

**US Army Corps
of Engineers®
Chicago District**

**LAKE MICHIGAN
DIVERSION ACCOUNTING
WATER YEAR 1997
ANNUAL REPORT**



EXECUTIVE SUMMARY

This document is the Water Year (WY) 1997 Annual Report of the Chicago District, U. S. Army Corps of Engineers activities in the monitoring and review of the accounting of Lake Michigan diversion flows through Chicago, Illinois as directed by 1980 amendment to the U. S. Supreme Court Decree. Additionally, this report serves to summarize the Corps' major accomplishments with respect to the mission as mandated by the Water Resources Development Act of 1986, PL99-662, Section 1142. This act gave the Corps complete responsibility for diversion accounting effective 1 October 1987. This report provides an overview and audit of flow measurements and accounting computed by the Corps of Engineers for WY 1996, 1 October 1995 through 30 September 1996.

The Lake Michigan Diversion Accounting Report for WY 1996 has been completed. The State of Illinois diverted 3,108 cfs during WY 1996. This diversion is 92 cfs less than the 3,200 cfs 40 year average diversion specified in the modified decree. The running average of the diversion for WY 1981 through WY 1996 is 3,418 cfs, or 218 cfs over the annual allocation. Also, the annual average diversion has exceeded the 3,680 cfs annual limit three times, once more than the maximum number of times allowed in the decree. Additionally, the absolute annual maximum of 3,840 cfs has been exceeded during the WY93 accounting period. The cumulative deviation is now -3,493 cfs-years. The negative sign indicates a cumulative flow deficit. The maximum allowable cumulative flow deficit specified in the decree is 2,000 cfs-years.

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INTRODUCTION

The diversion of water from the Lake Michigan watershed is important to the Great Lake states and to the Canadian province of Ontario. The states and province that border the Great Lakes have concerns with diversions during periods of low lake levels and the long term effects of diversion. To insure these concerns are considered, the U.S. Army Corps of Engineers is responsible for the accounting of flow diverted from the Lake Michigan watershed.

The Water Year (WY) 1997 Annual Report on Lake Michigan Diversion Accounting presents activities by the Corps of Engineers in accounting for the diversion from Lake Michigan by the State of Illinois. The accounting of the diversion is performed according to the guidelines established in the 1980 modified U.S. Supreme Court Decree concerning the diversion.

Presented in this report is the history of the diversion and its accounting, the certification of WY 1996 diversion flows, a description of the sources of the diversion, a description of the accounting procedures, and a summary of all significant activities that occurred during WY 1997.

AUTHORITY FOR REPORT

Under the provisions of the U.S. Supreme Court Decree in the Wisconsin, et al v. Illinois et al, 388 U.S. 426, 87 S.Ct. 1774 (1967) as modified by 449 U.S. 48, 101 S. CT. 557 (1980), the Corps of Engineers monitors the measurement and computation Lake Michigan diversion by the State of Illinois. The terms of the modified decree require the Corps of Engineers to prepare an annual report on the accounting of the Lake Michigan water diverted by the State of Illinois and actions taken by the involved agencies.

HISTORY OF THE DIVERSION

Water has been diverted from Lake Michigan at Chicago into the Mississippi River Watershed since the completion of the Illinois and Michigan (I & M) Canal in 1848. At that time, the diversion averaged about 500 cubic feet per second (cfs). The I & M Canal was built primarily to serve transportation needs by providing a connecting watercourse between the Great Lakes and the Mississippi River system.

With the development of the Chicago metropolitan area, sewer and drainage improvements led to severe sanitation problems in the mid to late 1800's. The newly constructed sewers moved water and wastes into the Chicago River, which until 1900 drained to Lake Michigan. The water quality of Lake Michigan deteriorated and contaminated the city's primary water supply.

A second problem that occurred during this time period was an increase in the overbank flooding within the city. As more roads were built and buildings constructed, the sewer system was correspondingly expanded. The increase in impervious area from the newly constructed roads and buildings increased the rate and volume of stormwater runoff and resulted in increased flooding.

As a solution to the sanitation and flooding problems, construction of the Chicago Sanitary and Ship Canal (CSSC) was undertaken. Construction of the CSSC allowed the flow direction of the Chicago River to be reversed (Figure 1). Construction of the Chicago Sanitary and Ship Canal was completed in 1900 by the MWRDGC. The CSSC followed the course of the older I & M Canal. The CSSC is much larger than the I & M canal and can handle the Chicago River flow, as well as increased shipping. In the 1930's, the Chicago River Controlling Works (CRCW) was constructed at the mouth of the Chicago River. The CRCW regulates the amount of Lake Michigan water allowed to pass into the river and restricts river flooding from entering Lake Michigan. The Lockport Lock and Dam controls the water level in the CSSC.

Between 1907 and 1910, the MWRDGC constructed a second canal called the North Shore Channel. It extended from Lake Michigan at Wilmette in a southerly direction 6.14 miles to the north branch of the Chicago River. The Wilmette Pumping Station, also known as the Wilmette Controlling Works, regulates the amount of Lake Michigan flow allowed down the channel through the use of one vertical lift gate.

Construction of a third canal, the Calumet Sag Channel, was completed in 1922. The canal connects Lake Michigan through the Grand Calumet River, to the CSSC. The Calumet Sag Channel was constructed to carry sewage from South Chicago, Illinois and East Chicago, Indiana. The Blue Island Lock and Dam controlled flow through the canal. The O'Brien Lock and Dam, which replaced the Blue Island Lock and Dam, was completed in 1967 and is located on the Calumet River. The O'Brien Lock and Dam regulates the flow of Lake Michigan waters down the Calumet Sag Channel. Figure 2 shows the affected watershed.

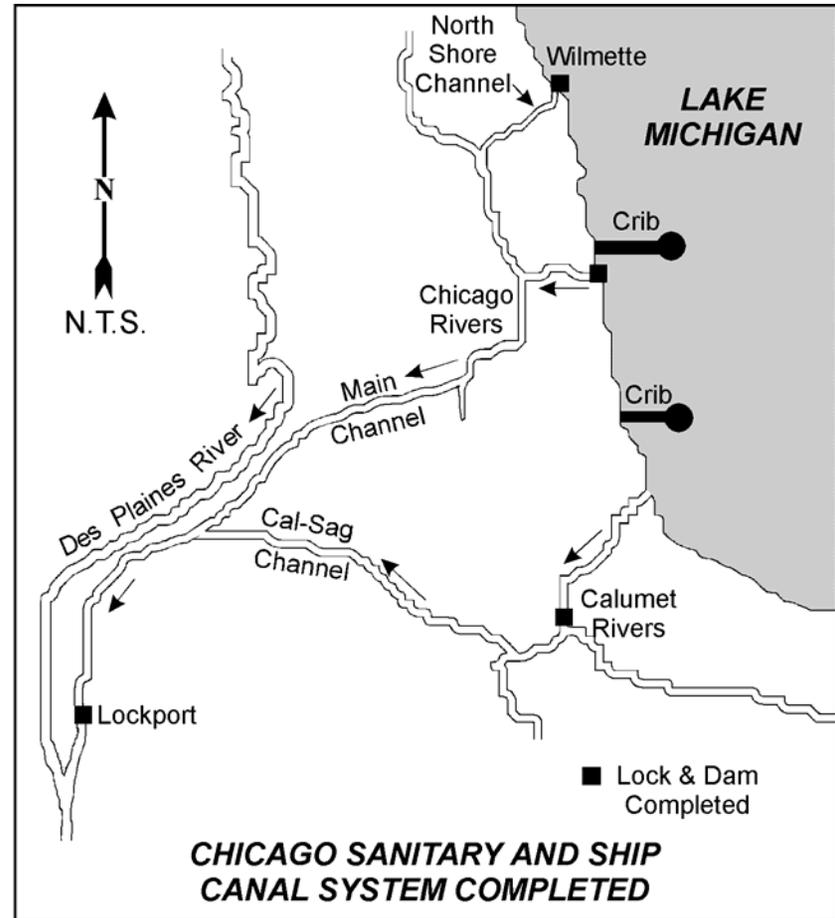
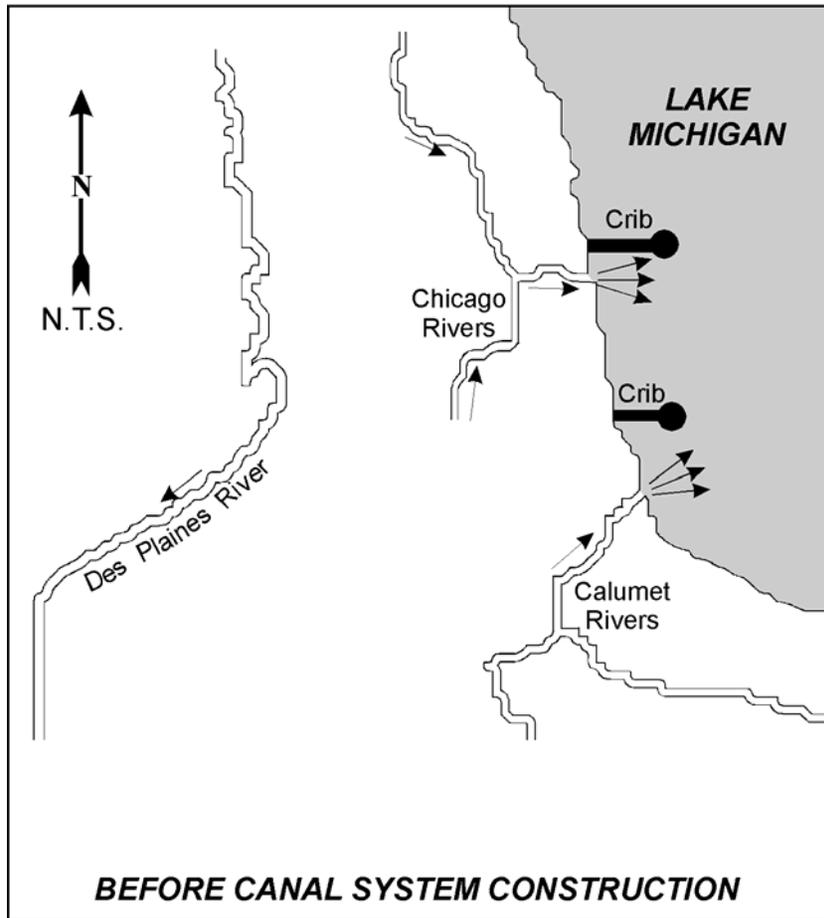


FIGURE 1 DEVELOPMENT OF THE CHICAGO SANITARY AND SHIP CANAL SYSTEM

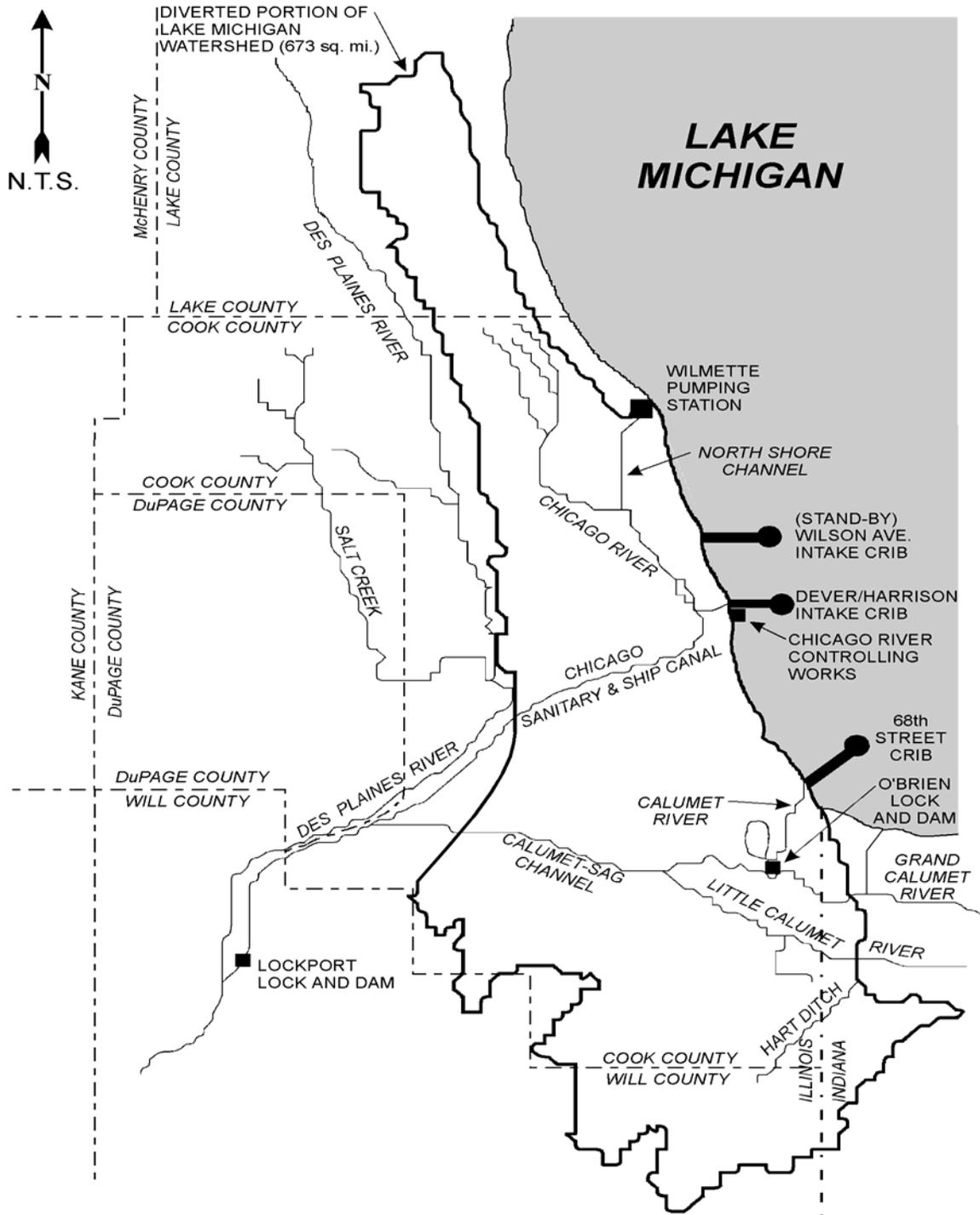


FIGURE 2 LOCATION PLAN - LAKE MICHIGAN DIVERSION AT CHICAGO

SIGNIFICANT HYDROLOGIC EVENTS

During WY 1997, a total of 31.01 inches of precipitation fell at the National Weather Service (NWS) O'Hare Weather Station. This recorded precipitation for WY 1997 is 13% less than the long term (1951-1990) average of 35.82 inches. The recorded monthly rainfall data during WY 1997, and the deviation from long term annual and monthly average precipitation, are tabulated in Table 1.

TABLE 1 WY 1997 MONTHLY AND ANNUAL PRECIPITATION (INCHES)
National Weather Service, O'Hare Weather Station

<u>Month</u>	<u>1951 - 1990 Average</u>			<u>Percent of Average</u>
	<u>Precipitation</u>	<u>Precipitation</u>	<u>Deviation</u>	
Oct-96	2.32	2.41	-0.09	96%
Nov-96	1.48	2.92	-1.44	51%
Dec-96	1.21	2.47	-1.26	49%
Jan-97	1.38	1.53	-0.15	90%
Feb-97	5.56	1.36	4.20	409%
Mar-97	1.57	2.69	-1.12	58%
Apr-97	1.76	3.64	-1.88	48%
May-97	2.69	3.32	-0.63	81%
Jun-97	3.81	3.78	0.03	101%
Jul-97	3.04	3.66	-0.62	83%
Aug-97	4.50	4.22	0.28	107%
Sep-97	1.69	3.82	-2.13	44%
Annual	31.01	35.82	-4.81	87%

STATUS OF ACCOUNTING REPORTS

Lake Michigan diversion flow data is summarized in accounting reports prepared on an annual basis as flows are certified. Since implementation of the modified Supreme Court Decree of 1 December 1980 and before this report, the Corps of Engineers has certified diversion flows for WY 1981 through WY 1995. The WY 1996 Lake Michigan Diversion Accounting Report is certified and included as appendix A of this Water Year 1997 Annual Report. The State of Illinois diverted 3,108 cfs during WY 1996. This diversion is 92 cfs less than the 3,200 cfs 40 year average diversion specified in the 1980 modified decree. Table 2 shows the accounting year, the certified flows, the running average flows, and the cumulative deviation from the allowable diversion of 3,200 cfs.

The running average diversion for the period WY 1981 through WY 1996 is 3,418 cfs, 218 cfs greater than the 3,200 cfs 40 year average diversion specified by the

modified decree. Also, the annual average diversion has exceeded the 3,680 cfs annual limit three times, once more than the maximum number of times allowed in the decree. Additionally, the absolute annual maximum of 3,840 cfs has been exceeded during the WY93 accounting period. The cumulative deviation, the sum of the differences between the annual average flows and 3,200 cfs, is -3,493 cfs-years. The negative cumulative deviation indicates a cumulative flow deficit. The decree specifies a maximum allowable deficit of 2,000 cfs- years over the first 39 years of the 40 year averaging period.

Data collection and preparation, diversion computation, and report writing for the WY 1996 accounting report was performed by the Corps. Data collection and preparation for this report began in Fiscal Year (FY) 1997. Certification of the WY 1997 accounting report is scheduled for FY 2000.

TABLE 2 STATUS OF THE STATE OF ILLINOIS DIVERSION
Under the 1980 modified U.S. Supreme Court Decree

<u>Accounting Year</u>	<u>Certified Flow (cfs)</u>	<u>Running Average (cfs)</u>	<u>Cumulative Deviation (cfs)</u>
1981	3,106	3,106	94
1982	3,087	3,097	207
1983	3,613	3,269	-206
1984	3,432	3,310	-438
1985	3,472	3,342	-710
1986	3,751	3,410	-1,261
1987	3,774	3,462	-1,835
1988	3,376	3,451	-2,011
1989	3,378	3,443	-2,189
1990	3,531	3,452	-2,520
1991	3,555	3,461	-2,875
1992	3,409	3,457	-3,084
1993	3,841	3,487	-3,725
1994	3,064	3,456	-3,589
1995	3,197	3,439	-3,586
1996	3,108	3,418	-3,493

SOURCES OF DIVERSION

The Lake Michigan diversion consists of three primary components. These components are domestic pumpage from Lake Michigan used for water supply and not returned to Lake Michigan, stormwater runoff from the diverted Lake Michigan watershed, and direct diversions through the three lakefront control structures.

Domestic pumpage from Lake Michigan is used for water supply and its effluent is discharged to the canals by various Water Reclamation Plants (WRP's). Currently,

the WRP's that divert domestic pumpage from the lake either discharge to the canal system or to the Des Plaines River and its tributaries. In the future as more communities convert to Lake Michigan water supply, water supply effluent may also be discharged to the Fox River. The Fox River is approximately 35 miles west of downtown Chicago.

Stormwater runoff that previously drained to Lake Michigan through the Chicago River and the Calumet River now drains to the Chicago Sanitary and Ship Canal (CSSC) and the Calumet Sag Channel, respectively. The Calumet Sag Channel drains to the CSSC, and the CSSC ultimately drains into the Illinois River and the Mississippi River. The drainage area of the diverted Lake Michigan watershed is approximately 673 square miles.

Direct diversion locations are at the Chicago River Controlling Works (CRCW), the O'Brien Lock and Dam, and the Wilmette Controlling Works. These controlling structures are located downtown, at the south end, and at the north end of the Chicago area, respectively.

The direct diversion consists of four components; lockage, discretionary flow, navigation makeup flow, and leakage. The lockage component is the flow used in locking vessels to and from the lake. The purpose of the discretionary diversion is to dilute effluent from sewage discharges. When large storms are forecast, the canal is drawn down before the storm to prevent flooding. If the runoff is not enough to refill the canal, navigation makeup water is passed. The leakage component is water estimated to pass, in an uncontrolled way, through or around the lakefront structures.

ACCOUNTING PROCEDURES

Diversion accounting uses both measured and estimated flows. A series of hydrologic and hydraulic computer models use various meteorological data to simulate flows not measured. These simulated flows as well as measured flows are used to compute the diversion. Along with the diversion calculation, a number of water budgets verify simulated flows and estimate the reliability of the computed diversion.

DIVERSION COMPUTATION

An acoustic velocity meter (AVM) was installed and has been operating at Romeoville (five miles upstream of the Lockport Powerhouse and three miles upstream of the Lockport Controlling Works) since 12 June 1984. The AVM directly measures total flow through the canal above both the Powerhouse and the Controlling Works. The overwhelming majority of the Lake Michigan diversion and some non-Lake Michigan flows pass through the AVM. The diversion accounting procedure uses the flow measured at Romeoville and deducts flows not accountable in the diversion. Diversion flows which bypass Lockport are added to yield the net computed diversion of water from Lake Michigan. This procedure represents the accounting technique as required by the modified Supreme Court Decree.

The flow measured at Romeoville was approximately 102% of the annual diversion during WY 1996. Approximately 92% of the diverted water was measured by the AVM during WY 1996. This portion of the diversion measured at the AVM is being reduced due to the influx of western suburbs using Lake Michigan water as their primary domestic water supply source. Most of these new users of Lake Michigan water do not discharge their sewage effluent to the canal system. As more communities are added, more water will be discharged outside the canal system, further lowering the percentage measured by the AVM.

Deductions from the Romeoville AVM flow include runoff from 217 square miles of the Des Plaines River watershed discharged to the canal, groundwater supply effluent and groundwater seepage into the Tunnel and Reservoir Plan (TARP) tunnels discharged to the canal, and Indiana water supply discharged to the canal through the Calumet River system and the Calumet Sag Channel (see figure 2 for locations). The computer models of the Des Plaines watershed area estimate the runoff deduction. The groundwater pumpage deductions are obtained directly from pumping records. The Indiana water supply is computed from pumping records and a calculation to determine the portion of the water supply draining west to the Calumet Sag Channel.

The additions for diversion flow that do not flow through Romeoville are primarily Lake Michigan water supply pumpage effluent treated and released to the Des Plaines River or its tributaries. This flow is obtained directly through pumping records of the communities involved and accounts for approximately 8% of the diversion in WY 1996. As more communities convert to Lake Michigan water supply, the percentage will increase.

DIVERSION BUDGET CHECKS

Water budgets verify those flows not measured. Most of the budgets compare simulated flows to recorded flows and these comparisons indicate the accuracy of the diversion accounting. The four primary budgets are the budgets for the three major Water Reclamation Plants (WRP's) that serve the area involved in diversion accounting and the canal balance budget for the CSSC. The Upper Des Plaines pump station budget will also become a significant budget after measurement problems are resolved. The remaining budgets estimate runoff from stream gaged areas in the Lake Michigan watershed or are budgets of non-simulated flows such as water supply pumpage. The budgets were discussed in detail in the WY 1996 accounting report.

ACTIVITIES FOR FY 1997

The activities for FY 1997 centered on the WY 1995 diversion accounting modeling and initiating the data collection and input activities for the WY 1996 analysis. In addition, work began on the changes to the TNET files for the Calumet tunnel. Christopher Burke Engineering, Ltd. was hired by the Corps to review the model to ensure consistency with the as-built plans for the Calumet tunnel system and its dropshafts. They were also tasked with updating the TNET model to account for the new Calumet tunnel legs that went on-line during WY 1996. In-house, the Corps began the change over from computing solar radiation data using O'Hare meteorologic data to using the measured solar radiation data collected at Argonne National Labs. This change was necessary due to a change in how O'Hare collected and reported its cloud cover that occurred in February 1996. The changes to the TNET modeling and solar radiation are detailed in the WY 1996 accounting report attached herein. The efforts relating to the changes to the Calumet modeling and the computation of the solar radiation were carried over into FY 1998 and FY 1999 and were a primary reason for the delay in the release of the WY 1996 accounting report.

In addition to the activities listed above, ongoing work related to the potential switch to lakefront accounting continued. This work included:

- The USGS work with the lakefront gages at the Chicago River Controlling Works and O'Brien Lock and Dam.
- Ongoing mediation activities related to the Great Lakes Mediation Committee that was initiated in December 1995 including technical support and detailed analyses of long-term runoff and consumptive use values.
- The U.S. Water Conservation Laboratory detailed QA/QC analysis of three pumping stations.

ACTIVITIES FOR FY 1998 – FY2000

The efforts in FY 1998 focused on completing the WY 1995 accounting report, initiating the data input for the WY 1996 accounting report, and contracting efforts related to establishing the Fourth Technical Committee. In addition the lakefront activities listed above for FY 1997 continued in FY 1998.

The activities in FY 1999 focused on completing the WY 1996 accounting report, coordination of activities related to the Fourth Technical Committee, and ongoing mediation activities related to the Great Lakes Mediation Committee. In addition the lakefront activities listed above for FY 1997 continued in FY 1999. A contract was initiated for work on a detailed QA/QC of ten primary water supply diverters in Chicago and five in the northern Chicago suburbs. The Corps also completed a hydraulic analysis of various alternatives for Navigation Makeup Reduction.

The efforts in FY 2000 will include initiation and completion of the WY 1997 accounting report. Lakefront accounting for WY 1997 will also be initiated in FY 2000. Corps activities continue in support of the Great Lakes Mediation Committee including technical support. The previously completed studies on long-term runoff and consumptive use provided the technical basis of an agreement between the states to

potentially move the accounting process to the lakefront. The long-term runoff and consumptive use studies have been released in draft form and will be finalized in FY 2000 and be included in a final format with the Water Year 1999 Annual Report (release scheduled for early FY 2001). The Fourth Technical Committee will provide its final report to the Corps during FY 2000 which will be included in the WY 1998 Annual Report. In addition, activities related to the potential move to lakefront accounting have continued in FY 1998 through FY 1999 and will continue through FY 2000. Finally, the Corps and the State of Illinois are negotiating the agreement to execute a one-year demonstration study to look at the impacts of a change to the existing Navigation Makeup operations in an effort to reduce this component of diversion. The physical study is slated for FY 2001 and will potentially lead to a change in the Code of Federal Regulations.

ACCOUNTING REPORTS

The accounting report for WY 1995 was completed in FY 1998 and distributed at the beginning of FY 1999. The accounting report for WY 1996 was completed in FY 2000 and the accounting report for WY 1997 will be completed in FY 2000. Thereafter, additional accounting reports are expected to be completed in the second fiscal year following the end of the water year for which the diversion is computed.

SUMMARY AND CONCLUSIONS

SUMMARY

The Lake Michigan Diversion Accounting procedure continues to evolve and improve. Further improvements are being implemented. A comprehensive diversion accounting manual is being completed during FY 2000 to include all the improvements. This manual will be included in the WY 1998 Annual Report. Progress continues to be made on the Lakefront Accounting activities.

CONCLUSIONS

The Lake Michigan Diversion Accounting Report for WY 1996 has been completed as required by the Supreme Court Decree. The State of Illinois diverted 3,108 cfs during WY 1996. These flows are 92 cfs less than the 3,200 cfs limit specified in the decree. The running average of the diversion for WY 1981 through WY 1996 is 3,418 cfs, or 218 cfs over the annual allocation. Also, the annual average diversion has exceeded the 3,680 cfs annual limit three times, once more than the maximum number of times allowed in the decree. Additionally, the absolute annual maximum of 3,840 cfs has been exceeded during the WY93 accounting period. The cumulative deviation is now -3,493 cfs-years. The negative sign indicates a cumulative flow deficit. The maximum allowable cumulative flow deficit specified in the decree is 2,000 cfs-years.

APPENDIX A
LAKE MICHIGAN DIVERSION ACCOUNTING
WATER YEAR 1996 REPORT