO Flows for Five Study Area Waterway Segments (for specific rainfall intensity and duration)
  - Upper NSC
  - Lower NSC
  - NBCR
  - Chicago River
  - SBCR
- Determine Flows for CSOs on Waterway Segment (total segment flow ÷ # of CSOs)
- Develop Space Requirements for Primary Treatment Plus Disinfection Treatment Train to Treat CSO Flows.
- Using Aerial Photos for CSOs on Waterway Segment Categorize all Sites:
  - Space Requirements < Site = Full Primary Treatment
  - Space Requirements > Site = No Treatment
- Determine Land Availability for CSO Treatment on Each Segment
  - Consider possibility of extrapolating land availability for waterway segments with similar land characteristics
- Determine Costs for CSO Treatment Facilities at Sites With Sufficient Land Space for Full Treatment

Summary of CSO Flow Estimation Procedure

AECOM

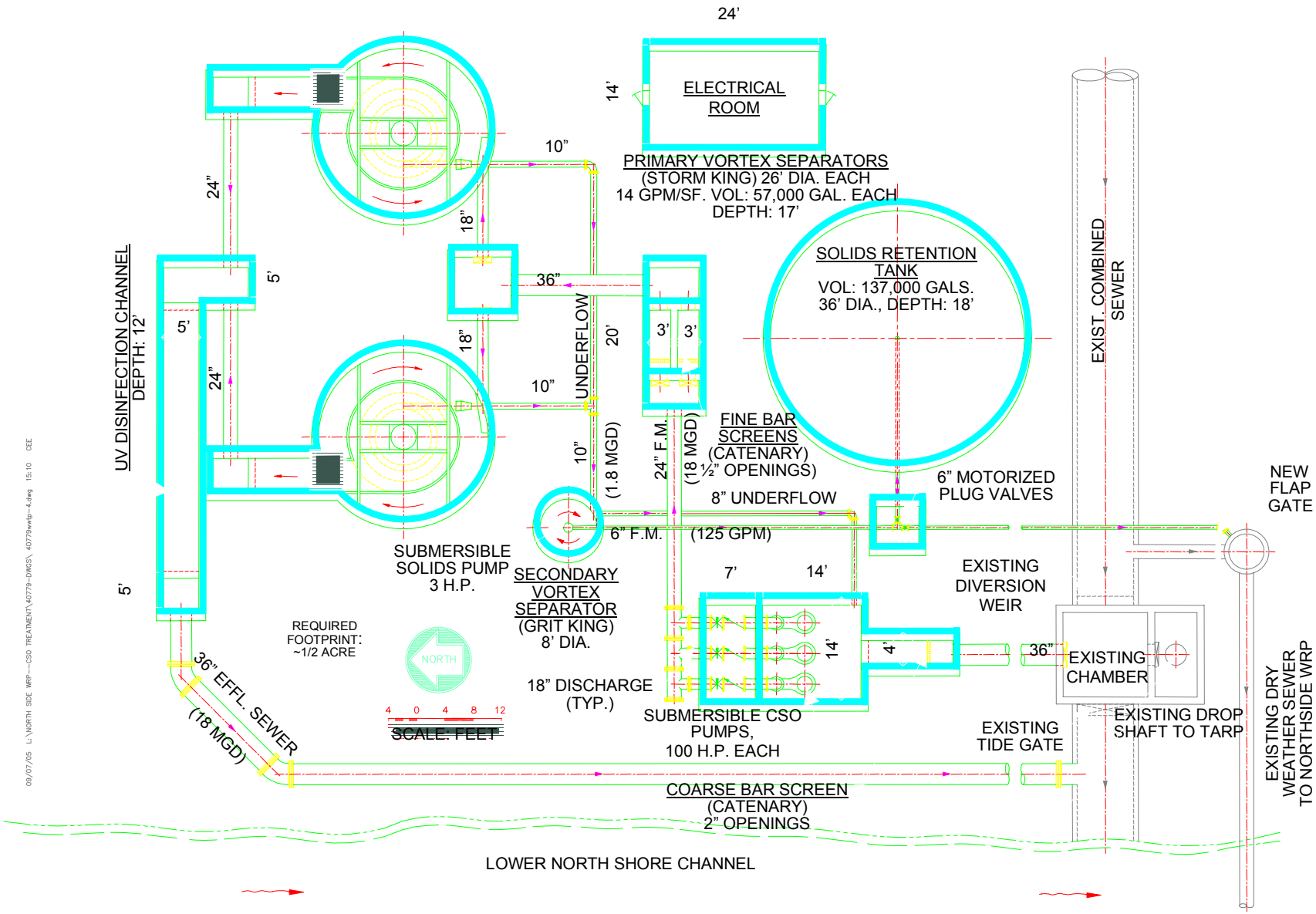
Treated Flow Using 2.80? Storm for Design Flow Capacity

Waterway Segment	Total Overflow Volume (MG)	Treated Overflow Volume
Upper NSC	1,178	1,113
Lower NSC	766	718
NBCR	1,904	1,784
Chicago River	112	105
SBCR	815	764
	4,784	4,483

94% of CSO Flow is treated if CSO treatment plant capacity is based upon design storm of 2.80?

Summary of CSO Treatment Capacities per Site & per CAWS			
CAWS	Recommended Design Flow for CSO Treatment	CSO Treatment Sites per CAWS	Recommended CSO Treatment Capacity Per Site
Upper NSC	520 Mgd	25 Sites	520 / 25 + 5% = 22 Mgd
Lower NSC	340 Mgd	20 Sites	340 / 20 + 5% = 18 Mgd
NBCR	850 Mgd	59 Sites	850 / 59 + 5% = 15 Mgd
Chicago River	49 Mgd	18 Sites	49 / 18 + 5% = 3 Mgd
SBCR	359 Mgd	48 Sites	359 / 48 + 5% = 8 Mgd

Layout of Typ. LNSC CSO Treatment Facility (18 mgd)



Study Area Land Availability for CSO Treatment

SUMMARY OF LAND AVAILABILITY STUDY			
Waterway Segment	**No. of CSO Treatment Plants/Total CSO's**	**Total Acreage Required**	**Total CSO Treatment Flow Capacity (MGD)**
Upper NSC	25/25	15	546
Lower NSC	20/20	10	360
North Branch	33/59	15	495
Chicago River	0/18	0	0
South Branch	27/48	8	216
Total	105/170	48	1607

Opinion of Probable Costs

End-of-Pipe CSO Treatment (105 Sites) Cost Summary

River Segment	Total Capital Costs, $ (million)	Total Annual O&M Costs ($)	Total Present Worth-O&M, $ (million)	Total Present Worth, $, Capital + O&M (million)
Upper NSC	$297.7	$1,009,000	$19.6	$317.3
Lower NSC	$194.5	$746,000	$14.5	$209.0
NBCR	$280.9	$1,164,000	$22.6	$303.5
Chicago River	$0	$0	$0	$0
SBCR	$119.4	$813,000	$15.8	$135.2
Total	**$892.5**	**$3,732,000**	**$72.5**	**$965.0**

Schedule Issues

- End-of-Pipe CSO Treatment is an “Interim” Measure
- Potential Implementation Schedule
  - Preliminary Design 2-3 years
    - Detailed Hydraulic Analysis
    - Detailed Site Surveys
  - Final Design 1-3 year
  - Construction 3-5 years

  Total 6-11 years (2012-2017)

  McCook Reservoirs scheduled to be Done by 2015
- Implementation Issues
  - Land Acquisition
  - Brownfield Problems
  - Public Acceptance

Outline of Presentation

Supplemental Aeration of the North and South Branches of the Chicago River

- Objective of Study
- Panel of Experts
- Purpose of Initiating Study
- Assumptions in Study
- Water Quality Standards
- Dissolved Oxygen Target for Study
- Short Listed Technologies
- Size and Location of Supplemental Aeration Stations
- % Compliance with Water Quality Target
- Costs for Supplemental Aeration of SBCR & NBCR

AECOM

Objectives of Study

To Determine the Supplemental Aeration Technology(ies) and Costs to Achieve Future Regulatory Dissolved Oxygen Levels for:

- North Branch of Chicago River (Downstream of Confluence with the North Shore Channel)
- South Branch of Chicago River

AECOM

Panel of Experts

- Dr. Marcello Garcia
  - Professor at University of Illinois
  - Intimate Knowledge of Chicago Area Waterway System
  - Leader in field of River Mechanics
- Dr. Mark Laquidara, P.E.
  - M&E Vice President
  - M&E Practice Leader
  - 25 Years Experience
- Dr. Dominique Brocard, P.E.
  - M&E Vice President
  - 30 Years Experience
  - Participated in Water Quality Assessment for the Charles River, Boston
- Dr. Tom Butts
  - 36 Years Experience With Illinois Waterway Survey
  - Participated in Planning for SEPA Stations

Purpose For Initiating Study

– Use Attainability Analysis (UAA)

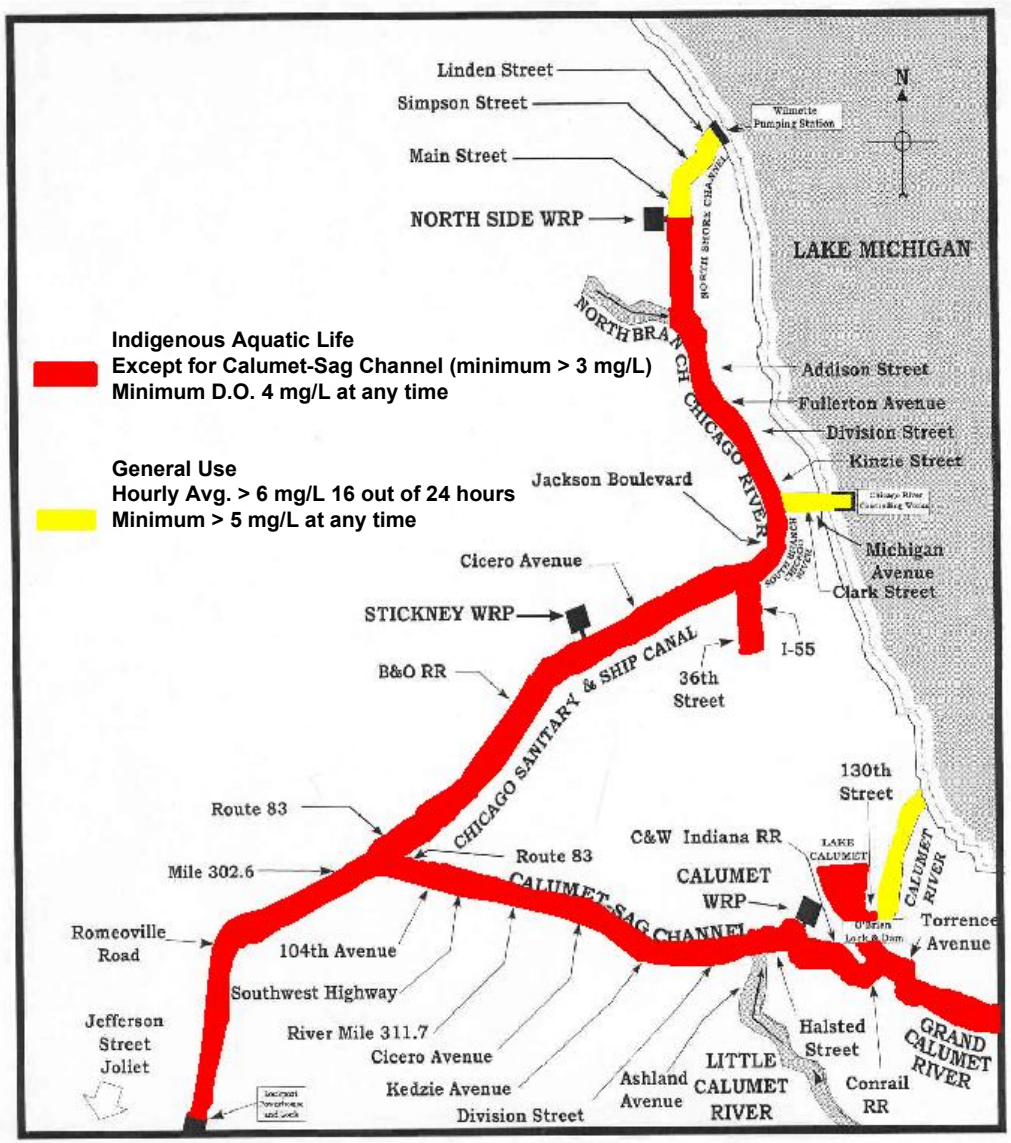
- Through UAA, IEPA is Reviewing Existing Use Classifications for Chicago Area Waterways (CAWs)
- Reclassifications Driven by Current and Potential Future Usage of CAWs
- District is a Stakeholder in UAA Process
- District Agreed to Perform Study of the Technologies and Cost of Supplemental Aeration for NBCR and SBCR

General Assumptions of Study

- TARP Tunnels are Fully Operational
- TARP Reservoirs are not On-line
- Other Technologies (i.e. End-of-Pipe CSO Treatment) are not On-line
- Devon and Webster Avenue in-Stream Aeration Stations are Operational

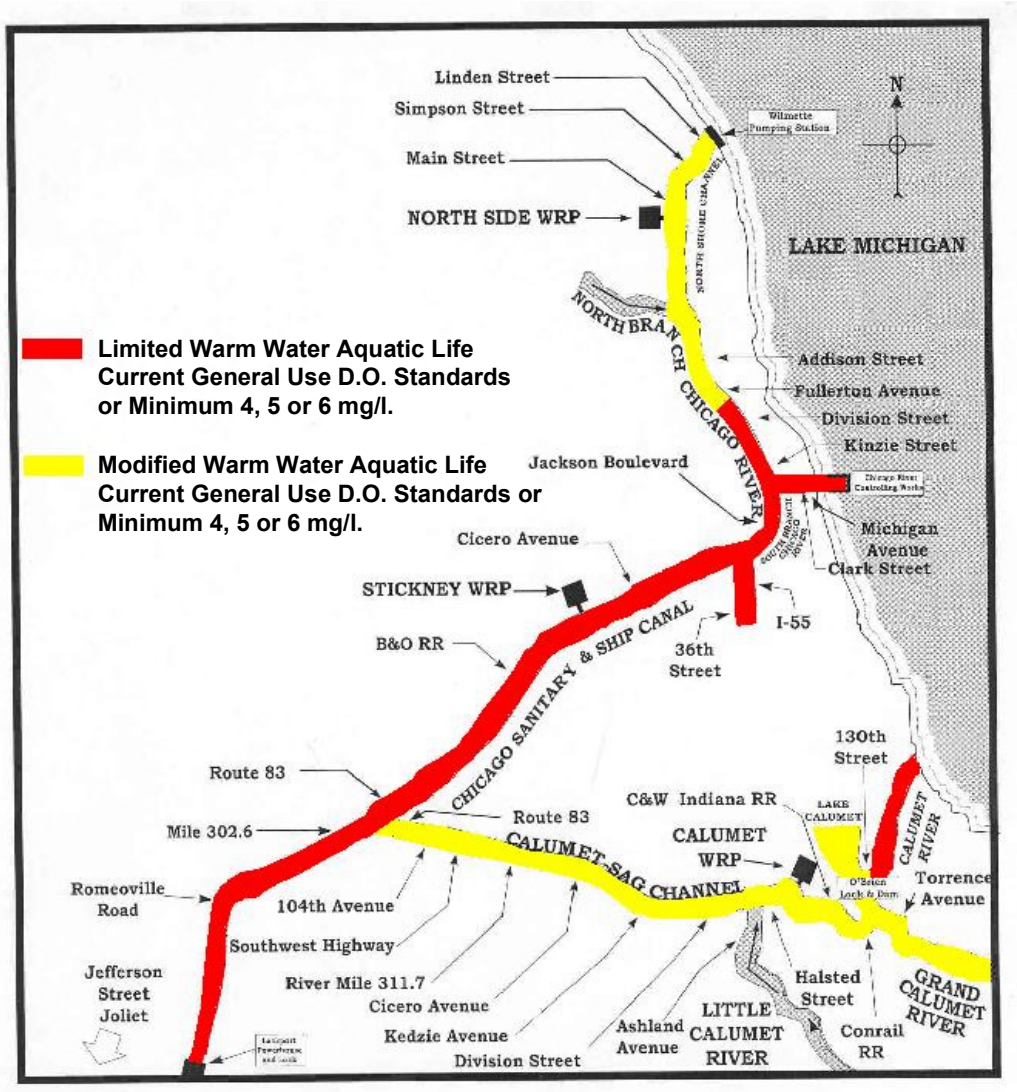
AECOM

Current Chicago Waterway System Dissolved Oxygen Standards



AECOM

Proposed Chicago Area Waterway System Aquatic Life Use Designations and Proposed Dissolved Oxygen Standards



Dissolved Oxygen Target For Study

- 90% Compliance With Minimum Waterway Dissolved Oxygen Concentration of 5mg/l
- % Compliance Determined By:
  - %Hourly D.O. Concentrations > 5mg/l

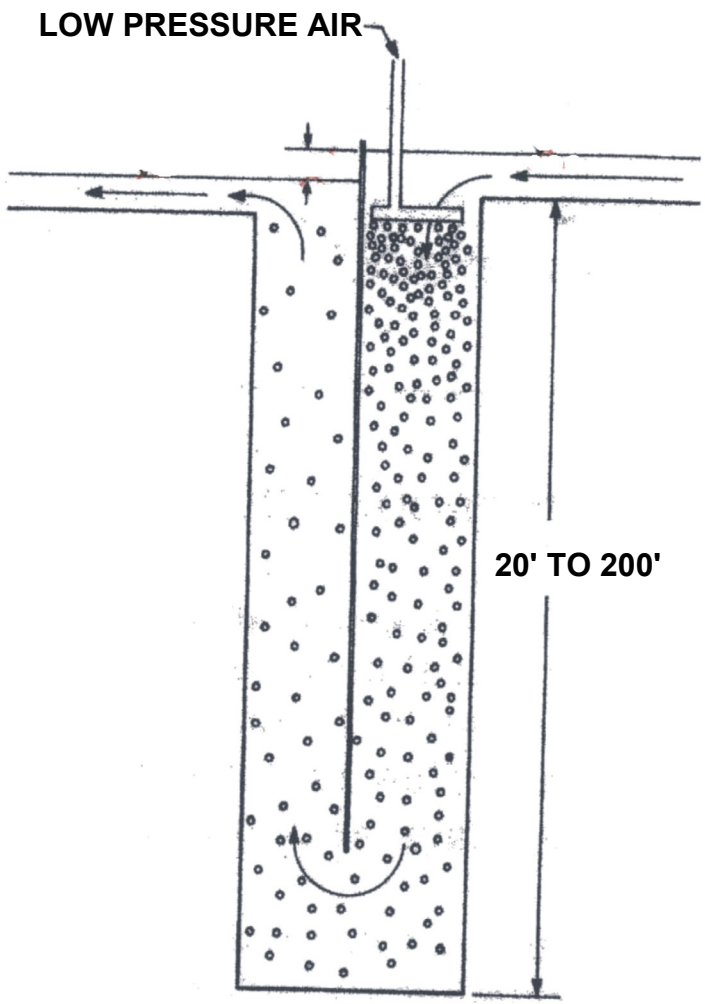
Supplemental Aeration of NBCR and SBCR

Short Listed Supplemental Aeration Technologies

- Compressed Air U-Tubes
- Free Fall Weirs (i.e., existing SEPA Stations)
- Ceramic Diffusers (i.e., existing Devon and Webster Avenue Stations)
- Jet Aeration

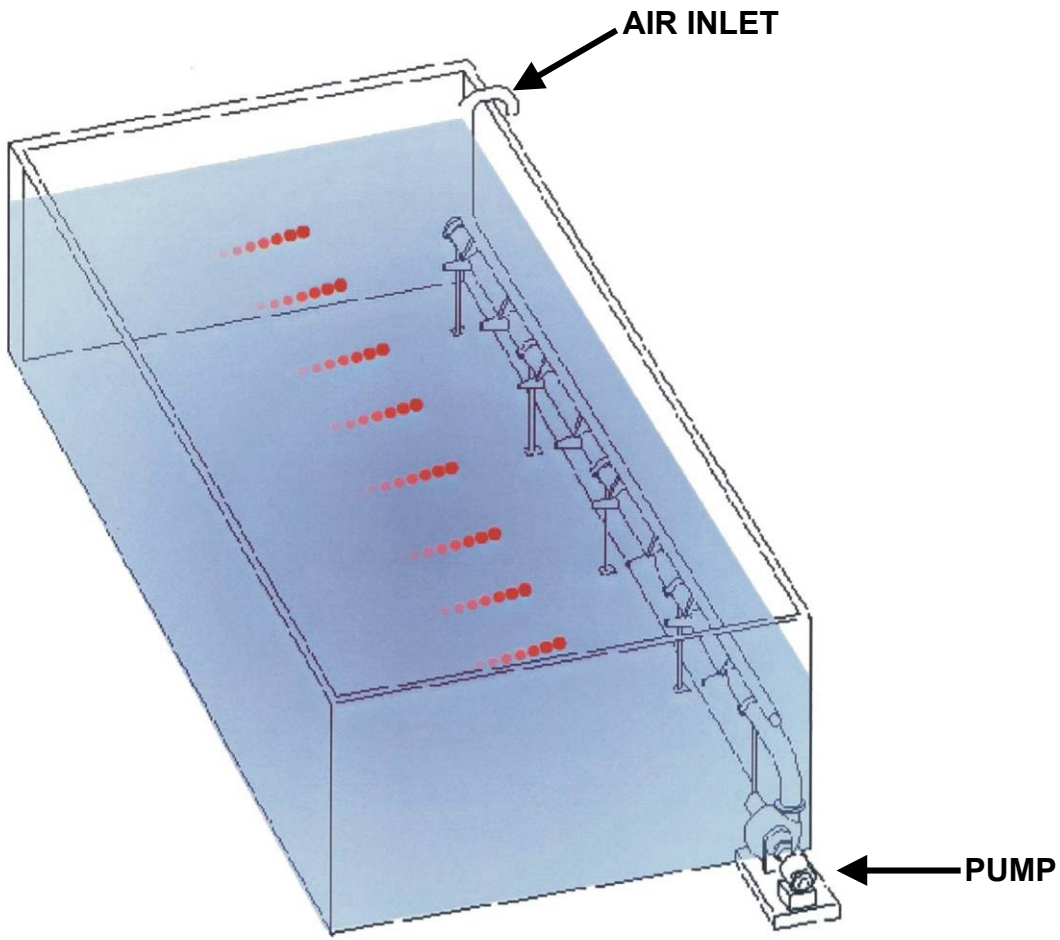
AECOM

Schematic of Compressed Air U-Tube Contactor



AECOM

Schematic of Jet Aeration System

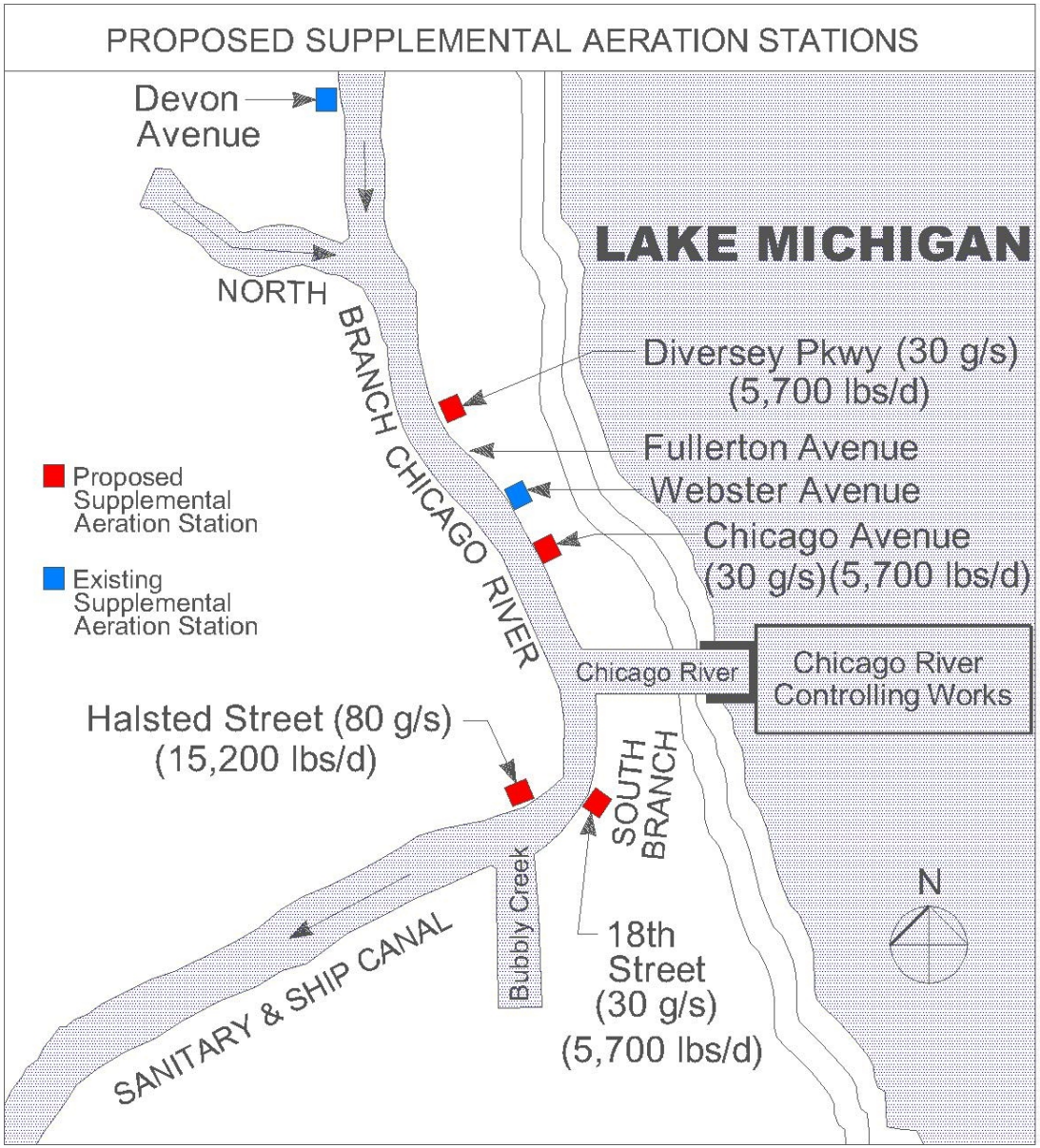


Supplemental Aeration Marquette Model Runs

Marquette Model Runs

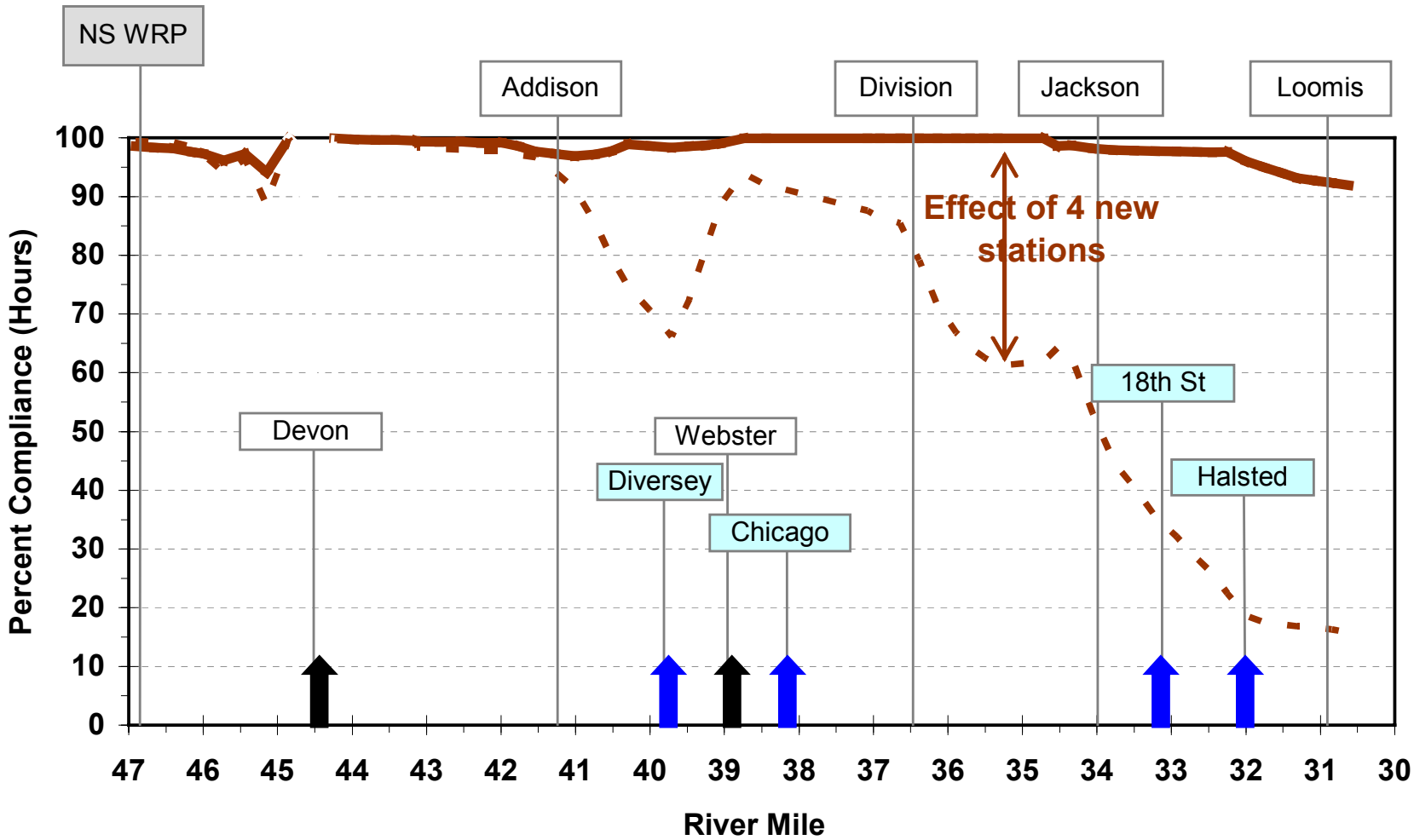
– With Operation of existing Devon and Webster In-Stream Aeration Stations and Target of 90% Compliance with Minimum D.O. of 5 mg/l; 4 New Aeration Stations:

Waterway	Location	Aeration Capacity
NBCR	Diversey	30 g/s (5,700 lbs/day)
NBCR	Chicago	30 g/s (5,700 lbs/day)
SBCR	18th Street	30 g/s (5,700 lbs/day)
SBCR	Halsted	80 g/s (15,200 lbs/day)


PROPOSED SUPPLEMENTAL AERATION STATIONS
Devon Avenue
NORTH BRANCH CHICAGO RIVER
LAKE MICHIGAN
Diversey Pkwy (30 g/s) (5,700 lbs/d)
Fullerton Avenue
Webster Avenue
Chicago Avenue (30 g/s)(5,700 lbs/d)
Proposed Supplemental Aeration Station
Existing Supplemental Aeration Station
Chicago River
Chicago River Controlling Works
Halsted Street (80 g/s) (15,200 lbs/d)
SOUTH BRANCH
Bubbly Creek
SANITARY & SHIP CANAL
18th Street (30 g/s) (5,700 lbs/d)
N

AECOM

Supplemental Aeration of North and South Branches of Chicago River, Percent of Hours Complying with 5 mg/l Criterion, All Time Periods



AECOM

Opinion of Probable Costs

- Capital Cost
  - $28.9 Million - $59.1 Million
- Annual O&M Costs
  - $449,000 - $2,419,000
- Total Present Worth
  - $38.7 Million to $116.3 Million

Cost of Four Supplemental Aeration Stations on NBCR and SBCR			
	Total Capital	Annual O&M	Total Present Worth
U-Tubes	$29,764,000	$449,000	$38,744,000
SEPA	$59,134,000	$2,859,000	$116,320,000
Ceramic Diffusers	$28,937,000	$1,020,000	$49,342,000
Jet Aeration	$51,145,000	$2,419,000	$99,527,000

Questions & Answers