CHEMICAL-PHYSICAL PROCESSES

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INTRODUCTION

The most recent advance in the art of sewage treatment is the application of physical-chemical technology to raw sewage treatment. In reality, physical-chemical treatment of sewage is not a completely new technology. Chemical treatment of sewage was widely practiced in England and the United States in the latter portion of the 19th Century. However, this technique gradually fell into disuse with the advent of activated sludge, because activated sludge systems achieved higher degrees of treatment (1). In the 1930's a number of systems employing physical and chemical treatment in combination were evaluated. These produced treatment superior to primary sedimentation followed by activated sludge (conventional treatment) but at a cost 1.5 to 2 times as great (2). This additional increment of cost discouraged adoption of physical-chemical treatment at that time.

During the last decade advances in physical-chemical treatment technology resulting from Environmental Protection Agency-supported research have significantly reduced the cost of physical-chemical treatment. In addition, it is apparent that higher levels of treatment will be required in the future to maintain water quality. As a result of these alterations in conditions, physical-chemical treatment is now an alternative to conventional treatment, especially for situations where significant phosphorus removal is required.

GOALS OF SEWAGE TREATMENT

The fundamental goal of sewage treatment is sufficient reduction in the level of pollutants in the wastewater to allow discharge to the environment. The pollutants in sewage are grouped into classes of similar compounds which have the same environmental impact rather than being individually dealt with. At present the five major pollutant groups of interest are: suspended solids, organic matter as measured by BOD, TOC or COD, phosphorus compounds, nitrogen compounds and pathogenic microorganisms. It is impossible to specify one set of effluent standards which is applicable to all or most situations. However, it is generally agreed that a good quality effluent will have the characteristics given in Table 1. In addition, complete disinfection will be required. As yet no general agreement on a nitrogen level is in evidence. It must be repeated the goals listed above are not design standards, but are guides in describing a good quality effluent.

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THE CLARIFICATION-ADSORPTION PROCESS

The physical-chemical treatment system which at present is most advanced in development, and which seems the best is the clarification-adsorption system schematically illustrated in Figure 1. In this system chemical clarification and filtration are utilized to achieve almost complete suspended and colloidal solids removal. With a high enough dose of the proper chemicals essentially complete phosphorus removal can also be obtained. The function of the activated carbon step is the removal of soluble organics. As in any conventional system preliminary screening, grit removal and final disinfection are provided. The filtration step is shown as optional but conservative design dictates its use. The positioning of this step prior to or after carbon adsorption is dictated by the type of waste-carbon contacting system provided. The three steps of chemical clarification, filtration and carbon adsorption will be discussed in some detail below.

This system does not provide ammonia or nitrate-nitrogen removal. Physical-chemical methods for soluble nitrogen removal are covered in another lecture of this symposium. Any of these nitrogen removal methods can be integrated into the clarification-adsorption system.

CHEMICAL CLARIFICATION

Chemical clarification provides the bulk of the pollutant removal achieved by this type of treatment system. In this unit operation an appropriate chemical is dosed to the wastewater and the mixture is flocculated and settled. All of these steps can be conducted in independent units, or combined into a single unit which is usually referred to as solids-contact clarifier.

Chemicals which have been successfully used to clarify raw sewage include organic polymers (3), iron salts (4), aluminum salts (5), and lime (6)(7). The inorganic coagulants have the advantage of providing for phosphorus removal. At present there is no rational method for predicting the dose of chemical required. For planning purposes, jar tests are suggested. Fortunately field control of the coagulant dose is possible. For all coagulants except lime the suggested method is monitoring of the clarifier effluent turbidity. Monitoring of phosphorus also appears promising, as good clarification is always obtained when sufficient chemical is added to provide good phosphorus removal. With lime as the coagulant excellent control is obtained by pH measurement. The pH required to achieve good clarification and phosphorus removal is dependent on the chemical characteristics of the sewage. In areas where the alkalinity and hardness are low the high lime process in which the pH is raised to approximately 11.5 is required. Generally, two-stage precipitation with intermediate recarbonation is utilized. In hard water, high alkalinity areas a low lime single-stage precipitation at pH 9.5 to 10 is sufficient.

Table 2 illustrates the treatment obtained with chemical clarification in pilot plants at a variety of locations. In addition to the expected high levels of suspended solids and phosphorus removal significant organic removal was obtained. Based on these data and others it can be expected that chemical clarification of raw sewage will consistently yield organic removal in the 65-75 percent range. With this degree of organic removal from chemical coagulation the carbon need provide only a small increment of additional removal to match the performance of a good secondary treatment system.

Sludge disposal plays a dominant role in the economics of any chemical clarification system. Only limited data on the characteristics of sludges resulting from the chemical treatment of raw sewage are available. These data indicate that with iron or aluminum salts as coagulants:

1. The resulting sludge volume sometimes exceeds and sometimes is less than primary sludge from the same sewage.

2. The chemical sludge is more difficult to dewater in a vacuum filter than the corresponding primary sludge.

However, with lime as the coagulation chemical dewatering is extremely rapid just by gravity thickening. Eimco (8) reported lime-raw sewage sludge solids concentrations of 15% to 25% after gravity thickening.

In addition to yielding a sludge amenable to rapid and easy dewatering lime is the only coagulation chemical which can be economically recovered. Recalcining the lime sludge in a furnace has been successfully conducted in a tertiary plant at South Lake Tahoe and has been state-of-the-art in water softening plants for a considerable period of time (9). In addition to regenerating the lime, the organic solids are incinerated thereby accomplishing ultimate disposal of the sludge. For these reasons it is anticipated that lime will be the coagulant of choice for most situations.

Design criteria for the coagulation equipment is similar to that used in water treatment plants. A flash mix of one minute, flocculation for 15 to 30 minutes and sedimentation at upflow rates of 0.5 and 1.0 gpm/ft^2.

CARBON ADSORPTION

The role of the carbon adsorption step is the removal of soluble organics from the wastewater. Although the chemical clarification step does the bulk of the pollution control job, the carbon adsorption step is required to produce a good quality effluent. The total organic removal achieved by the combination of clarification and carbon adsorption at several physical-chemical pilot plants is illustrated in Table 3. It can be seen that not only is the removal achieved quite high (95%+) but equally important the residual organics after treatment are quite low. These effluents are superior to the usual quality of secondary effluent (TOC $\approx$ 20 mg/l, COD $\approx$ 40 to 50 mg/l).

The results reported in Table 3 were obtained with carbon contacting systems employing granular carbon. In such systems the waste is passed either upward or downward through columns containing the carbon. Downflow columns function as packed beds and accomplish filtration of the wastewater. Flow rates of 2 gpm/ft^2 to 8 gpm/ft^2 have been employed. In this flow range essentially equivalent adsorption efficiency is obtained provided the same contact time is employed. At flow rates below 2 gpm/ft^2 adsorption efficiency is reduced, while at flow rates above 8 gpm/ft^2 excessive pressure drop takes place. Contact times employed are in the range of 30 minutes to 60 minutes on an empty bed basis. In general increases in contact time up to about 30 minutes yield proportionate increases in organic removal. Beyond 30 minutes the rate of increase falls off with increases in contact time and at about 60 minutes contact becomes negligible. Carbon beds to be operated at the lower end of the flow rate range are generally designed for gravity flow. Those systems designed for the higher flow rates employ pressure vessels. A pressure vessel is more expensive to contruct than a gravity flow vessel but it requires less land area, and provides greater ability to handle fluctuations in flow rate.

Provision must be made to periodically backwash downflow carbon beds because even if they are preceded by a filter they gradually collect suspended solids. In addition, biological growth takes place on the carbon granules and tends to clog the bed. It is advisable to include a surface wash and air scour to be assured of removal of the gelatinous biological growth.

Backwash of the carbon beds satisfactorily relieves clogging but does not completely remove the biological growth. Consequently, significant biological activity is manifest in the carbon beds at most times. This leads to the development of anaerobic conditions in the carbon bed and generation of sulfides. Aeration of the column feed has been utilized to prevent anaerobic conditions, but this produced so much biological growth that excessive backwash was required.

In an attempt to overcome these difficulties upflow carbon columns have been operated in a slightly expanded mode (about 10% expansion). This allows for significant accumulation of biological activity on the carbon granule with little increase in head loss. Consequently, aerobic conditions can be maintained and sulfide generation prevented.

If the expanded bed system is utilized backwash facilities must still be provided as it has been found necessary to occasionally remove excess growth. With this system the flow rate range which can be used is more restricted than with packed bed systems. With the commercial sizes of carbon available (8x30 mesh or 16x40 mesh) flow rates above 4 to 5 gpm/ft^2 are required to achieve the proper degree of expansion. In addition, care must be exercised to avoid hydraulic surges which could wash carbon out of the system. The filtration section of the physical-chemical treatment plant must follow carbon contact when the expanded bed system is used.

The latest carbon contacting scheme to be applied to waste treatment utilizes powdered carbon (particle size below 200 mesh). This procedure provides for a mixture of a carbon slurry and the wastewater in a Reactor-Clarifier. Polymer addition is generally required to achieve a good gravity separation of the carbon from the wastewater following contact. The potential advantages of this system are the use of a cheaper carbon (10¢ per pound vs. 30¢ per pound for granular carbon) and a simpler type of contacting system.

A critical aspect of the design of any carbon contacting system is the expected capacity of the carbon for the organics. In the chemical processing industries this is evaluated by running adsorption isotherm tests. In the waste treatment field isotherms are of limited utility because the biological activity which develops on the carbon tends to greatly enhance its apparent capacity for organic removal.

The role of the design engineer is to utilize a system which makes greatest utility of the capacity of the carbon regardless of what the capacity is. In order to provide a good effluent and utilize most of the available capacity, countercurrent contact is required. This is achieved by having the waste flow through a number of contactors or stages in series in one direction, while the carbon moves in the opposite direction. In the powdered carbon contacting system this is exactly the procedure used. With granular carbon this procedure cannot be used as undesirable attrition losses will take place. Rather when an undesirable effluent is obtained the lead contactor is removed from service and a spare contactor with fresh carbon placed at the end of the line. Each contactor is then moved up one position in the line. This is accomplished by piping and valving a series of columns to shift the inflow and outflow points of the series accordingly rather than physically moving the columns. As the number of stages increases, the piping and valving arrangement becomes more complex and costly. In design, a compromise between the advantage of adding another stage to more closely approach the highest use of the carbon capacity, and the cost of each additional stage must be achieved.

An alternate arrangement which is used in some plants provides parallel flow through a number of identical contactors. Each is at a different stage of exhaustion and produces a slightly different effluent quality. These individual effluents are blended to produce the final product.

Table 4 reviews the various factors which must be considered in designing any carbon removal system.

In Table 5 carbon capacities obtained in field operation at various pilot plants are given. In view of the fact that the waste, effluent criteria, number of contact stages etc., varied from plant to plant it is not surprising that some spread in the results is observed. These capacities are expressed as pounds of organics removed (either as COD or TOC) per pound of carbon. For general planning purposes a capacity of 0.5 pounds of COD per pound of carbon is reasonable. This is approximately equivalent to a requirement of 500 pounds of activated carbon per million gallons of sewage treated.

A carbon requirement at this level would be prohibitively expensive if regeneration and reuse of the exhausted carbon were not possible. At present a technically and economically feasible method is available for the regeneration of granular activated carbon. This method requires heating of the carbon in a multi-hearth furnace in the presence of steam to $\approx$ 1750°F. This treatment burns away the adsorbed and trapped organics. During a regeneration cycle some of the carbon is physically lost by burning and attrition, and some of each particle's capacity is lost by alteration of surface properties. The overall loss expressed as percent by weight of virgin carbon required to restore the total original capacity of the batch ranges from 5 to 10 percent (10). Thus, for planning purposes carbon make-up requirements at a plant should range from 25 to 50 lbs per million gallons of sewage treated.

At present experiments on a fluidized bed regeneration system for powdered carbon are moving into the large-scale pilot stage. Successful completion of these tests will be a big step forward in making a powdered carbon system a technical and economic reality. The key factor will be maintaining the carbon loss at a low enough level during the regeneration.

DESCRIPTION & PERFORMANCE OF SOME PHYSICAL-CHEMICAL PILOT PLANTS

In the previous sections of this paper summaries of performance from a variety of physical-chemical treatment plants were presented. In this section a somewhat more detailed look will be taken at a selection of these plants.

Ewing-Lawrence (4)

For the last several years FMC Corporation has been conducting studies of physical-chemical treatment at the Ewing-Lawrence Treatment Plant near Princeton, N.J. Figure 2 illustrates the clarification section of the plant. These units were somewhat overdesigned to insure a good feed to the adsorption section of the plant, as the major purpose of the research was to evaluate carbon performance. Figure 3 is a schematic of the overall plant. Packed bed versus expanded bed carbon contact in parallel was studied at this plant. Figure 4 indicates that the performance of the packed bed contactor was slightly superior to that of the expanded bed contactors. However, the investigators indicated that the advantage was not sufficient to offset the need to backwash more frequently and the potential difficulties from anaerobic conditions in the carbon beds. Figure 5 illustrates the BOD removal obtained over a 3-1/2 month period. It can be seen that despite considerable variation in influent strength a consistently good effluent was produced. This figure also reiterates that the bulk of the treatment is accomplished in the chemical clarification step.

Blue Plains (7)

At the Blue Plains treatment plant in Washington, D.C., a pilot physical-chemical treatment system is being operated as part of a joint effort of EPA and the District of Columbia. Figure 6 is a schematic of the treatment system. Two-stage high lime clarification is provided with a small dose of ferric chloride in the second stage for flocculation of calcium carbonate. This stage of the plant has a capacity of 100,000 gal/day. The filtration, ion exchange and downflow two-stage carbon beds have a capacity of 50,000 gal/day. This plant is highly automated and thus runs with a miniumum of manual control. For example, the lime dose is automatically set by monitoring the pH and alkalinity in the clarifiers, and backwash of the filters, ion exchange columns, and carbon columns is automatically initiated by pressure drop and/or a time cycle.

Figure 7 illustrates the treatment performance obtained at this plant for a variety of pollution control parameters. Nitrogen removal was obtained by the use of an ion exchange process with a zeolite which has a high affinity for ammonium ion. Again, these data indicate that the bulk of the work is done by the clarification step with the filter and carbon columns serving as polishing devices. Table 6 gives the average effluent characteristics for this installation. This effluent is far better in quality than normal secondary effluent.

Salt Lake City, Utah (8)

Under contract between EPA and Eimco Corporation an evaluation is being conducted of a physical-chemical treatment system employing powdered carbon contact after chemical clarification. Figure 8 illustrates the pilot plant. Two countercurrent stages of carbon contact in Reactor-Clarifier are provided following chemical clarification. Some results with lime as the coagulant are given in Table 7. These results are not quite as good as in the plants using granular carbon discussed previously. The effluent, however, must still be classified as of good quality. One potential advantage of this contacting system is the ability to pace the carbon dose to the organic demand. Evaluation of powdered carbon regeneration will take place at this installation. The spent carbon will be dewatered on a vacuum filter prior to being fed to the fluid bed furnace.

Rocky River, Ohio (3)

Several studies have been made utilizing polymer addition to existing primary plants followed by small-scale pilot carbon adsorption. One such study was done at the 10 MGD primary facility at Rocky River, Ohio. An anionic polymer was added to the existing primary clarifier at a dosage of 0.3 mg/l, and a

side stream of clarified effluent was applied to small carbon columns for a period of about one month. The summary of the data is shown in Table 8. It can be seen that, even with less than optimum clarification, effluent comparable to good secondary effluent was produced with 33 minutes carbon contact time. On the basis of this preliminary work the City of Rocky River applied for and was awarded a Research and Development Grant from EPA to help support a full-scale investigation of the clarification-adsorption process for secondary treatment.

One of the principal motivations for the city to use physical-chemical treatment is shown in Figure 9. The installation of conventional activated sludge facilities would necessitate the condemnation of a considerable area of expensive property, whereas a carbon adsorption system could easily fit into the existing site. Testing has been undertaken to determine what coagulant or combination of chemicals will be used in the clarification system. If phosphorus removal is required an inorganic coagulant will necessarily be the choice.

ADVANTAGES OF PHYSICAL-CHEMICAL TREATMENT VS. CONVENTIONAL TREATMENT

Several times in this discussion advantages of physical-chemical treatment have been referred to. Perhaps the most important is the stability of operation provided by a treatment system based on physical and chemical technology. Biological systems are notoriously sensitive to changes in environmental conditions. If a toxic material gains even temporary entrance to the plant or a hydraulic peak occurs not only will the efficacy of the biological plant drop off but recovery may take several days to several weeks. In a physical-chemical plant the filtration system backs up the clarifier and the carbon system backs up the first two thus upsets should be unlikely. In addition, it can be expected that an immediate recovery of the plant will take place once the source of upset is eliminated. This inherent stability of performance is also reflected in greater design and operational flexibility. Whole sections of a physical-chemical plant can be cut in or out of the process stream as required, and a temporary overload can be absorbed with little effect. A list of many of the major advantages of a physical-chemical system is given in Table 9. Most have been discussed at some point in this paper.

COST ESTIMATES

One of the uncertain factors concerning physical-chemical treatment is the cost of the process. Definitive data will not be available until large-scale plants have been built and are in operation for several years. Even then local conditions may significantly affect the actual costs. Smith (11) has taken the available information from pilot plants and preliminary designs of several proposed large-scale plants and has made cost estimates for various

size plants referenced to October 1970. Amortization was 6 percent for 24 years. These are presented in Table 10. Note that ranges are given for each plant size. These ranges represent the spread of data available. As a comparison Smith's estimate for primary and secondary treatment with sludge incineration is 16.5 cents per 1000 gallons at the 10 MGD level. With the addition of single stage lime for phosphorus removal the cost would rise to 23.5 cents per 1000 gallons which is essentially the same as physical-chemical treatment.

FUTURE DEVELOPMENTS

As a result of the advantages of physical-chemical treatment discussed above and the favorable economic comparison, a number of full-scale treatment plants are being planned or designed. These are listed in Table 11. Only the first two, Rocky River and Painesville, Ohio, will receive Federal research funds. All the others are being planned with no expectation of Federal funds other than the normal construction grant.

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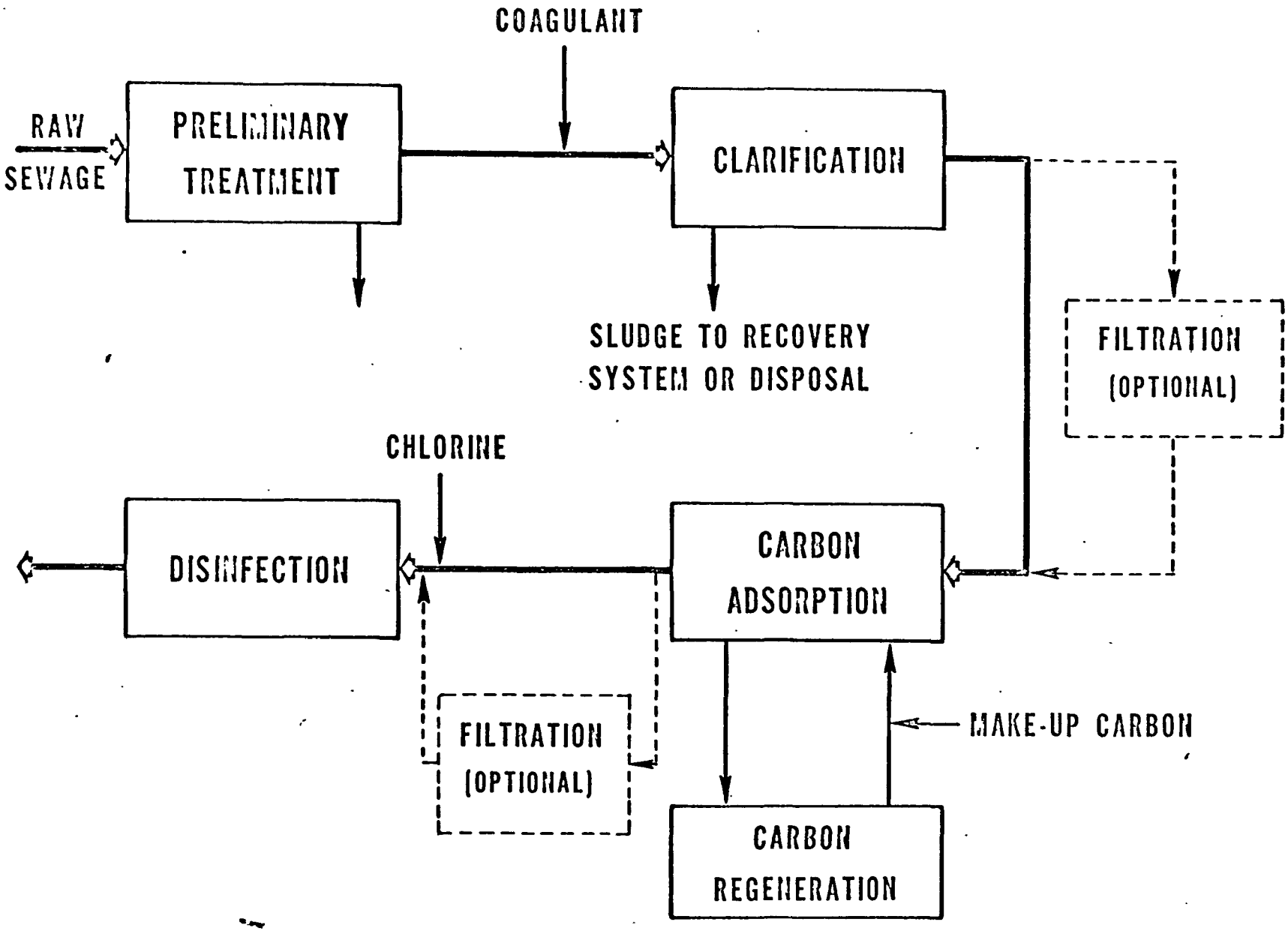


FIG. 1. FLOW DIAGRAM OF A PHYSICAL-CHEMICAL TREATMENT SYSTEM

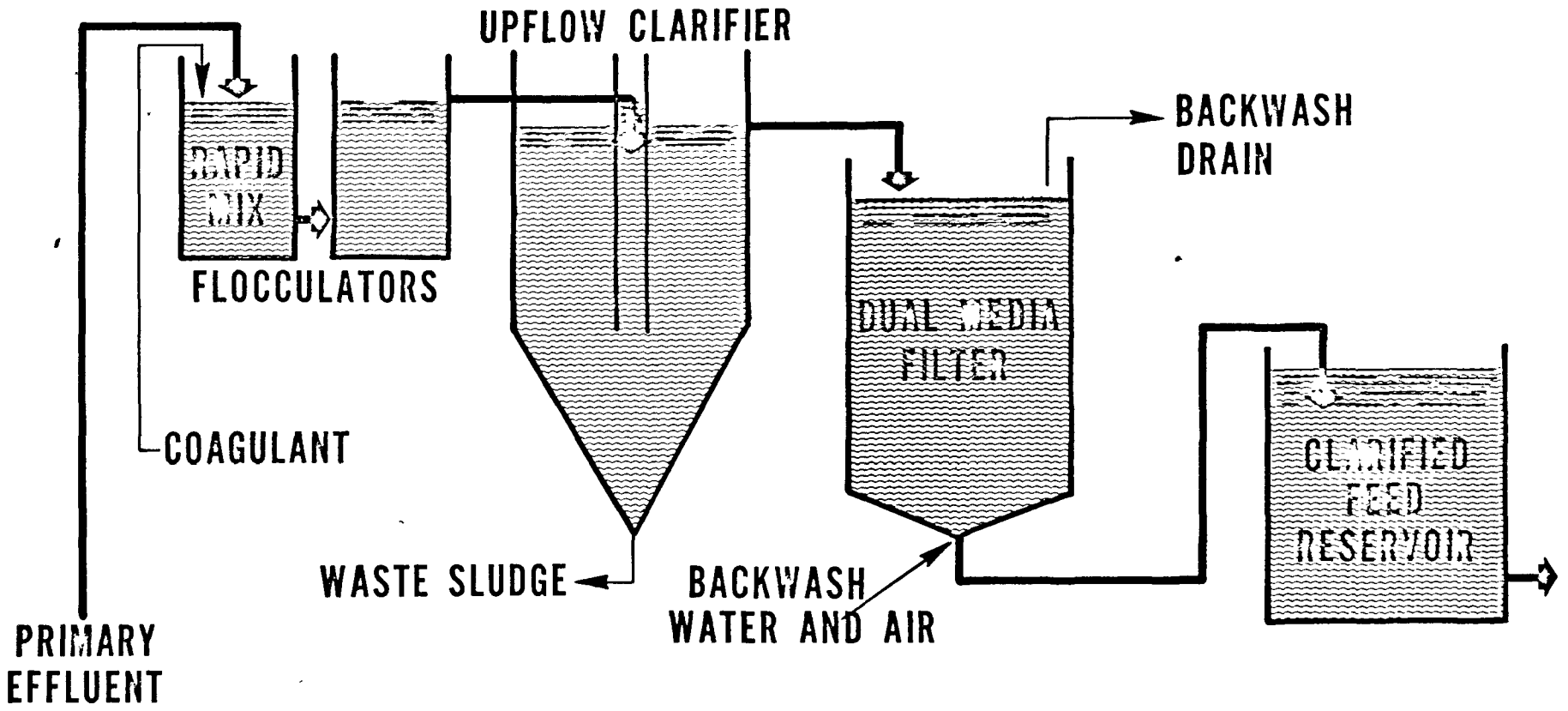
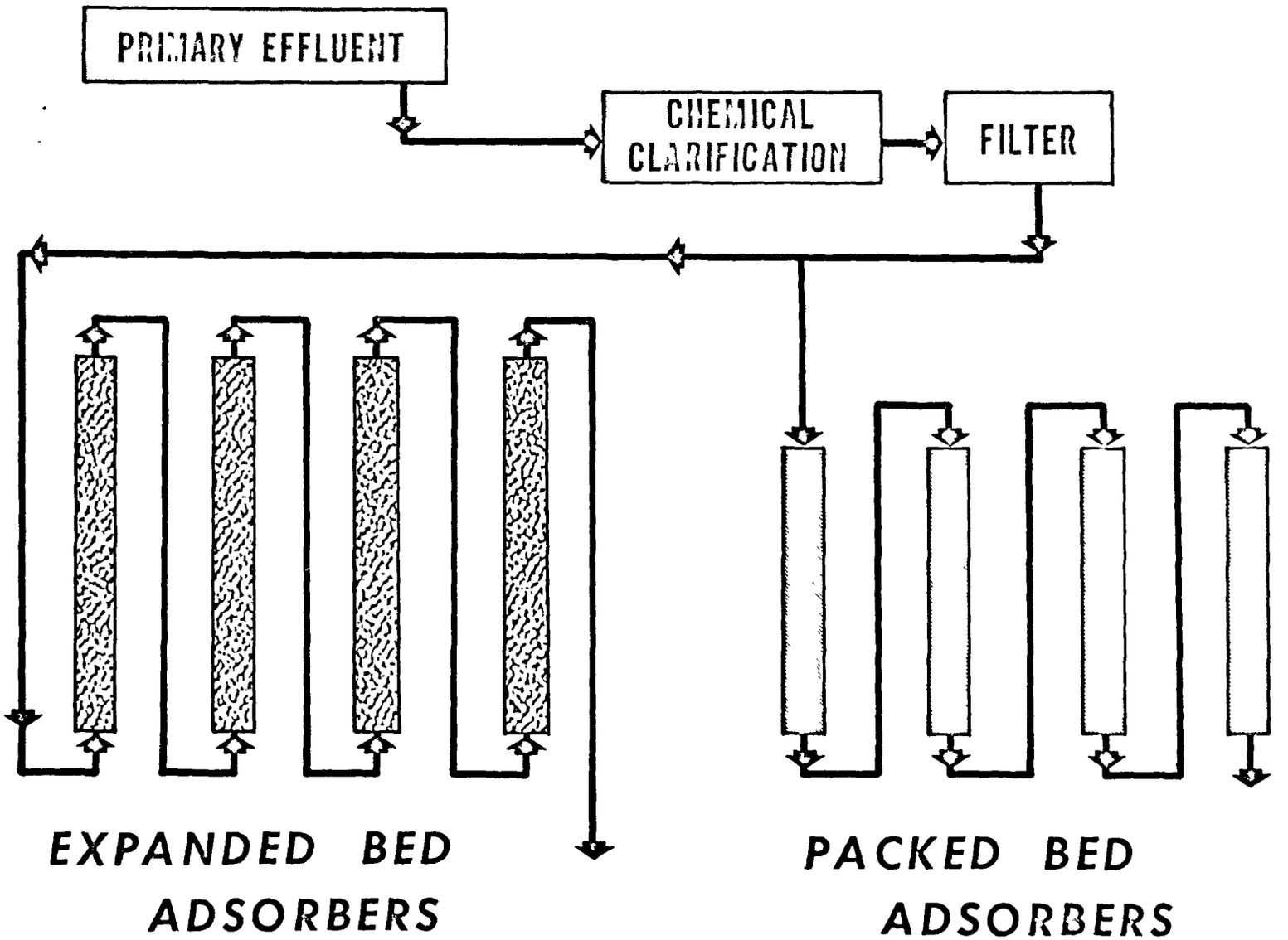


FIG. 2 FLOW DIAGRAM OF CLARIFICATION SYSTEM

FIG. 3

EXPERIMENTAL SET-UP FOR 24 FT. CARBON BEDS



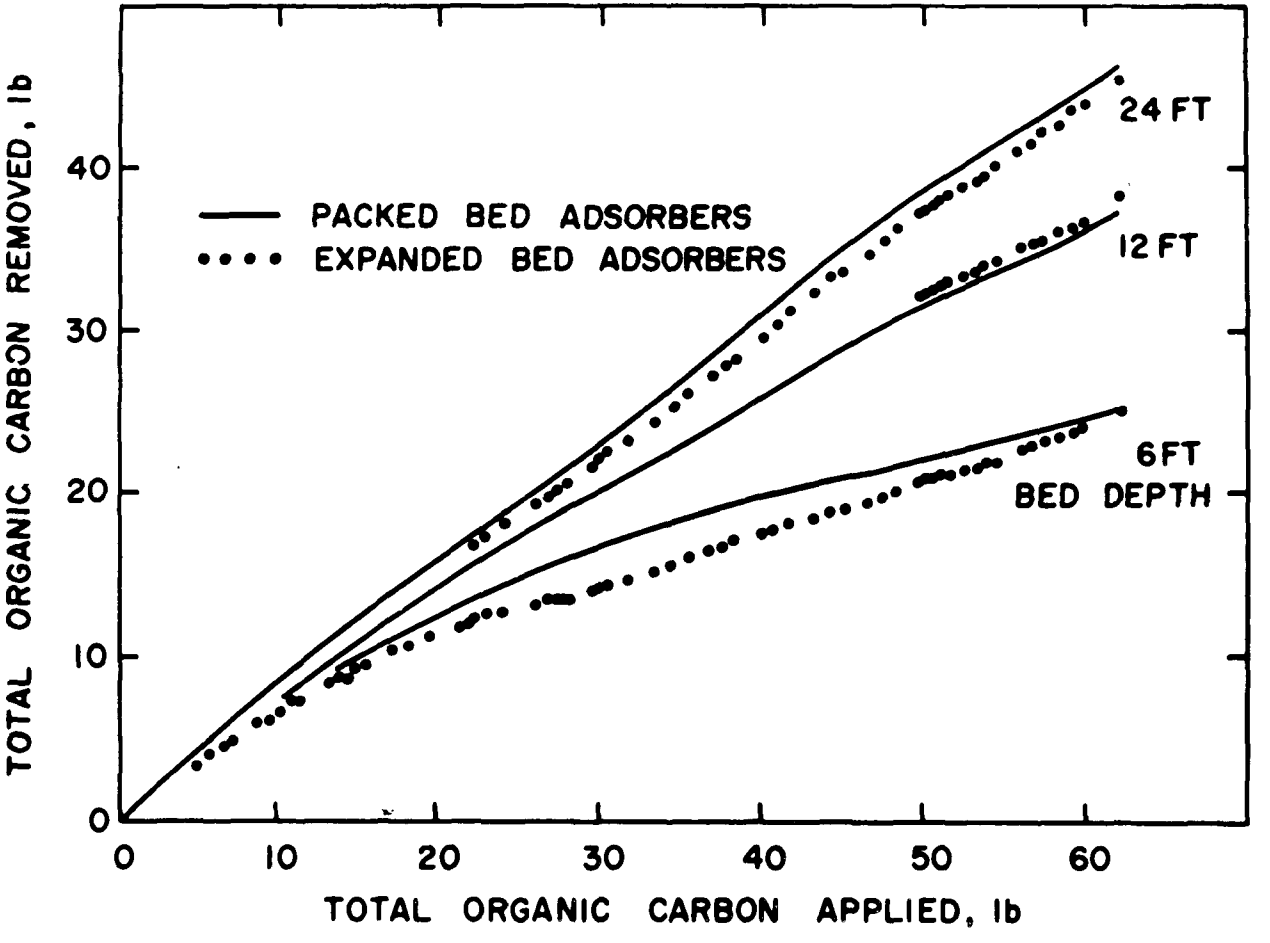


FIGURE 4 -Cumulative sorption of total organic carbon for packed-bed and expanded-bed adsorbers as a function of TOC applied. (Lb × 0.454 = kg; ft × 0.3 = m.)

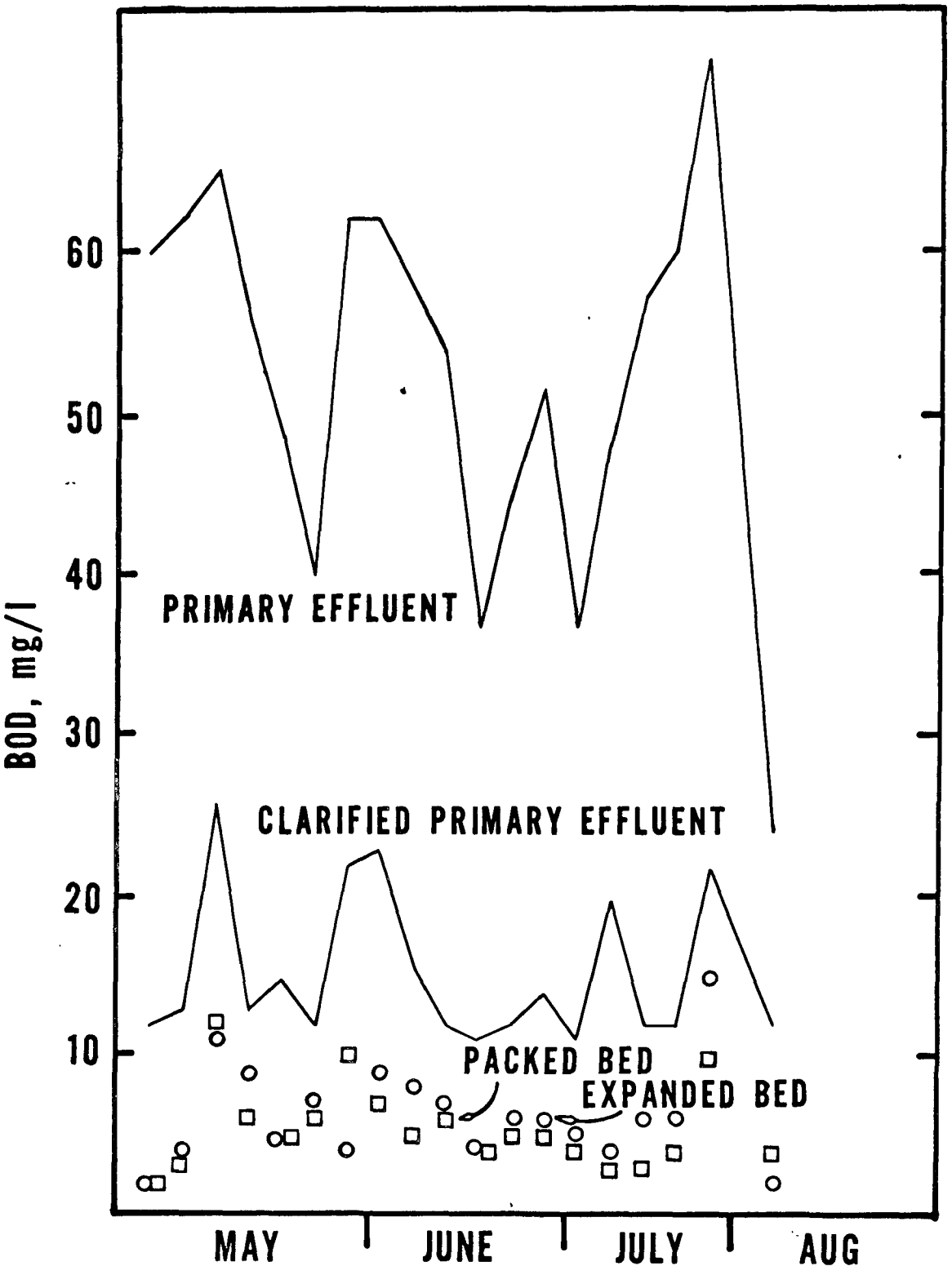


FIG. 5 REMOVAL OF BOD BY CHEMICAL CLARIFICATION AND ACTIVATED CARBON

FIGURE 6

INDEPENDENT PHYSICAL CHEMICAL TREATMENT
LIME PRECIPATION

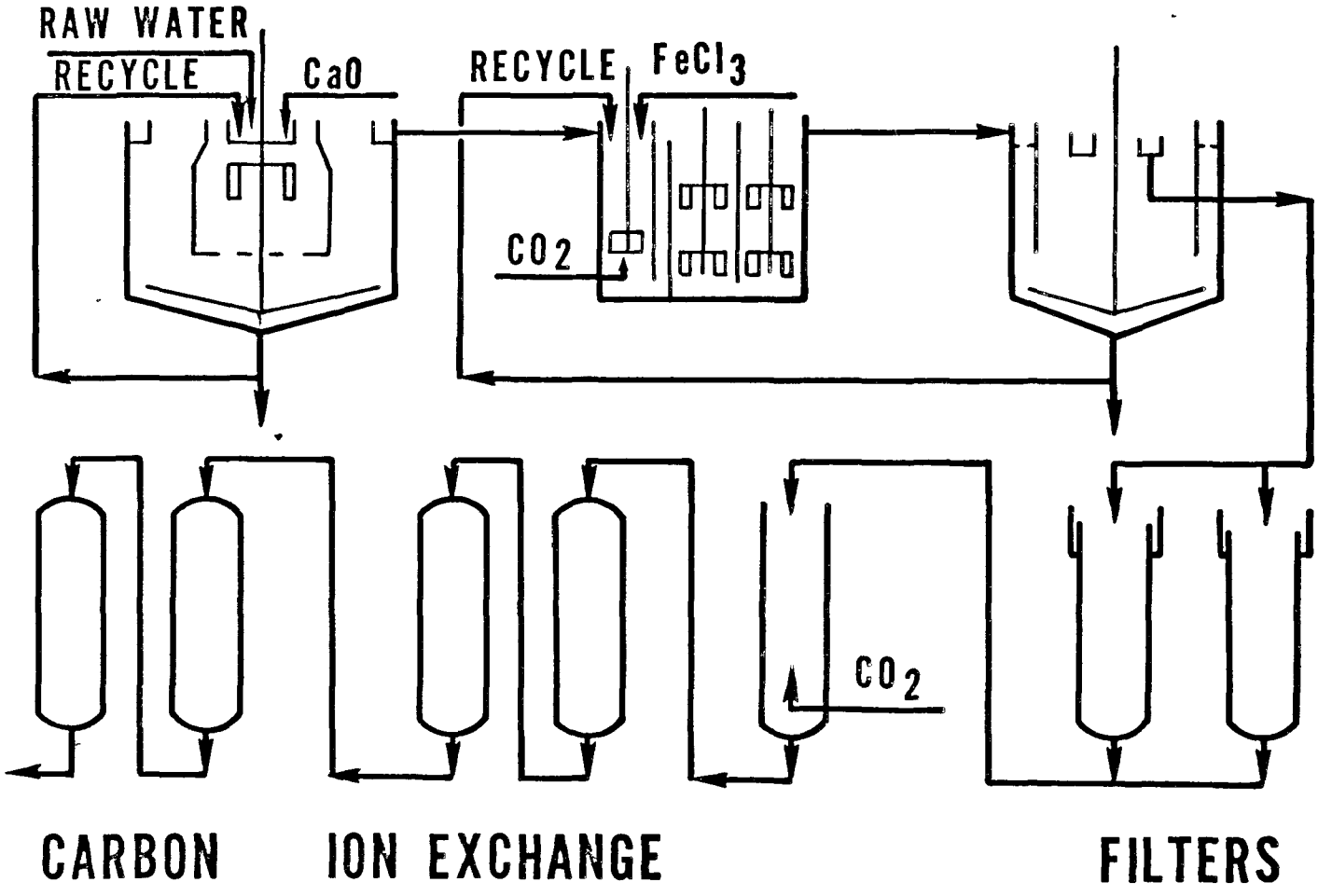


FIG. 7 REMOVAL EFFICIENCIES
PHYSICAL CHEMICAL TREATMENT
BLUE PLAINS PILOT PLANT

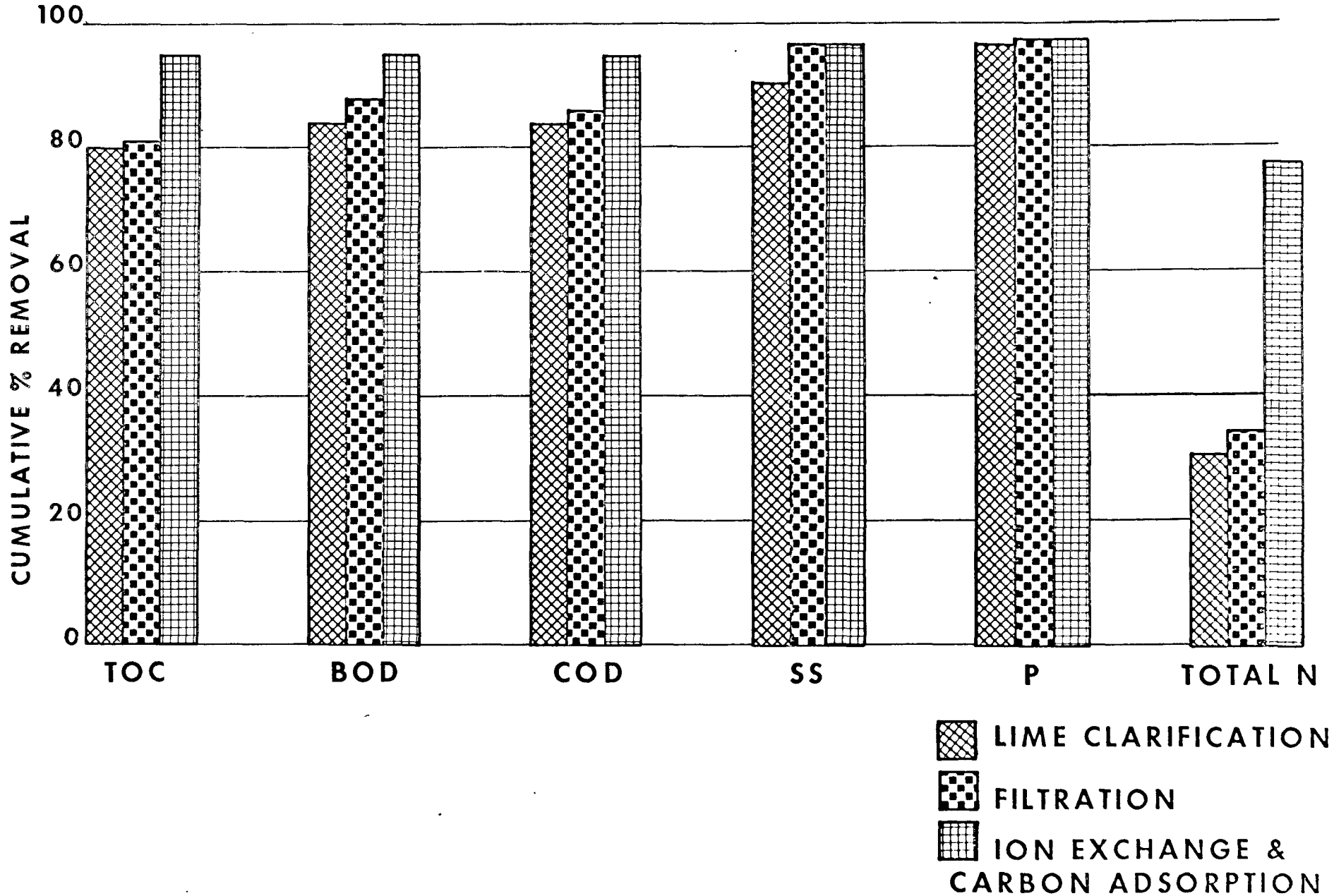


FIGURE 8

PHYSICAL/CHEMICAL TREATMENT PROCESS

EIMCO ENVIROTECH

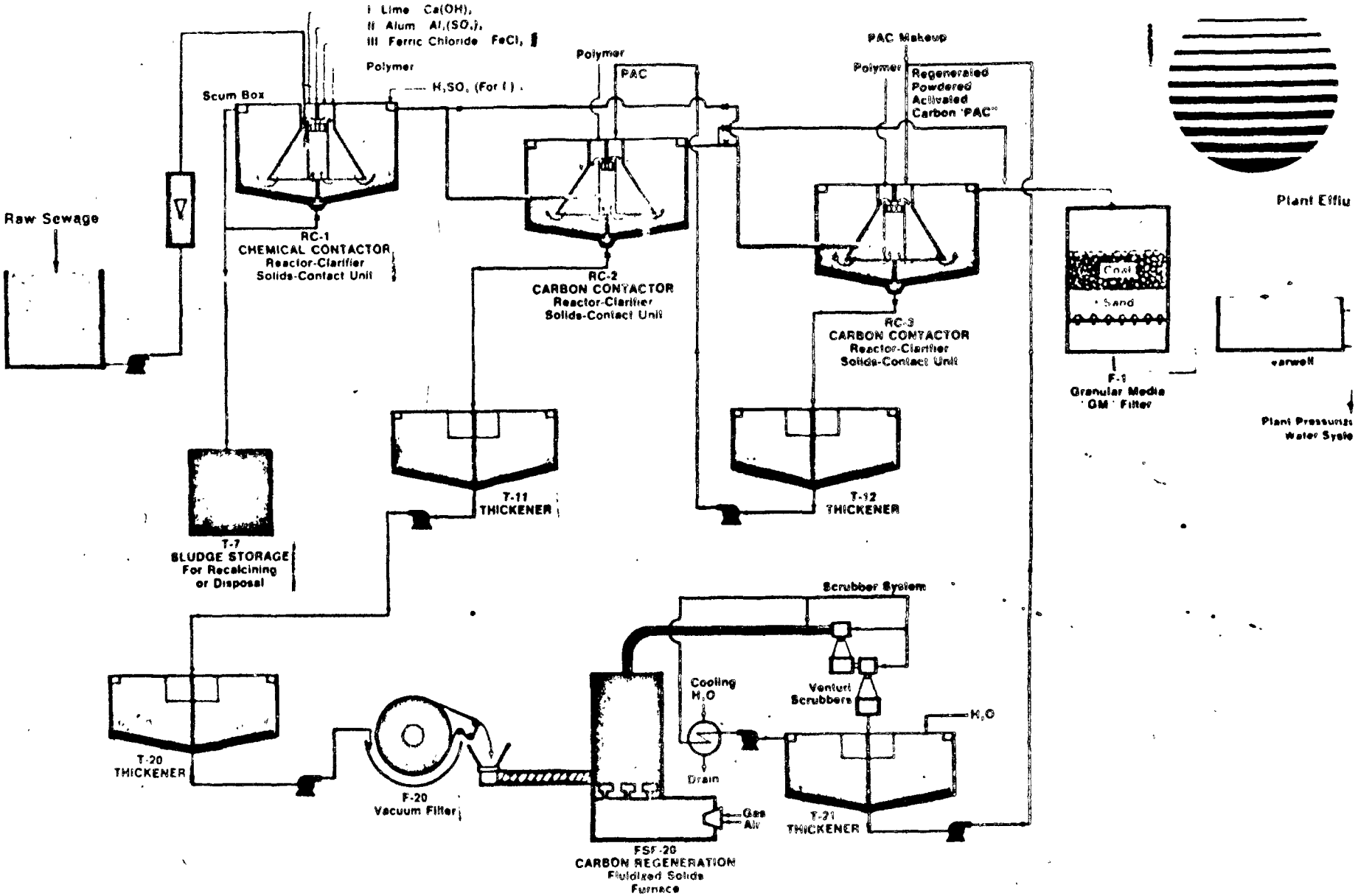


FIGURE 9

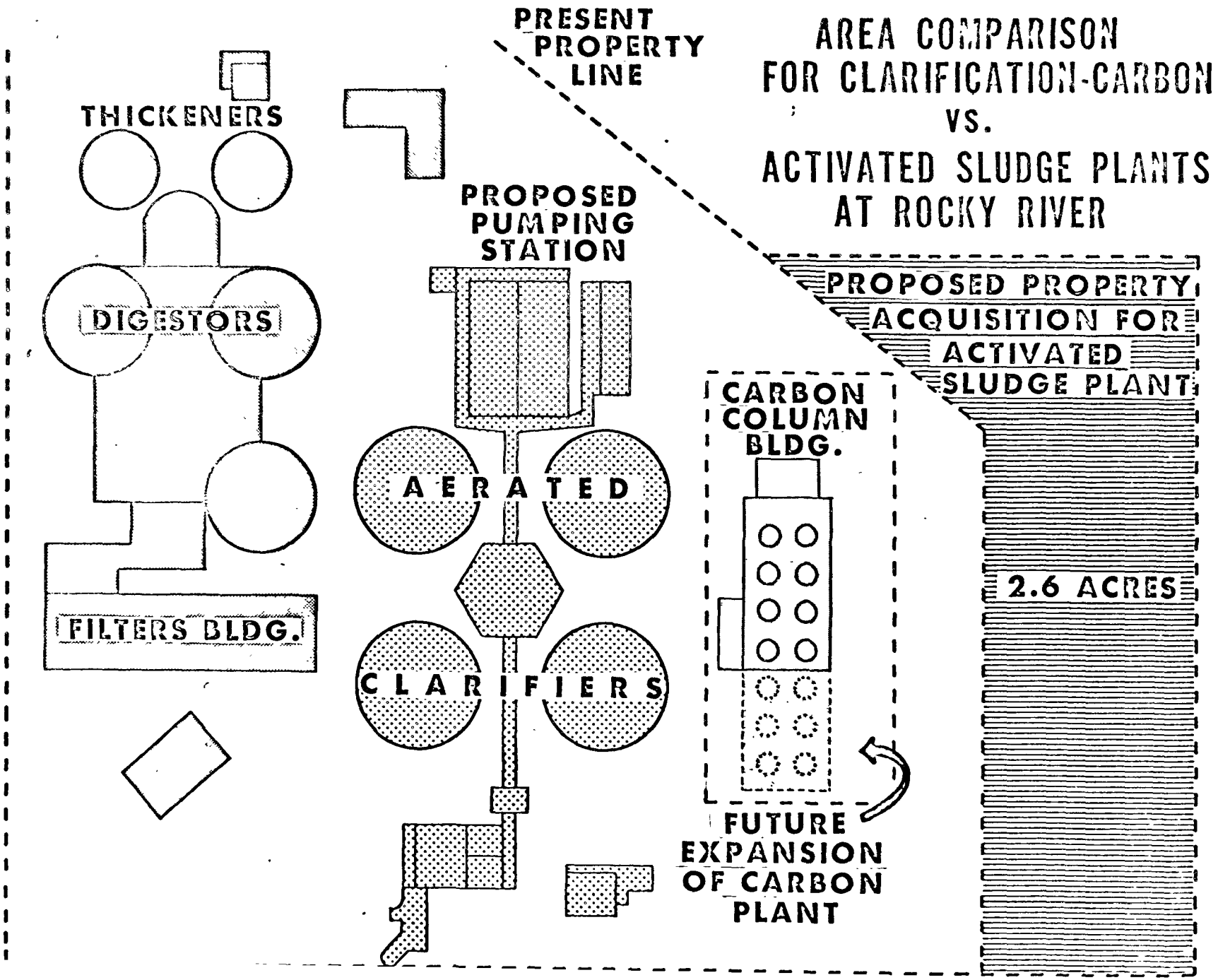

AREA COMPARISON
FOR CLARIFICATION-CARBON
VS.
ACTIVATED SLUDGE PLANTS
AT ROCKY RIVER
PRESENT PROPERTY LINE
PROPOSED PROPERTY ACQUISITION FOR ACTIVATED SLUDGE PLANT
2.6 ACRES
THICKENERS
DIGESTORS
FILTERS BLDG.
PROPOSED PUMPING STATION
AERATED
CLARIFIERS
CARBON COLUMN BLDG.
FUTURE EXPANSION OF CARBON PLANT

TABLE 1.

DESIRED EFFLUENT QUALITY

BOD	10 MG/L
COD	60 MG/L
SS	10 MG/L
P	1 MG/L

TABLE 2

ACHIEVEMENTS OF CHEMICAL CLARIFICATION

PLANT	CHEMICAL	ORGANIC REMOVAL %	SS REMOVAL %	P REMOVAL %
EWING-LAWRENCE	170 mg/l $FeCl_3$	80	95	90
NEW ROCHELLE (ZM)	LIME pH 11.5	80	98	98
WESTGATE,VA.	125 mg/l $FeCl_3$	70	-	-
SALT LAKE CITY	80-100mg/l $FeCl_3$	75	-	80
BLUE PLAINS	LIME pH 11.5	80	90	95

TABLE 3

TOTAL TREATMENT P-C PLANTS

PLANT	ORGANIC REMOVAL %	EFFLUENT CONCENTRATION
BLUE PLAINS	95-98	TOC=6
LEBANON	95	TOC=11
EWING-LAWRENCE	95-98	TOC=3-5
NEW ROCHELLE	95	COD=8

TABLE 4

CONSIDERATIONS IN CARBON TREATMENT, DESIGN

1. TYPE OF CARBON-GRANULAR OR POWDERED
2. CONTACT TIME
3. FLOW RATE
4. CONFIGURATION-SERIES OR PARALLEL
5. NUMBER OF STAGES
6. FLOW DIRECTION - PACKED OR EXPANDED
7. HYDRAULIC FORCE - PUMPED OR GRAVITY
8. ORGANIC CAPACITY

TABLE 5

CARBON CAPACITY IN P-C TREATMENT PLANTS

PLANT	CARBON CAPACITY	
	LBS TOC / LB A.C.	LBS COD / LB A.C.
BLUE PLAINS	0.15	0.41
EWING-LAWRENCE	0.3	-
NEW ROCHELLE(ZM)	-	0.6
LEBANON	0.22	0.5

TABLE 6

EFFLUENT QUALITY-P-C PILOT PLANT AT BLUE PLAINS

TOC	6mg/l
BOD	5mg/l
COD	13mg/l
SS	5mg/l
TOTAL P	0.15mg/l
TOTAL N	4.6mg/l

TABLE 7.

POWDERED CARBON PILOT PLANT OPERATING CONDITIONS

FLOW RATE 50 GAL/MIN

CHEMICAL 425 mg/l LIME TO pH 10.8

CARBON 150 mg/l + 0.4 mg/l polymer

RESULTS

	COD	BOD	SS	P
RAW SEWAGE	222	144	200	7.3
CLARIFIED EFFLUENT	65	47	28	1.4
FINAL EFFLUENT	35	13	7	0.4

ALL RESULTS GIVEN IN mg/l

TABLE 8

ROCKY RIVER WASTE TREATMENT PLANT CLARIFICATION-CARBON PROCESS

	RAW	POLYMER CLARIFICATION	CARBON CONTACT TIME, MINUTES			PERCENT REMOVED
			14	23.4	32.6	
SUSPENDED SOLIDS, mg/l	107	65	13	15	7	93.3
BOD, mg/l	118	57	21	11	8	93.3
COD, mg/l	235	177	67	50	44	81.3

TABLE 9

ADVANTAGES OF PHYSICAL-CHEMICAL TREATMENT VS. CONVENTIONAL PRIMARY + SECONDARY

1. LESS AREA REQUIREMENT-½ TO ¼
2. LOWER SENSITIVITY TO DIURNAL VARIATION
3. NOT AFFECTED BY TOXIC SUBSTANCES
4. POTENTIAL FOR SIGNIFICANT HEAVY METAL REMOVAL
5. SUPERIOR REMOVAL OF P COMPOUNDS
6. GREATER FLEXIBILITY IN DESIGN AND OPERATION
7. SUPERIOR ORGANIC REMOVAL

TABLE 10

PRELIMINARY COST ESTIMATE PHYSICAL-CHEMICAL TREATMENT

Total Amortization + O&M, cents per 1000 gallons

Plant Size, MGD	5	10	100
Chemical Clarification*	9.5-13.5	7.3-9.6	4.0-5.3
Carbon Adsorption	11.5-18.0	9.1-13.5	4.5-7.8
Filtration	2.9-4.5	2.1-3.3	1.0-1.4
TOTAL	23.9-36.0	18.5-26.4	9.5-14.5

* Two-stage lime recalcination of sludge.

TABLE 11.

PHYSICAL CHEMICAL TREATMENT PLANTS

SITE	CAPACITY	STATUS
ROCKY RIVER, OHIO	10	BIDS TAKEN
PAINESVILLE, OHIO	5	DESIGN
CLEVELAND, OHIO	10	DESIGN
FITCHBURG, MASSACHUSETTS	15	DESIGN
WATERFORD, NEW YORK	2	PLANNED
CORTLAND, NEW YORK	10	PLANNED
CLAY, NEW YORK	10	PLANNED
NIAGARA FALLS, NEW YORK	60	PLANNED
GARLAND, TEXAS	30	DESIGN
OWOSSO, MICHIGAN	6	DESIGN