Group I, Phase I

Supplement to Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the

Corn Wet Milling Subcategory Grain Processing Segment of the Grain Mills

Point Source Category

August 1975

U.S. Environmental Protection Agency
Washington, D. C. 20460

WG-II

SUPPLEMENT TO DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

CORN WET MILLING SUBCATEGORY
GRAIN PROCESSING SEGMENT OF THE
GRAIN MILLS POINT SOURCE CATEGORY

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SECTION I

CONCLUSIONS

An extensive review of available data on the application of activated sludge and deep bed filtration for treatment of various wastewaters was conducted. Sources of data included the technical literature, field inspections, special consultants and expert opinions, corn wet milling companies, and equipment manufacturers. The data unequivocally and unmistakably substantiate the fact that high strength biodegradable organic wastes, such as those generated by corn wet mills, can be successfully treated with biological treatment processes, particularly complete mix activated sludge. With proper design and operation of treatment facilities, a stable high quality effluent can be attained on a reliable and sustained basis.

Ample evidence also exists to demonstrate that deep bed filtration is being applied successfully outside the corn wet milling industry. Filtration is used to treat potable water supplies, effluent from domestic sewage plants, and biologically treated effluents from many industrial waste treatment operations. Filtration can be applied to the corn wet milling industry, and, in fact, is being successfully employed by one company in the industry, despite inadequacies with in-plant controls and the preceding biological treatment process.

The treatment of variable, high strength wastewaters is not an enigma in sanitary engineering and pollution control practice. Indeed, numerous treatment applications have been made in many industries similar to corn wet milling, all with successful results. Not only have high degrees of pollutant removal been achieved through biological treatment, but additional pollutant reductions or effluent "polishing" have been demonstrated with filtration. The performance of these measures with corn wet milling wastes can be reasonably and unmistakably predicted.

On the basis of this study, it is concluded that the New Source Performance Standards as promulgated can be met by applying the technology prescribed for the corn wet milling subcategory in the Development Document for the Grain Processing Industry. Data on treatment of similar wastes strongly indicate that the standards quite probably can be achieved through biological treatment without filtration. Deep bed filtration, as with other "polishing" devices, provides additional assurance of maintaining a high quality effluent and minimizes or reduces the effects of biological treatment plant upsets. Such upsets can usually be attributed to poor in-plant control, faulty design, improper operation and human error. Polishing mechanisms such as filtration reduce the effects of such circumstances and are well demonstrated in achieving high quality effluent on a long-term basis.

The costs required for new corn wet mills of various sizes to meet the New Source Performance Standards were reevaluated and are indicative of current pollution control technology. These costs are based on January 1975 dollar values and include waste treatment facilities and necessary in-plant controls or cooling system designs. Evaluation of nonwater quality aspects of applying the recommended technology indicated that energy, air pollution, and solid waste impacts will be minimal.

SECTION II

RECOMMENDATIONS

Based on an extensive review of technical data, it is recommended that the New Source Performance Standards for the Corn Wet Milling Subcategory be implemented as promulgated on March 20, 1974. As the data reviewed demonstrate, new plants employing best available demonstrated control technology can readily achieve these standards. The New Source Performance Standards as recommended are as follows:

	BOD	Suspended Solids	pH
kg/kkg	0.357	0.179	
lbs/MSBu	20.0	10.0	
units			6-9

SECTION III

INTRODUCTION

On May 5, 1975 the U.S. Court of Appeals for the Eighth Circuit, issued its decision on Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Corn Wet Milling Subcategory of the Grain Milling Industry. The Court determined that it had no jurisdiction over Effluent Limitation Guidelines; but indicated this is a matter to be decided by the District Court. The Court did find it had jurisdiction over New Source Performance and Pretreatment Standards.

A. COURT FINDINGS

In reviewing the New Source Performance Standards for the Corn Wet Milling Subcategory, the Court noted the New Source limitations are identical to the 1983 guidelines. The 1983 guidelines assume the technology available to meet the 1977 guidelines will be supplemented by additional technology in 1983. After reviewing the basis for the 1977 guidelines, the Court concluded that the recommended 1977 technology, when employed in a new corn wet milling plant, would enable that plant to comply with the 1977 guidelines. However, the Court concluded that the record does not support EPA's determination that technology is available to meet the New Source Performance Standards. This technology, in the Court's view, would be required to remove an additional 30 pounds of BOD and 60 pounds of suspended solids per MSBu (0.536 kg/kkg BOD and 0.714 kg/kkg TSS) beyond the 1977 guideline limits of 50 pounds per MSBu (0.893 kg/kkg) of both BOD and suspended solids. The Court felt that, according to the record, deep bed filtration was being called on to provide most of the incremental reduction in BOD and suspended solids. They concluded that within the record there are no concrete data, test results, literature, or expert opinion in support of the "prediction" that filtration will permit a new corn wet mill to meet the New Source Performance Standards. To base standards on transfer technology, the Court stated that EPA must: 1) determine that the technology is available, 2) determine that the technology is transferable, and 3) make a <u>reasonable</u> prediction that the technology will be capable of removing the increment required by the New Source Performance Standards.

The Court also concluded that the costs required in adopting the New Source Performance Standards were not covered adequately in the record. Two problems were cited. First, EPA did not project <u>separate</u> capital and operating costs for control technology implemented at new plants. Second, EPA used 1971 prices in making cost estimates, despite the fact that more current data were available.

B. COURT DIRECTIVES

On the basis described above, the Court remanded the New Source Performance Standards to EPA. Their directive was that EPA, within 120 days, either furnish support for the present New Source Performance Standards or establish new standards.

C. PURPOSE OF THIS REPORT

The purpose of this report is to review the basis for the Corn Wet Milling New Source Performance Standards, review the technology recommended to meet these standards, and recommend further action to EPA in following the Court's directives. This report presents a detailed evaluation of the treatment technologies identified to meet the New Source Performance Standards: namely, activated sludge followed by deep bed filtration, although other technologies or even activated sludge alone may be capable of meeting the standards. Other technologies were briefly reviewed and may be applied, but the identified technologies cited above clearly represent the most practical and common approach to treatment of corn wet milling wastes.

The Court's conclusion that deep bed filtration was being called upon to remove an incremental 30 lb of BOD and 40 lb of TSS per MSBu (0.536 kg/kkg BOD and 0.714 kg/kkg TSS) is not entirely correct. An analysis of existing plants and their capabilities of meeting 1977 and 1983 Effluent Guidelines cannot be extrapolated directly to new corn wet mills. New mill in-plant controls will provide raw waste load reduction and stabilization and thus will greatly contribute to treatment plant performance. This report logically develops attainable effluent levels from new corn wet mills employing best available control technology and compares these levels with the present New Source Performance Standards.

D. ORGANIZATION OF THIS REPORT

This report is divided into ten sections. Section I summarizes the conclusions of the report. Recommendations to EPA based on the findings documented herein are presented in Section II. Section III summarizes the decision by the U.S. Court of Appeals, Eighth Circuit, and reviews the sources of data used to prepare this document. Section IV is an evaluation of the effectiveness of biological treatment systems, particularly the activated sludge process, handling corn wet milling wastes and other high strength organic wastes. In-plant control technologies applicable to new corn wet mills are discussed in Section V. Section VI evaluates deep bed or tertiary filtration, a technology for reducing BOD and suspended solids levels in secondary effluents. A discussion of Clinton Corn Processing Company's (Clinton, Iowa) waste treatment facilities is presented in Section VII. Clinton employs much of the end-of-pipe treatment technology recommended to meet New Source Performance Standards, including filtration, although the plant is subject to operational limitations as discussed in the section. In Section VIII, predicted performance of new plants is presented.

Model plants with accompanying treatment facilities are outlined. Effluent levels are predicted in terms of pound of pollutant per unit quantity of raw material. Associated costs to meet New Source Performance Standards are also given. Section IX evaluates the non-water quality aspects of compliance with New Source Performance Standards, including energy requirements, air pollution, and solid waste disposal. Section X is a summary of the findings of this study.

E. SOURCES OF DATA

The detailed information on which this report is based was drawn from a variety of sources including the literature, field inspections, special consultants and expert opinion, corn wet milling companies, equipment manufacturers, and the Environmental Protection Agency.

An intensive review of the literature was conducted on deep bed filtration with particular emphasis on filtration of biologically treated effluents. Pertinent findings from this review are cited in Section VI of this report. The entire Literature Review (1) is summarized in the supporting documentation contained in a record on remand which is available for review.

The use of the activated sludge process in municipal and industrial waste treatment, including corn wet milling was investigated to document its effectiveness in handling high strength organic wastewaters. Of particular concern was the application of activated sludge to industrial wastes similar to those generated by corn wet milling. These similar wastes include brewing, distilling, malting, edible oil refining, and wine production. Data were drawn from the literature and from EPA experience.

Dr. E. Robert Baumann, Anson Marston Distinguished Professor of Engineering, Iowa State University, was retained to provide additional technological insight into advanced waste treatment concepts and applications. Dr. Baumann is one of the leading authorities on filtration of secondary treatment plant effluents, and is the author of numerous papers and textbooks in sanitary and environmental engineering.

Dr. Raymond C. Loehr, Professor of Engineering, Cornell University, was also consulted in the development of this report. Dr. Loehr is a recognized expert in the treatment and disposal of high strength organic wastes.

In addition, Dr. Charles M. Cook, Technical Advisor to the Director of Monitoring and Data Support Division of EPA, reviewed and evaluated the data and statistics developed in this study.

A specific request (2) was made to a number of corn wet milling companies for data regarding:

1. Performance of existing treatment and pretreatment plants

including related production and product-mix figures, and treatment costs.

2. Previous pilot plant studies.

3. Relationship between raw aste characteristics (and treatability) and product mix.

4. Projection of new plant costs, raw waste characteristics, additional in-plant controls, and power requirements for the model 30,000, 60,000 and 90,000 bushels/day corn wet mills.

Responses to some or all of the specific information requested were made by six companies. Two meetings were held in Washington, D.C. with representatives of Anheuser-Busch, Inc., CPC International Inc., and Penick & Ford, Ltd.; and one meeting was held with A. E. Staley Manufacturing Company in Decatur, Illinois.

Several field inspections were conducted including two visits to Clinton Corn Processing Company in Clinton, Iowa and a visit to the CPC International, Inc. plant in Corpus Christi, Texas. A brief three-day sampling program was conducted at the Clinton waste treatment plant in an attempt to assess the efficacy of their deep bed filtration system. Visits were also made to the Metropolitan Sanitary District of Greater Chicago and to Du Page County, Illinois to discuss their experience with deep bed filtration and to observe filter installations.

Much information was provided by waste treatment equipment manufacturers, particularly regarding filtration. The following filter manufacturers were contacted and provided data during the study:

Can-Tex Industries
Crane-Cochrane
Dravo Corporation
Ecodyne Corporation
Envirotech
General Filter Company
Hardinge Division, Koppers, Inc.
Hydro-Clear Corporation
Hydromation
Infilco-Degremont
Neptune Microfloc, Inc.

Finally, information was provided by EPA on several pertinent projects. Specifically, detailed data were supplied on the treatment of other high strength food wastes, such as those described in the Development Documents for the Miscellaneous Foods and Beverages, Fruits and

Vegetables, and Pulp and Paper Point Source Categories. Information was also received on the EPA Demonstration Project on deep bed filtration of treated oil refinery wastes.

All of the information from the above sources was carefully reviewed and considered in preparing this report. Materials used directly in the report are referenced herein, and all data are included in the record which supplements the report.

Distillery wastes have been shown to be amenable to biological treatment. Smith (12) reported that 90 percent or better BOD reduction can be attained with biological treatment processes such as trickling filters and activated sludge. Raw wastes from distilleries generally contain 500 to 1000 mg/l BOD and 50 to 200 mg/l or more TSS. Effluent data for several distilleries are shown below (8, 13):

Distillery	Range of Effluent BOD Concentrations mg/l	Range of Effluent TSS Concentrations mg/l
1	20 - 40	25 - 40
2	12 - 40	12 - 70
3	20 - 50	20 - 50
4	10	20 - 40
5	3 - 15	10 - 100

On the following page is shown Table 119 from the Miscellaneous Foods and Beverages Draft Development Document. This table summarizes the performance of 11 treatment facilities handling wastes from grain distillers operating stillage recovery systems.

Biological treatment has been successfully applied to bakery and winery wastewaters. One bakery in the mid-south provides complete treatment of high strength wastes (14). Treatment includes equalization, dissolved air flotation, trickling (roughing) filter, activated sludge, and stabilization ponds. High strength wastes with a BOD concentration in excess of 2000 mg/l are consistently reduced to less than 10 mg/l. Treatment performance levels in 1974 were:

	Average Influent Concentration (mg/l)	Range of Effluent Concentrations (mg/l)	Percent Removal
BOD	2210	7 - 9	99.6
TSS	1020	6 - 15	98.5 - 99.4

High strength wastes from winery operations have been shown amenable to biological treatment processes (15, 16, 17, 18). Wineries generate medium to high strength organic wastes with BOD levels of 1000 to 2000 mg/l. BOD removals of 90 to 97 percent and suspended solids removals of 67 to 90 percent are documented in the Miscellaneous Foods and Beverages Draft Development Document.

TABLE 119

TREATMENT SYSTEM SUMMARY
SUBCATEGORY A22

Plant	Treatment System Description	Percent Removal	
		BOD	TSS
85A01	Activated Sludge, Bio Disc.	97.5*	90.7*
85A02	Aerated Lagoon Stabilization Pond	37.0	75.7
85A04	Aerated Lagoon, Stabilization Ponds	93.3	84.4
85A05	Aerated Lagoon, Stabilization Ponds	93.3	73.8
85A07	Activated Sludge	91.9	82.8
8A5A15	Bio Disc.	----	----
85A17	Activated Sludge Contact Stabilization	35.6**	93.2
85A18	Activated Sludge, Contact Stabilization	96.6	94.3
85A22	Aerated Lagoon, Stabilization Pond	96.2	72.2
85A27	Aerated Lagoons	98.7	34.3***
85A29	Aerated Lagoons Trickling Filters, Stabilization Ponds	97.3	----

* Activated Sludge Portion
** Before Contact Stabilization Added
*** No Clarification after Aeration

One winery in New York State employed an aerated lagoon system to treat its wastes (19). Average raw waste flow is 0.85 mgd (3217 cu m/day). Influent BOD ranges from 1000 to 4400 mg/l and averages 2300 mg/l. Yearly average BOD reductions for a four-year period were as follows: 1970 - 94 percent, 1971 - 95.2 percent, 1972 - 95.6 percent, 1973 - 94.7 percent. Because of problems with ground-water intrusion and seasonal fluctuations in effluent quality, the winery installed an activated sludge treatment system in late 1973. Data from the first six months of operation (including start-up and shake-down procedures) indicate an average effluent BOD level of 30 mg/l and a suspended solids level of 75 mg/l. Data obtained later in 1974, after stabilization of the treatment process, indicate the following effluent characteristics (20):

	Effluent Concentrations (mg/l)	
	Range	Average
BOD	18-32	21
TSS	20-54	40

Another example of effective treatment of high strength organic wastes exists in the frozen specialty product industry. A manufacturer in Virginia has treatment facilities consisting of screens, floatable fat and solids removal, dissolved air flotation, anaerobic lagoons, trickling filters, contact aeration tanks (activated sludge), final setting tanks, and chlorination of final effluent. Based on an analysis of 54 daily samples, BOD and suspended solids are reduced by 99.7 and 99.3 percent, respectively. The very high influent raw waste levels (3500 mg/l BOD and 4500 mg/l TSS) are reduced to final effluent levels of 15 mg/l or less BOD and 35 mg/l suspended solids. Fat and oily material are reduced from 3000 mg/l to 1.5 mg/l, representing an overall removal efficiency of 99.9 percent. Maximum daily BOD and TSS values are 27 mg/l and 119 mg/l, respectively (21).

To further evaluate the effectiveness of biological treatment processes, data from EPA experience with the Fruits and Vegetables Industry were analyzed (22). This industry generates a very diverse array of high strength organic wastes. Within the industry there are numerous biological treatment systems demonstrating the ability to successfully treat these wastes without further polishing techniques such as filtration. EPA accumulated data on 10 activated sludge systems, two trickling filter systems, and 13 aerated lagoon systems providing treatment of fruit and vegetable processing wastes. These exemplary treatment facilities handle biodegradable wastes from 32 product commodities processed at these plants, ranging from corn, tomato products, and sauerkraut to jams, jellies, and dry beans.

At the fruit and vegetable plants employing activated sludge systems, raw waste BOD varied from 253 to 4096 mg/l. The activated sludge systems resulted in long-term BOD reductions from 95.5 to

99.7 percent. Sustained effluent (annual average) BOD levels ranged from 8 to 62 mg/l and averaged 20 mg/l for all plants. Corresponding effluent suspended solids levels ranged from 10 to 80 mg/l and averaged 31 mg/l. The new source performance standards for the corn wet milling industry would require a sustained effluent BOD and suspended solids load reductions of 97.4 and 96.9 percent, respectively, with biological treatment and the addition of deep bed filtration. Under representative waste use and waste flows in the industry these load reductions would represent final effluent levels of approximately 20 to 30 mg/l BOD and 10 to 20 mg/l TSS. Under present experience and application as described in Section VI, Evaluation of Filter Technology, deep bed filtration may be reasonably expected to provide at least an additional 50 to 75 percent removal of BOD and suspended solids beyond effective biological treatment.

The 13 aerated lagoon systems within the fruits and vegetables processing industry handle raw wastes with BOD levels ranging from 388 to 5642 mg/l and averaging 2126 mg/l. These treatment systems demonstrated long-term BOD reductions of 90 to 99.8 percent, an average of 97.9 percent.

Variability of the treated effluents from the treatment systems described above was analyzed. The ratio of maximum daily BOD and maximum monthly (30 consecutive days) BOD values was determined to be 2.0. The same ratios for suspended solids were calculated to be 1.8 for aerated lagoons and 2.6 for the activated sludge and trickling filter systems.

Analysis of the data gathered for the Miscellaneous Foods and Beverages and the Fruits and Vegetables Industries indicated that no statistical correlation existed between influent BOD and TSS levels. In other words, influent suspended solids values varied erratically in relation to BOD. Despite this variation, effective high-level waste treatment was clearly demonstrated to be available and practicable. Statistical analysis of fruits and vegetables treatment data also indicated that no relationship exists between influent and effluent TSS levels.

A concern raised frequently by the corn wet milling industry is the apparent sensitivity of the activated sludge system to fluctuations in the influent waste characteristics. As shown above, many existing activated sludge systems receiving variable, high strength organic wastes have been able to consistently produce a highly stable effluent with low BOD and suspended solids.

A. W. Busch (7) discusses operational problems at some length and summarizes as follows: "In short, most operational problems with fluidized systems [activated sludge] are built into design (lack of ability to control growth rate for example) or are due to faulty operating concepts." Referring to shock loads, he further states that "determination of such flow patterns and their anticipation in process and system design is a vital part of the engineer's responsibility."

The information presented above fully substantiates the ability of biological treatment systems to reliably produce very high pollutant reductions on a sustained basis with high strength food processing wastes. With reasonably prudent design and operation, a biological treatment system can effect overall BOD and suspended solids reductions in excess of 95 percent and can produce effluent levels of 30 mg/l and less, despite highly variable raw waste characteristics.

C. CORN WET MILLING INDUSTRY

When waste treatment has been required, the corn wet milling industry has for the most part used the complete mix activated sludge process. There are four mills that treat process wastes and eventually discharge treated effluent directly to waterways (one of the four recycles its effluent into the mill for reuse). All four of these mills employ complete mix activated sludge. Five mills provide pretreatment of process wastes prior to discharge to municipal systems, and a sixth mill is currently constructing pretreatment facilities. Three of these six pretreatment plants employ the activated sludge process; the remainder use other biological processes. A review of the performance of these treatment facilities is presented below in order to provide a better understanding of treatment practices within the corn wet milling industry.

1. CPC - Pekin, Illinois

CPC's Pekin, Illinois corn wet mill is an older, medium-sized plant located on the Illinois River. The mill uses a large volume of water, 20.5 mgd (77,593 cu m/day), for process and cooling purposes. Much of this water is used in once-through barometric condensers. Prior to the late 1960's, all of the wastes from the Pekin mill were discharged directly to the river without treatment. In 1968, CPC applied for and received a Research and Development grant from EPA's predecessor, the Federal Water Pollution Control Administration. The grant provided funds for development, design, and construction of waste treatment facilities. The treatment plant was designed to handle only concentrated process wastes (less than 1 mgd) and not the contaminated barometric discharge. Operation of the treatment facilities began in late 1970. Included in the scheme were equalization, cooling, nutrient addition, complete mix activated sludge (aeration and clarification with sludge recycle), dissolved air flotation, and reaeration. As the Final Grant Report (23) documents, numerous mechanical and other problems plagued the plant's first year of operation, and treatment performance has never reached the original design criteria on a long-term basis.

The following discussion concerns the performance of the waste treatment facility at Pekin. The industry has claimed that the Pekin treatment plant does not perform satisfactorily; that it is subject to shock loads and variations in raw waste and, therefore, is not capable of producing a stable effluent. Carryover of suspended solids in the effluent is a particular problem. This investigation confirmed the variability of treatment plant performance at Pekin, but it also established the reasons for this variability: Deficiencies in design and operation of the treatment system and deficiencies with in-plant waste controls within the manufacturing plant.

Initially the Pekin waste treatment plant was operated at a very high organic loading rate, specifically a food-to-microorganism (F:M) ratio of about 0.8. Experience has shown that treatment of corn wet milling wastes is effectively attained at much lower loading rates. For example, the new treatment facilities at Clinton and Muscatine, Iowa are designed for an F:M of 0.3 to 0.35. Pekin has since made in-plant changes to reduce waste loadings, but the treatment plant is still subject to influent shock loads that exceed normal design loading rates. Other design deficiencies include an undersized clarifier. The Pekin clarifier was designed at an overflow rate of 600 gallons per day per square foot (24.4 cu m per day per sq m). Although this value conforms with standard sewage treatment practice, it is considerably higher than loadings used at other treatment plants handling high strength organic wastes. Overflow rates of 400 gpd/sq ft (16.3 cu m/day/sq m) are more common in the miscellaneous foods and beverages industry (8). The Pekin Final Grant Report (23) stated that "[a] lower [clarifier] overflow rate should result in a lower sludge blanket, and less frequent floc carryover." The report also made note of severe raw waste shock loads - shock loads that could be controlled within the plant. The conclusion was that "further improvement in effluent quality will require stabilization of the waste load, and improved suspended solids removal."

CPC is well aware that the Pekin waste treatment facility needs improvement. An EPA evaluation of the plant in 1972 concluded: "With enlarged plant facilities it appears possible to reduce BOD and suspended solids concentrations below 25 mg/l. Performance of the existing waste treatment plant cannot be improved significantly by operational control modifications alone (24)." CPC has performed its own evaluations (25). Studies conducted from November 1972 to February 1973 concluded that additional equalization (to absorb the extremely high waste load fluctuations) and additional activated sludge facilities were required to improve the plant effluent. CPC's consultant performed studies in 1973 on effluent polishing techniques, including filtration and dissolved air flotation. The consultant concluded that new dissolved air flotation facilities were needed (26). The consultant's conclusions on filtration are discussed in Section VI of this report. Based on the findings of CPC and its consultant, extensive improvements to the treatment plant are now being implemented. These improvements include additional equalization basins, new aeration tanks, new clarifiers, and a new dissolved air flotation unit (27). Work is scheduled to be completed by late 1975.

Despite its limitations (and the present in-plant control inadequacies within the corn wet mill), the Pekin treatment plant has demonstrated its ability to perform well for extended periods of time. For example, between July 1972 and January 1973, BOD reduction was below 90 percent only 10 percent of the time, and the effluent design level of 40 mg/l BOD was met nearly 60 percent of the time (23). More recent data substantiate that the treatment facility can produce a stable effluent. From July 24, 1973 to August 21, 1973, BOD concentrations exceeded 100 mg/l only once and generally were below 50 mg/l. From October 8, 1973, to December 3, 1973, the same conditions were met. Particularly good performance was recorded in May and June of 1974. Average effluent BOD was 35 mg/l in May and 32 mg/l in June. Average TSS was 65 mg/l in May and 66 mg/l in June (27). Improved waste treatment and additional in-plant controls, which would be much easier to implement in a new manufacturing plant, would enable Pekin to produce a stable treated effluent on a reliable and sustained basis.

It should again be noted that the waste treatment plant at Pekin only receives the high strength waste waters constituting less than 10 percent of the total mill effluent. The major portion of the mill effluent consists of the contaminated barometric condenser cooling water discharge (once-through cooling water), which represents a dilute, but significant waste stream. Total waste loads to the receiving stream are about 600 lb/day (272.4 kg/day) from the treatment plant and 6000 lb/day (2724 kg/day) from the barometric cooling waters.

2. <u>CPC - Corpus Christi, Texas</u>

CPC's Corpus Christi plant is a small mill of more modern design than the mill at Pekin, Illinois. In 1970, the plant began installing waste treatment facilities to treat process wastes prior to discharge to the adjacent ship channel. The Corpus Christi plant suffers the same failing as Pekin; namely, direct discharge of contaminated barometric condenser water without treatment. The problem is not as severe as at Pekin, however, since the plant does employ a number of surface condensers. Barometric discharge accounts for 3.4 mgd (12,869 cu m/day) and 264 lb/day (119.8 kg/day) or 16 lb/MSBu (0.286 kg/kkg) of BOD on an average basis (28).

The Corpus Christi treatment facility is a piecemeal design. Beginning as an unsuccessful batch treatment operation, it was converted to an activated sludge system over a period of four years. The system originally consisted of three vertical steel tanks, each with sparged air and a submerged turbine mixer, followed by dissolved air flotation. Other components were gradually added, including nutrient addition facilities, an equalization and cooling basin, a primary tilted plate separator for starch wastes, a fourth aeration tank (of larger capacity than the first three), and a final clarifier. The flotation unit was not effective and is now used as a second clarifier. There is no skimmer on the clarifier, and solids tend to float to the top and pass over the weir. The aeration tanks are operated at a very high MLSS (mixed liquor suspended solids) level, between 6000 and 8000 mg/l (29, 30).

The limitations of the Corpus Christi treatment facility result in an effluent atypical of a well designed and operated activated sludge system. During the period December 1974 to April 1975, the effluent averaged 311 mg/l BOD and 730 mg/l suspended solids. Despite this poor performance and the discharge of untreated barometric condenser wastes, the total BOD discharge from the mill (including cooling water) was 57.4 lb/MSBu (1.025 kg/kkg) as a mean daily average and 64.6 lb/MSBu (1.154 kg/kkg) as a mean 30-day average. These levels are not much above the 1977 effluent guideline of 50 lb/MSBu (0.893 kg/kkg) for a maximum month. BOD discharged from the waste treatment plant was 41.8 lb/MSBu (0.747 kg/kkg) as a mean daily average and 48.3 lb/MSBu (0.863 kg/kkg) as a mean 30-day average (28).

As at Pekin, a stable effluent (in terms of BOD) is obtained at Corpus Christi during certain periods. For example, from February 9 to 21, 1975, effluent BOD ranged from 9 to 90 mg/l and averaged 43 mg/l. From March 14 to 29, 1975, effluent BOD values ranged between 10 and 64 mg/l and averaged 35 mg/l (27).

Because of alleged violation of state water quality standards and failure of the waste treatment facility to achieve acceptable effluent quality, CPC had extensive evaluations performed during 1974 and early 1975 (29). Concurrently, CPC intensified its effort to reduce waste loads within the plant. Additional facilities were installed to improve operation and divert, remove, or pick up wastes in-plant and to reduce the potential for accidental discharges. CPC's consultant recommended extensive modifications to the waste treatment plant, and work has begun to implement the new measures. The modifications include additional seeded equalization and a final stabilization lagoon.

3. American Maize - Hammond, Indiana

The American Maize corn wet mill is an older plant located on Lake Michigan. The plant discharges once-through cooling waters and treated process wastes to the lake. A major pollution abatement program was undertaken during the late 1960's. Surface condensers replaced most of the barometric condensers. Only two small barometric condensers remain in the syrup refinery, one of which is not presently being used.

American Maize's waste treatment system is a series of three lagoons that was converted to essentially an activated sludge system with polishing ponds. Aerators were installed in the first lagoon and a clarifier with sludge return was added in 1968, process and sanitary wastes were segregated in 1969, and aerators were installed in the two polishing lagoons receiving activated sludge effluent in 1970.

The 1977 effluent guidelines would allow American Maize to discharge a maximum of 3250 lb/day (1475.5 kg/day) of BOD and suspended solids for any 30 consecutive days and 9750 lb/day (4426.5 kg/day) for any one day. A look at American Maize NPDES reports (31) shows that the plant is currently meeting these levels. Discharge levels for January through March 1975 are shown below:

	Average for Month				Maximum for Month			
	BOD		TSS		BOD		TSS*	
	lb/day	kg/day	lb/day	kg/day	lb/day	kg/day	lb/day	kg/day
Jan	1722	782	1995	906	3819	1734	5600	2542
Feb	1418	644	2002	909	2193	996	6756	3067
Mar	421	191	2080	944	1313	596	5286	2400
1977 Effluent Guidelines	3250	1476	3250	1476	9750	4427	9750	4427
NPDES Permit Levels	2000	908	--		10,000	4540	--	

Calculated by assuming that maximum flow and maximum TSS concentration occurred on same day.

The current discharge levels for American Maize are well under both the NPDES permit levels for the plant and the 1977 effluent guideline levels.

The total discharge levels from American Maize do not necessarily indicate that all components of the waste treatment system are operating well. For example, during the period April 1974 through March 1975, monthly average values of TSS in the clarifier overflow ranged from 66 mg/l to 1292 mg/l. Averages for TSS during the first three months of 1975 were 628, 651, and 277 mg/l, respectively (32). The major portions of the American Maize treatment system were originally designed for an entirely different process and, hence, do not reflect current design standards for activated sludge systems. The polishing lagoons, however, provide additional treatment capacity. Thus, although the total system does not include a well-designed activated sludge process, American Maize is easily meeting 1977 effluent guidelines with current technology, despite frequent upsets in their adapted activated sludge system.

4. Clinton Corn Processing Company - Clinton, Iowa

Clinton Corn has recently installed new waste treatment facilities that include deep bed filtration, part of the 1983 recommended control technology. Accordingly the Clinton treatment system is discussed separately in Section VII.

5. Pretreatment Facilities

There are five corn wet mills that presently provide pretreatment of wastes prior to discharge to municipal collection and treatment systems. These plants include Anheuser-Busch - Lafayette, Indiana; Cargill - Cedar Rapids, Iowa; Penick & Ford - Cedar Rapids; and A. E. Staley - Decatur, Illinois and Morrisville, Pennsylvania. A sixth mill, Corn Sweeteners - Cedar Rapids, is constructing pre-treatment facilities. The two Staley plants and Corn Sweeteners' plant employ the complete mix activated sludge process, and

Anheuser-Busch operates an aerated lagoon system. Penick & Ford's system is a unique fungal digestion process, with a final clarification step soon to be added. Cargill's pretreatment is rather limited, consisting of settling tanks and some aeration.

All five of the existing pretreatment facilities are operating successfully from the standpoint that requirements of the municipalities involved are being met. For example, Anheuser-Busch's aerated lagoon system consistently removes 50 percent and more of the BOD in the raw waste (33).

D. SUMMARY

Biological treatment processes, particularly activated sludge, are proven and effective means for handling domestic and industrial wastewaters. The activated sludge process has been demonstrated in thousands of applications as a versatile pollution abatement technology and is well-suited for treatment of high strength organic wastes.

Many experts in the field of environmental and sanitary engineering attest to the applicability of activated sludge. Furthermore, an extensive evaluation of biological treatment systems in industries generating wastes similar to corn wet milling proves that these systems can effectively treat variable high strength wastes and can produce stable, high quality effluents. With good design and operation, such a treatment system will consistently produce an effluent containing 30 mg/l BOD and TSS, despite raw waste variations. This has been demonstrated with a wide variety of industrial wastes, including those generated by breweries, edible oil refineries, malting plants, distilleries, bakeries, wineries, and fruit and vegetable processing plants.

The activated sludge process has been applied by a number of corn wet mills in the treatment of their wastes. No plant has implemented a properly designed and operated treatment facility coupled with good in-plant control. Thus there is presently no example of best practicable control technology within the industry. Factors such as limitations in design and operation of the treatment facilities, lack of in-plant controls, and discharge of untreated wastes have prevented treatment plants from attaining optimal performance on a long-range basis. A treatment facility at a new corn wet mill that incorporates good in-plant controls in its design will not be subject to upset conditions and thus will achieve long-term performance comparable to the high levels achieved by other industries.

On the basis of experience of treating similar waste from other industries it is generally concluded with reliance that with the most careful design, operation, and in-process control, the New Source Performance Standards can be achieved through demonstrated performance of biological treatment systems. Deep bed filtration provides an additional assurity as to the achievement of the required high quality effluent on a reliable and sustained basis.

SECTION V

IN-PLANT CONTROLS

As the Development Document for the Grain Processing Industry (9) indicated, there are many water recycling and reuse techniques presently employed in corn wet mills. These techniques have resulted from efforts to improve product recovery and simultaneously to reduce raw waste loads. In-plant controls are continuously being developed and improved.

The Development Document also pointed out that not all existing corn wet mills employ every available in-plant control to conserve water and reduce waste loads. Age of the plant and physical constraints such as space within the plant and land availability are often determining factors. This is not the case with new plants. A new corn wet mill will be able to incorporate, in design, many in-plant controls that are less readily retrofitted into existing plants. These controls would include segregation of process and sanitary wastes, recirculating or noncontact cooling systems, spill containment facilities or overflow tanks, holding tanks to collect discharges of concentrated wastes or acids, clean-in-place (CIP) cleaning systems, and instrumentation to monitor and control process variables and resultant waste streams.

After consultation with the industry (34) and with process equipment suppliers, it has been determined that a new plant designed or constructed today would incorporate the majority of available in-plant controls as a matter of good practice with or without the demands of pollution control regulations. In fact, with some process equipment such as evaporators, there would be little choice. Process equipment with the most modern water conservation and pollution control features would also be the most attractive from an economic or product yield point of view.

The only exception that might be taken regards cooling systems. A new plant built today that did not face stringent effluent limitations might employ a once-through cooling water system using barometric condensers. The mill would thus discharge a high volume, low concentration, contaminated waste stream. Faced with effluent limitations, the new plant designer has two choices. One is to install barometric condensers utilizing a recirculating water system. A cooling tower would be needed, and the blowdown from the tower would require treatment along with process wastes. The second choice is to install surface (noncontact) condensers, with or without recirculation, that would prevent contamination of the cooling water stream. Surface condensers are more costly to buy and operate than barometric condensers.

The lack of adequate in-plant controls, coupled with treatment plant deficiencies at existing corn wet mills, contribute to the inability to identify a truly exemplary treatment system meeting potentially achievable performance in the industry. These same deficiencies in current practice also make it very difficult to extrapolate current treatment performance to new sources. One cannot conclude that existing treatment systems are performing as well as possible. It would be more valid to look at periods of good performance at existing treatment plants reflecting the absence of upset conditions, since a waste treatment plant serving a new mill would experience less raw waste variability and shock loads. Better in-plant controls will reduce raw waste fluctuations.

In summary, a high degree of in-plant control can be reasonably expected at any new corn wet mill. Such control will be an integral part of the basic process design and, if supplemented with flow equalization, will largely eliminate major raw waste fluctuations. Elimination of raw waste fluctuations will allow the subsequent waste treatment processes to produce a stable, high-quality effluent. In considering the cost of the in-plant controls for new sources, only the cost of a recirculating or noncontact cooling water system is directly attributable to pollution abatement.

TABLE 9-1 (CONTINUED)

RESULTS OF STUDIES OF FILTRATION OF EFFLUENTS FROM SECONDARY BIOLOGICAL TREATMENT

LOCATION	TYPE OF FILTER	INFLUENT SOURCE	BED CHARACTERISTICS MEDIA	BED CHARACTERISTICS SIZE	BED CHARACTERISTICS DEPTH	HYDRAULIC LOADING	SUSPENDED SOLIDS IN	SUSPENDED SOLIDS OUT	SUSPENDED SOLIDS REMOVAL	RUN LENGTH	REFERENCE
			type	mm	in	gpm/ft^2	mg/l	mg/l	percent	hr	
[illegible]mouth, England	Pressure Upflow	Activated Sludge	Sand	1-2	60	5.3	17	7	60	-	(22)
[illegible] Main [illegible]nage, Freehold [illegible]rks, England	Gravity Downflow	Activated Sludge	Sand	0.5-2.5	-	1.3-2.4	12	5	58	-	(22)
[illegible], U.K.	Gravity Downflow	Trickling Filter	Sand	1.1	-	1-3	20	5	75	-	(22)
[illegible]bourne Works, [illegible], England	Gravity Downflow	Trickling Filter	Sand	1.5-3	-	1.6-3.2	21	5	75	-	(22)
[illegible], England	Simater Radial Flow	Trickling Filter	Sand	1-2	-	4-6	22	9	60	-	(22)
[illegible]ameside, England	Immedium Pressure Upflow	Activated Sludge	Sand	1-3	63	3.3	9	2	74	-	(23)
						3.3	46	8	84		
						5.0	8	6	20		
						5.0	37	10	74		
[illegible]ameside, England	Permutit Upflow	Activated Sludge	Sand	0.60-1.20	57	3.3	9	1	86		(23)
						3.3	32	7	78		
						5.0	11	4	60		
						5.0	28	5	83		
[illegible]ameside, England	Simater Radial Flow	Activated Sludge	Sand	0.5-1		3.3	11	3	74		(23)
						3.3	51	7	86		
						5.0	11	4	62		
						5.0	24	10	58		
[illegible]ton-Under-Lyne, [illegible]land	Immedium Upflow	Trickling Filter	Sand	1-2	60	4.5-5.0	30	8	80		(24)

treatment to meet increasingly stringent effluent requirements. Filtration applications in wastewater treatment include:

1. removal of biological floc from secondary effluent,
2. removal of precipitates in the process of phosphorus removal, and,
3. removal of solids remaining after chemical treatment (36).

Filtration as a tertiary treatment method following secondary processes has long been practiced in Great Britain. While the British practice tends toward the upflow pressure mode, their experience includes gravity downflow, bi-flow, and radial-flow methods, many of which are patented processes. In the United States the tendency is toward the conventional downflow gravity method, although some pressure filters are presently in use (35, 40).

The EPA Process Design Manual for Suspended Solids Removal (35) devotes considerable attention to granular media filtration. The manual states that "this process [filtration], long applied in treatment of municipal and industrial water supplies, is becoming widely used for wastewater treatment both in upgrading existing conventional plants and in designs of new advanced treatment facilities." Data on numerous filter installations treating biological or secondary effluents are given in the manual in Table 9-1, which is reproduced in this report on the following three pages. Note that in all of these examples, filter effluent suspended solids never exceeded 10 mg/l, despite influent levels which varied as high as 50 mg/l. Removals were above 60 percent and often were 80 percent and higher. In developing the New Source Performance Standard for the corn wet milling industry, deliverance of a biologically treated effluent to the deep bed filtration stage at a concentration level of 75 mg/l BOD and TSS is assumed, eventhough experience with biological treatment for similar wastes for other food processing industries indicate achievement of a BOD and TSS effluent level of 30 mg/l is generally achievable by biological treatment. An additional 50 to 75 percent removal of BOD and TSS is attributable to deep bed filtration beyond biological treatment.

Many tests have been conducted on both pilot plant and plant scale levels to determine the effectiveness of the filtration process for suspended solids and BOD removal, to further refine the process, and to develop design criteria. Gravity downflow filtration has been found to be a cost-effective means of reducing suspended solids in the effluent from wastewater treatment facilities. Both conventional and special design filter beds have been tested. Filtration of wastewaters has been successfully demonstrated without chemical addition. In some instances, chemical addition has improved the filterability of biologically treated wastewaters and thus has increased BOD and suspended solids removals.

Hsiung and Cleasby (41) performed studies to develop a simple and rational method for design and operation of water treatment filters. Optimum cost for filtration was obtained by developing performance curves with the flow rate determined by consideration of either filtrate quality or head loss. They concluded that the results of this study may be applicable to sewage solids and that such applicability should be investigated.

Lynam et al (42), in studies conducted at Chicago Metropolitan Sanitary District's Hanover plant, found rapid sand filtration of activated sludge effluent to be a cost-effective process that consistently produced effluent suspended solids of less than 5 mg/l. Removals of 76.5 percent were obtained. The study reports that chemical addition (alum followed by polymer) provided insufficient improvement of filtrate quality over plain filtration to warrant its inclusion in future designs.

Tchobanoglous (43) evaluated the performance of various filter configurations including conventional and special bed designs and the effects of chemical addition. His conclusions were: 1) filtration efficiency without chemical addition is a function of filter bed grain size, 2) in most dual-media filters as presently designed the sand underbed contributes little to overall suspended solids removal, and 3) polyelectrolytes can be used to aid in removal of suspended solids. At a filtration rate of 5.15 gpm/sq ft (3.5 liters/sec/sq m) and with polyelectrolyte addition, an average influent suspended solids concentration of 23.5 mg/l was reduced to 1 to 3 mg/l. Filter operating periods (run lengths) were between 4 and 5 hours. Suspended solids removals ranged from 87 to 96 percent.

Tchobanoglous and Eliassen (44) investigated filtration of activated sludge effluent in a pilot plant study. They developed a generalized rate equation based on size of filter medium, rate of filtration, influent characteristics, and the amount of material removed within the filter. Using 0.488 mm diameter sand, suspended solids were reduced from 6.3 mg/l to 2 mg/l, a 68 percent removal. Filtration rate was 5.8 gpm/sq ft (3.9 liters/sec/sq m) and run length was 6.25 hours. The top 1-inch (2.54 cm) of the filter removed 75 percent of the suspended solids, and no solids were retained below a depth of 6 inches (15.2 cm).

Baumann and Huang (45) conducted a pilot plant study using effluent from the Ames, Iowa standard rate trickling filter. Objectives were to determine the feasibility of using granular filtration as an effluent polishing step and to develop a method and pilot plant test procedure to be used in the design of filters for tertiary wastewater treatment. They concluded that use of a dual-media filter (anthracite over sand) increases filter capacity and provides for better utilization of the filter depth and that it is desirable to have the anthracite as coarse as possible and the sand as fine as possible. Best results were obtained by a bed of coarse anthracite overlying fine sand, which produced a better quality effluent without significant head loss development as compared with a coarser sand topped by the same size anthracite.

Culp and Hansen (46) found that up to 98 percent of the suspended solids found in an extended aeration treatment plant effluent with 24-hour aeration of domestic sewage could be removed by filtration. Turbidities as low as 0.3 jtu were obtained without the use of coagulants.

Culp and Culp (47) report that filterability of sewage solids is affected by the degree of flocculation attained in the secondary process and that activated sludge achieves the best flocculation results as compared to trickling filter and physical-chemical processes. Flocculation is proportional to aeration time and inversely proportional to F:M ratio. Aeration basin MLSS variations in the normal operating ranges of 1,500 to 5,000 mg/l do not affect filterability. With domestic wastes, suspended solids removals from 70 to 98 percent can be obtained at aeration times of 6 to 10 hours, respectively. Biological processes, in general, produce a more fully developed floc than chemical coagulation, and the higher removal percentages were obtained with the effluent from an extended aeration plant. Culp and Culp present the following levels as guides to the suspended solids concentrations that might be achieved when filtering a typical secondary effluent without addition of chemical coagulants:

Process	Effluent TSS
High-rate trickling filter	10-20 mg/l
Two-stage trickling filter	6-15 mg/l
Contact stabilization	6-15 mg/l
Conventional activated sludge	3-10 mg/l
Activated sludge with load factor (F:M) less than 0.15	1-5 mg/l

Culp and Culp indicate that, although mixed-media filters can tolerate higher suspended solids loadings than other filtration processes, there still is an upper limit at which economically long runs can be maintained. The authors state that:

With activated sludge effluent suspended solids loadings of up to 120 mg/l, filter runs of 15-24 hr at 5 gpm/sq ft [3.4 liters/sec/sq m] have been maintained when operating to a terminal head loss of 15 ft [4.6 m] of water. Suspended solids concentrations of 300 mg/l or more will lead to uneconomically short filter runs, even when using a mixed-media filter...Should the secondary plant involved have a history of frequent, severe upsets resulting in secondary effluent suspended solids concentrations of 200-500 mg/l, an intermediate settling tank between the secondary clarifier and the filter with provision for chemical coagulation during upset periods should be made (47).

One advanced wastewater treatment plant that includes dual-media filtration has been in operation since 1968 (48). The effluent is of such high quality that turbidity is monitored rather than suspended solids. The effluent from this plant is used to recharge the water table in Nassau County, New York. The process as reported by Vecchioli et al provides for the removal of suspended solids, phosphates, dissolved organics, and MBAS (i.e., detergents or surfactants). Treatment after activated sludge includes clarification (where alum is added), dual-media filtration, and activated carbon adsorption. Suspended solids removals of 99 percent are obtained.

Most filtration rates reported in the literature vary from a low of 1 to a high of about 10 gpm/sq ft (0.7 to 6.8 liters/sec/sq m). In optimization studies, the rate has been established at about 6 or 7 gpm/sq ft (4.1 to 4.7 liters/sec/sq m). Studies of ultra-high rate filtration of activated sludge effluent in Cleveland (49) concluded that no significant relationship existed between filtration rates and effluent BOD, COD, and TSS concentrations in the range of rates (8 to 32 gpm/sq ft or 5.4 to 21.7 liters/sec/sq m) used in the studies. The investigation also revealed that for influent concentrations of less than 30 mg/l, the filter effluent generally remained in the range of 1 to 12 mg/l with or without polymer or coagulant and polymer addition, but for influent concentrations above 60 mg/l, filtration with coagulant and polymer addition produced a higher quality effluent.

During the ultra-high rate filtration study in Cleveland (49), an upset condition caused by the breakdown in the sludge incineration process forced the recycling of digested sludge through the plant. The filter effluent rapidly deteriorated from 2 to 10.2 mg/l suspended solids. To correct the problem, chemical addition of alum and polymer restored the effluent quality to an acceptable 5.1 mg/l. Filter efficiencies were 88, 54, and 93 percent before the upset, during the upset, and after chemical addition, respectively.

In evaluating granular media filtration as a method for upgrading waste treatment facilities, Middlebrooks et al (50) state: "The simple design and operation of this process makes it applicable to wastewater streams containing up to 200 mg/l suspended solids. Filtration rates can range from 25 to 50 gpm per sq ft [17.0 to 39.9 liters/sec/sq m] for coarse solids to 2 to 5 gpm per sq ft [1.4 to 3.4 liters/sec/sq m] for colloidal suspensions. The versatility of filter bed designs (media sizes and depths) is such that nearly any effluent quality can be achieved."

Tertiary filtration has been applied successfully to many types of industrial wastes. Industries that are either employing filtration or have successfully tested and are installing filters include: steel manufacturing, petroleum refining, brewing, corn wet milling, wine processing, and food processing (51, 52, 53, 54, 55, 56).

Multi-media filtration has had particular application in the petroleum refining industry, where at least three refineries are known to successfully treat refinery wastewaters after biological treatment. These applications represent some of the longest-term use of modern filtration facilities employed with biological treatment systems for treatment of strong industrial waste (BOD up to 800 mg/l and TSS up to 300 mg/l) (57).

Ample supportive data is available on the long-term performance of these systems. These plants in which multi-media filtration has been applied include Amoco Oil Company, Yorktown, Virginia; Marathon Oil Company, Robinson, Illinois; and Southwestern Oil and Refinery, Corpus Christi, Texas. At the Amoco Oil Company, Yorktown, Virginia plant, the filtration system follows an aerated lagoon biological system. The plant served as an EPA demonstration project. Quarterly reports submitted to EPA establish the underdesign of the aerated lagoon and substantiate poor performance of the biological system. Upsets in performance of the biological system in turn gave rise to operational difficulties with the subsequent filter, resulting in shorter filter runs and performance reduction. Even under these limitations, the filter has been effective in reducing influent TSS of 25 mg/l to 10 mg/l in the final effluent on a sustained basis, a pollutant reduction of 60 percent.

The successful application of filtration is also quite well documented at the Marathon Oil Company, Robinson, Illinois plant. The filter handles effluent from an activated sludge biological treatment system and is designed for a maximum influent TSS of 40 mg/l. In recent months (after installation of the filter) effluent from the biological system has averaged 49 mg/l TSS, and the filter has been successful in reducing the waste load to a TSS of 11.2 mg/l over the last 18-month period - a total TSS reduction through the filter of approximately 77 percent. It is important to note that this filter performance resulted with an average overload in relation to filter design loading of 25 percent. Also, prior to installation of the filter, average effluent TSS from the biological system was 19 mg/l as compared to 49 mg/l after the filter installation - seemingly indicating less emphasis on proper operation and maintenance of the biological system after installation of the filter and increased reliance on the filter for production of a high-quality effluent. Similar results were attained at the Southwestern Oil and Refining Company, Corpus Christi, Texas, as shown by 4 months of data (22).

A fourth refinery, Clark Oil at Hartford, Illinois, has recently installed treatment facilities that include an activated sludge system followed by dual-media filters. The plant was started up in early 1975 and presently meets the Illinois EPA effluent requirements of 20 mg/l BOD and 25 mg/l TSS, <u>without the dual-media filters</u>. The filters have yet to be put on-line, but will be shortly in anticipation of more stringent effluent requirements.

Average BOD levels in the biological effluent were 14.1 mg/l in April 1975 and 7.7 mg/l in May 1975 (58).

Another example of successful application of biological treatment and multi-media filtration to high strength organic wastes can be found at Welch Foods' Brocton, New York grape processing plant. The treatment system consists of activated sludge followed by filtration. The seasonal average BOD concentration in the raw waste is 4096 mg/l. A summary of the filter performance is presented below:

	Activated Sludge Effluent		Multi-media Filtration Effluent	
	BOD (mg/l)	TSS (mg/l)	BOD (mg/l)	TSS (mg/l)
Season Average	20.6	28.1	8.1	8.4
Maximum 30-Day	34.0	78.1	13.0	9.2
Maximum Day	114.0	216.0	32.0	20.0

The data indicate the following filter performance levels:

	Percentage BOD Removal	Percentage TSS Removal
Seasonal Average	61	70
Maximum 30-Day	61	88
Maximum Day	72	91

The data also indicate that BOD and TSS levels in the filtered effluent were 13.0 mg/l and 9.2 mg/l, respectively, for the maximum month (30 consecutive days). Maximum day BOD was 2.5 times the maximum month value, and maximum day TSS was 2.2 times the maximum month value. On a seasonal average basis, BOD reduction was 99.5 percent through the activated sludge system and 99.8 percent through the activated sludge and filter combined (22,59).

The table on the following page was taken from the Development Document for the Renderer Segment of the Meat Products and Rendering Processing Point Source Category (60). It is a summary of filtration results for a variety of biologically treated effluents. The Development Document concluded that "the rapid sand filter has also been receiving more extensive application in municipal sewage treatment for tertiary treatment; thus, its use in tertiary treatment of secondary treated effluents from any type of meat or rendering processing plants appears to be a practical method of reducing BOD and suspended solids to levels below those expected from conventional secondary treatment."

A positive feature of filtration is the ability to handle reasonable fluctuations in solids loadings without serious impairment of effluent quality. These fluctuations can be absorbed by increased backwash frequency. This point is discussed by E. R. Baumann in Design of Filters for Advanced Wastewater Treatment (61):

Table 13A. Effluent Quality from Conventional Filtration of Various Biologically Treated Wastewaters

Influent Source	Filter Type	Filter Influent (mg/l) BOD	Filter Influent (mg/l) TSS	Filter Effluent (mg/l) BOD	Filter Effluent (mg/l) TSS
Activated Sludge	Gravity mixed media	15-20	10-25	4-10	2-5
Activated Sludge	multi-media	11-50	28-126	3-8	1-17
Extended Aeration plus settling	pressure, multi-media	7-36	30-2180	1-4	1-20
Trickling Filter	Gravity, Sand	15-130	8-75	2-74	1-27
Activated Sludge with Clarifier	multi-media	-	18 (AVE)	-	2.4 (AVE)
Contact Stabilization (raw waste includes cannery)	mixed-media	-	-	2-4	2-8
Miscellaneous	sand (slow and rapid)	10-50	15-75	2-6	3-10
Trickling Filter with Nitrification	sand	-	-	9-28	3-7

The process of filtration is one which is unusual in that it will never, if properly designed, provide a grossly inferior quality of effluent. In general, if a filter can provide the desired effluent quality under normal conditions, upsets in pretreatment processes will provide shorter filter runs and not significantly poorer effluent quality. Thus, if under normal conditions the effluent SS are running at 18 mg/l and suddenly increase to a level of 30 or 40 mg/l, the principal effect will be a significant decrease in run length but a relatively lesser increase in effluent SS.

C. EXPERT OPINION ON APPLICABILITY OF FILTRATION TO CORN WET MILLING WASTES

CPC International, Inc. has submitted a consultant's report on the application of deep bed filtration as an effluent polishing technique at the Pekin, Illinois corn wet mill. The report (26) presents the results of pilot studies conducted in 1973. It was concluded that in-depth filtration was technically not a reliable method for meeting the required Illinois EPA effluent standards of 25 mg/l TSS and 20 mg/l BOD. The Eighth Circuit Court cited this report in their decision (footnote at 39).

The filtration report and test data were reviewed by Dr. E. Robert Baumann of Iowa State University, a recognized expert on filtration of water and wastewater. The complete text of Dr. Baumann's analysis, including comments on the ability of the recommended technology to meet the New Source Performance Standards, is appended in this report (62).

Dr. Baumann concluded that the filter test results in the consultant's report to CPC do not lead to the conclusion that filtration is an unacceptable technology for meeting the New Source Performance Standards. In reviewing the test data, he noted that "it would appear that with only a few exceptions the filter runs were being made during periods while the activated sludge process was upset." In other words, the effluent being tested was not characteristic of effluent from a well-run treatment system. Dr. Baumann stated that "it must be concluded that on the basis of the few runs relating to near normal activated sludge process performance in the Weston report that dual media and multi media filters both performed adequately with respect to effluent polishing." Dr. Baumann's observations included the following points:

1. "The failure of the coarse dual media filter was obviously due to improper media selection...The performance of the multi media filter is not at a level that would be expected with proper design."

2. Anionic polymers apparently were effective, "but their use was not followed with an experimental design that employed a rational basis for selection of dosages."

3. Contact time for formation of a filterable floc was apparently not provided.

4. "A redesigned multi media filter using the top two media about like that in the fine dual media filter and a smaller sized garnet compatible with them should provide excellent operation at rates even as high as 3 to 4 gpm/sq ft provided that adequate contact time is provided with the anionic polymers."

Dr. Baumann also concluded that the ability of deep bed filter to function as a back-up system during a biological treatment upset was clearly demonstrated by the test data. During the filter runs involving very high influent suspended solids (415, 900, 1490 mg/l), both the dual-media and multi-media filters produced removals of 94 to 99 percent.

Dr. Baumann summarized his findings on the CPC filtration report as follows:

In general, the Weston report demonstrates the fact that deep bed filters can consistently provide from 50 to 70 percent removal of suspended solids from a wastewater that has been given adequate pretreatment. The report also demonstrates the fact that deep bed filters will, in general, provide an adequate back-up system for the trapping of most of the solids that may be carried over from the activated sludge process when upsets involving bulking sludge occurs.

Dr. Baumann also evaluated the ability of the recommended treatment technology to meet the 1983 effluent guidelines. He concluded that the guidelines can be met provided that:

1. The activated sludge system is designed for a low loading rate or F:M ratio.

2. Adequate controls for sludge bulking are provided in design, i.e., polymer feed capability, hydrogen peroxide addition, deeper clarifier design.

3. The deep bed filter media is properly sized and matched, the wastewater is chemically pretreated prior to filtration, and adequate contact time is provided for floc removal.

In assessing the 1983 and New Source effluent levels, Dr. Baumann stated that "I would expect such a plant [properly designed and operated activated sludge-granular media filtration with chemical pretreatment] to be able to meet the BAT effluent standards for a medium size corn wet mill".

D. SUMMARY

Deep bed filtration is a demonstrated and available technology. It is universally applied in the treatment of water supplies for municipalities and industries and can produce effluents containing essentially no suspended solids in these applications. Filtration has been successfully employed in the treatment of municipal and industrial secondary (biologically treated) effluents. The literature and other data clearly document this fact. The process has been sufficiently demonstrated to enable the development of meaningful design criteria and has been employed in numerous applications. In municipal applications, a well-designed filter can be expected to reduce suspended solids by 80 percent and more and to produce an effluent containing less than 10 mg/l TSS. Similar results can be anticipated with industrial wastes if the preceding biological treatment system is well designed and operated. It has also been demonstrated that deep bed filtration performs as an effective back-up system during periods of biological treatment upset and thus helps to insure that a stable effluent will be produced.

Filtration is applicable to corn wet milling wastes. The process has been demonstrated with other high strength organic wastes. Expert opinion supports this applicability, as well as the ability of a well designed treatment system to meet the New Source Performance Standards. Furthermore, as will be shown in Section VII, deep bed filtration has been successfully applied in the full scale treatment of wastewaters at an existing corn wet mill.

SECTION VII

CLINTON CORN WASTE TREATMENT

The Clinton Corn Processing Company's corn wet mill is of particular concern since it has installed much of the end-of-pipe treatment technology recommended to meet the New Source Performance Standards,; namely, activated sludge followed by deep bed filtration. It is important to evaluate efforts at Clinton in the proper perspective. Although some general conclusions can be made, there are many conditions at Clinton that do not apply directly to projected conditions at new plants. The following discussion summarizes Clinton's pollution abatement efforts, evaluates the current performance of Clinton's new waste treatment facility, and finally specifically evaluates the performance of Clinton's deep bed filters.

A. BACKGROUND AND POLLUTION ABATEMENT EFFORTS

The Clinton mill is a large, old plant located on the Mississippi River in Clinton, Iowa. The manufacturing plant includes corn processing facilities and a distilled spirits operation. The plant has undergone almost continuous improvement and expansion.

Prior to 1973, all wastes from the Clinton plant were discharged directly to the Mississippi River. A major pollution abatement program was undertaken to reduce waste loads to the river. Several barometric condensers within the plant have been replaced with surface condensers, thereby reducing pollutant loads. Clinton plans to make further condenser replacements and improvements. Sanitary wastes have been segregated from process wastes and routed to the municipal sewage treatment plant. Steps have been taken and still are being taken to reduce raw waste loads and spills within the plant.

A major portion of the pollution abatement program was the construction of new waste treatment facilities. Land is limited at the corn mill site, and the treatment plant had to be located almost a mile away. The treatment facilities include cooling towers, a biological packed tower or trickling filter with synthetic media, complete mix activated sludge (aeration and clarification), chlorination, and dual-media filtration. Screening and limited equalization of the raw waste are provided at the manufacturing plant. The biological tower was installed in September 1973, the filters were placed into service in November 1974, and the full design waste load was being treated as of April 1, 1975.

The treatment plant was designed to handle 3 mgd (11,355 cu m/day) of process wastes. The treated effluent is returned to the mill for cooling uses. Ultimately, spent barometric condenser water is discharged directly to the river from the mill.

Clinton is still implementing in-plant controls to reduce waste loads. Clinton believes that their present program and new waste treatment facility will allow the plant to meet by January 1976 the standards of the NPDES permit issued April 17, 1975 (63). The NPDES permit levels are identical to the 1977 Effluent Guidelines.

B. EVALUATION OF TREATMENT PLANT PERFORMANCE

In evaluating data from the Clinton waste treatment facility, there are a number of factors that must be considered. At issue here are New Source Performance Standards and the ability of a new corn wet mill with proper in-plant controls, cooling water practices, and waste treatment to meet the New Source Performance Standards. Although Clinton's treatment facilities include activated sludge and deep bed filtration, the following points must be strongly considered:

1. Clinton is an older mill lacking many in-plant control measures. Clinton still experiences in-plant accidental spills, such as acid spills (June 2) and sugar spills (June 8), that materially affect raw waste load variability and treatment plant performance (63).

2. Although changes are planned, Clinton continues to use large volumes of once-through barometric condenser water that contribute greatly to total waste load discharge to the river.

3. The Clinton waste treatment plant is receiving higher suspended solids loadings in the raw waste than were anticipated in design. Presently, only screening of the raw waste prior to equalization is provided. Additional pretreatment facilities are planned to alleviate the problem of excessive raw waste suspended solids.

4. Limited raw waste equalization is provided at Clinton. Detention time provided in the equalization basin is only 5 to 6 hours. The Development Document for the Grain Mill Industry (9) recommends 12 to 18 hours, and several mills have provided up to 24 hours of equalization.

5. The Clinton waste treatment facility is new and still undergoing shake-down operations. Operating parameters such as amount of sludge recycled, dissolved oxygen levels in aeration, and amount of recycle through the biological tower (trickling filter) are still being varied to determine optimum operating conditions.

6. Aeration basin dissolved oxygen levels were found to be insufficient in the original design. On June 14, 1975 additional aeration equipment was installed in the basins. Improvement in plant performance, particularly regarding mixed liquor settleability, has been observed since that time.

7. The existing data record does not necessarily indicate the performance of the deep bed filters. A malfunctioning check valve has permitted flow to bypass the filters at various times. The

limited historical data on treated effluent, therefore, include the contribution of unfiltered wastewater during undeterminable periods of time.

8. Total discharge to the river from the Clinton mill includes water treatment sludge. This results from treatment of river water prior to in-plant process uses. Clinton has installed a clarifier and filter system for river water treatment, and the sludge will eventually be disposed of at a landfill. This will greatly reduce the suspended solids and a portion of the BOD presently discharged to the river from the mill.

Despite the limitations discussed above, the Clinton waste treatment facility is functioning quite well, producing a high-quality effluent in terms of BOD and turbidity. Clinton has supplied daily sampling data for their waste treatment facility (64). This data is the most current and representative information available, particularly after April 1, 1975, when the full design waste load was being treated. The data indicate that during the period November 1974 to May 1975, average monthly BOD loadings to the treatment facility ranged from 1264 mg/l to 1691 mg/l in terms of concentration and 27,409 lb/day to 36,668 lb/day (12,443 to 16,647 kg/day) in terms of load. Monthly suspended solids levels ranged from 336 mg/l to 600 mg/l and 7286 lb/day to 11,009 lb/day (3308 to 4998 kg/day).

Treatment plant effluent levels for November 1974 to May 1975 are summarized below:

Clinton Waste Treatment Efffluent

	BOD			Turbidity	TSS*		
Month	mg/l	lb/day	lb/MSBu	jtu	mg/l	lb/day	lb/MSBu
Nov 1974	54	1091	10.9	-	133	2440	24.4
Dec 1974	44	844	8.4	8.3	74	1419	14.2
Jan 1975	86	1864	18.6	18.4	147	3087	30.9
Feb 1975	39	846	8.5	20.6	54	1172	11.7
Mar 1975	17	369	3.7	5.2	70	1518	15.2
Apr 1975	16	334	3.3	6.8	101	2106	21.1
May 1975	26	585	5.9	4.9	135	3040	30.4

*Not necessarily filter effluent.

Suspended solids levels in the effluent are higher than anticipated, but it must be recalled that these levels do not reflect filter performance, since part of the secondary effluent bypasses the filters.

If Clinton Corn was to eliminate its direct discharge of contaminated cooling water, either by recirculation or installation of surface condensers, the above treatment data show that the 1983 Effluent Guidelines (20 lb/MSBu BOD and 10 lb/MSBu TSS for maximum month) are well within reach at an existing plant with present-day technology, even without filtration of the total secondary effluent. Since the 1983 guidelines are identical to the New Source Performance Standards, Clinton, an existing facility, would be meeting standards for new sources.

C. PERFORMANCE OF DEEP BED FILTERS

From an operational point of view, Clinton indicates that their deep bed filters are performing quite satisfactorily (63). There have been no problems with clogging, excessive head loss, or excessive backwashing. Backwash cycles are normally 12 to 16 hours apart. Shorter filter runs do occur when clarifier overflow solids increase and thus solids retained in the filter increase, demonstrating the ability of the filters to handle variations in solids loading.

Filter operation was monitored at Clinton between November 25, 1974 and February 16, 1975. Reductions in COD, BOD, suspended solids, and turbidity were determined (64). The data are presented on the following page. Suspended solids removals ranged from 45 to 100 percent and averaged 77 percent. BOD reductions through the filter alone ranged from 6 to 53 percent and averaged 29 percent.

Additional limited sampling was performed by EPA's contractor during June 9-11, 1975. A summary of the data collected is included in the second table that follows. Results of this sampling indicated suspended solids removals of 50 to 68 percent attributable to the filter. BOD removals were 0 to 32 percent. Abnormally high raw waste suspended solids and an aerator failure in one of the aeration basins may have been the cause of increased effluent BOD and TSS values during the sampling period (65).

D. SUMMARY

Data from the Clinton Corn waste treatment facility is of interest since deep bed filtration is used following complete mix activated sludge. Despite the fact that the corn wet mill is quite old and both the mill and the treatment plant suffer from several limitations, the following conclusions can be made:

1. The Clinton Corn wet mill will meet the 1977 Effluent Guidelines in 1976.

2. The complete mix activated sludge process, when applied to corn wet milling wastes, can produce a stable, high quality effluent with BOD concentrations of less than 30 mg/l.

3. Deep bed filtration is transferable to the corn wet milling industry and has been demonstrated as an effective treatment process at an existing corn wet mill.

SAND FILTER OPERATIONS - W.W.T.P.

Week	Sand Filter Influent (Clarifier Overflow) COD, ppm	BOD, ppm	SUS.S., ppm	TURB, JTU	Sand Filter Effluent COD, ppm	BOD, ppm	SUS.S., ppm	[illegible]
[illegible] - 12/1/74	263	52	182	14.5	301	44	63	[illegible]
12/2 - 12/8	156	24	90	11.4	178	15	28	10.5
12/9 - 12/15	207	74	132	15.5	191	38	72	15.2
12/16 - 12/22	156	32	97	7.7	156	19	10	6.1
12/23 - 12/29	179	17	80	5.9	187	16	2	5.4
12/30 - 1/5/75	195	23	123	8.5	183	17	49	7.4
1/6 - 1/12	238	37	116	11.2	206	29	46	10.6
1/13 - 1/19	DOWN							
1/20 - 1/26	DOWN							
1/27 - 2/2	124	15	74	4.4	112	7	0	4.4
2/3 - 2/9	130	15	96	8.9	90	12	15	8.3
2/10 - 2/16	196	17	84	9.8	210	13	5	8.7

REMARKS - Normal operation of sand filters - backwash occurs between 12-16 hours of operation. We have run as long as 96 hours without backwash. Heavy solids overflow from the clarifiers will cause backwash every 2 hours.

Due to problems with check valves for No. 4 Pit, overflow from Pit 4 to Pit 5 occurred at times during Jan.-Feb. This accounts for the high suspended solids in the effluent.

CCPC
June 12, 197[illegible]

CLINTON CORN SAMPLING DATA

Date	Time	Sample Type	Raw Waste TSS	Raw Waste Turbidity	Raw Waste Total BOD	Raw Waste Soluble BOD	Influent to Filter TSS	Influent to Filter Turbidity	Influent to Filter Total BOD	Influent to Filter Soluble BOD	Effluent from Filter TSS	Effluent from Filter Turbidity	Effluent from Filter Total BOD	Effluent from Filter Soluble BOD
[illegible]	10:45 am- 1:45 pm	comp	309	66	1600	1400	38	15	31	8	12	9	24	16
[illegible]	1:30 [illegible]	grab					38	17	34	6	15	23	25	17
[illegible]-1	8:00 am- 3:00 pm	comp	325	80	1490	1400	91	51	47	8	34	27	48	29
[illegible]-10	11:30 am	grab					93	56	47	5	36	36	46	29
[illegible]-11	7:30 am- 2:30 pm	[illegible]	[illegible]31	186	3500	2360	125	76	75	12	62	50	51	39
[illegible]-11	8:00 am	grab					88	56	53	11	38	34	50	32
[illegible]-11	10:00 am	grab					95	88			62	62		
[illegible]-11	12 noon	grab					114	82			57	63		
[illegible]-11	2:00 pm	grab									70	76		

Note: BOD and TSS values in mg/l, turbidity values in jtu.

SECTION VIII

ABILITY OF CORN WET MILLS TO MEET NEW SOURCE PERFORMANCE STANDARDS

To determine achievable effluent limitation levels and to develop associated cost data, three model new corn wet milling plants were synthesized. Since the present trend within the industry is toward production of sweeteners, the new mills are logically assumed to convert the large part of their grind into syrups. To evaluate a range of plant sizes for cost evaluation and pollution control impact, three mills of 30,000; 60,000; and 90,000 bushels/day capacity were developed.

A. DESIGN CRITERIA

Important parameters used to develop the three model plants included wastewater flow to be treated, BOD loading, and suspended solids loading. Data received from industry (64, 66, 67) on projected raw waste flows for new mills ranged from 8333 gal/MSBu to 66,667 gal/MSBu (1.2 to 9.9 cu m/kkg). Data from more recently constructed and operating corn wet mills in the 30,000 bu/day size range indicate that a waste flow of 1 mgd (3785 cu m/day) or 33,333 gal/MSBu (5.0 cu m/kkg) may reasonably be anticipated for a plant employing recirculation of cooling water. Since the latter value falls within the mid-range of values projected by industry and is demonstrated at mills presently in operation, it was chosen as the design value. This value reflects wastewater loadings resulting from in-plant controls presently practiced at newer mills in the industry. These plants do not necessarily reflect the incorporation of all in-plant pollution reduction controls that are known to have application within the industry.

Industry projections of new sweetener plant raw waste BOD load ranged from 233 to 500 lb/MSBu (4.2 to 8.9 kg/kkg). For design purposes, a load of 400 lb/MSBu (7.1 kg/kkg) was selected for a new plant, a value that corresponds to the level selected for the model plant in the Development Document (9). The cost of treatment facilities for a new plant generating only 250 lb/MSBu (4.5 kg/kkg) of raw waste BOD (at the lower end of the load range projected by industry) was also evaluated to determine the significance of the design value upon treatment facility capital and operating costs.

Projections of suspended solids loads for new corn wet mills submitted by the industry ranged from essentially zero to 166 lb/MSBu (3.0 kg/kkg). Information on existing mills indicates average suspended solids loadings of 200 lb/MSBu (3.6 kg/kkg), and this value was chosen as a conservative number.

New plant raw waste criteria used in this evaluation are summarized below:

Capacity (bu/day)	Flow gal/MSBu	mgd	BOD lb/MSBu	lb/day	TSS lb/MSBu	lb/day
30,000	33,333	1.0	400	12,000	200	6,000
60,000	33,333	2.0	400	24,000	200	12,000
90,000	33,333	3.0	400	36,000	200	18,000

B. WASTE TREATMENT COMPONENTS

As discussed in Section IV, data available from treatment applications involving high strength organic wastes indicate that a well designed and operated activated sludge system (or other biological process) preceded by equalization and coupled with good in-plant waste controls will produce a stable, high quality effluent. This has been demonstrated within numerous industries and at least at one corn wet mill. Furthermore, available data indicate that deep bed filtration is an effective means of polishing effluent from biological treatment systems. This is discussed previously in Sections VI and VII.

Based on the above information, the treatment systems for the model new corn wet mills are assumed to contain the following components or unit processes:

1. Grit removal
2. Flow equalization
3. Nutrient addition
4. pH control
5. Complete mix activated sludge
6. Secondary clarification
7. Chlorination of effluent
8. Chemical coagulant addition
9. Deep bed or mixed-media granular filtration
10. Sludge thickening
11. Sludge centrifugation

An aerated grit chamber is provided with a design capacity of 2.5 times the average wastewater flow. The detention time is selected as 3 minutes, with 5 cubic feet per minute (cfm) of air (0.14 cu m/min) being provided per linear foot (0.305 m) of grit chamber. The detention time in the equalization basin is chosen as 18 hours at average daily flow. Aeration and mixing are also provided. The activated sludge process design is based on an F:M of 0.3, MLSS concentration of 2000 mg/l, and aeration requirement of 1500 cfm/lb (93.6 cu m/min/kg) of BOD applied. The clarifier overflow rate is chosen at 350 gpd/sq ft (14.2 cu m/day/sq m) with a detention time of 4 hours. The filters are sized for a loading rate of 4 gpm/sq ft (2.7 liters/sec/sq m). All of the above design values are based on widely used and accepted sanitary engineering design criteria.

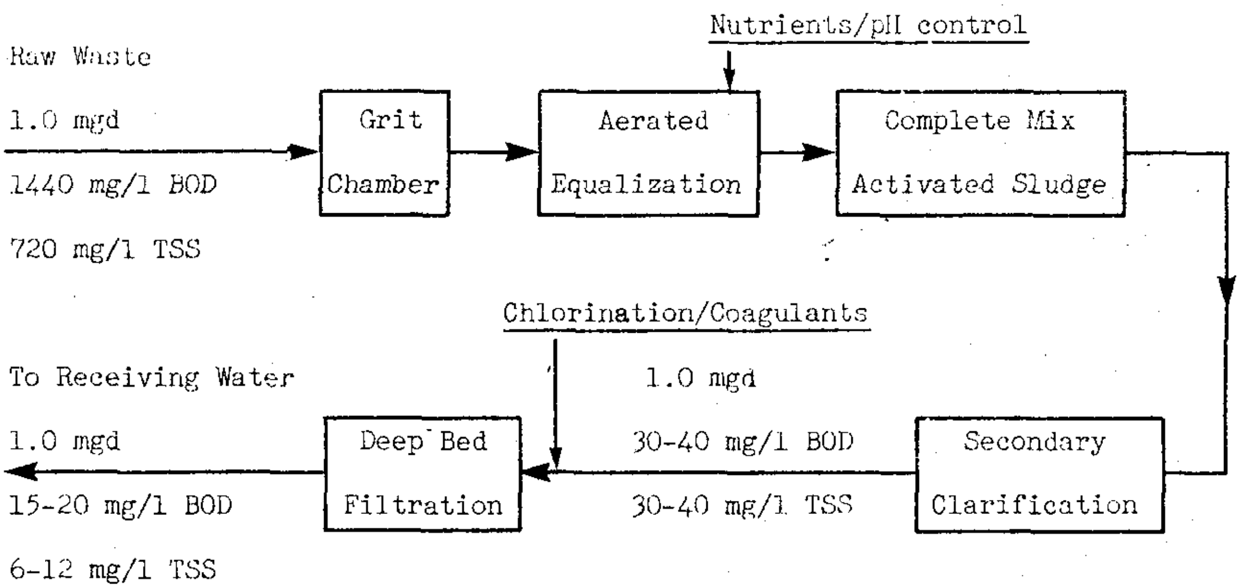
C. PERFORMANCE OF WASTE TREATMENT FACILITIES

Information gathered on treatment of brewery, distillery, and many other food processing wastes and information on stable operation attainable with treatment of corn wet milling wastes provide a sound basis for predicting corn wet milling waste treatment facility performance. The data indicate that a well designed, operated, and maintained system treating wastes from a new corn wet mill will produce an effluent containing 30 to 40 mg/l of BOD and total suspended solids (TSS) on a long-term average basis. For the model new corn wet mills outlined above, these levels correspond to 8.3 to 11.1 lb/MSBu (0.148 to 0.198 kg/kkg) of BOD and TSS. Data on filtration of effluents from biological treatment of municipal and industrial wastes provide an equally firm basis to conclude that a properly designed deep bed filter will reduce the above effluent BOD levels by 50 percent and the effluent TSS levels by 70 to 80 percent. These reductions are predicated on good biological treatment preceding the filter. The filter effluent for the model plant will contain a BOD load of 4.2 to 5.6 lb/MSBu (0.075 to 0.100 kg/kkg) and a TSS load of 1.7 to 3.3 lb/MSBu (0.030 to 0.059 kg/kkg) on a long-term average basis. A schematic diagram of the recommended treatment system and a tabulation of the achievable effluent levels for a 30,000 bushel/day corn wet mill are presented on the following page.

The effluent values presented above represent long-term averages and must now be related to the maximum monthly and maximum daily levels in the New Source Performance Standards. The corn wet milling industry has suggested that these relationships may best be established by the use of calculated variability factors. While such statistical calculations are not without merit, there are important limitations in utilizing this approach that must be recognized for the corn wet milling industry. First, the data base must reflect good, stable operation, including good in-plant controls and end-of-pipe treatment. Second, the data base must be applicable to new plants. The data on existing treatment plant performance in the corn wet milling industry are deficient in both respects. All existing complete treatment plants suffer from either severe design and operating deficiencies or inadequate in-plant controls. Plants operating under such less than desirable conditions will invariably experience greater effluent fluctuations and more frequent biological system upsets. In other words, such plants will inherently generate a higher variability factor than well-designed and operated facilities at mills with good in-plant controls. Moreover, not one of the mills for which meaningful

EFFLUENT PERFORMANCE LEVELS FOR A

NEW 30,000 BUSHEL/DAY CORN WET MILL



1. Raw waste characteristics

   Flow 1.0 mgd

   BOD 1440 mg/l = 12,000 lb/day = 400 lb/MSBu

   TSS 720 mg/l = 6,000 lb/day = 200 lb/MSBu

2. Waste characteristics after grit removal, equalization, activated sludge, and clarification

   Flow 1.0 mgd

   BOD 30-40 mg/l = 250-334 lb/day = 8.3-11.1 lb/MSBu

   TSS 30-40 mg/l = 250-334 lb/day = 8.3-11.1 lb/MSBu

3. Waste characteristics after deep bed filtration

   Flow 1.0 mgd

   BOD 15-20 mg/l = 125-167 lb/day = 4.2-5.6 lb/MSBu

   TSS 6-12 mg/l = 50-100 lb/day = 1.7-3.3 lb/MSBu

SECTION IX

NON-WATER QUALITY ASPECTS

Factors such as air pollution control and solid waste disposal are discussed in the Grain Processing Development Document (9). This discussion of nonwater quality aspects remains valid based on this additional study.

One industry representative has provided data (67) on projected power requirements for new corn wet mills. These projected demands in terms of kilowatt-hours (kwh) are presented below:

Capacity (bu/day)	Power Requirement (kwh/bushel)	Power (kwh/day)
30,000	4.5	135,000
60,000	4.0	240,000
90,000	3.8	342,000

The same industry representative estimates that waste treatment power requirements to meet New Source Performance Standards will be 10 or 15 percent of total mill power requirements. This estimate appears to be high based on analysis of data provided by the corn wet milling industry in 1973 and projections of power requirements for new treatment facilities. These data indicate that a maximum increase of only 3 to 5 percent would be reasonably expected for treatment facilities at a new corn wet mill.

SECTION X

SUMMARY

INTRODUCTION

Public Law 92-500 requires the Agency to publish performance standards for new sources under authority of Sections 306(a) and 307(c).

Effluent Limitations for Existing Sources, New Source Performance Standards and Pretreatment Standards for New Sources for the Grain Mills Point Source Category were proposed on December 4, 1973 (38 FR 33438) and promulgated on March 20, 1974 (39 FR 10512).

On May 5, 1975, the U.S. Court of Appeals for the Eighth Circuit remanded to the Agency the new source performance standards and the pretreatment standards for new sources for the corn wet milling subcategory of the Grain Mills Point Source Category (40 CFR 406.15 and 406.16) promulgated by EPA under Section 306 and 307 of the Federal Water Pollution Control Act Amendments of 1972.

The new source standards for TSS and BOD were identical to those for 1983. They are based on the availability of the technology underlying the 1977 limitations plus the addition of deep bed filtration. The Court upheld the availability of the 1977 technology and the ability of that technology to meet the 1977 limits in new plants. However, it concluded that the record did not demonstrate that deep bed filtration would achieve the incremental reduction necessary to meet the new source standards.

Moreover, the Court held that the Agency's analysis of the costs associated with the new source standards were deficient in two respects. First, the capital and operating costs for the new plants were not separately prepared but developed by reference to the incremental cost of modifying existing sources to go from 1977 to 1983 levels. Second, the costs were based on 1971 prices.

The Court remanded the new sources standard for further substantiation of both the technical aspects and the cost calculations. The Agency was to promulgate revised standards and additional supportive evidence for the present new source standards within 120 days (i.e., September 2, 1975).

The purpose of this document is to provide supportive evidence for EPA's tentative conclusion not to revise performance standards for new sources in the corn wet milling subcategory of the grain mills point source category in accord with the Court's remand order.

TECHNICAL BASIS

An extensive analysis was conducted of available data on the application of activated sludge and deep bed filtration for treatment of various waste waters. Sources of data included the literature, field inspections, special consultants, expert opinions, corn wet milling companies, and equipment manufacturers. The review focused on the technology identified by EPA to meet the New Source Performance Standards; namely, good in-plant waste control and maximum water recycling, activated sludge biological treatment, and deep bed filtration. The data unequivocally and unmistakably substantiates the fact that high strength biodegradable organic wastes, such as those generated by corn wet mills, can be successfully treated with biological treatment processes, particularly complete mix activated sludge. With proper design and operation of treatment facilities, a stable high quality effluent can be attained on a reliable and sustained basis. The data strongly support the new source performance standards as originally promulgated.

Corn wet milling wastes may originate from a number of unit operations in the wet milling process--steepwater evaporation, modified starch production, and syrup refining as well as less pollutant producing processes of feed de-watering, oil extraction and refining, and general plant cleanup.

Waste waters from the industry can generally be characterized as high-volume, high-strength discharges. Based on summary data from 12 of the 17 corn wet mills, BOD varies widely, from 255 to 4450 mg/l, with a corresponding range in COD. Those plants with very low BOD_5 values typically have barometric condensing systems using once-through cooling water. At the other extreme, the very concentrated wastes are from plants using recirculated cooling water (either surface or barometric condensers).

Suspended solids levels in the total waste streams show similar variations ranging from 81 to 2458 mg/l. The plants with low suspended solids concentrations are those using barometric condensers with once-through cooling water. The inter-relationship of pollutant loads, pollutant concentrations, waste flow, and plant production is discussed in Appendix A.

BOD_5 in terms of raw material input (shelled corn) ranges from 2.1 to 12.5 kg/kkg (119 to 699 lbs/MSBu), and averages 7.4 kg/kkg (415 lbs/MSBu). Similarly, the suspended solids in the total plant waste waters range from 0.5 to 9.8 kg/kkg (29 to 548 lbs/MSBu) and average 3.8 kg/kkg (211 lbs/MSBu). These data emphasize again the wide variation in waste characteristics from the corn wet milling industry. The waste water flows vary from 3.1 to 41.7 cu m/kkg (21 to 280 gal/SBu) with an average of 18.3 cu m/kkg (123 gal/SBu). Those plants with lower waste flows per unit of production are those that employ recirculating cooling water systems.

Most plants segregate their major process waste water from cooling water prior to treatment. Once-through cooling water systems are being replaced with recirculating systems, in several instances.

In the development of New Source Performance Standards for the Corn Wet Milling Subcategory, a specific methodology was followed. In determining representative raw waste loading for new corn wet mills, a medium-sized mill with a daily grind of 1524 kkg (60,000 SBu) was selected. This hypothetical mill would practice good in-plant control and incorporate use of recirculated cooling water. The waste water characteristics of this mill reflect actual industry practice based on average data received from existing mills. These waste water characteristics would be as follows:

Flow	11,355 cu m/day	(3.0 mgd) (50 g/SBu)
BOD_5	7.14 kg/kkg	(400 lbs/MSBu) 960 mg/l
Suspended Solids	3.57 kg/kkg	(200 lbs/MSBu) 480 mg/l

The pollutant potential of the raw waste discharge from a 60,000 SBu/day corn wet mill is equivalent to the untreated waste expected from a domestic population of 138,000.

In the development of the new source performance standards, a number of alternative treatment systems were identified for the representative corn wet mill. The investment and annual cost for each alternative, and the resultant pollutant load reductions were identified (9).

The specific technology identified to facilitate compliance with the recommended New Source Performance Standard for the Corn Wet Milling Subcategory, Grain Mills Point Source Category was a combination of biological/physical treatment. For the Corn Wet Milling Subcategory of the grain milling industry, the new source performance standard and best available technology economically achievable comprise improved solids separation following activated sludge or comparable biological treatment. Improved solids separation can be represented best by deep bed filtration although alternative systems may be available. The "exemplary" technology includes 12 to 18 hours of aerated equalization ahead of a complete-mix activated sludge process with associated chemical feed, sedimentation, sludge dewatering facilities (centrifugation), grit removal, pH adjustment, nutrient addition, and deep bed filtration of the biologically-treated effluent. BOD_5 and suspended solids concentrations of 20 to 30 mg/l and 10 to 20 mg/l respectively, are expected in the effluent from this series of treatment processes. These concentrations correspond to effluent loads of 0.15 to 0.22 kg/kkg (8.3 to 12.5 lbs/MSBu) of BOD_5 and 0.07 to 0.15 kg/kkg (4.2 to 8.3 lbs/MSBu) of suspended solids. BOD_5 and suspended solids reductions expected are about 97.4 and 96.9 percent respectively.

In achieving the recommended new source performance standards through this technology, deep bed filtration of biologically treated waste attributes to an additional 50 to 75 percent BOD_5 and suspended solids removal beyond biological treatment, alone. Biological treatment, alone, attributes to producing an effluent before filtration of 75 - 125 mg/l BOD_5 and suspended solids, with corresponding overall BOD_5 and TSS reductions of 90 and 80 percent.

In meeting the New Source Performance Standard, the pollutant potential of the representative plant is reduced from the equivalent of 138,000 people to 6,700 people in terms of waste load.

In evaluating waste water control in the corn wet milling industry, it is essential to evaluate both in-plant control measures and effluent treatment systems. Good in-plant controls can greatly reduce the total raw waste load and improve treatment plant efficiency. Various in-plant controls identified for New Source Performance Standards include:

1. Isolation and treatment of all process waste waters. No process wastes should be discharged without adequate treatment.

2. Elimination of once-through barometric cooling waters, especially from the steepwater and syrup evaporators. This change can be accomplished by recirculating these cooling waters over cooling towers or replacing the barometric condensers with surface condensers.

3. Isolation of once-through noncontact (uncontaminated) cooling waters for discharge directly to the receiving waters or provision of recirculating cooling tower systems with the blowdown directed to the treatment plant.

4. Installation of dikes at all process areas subject to frequent spills in order to retain lost product for possible reuse or by-product recovery.

5. Installation and maintenance of modern entrainment separators in steepwater and syrup evaporators.

6. Surveillance and monitoring of major waste streams to identify and control sources of heavy product losses.

7. Provision of extensive waste treatment for the resulting process waste waters consisting of: flow and quality equalization, neutralization, biological treatment, and solids separation. The biological treatment methods available include activated sludge, pure oxygen activated sludge, bio-discs, and possible combination of other biological systems.

8. Institution of maximum water reuse practices at all plants over and above the current levels of practice.

9. Provisions to improve solids recovery at individual waste sources.

In-plant housekeeping and good operation can have a major impact on the raw waste loads from a mill. Diking of spill areas, monitoring and careful operation have been reported to reduce raw waste loads by 25 to 50 percent in some plants. The combination of in-plant controls and proper waste treatment constitutes a practicable means for achieving the specific effluent limitations.

FINDINGS AND DETERMINATIONS

The end-of-pipe treatment technology recommended for new corn wet mills, activated sludge and filtration, was reviewed within and without the corn wet milling industry. The activated sludge process has been proven as an effective treatment method in numerous applications. These applications include municipal or domestic wastes and high strength organic industrial wastes. Of particular emphasis in this study were applications of the activated sludge process to food processing wastes with characteristics similar to those generated by corn wet mills. The data established the fact that the activated sludge process can effectively treat these high strength wastes and produce an acceptable long-term average effluent quality.

In industries generating wastes similar to corn wet milling wastes, such as brewing, distilling, and malting, the data show that consistently high levels of effluent reduction are attained on a long-term basis. High quality effluents with BOD and suspended solids less than 30 mg/l are consistently and routinely produced at many treatment facilities. This has been demonstrated with a wide variety of industrial wastes, including those generated by breweries, edible oil refineries, malting plants, distilleries, bakeries, wineries, and fruit and vegetable processing plants.

Within these industries raw waste loads range generally from 750 to 6700 mg/l of BOD_5 and 50 to 4000 mg/l total suspended solids. Biological treatment with or without filtration has been demonstrated to result in overall BOD and TSS removals ranging between 87 and 99.4 percent BOD, and 67.0 and 99.4 percent total suspended solids, generally greater than 96 percent for BOD and suspended solids. Effluent levels as low as 10 to 20 mg/l BOD and suspended solids have consistently been achieved. For purposes of comparison of waste strength, corn wet milling wastes ranges between 250 to 4450 mg/l BOD, and 80 to 2450 mg/l total suspended solids.

Data and experience indicate that these industries are subject to most of the same elements of waste load variability, waste strength, and required treatment mechanisms as experienced within the corn wet milling industry. In fact, a detailed statistical evaluation of raw waste load variability for both the brewing and corn wet milling industry performed in this study indicate an unmistakable similarity in waste characteristics, waste load variability, and general nature and biodegradability of the waste. Waste waters generated by two breweries which now discharge treated wastes to navigable waters substantiate the treatability of brewing waste to very high pollutant reduction levels. Corn wet milling waste is not unique among many food processing wastes, and presents no enigma in accomplishing high levels of treatment under present sanitary engineering practice.

Activated sludge has yet to be applied to its fullest potential within the corn wet milling industry because of poor in-plant waste controls, design inadequacies, and operational deficiencies. If these were eliminated, the activated sludge process could successfully treat corn wet milling wastes and reliably produce an effluent with BOD5 and TSS of 30 mg/l or less on a long-term average basis. The New Source Performance Standards can be met at an existing corn wet mill employing present day technology.

Deep bed filtration is a demonstrated and available technology. It is universlly applied in the treatment of water supplies for municipalities and industries and can produce effluents containing essentially no suspended solids in these applications. Filtration has been successfully employed in the treatment of municipal and industrial secondary (biologically treated) effluents. The literature, expert consultants, and other data clearly document this fact. The process has been sufficiently demonstrated to enable the development of meaningful design criteria and has been employed in numerous applications. In municipal applications, a well designed filter can be expected to reduce suspended solids by 80 percent or more and to produce an effluent containing less than 10 mg/l TSS. Similar results can be anticipated with industrial wastes if the preceding biological treatment system is well designed and operated. It has also been demonstrated that deep bed filtration performs as an effective back-up system during periods of biological treatment upset and thus helps to insure that a stable effluent will be produced.

In addition to applications outside the corn wet milling industry, filtration may be successfully applied to corn wet milling wastes. The process has been demonstrated with other high strength organic wastes. Expert opinion supports this applicability, as well as the ability of a well designed treatment system to meet the New Source Performance Standards. One corn wet milling company has successfully applied deep bed filtration following biological treatment on a full-scale basis. At Clinton Corn Processing Company in Clinton, Iowa, filtration has been demonstrated as an effective means of further reducing BOD and suspended solids levels in treated corn wet milling effluent. Suspended solids reductions of 50 to 100 percent and averaging better than 75 percent were demonstrated with deep bed filtration of treated corn wet milling wastes. BOD reduction of up to 50 percent was demonstrated.

Industries that are either employing filtration or have successfully tested and are installing filters include: steel manufacturing, petroleum refining, brewing, corn wet milling, wine processing, and food processing. Multi-media filtration has had particular application in the petroleum refining industry, where at least three refineries are known to successfully treat refinery waste waters after biological treatment. These applications represent some of the longest-term use of modern filtration facilities employed with biological treatment systems for treatment of strong industrial waste.

The costs required for new corn wet mills of various sizes to meet the New Source Performance Standards were reevaluated and are indicative of current pollution control technology. These costs are based on January 1975 dollar values and include waste treatment facilities and necessary in-plant controls or cooling system designs.

Based on an extensive review of technical data, the New Source Performance Standards for the Corn Wet Milling Subcategory should be implemented as promulgated on March 20, 1974. As the data demonstrate, new plants employing best available demonstrated control technology can readily achieve these standards.

A reasonable prediction of waste treatment facility performance at a new corn wet mill indicates that the New Source Performance Standards can be readily attained with currently available technology. There is adequate provision in the standards for anticipated fluctuations in effluent quality.

There are no increased economic costs, intermediate effects, programatic or energy consequences expected as a result of the technology reevaluation for the New Source Performance Standard. Evaluation of the nonwater quality aspects of applying the recommended technology indicated that energy, air pollution, and solid waste impacts will be minimal.

Based on the above outlined study and analysis, the Administrator has evaluated data and the performance of biological treatment and deep bed filtration, waste load variability, industrial application of pollution control techniques for grain processing as well as similar types of wastes, and has concluded that the New Source Performance Standards as originally promulgated are proper and well-founded.

The Administrator has determined that the technology is available and transferrable with reasonable prediction that the technology will be capable of removing the increment required by the New Source Performance Standards. The costs associated with the technology do not preclude or adversely affect its effective use and application.

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APPENDIX A

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EXPLANATION OF INTER-RELATIONSHIP OF POLLUTANT CONCENTRATION, UNIT POLLUTANT LOAD, PROCESSING RATE, AND WASTE WATER FLOW

The expression of pollutant loads in terms of concentrations (mg/l) is useful for identifying and evaluating the characteristics and performance of treatment measures for organic biodegradable wastes. Concentration for biodegradable organic waste waters expresses a commonality for comparison of waste water characteristics and treatability results regardless of the source of the similar organic biodegradable waste. For effluent limitations guidelines purposes, the specific limitations are commonly expressed in terms of unit pollutant per unit of raw material processed or product, whichever is most applicable. The new source performance standards for the corn wet milling subcategory are expressed as unit production of pollutant e.g., BOD_5 or TSS per 1000 standard bushels (MSBu) of shelled corn (raw material). Concentration levels in terms of waste loads can be related as follows:

$$\text{Waste water concentration, mg/l} = \frac{U \times P}{8.34 \times F}$$

Where:

U = unit pollutant load per unit of production, lbs/MSBu of shelled corn

P = Daily grind rate, MSBu of shelled corn/day

F = representative or actual flow rate, million gallons per day (MGD)

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