DEVELOPMENT OF A FLOOD AND POLLUTION CONTROL PLAN FOR THE CHICAGOLAND AREA

THE CHICAGO UNDERFLOW PLAN

FLOOD CONTROL COORDINATING COMMITTEE

DECEMBER, 1972
In order to comply with established waterway quality standards by the Illinois Pollution Control Board and the Metropolitan Sanitary District of Greater Chicago, and to eliminate the flooding and associated release of floodwater into Lake Michigan, a two-fold program of attack will be required. First, the massive upgrading and enlargement of the sewage treatment facilities, and second, the interception, detention and subsequent treatment of polluted water spilled from combined sewers in times of storms.

The presentation contained herein deals primarily with the problems of waterway flooding and pollution control related to combined sewer spillages.

The recommended solution to flood and pollution control, includes a comprehensive pattern of tunnels under the existing waterways, or “Underflow Tunnels,” which will intercept and convey the mixed sewage and storm water runoff to large storage reservoirs constructed in existing or new rock quarries. There the combined flow will be detained, aerated and subsequently pumped through upgraded sewage treatment plants before passing to the Chicagoland waterways.

The recommended “Chicago Underflow Plan” has been programmed to be completed within a ten-year construction period, beginning in 1973, at an estimated cost of one billion, two hundred twenty-three million dollars.
NINETEENTH CENTURY PROBLEMS

The history of the development of drainage and sewerage of the Chicago Metropolitan Area dates back to the early decades of the nineteenth century. From the beginning, the type of drainage was that of "combined" sewers, conveying in the same conduit systems, the combined flow of stormwater, runoff and household and industrial wastes, which was generally considered, by most cities at that time, to be the most logical and practical scheme of urban drainage. These initial systems of "combined" sewers have now spread their lines to serve 375 square miles of the Metropolitan Area, having a total length of more than 5,000 miles.

For many decades from 1833 to 1900, all or most of the pollution originating within the growing City and some adjacent areas spilled, untreated, from the combined sewer outlets into the Chicago River and Lake Michigan.

Although the deepening of the small Illinois and Michigan Canal in the year 1871 allowed partial diversion of some of this pollution into the Mississippi River Watershed, it was not until after the formation of the Sanitary District of Chicago in 1889 now named The Metropolitan Sanitary District of Greater Chicago, that a major and successful effort was made toward pollution and flood control.

THE CANAL SYSTEM

The original program of the Sanitary District of Chicago produced the Sanitary and Ship Canal, completed on January 16, 1900 and its two tributary canals, the North Shore Channel in 1910 and the Calumet-Sag Canal in 1922. See Exhibit 1. Intercepting conduits and pumping stations completed in 1907 intercepted all open discharge of polluted waters into Lake Michigan, and delivered this pollution to the Chicago River System at Lawrence Avenue and at 39th Street and to the Calumet-Sag Channel at 127th Street. Clean water withdrawn from Lake Michigan at the points shown in Exhibit 1, diluted the pollution and conveyed the mixture southwestward through the new canal system into the drainage basin of the Illinois River, and thence to the Mississippi River. This reversal of the direction of flow in the Chicago and Calumet Rivers was widely publicized...first as a great achievement but later as lake diversion, considered unfair by other states bordering on the Great Lakes. Dilution ratios for the untreated sewage, equal to 3% per 1,000 population were recommended to maintain what was then considered a sufficient level of sanitation, pending the development of sewage treatment facilities, which began in the twenties with the completion of the initial stages of the Calumet Sewage Treatment Works in 1922 and North Side Sewage Treatment Works in 1927. Construction was, however, limited by the economic capabilities of the growing city.
**HISTORICAL BACKGROUND**

**CONTROLLED LAKE DIVERSION**

Three decades after the completion of the Sanitary and Ship Canal, an edict of the United States Supreme Court in April, 1930, established a rigid schedule of reduced lake diversion for dilution purposes. The goals of pollution control were drastically advanced and an accelerated program of sewage treatment was adopted, culminating in what was then termed "complete" treatment of all the sewage in the Sanitary District area. More rigid limitations of lake diversion was recently established by the United States Supreme Court in 1967, limiting the total withdrawal to 3,200 cfs average flow including domestic water supply and runoff from the Chicago and Calumet River Drainage Area, originally tributary to Lake Michigan.

**WORLD’S LARGEST FACILITIES FOR POLLUTION CONTROL**

The restrictions imposed by the Supreme Court decision in 1930 resulted in the construction of the world’s largest facilities for control of water pollution, but which, by themselves, are now considered insufficient.

The Metropolitan Sanitary District of Greater Chicago now serves more than 5,500,000 persons living in an 860 square mile area which includes the City of Chicago, and 117 adjacent communities within Cook County. The industrial load which must also be collected and treated is equivalent in pollution content, to approximately 4,500,000 additional persons, making a total population equivalent of approximately 10,000,000 persons.

**THE EXPANDING PROBLEM**

The burgeoning population and industrial growth, coupled with the restricted dilution imposed by the edicts of the Supreme Court, have created an imbalance in the oxygen conditions of the waterways so that the so-called "complete" treatment of sewage must now be upgraded, and all or most of the combined-sewer spillage must be captured and routed through the upgraded treatment plants.

Also, the increased proportion of impervious surfaces, in the form of roofs and pavements and the more rapid conveyance of runoff by auxiliary outlet sewers have so greatly increased the peak runoff rates from the combined-sewer drainage areas as to greatly overload the flow capacity of the open watercourses (including the Sanitary and Ship Canal) and make necessary the reversal of flow in the main waterways during periods of high storm-water runoff. Exhibit 1 shows the points where the surcharge of polluted backflow is released into Lake Michigan from the North Shore Channel, the Chicago River, and the Calumet River. These backflows are now occurring at increasing frequencies, thus reinstating the basic problem of lake pollution which plagued the city government a century ago.

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**EVALUATION OF ALTERNATIVE SYSTEMS**

**FLOOD CONTROL COORDINATING COMMITTEE**

Recognizing the existence of many possible solutions to the problems of flood control and water pollution abatement, officials of the State of Illinois; the County of Cook; the Metropolitan Sanitary District of Greater Chicago and the City of Chicago formed a Flood Control Coordinating Committee.

They appointed a Technical Advisory Committee on November 2, 1967 to study the merits of the several leading alternative plans. After many meetings in years 1967-1968, the committee could not arrive at a final recommendation.

The Flood Control Coordinating Committee was reactivated in November, 1970 by officials who were determined that progress must be made in the development of a flood and pollution control plan. A new Technical Advisory Committee was appointed and directed to make an impartial evaluation of all possible alternative solutions.

Under the financial sponsorship of the Metropolitan Sanitary District of Greater Chicago; The State Institute for Environmental Quality; and the Department of Public Works, City of Chicago, a systems study was undertaken to develop a plan for that part of the Chicago land Area served by combined sewers.

A team of engineers from the City, Metropolitan Sanitary District, County, State and Federal agencies was enlisted and a number of consulting engineering firms and individuals hired to perform this engineering task. Advisory Groups of engineers were established in Sewage Treatment, Geology and Water Supply, Power, Alternative Systems, Benefits and Financing.

The aim of the systems study was to develop a plan to eliminate the deleterious effect of the spillage of mixed sewage and storm water from the combined sewers into the surface waterways of the Chicago metropolitan area. Such systems must provide for compliance with the standards established by the Illinois Pollution Control Board and the Metropolitan Sanitary District of Greater Chicago. Also, the plan must provide flood control benefits for the several surface waterways without the release of flood waters into Lake Michigan at the Wilmette Controlling Works, the mouth of the Chicago River, or through the Calumet River.

**TWENTY-THREE ALTERNATIVES**

After a thorough search of records and extensive investigation, twenty-three separate alternatives were identified for study. See Exhibit 2.

Early evaluation by the Technical Advisory Committee led to the recommendation that six of the original twenty-three alternatives should not receive further study, namely: K, L, M, N, P and T.
EXHIBIT 2 — ALTERNATIVES

ALTERNATIVE A:

DEEP TUNNEL PLANS WITH MINDED AND SURFACE STORAGE IN THE CALUMET AREA

The plan involves the excavation of a deep tunnel system in the Calumet area to convey combined sewage to surface storage basins. The system includes the construction of tunnels beneath the Calumet area, connecting to surface storage basins located at various points throughout the area. This alternative is designed to improve water quality and reduce the risk of flooding in the Calumet area.

ALTERNATIVE B:

COMPOSITE PLAN

The composite plan involves the combination of the deep tunnel plan with additional surface storage basins. This alternative aims to provide a more comprehensive solution to the drainage and flood control issues in the Calumet area. It includes the use of existing basins as well as new storage facilities to enhance water management.

ALTERNATIVE C:

CHICAGO UNDERGROUND PLANS

The Chicago Underground Plan involves the use of tunnels below the surface to convey combined sewage to storage basins. This plan is designed to reduce surface flooding and improve water quality by diverting sewage to underground storage facilities.

ALTERNATIVE D:

STATE OF ILLINOIS DIVISION OF WATERSHED PLANS

The Illinois Division of Watershed Plans includes a series of tunnels to transport water from various locations to surface storage basins. This alternative focuses on the efficient use of underground infrastructure to manage water resources and prevent flooding.

ALTERNATIVE E:

METROPEL TUNNEL計劃

The Metropolitan Tunnel Plan proposes the excavation of tunnels to convey combined sewage to surface storage basins in the Calumet area. The tunnels are designed to be used in conjunction with surface storage facilities to provide a comprehensive solution to drainage issues.

ALTERNATIVE F:

CHICAGO UNDERGROUND PLAN—LOCKPORT

The Lockport underground plan involves the use of tunnels beneath the Lockport area to convey combined sewage to surface storage basins. This alternative aims to improve water management by utilizing existing basins and increasing their capacity to store sewage.

ALTERNATIVE G:

RAVEN-Williams CHANNEL IMPROVEMENT PLAN

The Raven-Williams Channel Improvement Plan focuses on the rehabilitation and expansion of existing channels to improve water flow and reduce flooding in the Calumet area. This alternative aims to enhance the natural water drainage system through channel adjustments.

ALTERNATIVE H:

PLUMB-INDOOR/OUTDOOR STORAGE

This alternative involves the installation of indoor and outdoor storage tanks to manage combined sewage. Indoor tanks can be used for long-term storage, while outdoor tanks can be utilized for temporary storage during peak flow periods. This approach offers flexibility in managing water resources.

ALTERNATIVE I:

METROPEL BOUNDARY STORAGE CAMERON PLAN

The Metropolitan Boundary Storage Plan involves the use of boundary storage tanks located at various points along the Calumet area. These tanks are designed to store excess sewage during peak flow periods, reducing the burden on existing drainage systems.

ALTERNATIVE J:

SHEAFFER PLAN

The Sheaffer Plan proposes the development of a large-scale surface storage facility in the Calumet area. This alternative aims to provide a significant capacity for sewage storage, complementing existing drainage systems and improving water quality.

ALTERNATIVE K:

NICOOL, CALUMET AND O'HARE STORAGE PLANS

The NICOOL, Calumet, and O'Hare Storage Plans involve the development of storage tanks in the Calumet area. These plans are designed to manage sewage overflow, reduce flooding, and improve water quality by providing additional storage capacity.

ALTERNATIVE L:

PLUMB-INDOOR/OUTDOOR STORAGE

This alternative involves the installation of indoor and outdoor storage tanks to manage combined sewage. Indoor tanks can be used for long-term storage, while outdoor tanks can be utilized for temporary storage during peak flow periods. This approach offers flexibility in managing water resources.

ALTERNATIVE M:

SEPARATE SYSTEM OF SANITARY SEWERS

The separate system of sanitary sewers plan involves the construction of separate systems for stormwater and sewage. This alternative aims to prevent sewage from entering stormwater systems, reducing the risk of pollution and improving water quality.

ALTERNATIVE N:

SEPARATE SYSTEM OF SANITARY SEWERS

This alternative involves the installation of separate systems for stormwater and sewage. The plan aims to reduce cross-contamination and improve water quality by maintaining distinct systems for different types of water.

ALTERNATIVE O:

PLUMB-INDOOR/OUTDOOR STORAGE

This alternative involves the installation of indoor and outdoor storage tanks to manage combined sewage. Indoor tanks can be used for long-term storage, while outdoor tanks can be utilized for temporary storage during peak flow periods. This approach offers flexibility in managing water resources.

ALTERNATIVE P:

PLUMB-INDOOR/OUTDOOR STORAGE

This alternative involves the installation of indoor and outdoor storage tanks to manage combined sewage. Indoor tanks can be used for long-term storage, while outdoor tanks can be utilized for temporary storage during peak flow periods. This approach offers flexibility in managing water resources.
EVALUATION OF ALTERNATIVE SYSTEMS

Alternatives K, L, M and P are basically limited to flood control and would not meet the water quality standards now required for the surface waterways of the Chicago Region.

If Alternative N were to be considered, it would require a collecting system and local storage facilities not unlike those contained in many of the other alternatives. Therefore, the Sheaffer Plan (Land Disposal) is considered an extension of these systems and has been given no further consideration in this study.

The cost of Separation, Alternative T, including all public sewers and plumbing alterations in both private and public buildings was estimated for the existing combined sewer drainage areas at upwards of four billion dollars. The disruption of public streets and required plumbing alterations would be enormous and would result in no flood control. Alternative T was dropped from the study.

STANDARD MODIFICATIONS

The remaining seventeen alternatives systems were then subjected to exhaustive comparative evaluations.

Retaining the principal features of each of these alternative systems, four standard modifications "Mods" were made of each system, gauged to achieve flood control and no backflow to Lake Michigan. These were based on a complete repetition of the precipitation patterns which occurred during a twenty-one year period, 1949 to 1969, inclusive and which period included the largest storms of record. Computer studies applied the impact of such a repetition upon a maximum future land use. Mods 2, 3 and 4 were sized and tested to meet the following requirements:

Mod 1 (Storage Varied)—Original Plan (proposed by various authors).

Mod 2 (120,000 AF)—Contain largest storms of record.

Mod 3 (50,000 AF)—Prevent backflow to Lake Michigan without waterway channel improvements.

Mod 4 (20,000 AF)—Capture one year storm and make waterway improvements to prevent backflow to Lake Michigan.

EVALUATION OF SUBSYSTEMS

Various subsystem elements were evaluated, including cost of expanding existing treatment plants; cost of new treatment plants for various capacity and effluent requirements; cost of tunnels of various sizes using drill and blast methods and machine mining methods, both lined and unlined; cost of near surface collecting sewers and drop shafts to various levels; cost of construction of pits or openings for the storage of overflow waters; cost of mining, "room and pillar method" for storage space in various rock strata; cost of surface storage facilities; cost of aeration in waterways, pits or quarries, mined chambers, surface reservoirs and tunnels; cost of waterway dredging and other waterway improvements; requirements for protecting the aquifer and filtered water tunnels; strength of rock and drillability in various formations; rock boring to determine the location and elevation of strata; limitation of rock blasting charges with relation to surface damage; coefficient of friction in lined, machine mined and unlined conveyance tunnels; deterioration of rock with time; effect of earthquakes on mined areas or tunnels; maximum permissible velocities of flow through lined and unlined tunnels. These subsystems have been used in the formation, evaluation, and cost of the Alternative plans.

Each of the Alternatives plans were evaluated for various levels of storage (Mod. 2, 3 and 4) as to the present worth capital cost and the annual cost, including maintenance, operation and in some systems revenue. Statements of the benefits and the environmental impact for each Alternative were prepared.

Exhibit 2 summarizes the basic cost data, relocation problems and land and easement requirements for all alternatives, and for each of their modifications.

EVALUATION REPORT OF ALTERNATIVE SYSTEMS

In January, 1972, an interim report entitled “Evaluation Report of Alternative Systems” was submitted by the Technical Advisory Committee to the Flood Control Coordinating Committee. This report presented the system’s evaluation with regard to present worth capital cost; annual cost, including maintenance, operation, equipment replacement and in some systems revenue; land acquisition; underground easements; benefits; relocation of people and industries; and statements of the environmental impact both for the construction period and for the permanent facility, for all seventeen alternatives and for three separate modifications. Exhibit 3 shows the Summary Evaluation Table.
### EXHIBIT 3—EVALUATION TABLE

#### MOD 2—CONTAIN STORM OF RECORD

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#### MOD 3—STORAGE TO PREVENT LAKE BACKFLOW WITHOUT WATERWAY IMPROVEMENTS

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#### MOD 4—CAPTURE ONE-YEAR STORM AND MAKE CHANNEL IMPROVEMENTS TO PREVENT LAKE BACKFLOW

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*Note: It is the opinion of the Metropolitan Sanitary District and the City of Chicago on whom the opinion is requested that the lake act as a public trust and for the public welfare and the public benefit and not for the use and enjoyment of the lake or for the use and enjoyment of any person or persons, and that the public benefits from the protection, conservation and recreation of the lake in the Metropolitan area and all other areas adjoining. Therefore, it may be presumed that the public benefits from the protection, conservation and recreation of the lake, the benefits of that project are equal to the least costly alternative in each kind.
RECOMMENDATION OF FLOOD CONTROL COORDINATING COMMITTEE

After extensive review of the evaluation report, the Flood Control Coordinating Committee unanimously agreed that the "Chicago Underflow Plan" (Alternatives "G", "H", "J" and "S"—Mod 3) are less costly and would be more environmentally acceptable to the community than any of the other plans presented. Detailed studies and layouts along the lines of these plans were then continued to develop the final plan.

RECOMMENDED PLAN

The system recommended herein, a composite of the several Underflow Plan Alternatives, is outstanding in its relative storage economy and simplicity. It will capture the total runoff from all of the record meteorological sequences of history, if they were to recur on future ultimate developed drainage basins, except for the peak few hours of three of the most severe storm events. The system will convey these captured combined sewer flows through high velocity, out-of-sight underflow tunnels below the routes of the existing surface water-courses to large pit-type detention reservoirs. Exhibit 4 shows the general location of the conveyance tunnel system and storage reservoirs.

STORAGE RESERVOIR FACILITIES

The primary storage reservoir is located in the area now occupied by the sludge lagoons of the Metropolitan Sanitary District in the McCook-Summit area. This reservoir will be in the form of a 300 to 330 feet deep rock quarry, with a maximum water depth of approximately 200 feet. In the heaviest storm event, and water surface dimensions averaging about 1,000 feet wide by 2½ miles long. Total storage capacity of the reservoir with the water surface at its maximum level of — 100 CCD, will be 57,000 acre-feet.

Exhibit 5 shows the general layout of the reservoir, conduits and pumping facilities. The lower 100 feet of depth of the reservoir will be divided into three basins by transverse dike, providing two small basins, each with a volume of 5,000 acre-feet for the more frequent small runoff periods. The larger runoff volumes will flood the remaining basin and the water surface will rise in elevation over the entire reservoir.

The dewatering pumping station shown on Exhibit 5 will discharge from the storage reservoir to the West-Southwest Treatment Plant at an average rate of about 700 c.f.s. The station's total capacity will be 2400 c.f.s. in order to dewater the conveyance tunnels and Steam Quarry into the reservoir within three days following a storm.
RECOMMENDED PLAN

Computer studies indicate that the storage utilized in Basins 1 and 2 will exceed their combined volume (10,000 acre-feet) at an average frequency of six or seven times per year and that these two basins alone will entrap more than 70% of the annual combined sewer spillage containing over 95% of the annual Suspended Solids.

The use of a deep pit storage basin of such magnitude and depth requires that aeration be provided to insure positive odor control by floating equipment. This is necessary because the range of liquid levels varies over 200 feet. It is proposed to use submerged turbine aerators provided with a downflow draft tube with air injection below the propeller.

The submerged turbine aerators will be provided with a bar screen to prevent large ice chunks from being drawn into the draft tube and damaging the blades. The aerators will be provided with legs to protect the draft tube and will need a minimum of 20 feet of water to operate. When floating at greater depths, it is considered that active aeration will be limited to the upper 50 feet of the water in storage.

Aerators, in the heaviest rainfall year will be in near continuous operation in or above Basins 1 and 2. A lesser amount of aeration on an intermittent schedule will be required in Basin No. 3.

An aerated reservoir of lesser depth and volume of 1,800 acre-feet, will be provided near the proposed O'Hare Water Reclamation Plant, to serve the combined sewered area of the suburban communities to the northwest.

Another reservoir will utilize the existing Stearns rock quarry in the vicinity of 28th and Halsted Streets. This reservoir will provide approximately 4,000 acre-feet of storage space and will be used only during record storm events to flatten out the peak discharge through the conveyance tunnels.

UNDERFLOW CONVEYANCE TUNNELS

There are approximately 120 miles of underflow conveyance tunnels intercepting 640 sewer overflow points in the 375 square mile area served by combined sewers. Most of the conveyance tunnels will be constructed in the Silurian Dolomite rock formation 150 to 300 feet below the surface of the waterways. In some areas, the smaller tunnels will be constructed in the clay overburden. See Exhibit 6 and 7 for profile of the underflow tunnels.

EXHIBIT 6—TUNNEL PROFILES

MAINSTREAM SYSTEM

DES PLAINES RIVER SYSTEM

MAINSTREAM BRANCHES

DES PLAINES RIVER BRANCHES
The tunnels will in general be drilled by mining machine (moles), except for the largest sizes which will probably be constructed by the conventional drill and blast method.

Three main conveyance tunnel systems fork out from the primary reservoir facility located in the McCook-Summit area. See Map, Exhibit 4. The Des Plaines Tunnel System extends north along the Des Plaines River to the Village of Des Plaines, thence northwest terminating at the Village of Palatine. The Mainstream Tunnel System extends under the Sanitary and Ship Canal, the North and South Branches of the Chicago River and the North Shore Channel to the Wilmette controlling works. The Calumet Tunnel System extends south and south-easterly along public right-of-way to the Sag Channel, thence eastward under the Little Calumet, Grand Calumet and Calumet Rivers to near the State Line. The storage space in the conveyance tunnel system is 9,100 acre-feet.

The spillages will be delivered to the underflow tunnels by hundreds of vertical drop shafts, capturing the present spillage from the existing riverbank sewer outlets of five thousand miles of near-surface sewer systems. A typical drop shaft is shown in Exhibit 8.

The drop shafts will have a split vertical shaft, one side for water and the other side for air. The center dividing wall will have slots to insulate sleepers in the falling water. This reduces the impact when the air-water mixture hits bottom. An air separation chamber is provided to reduce the amount of air entering the tunnel. At the top, a vent chamber will allow air to escape during filling and to be drawn in during dewatering.
GROUNDWATER PROTECTION AND RECHARGE

The Recommended Plan is sited in rock units of the Silurian System of the geologic strata underlying the Chicago area. These limestone and dolomite rock units, together with the hydrologically interconnected overlying glacial drift, comprise the so-called shallow aquifer of the region.

The preservation of groundwater quality and quantity can be achieved by establishing or maintaining two physical conditions throughout the project area: high piezometric level within the aquifer in relation to hydraulic grade levels in subsurface project features, and adequate limitation of groundwater infiltration into the subsurface excavations.

High piezometric levels within the aquifer will provide protection against seepage from tunnels and storage excavations, thus preserving groundwater quality. These levels occur naturally in much of the project area, and must be established by recharge systems in other parts of the project area. The differential head provided by high piezometric levels within the aquifer will tend to cause infiltration into underground excavations. The limitations of the quantity of this infiltration can be realized in some parts of the project area, by relying principally upon the natural low permeabilities which are known to exist within the lower dolomitic rock formations. A low leakage rate can be achieved by grouting of only major fractures and fissures in the rock. In other areas, extensive grouting and/or lining of the tunnels will be required to maintain high infiltration rates.

Additional data on protection of groundwater and limitation of infiltration into tunnels and storage areas is available in the Technical Reports.

OPERATION

The general operation of the Underflow System is as follows: Rainfall runoff and/or snow-melt enters the sewer system mixing with household and industrial wastes. This combined flow travels through the sewers to a control or diversion chamber located near the waterways. In dry weather or very minor rainfall periods all of the flow is diverted to the existing interceptor for conveyance to the sewage treatment plants.

In storm runoff periods exceeding the interceptor or treatment plant capacity, storm overflow passes through the drop shafts to the large conveyance tunnels under the waterways. Flow is conveyed to the storage reservoirs. At McCook, it will first enter the primary basins Nos. 1 and 2. If flow exceeds 10,000 acre-feet, the capacity of the two primary basins, spillage will occur to basin No. 3. Immediately after the flows in the conveyance tunnels have subsided, the dewatering pumps are turned on at the principal reservoir site to pump the water in the tunnels to the reservoir. The pumps have capacity to perform this operation in two days. If the Stearns Quarry is filled, it will require a total of three days. Flushing water may then be taken in from the waterway at selected drop shafts to cleanse the conveyance tunnels.

The combined sewer overflows will be detained in the storage basins from the maximum single storm for up to 50 days. The most frequent occurrence for a single storm, however, will be between 2 and 10 days. Overflow water will be in the reservoir from the sequence of rainfall events for much longer periods. Computer simulation studies show that in a recurrence of the heaviest water year, 1954, the basins would have live detention water for 288 days out of 365 days. This is based on the average dewatering rate to the treatment plant of 700 c.f.s. in the dry weather post rainfall periods.

In the post storm period, the dewatering pumps will be operated to pump the stored water to the treatment plant. Pumping will be at a variable rate which, when added to the plant's raw sewage influent will equal 1.5 times the dry weather flow. This will require expansion of the existing treatment plant facilities.

In the very large storms, when the stored water has undergone prolonged aeration, pumping at rates in excess of those acceptable by the secondary and tertiary treatment units can be routed directly to the chlorination facilities and then to the waterways.

If the storm is of a magnitude that will exceed the storage or conveyance capacity, gates at the drop shafts on selected gravity sewer systems can be operated to force the water to overflow at such selected locations to the waterways. Thus, in these rare events, priority protection can be given to small streams and the low elevation pumped areas.
The solids that have been deposited in the aerated storage basin have to be removed periodically. It is estimated that a two to three year period will be allowed for solids storage. The solids in this period of time will be stabilized to the extent that further digestion should not be necessary. The aeration equipment in the basin can be used to aerobically digest recently deposited solids that might occur immediately prior to a planned quarry cleaning operation. The settled material will be removed by a floating dredge discharging through a pipe system with other sludge to the Metropolitan Sanitary District land reclamation.

**BENEFITS**

A brief listing of anticipated benefits to be derived from completion of the system of flood and pollution control proposed herein, includes the following:

1. Protection of the valuable water resources of Lake Michigan from flood release of river water as now required through the existing Chicago River, the North Shore Channel and the Calumet River into Lake Michigan.
2. Achieving and maintaining acceptable water quality (in accordance with regulations of the Illinois Pollution Control Board and the Metropolitan Sanitary District) in the open waterways known as the Chicago River and its branches, the Sanitary and Ship Canal, the North Shore Channel, the Calumet-Sag Channel, and those portions of the Calumet River, Des Plaines River, Salt Creek and other open waterways, under the jurisdiction and control of the Metropolitan Sanitary District of Greater Chicago.
3. Reduction of surface and basement flooding by underground backwaters or overbank flooding.
4. Improvement of recreational values of all surface waterways.
5. Increase in property values due to general improvement of environment.

**POST CONSTRUCTION ENVIRONMENTAL IMPACT**

The surface environmental disturbances of project features after construction will be minimal. Most elements of the project are located underground. Features on the surface are generally to be located in areas that are already in industrial use. Quarry and surface reservoirs are already surrounded by lands that would provide an effective barrier to urban encroachment.

Since odor nuisances must be avoided, all reservoirs expected to detain water for over 3 days will be designed with sufficient mechanical aeration equipment to oxidize matter contained in the combined sewer overflow from the maximum storm.

Conveyance tunnels will be located in the Niagara Group about 300 feet below the ground surface. Ground water levels in the Niagara aquifer should be above the proposed tunnels in most places. These high ground water levels will cause water flow into the tunnels and consequently there will be no danger of aquifer pollution. The quantities of water infiltrating into the tunnels would be small in relation to the aquifer potential and there would be no adverse effects on the long term water supply. In areas such as McCook where the upper aquifer is overdeveloped and water levels are low, the aquifer would be recharged with potable water to prevent efluviation of polluted water from tunnels and reservoirs.

It is expected that little or no fish kills would occur during overflow periods. In the first place, the prevalent dry weather Dissolved Oxygen (DO), temperature during the summer and ammonia-nitrogen levels in the Mainstream Waterway and Calumet Sag Channel would not be conducive to game fish life. In other watercourses, warm water biota, and native game fish would not be greatly affected by the short dips in DO during the infrequent overflow events.

**COST**

The total cost of the recommended Chicago Underflow Plan is estimated as follows:

<table>
<thead>
<tr>
<th>Description</th>
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<tr>
<td>Surface Collection and</td>
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<tr>
<td>Total Project Cost</td>
<td>$1,148,200,000</td>
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<td>(1972 Base)</td>
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<td>$1,223,200,000</td>
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The total of the equivalent annual operating and maintenance costs, replacement of equipment costs and water costs for aquifer protection is estimated at $13,600,000 per year.
RECOMMENDED PLAN

FUNDING
The total Flood and Pollution Control Program consists of two major parts: the recommended Chicago Underflow Plan for correction of the combined sewer overflow problem; and a series of other projects (identified by the MSDG) whose principal objectives are an increase in treatment levels, efficiencies, and capacities at plants, and extension and capacity increase of interceptor sewer facilities. It has been determined that construction of both program parts is required to meet water quality standards of the Illinois Pollution Control Board. Moreover, both program parts must be considered in financial analyses since their construction will be funded from the same sources for the most part. The total project costs of the facilities of the program have been estimated at $2,653.4 million with $1,223 million required for the Chicago Underflow Plan and $1,437 million required for the enlargement and upgrading at treatment facilities and other work related thereto. The base year for the project cost estimates is 1972.

Three basic construction schedules were examined to evaluate the effects of variation of time and program implementation: a 5-year, 10-year, and 15-year program. In each of these cases, a 6 percent per annum construction cost escalation was included as a factor.

A 10-year construction program is recommended for adoption as the plan implementation schedule. Exhibit 9 indicates the division of awards between the Chicago Underflow Plan and the combination of the numerous other projects of the recommended 10-year program.

Shown in Exhibit 9 is a schedule of existing and pending allocation of funds from local, State and Federal sources totaling $1,428,000,000. This includes a Federal allocation based on the provisions of the House Bill H.R. 11896, which is now in committee to resolve the differences between it and the Senate Bill S.2770. (On October 18, 1972, just prior to printing of the report, the Federal Water Pollution Control Act Amendments of 1972 became law.) State and local matching funds would be deferred out of the $750 million State Bond Issue that passed on November 3, 1970, and the MSDG $350 million Bond Issue approved on September 22, 1969.

Other funding beyond that provided by these sources is required. For the purpose of this analysis, this funding is assumed to be forthcoming from continuation of local, State and Federal funding programs in the later years of the 10-year plan implementation schedule.

A more extensive description of the sources of funds and their estimated amounts is contained in the Technical Reports.

EXHIBIT 9—FINANCING

A 10-year construction program is recommended for adoption as the plan implementation schedule. Exhibit 9 indicates the division of awards between the Chicago Underflow Plan and the combination of the numerous other projects of the recommended 10-year program.

Shown in Exhibit 9 is a schedule of existing and pending allocation of funds from local, State and Federal sources totaling $1,428,000,000. This includes a Federal allocation based on the provisions of the House Bill H.R. 11896, which is now in committee to resolve the differences between it and the Senate Bill S.2770. (On October 18, 1972, just prior to printing of the report, the Federal Water Pollution Control Act Amendments of 1972 became law.) State and local matching funds would be deferred out of the $750 million State Bond Issue that passed on November 3, 1970, and the MSDG $350 million Bond Issue approved on September 22, 1969.

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DIVISION OF AWARDS

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EXISTING OR PENDING (FUNDING)

|                | 829.0 | 849.5 | 355.0 | 1,432.5 |

ADDITIONAL FUTURE (FUNDING)

|                | 375.0 | 395.0 | 395.0 | 1,362.0 |

AS COMPILED—AUGUST, 1972

*INCLUDES POSSIBLE FEDERAL FUNDS FOR FLOOD CONTROL, RECREATION, URBAN DEVELOPMENT AND REIMBURSEMENT FOR PREVIOUSLY COMPLETED MSDGC PROJECTS.

NOTE:
ALL NUMBERS ARE IN MILLIONS OF DOLLARS.
CONSTRUCTION SCHEDULE

The Underflow Project has been scheduled over a ten-year construction period, commencing in 1973 and totally operational by the end of 1982. See Exhibit 10.

The construction has been divided into a completely operational first phase, followed by a second phase which would complete all elements of the plan.

The first phase of the Mainstream System would include the entire main tunnel, with drop shafts, from the reservoir facilities in the McCook-Summit area to Wilmette, and a portion of the reservoir and pumping station facilities. With this portion operational, it would provide about 95 percent reduction of the pollution load spilled from the combined sewers in the area served. Because of the relatively small storage (14,000 acre-feet in tunnel and reservoir), overflow would still occur 1 to 2 times per year but considerable improvement in the Mainstream water quality will be evident.

The first phase of the Des Plaines System designated as the O’Hare Northwest System will be the entire tunnel, reservoir and pumping station system, leading to the O’Hare Water Reclamation Plant, now under design. Full benefits will be received when that system is made operational.

In the Calumet System, the first phase would include the construction of the conveyance tunnel from the 95th Street Pumping Station along the Calumet and Little Calumet Rivers to the outlet of the 125th Street Pumping Station. This would eliminate all spillage, Lake-side, of the O’Brien Locks.

ENGINEERING DETAILS

As in all major projects, the final arrangement and dimensions of many components must be left open for possible adjustment or revision during detailed engineering design in the contract preparation stage. Some of the features which will require further study are: the feasibility of separating the Calumet System from the Mainstream System, if economical and environmentally acceptable locations for storage reservoirs can be found in the Calumet area; the elimination of the long length of tunnels to the Palatine area, if other suitable solutions of handling the combined sewer overflow problems for that area can be found; the exact tunnel configuration and alignment in many areas; the exact location of pumping stations and reservoir facilities; the details of the aeration and sludge handling facilities; the desirability of raising the freeboard level at the Wilmette Controlling Works; the alignment and location of the near surface collecting sewers and drop shaft facilities, and many other details.
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Mr. Carl W. Hesse, Chief Regional &
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Mr. Richard H. Golferman, Under Sec'y.
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Mr. Bruce Barker, Assistant Chief Water Resources

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Mr. Robert Sasman, Hydrologist

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Dr. Geo. M. Hughes, Assoc. Geologist

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Mr. Frank Dalton, Asst. Chief Engr.
Mr. Robert Barbolim, Asst. Chief Engineer
Mr. David Lordi, Chief-Res. & Lab.
Mr. Joseph Irons, Pr. Civ. Engineer
Mr. Raymond Leland, Engr. Sewer Design
Mr. Richard Lanyon, Engr. Fl. Control
Mr. Robert McCarthy, Engr. Pr. Des.
Mr. Norvel Anderson, Sanitary Engr. Consultant

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Mr. Marshall Suloway, Chief Engineer
Mr. Clint J. Keeler, Chief Water &
Sewer Design Engineer (Proj. Director)
Mr. David E. Westfall, Coordinating Engineer,
(Project Manager)
Mr. A. L. Tholin, Consultant
Mr. Wm. Donovan, Civil Engineer
Mr. Joseph Harrison, Civil Engineer
Mr. R. Gurashi, Civil Engineer
Mr. Thomas Hixson, Application Designer

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Mr. Jack Steiner, Sanitary Engineer

CONSOER TOWNSEND AND ASSOCIATES
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Mr. John Ward, Sanitary Engineer
Mr. Gerald J. Dillely, Sanitary Engineer

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Mr. Carl W. Reh, Partner
Mr. Arthur H. Adams, Associate
Mr. Patrick J. Yonakis, Engineer

HARZA ENGINEERING COMPANY
Mr. Richard Harza, Vice President
Dr. Ramon LaRusso, Associate
Mr. John Priest, Dept. Head Water Res.
Mr. Richard C. Acker, Geol. Dept. Head
Mr. L. D. Nichols, Power Resources Engr.

METCALF AND EDDY, INC.
Dr. Clair Sawyer, Consultant
Mr. John Lauer, Civil Engineer
Mr. Wm. Smith, Civil Engineer

WARREN AND VAN PRAAG, INC.
Mr. Robert Emmons, Associate
Mr. Charles R. Reeves, Associate

PROJECT DATA SUMMARY

Combined Sewer Systems
Area Served..............................................375 Square Miles
Sewer Mileage........................................5,000
Sewer Outlets.........................................540
Communities Served...................................57

Recommended Facilities
Tunnels, Length........................................120 Miles
Tunnels, Diameter....................................10 to 14 Feet
Tunnels, Inside Volume................................9,100 Acre-Feet
Reservoirs, Location & Storage Volume
McCook..................................................57,000 Acre-Feet
Steam's Quarry......................................4,000
O'Hare Water Reclamation Plant.................1,800

Total Detention Storage................................71,900 Acre-Feet
Equivalent Depth over Combined-Sewer Area........3.6 Inches

Dewatering Rate
Tunnels to Reservoir (Maximum).....................2,400 c.f.s.
Reservoir to Treatment Plant (Average)...........700 c.f.s.

Projected Operational Statistics from 21 Year Computer Simulation
Number of Combined Sewer Overflows..................3
Reduction in Combined Sewer Overflow Quantity....98.1%
Reduction in Combined Sewer Overflow Pollutants....99.9%
Meets State and Federal E.P.A. Waterway Standards
No Backflows of Waterways into Lake Michigan.

This Report is Condensed from the "Summary of Technical Reports" August 1972

TECHNICAL ADVISORY COMMITTEE

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Director, Inst. for Environ. Quality
State of Illinois

Mr. Arthur Janura, General Superintendent
Cook County Forest Preserve District
County of Cook

Mr. Ben Sosweitz, General Superintendent
Metropolitan Sanitary District of Greater Chicago
Alternate: Mr. Forrest C. Neil
Chief Engineer

Mr. John Pfeffer, Secretary
Dir. of Engrg. Research and Planning
Inst. for Environmental Quality
State of Illinois

Mr. Clirt J. Keeler, Chief Water and Sewer Design Engineer
Bureau of Engineering
Department of Public Works
City of Chicago