THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

RESEARCH AND CONTROL DEPARTMENT

FIRST ANNUAL REPORT

1966

PRESIDENT

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

100 EAST ERIE ST., CHICAGO, ILLINOIS 60611 . . . SUPERIOR 7-8900

\. JOEL KAPLOVSKY, PH. D.
ECTOR OF RESEARCH AND CONTROL

March 16, 1967

Mr. Vinton W. Bacon
General Superintendent
Office

Dear Sir:

We are transmitting herewith the 1966 Annual Report of the Department of Research and Control.

This being the first Annual Report for the Department, some leadway was taken in its preparation in order to establish continuity with activities of the near past. The various functions and operations of the Department are set forth in sufficient detail so that a baseline could be established for future presentations.

Attention is directed in particular to the section on Sludge Concentration. The fundamentals, magnitude, and complexity of the problem are discussed. The findings are summarized and recommendations are set forth.

Very truly yours

A. Joel Kaplovsky

A. Joel Kaplovsky, Ph. D.
Director of Research and Control

AJK:rlm

MARCH, 1967

FOREWORD

This 1966 report is the first annual report of the Department of Research and Control. In recognition of the need for greater emphasis on the scientific approach to the art of sewage treatment and disposal, the Board of Trustees created a separate Department of Research and Control under the general direction of the General Superintendent effective on January 1, 1966. In previous years, most functions of this department were carried out through the Sanitary Division of the Department of Engineering. Resumés of the past activities appear in appropriate annual reports of that Department. However, because this is the first annual report of a newly created department, pertinent background material has been included in order to assist the reader in understanding the various functions of the department, as well as their relation to the present and future operations of the District.

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GENERAL INTRODUCTION

The Metropolitan Sanitary District of Greater Chicago, due to its immensity, complexity, development and location with regard to Lake Michigan and downstream waterways, has certain inherent problems and related research needs which oft arise years ahead of the needs of other communities in the nation. This almost perpetual need for pioneering has forced the Sanitary District to maintain active basic research on almost every phase of sewage treatment and disposal.

These needs are the result of the large population and industrial community being serviced by the District; the maintenance of Lake Michigan in the highest possible state of purity as a source of water supply and a priceless recreation resource; the limited water resources available for dilution of treated effluents; a combined sanitary and storm sewer system; the world's largest single treatment plant, the operation of which is unique; and the constant and rapid economic and population growth in the territory serviced by the District.

The Sanitary District, growing at a rapid rate, has essentially no self-purification capacity available in its receiving waterways for the increased waste loads resulting from this growth. Consequently, it is forced to exert a maximum effort toward waste treatment, including research in almost every phase of waste treatment and water pollution control. Because the District is constantly faced with the need for providing the highest possible degree of sewage treatment, it appears certain it will become the first large metropolitan area of the nation required to develop means for tertiary treatment.

Preliminary projections for such advanced treatment make it abundantly clear that enormous costs are involved. Therefore, efforts must now be directed toward improving the economic factors associated with these anticipated needs. Operating costs alone have been estimated at double the present budget. Optimizing operations in existing facilities to increase present efficiencies and improve the characteristics of waste received can do much toward reducing the overall costs associated with these future demands. At the same time, effort must be directed, through use of new techniques, to achieve the most economical solutions patterned to the needs and system employed within the District.

The Metropolitan Sanitary District has a long and proud history of pioneering in both research and practice in the waste treatment field. Since the early 1920's, dozens of publications and hundreds of special reports (47) are evidence of their research in waste treatment and stream pollution, both basic and applied. The means of continuation of this pioneering tradition now rests in the Department of Research and Control, where new research will contribute to the basic and applied research needs of the sanitary field. To achieve this a major objective of the Department must be to provide and maintain the facilities and staff to perform the most competent research possible.

The resources and staff needed for these responsibilities have been developing over the past several years. Plans for a new research center for the District were initiated in 1963, and the building, 25,000 sq. ft. of compact work space filled with modern equipment, was occupied in 1966. Simultaneously, with the development of these facilities, a program of manpower enhancement was initiated. The 1963 staff of 83 men was increased to 92 in 1964. In 1964, a significant change in personnel classification was made within the then Sanitary Division, which permitted successful recruitment of high caliber research personnel. A new research chemist series was prepared and adopted which could compete effectively in the current manpower market. In addition, significant changes in minimum qualification requirements were made. The existing Civil Service sanitary chemist series was based upon qualification requirements with heavy emphasis on experience. In contrast, the new research chemist series emphasized academic requirements by permitting additional academic training as a substitute for equivalent experience. This parallel system of civil service classification has proven quite successful since it permits professionals with long experience to advance and still provides a future growth opportunity for the increasing number of more highly academically trained professionals. Applying the advantages of both civil service series provided the flexibility needed to obtain and maintain the excellent research teams.

Although no increase in personnel was provided in the 1965 budget, sixteen Engineering Assistants were acquired "on loan" from other divisions of the Engineering Department. When Research and Control received department status in 1966, these Engineering Assistants were made a permanent part of the department and the total staff was increased to 154 men.

This increase included not only positions for additional professional and non-professional personnel, but also an expanded administrative and clerical staff, plus maintenance personnel for the new Research and Control building.

The functioning department consists of four divisions: namely, Administrative, Control, Research, and Industrial Waste. The Research and Control Divisions are further subdivided, depending upon function and/or location. In order to utilize manpower, facilities, and equipment at the most efficient operating levels, all the analytical work of the Industrial Waste Division, and most of the routine type analyses associated with research, are done by the various sections in the Control Division.

The overall control group provides the following services: (1) Laboratory control for large plant operations; (2) Laboratory control for small plant operations; (3) Material testing; (4) Industrial Waste analyses; (5) Supplemental research support; (6) Shift laboratory for filter operation at the Southwest Treatment Plant.

In order to comply with this massive need covering a multitude of problems in different scientific fields, an approach was required which would provide the services needed at the lowest possible cost. Specialization has become the order of the day. Such specialization is feasible in large operations and facilities as the Metropolitan Sanitary District. Each associated scientific discipline was provided for in separate laboratory areas in the new 1.5 million dollar research and control building. These include sanitary chemistry, sanitary microbiology and bacteriology, waste treatment research, waterways, radiochemistry, industrial waste and materials testing. In this way, specialized teams capable of providing the highest quality of services in specific fields are available for all projects. This task force approach not only avoids duplication of personnel and facilities by centralizing the flow of special work but also provides a higher caliber of services. Hence, each project director and his group need not become "Jack of all trades".

A large segment of the department services includes routine analytical work for plant control. The volume of this work justifies automated analyses in several areas. Similar to running a clinic where routine measurements or tests are made on each patient, provisions were made in the building design of the Research and Control laboratory to enhance the flow of the routine portion of the research load through the automated equipment being used in other areas. In this way, much of the analytical volume associated with research studies is handled by the control group, permitting a researcher to use his time to greater advantage.

The Research Division is basically subdivided into: (1) Waste Treatment Methods; (2) Waterways (including water quality monitoring); (3) Microbiology; (4) Radiochemistry; (5) Methodology; (6) Special investigations associated with plant control, stack gases, boiler water, corrosion, odors, etc.

The primary research phases of waste treatment and stream quality are fortified with the analytical tools provided by microbiology, radio-chemistry, methodology (instrumentation and new methods), computers, mathematical models, and pilot and full scale testing. The analytical groups afford a high degree of specialization which are capable of providing higher quality service wherever needed for all research problems.

The present organized services have resulted in many opportunities where valuable services to the Sanitary District were provided, and it is expected that the department will be called upon to provide such support in the future. However, these diversions result in delays in the completion of planned research, and, therefore, they should be carefully screened before setting aside high priority work. In addition, a significant advantage would be achieved if a full complement of personnel could be obtained and maintained. During the past year, in spite of resignations of key personnel, the department has been able to cope fully with the needs of the District.

Of necessity, the research and special investigative work has been quite diversified. The problem areas can be segregated generally within the following groups:

(1) Efficiency of plant operation.

(2) Cost of operations.

(3) Engineering design.

(4) Stream Quality studies.

(5) Stream quality control.

(6) Plant quality control and general research.

Some areas of study can be completed within a reasonable time, and the findings reported upon; others are continuing programs for extended periods; and still others represent the beginning of long overdue permanent data collection programs. In general, the findings of the initial effort dictate whether additional work is needed. Further, the size of each undertaking is not always evident initially.

The Research and Control Department is geared to handle volume and still maintain the highest quality of work. Various systems of analytical support are available to keep the researcher engaged in research, because the associated routine aspects are assigned as a control section function. In this way, heavy analytical loads can be handled with high production techniques or instrumentation.

In view of the proposed Metropolitan Sanitary District multi-million dollar programs for needed advanced treatment in the not too distant future, it becomes even more imperative that research precede these undertakings not only to supply fundamental criteria for design as they relate to our present facilities and operations, but also to advance much basic information to insure maximum efficiency and control, so that desired water uses can be maintained at all times.

ADMINISTRATION

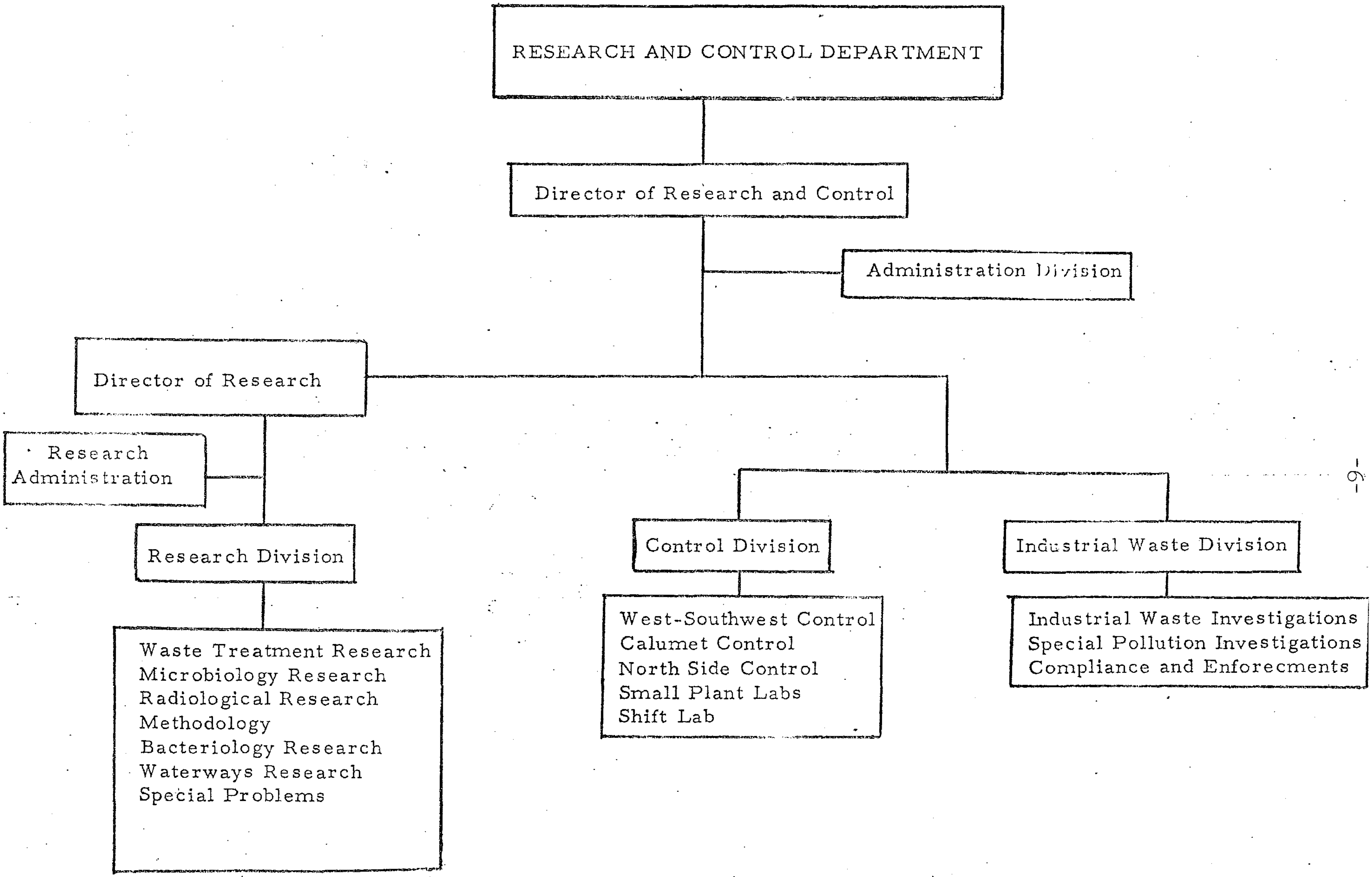
General

On January 1, 1966, the Research and Control Department was formed from what was formally the Sanitary Division of the Engineering Department. The Research and Control Department is composed of four divisions: administration, research, plant control, and industrial waste control as shown in the Table of Organization on following page. The Administrative Division is responsible for payroll preparations, time-keeping records, personnel, purchase requisitions, and budget preparation. In 1965 while part of the Engineering Department we had 93 budgeted positions in the Sanitary Division plus 16 engineering assistants on loan from the Construction Division of the Engineering Department. In 1966 when the new Department was formed we had 154 budgeted employees. Of this number 52 positions are professional, whereas 102 are sub-professional and non-professional positions. The actual distribution of positions are shown as follows:

DEPARTMENT OF RESEARCH AND CONTROL

Budgeted Titles

Title	Number
Director of Research and Control	1
Director of Research	1
Sanitary Chemist 5	3
Sanitary Chemist 4	5
Sanitary Chemist 3	8
Sanitary Chemist 2	10


RESEARCH AND CONTROL DEPARTMENT
Director of Research and Control
Administration Division
Director of Research
Research Administration
Research Division
Waste Treatment Research
Microbiology Research
Radiological Research
Methodology
Bacteriology Research
Waterways Research
Special Problems
Control Division
West-Southwest Control
Calumet Control
North Side Control
Small Plant Labs
Shift Lab
Industrial Waste Division
Industrial Waste Investigations
Special Pollution Investigations
Compliance and Enforecments

Title	Number
Sanitary Chemist I	14
Research Chemist 3	4
Research Chemist 2	3
Research Chemist I	2
Industrial Waste Expediter	2
Civil Engineer 2	1
Operating Engineer B	5
Investigator	1
Laboratory Technician	26
Research Technician	4
Laboratory Assistant	31
Engineering Assistant 2	2
Engineering Assistant 1	18
Maintenance Laborer B	4
Secretary	1
Head Clerk	2
Principal Clerk	3
Principal Stenographer	2
Senior Typist	1
	154

Seventeen of the 154 positions were budgeted only a part of the year because we were not completely moved into our new Research & Control building. New positions were staggered between 6 and 11 months.

In May 1966, the Research and Control Department formally moved into their new installation at the West-Southwest Treatment Works. This was a 1.5 million dollar research laboratory, which when fully staffed would have a compliment of approximately 80 people. A separate administrative group was assigned to the new building.

The total budget for the sanitary division in 1965 was 894,994.00 dollars of which approximately 98% was expended. The total budget for the Research and Control Department for the year of 1966 was 1,405,983.00 dollars and approximately 88% was expended.

Research Chemist Series

It is fundamental for the success of any recruitment program and/or retention of good professional men that it must be supplemented with a strong civil service program. Not only must professional requirements be of the highest caliber, the benefits and salary ranges must meet the market of supply and demand. Accordingly, the District has implemented the recommendations of the then Sanitary Division to expand its civil service program by adopting a Research Chemist Series. This series included new titles and classifications from Research Chemist I through IV. The group not only contains a salary range commensurate with supply and demand, but also significant changes in the minimum qualification requirements. The former civil service Sanitary Chemist Series included minimum qualification requirements with emphasis heavily upon experience. In contrast, the research chemist series emphasizes academic requirements in such a way that those achieving additional academic training can substitute such training for a specified amount of experience. This parallel system of civil service classification permits a professional with long experience to advance and still provides a future growth potential for the increasing number of more highly academically trained professional without having to compete directly with the professional of long experience. This flexibility permits recruitment of research talent.

Operation Costs

Commencing with 1964, the then Sanitary Division adopted a procedure for segregating costs and analyses as they relate to different operational functions. This procedure was implemented primarily to obtain reasonably accurate unit costs. These values were proposed and approved for use in estimating analytical costs for the Federal Administration projects. The following Table compares not only the number of analyses in the years 1964, 1965, and 1966 but also shows how the costs per analyses changed in this time period.

RESEARCH AND CONTROL DEPARTMENT SUMMARY COSTS

A. TOTAL COSTS

	No. of Analyses	$ Cost/Analysis *
1964	259,672	2.54
1965	328,698	2.71
1966	392,169	2.25

B. RESEARCH COSTS

	No. of Analyses	$ Cost/Analysis *
1964	38,832	6.26
1965	86,901	4.40
1966	148,665	2.61

* Includes personnel, supplies, new equipment

It is clearly evident that the total costs which include the personnel, supplies, and new equipment, exhibits an unusually low cost per analysis for the

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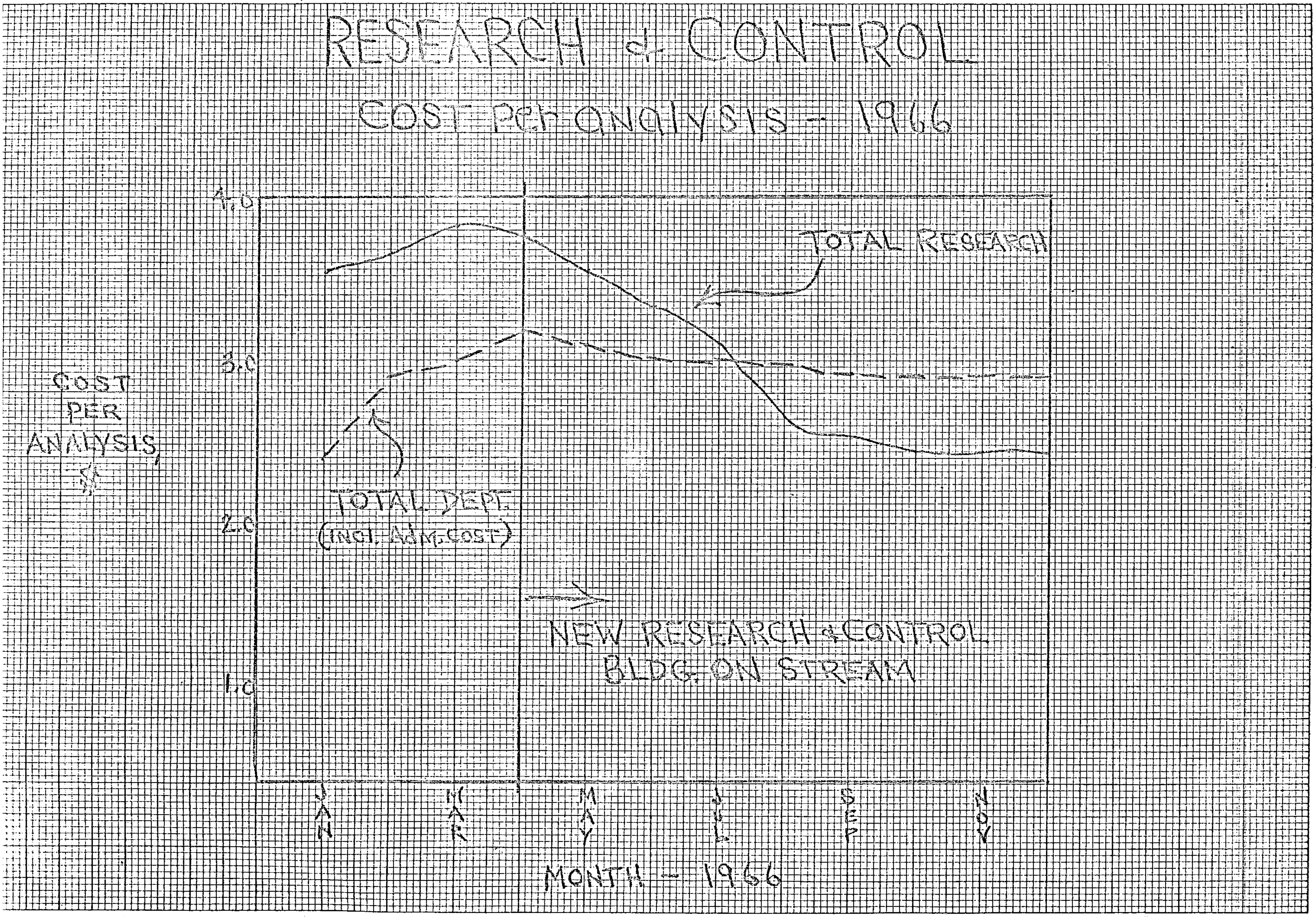

RESEARCH & CONTROL
COST PER ANALYSIS - 1966
4.0
3.0
2.0
1.0
COST PER ANALYSIS, $
TOTAL RESEARCH
TOTAL DEPT. (INCL. ADM. COST)
NEW RESEARCH & CONTROL BLDG. ON STREAM
JAN
MAR
MAY
JUL
SEP
NOV
MONTH - 1966

District. Also from this table it can be seen that the number of research analyses have sharply increased and the cost per analysis showed a marked decline.

Wtih regard to research cost, it is projected that with the leveling off of personnel in 1967, and an anticiptated increase productivity, the unit costs for research and other laboratory work should decrease further. The basis for this observation is readily evident in the figure on the following page titled "Research and Control Department - Cost per Analysis 1966". The figure shows that after placing the new research and control building on stream with its automated systems, there was a progressive reduction in costs per analysis for research thereafter. As more systems become automated, the productivity should increase without a significant increase in total expenditure and a lower cost per analysis.

INDUSTRIAL WASTE CONTROL

I. Introduction

During the summer of 1963 the District embarked upon an accelerated program for control of waste from industrial establishments. This program was given impetus by the adoption of the new Industrial Waste Ordinance (1962), which was primarily designed for regulation of industrial waste discharges to The Metropolitan Sanitary District sewerage system. The 1946 Ordinance provides the Metropolitan Sanitary District with the authority to control and abate pollution of waters within the District caused by the discharging of industrial and other wastes. The assignment for this accelerated program was given to the Sanitary Division of the Engineering Department which has since become the Research and Control Department.

II. Objective

It was readily apparent at the onset that the number of industrial establishments within The Metropolitan Sanitary District of Greater Chicago was not only numerous, but diversified and heavily endowed with fabrication and metal plating industries. This realization dictated that a program be implemented whereby a reduction of existing pollution and the prevention of new pollution would be accomplished so that a rate of control would be established wherein a large backlog be eliminated and still keep pace with new problems. In 1963 there were approximately 13,500 business establishments within The Metropolitan Sanitary District. In 1966, this number exceeded 15,000. Conservatively, 5% of our industry will change its existing process waste each year through modification of existing process, new developments, or additions. Translating this to the present we are faced with about 750 new problems requiring our attention each year. In order to catch up on a backlog of existing industries, it was necessary to contact between 1,700 industries in 1963, and approximately 2,000 establishments by 1966. Even at this pace it would take a number of years to cover the needs fully. In addition, an ever increasing number of approved discharges had to be provided for by means of a follow-up program. Since the number of approved installations were approximately 10% of those screened, it became quite clear that the accelerated program would create a rapidly increasing number of approved installations that would require increased manpower for full control.

III. Personnel

At the onset of the program in 1963, the Industrial Waste Control Section of the then Sanitary Division was reorganized and the personnel that were initially carrying out stream sampling at remote locations were consolidated and assigned to Industrial Waste Control phase. This group was comprised of 22 employees as follows: One Coordinator, two Civil Engineers, two Industrial Waste Expeditors, one Sanitary Chemist, and Sixteen Laboratory Assistants.

By mid 1964, the Industrial Waste Control Section added to its staff another Sanitary Chemist and a Sanitary Engineer, but lost two Civil Engineer titles. In order to bolster the personnel needed for fiscal 1965, sixteen Engineering Assistants were "loaned" to the Sanitary Division to do industrial waste field work. The existing field personnel then under the supervision of the Industrial Waste Section were transferred to different laboratory areas to assist in handling the increased work load such as was coming in from the Industrial Waste Section. On January 1, 1966, after the Sanitary Division became the Department of Research and Control, the Industrial Waste Control Section became a Division. At that time, the Division staff increased to 26 persons and included on a permanent basis 20 Engineering Assistants of which 18 were Engineering Assistants I and 2 were Engineering Assistants II. This change also included the addition of an Investigator. No change in personnel was requested for fiscal 1967.

IV. Operations

Prior to the implementation of the accelerated Industrial Waste Control Program, an average of 50 industrial plants per year received technical studies with approximately 30 emergency calls. During this period the Industrial Waste Control Section cited approximately 12 industries per year with infractions of the Ordinance. To the best of knowledge, no requests for Show Cause proceedings had taken place.

In 1963 the patrol boat "John N. Cullerton" was used primarily for patrolling or surveillance of the waterways with regard to waste dischargers. Shortly thereafter, the boat was converted to a floating laboratory and placed under the supervision of the Waterways Research Group. The boat facility was thereafter used primarily for research. However, at the same time the boat doubled as a patrol against direct discharges to our waterways. Whenever the

Industrial Waste Section received any urgent requests for a stream level checkout the boat was made available for this purpose.

The general administration instituted a bi-monthly helicopter flight program early in 1965. This provided the Industrial Waste Group with complete flexibility so that control could be implemented by air, as well as by land and water.

By mid 1965, the use of automatic equipment to supplement its manual sampling, monitoring, and surveillance programs had been incorporated. This equipment consists of line, battery, gas and vacuum activated sampling devices, and flow gauging instruments. Other equipment purchased was a smoke generator, manual and automatic pH sensing equipment, and sewer detecting equipment.

The Division is comprised of investigators, chemists, engineers, technicians, and field survey crews who carry out the Industrial Waste Control Program excluding the laboratory services used for numerous analyses. A brief summary of the Division's operations follows:

> Investigators make personal calls on each industry and conduct initial surveys of the liquid waste handling facilities. If it appears that there may be a problem, a formal technical study involving representative sampling of waste discharges is recommended.
>
> The technical studies are under the supervision of the professional personnel, and waste samples are submitted to The District's analytical laboratories. The analyses are reviewed at Industrial

Waste Control Division headquarters, where a decision is made regarding compliance with the waste ordinance. The company is notified by registered letter along with a copy of the analyses. A schedule of engineering and construction is required by The Sanitary District for its review and approval within a specific time period. The subsequent period also involves meetings with the company's consultants and their engineers. Visits to the plant are made periodically to check progress of facilities being installed.

When the company has advised that the necessary facilities have been placed in operation, a follow-up study is made by the Industrial Waste Control Division. If the wastes are acceptable, the industry is notified by letter and placed on the Division's approved list.

If at any time it is determined that an industry is not cooperating or not showing good faith, the Division requests an order from the Board of Trustees of The Metropolitan Sanitary District for a Show Cause Hearing to determine why their discharge should not be discontinued.

However, all industries are subject to re-evaluation to insure continued compliance with the ordinances. The Metropolitan Sanitary District also has a continuing operation of re-evaluation and review to maintain pace with industrial expansion and process changes in existing plants.

V. Accomplishments and Program Status

Table I represents a summary of the Industrial Waste Control Division's key activities for the year of 1966, whereas Table II represents the summary of the same activities since the Division's inception. The latter is included for the purpose of providing a picture of change.

The enormous number (4900) of plants visited, and the many emergencies and special investigations (1200) handled by the Division, depicts the high functional capability and efficiency of the Division.

One of many examples of a typical problem that the Field Survey Group has been confronted with is the investigation of oils that have access to our North Side Treatment Plant. (38)

This is an extremely complex problem which involves the discharge of many industries of which the majority are located in Chicago. As substantiated in the aforementioned report, the Industrial Waste Control Division has been able to effectuate the removal of a considerable amount of oil from the sewers. However, due to the ever increasing number of industries within the District, and the unregulated control until the passage of a new waste ordinance by the City of Chicago, progress was limited. The problem will need considerable effort by all parties concerned before a satisfactory solution is achieved.

VI. Industrial Waste Ordinances

The industrial waste and pollution control ordinances now in force do not provide for handling all the existing diversified problems which confront the Industrial Waste Control Division. Maximum protection of

TABLE I

Industrial Waste Division - Summary of Key Activities for the Year of 1966

Industries expedited	1290
Industries notified of violations	71
Industries completing abatement facilities	63
Industries to Show Cause - why pollutional discharges should not be discontinued	18
Technical Studies	257
Emergencies and special investigations	405

Constituents Removed from the Waterways - Lbs/day

BOD	600
COD	1400
Total Suspended Solids	600
Phenolics	100
Hexane Solubles	700
Alkalinity	150
Acid	500
Cyanide	100
Chromium	50

Constituents Removed from Sewers - Lbs/day

Hexane Solubles	3500
Acid	1900
Alkalinity	2900
Chromium	450
Cyanide	200

TABLE II

Industrial Waste Division - Summary of Key Activities from July, 1963 to March, 1967

Industries expedited	4,900
Indistries notified of violations	232
Industries completing abatement facilities	123
Industries to Show Cause why pollutional discharges should not be discontinued	25
Technical Studies	850
Emergencies and Special Investigations	1,200

Constituents Removed from the Waterways - Lbs/day

BOD	40,500
COD	145,000
Total Suspended Solids	93,500
Phenolics	700
Hexane Solubles	19,700
Alkalinity	3,600
Acid	5,200
Cyanide	1,000
Chromium	350

Constituents Removed from Sewers - Lbs/day

Hexane Solubles	24,500
Acid	7,500
Alkalinity	8,000
Chromium	1,300
Cyanide	1,100

our sewerage system, and waste treatment plants is difficult to maintain in our rapidly changing District. The ordinances have not been designed to regulate fully the strength and character of wastes received by our systems. In most cases damage to our collection system or treatment facilities has to be established. Preventive control is very weak since it is limited to a few parameters.

The ordinances should be strengthened with more definitiveness, such as the incorporation of service charges. This would provide an incentive to industry to maximize internal control so that charges would be kept at a minimum. The ordinances must also be devised to provide a system whereby the concentration of certain constituents having accumulative characteristics can be controlled before damage is apparent.

CONTROL LABORATORIES

I. Introduction

The primary function of the Control laboratories is to give support to the operations of all the District treatment plants. To perform this function, there are three large laboratories located in the three principal plants; North Side, West-Southwest Complex, and Calumet. There are also three smaller satellite units situated in strategic areas of Cook County. In the Northwest quarter, there is Hanover Park; in the South, Hazelcrest; and in the Southwest portion, the Lemont-Lockport control points.

The largest of the Control laboratories is located at the West-Southwest Complex in Stickney. At this laboratory, chemical analyses are performed for the West Side Treatment Works, the Zimmerman Wet Air Oxidation Plant, and the Southwest Treatment Works. Included with the latter plant is the anaerobic digestor units and the fertilizer production plant. Within this complex are four separate and different means of waste treatment; the Imhoff anaerobic tanks, the anaerobic high rate digestors, the anaerobic activated sludge process, and the Zimpro oxidation method. Consequently, this variation in treatment requires individual service which is provided daily by the General Control Laboratory.

Prior to May 16, 1966, the General Control Laboratory, known formerly as the Main Lab, was located on the fourth floor of the Pump-Blower House at the Southwest Treatment Plant. As of that date, it was moved into the new Research and Control Laboratory building. The move was accomplished on a weekend with full service resumed on Monday morning.

Since the re-location, the laboratory has had many changes in its development. The staff has been increased by the addition of women chemists, technicians, and assistants. The arrival of women in these positions has marked an historical turning point in the Department.

The use of automated equipment in the lab is another turning point of significance. The utilization of instruments has not reduced the number of employees, but has in fact provided an opportunity for them to become more proficient. More samples may be analyzed in the same period of time with a hgiher degree of efficiency and accuracy than by the old "wet" methods of chemical analyses.

II. Analytical Services

Basically, the analytical support is the same throughout the District. The quantity of samples differs in relation to the size or complexity of the installations. Samples are taken at the various steps of treatment as indicators of the efficiency of the operation at a particular point and for the quality of the final product. Representative sampling is very important in the appraisal of a plant's performance. Therefore, a continuous review of the sampling methods has been conducted by the M&O and R&C Department.

A typical array of the daily work load performed by the larger plant control laboratories exclusive of the shift lab is tabulated below:

	Number of Samples
BOD	60
Solids:	
Suspended	60
Total	30
Settleable	15
Alkalinity	15
COD	15
Nitrogens	80
Hexane Solubles	5
Oils (all determinations)	5

	Number of Samples
Coals (all determinations)	5
Ferrics (all determinations)	5
Trace Metals & Toxic elements (all determinations)	10
Fertilizer (all determinations)	5
Phosphates	10

The above groups do not include special work for Industrial Waste, Waterways, etc.

Automatic equipment has been installed in all the plants. At the North Side plant, the M&O and R&C Departments are studying the use of refrigeration with the automatic equipment to preserve the sample until it is analyzed. On-the-spot determinations are also being studied, such as various types of dissolved oxygen analyzers and the use of the Technicon Auto-Analyzer for chemical oxygen demands. The latter instrument is currently in use at the North Side plant on the preliminary effluent. The role the control laboratory plays in these endeavors is to supply the necessary data to the engineers for their use in plant operations control.

The control laboratories then have a secondary function of supporting the research activities of other Departments. There is also the work of the industrial waste and sewer control sections which requires special consideration. Particular attention is given to industrial waste loadings that may affect a plant's operations. In such cases, these samples are very carefully examined to identify their source. When a hazardous waste has been identified, the information is given to the Sewer Control Sections of the M&O Department, and the industrial waste sections who take the necessary steps in preventing a reoccurence.

The waste control program receives all its analytical data from the control laboratories. Industrial waste samples are brought to the laboratories from the entire area of the Metropolitan Sanitary District. The wastes are analyzed for their affect on the sewer system, plant operations, and stream pollution. The analysis of industrial waste is a separate field in itself, and consequently demands the specialization that it receives. Similarly, there is the field of stream pollution which is another phase of the laboratory commanding particular attention. While stream pollution is a branch of Research, the routine analytical work is performed by the Control laboratories whenever possible.

III. Additional Services

Another activity of the Control Division not generally known is the materials, and the oil and lubrication laboratories. These two labs provide a quality control of all contract purchases of coal, ferric chloride, fuel oils, greases, soaps, sweeping compounds, and all lubrication products. Every barge of coal purchased by the District is examined for its BTU value, sulfur, and ash content. Each car of ferric chloride arriving at the Southwest plant is assayed for its ferric content. The ferric used in the production of fertilizer is monitored daily by the laboratory. Fuel oil is also checked to be of the quality specified by contract. In addition to the quality control work, the oil lab provides a necessary assistance program of periodic inspection of oils used in the machinery throughout the District. Examination of the oil in use is an aid in detecting possible equipment breakdown.

IV. Data Dissemination

Dissemination of the data is accomplished by several means determined by its necessity. Information essential to the daily operations is phoned directly to the plant operators. Other data is reported by the use of standard forms and by log books. The communication procedures are established with M&O in order to provide the most expedient and efficient service to the Maintenance and Operation Department.

It has always been the practice of the Research and Control Department that since the District is primarily in the business of waste treatment that the analytical services to enhance plant operation efficiency is of the first priority. In fact, approximately 50 percent of the Departments analytical services at a minimum must be made available for such control work.

An indication of the support given by the control group laboratories to plant operation and industrial wastes control is shown in the following tabulation:

	Control analyses		Controls cost/analyses *
	Normal	Industrial	$
1964	209,658	11,182	1.29
1965	217,400	24,397	1.21
1966	224,228	19,276	1.26

* Total costs includes labor, materials and equipment.

However, the above listings do not include the many analyses performed by this group for the various research programs which are reviewed elsewhere.

Enumeration of all the types of tests performed, the kinds and sources of samples, the special requests handled, and the various services offered by the laboratories would be a voluminous task. A few of the phases have been mentioned as a means of relating what the role of the laboratory is in the overall operation of the Metropolitan Sanitary District.

SPECIAL SERVICES FOR PLANT OPERATION AND CONTROL

1. Shift Laboratory Tests

The shift laboratory personnel consists of four Laboratory Technicians who provide this service 24 hours per day, 7 days per week. These men carry out tests which are important for the efficient operation of the Filter Room; namely, the determination of the cake moisture (composite of all filters in service) every four hours, tons of water evaporated, and tons of dried solids produced per hour per line every four hours. Through these tests, the four and twenty-four hour production of fertilizer is calculated.

The following tests performed by the shift laboratory personnel are:

(1) The determination of mixed liquor solids in each of the three batteries every eight hours. The results of the mixed liquor solids are used by the plant operating engineers to calculate the sludge volume index and to know the concentration of mixed liquor solids.

(2) The determination of return sludge solids in each of the three batteries every eight hours. The results of the return sludge solids are used by the plant operating engineers to figure their waste to the concentration tanks and return to the batteries.

(3) The determination of moisture in the mixes for each line in service every eight hours. The results of the moisture in the mixes are used by the boiler engineers to make adjustments in each drying line.

(4) The determination of filter feed solids every four hours. The results of the filter feed solids are used to make adjustments in the concentration of the

solids and also in the calculation of total tons of dried solids pumped to the filter room per twenty-four hours.

(5) The determination of volatile solids in the Zimpro solids every four hours. The results of the Zimpro volatile solids are used to make adjustments in the concentration of the Zimpro solids.

(6) The determin ation of percent ash in the cake, moisture and pounds per cubic foot of fertilizer every eight hours. The results are included in the daily production report.

(7) The vacuum, pH used in the filter room, and the number of filters and drying lines in service every four hours are recorded in the daily production report.

2. Chemical Boiler Treatment

The purpose of the internal chemical treatment of the boilers is to control erosion, prevent scale formation, and produce good quality of steam by preventing carry-over, which is caused by foaming and priming. Also, through the results of the analyses, leaks in the boilers can be detected.

Daily chemical tests are performed on all boilers in service for alkalinity, phosphate, sulfite, dissolved and suspended solids and anti-foam.

From the results obtained a written report of recommendations is made daily to the boiler and boiler feed engineers by the boiler water laboratory technician under the supervision of a chemist.

The recommendations include changes in continuous blowdown, mud drum blowdown, and the rate of pumping caustic, phosphate, sulfite, and anti-foam.

3. Quality of Steam Generated.

The 24-hour charts from all boilers in service are collected daily by a laboratory technician. The average micromhos of solids and gas fractions are checked in each boiler steam quality meter in order to check the performance of the boilers and the meters.

When a meter is out of order, or shows abnormally high or low readings, the actual fractions of the solids and gases are collected and analyzed. The results of the analysis are reported to the instrument men and the engineer in charge of the boilers. Usually one or two steam quality meters are checked weekly, and the results are reported to the instrument men and to the engineer in charge of the boilers.

4. Turbine Blade Deposits

For years soluble mineral deposits on turbine blades were known to cause trouble especially in industrial plants. At the Southwest Plant we have been troubled by such deposits on the turbine blades on all three generators. However, no bothersome deposits occur on the turbine blades of the pumps and the blowers, even though we use the same steam. The reasons may be that pumps and blowers are not in service for long periods of time as are the generators and that steam is extracted from the generators only. When the deposits increase the efficiency of the generator is reduced.

Prior to December 1964, when a generator had to be taken out of service due to increased deposits on the blades, it required a long period of time before the unit went back into operation. The removal of the deposits required mechanical cleaning. The shaft with the blading had to be removed from its place and every blade had to be scraped by hand.

It was an expensive method of cleaning. Since the analysis of the deposits showed that they contained mostly carbonates and chlorides, and they were 97% soluble in hot water, the chemist in charge of the boiler treatment, E. N. Sakellariou, recommended that it would be feasible to remove the deposits by washing the turbine with hot condensate water while revolving the turbine slowly. The washing of the turbine was adopted and it required four to five hours to complete.

In October 1964 the use of a new anti-foam was introduced to reduce carry-over. However, no improvement in the prevention of deposits was noted. Subsequently, it was recommended to employ a turbine defoulant. Beginning July 1965, the new turbine defoulant to the boiler feed line was implemented. The performance of the turbines is considered excellent, None of the generators have been out of service because of turbine blade deposits since August 27, 1965.

Judging from the performance of the units and from actual examination of the blades of generator No. 2 in March 8, 1967 when the unit was down for other type of repairs, it is evident that the addition of the turbine defoulant has prevented new deposits as well as removing the old deposits from the blades.

5. Demineralizers

All samples produced from each unit at the final regeneration are brought to the laboratory and are analyzed by the technician for pH, dissolved solids, and chlorides. For each regeneration there are seven to ten samples to be analyzed, (Samples taken by the engineers every 10,000 gallons). When there is any discrepancy in the results, the engineers are notified. The four demineralizers performed normally after changes were made on No. 1 and No. 3 units. On investigation, the resins of No. 1 and No. 3 units showed a considerable reduction in exchange capacity and were replaced with new and higher exchange capacity.

6. Boiler Feed Water Make-up

The boiler feed water make-up was equal to 4.3% of the steam generated. All the boiler make-up water was demineralized. No raw water was used for the boilers during 1966.

7. Condensates

The readings of the micromhos on all condensates, blowers, Zimpro return, and generators are checked daily from the continuous strip chart. If any unusually high reading is noted, an actual condensate from that units is collected and analyzed for pH, dissolved solids, and ammonia for possible contamination by leaky condensers.

The Zimpro condensate return was found to be contaminated three times through a leaky condenser. The engineer was notified and the condensate was wasted until repairs were made. Also a generator was taken out of service due to condensate contamination.

8. Bearing Cooling Water

A sample of the bearing cooling water is obtained by the boiler laboratory technician every week and analyzed for chromate content. If the chromate content exceeds a predetermined level, the boiler engineer is notified of additions needed to bring the solution to proper limits in order to inhibit corrosion.

9. Blower, Asbestos, Air Filters

The purpose of sampling and testing of raw and filtered air is to detect any particulate contamination in the filtered air due to a break in asbestos bags, infiltration, or any other causes. The ultimate goal is to prevent clogging of the air diffuser plates in the activated sludge process.

There are 14 air sampling places; a separate one for each of the 12 compartments. There is also a sampling place for the raw air and the combined filtered air (Air Main).

The raw, filtered air, and six individual compartments are sampled once a month.

Preweighed paper thimbles are used to collect the dust from each unit. At the end of the month the thimbles are removed, dried overnight, and the amount of dust is determined.

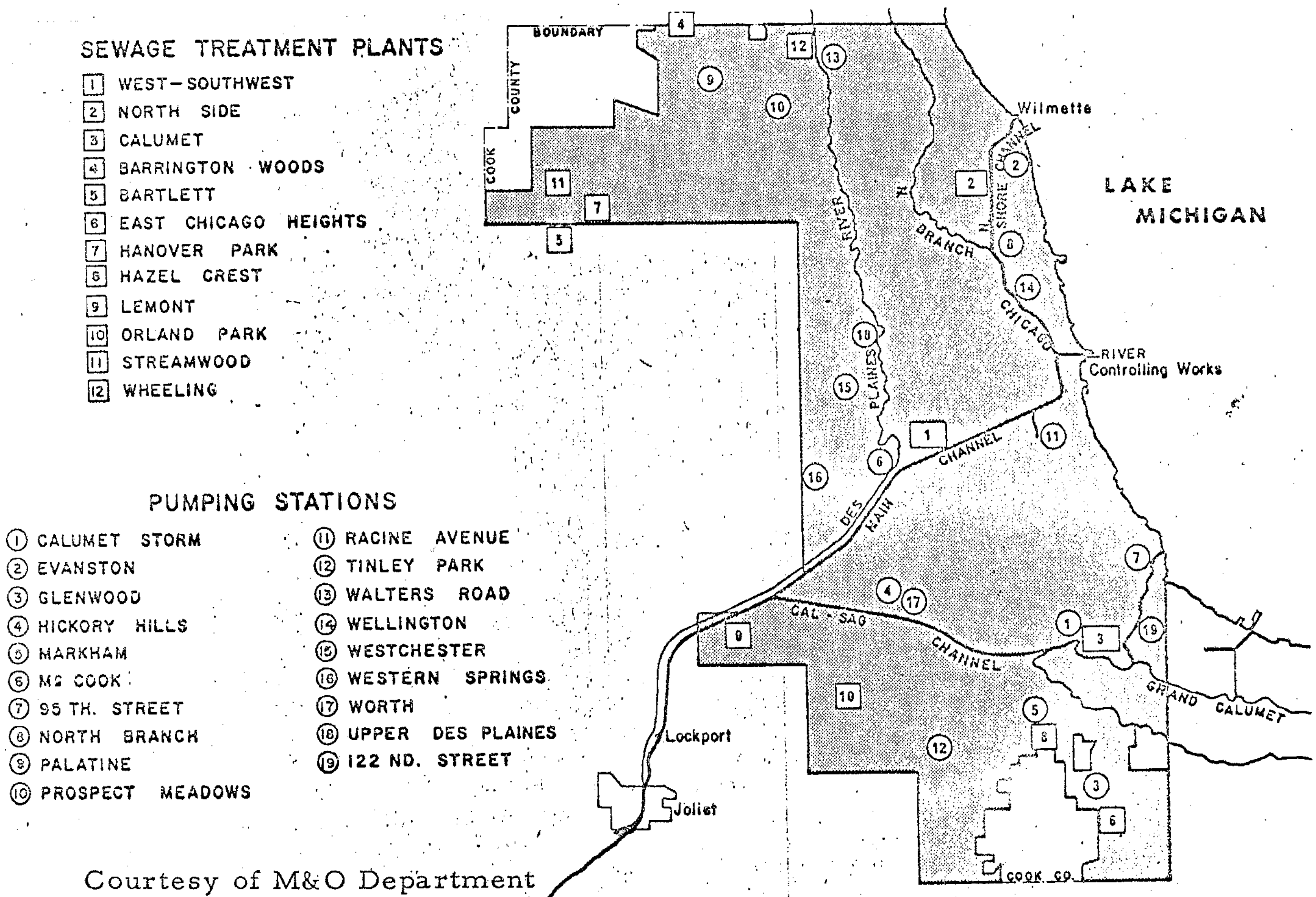
The average dust concnetration in the raw air was 8.7 mg/1000 cu. ft. of air, and the filtered air in the air main was 0.04 mg/1000 cu. ft. The average dust concentration immediately following the bag filter was 0.03 mg/1000 cu.ft. The increase of dust concentration following bag filters was probably due to air infiltration ahead of the blowers. Tests show 99.5% dust reduction in the air main and 99.6 immediately following the

SMALL PLANT LABORATORY OPERATIONS

The small plant laboratories are in areas not serviced by the three large plants of the District. Hazelcrest - far south; Lemont - southwest; and, Hanover Park - far northwest. These three laboratories give analytical support to eight Sanitary District operated plants and sixty-three private plants throughout the District. The Sanitary District operated small plants handle flows ranging from 50,000 to 2.5 million gallons/day. The raw sewage entering these plants may be entirely domestic or a combination of domestic and industrial waste. The private plants include: institutional (schools, nursing homes, etc.), trailer courts, motels, and industrial plants.

The laboratory at Hazelcrest was remodeled and enlarged a few years ago to increase its analytical capabilities. It is operated by a full-time Laboratory Technician. The laboratory in the Lemont Treatment Plant is a new facility which serves as the last check point on the Sanitary and Ship Canal within the jurisdiction of the Sanitary District. The Canal, at this point, is the final effluent of the Sanitary District, except for a relatively small portion of the far northwest corner of Cook County. This laboratory, operated by two technicians, helps to keep a check on the waterways quality; it services the automated sampling station at Lockport and lends support to the other plants in its vicinity. Many of the samples collected by the Waterways patrol boat are processed at this laboratory. The Hanover Park laboratory services one of the newest treatment plants of the Sanitary District. Ultimately, this plant will operate as a tertiary treatment plant; some preliminary investigations along this line are already under way. The staff, a chemist and two technicians, also provides lab support to small plants in that area.

The coordinator of the small plant laboratories, who acts as the liaison between the Director of the Department and plant operating personnel, meets with the Director once each week to discuss and interpret results. These meetings combine laboratory results and operational data from the three major facilities as well as the small plants.



Courtesy of M&O Department

RESEARCH DIVISION

Introduction

The organization of this division consists of the following sections and functions:

Administration provides the division and the main laboratory with clerical, storekeeping, shipping and receiving, janitorial and building operator's services.

Waste Treatment Research carries out direct research on present and anticipated problems in the treatment and disposal of sewage. Responsibilities here include lab scale to full scale studies of all phases of treatment. Plant scale research on flotation for sludge concentration and vacuum filter studies illustrates the scope of the work done.

The Waterways Research and Stream Surveillance has a continuing responsiblity to assess the quality of the waterways within the jurisdiction of the Metropolitan Sanitary District, to determine the sources, quality, and quantity of contaiminants in the various discharges, and to evaluate measures needed to maintain prescribed water quality. It must also provide information on stream quality and industrial waste discharges as they affect the Calumet Region Waterways to fulfill the District's responsibilities resulting from the Lake Michigan Water Pollution Enforcement Conference of the Federal Water Pollution Control Administration in 1965. A subsection of the Waterways Section, the data evaluation program, utilizes computer techniques in the digestion and interpretation of the voluminous data generated. Computer techniques of data reduction were used effectively in the study of chlorination of treatment effluent.

The eventual computer treatment of all data should result in the elevation of this program to section status.

The Methodology, Special Problems, and Radiochemical functions are combined under one head to provide these services to the Research and Control program. Methodology evaluates new instruments, develops or applies new analytical methods, and, in general, acts as the testing ground for new ideas on improving the productivity, quality, and/or efficiency of laboratory operations. Special Problems carries out any investigations needed to identify or characterize new, exotic, or otherwise troublesome materials involved in the treatment processes of the District. Radiochemistry provides the equipment, tagged radiochemicals, and the technical support for carrying out studies employing this new scientific tool.

The Microbiology and Bacteriology Sections, are combined under one head, perform the special research on the biological treatment systems and provide the bacteriological support to the Research and Waterways programs. A detailed review of the programs carried out by these sections is described in subsequent paragraphs.

REAERATION OF VACUUM FILTER FEED
Project A-3-64

In reaeration of filter feed prior to vacuum filtration, the goal is increased fertilizer production on the filter floor with reduction of ferric chloride consumption. It is necessary to determine the decrease in cake moisture, the decrease in filtration time, and the decrease in ferric chloride consumption for various air flow rates, and detention times on a continuous flow basis for both spiral and ridge and furrow aeration designs.

Finally, it is necessary to determine whether reaeration is economical and practical. Can an existing filter feed holding tank be modified to do the job or must one build additional tanks?

Henry J. King (1956) in an interoffice memo based on the work under the direction of Messrs. Beck, Sakellariou, and Krup at the plant laboratory projected savings of $300,000 annually in chemical costs by reaeration. (These were batch aeration studies).

Batch aeration tests in a scaled down model of a concentration tank with spiral aeration design under the direction of G.A. Ettelt in 1965 gave a 3% reduction in cake moisture with 2 hour reaeration time and 6.0 cu. ft. of air per gallon of sludge.

A preliminary report on the first phase, REAERATION UNDER SPIRAL CONDITIONS on a continuous flow basis indicates potential benefits such as: 20% reduction in ferric chloride requirements; reduced cake moisture of 0.5 to 2.0%; 25-40% reduction in filtration time. This was achieved with 3 hour reaeration time and 5-10 cu. ft. of air per gallon of sludge. The second phase study will be on REAERATION UNDER RIDGE AND FURROW CONDITIONS which may reduce the air requirements. Aeration tank changes are presently under way.

AIR POLLUTION

Research on stack gases began in 1950. The first gas scrubber on 7-B line went into operation in 1960. Gas scrubber acceptance tests were made on 4-A, 4-B, 3-A and 3-B in 1966 and 2-A in 1967. 2-B scrubber is already in operation but no acceptance test has yet been made. 1-A and 1-B gas scrubbers are being built; with their completion in 1967, all 14 lines will be equipped with gas scrubbers.

Speical stack gas tests were made on May 27 and June 3, 1966.

Scrubber water tests and their effect on treatment plant operation were continued in 1966.

A pilot plant catalytic combustion unit for the Wet Air Oxidation Plant stack gases is being tested.

Research and Control personnel aided the special investigation into the tragic four fatalities at the North Side Treatment Plant on June 15, 1966. Humidity, temperature and gas analysis were determined.

PILOT ACTIVATED SLUDGE PROJECTS

The complexity of operation of the Southwest Treatment Plant has approached a state in which its self-produced wastes may be the source of future problems. Filtrate from the vacuum filters, effluent from the Zimpro wet air oxidation plant, draw-off from the anaerobic digesters and stack gas scrubber water lead the parade of present wastes produced by the S. W. T. P. Due to the increased volume of self-produced wastes, which is returned to the Southwest Headworks, evaluation of their effects on plant performance becomes a necessity.

Two 130-gallon per day pilot activated sludge units have been fabricated and successfully operated In 1965, an evaluation of the effect of centrate from a solids bowl centrifuge on the activated sludge process was undertaken with the use of the two experimental units. (Centrate would be another self-produced waste, if solid bowl centrifuges are incorporated in the operation of the S. W. T. W.) This centrate study was supported by Federal Demonstration Grant WPD 77-01, and a final report was presented in February, 1966 in Research Paper Series #12. It was concluded in this evaluation that:

(1) The centrate solids from a solid bowl centrifuge contain fines preferentially separated from the feed with dissoluted zoogloeal masses and filamentous forms.

(2) Primary treatment could remove the bulk of centrate solids from centrifugation installations operating at solids recoveries of at least 70%.

(3) Continuous return of centrate solids to a conventional activated sludge process, after centrifugation of total waste solids output at solids recovery of 80%, will not affect the plant effluent quality or unit reductions of the activated processs

(4) At conditions noted above, a rise in SVI will result but the condition will not progressively deteriorate.

(5) Centrifugation will increase the content of filamentous forms in activated sludge process when they are initially present at high levels.

A second project along these same lines was undertaken to evaluate the effect of Zimpro effluent supernatants. This effluent contains a relatively high amount of oxidized and highly refractory soluble organic material in concentrations uncommon to normal domestic sewage. The importance of such a study is amplified by possible increased capacity of Zimpro, which could result in a marked increase in raw waste loading.

Although this study has not been completed, preliminary results indicate that addition of Zimpro effluent supernatant to activated sludge up to a maximum dosage of 1% by volume of influent flow can result in secondary effluents with an increased nitrogen content, but with BOD, COD, suspended solids and bacteriological composition comparable to a conventional process not treating Zimpro. Preliminary results also indicate a possible effect of increasing the Sludge Volume Index The continuation of this study involves a more thorough look at the Zimpro effect on SVI in both acclimated and non-acclimated systems.

VACUUM FILTER STUDY
Project A-3-1-65

Three vacuum filters at the Southwest Plant filter floor were isolated and converted to independent sludge conditioning and operation, thereby providing a testing installation. This construction change was authorized by the Board of Trustees in July 1965 and $50,000 was made available for this purpose. The basic objective of this study is to determine if a factor or factors influencing the performance of the vacuum filters can be related to, or responsible for, the drop in tonnage from the heat drying plant in the past few years.

The first phase of the study, reported October 24, 1966 by G. A. Ettelt, Pilot Vacuum Filter Study from April 25 to July 11, 1966, A-3-1-65, Research Paper Series No. 16, concluded that (1) blinding and smearing of the filter blanket decreases the filter yield; (2) smearing is the consequence of operation; (3) fungi growth is associated with blinding conditions; (4) concentrated hydrochloric acid wash was effective in temporary restoration of blanket coverage, and (5) 50% caustic wash with present drain valve leakage was not beneficial.

The second phase of this study, using fungicide to eliminate fungus growth, will be completed early in 1967. The successful completion of this project should provide information towards increasing the heat drying plant tonnage.

SLUDGE CONCENTRATION

I. Introduction

Sludge concentration or thickening has been defined as a process of removing water from sludge after its initial separation from the waste water. The basic objective of concentration is to reduce the volume of sludge to facilitate handling in subsequent solids disposal processes.

The Metropolitan Sanitary District of Greater Chicago, with its various sludge handling processes such as Imhoff drying, fertilizer production, wet air oxidation and high-rate anaerobic digestion, injects a few of its own variables which in effect dictate an approach to the sludge concentration problem somewhat governed by facilities and needs.

Operating conditions, existing facilities, and capacities require that the approach to studying the sludge concentration problem take several directions simultaneously. The needs at the District should cover three phases:

(1) An immediate program to supply additional sludge handling capacity for existing and near future conditions.

(2) Continuous program to optimize existing facilities and provide new design criteria for future construction.

(3) Basic research in sludge concentration for the long haul.

In view of the need for immediate additional capacity from existing facilities, studies for increasing the sludge dewatering capacity (vacuum filters) in our heat drying operation (16) and the addition of chemical additives to the flotation tanks for temporary sludge disposal relief (19) were made a part of the sludge concentration program. In addition, studies to optimize the existing flotation process through modifications with or without chemical additives, have been expanded and continued in anticipation of using the newly acquired criteria for future design of additional facilities (20). Further research has been completed setting forth the efficiency and costs associated with new procedures for handling sludge such as by centrifugation (9). Proposals have been made for the basic study of the biological characteristics of our activated sludge for the purpose of establishing the factors which control and/or improve the agglomeration of the sludge particles and thereby effect thicker sludge (21). At the same time, Research and Control recommendations have been adopted to increase the preliminary sludge to activated sludge ratio (P/S) which would modify the characteristics of the mixture sufficiently to enhance greater sludge concentration for use in the WAOP (22).

II. Existing Conditions

The character and composition of the sludge (mixture of solids and water) produced in the Sanitary District plants is clearly influenced by its waste collection units and subsequent treatment. In addition, these facilities are sufficiently different than those employed elsewhere in the country, whereby the efficiency and economics observed at other waste treatment works are not readily transferable to our particular system. Our North Side Treatment Works produces approximately 110 tons of sludge daily of which approximately 15% is primary solids. The latter percentage is low and is due to a short preliminary detention time at this treatment works. Sludge processing is not carried out at the North Side Plant, and the accumulated solids are pumped to the West-Southwest Works for processing. At the Calumet Treatment Works an average of 85 tons of solids are digested daily. This plant receives a high percentage of industrial wastes, whereas the North Side Plant has a comparatively small percentage of industrial load. This condition is reflected by the ash content and character of the sludge, thus the Calumet Works provides a greater potential for concentration of solids by plain sedimentation of mixtures of preliminary and secondary sludges. However, as at the North Side Works, the Calumet Plant affords very little preliminary solids detention. The preliminary solids also comprises only a small percentage of the total waste solids produced at this latter facility.

At the West-Southwest Works, the sludge handling facilities are more diversified, and the approach to studying the solids concentration problem becomes more involved. Of the incoming raw sewage, approximately 60% of the total flow of roughly 800 million gallons to the West-Southwest Works receives Imhoff tank treatment, whereas the 40% balance receives standard preliminary sedimentation of short duration. The overflows from each of these sedimentation facilities are combined for secondary treatment. However, 60% of the preliminary solids load at this large treatment works is digested by the Imhoff process and is not available for blending with secondary sludge which is needed to improve its sludge concentration characteristics. The Imhoff process retains these settleable solids in its system for further stablization and subsequent disposal as air dried solids. Moreover, with the short detention time afforded by the preliminary sedimentation units at the Southwest section of this plant, only approximately 8% preliminary solids is available for improvement of the preliminary to secondary solids ratio at the West-Southwest Works. This condition prevents forming to any significant magnitude the more favorable sludge mixture characteristic required for implementing improved solids concentration. This may be compared to other waste treatment facilities in the country where a preliminary to secondary sludge ratio in thickening may vary between 40% and 50%. The net results, even at best, is a difficult low-compressional sludge with unusually difficult dewatering characteristics. The comparatively small amount of preliminary solids, with its higher BTU value than secondary sludge, is collected from the Southwest segment of the Stickney Works and blended with the feed solids entering the Wet Air Oxidation process to improve its efficiency. In short, except for the approximately 110 tons of 15% primary to secondary ratio sludge from the North Side Works, the solids concentration problem at the Stickney Works boils down to treating pure activated sludge. Concentrating sludge, essentially 100% activated sludge solids, from a standard activated sludge system, is rare throughout the country.

Presently, approximately 900 tons of sludge solids per day are handled at the Stickney Works. The heat dried operation has approximately 450 tons/day of firm capacity. The Wet Air Oxidation anticipates after present modifications, 240 tons of firm capacity per day. The Imhoff tanks handle approximately 175 tons/day and the high-rate digestion, 100 tons. Due to existing sludge handling efficiencies and periods of downtime, these sludge facilities are frequently hard pressed and over taxed.

Other large activated sludge plants throughout the country report detention times within their preliminary units of approximately one hour. Here at the District they may vary between 5 and 30 minutes, depending upon the season of the year and the climatic conditions. However, not all of the other large plants in the country are classed as standard activated sludge systems such as exists at the Stickney Works. Some are high-rate activated sludge plants, which produce not only a higher ratio primary to secondary sludge but a secondary sludge with different characteristics which in turn provides a waste mixture more amenable to concentration. In summation, there are a number of factors and conditions which influence the effectiveness of thickening waste solids from an activated sludge system,under normal circumstances and with the existing facilities and operational procedures at the West-Southwest Works,we are dealing with a characteristic sludge which is not handled at other large city installations.

A few additional points are warranted to correlate earlier sludge concentration studies with present work. Initially, and before additions were made to the existing wet air oxidation process, bringing it up to its present 240 tons firm capacity, this process had a designed capacity of 200 tons or 140 tons firm capacity. Since the initial Zimpro design had sufficient compressed air capacity for a least 240 tons at present sludge concentration levels,two approaches existed to increase the capacity from 140 to 240 tons and take advantage of the excess available air. Increasing the loadings through the reactors per unit time could be accomplished by either a further concentration of the solids or by increasing the pumping capacity at existing concentrations. Research was performed employing centrifugation (9, 4). Although the evaluation completed by Mr. Gregory Ettelt had a favorable economic picture for the Zimpro operation the procedure was set aside for the approach of utilizing increased pumping capacity. In effect, however, by consuming the excess air capacity,further concentration of feed solids to the Zimpro process became less urgent. However, it remains to be demonstrated that the existing solids thickening facilities employed solely for the Zimpro process will be able to deliver the same solids concentration at the 240 TPD rate as they did at the 140 TPD rate.

Concentration facilities of the feed sludge to the heat dried operation (450 tons) has been frequently over extended. Formerly, 12 sedimentation tanks provided the solids thickening for this operation. One tank was converted to a holding unit and four were transferred to the Zimpro concentrating facilities, leaving seven tanks to handle the same tonnage load. The vacuum filter operation of the heat dried process will benefit from solids thickening only if the solids concentration is relatively uniform. Periods of higher sludge flow to the seven concentration tanks does not afford this. The 175 tons of solids handled by the existing Imhoff units was not considered as needing concentration studies. However, of the total 900 tons of sludge requiring processing at the Stickney Works only 100 tons of high rate digestion becomes an object of immediate sludge concentration attention. This was a consequence of being the most expeditious approach to alleviate current solids disposal needs. The additional capacity which could be anticipated from this latter facility may reach 40 to 50 tons per day.

At the same time that studies were being conducted on solids thickening, considerable effort was directed toward other potentials for achieving a greater solids handling capacity, namely, the filter floor or the fertilizer production (16). An improvement of 1% in moisture content in the filter cake is equivalent to an additional handling capacity of approximately 40 tons per day, plus other operation and maintenance benefits. The direction or needs for sludge concentration per se had been slightly altered.

Crash program employing chemical additives to enhance solids thickening were also set in motion (19). These efforts were directed primarily at increasing the concentration of the feed solids to the high rate digestion facility until such time as the flotation technique could be further optimized and tested.

III. Fundamental Considerations

In general sludge concentration can provide a number of advantages

(1) Higher concentration represent an improvement in digestion operation and cost because space is conserved. The heating requirement is decreased. Less supernatant is produced and higher solids loading to the digestor per cubic foot is possible. In addition, the microorganisms active in the digestion process are more efficient because they are doing more work per unit of solids loading. Since the MSD high rate digestion system is hydraulically loaded the detention time is not effected by solids loading.

(2) The reduction in sludge volume is reflected in a lower cost of sludge pumping and ultimate disposal.

(3) A cost of chemical conditioning if applied prior to sludge dewatering is reduced because of increased solids concentrations.

(4) Elimination of water is accomplished ahead of the digestion process and subsequent dewatering where it is most easily attained.

(5) Daily fluctuation in sludge quantity and quality are minimized.

(6) Sludge concentration generally reduces treatment cost due to savings in a physical plant size, labor, power, and etc..

Concentration of solids presently relies upon proven techniques that elevate the process to an engineering science if not an exact science. As pointed out previously sludge concentration depends upon several variables in the treatment process, and the initial composition of the raw waste is very important. The raw preliminary solids and the subsequent biological flocs from the secondary system can vary considerably from plant to plant. The biological sludges are bulky and do not concentrate as well as preliminary solids. Some of the important factors which control the final sludge concentration produced is the initial concentration of the sludge to be thickened, the density of the particle, their size and shape, the temperature and the age of the sludge, ratio of organics to inorganics and for activated sludge the design of the process itself. For the latter alteration or modification in the operation, design or technique of the activated sludge processes have improved the thickening ability of the secondary sludge in many installation throughout the country. These applications not only provided high separation efficiency in the final clarifiers (e. g. Battery D at the North Side Plant) but a sludge thickening facility can concentrate such sludges to a greater extent than obtained otherwise.

The simplest method of concentrating solids is by gravity, without the use of mechanical or chemical aids. However, in order to produce higher concentration of solids than is possible by simple gravity settling, requires other process techniques. Such successful approaches include dissolved air flotation, centrifugation, chemical conditioning and modifications of activated Sludge process.

IV. Research on Solids Concentrations

The Metropolitan Sanitary District have applied over a period of years many techniques involving the aforementioned processes. In the past three years a marked increase in testing has been implimented to optimize, expand, and finalize the procedures with regard to MSD sludges utilizing dissolved air flotation, centrifugation, and chemical conditioning.

Since the fall of 1963 Research and Control has conducted a number of tests and experiments toward improving sludge concentration and de-watering of solids. An indication of the extent of this activity can be gained from the numerous interim reports and the research papers series. Of the eighteen research papers, covering several subject problems, eleven of the eighteen research paper series relate to the solids handling problems at the MSD and seven are directly related to solids concentration and four indirectly. The latter four relate to the handling of solids after stabilization.

An excellent condensation of research and operation experience in sludge de-watering at our MSD plant is set-forth in Research Paper Series No. 10 (10) by Messrs. Ettelt and Kennedy covering progress through the fall of 1965. Subsequent work on de-watering and sludge concentration appear elsewhere in reports and papers (16,19,23). The following summary from this research paper is pertinent.

(1) Utilizing 100% activated sludge and flotation achieved 3.1% solids concentration. A combination of 15% preliminary and 85% activated sludge yielded an average of 4.5%. The effect of even this small amount of preliminary solids is most significant. The preliminary - activated mixtures afforded greater disposal capacity than activated alone resulting in a reduction of cost of 21% or $5.00 a ton. Clearly the benefits of thicker feed are substantial.

(2) Prior to modification of the Zimpro process this thickening of feed sludge from 3% solids would have diminished a unit cost by $15.50 per ton and $3.75 per ton under the modified installation provided an additional quantity of compressed air is made available. Significantly, subsequent sludge concentration savings as they relate to the modified Zimpro installation can not now exceed $3.75 /ton

(providing the same 3% solids can still be obtained after expansion) and becomes the economic limit for future concentration processing for Zimpro feed.

(3) The solids concentration of 1.5% is provided by sedimentation thickening of 100% activated sludge. Blending of preliminary and activated sludge in approximate ratio of 1 to 1 affords concentration from 3 to 5%. Other laboratory settling experiments with mixing in the compressional settled zone produces 30 to 100% gain in solids thickening. This technique was translated to a 24 foot diameterpilot unit designed for this purpose and more frequently known as the picket type thickener. With 50% activated to preliminary solids ratio, thickening was possible up to 4.4% solids. However, with a good low sludge volume index activated sludge alone the concentration averaged only 3%. In addition, to these studies on sedimentation, the use of th e wet air oxidation solids with its high specific gravity as a weighting agent was tested. However, the gain in solids and volatile content did not exhibit a synergistic effect. The addition of polyelectrolytes to these settling experiments showed 2 to 4 fold gains in solids loading. However, the dosages of the chemicals required were considered quite excessive.

(4) The disc - (nozzle) and countercurrent solids bowl (decanter) and concurrent solids bowl centrifuges were utilized for concentrating solids. The disc type was tested with and without vibrating screens, rotary screens with overhead sprays and cyclones. In one study the effluent resulting from the solid bowl centrifuge were fed to the disc type centrifuge.

The work completed and findings from these experiments are set forth in a number of reports and papers (9, 4,5). The concurrent flow solid bowl centrifuge showed the best results. The solids concentration observed varied between 6.6% and 7.5% depending upon the quality of the activated sludge. Significantly, however, when mixtures of 50% preliminary and activated sludge were applied solids concentration as high 9.8% were achieved.

As with sedimentation devices the addition of polymers resulted in improved solids concentration when thickening good quality 100% activated sludge. Further, with the 50% preliminary activated mixture, solids concentrations approached 12.5% solids

(5) The dissolved air flotation process was studied quite extensively during the past three years (19, 10, 6, 24). From the inception of these studies both in the laboratory and with pilot units this process demonstrated solids thickening superior to that of sedimentation. Based on early tests with 50 and 75 square foot pilot flotation units, total pressurization appeared to be the more desirable method, and subsequent studies were devoted to optimizing this approach. However, on a full scale basis using a much larger tank of 3,270 sq. ft. the detrimental effect associated with inlet turbulence became prominent, and solids loading was 30% less than the smaller test units. The Research and Control group recommended expansion wells (25). These were installed tangentially to the inlets within the unit. An increase in production of approximately 75% resulted.

Combining the floated and settled sludges a concentration of 3.5% was achieved. Since this represented a gain of 130% in solids thickening compared to sedimentation, the flotation process was selected for concentrating sludge at the high-rate digestor. Once the flotation facilities were on stream a second important difficulty arose, namely, the inability to attain the same air solubility achieved with the experimental unit. Even on full scale the units, utilizing North Side sludge containing 15% preliminary and 85% activated sludge, provided solids concentration of 4.5%. This concentration is 50% greater than that obtained by sedimentation and 40% more than that obtained by flotation of 100% activated sludge. Interestingly there were a few instances when a abnormally high percentage of preliminary solids was received at the flotation unit. The floated solids concentration reached 8%.

A modified experimental flotation unit utilizing polymer dosages as much as 18 lbs per ton was tested (24). This was a small unit of only 15 sq. ft. which employed pressurization of the dilution stream. The floated solids recovery showed a five-fold increase in surface loading but only a 10% gain in solids thickening compared to the large scale units. The results did indicate that recent developments with dilution pressurization may have been sufficient to supplant the total pressurization now employed at MSD.

V. Summary Observations

It has been demonstrated that in full scale testing using 100% activated sludge a concentration of 1.2 to 1.8% solids, will be achieved whereas flotation of this material will produce concentrations between 3 and 3.5%. If we have a mixture with 15% preliminary solids, as is available from our North Side Plant, 2.7 to 3.3% solids is obtained and with flotation we achieve levels between 3.5 and 4.5% solids. If we include polymers at a rate of 18lbs. per ton a further increase in solids concentration of approximately 24% may be realized. However, a cost estimate shows this chemical dosage to be less economical compared to the alterntive of building more digestors.

Presently pressurization of the recycle flow seems the more efficient method. A full scale unit is being prepared for testing of this modified approach. The objective is to float as completely as possible the solids which require concentration. As complete flotation of all the solids is approached the concentration of thickened sludge should be approximately 4% for waste activated sludge alone and approximately 5% for North Side Sludge. These values correspond to an increase in tonnage of approximately 25%. However, it must be reiterated that as we increase the preliminary to secondary ratio by providing increase preliminary detenttion time still greater solids concentration can be anticipated. Full scale testing of the recycled pressurization method is required because in large size units the finding do not always follow completely the pilot and semi-plant scale testing. What is now needed is a separate pumping station with minimal shearing action for the waste sludge flow. In addition an efficient detention tank must be obtained and installed. Piping changes required are extensive and it was therefore recommended that in order to provide a proper experimental evaluation, one of the large flotation units would require conversion (19,26).

In a more recent report from Mr. G. Ettelt who is the research project engineer for the Research and Control Department on Solids Concentration, a very significatnt point was made. Although large scale testing is underway with the flotation processes,including modifications of air input and pressurization plus polymer addition,it must not be construed to imply that air flotation is not a successful concentrating process at the West-Southwest Treatment Works in its present state of development. The future tonnage requirements could be met with adequate concentration by flotation. Recent studies could improve the process further. Conversion should be based on the results of these experiments if successful. Thus far cheaper concentrating processes cannot deliver the solids concentration afforded by flotation. Those processes that can de-water solids to a greater degree than flotation are too costly for application at our facilities, at the present time.

VI. Implementation

The finding from years of testing, development and optimization of the flotation technique will be put into practice in the not too distant future. As pointed out by Mr. Furlong, Chief of M&O, in his letter to Mr. Bacon on Jan. 25, 1967 (27), a full scale testing unit will be put on stream at an estimated cost of $45,000. This facility will employ the findings from the many experiments and studies carried out by the Research and Control Department. Conversion of No. 1 flotation tank to pressurize recycled operation at the Southwest Sewage Treatment Works has be proposed and approved. The projected accomplishment set forth in Mr. Furlong's letter of Jan. 25, that increased concentration to 4% activated sludge is anticipated,appears conservative based upon the findings of the Research and Control Department.

VII. Additional Considerations

It is anticipated that benefits will level off as we increase the ratio of primary to secondary sludge with regard to flotation application. It is possible as the P/S ratio increases the efficiency of flotation will level off and some other thickening process, such as those which have proved successful at other installation, may become more favorable.

There is a need to consider the total solids concentration problem not only as it relates to thickening before stabilization but also to the need for thickening after stabilization and prior to ultimate disposal. Thickening by centrifuge has some interesting possibilities in this regard. To this end, it has been demonstrated that activated sludge can be concentrated using concurrent solid bowl centrifuges with a good capture of solids producing concentrations in excess of 6.6% (9).

It also has been demonstrated that centrate return will not impair the plant operations (17). The economics involved in centrifugation did not warrant recommending this process as a means of concentrating solids prior to high rate digestion, even though the economics did appear reasonable for the concentration of solids by centrifugation prior to the recent modification in the Zimpro process.

Present plans at the District is to proceed with land disposal. Land dis-p osal involves pumping long distances and any practice that will reduce the volume which must be transported has economic advantages. Although the high rate digestion process is hydraulically fed on a time sequence there are intermittent periods when the stabilized mixture is withdrawn to provide room for feeding undigested material. It seems appropriate that an investigation should be made in the use of centrifugation to concentrate the digester drawoff with the possibility of employing the same equipment used to concentrate the feed. The use of centrifugation for a dual purpose as indicated above could conceivably result in a more favorable economic picture.

VII Summary Conclusions and Recommendations for Future Solids Concentration Considerations

1) Higher primary to secondary solids ratio improves sludge thickening. Greater Solids concentrations can be expected from all thickening facilities fed this mixture after expansions of So. W. preliminary tanks are completed.

2) Dissolved air flotation has demonstrated to be the best thickening process (exclusive of dewatering devices) and new concentration facilities should be based on this process.

3) Since dissolved air flotation has the capability of providing the limiting solids concentration by thickening processes apart from dewatering techniques research involving solids concentration per se should be committed to optimization of this process.

4) Chemical additives as polyelectrolytes have shown to benefit solids thickening and studies should be extended with such agents.

5) Sludge concentrations facilities for Zimpro process should be observed after the expansion of the latter. Suspected inadequate capacity may result. Expansion of these solids concentration facilities with conversion to flotation would then be warranted. In which case expansion should be sufficient to permit return of four concentration tanks back to the heat dried process.

6) Research into the characteristics and nature of the biological flocs in the activated sludge may contribute to means of improving floculation and thus concentration. Such research is past due and should not be delayed.

7) Critical evaluation and research into modification of the activated sludge process itself should be expanded with a purpose of enhancing the thickening ability of the activated solids.

WATERWAYS RESEARCH AND STREAM SURVEILLANCE

The responsibility for maintaining adequate water quality of the streams and waterways in the District rests with the Metropolitan Sanitary District of Greater Chicago. Because this quality is largely influenced by effluent discharges of the District plants, by certain industries, as well as by storm overflows from the District interceptor system, constant surveillance of existing quality is mandatory. This surveillance program will, therefore,provide the baseline data from which assessment can be made of the effectiveness of abatement measures planned and placed into effect in subsequent periods. The data collected from these studies are also useful as part of a quantitative evaluation of projected control measures such as control of dilution water flows, calculation of treatment improvement requirements, and the locations of these improvements.

A second responsibility is the direct result of the 1965 Federal Conference on the Pollution of the Interstate Waters of Lake Michigan, The Grand Calumet River, Little Calumet River, Calumet River, Wolf Lake, and their tributaries. This conference resulted in a requirement that the various public agencies carry out a water quality monitoring program in this area. The Metropolitan Sanitary District, in fulfilling its responsibilities, has been monitoring twelve stations on the streams within its jurisdiction on a once per week basis.

For these purposes the District has provided a 27 foot power boat equipped with sampling gear and on-board analytical facilities. A staff varying from six to ten persons, depending upon the programmed work, assisted by personnel at the several control laboratories carries out the assigned work. Automobile sampling crews supplement the sampling program of the boat.

A comprehensive report of the water quality conditions found during the surveillance activities of 1965 and 1966 has been prepared and published. (18) The summary and conclusions from that report, reproduced below, reveal the deteriorated water quality of the District Waterways and focus on specific quality conditions that must be improved in order to acommododate the needs of the people and industry within the District.

The Metropolitan Sanitary District of Greater Chicago has carried out a comprehensive water quality investigation of the waterways under its jurisdiction and has reported the results obtained during 1965 and 1966 for the following physical, chemical, and bacteriological parameters: Temperature, Dissolved Oxygen, Hydrogen Ion Concentration (pH), Total Alkalinity, Specific Conductance, Chloride, Sulfate, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Turbidity, Organic Nitrogen, Ammonia Nitrogen, Nitrite plus Nitrate Nitrogen, Calcium, Mangnesium, Potassium, Sodium, Heavy Metals (Manganese, Copper, Zinc, Chromium, Nickel, Cadmium, Lead), Phenols, Suspended Solids, Dissolved Solids, Hexane Solubles, Phosphate, Total Coliforms, Fecal Coliforms, and Fecal Streptococci.

The report presents these data, where applicable, as annual and seasonal summaries, including maxima, minima, and mean values or medians. The frequency distribution of Dissolved Oxygen levels is also presented at certain critical locations, including three locations where continuous monitoring or more frequent sampling was employed.

The water quality conditions found in these waterways are summarized in subsequent paragraphs.

North Shore Channel and North Branch, Chicago River

Temperature: Incoming lake water temperature rose rapidly as the water moved southward, receiving the warmer discharges from the North Side Sewage Treatment Works and other cooling water discharges. The rise in temperature averaged about 6° C, in the range 9.5° to 28.0°, during the months of May through October.

Dissolved Oxygen: Rapid depletion of DO occurred. Incoming waters containing over 10 mg/l were reduced to zero at several locations. A frequency analysis at the Cortland Avenue station (mile point 37.53) showed 95 percent of the 21 observations in July to September 1965 to be below 3.0 mg/l, 57 percent below 2.0 mg/l, and 29 percent below 1.0 mg/l. Nineteen percent were zero.

Hydrogen Ion Concentrations were found to be in the neutral range of 8.7 to 6.9 pH units; Total Alkalinity ranged from 96 to 200 mg/l, as Calcium Carbonate; Specific Conductance ranged from 220 to 650 micromho; and, Turbidity, from five to 45 Jackson units.

BOD: The BOD of the entering lake water was found to be about two mg/l. Inputs from various discharges, including the North Side Treatment Works, resulted in levels reaching an average of nine mg/l in 1965. A maximum of 50 mg/l was found.

COD: The COD levels showed changes similar to that found for BOD, ranging from an average of 14 mg/l at the lake to a high average of 59 mg/l. A maximum of 120 mg/l was recorded.

Ammonia, Organic and Nitrite plus Nitrate Nitrogen: Ammonia Nitrogen levels increased sharply from less than 0.5 mg/l at the lake to an average of over 6.5 mg/l; Organic Nitrogen from 0.4 to 3.5 mg/l and Nitrite plus Nitrate Nitrogen from about 0.25 to about 2.7 mg/l.

Metals: Calcium, Magnesium, Potassium, and Sodium ranged as follows: Ca - 35 to 57; Mg - 10 to 22; K - 1.2 to 7.7; and Na - 3.3 to 46. Of the Heavy Metals analyzed, only Manganese, Copper, and Zinc were found at levels above the detectable limit of the analyses. Manganese was found in the range of 0.02 to 0.09 mg/l. Copper in the range 0.03 to 0.7 mg/l, and Zinc from 0.01 to 0.12 mg/l. Chromium (0.02 mg/l), Nickel (0.03 mg/l), Cadmium (0.01 mg/l), and Lead (0.10 mg/l) were not found at these test detection limits.

Total Coliforms, Fecal Coliforms, and Fecal Streptococci: Geometric mean densities reached as high as 919,000 per 100 ml and individual test results were as high as 7.4 million per 100 ml. In the first two miles of waterway below the lake, geometric means were below 1,000. At the Dempster station counts rose sharply and remained high at all subsequent downstream stations.

Fecal Coliform and Fecal Streptococci exhibited similar patterns, ranging from a low of less than ten to over 1.1 million for fecal coliforms and from less than ten to 70 thousand for the fecal streptococci.

South Branch and Sanitary and Ship Canal

Temperature: Although the temperature of the canal waters drops upon mixing with incoming lake water of the Chicago River, further extensive uses for cooling and the influx of effluent at the West-Southwest Sewage Treatment Works raises the canal temperatures to high levels. A maximum of 37° C was observed at one station, with several other stations having maximum of 36° and 35° C.

Dissolved Oxygen: Nearly all stations in this reach of the canal, some 32 miles of stream, registered levels of less than one mg/l. Frequency distributions at Lawndale (mile point 21.98) show 95 percent of the tests during July-September below three mg/l, 80 percent below two mg/l, 40 percent below one mg/l, and 15 percent zero mg/l. Similar data at Willow Springs (mile point 16.84) for the period June through September 1966 show 84 percent below three mg/l, 56 percent below two mg/l, 52 percent below one mg/l, and four percent at zero.

Hydrogen Ion Concentrations were found to be in the neutral range of 8.0 to 6.9 pH units; Total Alkalinity ranged from 100 to 200 mg/l, as Calcium Carbonate; Specific Conductance ranged from 230 to 900 micromho; and Turbidity from 3 to 34 Jackson units.

BOD: The observed range in this section of the waterway was from a low of one mg/l to a high of 17 mg/l.

COD: The observed range was a low of 8 mg/l and a high of 104 mg/l, with many of the stations having maxima above 50 mg/l.

Ammonia, Organic, and Nitrite plus Nitrate Nitrogen: The ammonia nitrogen levels remain high in this portion of the waterways system. The Stickney effluent contributes a large input, doubling the average level at this point. Maxima at various stations range between 4.4 and 12.1 with many values above 8.0 mg/l.

Organic Nitrogen levels also remain at high levels, as expected, with average concentrations in the general level of 2.0 to 5.0 mg/l.

Nitrite plus Nitrate Nitrogens remain at the general level of about 1.0 mg/l.

Metals: Calcium, Magnesium, Potassium, and Sodium ranged as follows: Ca - 32 to 72; Mg - 12 to 25; K - 2.9 to 9.3; and Na - 16 to 73. Of the Heavy Metals analyzed, only Manganese, Copper, and Zinc were found at levels above the detectable limit of the analyses. Manganese was found in the range 0.02 to 1.70 mg/l; Copper from 0.03 to 0.18 mg/l, and Zinc 0.01 to 0.32 mg/l.

Total Coliforms, Fecal Coliforms, and Fecal Streptococci: The mean Total Coliform densities at all stations in this portion of the waterway was above 5,000 per 100 ml and as high as 429,000. Counts as high as 5.7 million were also observed.

Fecal Coliform levels ranged from a minimum of 10 to a maximum of 1.4 million, with the geometric mean above 1,000 per 100 ml at all stations.

Fecal Streptococcus densities followed a similar pattern. Counts ranging between less than 10 to 120,000 per 100 ml and the geometric mean values from 82 to 13,580 per 100 ml.

Calumet River, Little Calumet River, and Cal-Sag Channel

Temperature: Range 0.0° to 35.0° C in the period of one calendar year. Seasonal mean ranges: Winter 5.0° to 10.0°; Spring-Fall 11.0 to 17.0°; Summer 20.0 to 28.0° for the various stations.

Dissolved Oxygen: Range 0.0 to 12.2 in the period of one calendar year. Seasonal ranges were: Winter 2.6 to 12.2: Spring-Fall 1.0 to 8.9; and Summer 0.0 to 7.0. Nearly all the high DO results were at the station nearest the lake, and the low results near the location of the Calumet Sewage Treatment Works discharge.

BOD: Range less than 1.0 to 18 mg/l, with the higher levels near the location of the Calumet Sewage Treatment Works discharge.

COD: Range 4.0 to 80 mg/l, with the higher levels near the location of the Calumet Sewage Treatment Works discharge.

Ammonia, Organic and Nitrite plus Nitrate Nitrogen: Ammonia Nitrogen, range less than 0.1 to 14.0 mg/l. Again the Calumet Sewage Treatment Works discharge is the major source of this substance; however, a substantial amount enters the stream in the immediate vicinity below Ewing Avenue.

Organic Nitrogen, range less than 0.1 to 13.0 mg/l.

Nitrite plus Nitrate Nitrogen, range 0.1 to 14.2 mg/l.

Hydrogen Ion Concentration: pH range 6.3 to 8.7. The low pH values, 6.3 to 7.0, were found at all stations except 106th Street. The influence of the steel mill effluents is evident in this area of the waterways. Total Alkalinity ranged 43 to 345 mg/l, as Calcium Carbonate. Specific Conductance from 200 to 1,000 micromho; Chloride from 5 to 251 mg/l, and the Sulfate from 10 to 323 mg/l. Except for alkalinity, the concentrations of these ionic substances increased as the water moved away from the lake.

Phenols: Although the discharge of phenolic substances can occur throughout the whole year, the highest concentrations in the waterway are likely to occur in winter. This is due to low water temperatures, retarding the biological destruction of these substances. The winter time levels found ranged from less than one microgram per liter to 146 micrograms per liter. However, the highest recorded was 172, which occurred during the summer.

Hexane Solubles: These substances indicate the presence of oil, grease, and similar fatty materials or petroleum products. Concentrations found ranged from one mg/l to 481 mg/l. The annual averages ranged from 34 to 52 mg/l for the stations in this section of the waterway.

Total Phosphate: Concentrations ranged from less than 0.01 mg/l to 8.50 mg/l, with the higher levels occurring near the Calumet Sewage Treatment Works outfall, as expected.

Metals: Calcium ranged between 31 and 121 mg/l; Magnesium between 9.4 and 42 mg/l; Potassium 1.4 to 19.4 mg/l; and Sodium 4.8 to 164 mg/l. The low values occurred at stations near the lake. The high values near the outfall of the Calumet Sewage Treatment Works. Of the heavy metals analyzer, only Manganese, Copper, and Zinc were found at levels above the detectable limits of the analyses.

Total Coliforms, Fecal Coliforms, and Fecal Streptococci: The highest counts of Total Coliforms occurred in the vicinity of the Calumet Sewage Treatment Works outfall, where geometric means of 355,000 occurred in the summer. Counts here ranged between 20,000 and 11 million. In the reach between the lake and 130th Street the geometric mean values were below 2,000 per 100 ml and ranged between 10 and 77,000. Fecal Coliform counts followed a similar pattern. Counts as high as 900,000 per 100 ml were recorded near the Calumet Sewage Treatment Works. The Fecal Streptococcus counts reached a high of 110,000, also in the vicinity of the Calumet outfall.

A few samples obtained on the Cal-Sag between the Calumet Sewage Treatment Works and Sag Junction showed high counts of Total Coliforms, Fecal Coliforms, and Fecal Streptococci comparable to the levels found near the Calumet outfall, but with some reduction in count in the downstream direction.

Lockport and Lemont, Sanitary and Ship Canal

Temperatures: Monthly averages range between 6° and 28° C at Lemont and 10° to 30° at Lockport.

Dissolved Oxygen: The worst month of record, July 1966, showed 100 percent of the Lemont samples at or below 0.5 mg/l. June 1966 was 73 percent and September 1965 71 percent. At Lockport, the July 1966 record was 94 percent at or below 0.5 mg/l; with September 1965 at 76 percent, and June 1966 at 60 percent.

Hydrogen Ion Concentration ranged between 7.1 and 7.8 pH units. Total Alkalinity was between 140 and 225 at Lemont and between 120 and 190 at Lockport. The Specific Conductance range was 555 to

1,165 micromho. Total Dissolved Solids ranged between 380 and 780 mg/l. Turbidity averages were between 25 and 60 Jackson units, and the Suspended Solids varied between 14 and 80 mg/l. Chlorides fluctuated between 48 and 102. All of the above values represent the range of the monthly averages in the two year period of record.

BOD and COD: At Lemont, the monthly average BOD values ranged between 4.0 and 9.4 mg/l, and the COD range was 26 to 59 mg/l. The BOD average at Lockport were between 4.6 and 14.6 mg/l with the COD between 28 and 51 mg/l. The higher BOD values at Lockport were unexpected, especially since the COD levels between Lemont and Lockport do not change appreciably. One possible explanation for this discrepancy is the possibility that Lockport samples are in the active stages of nitrification.

Ammonia and Organic Nitrogen: The monthly average ammonia levels ranged between 3.3 and 6.3 mg/l, and the Organic Nitrogen between 1.6 and 3.5 mg/l, with no apparent difference between the Lockport and Lemont stations.

Flow: The range of monthly mean discharges at Lockport was 2,200 to 4,200 cfs for the two year period of this study.

The DesPlaines River at Lemont Road Bridge

Temperature range was zero to 28° C. Dissolved Oxygen frequency distribution showed the worst month of record July 1966 with only 10 percent of all results below 3.0 mg/l. August 1965 was 9 percent.

None of the samples taken in this two year period were below 2.0 mg/l. pH fluctuated between 7.6 and 8.7; Total Alkalinity between 160 and 280; Specific Conductance 620 to 1,169 micromho; Dissolved Solids 360 to 890 mg/l; Chloride 53 to 130 mg/l; Turbidity 30 to 142 Jackson units; Suspended Solids 30 to 145 mg/l; BOD 3.4 to 10.8 mg/l; COD 30 to 54 mg/l; Ammonia Nitrogen 0.3 to 1.5 mg/l; and Organic Nitrogen 1.2 to 3.0 mg/l. Average Flow ranged from a low of 30 to a high of 2,000 cfs.

It should be noted that the high COD, BOD, Suspended Solids, and Turbidities all occurred during the summer period, suggesting that the BOD and COD is due to algae growth rather than organic waste discharges. This observation further suggests that the DO values might reach lower levels than those recorded, during night time respiration of the algae.

CONCLUSIONS

1. The high temperatures (over 30° C) found in some parts of the canal system decrease the natural self-purification function of these waters by reducing oxygen solubility and increasing the rate of oxygen consumption.

2. Extremely low oxygen levels occur throughout the canal system, reaching zero throughout a large portion of the main channel. Fish and desirable wildlife cannot exist under these water quality conditions.

3. The mineral constituents (alkalinity, total dissolved solids, chloride, calcium, sodium, etc.) increase considerably above the levels present in the dilution water from the lake, exceeding the 500 mg/l dissolved solids limits of the Public Health Service drinking water standards.

4. The Hydrogen Ion Concentration (pH) of these waters is within the natural safe limits for most water uses, except for the Calumet portion where the low pH levels can result in progressive corrosion to navigation equipment, concrete, and other structures within the waterway.

5. The Ammonia and Organic Nitrogen found throughout the canal system are at levels that can result in a very large oxygen demand due to oxidation to nitrate by nitrifying bacteria. This oxidation can cause a serious oxygen depletion in the adjacent receiving waters in the future as well as the downstream waters. The nitrates resulting from this oxidation will be available as a nutrient for the prolific

development of algae blooms.

6. The concentrations found of certain metal ions indicate that these waters may become toxic to fish and aquatic life.

7. The extremely high concentrations of fecal bacteria found throughout the canal system indicate that a serious health hazard exists for those coming in contact with these waters.

8. The high level of hexane soluble materials found in the Calumet portion of the waterway is directly related to the presence of oil slicks and slimy coatings on navigation equipment, bridges, and pilings, causing the waters to be unsightly and aesthetically displeasing.

9. The phenolic substance concentrations found in the Calumet portion of the waterway are sufficient to induce taste and odor problems for a municipal water supply.

10. The information collected by this study can be used as a base for the assessment of progress in the abatement of pollution and the control of water quality of these waters.

11. The information collected is the baseline from which further additional studies must be undertaken to develop specific criteria for all dischargers, so that the resultant water quality is maintained at the desired level corresponding to the adopted water uses.

APPLICATIONS OF DIGITAL COMPUTATION TO RESEARCH AND CONTROL

The Metropolitan Sanitary District of Greater Chicago Waterways are a network of open channels fed by Lake Michigan, treatment plant effluents, and during rainfall by storm sewers at many locations.

The waterway system serves several purposes:

1. It supports seaway traffic
2. It is a recipient of treated waste effluents from the environs
3. In times of storm the waterway is a drainage canal preventing floods.

Consequently, in the light of its several functions the flows in the sanitary canals are usually unsteady, oftentimes far removed from steady state.

The Research and Control Department is faced with a considerable task in researching the needs for the present and future control of water borne pollution.

The development of a mathematical model describing the pollutional state, so to speak, of the waterway in terms of the independent variables, time and distance, during unsteady flow conditions would not only be interesting but an integral part of the overall needs to establish waste assimulative capacity of the receiving streams.

Fluid Dynamics of Open-Channel Flow

One long range goal of the Research and Control Department is the development of a mathematical model for describing the water quality and/or hydraulic changes occurring in the District canal system for given boundary values. As a first approach a model was developed to compute flow rate and surface elevation in canal networks, for given time dependent boundary conditions.

The basis of the model is the set of partial differential equations of continuity and of motion. The dependent variables are velocity and water surface elevation. Independent variables are time and distance. The set of equations constitute a non-linear hyperbolic system which can not be solved analytically. Consequently, the partial differential equations were approximated by finite difference equations and solved numerically by programmed digital computation. The program was written in quite general fashion so that a large variety of canal networks may be simulated as well as many types of boundary conditions. Applications were made to District canals and the results indicated that the one-dimensional model was quite suitable.

As stated earlier, the ultimate goal is a mathematical approximation to waterway compositional dynamics. However, the program should also be presently useful in flood control planning, canal modification studies, and canal operations.

Detailed reports covering the theory, implementation, and applications may be found in Research Paper Series 7, 11, 13, 14, and 15 of the Department of Research and Control.

Evaluation of Routine Laboratory Data

One of the pressing needs of the Research and Control Department are systems for processing the vast quantities of data associated with the monitoring of treatment plant streams and waterways. In order to meet these needs a group (presently existing as a sub-section with two people) has been set up within the department to write and execute program routines for logging daily analyses and producing periodic reports. At present the Data Evaluation group is engaged in evaluating the 1966 results for the major and small treatment plants. The routines are being written in general fashion and will be employed for data in future and past years, the only exceptions being special projects.

Evaluation of Non-Routine Laboratory Data

By the very nature of its work the laboratory will devote a considerable portion of time to research and development. One of the functions of the Data Evaluation group will be to assist in the processing and correlation of the data from other sections which are not of a routine nature. One such program has been completed.-- the summarizing and correlation of chlorination data for the three major treatment plant effluents.

Systems Analysis

Once the control data have been systemized,and time becomes available, the Data Evaluation group intends to proceed into areas of a more progressive nature. For example, model studies and time-series analyses of plant and waterway data.

METHODOLOGICAL & RADIOLOGICAL RESEARCH GROUP

The activities of this group for 1966 can be divided into four classifications; instrumentation, radiological research, methodological research, and special problems. The entire group worked as a team on its many problems, projects and associated inter-related activities.

The primary group function is instrumentation, both laboratory and process. The first involves the purchasing installation, calibration, and evaluation of preliminary data resulting from the instrumentation. Secondly, in order for the use of new instrumentation to become a routine activity a period of transition from research to control operation is required.. For laboratory instrumentation this involves further tests, training of personnel and finally preparation of a supplimentary guide to the operational manual supplied with each new instrument. In 1966, the recently purchased instruments were moved to the new Research and Control Laboratory, installed and quickly placed in operating condition.

Personnel were trained in operating and using these instruments.

In process instrumentation other transition problems arise. This primarily includes problems in sampling, the challenge of continuous maintenance free operation and interpretation and correlation of data. To date, three systems have been placed on stream for testing with varying degrees of success. Other systems are being further studied in the laboratory before attempting process monitoring.

In radiochemical research, most efforts have been involved with installing, testing, and calibrating new instrumentation. One tracer study was initiated in

1966, and satisfactorily completed in early 1967.

Natural radioactivity is being measured in selected samples for application to environmental monitoring and industrial waste control.

Methodology research involves evaluating new methods for various waste parameters together with re-evaluation and checking of existing methods. This has produced many interesting results; both the phosphate and low level ammonia methods have been modified. The phenol and cyanide tests were evaluated and proposed changes were studied. The use of gas chromotography, and infra-red and atomic absorption spectophotometry, were expanded to include new parameters, lower detection limits, and an increased variety of sample types.

Because of the analytical capabilities and special analytic techniques available in this group, various special investigations were assigned for study. These included assistance in the North Side Treatment Plant air main tragedy, the Lawndale Lagoon odor problem, and analytical back-up for the vacuum filter study, the pilot aeration study, analyses of special industrial waste samples, and special waterways analyses, as cyanide and heavy metals.

Some of the training functions of the Department have been assumed by this section. This has been discussed in another portion of the annual report. Two papers, one of which is being published, were presented by group members before technical meetings.

The section also reviews and/or writes specifications for instrumentation, equipment, and supplies, as necessary, for the Department.

Prior to 1966 the methodology group was involved in only laboratory instruments, special problems,and ordering supplies for New R & C Lab under construction. Crowded quarters, limited numbers of personnel, and the necessity to locate in several areas hindered the application of modern instrumentation analytic procedure. Following activation of the new Research & Control Laboratory the application of modern methodology to the many problems facing the MSD began in earnest. With advanced techniques now being developed for the many new instruments the future looks bright for increased laboratory productivity and efficiency. Probably all major pollution components will either be automated or at least instrumented with the exception of solids. Process instrumentation should advance even more rapidly. Automatic measurement of DO, Turbidity, and continuous COD, hopefully will be put on stream in several locations.This will provide data needed for eventual automatic plant control and finally for computerization of sewage treatment and water pollution control.

Instrumentation Progress

Presently, most common cations and anions can be measured instrument ally. Problems exist in handling two types of samples, irrespective of the type of analysis. These are samples with floating oil and samples with very high solids. This does not mean the problem is unsolvable but only difficult. For samples with normal solids to moderately high solids (return sludge), the following are measured routinely with instruments. Total nitrogen, total phosphate, ammonia, orthophosphate, iron, sulphate, sodium, potassium, calcium, magnesium, zinc, cadmium, manganese, copper, chromium, lead and nickel. In addition, many other analyses could be done instrumentally if a sufficient number of samples were available to justify the set up. Chemical oxygen demand can be measured on low solid samples from 15 to 20,000 ppm and is discussed in the process section. Phenol and cyanide have not yet been automated because the levels of interest may be below practical detection limits for these automated tests. However, the number of samples may warrant further study at a later time.

All solid analyses (settleable, suspended and % ash) cannot be measured by automation. Neither can BOD, nor hexane solubles be done, except manually. These tests are limited by legal definition of terms, and it may be necessary to redefine terms to correspond to new tests.

Handling high solids samples is the next problem being attacked in developing automated laboratory - further work using the Technician SOLID prep and an "on stream" homogenizer are being considered. When the solid problem is solved the problem of floating oil will be attempted.

Application of Lab Instruments

There are three Technicon units in the laboratory. One unit is used full time to measure total nitrogen in routine control and research samples. A second unit is used to measure phosphate, ammonia, and iron, also on routine and research samples. The third unit is used for C.O.D. measurements.

All three units are in use 6 to 8 hours per day averaging 10 to 20 analyses per hour. Little time is left for either developing new procedures or measuring additional parameters. Other parameters which can be measured with these instruments include chloride, nitrite, nitrate, fluoride, phenol, detergents (MBAS) and cyanides.

There are two Atomic Absorption Spectrophotometers in the laboratory. One of these is used daily to measure heavy metals in industrial waste samples. Waterway and research samples are also checked for cations. The metals usually checked are Zinc, Cadmium, Copper, Chromium, Lead, Iron, Manganese, Nickel, Calcium, Magnesium, Sodium, and Potassium. In addition at least ten other cations can be checked if desired. The second unit is available to carry on research in methodology and automation. In particular the determination of metals in lubricating oil was investigated.

The gas chromatograph has been used to measure individual volatile acids as found in various sewage treatment plant samples, in particular those associated with digestor operation. In addition, gas analysis as applied to air pollution and digestion studies has been attempted.

The polaragraph is a research instrument which has special applications in studying redox systems. To date the concentration of sulfide ion in various standards and samples has been measured.

The Infra-red Spectrophotometer together with column chromatography has proved to be a new and useful tool. The IR Spectra has been used to identify many organic compounds. Oils from plant operations, industrial waste samples and research samples have been analyzed on the infra-red spectrophotometer to determine type and and possible origin.

Ratio - Recording Spectrophotometer (Model DK-2A) is used in both routine analysis (i. e. detergents, phenol) and in research investigations.

Besides the above instruments, there are specialized intruments as the Coulter Counter, Automatic Titrator and various specialized equipment that are only used for special studies. These are all available for special problems that may arise.

All radiation detection instruments are in working order. Present work involves use of liquid scintillation counter to detect "natural" oils in mineral oils by natural radioactivity due to carbon - 14. This may be an important tool in tracing industrial wastes. A Carbonaceous Oxygen Demand Analyzer (TCOD) is being tested in the laboratory. If laboratory test prove successful several field tests are planned. The instrument would be used to continuously monitor effluents or influents. The unit was designed by Beckman Process Division for continuous, automatic operation. The major problem is providing a feed sample continuously to instrument which will not plug hoses or the injection orifice. The instrument works by measuring the CO_2 involved when the sample is burned on a special catalyst in a high temperature oven in the presence of oxygen gas. The CO_2 is measured by a non-dispersive infra-red analyzer.

The laboratory is comparing a Union Carbide D. O. Analyzer against the Winkler Method and a Beckman D. O. anlayzer. The analyzer measures the electrode potential of a Thallium electrode against a standard reference cell. The potential is a function of oxygen concentration. By not having a membrane the electrode can be operated under especially difficult conditions. The test probe is "on stream" in the mixed liquors of battery A at the West Southwest Treatment Plant.

In addition to the major instruments a large number of small instruments are used by the laboratory. In general these instruments are the responsibility of the supervisor of the laboratory in which they are used. These include conductivity meter, pH meters, redox meters, colorimeters, turbidimeters, amperometric titrators, automatic titrators, dissolved oxygen meters and Warburg respirometers.

MICROBIOLOGY AND BACTERIOLOGY

The Microbiology and Bacteriology Sections, under one head, provide both analytical support and research functions to the Department. Microbiology research is carried out primarily at the North Side laboratory facilities, where specialized equipment has been installed for this prupose. Facilities at the main laboratory are primarily adapted to analytical control work, although some research can be conducted as well. The combined laboratory staff, a total of nine professional and technical personnel, has been engaged in the following studies: Vacuum filter blinding; Waterways Surveillance; Chlorination of Effluents; and Bacterial Densities in Combined Sewer Overflows. These are described in subsequent paragraphs.

I. VACUUM FILTERS

Prior to the pilot study of the vacuum filters, there was established a definite relationship between the "blinding" of the filters and the fungal densities. This was accomplished by numerous samples taken and fungal densities and types derived by plate counts and microscopic examinations. A subsequent report was presented on the effect of iron (ferric) on a Penicillium Sp. isolated from the filters. From the data presented, it appeared the ferric iron was reduced by the fungus, which is very unusual. The possible means proposed were: (a) the iron was dissolved in the medium, or (b) chelation by an organic acid, e.g., citrate. Further study was recommended.

During the pilot vacuum filter study - Phase I and Phase II, a clearer understanding of the fungal relationship with the "blinding" was sought as well as the effect of "Biocide" on the fungi.

By various bacteriological analyses and isolations, it was found that fungal densities have increased in the deposits as the filters have become "blinded". The dominant types of fungi have been isolated and total sixteen (16) in number (eleven (11) yeast and five (5) molds). Five (5) isolates of these were from the filtrate after "Biocide" application and not from the deposits. These five (5) isolates were composed of four (4) molds and one (1) yeast. The remaining eleven (11) isolates from the deposits were one (1) mold and ten (10) yeasts. The only mold from the filter deposits was identified as <u>Penicillium janthinellum</u>.

At the present time, the identification of the yeast by biochemical tests are being completed. The "Biocide" application has limited the population of the deposits, but has not prevented the deposits from forming. The fungi itself may not be the sole cause, but may act in combination with other agents as the cause or may be the effect of another agent.

II. WATERWAYS SURVEILLANCE PROGRAM

The bacteriological data collected in support of this program and the Calumet Surveillance Program has been reported in the Waterways report ( ).

Using the samples collected for this program, a study of the two (2) popular media used for the fecal streptococci (membrane filter) test is being conducted. The data obtained at the present time indicate that both media (KF Streptococci Broth + TTC and M-Enterococci Agar) will equally support the "enterococcus group", but also some species of the "viridans group". That portion of the "viridans group" that grows is specific for each of the media in question. Further study is indicated on a greater variety of samples and locations.

III. BACTERIAL DENSITIES OF CHLORINATED EFFLUENTS

Coliform densities were determined on effluents that were chlorinated at controlled dosage and contact time. This was performed at each of the major plants for approximately a year. The mean minimum dosage at the various contact times to achieve an effluent quality of below 5,000 coliform/100 ml. was determined. This data was reported in the fall of 1966.

IV. BACTERIAL DENSITIES OF COMBINED SEWER OVERFLOWS

This was in support of the test chlorination of storm overflow at the 95th Street Pumping Station. Total coliform, fecal coliform and fecal streptococci densities were performed on all samples. From the data of the two (2) major storms, it was indicated that the chlorination was effective.

CHEMICAL ADDITIVES

Periodically, laboratory tests are made to evaluate chemical additives as agents for improving solids concentration or solids dewatering. Such tests are necessary because of the large number of new chemicals and improvements of existing chemicals that are continually made available by manufacturers. This situation has been augmented in recent years by the advent of a class of chemicals called polyelectrolytes. The latter additives have indicated tremendous potential. Field evaluation of all these agents, either on pilot or full scale facilities, would be too voluminous to handle.

Laboratory tests have been mainly directed to two areas. Vacuum filtration and dissolved air flotation. However, sedimentation, centrifugation, and drying have also been included from time to time. Filtration evaluation is based on the modified Buchner Test (28). The pressure cell test (6) (29) is employed for flotation. Full scale plant tests have been made both on filters and flotation tanks with additives which were first indicated beneficial by these laboratory tests. Both full scale tests provided meritorious results. (19). Further full scale tests are anticipated.

SPECIAL PROBLEMS

Several special problems were worked on by the Department of Research and Control, a few of which are set forth below:

Lawndale Lagoon Odor Study

On June 18, 1965, the then Sanitary Division of the Engineering Department was instructed to proceed with a study of the lagoon odor problem at Lawndale. Since the odors had subsided, we were obliged to examine the problem more deeply by attempting to create "Odors for Study Purposes". An extensive series of tests was conducted and reported upon in March 1966. A detailed summary setting forth our findings, recommendations, and control procedures are incorporated in a letter of March 21, 1966 to the president of the District.

The Research and Control Department recommendations were based on fact. In 1966, the recommendations were followed, and the District did not experience the odor problem of 1965.

Chlorination of Major Treatment Plant Effluent

During the period from October 1965 to October 1966, a once a week study was made of the Total Coliform densities emanating from the three major Sanitary District treatment plants. The study included the chlorination of the samples obtained, and from this data the theoretical chlorine dosages required to reduce to 5,000 total coliforms per 100 mls for three contact times were calculated.

The data was divided into three time periods:

Winter	(December to March)
Summer	(June to September)
Spring and Fall	(April & May and October & November)

Based on the overall data for the year, the following chlorine dosages (mg/l) were required for 95% confidence:

Treatment Plant	Contact Time - Minutes		
	10	20	30
North Side	2.5	1.8	1.1
Calumet	4.4	3.5	2.8
West-Southwest	3.9	2.8	2.5

This study was carried out with the joint cooperation of the Quality Control Laboratories, the Microbiology Laboratories, and Waterways Research.

95th Street Pumping Station Discharge

During 1966, the 95th Street Pumping Station (located lakeward of O'Brien Locks and Dam) was forced to by-pass into the Calumet River for a total of approximately one month ($\sim$50 cfs). This by-passing was caused by the necessary cleanout of the connecting interceptor by an industrial tar discharge. The resulting overflow into the river was chlorinated to prevent the possibility of contamination of Lake Michigan, and the bacterial populations and chemical contents of downstream and lakeward river and harbor stations were monitored. The findings from the monitoring program were used to control the chlorine dosages, thereby protecting the receiving waters from the potential health hazard associated with otherwise untreated waste discharges.

FEDERAL DEMONSTRATION GRANTS

The Research and Control Department received its first Federal Grant in the form of Demonstration Grant WPD 77-01-65 received from the Division of Water Supply and Pollution Control Department of Health,Education, and Welfare. The grant totaled $35,706.00 and was utilized for the research project entitled "Effect of Centrate from Solid Bowl Centrifuge on Activated Sludge Process." (12) The grant covered fabrication of the two pilot activated sludge units; auxiliary pumps and equipment; rental of continuous flow centrifuge; analytical support; and operational plus administrative costs. The project was successfully completed and a report was submitted to the Department of Health, Education, and Welfare in February 1966. A brief summary of this project appears in the section on "Pilot Activated Sludge Projects".

A second Demonstration Grant was submitted titled "Activated Sludge Solids Concentration by Expansion Wells". This demonstration grant was approved by the advisory consultants to the Department of Health, Education and Welfare (36). However, due to the lack of Federal funds at the time, the demonstration project did not come to fruition.

Construction of the new Research and Control laboratory was truly a dream come true for many of the older employees who well remember the old main laboratory, as it was then called, located atop the pump and blower building.

Occupancy of this new laboratory facility took place May 16, 1966. This two-level building is T shaped. On the upper level, the instrumentation room is located at the center with the Research laboratory and Bacteriology laboratory on one side, and the General Control Laboratory on the other. The leg of the T is an auditorium or training wing. This room includes a demonstration work area, a sound and remote controlled projection room, and it seats 156 people. The administrative offices are located on this level as well as the conference room and library. The lower level comprises the material testing laboratory, industrial waste laboratory, oil testing laboratory and a radiochemical laboratory. The mechanical and electrical equipment necessary for the heating and ventilating fan systems are also on the lower level, including the chiller units which supply the entire buildings' three zones with air-conditioning. The lunch room and all storerooms are located on this lower level. Included in storeroom facilities is a parts storage room, one for bottles, a glassware room, chemical room , a bulk storage area, and unique* volatile chemical room.

All sink waste piping in this laboratory is made of pyrex glass. These wastes empty into a neutralization basin containing lime. After being neutralized

*By unique it is a fire and explosion protected room alarmed with 2 banks (3 tanks each) of CO_2, in series, ready to empty into the volatile chemical storage room should the temperature rise to the alarm point.

they are pumped with either of two ejections pumps up to the sanitary sewer. Two water stills, rated at 10 gals. per hr. each, can produce 20 gals. per hr. which is collected in a 100 gal. storage tank. From here, the distilled water is pumped up to a 150 gal. head tank of stainless steel. The distilled water flows by gravity to the sinks at every laboratory bench. This water flows through a 316 stainless steel system from the time it is pumped from the lower level up to the head tank and including withdrawal from the stainless, spring loaded tap. All air entering the building through the air intakes is triple filtered. This includes the 50 percent outside make-up air that is exhausted through the fume hoods, the remaining 50 percent being made up of building air. Among some of the special features is a two-story pilot laboratory for scaled up experimentation, a dark room, and an instrument repair room.

The laboratory areas were laid out by the analyst, who arranged the various facilities and utilities to expedite the flow of work. The building was then designed, keeping the basic plan completely intact. The net result, is a compact, integrated analytical capability to carry on the work in the various sciences efficiently, accurately, and in great volume. This building has 25,000 sq. ft. of laboratory space with all work benches having utilities every 8 ft., and certain of the laboratories having non-skid floors as in the oil testing laboratory. The word utilities here includes electricity, 120V - 35 amp and 240 V - 70 amp service, air, vacuum, natural gas, and water. There are three elevators available; one for freight and two smaller ones inside, sometimes called dumb-waiters, which are used for moving samples, materials and equipment, and gas cylinders from one level to the other. There are two other rooms located on the lower level. One is the sample preparation room which is used for storage and grinding of coal samples, compositing of fertilizer samples, also the storage and compositing of Industrial waste samples to name a few. The other is the bottle washing room which contains a machine, similar to those used in dairies, for washing the three common sizes of bottles used - the pint, quart and gallon.

There are four stainless steel environmental rooms. One is held at 37° C in the Bacteriological laboratory, one is maintained at 20° C for BOD work, one refrigerator is at 6°C in the General Laboratory, and one refrigerator is held at 6°C located just inside the rear outside door of the building and available for sample drop at all times even when laboratory personnel are absent and the remainder of the building is locked. Among some of the other features that should be mentioned is a building free from vibration, washroom facilities for men and women on both floors, and a parking lot that will accommodate 85 cars.

Quoting the dedication talk given by Dr. Leon W. Weinberger of the Dept. of the Interior. "This laboratory indicates that current and future emphasis will be on solving rather than merely defining the country's water pollution problems.

"Demands on pure water are bound to increase due to increases in industrial plants, population and agricultural growth, but our water pollution problems will also increase.

"By the application of pollution control technology - and this new laboratory a prime example - we can have an abundant supply of fresh, pure water for all future generations."

It is understandably true, that everyone who was directly or indirectly associated with this undertaking is both pleased and proud of the outcome. Now the personnel of the Research and Control Department must take full advantage of such fine equipment and facilities by giving a maximum effort toward expediting solutions to some of the many problems which would further improve the quality of the District's waterways. At the same time, it is hoped that these findings will help solve some of the problems existing in other areas of the nation.

TRAINING AND QUALITY CONTROL ACTIVITIES

The rapid increase and constant turnover of personnel, as well as rapid growth in responsibilities of the Research and Control Department, necessitated an acceleration in the program for orientation and technical development of the departmental staff. Programs that have been initiated to accomplish this are as follows: professional society meetings and conferences; extramural technical training; intramural technical training; technical seminars; safety programs; staff meetings; and quality control programs.

All technical personnel are encouraged to attend their professional society meetings in order to aid in their professional development and growth. Whenever possible and within the policies and directives of the District, staff members are encouraged to present technical papers and to participate in professional committee activities. Usually the senior staff are allowed to attend one to two professional society meetings annually at District expense. Extramural training is supported through the District's policy of reimbursement of tuition for courses taken at accredited schools, provided such training does not interfere with work requirements and is in fact directly pertinent to the employee's job. A number of employees have taken advantage of this opportunity and the interest is still evident by present participation.

All new employees must be orientated to their jobs before thay can become effective workers. This is usually done through direct training by their supervisors In addition, orientation lectures are periodically scheduled in which the employees are given a basic description of the overall processes and practices of the District, as well as technical discussions of the work being done by the laboratories. One such program of intramural training has already been completed for laboratory assistants and lab technicians, in which fifteen (15) lectures of one-half hour length were presented. A second program for Chemist I and II employees is currently under way. These lectures are presented by selected senior staff and specialists from within the Department, and attendance at the main laboratory auditorium has averaged over twenty (20) employees per lecture.

The purpose of the technical seminar program is to provide the latest technical knowledge on a subject pertinent to waste treatment and water pollution control. Assignment schedules are developed with the professional staff and the staff members encouraged to select topics of current interest for presentation before the group. Being a relatively new activity, only one seminar has been given to date, but others have been scheduled for presentation at monthly intervals.

The Research and Control Department participates in the general safety programs of the District by providing the necessary technical support as needed. In addition, it maintains a safety committee to consider situations peculiar to laboratory operations and to recommend appropriate safety measures. The existing committee has already provided many specific recommendations which have been put into practice.

Regularly scheduled biweekly staff meetings are held in order to acquaint the supervisory and professional staff of various activities within the Department, as well as to discuss matters involving the administration of the Department. Minutes are taken of these meetings and are distributed to attendees for reference.

Finally the laboratory programs are monitored internally for quality control purposes by routine "check" samples and by special unknowns prepared by the Methodology laboratory and distributed to all control labs in the District. Monthly reports from the various control laboratories are submitted to the Dept., for review and evaluation. These programs of self-analysis within the Department have already resulted in quality improvement. Their ultimate goal is the constant reassurance of unquestioned reliability of all laboratory data.

RESEARCH PAPER SERIES AND SPECIAL REPORTS

In 1963 the then Sanitary Division established a Research Paper Series for the expressed purpose of having a complete and condensed summary of research carried out at the District on each specific phase of work. Understandably, there are numerous memos and interim reports which have been written and serve to indicate progress as the work was being conducted.

As of the writing of this report, the research and control group has written 18 research papers. This series includes such subjects as artificial aeration, sludge thickening by dissolved air flotation; solids concentration by various types of centrifuges, cyclones, and screens; concentration of the Zimpro ash solids; vacuum filter studies; stream quality conditions; and several papers on the use of computers for the purpose of better understanding the hydraulics of our waterways.

Other papers or manuscripts have been prepared by staff members of the Research and Control Department but are not included, by definition, as a research paper. These manuscripts cover subject matter such as "Automatic Kjeldahl Nitrogen Measurements in Waste Treatment" (42); "Expansion and Modernization of Analytical Capabilities at The Metropolitan Sanitary District of Greater Chicago" (43); "Problems in Detecting and Controlling Oils, Fats and Greases at Their Source" (45); "Some Analytical Problems Encountered in the Analysis of Stream for Pollutants in the PPM and PPB Range" (46).

In addition to the above two groupings, there have been a number of special reports which have been prepared by the Research and Control group.

These involve such problems as The Use of Chemical Additives, (34); the High Sludge Volume Index Problem (33); Odor Study at the North Side Plant, Battery D (48 Lawndale Lagoon Odor Problem (37); 95th Street Pumping Station Chlorination Study (39); Plant Effluent Chlorination (35); Scrubber Water Return (30); I&M Canal Aeration Study (40); North Branch Quality for Marina (41); Monitoring (32); Special Industrial Waste Problems (31); to name a few.

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