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Integrated Steel Plant Pollution Study for Total Recycle of Water

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EPA REVIEW NOTICE

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Integrated Steel Plant Pollution Study for Total Recycle of Water

by

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ABSTRACT

This report presents the results of an engineering study of five integrated U.S. steel plants so that each might achieve the total recycle (zero discharge) of water. Conceptual engineering for the facilities required to reach that goal, as a next stage after achieving BAT compliance, was performed in two stages. Stage one, considering waters that are contaminated by chemicals, suspended solids, etc. and stage two, the contaminated waters plus non-contact cooling water. Capital and operating costs were estimated and energy requirements were developed. Technologies were compared and the most promising, although not all of them proven on the scale required at integrated steel plants, were selected as being applicable.

Additional water related air pollution control facilities were considered as being installed and the use of contaminated water for coke and slag quenching was considered as being replaced by uncontaminated water.

Problems identified as requiring investigation before implementation of total recycle could be met were: development and verification of the technologies selected to insure performance of each on the individual wastes and combinations of wastes being treated; determination of the environmental impacts of increased off-site power generation, additional fuel requirements, and solids disposal; cost-benefit analyses of total recycle of water; sociological effects of possible plant closings; meteorological and hydrological effects of increased water losses, especially in water short areas; and the effects of totoal recycle on plant production during and after construction of the facilities.

It is estimated that implementation of total recycle of water, including non-contact cooling water, would increase the cost of steel by 4 to 5 percent, create an energy demand of over 1,000 MWe and require the use of over 25 million kkg (28 million tons) of coal.

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SECTION 1.0 - SUMMARY

Five integrated steel plants were studied to determine the facilities needed for each of the plants to achieve total recycle of water with facilities to meet BAT requirements being installed as a first stage. Based on this study the following conclusions were drawn:

1. A typical plant does not exist. Due to process requirements, location, etc., each plant is a unique and individual entity and only generalized findings can be transferred from one plant to another. Studies of more plants would most probably reinforce this conclusion.

2. Significant in-plant problems would be created if the requirement of total recycle is imposed on the steel industry. These problems include possible disruption of production facilities during and after construction, increased in-plant traffic, broader safety requirements, and the need for more extensive monitoring of water quality and control of water systems to reduce the chance of outages of production facilities due to water system failure.

3. An additional 1,183 MWe (Megawatts electric) of offsite electrical power generation will be required over the next ten years if total recycle, including non-contact cooling water is applied to integrated steel plants. This represents 0.5 percent above the predicted 10-year growth of U.S. generating capacity and an increased 0.8 percent of the total usage of electricity by all manufacturing industries in the U.S.

4. Water consumption, water lost to evaporation, etc., will increase by almost 100 percent over the present consumption for the five plants studied if total recycle, including non-contact cooling water, is implemented. The water consumption under total recycle averaged 11 m^3/kkg (2,794 gal/ton) for the five plants studied with a range of from 3.2 to 16 m^3/kkg (839 to 4,215 gal/ton). Present consumption for the five plants averaged 4 m^3/kkg (1,048 gal/ton) with

a range of from 1 to 6.1 m^3/kkg (405 to 1,550 gal/ton). The total estimated increase in water consumption for all U.S. integrated steel mills is estimated to be 996 x 10^6 m^3/year (270,000 x 10^6 gal/year). While relatively unimportant in most water rich areas, this loss of water could have serious impact on the more arid regions.

5. For total recycle, in-plant energy requirements would increase considerably. If natural gas were used approximately 205 m^3/kkg (6,590 ft^3/ton) of gas would be required. Coal usage would be 0.25 kkg/kkg (0.25 ton/ton). If these fuel requirements are expanded to the entire U.S. integrated steel industry, 29 x 10^9m3 per year (1,030 x 10^9 ft^3 per year) of gas would be required or 35 x 10^6 kkg (39 x 10^6 tons) of coal would be required.

6. Cost estimates were prepared to construct and operate facilities to comply with the requirements of BAT and the two stages of total recycle. The cost to construct facilities to comply with the BAT requirements as a first step towards total recycle ranged from $1.91/kkg to $3.95/kkg ($1.73/ton to $3.58/ton) with an average of $2.67/kkg ($2.42/ton). The total estimated cost to attain total recycle, excluding non-contact cooling water, ranged from $7.63/kkg to $32.11/kkg ($6.92/ton to $29.13/ton) with an average of $13.15/kkg ($11.93/ton). The total estimated cost to attain total recycle, including non-contact cooling water, ranged from $10.77/kkg to $33.21/kkg ($9.77/ton to $30.13/ton) with an average of $16.91/kkg ($15.34/ton). The Kaiser-Fontana plant was not included in these ranges or averages since it presently is very close to compliance with BAT requirements and, therefore, would require considerably fewer facilities than the other plants.

   If the averages, excluding Kaiser-Fontana, are applied to the U.S. integrated steel industry the cost to attain BAT would be in excess of $380,000,000. The total amount to attain total recycle, excluding non-contact cooling water, would be $1,847,000,000 and $2,030,000,000 including contact cooling water. Average numbers should be used with caution, however, since there are large differences in the amounts of wastewater treatment equipment presently installed from plant to plant.

The estimates are based on 1978 dollars and provisions have not been included for escalation over the period of time required to meet the desired goals. The cost of necessary research and development has not been included in the total costs.

7. Based on current price and not including escalation or the costs of research and development, it is estimated that the cost per kkg (ton) of steel could increase by 3 to 4 percent for total recycle, excluding non-contact cooling water, and 4 to 5 percent including non-contact cooling water.

8. Before any commitment is made to implement total recycle of water, research projects, environmental assessments and economic studies should be initiated to:

   A. Determine the effectiveness, reliability and verified costs for the treatment of by-products coke plant wastewaters and blast furnace gas washer system blowdown, as well as systems for the removal of dissolved solids from individual waste streams and various combinations of waste streams.

   B. Determine whether there is any commercial value for, or alternative environmentally acceptable methods of disposal of dissolved solids removed from the final waste streams.

   C. Assess the meteorologic and hydrologic effects of grossly increasing the evaporation of water from integrated steel plants.

   D. Evaluate the environmental effects of the required increased power generation in highly industrialized areas such as the Monongehela Valley and Southern Lake Michigan.

   E. Evaluate all other economic and socialogical aspects which would be affected by total recycle.

9. It is estimated that from the time a decision is made to implement total recycle until a plant is constructed will take up to thirteen years.

SECTION 2.0 - INTRODUCTION

2.1 PURPOSE OF THE PROJECT

The purpose of the project reported on, herein, was to perform engineering studies of at least five and not more than nine integrated U.S. steel plants and to prepare conceptual engineering designs for each which would enable them to achieve total recycle (zero discharge) of water. Also to be included were water related aspects of air pollution, i.e., additional water required to reduce existing air pollution and prevent air pollution that might occur as a result of water treatment or disposal. Total recycle was to be achieved as "add-on" steps subsequent to meeting BAT requirements.

2.2 SCOPE OF THE PROJECT

A literature search of technologies applicable to achieve the goals of BAT compliance and total recycle of water within an integrated steel plant was performed. Included in Section 3 and Appendix G are the results of the literature search and descriptions of the various manufacturing processes encountered in an integrated steel plant.

The American Iron and Steel Institute and its member corporations provided information used in the selection of the five integrated steel plants studied. Section 4 describes the methodology used in the selection of the steel plants to be studied and the descriptions of the water and waste treatment systems of the plants selected. Appendices A, B, C, D and E contain detailed descriptions of the plants studied.

From the initial list of available technologies, seventeen were considered in more detail. Section 5 describes the rationale for the selection of the technology applicable and ultimately used in developing systems for each plant to meet BAT and total recycle. Section 5 also describes the suggested BAT and total recycle systems for each of the five integrated steel plants. Appendices A, B, C, D and E contain more detailed descriptions of the five plants. Cost estimates for each of the systems are contained in Appendix F.

Section 6 presents the conclusions drawn and recommendations are made for further study to more firmly establish the economic, energy, environmental, and sociological effects of attaining total recycle in U.S. steel plants.

SECTION 3.0

SOURCES AND QUANTITIES OF POLLUTANTS IN AN INTEGRATED IRON AND STEEL PLANT AND POSSIBLE METHODS FOR THEIR REMOVAL

This section discusses, in general terms, discharges of wastes to the atmosphere, water uses and wastewater discharges, and solid waste discharges from typical integrated steel plants. For a discussion of the iron and steel making processes see Appendix G.

3.1 AIR EMISSIONS

An integrated steel plant discharges wastes to the atmosphere from various operations, especially during the production processes of coke making, sintering, iron and steel making. Table 3-1 is a list of the principal sources of air pollution (1) (2) (3) (4). Other points and air emissions contributing minor amounts of contaminants include heating furnaces, coke oven charging, raw material handling operations, storage piles and blast furnace bleeders.

Many of these sources of air emissions can complement total recycle systems by combining their disposal with water system discharges such as blowdown (5). Air emissions containing significant sensible heat which could be cooled by use in the evaporation of blowdowns include those from slag handling and steelmaking furnace gases. Certain other air emissions require wet scrubbing which could employ certain blowdowns or other treated wastewaters. Coal preparation systems and pug mills represent sources of suitable dusty emissions. Any wastewaters used should not contain significant volatiles or other contaminants which could create environmental pollution, damage or health hazards by discharge to the air during such evaporative or scrubbing uses. An important example of such unacceptable disposal combinations is coke quenching with by-product wastes such as ammonia liquors. This is discussed in Section 3.2.1.

Dry coke quenching is a potential solution to the problem of emissions from coke quenching. Systems have been developed for coke cooling by inert gases within an enclosure. The gases are cooled for reuse by circulating through waste heat boilers which produce steam as a useful by-product. The air emissions are readily controlled by dry pollution control

TABLE 3-1

INTEGRATED STEEL PLANT PRINCIPAL AIR POLLUTION SOURCES

Source Description	Principal Contaminant
COKE MAKING	
Coke Preparation	Particulates
Coke Pushing	Particulates
Coke Quenching	Particulates
Coke Screening	Particulates
Coke Charging	Particulates
Door Leaks	Vapors and Particulates
Final Cooler Water C.T.	Drift & Vapors
Coke Gas Desulfurizing	H_2S gas
SINTERING	
Feed Handling	Particulates
Pug Mill	Particulates
Windbox Gases	Particulates SO_2 gas
Sinter Handling	Particulates
IRON MAKING	
Skip Filling	Particulates
Blast Furnace Gases	Particulates
Recirculation Cooling Tower	Drift
Slag Handling	H_2S & SO_2
Cast House	Particulates
BOF STEELMAKING	
Furnace Gases	Particulates
Molten Iron Reladling	Particulates
Charging, Tapping, Slagging	Particulates
Flux Handling	Particulates
Slag Handling	Particulates
OPEN HEARTH FURNACE	
Furnace Gases	Particulates
Charging, Tapping, Slagging	Particulates
Slag Handling	Particulates
ELECTRIC FURNACE	
Furnace Gases	Particulates
Charging, Tapping, Slagging	Particulates
Flux Handling	Particulates
Slag Handling	Particulates
MISCELLANEOUS SOURCES	
Hot Scarfing	Particulates
Cold Mill Fumes	Oil Vapor
Pickling Fumes	Mineral Acids
Galvanizing Fumes	Zinc Oxide

devices and it is reported there is an improved coke quality and reduced loss in coke fines when using the dry quenching process (6). These systems have been extensively developed in Russia, Japan and England (7) (8).

3.2 WATER USAGE AND DISCHARGES

An integrated steel plant uses water for many purposes; indirect cooling, descaling, rinsing, air cleaning, preparation of chemical solutions, sanitary uses, etc. Each production process has its own particular requirements for water quality and quantity. The water uses can be generally classified as non-contact or contact. Non-contact water is used only for indirect cooling and is not applied to any material or surface which can contaminate the water except for rise in temperature. Water conditioning chemicals are usually added to recirculation systems. Non-contact systems which are improperly designed or operated may, however, become contaminated. All other water uses are classified as (direct) contact uses and generally become contaminated, requiring some form of treatment before discharge or reuse. In a typical integrated steel plant the largest volume of water use is for indirect cooling while direct cooling contributes the largest volume of contaminated wastewater.

The water use diagrams, Figures 3-1 to 3-9, presented in this section show typical non-contact and contact water systems, points of application and treatment. It is not the intention of these figures to be considered as the recommended practices or conclusions of this study; the recommended water systems are fully developed in Section 5 where the description of treatment facilities and operating practices will be described in detail for each of the five plants.

3.2.1 <u>Coke Making and By-Product Plant Water Use</u>

Total water use at a coke plant is a function of the extent of by-product recovery, design of specific units, and degree of water recycling. Total demand is as low as 1150 m^3/hr (5,000 gpm) and upward to 10,225 m^3/hr (45,000 gpm) for a very large plant have been reported. Of this total from 70 to 95 percent is normally used for indirect cooling and for condensing steam with no contamination other than temperature change. The various areas requiring water are shown on Figure 3-1 and the quantities applied, per ton of coke produced, are given in Table 3.2.

TABLE 3.2

BY-PRODUCT COKE PLANT - WATER APPLICATION QUANTITIES

	l/kkg	gal/ton
Primary Coolers	6250 to 18750	1500 to 4500
Quenching	2100 to 6250	500 to 1500
Final Coolers	2100 to 8330	500 to 2000
Benzol Plant	2100 to 6250	500 to 1500
Desulfurization Plant	2100 to 8330	500 to 2000
Total	14600 to 47900	3500 to 11500

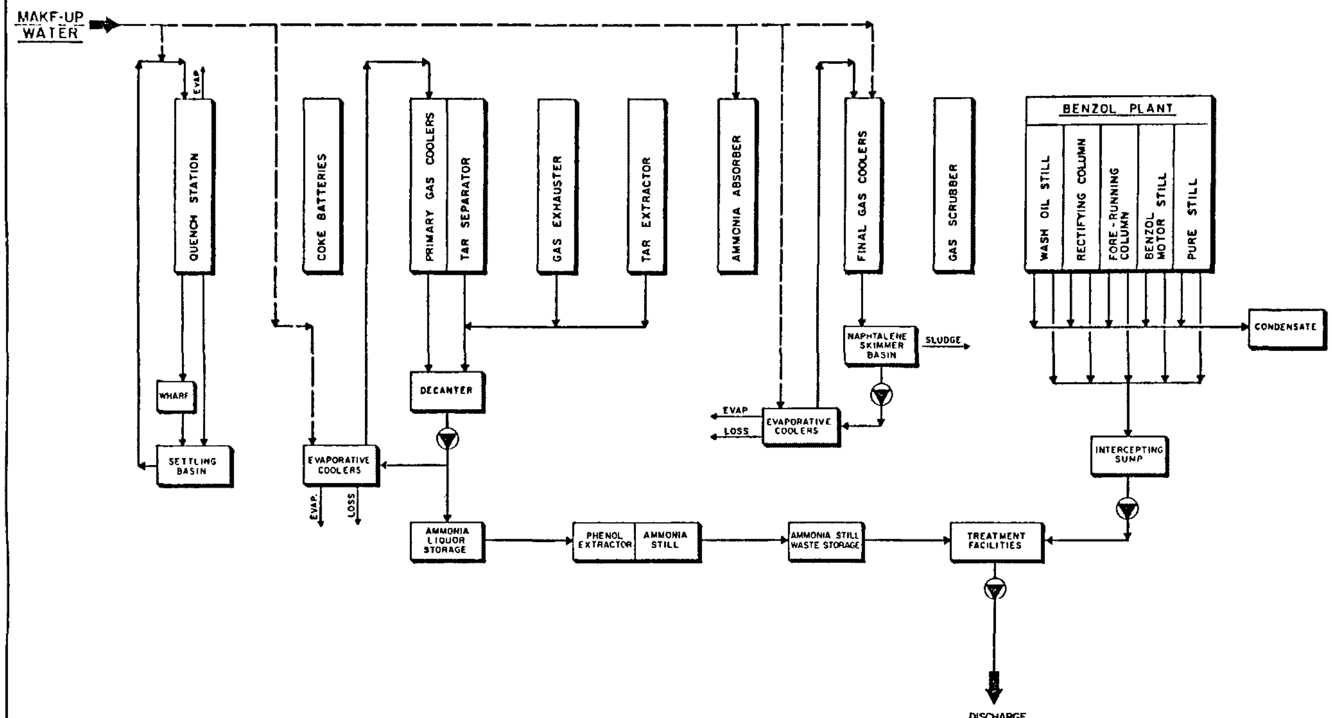
The heat absorbed by water (from all indirect cooling operations ranges from 3780 to 5040 kcal/hr (15,000 to 20,000 Btu/hr) per ton of coke produced.

The coke operations and by-product facilties vary from plant to plant and so, consequently, does the volume and quality of the wastewater streams. For typical coke and by-products plants the main sources of contaminated liquid wastes are excess ammonia liquor, final cooling water overflow and light oil recovery (benzol plant) wastes. Minor wastewater sources include coke wharf drainage, quench water overflow and coal pile runoff. Critical contaminants include ammonia, cyanide, oil, phenol, sulfide, BOD and suspended solids.

Methods of treatment of wastewater streams are discussed in Section 4 but it is appropriate here to discuss one method of wastewater disposal that is unique to coke plants, i.e., use of wastewater for coke quenching. The concept of coke quenching for the evaporative disposal of coke plant wastewater was based on the assumption that the potential water and air contaminants, from ammoniacal liquor, were burned by the heat from the coke. However, it has been determined that serious manufacturing and environmental problems may arise from this method of wastewater disposal.

1. Air pollution is created by the volatile constituents which, instead of being destroyed, are simply distilled and discharged to the atmosphere.

2. Some of the materials in the quenching wastewater are entrained in the coke and carried over to the blast furnace. The high chloride content of the waste deteriorate the structural components at the blast furnace.



U. S. ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP

INTEGRATED STEEL PLANT POLLUTION STUDY
FOR TOTAL RECYCLE OF WATER
BY-PRODUCT PLANT
WATER USE DIAGRAM

HYDROTECHNIC CORPORATION
ENGINEERS
NEW YORK N.Y.

FIGURE 3-1

3. Quenching mist can cause extensive corrosion to neighboring areas by salt deposition of chlorides and oxides of sulphur.

3.2.2 Water Use for Sintering

Sinter plants require relatively low quantities of water, as shown on Figure 3-2, for sinter mix preparation, cleaning the air and exhaust gases and for indirect cooling of the sinter and equipment. Most wastewater is discharged from the air and gas cleaning operations, as non-recycled cooling water and the balance is evaporated. If the procedure used for air and gas cleaning is dry, such as bag collection or dry electrostatic precipitators, contaminated water discharge is virtually eliminated. However, if mill scale is used as a part of the sinter mix, difficulty has been experienced with the use of bag filters or electrostatic precipitators in that volatilized oils clog the filter cloth or may cause explosions. Therefore, hiqn energy water scrubbers are generally used at these installations.

Wastewater from the air scrubbers is treated, either alone or in combination with blast furnace scrubber wastes, for suspended solids removal and is either discharged directly or a portion if recycled. The settled solids are dewatered for reuse in sintering and the separated water is returned to the thickener.

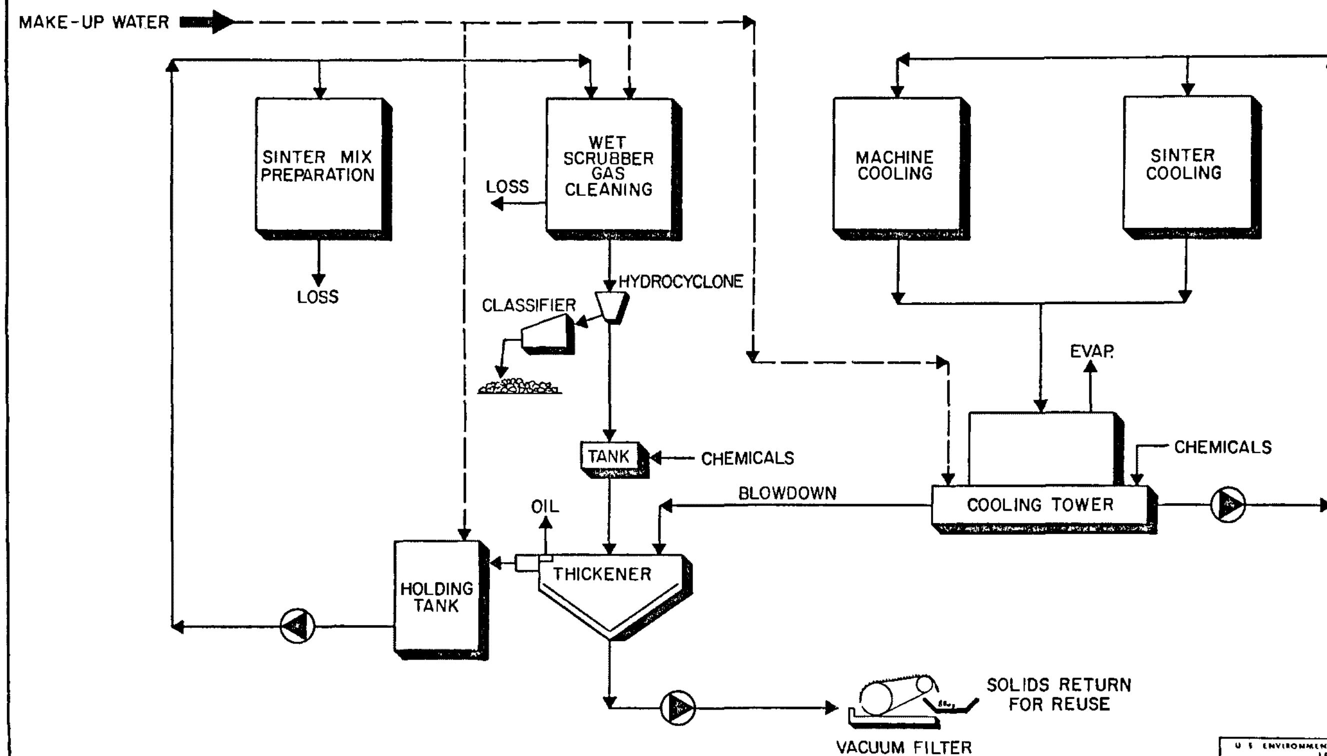
Where dry dust collection systems are used, water is added to the dry solids at a pug mill to allow them to be conveniently blended as part of the sinter mix. The water is completely evaporated in the sintering process.

Contact water applications for air cleaning have been reported to be from 434 to 1420 l/kkg (104 and 340 gal/t) of sinter produced with associated wastewater suspended solids concentrations of 4340 and 19500 mg/l and oil grease concentrations of 504 and 457 mg/l, respectively.

The non-contact cooling water is either cooled and reused with blowdown, or discharged directly without treatment.

3.2.3 Iron Making Water Use

Water is used in the blast furnace area of the steel plants for non-contact cooling of furnace and stove walls and for contact cooling and cleaning of blast furnace gases. Lesser amounts are for cooling slag, production of steam for turboblowers, and steam condensation. Additional water enters the area as a result of runoff from raw material storage piles.



U S ENVIRONMENTAL PROTECTION AGENCY

INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

SINTER PLANT
WATER USE DIAGRAM

HYDROTECHNIC CORPORATION
NEW YORK, N.Y.

FIGURE 3-2

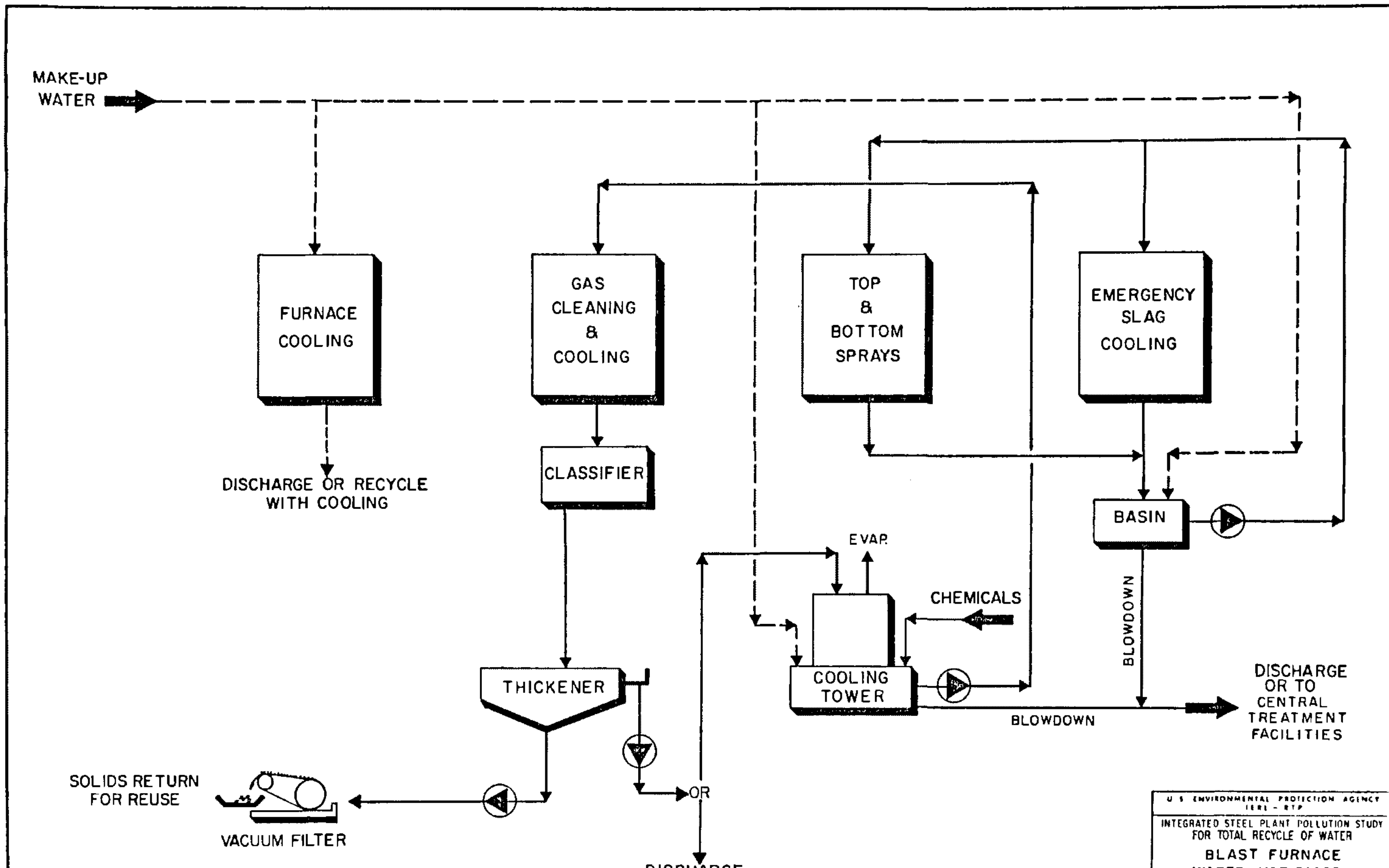
Figure 3-3 indicates the major water systems.

Non-contact cooling water quantities of approximately 21,000 l/kkg (5030 gal/t) of iron produced are generally applied at the blast furnace. Depending upon furnace design, the water temperature increase can be from 1 - 8 C° (2-15 F°). Lesser quantities of water are required for cooling stoves and turbo-blowers with quantities and temperature increases dependent upon individual design. The method of non-contact cooling water disposal varies at different plants. In most plants the water is utilized on a once-through basis, the complete flow is discharged at an elevated temperature to a receiving body of water and the makeup water supplies the total applied flow. At other plants the water is recycled after being cooled in atmospheric cooling towers with only a small percentage discharged as cooling tower blowdown or lost by evaporation. The amount of blowdown is dependent upon the cycles of concentration (dissolved solids) in cooling system, which in turn is a function of the makeup water quality.

Blast furnace gases are cleaned first by dry dust catchers, followed by wet processes which may include venturi scrubbers, gas washers, disintegrators and electrostatic precipitators. Depending upon the gas, water application for cleaning can range from 6300 to 17,000 l/kkg (1500 to 4100 gal/t) of iron produced. The wastewater is characterized by high suspended solids concentration, the major portion of which is removed by settling in thickeners before the wastewater is recycled or finally discharged. The settled sludge is dewatered and either disposed at landfills or recycled to the sintering plant. The water from dewatering operations is returned to the thickener. Additional contaminants in the water include phenol, cyanide and ammonia.

Blast furnace slag is cooled in slag pits either by slow air cooling with limited water sprays or by slag granulation with large amounts of water. If the use of water is strictly controlled, it all evaporates within the pit. If excess water is used, it is either discharged or is drained to a basin for recycling. When required, water is sprayed on the Blast Furnace burden to insure optimum moisture content when it is charged into the furnace. All water used for this purpose is lost to the system and no wastes are produced.

Steam driven turbo-blowers commonly compress air for injection into the blast furnace via the stoves. To protect the boilers and turbine blades, the water used for the production of steam must be of very high quality and makeup is usually demineralized by ion exchanger units. The concentrated regenerant fluids discharged from the exchangers are small in volume but must be treated. The steam, after use, is condensed to water



U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP

INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

BLAST FURNACE WATER USE DIAGRAM

HYDROTECHNIC CORPORATION
NEW YORK, N.Y.

FIGURE 3-3

and recycled with a portion blown down to prevent the buildup of dissolved solids in the system. Blowdown is generally characterized by a high pH. Additional wastes may be infrequently discharged from steam generating facilities due to boiler cleaning.

Significant quantities of contaminated wastewater occur as runoff from precipitation, especially from the areas of material storage. The runoff may have high suspended solids and other contaminants depending on the particular runoff area. Runoff from limestone storage areas would contain suspended solids, have an high pH and be extremely hard due to dissolved calcium; ore storage runoff would contain high amounts of iron, and is dependent upon the surface area and slope, the intensity and duration of the storm antercedent conditions and the porosity storage piles.

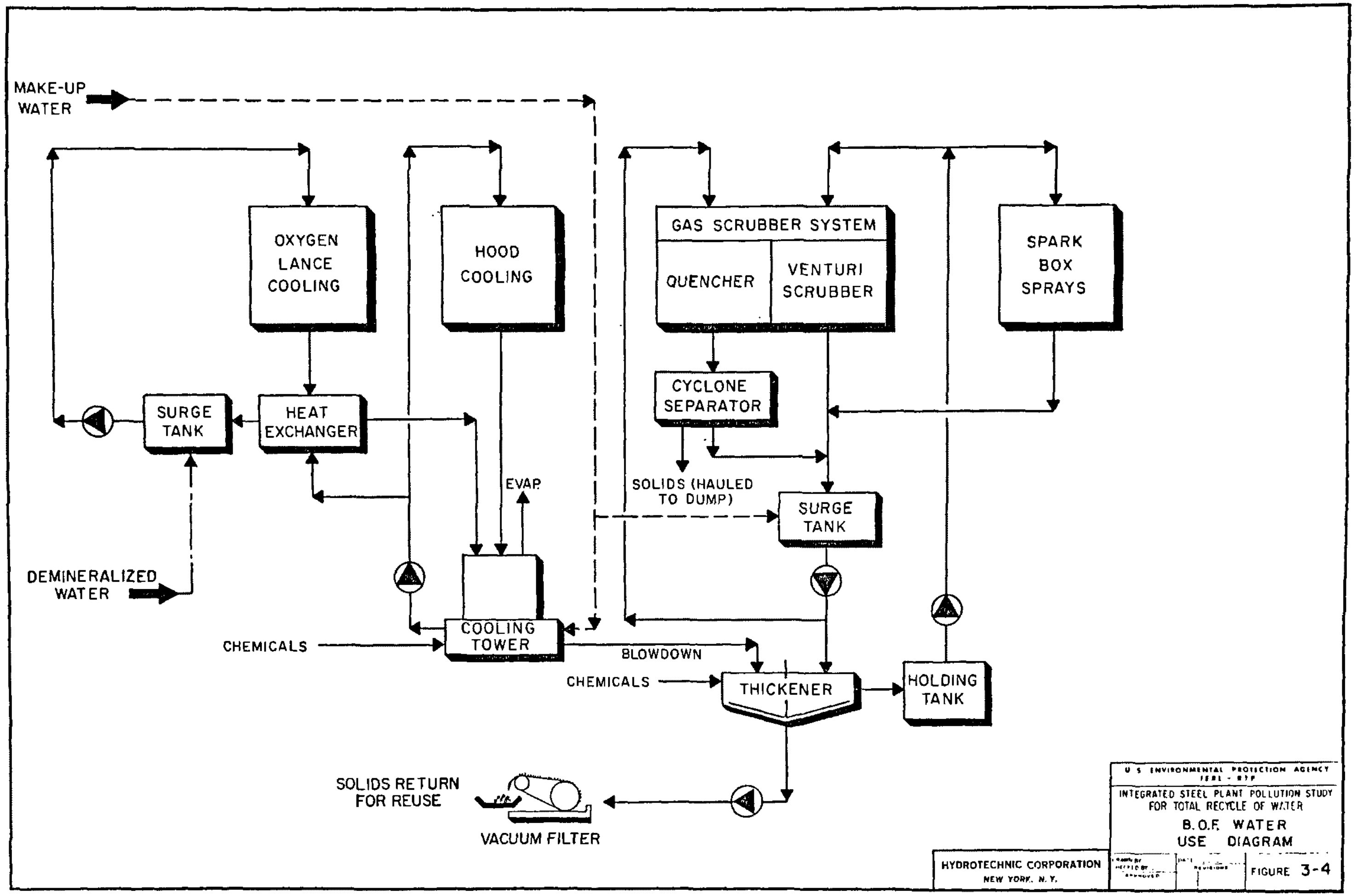
3.2.4 Steel Making Water Use

Water used in steel making processes is generally for three purposes: indirect cooling of furnaces and equipment, gas cooling and cleaning and, where vacuum degassing is installed, steam condensing, and cooling of seals and barometric condensers. Figure 3-4 illustrates typical BOF water systems.

Gas cooling in the BOF is via waste heat boilers and quenching sprays which may evaporate completely or produce a residual effluent which is added to the scrubber recirculating system. In the open hearth and electric furnaces gas quenching may not be separate from cleaning; the open hearth gases usually pass through a waste heat boiler before cleaning. Gas cleaning is accomplished by dry, semi-wet and wet methods. The dry method does not require contact water and the semi-wet method operates on an exact water balance whereby there is no direct water discharge from the system after evaporation. The wet method utilizes solids separation and discharge or system recirculation and blowdown. Therefore, water use for gas cooling and cleaning at BOF installations ranges from 209 to 3700 l/kkg (50 to 890 gal/t). Semi-wet systems are not used for open hearth furnaces and the water use for gas cooling and cleaning ranges from zero for dry systems to 2810 k/kkg (675 gal/t) for wet systems. Electric arc furnace installations utilize the dry, semi-wet and wet methods of gas cooling and cleaning with reported water use ranging from zero to 12,000 l/kkg (2880 gal/t).

Contact water use at vacuum degassing facilities is from the 1300 to 2900 l/kkg (310 to 695 gal/t).

All of the above contact wastewaters can be characterized as containing suspended solids, iron oxide and some trace metals (e.g., zinc, cadmium, etc.) and fluorides. The wastewaters are discharged to thickeners where the major portion of the entrained solids settle and the supernatant water over-


MAKE-UP WATER
OXYGEN LANCE COOLING
HOOD COOLING
GAS SCRUBBER SYSTEM
QUENCHER
VENTURI SCRUBBER
SPARK BOX SPRAYS
CYCLONE SEPARATOR
SURGE TANK
HEAT EXCHANGER
EVAP.
SOLIDS (HAULED TO DUMP)
SURGE TANK
DEMINERALIZED WATER
CHEMICALS
COOLING TOWER
BLOWDOWN
CHEMICALS
THICKENER
HOLDING TANK
SOLIDS RETURN FOR REUSE
VACUUM FILTER
U.S. ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
B.O.F. WATER USE DIAGRAM
HYDROTECHNIC CORPORATION
NEW YORK, N.Y.
FIGURE 3-4

flows for either recycle or discharge.

Additional contact water may be used in slag cooling and in the ingot casting areas. The slag is usually air cooled and any water used is evaporated on site. The water used for ingot mold preparation and cooling normally represents a very small quantity and is mostly evaporated during use.

Non-contact water application varies greatly according to the type of steelmaking furnace employed, modes of individual plant operations and individual design requirements. In all three types of steelmaking furnaces cooling water is required for hood or charging door cooling and for oxygen lance cooling. At open hearth furnaces additional cooling water is required at the dampers, at electric arc furnaces for the gas exhaust elbow, the transformers and the electric cables and at BOF installations the trunnion ring requires cooling. At vacuum degassers; transformer and seal cooling water is required.

The total volume of water required for these non-contact cooling uses varies widely. Reported applications in terms of quantity per unit of production ranged from 1920 to 47,800 l/kkg (460 to 11,470 gal/t). The water experiences temperature increases from 11 to 28 C^{o} (20 to 50 F^{o}). There is no uniform practice in the industry with respect to reuse of cooling water. At some plants all of the water, except for a small amount of blowdown, is cooled and recycled. In some plants a portion is cooled and recycled with the balance being discharged at the elevated temperature; other plants operate on totally once-through systems. The BOF non-contact cooling water systems generally use high quality water, especially in the lance cooling system as indicated in Figure 3-4. The extremely high temperatures incurred during oxygen blowing require demineralized water for lance cooling to avoid mineral deposits and corrosion at lance heat exchange surfaces. The demineralized water recirculates in a closed system; the cooling water from the tube side of a shell and tube heat exchanger is usually once-through or interconnected with the hood cooling water system.

3.2.5 Hot Forming Water Use

In hot forming facilities most of the water is used for the various direct contact applications, especially cooling and descaling, which may be in several successive applications. Non-contact cooling water uses are of less volume but are also significant.

3.2.5.1 Continuous Casting

Non-contact cooling water uses for a typical continuous casting facility total approximately 7,500 l/kkg (1800 gal/t) of which about 4,200 l/kkg (1,000 gal/t) is required for mold cooling and 3,300 l/kkg (790 gal/t) is used for machine cooling.

As shown on Figure 3-5, these waters are cooled and reused with a small blowdown, the discharge volume depending upon makeup water quality and operational cycles of concentration. The mold cooling system may use demineralized water recirculating in a closed system with the cooling side of the system heat exchanger tied into the machine cooling system as in the BOF lance and hood cooling systems (Figure 3-4).

Most contact water at continuous casting facilities is used for spray cooling the cast product as it exits from the mold. The water is sprayed only while a cast is in progress and it is characterized by high suspended solids and oils concentrations.

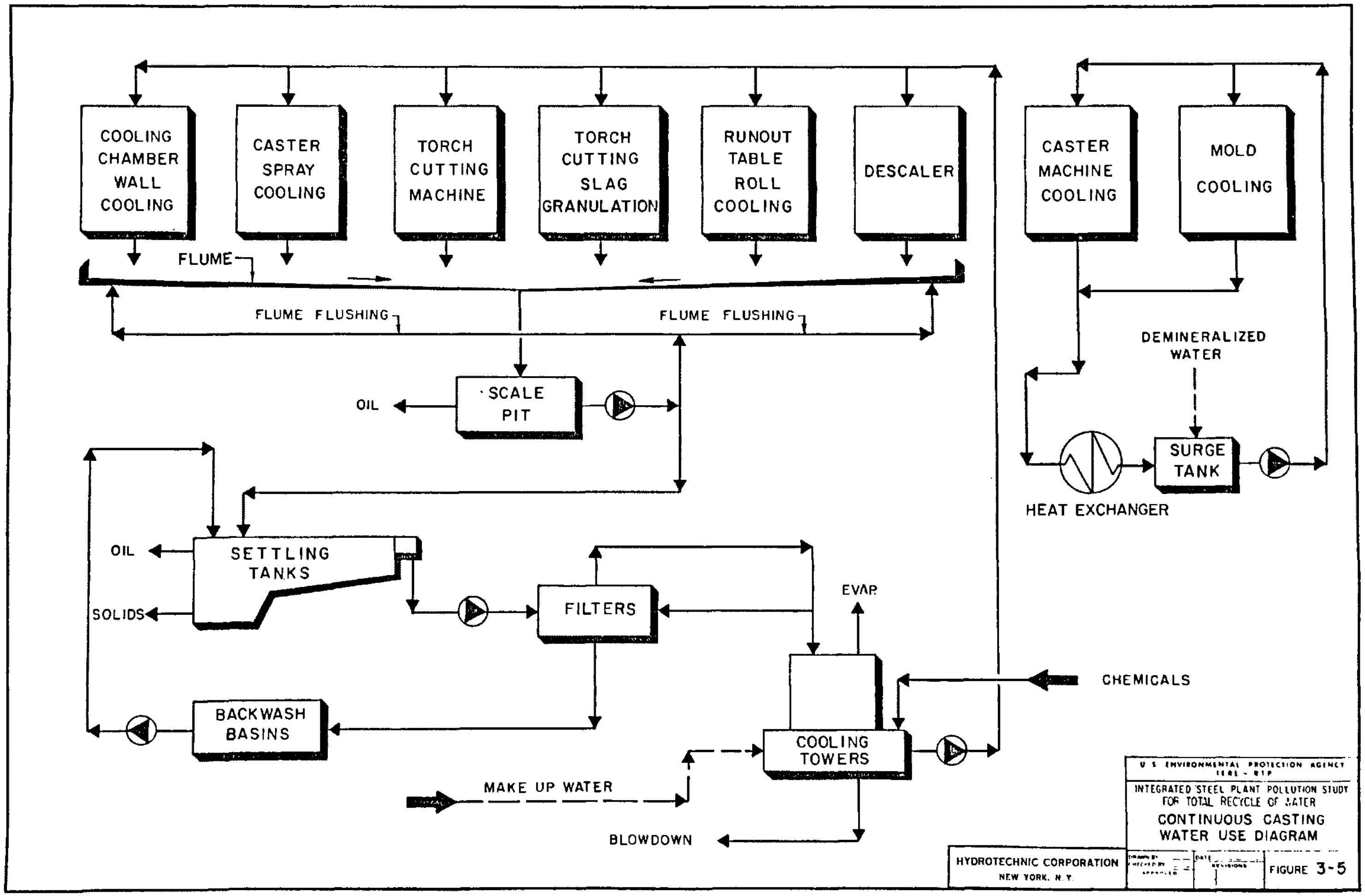
As shown on Figure 3-5, other contact water uses are roll cooling, descaling, etc. The wastewaters flow to a scale pit and settling basin for coarse solids removal and are then filtered and cooled prior to reuse.

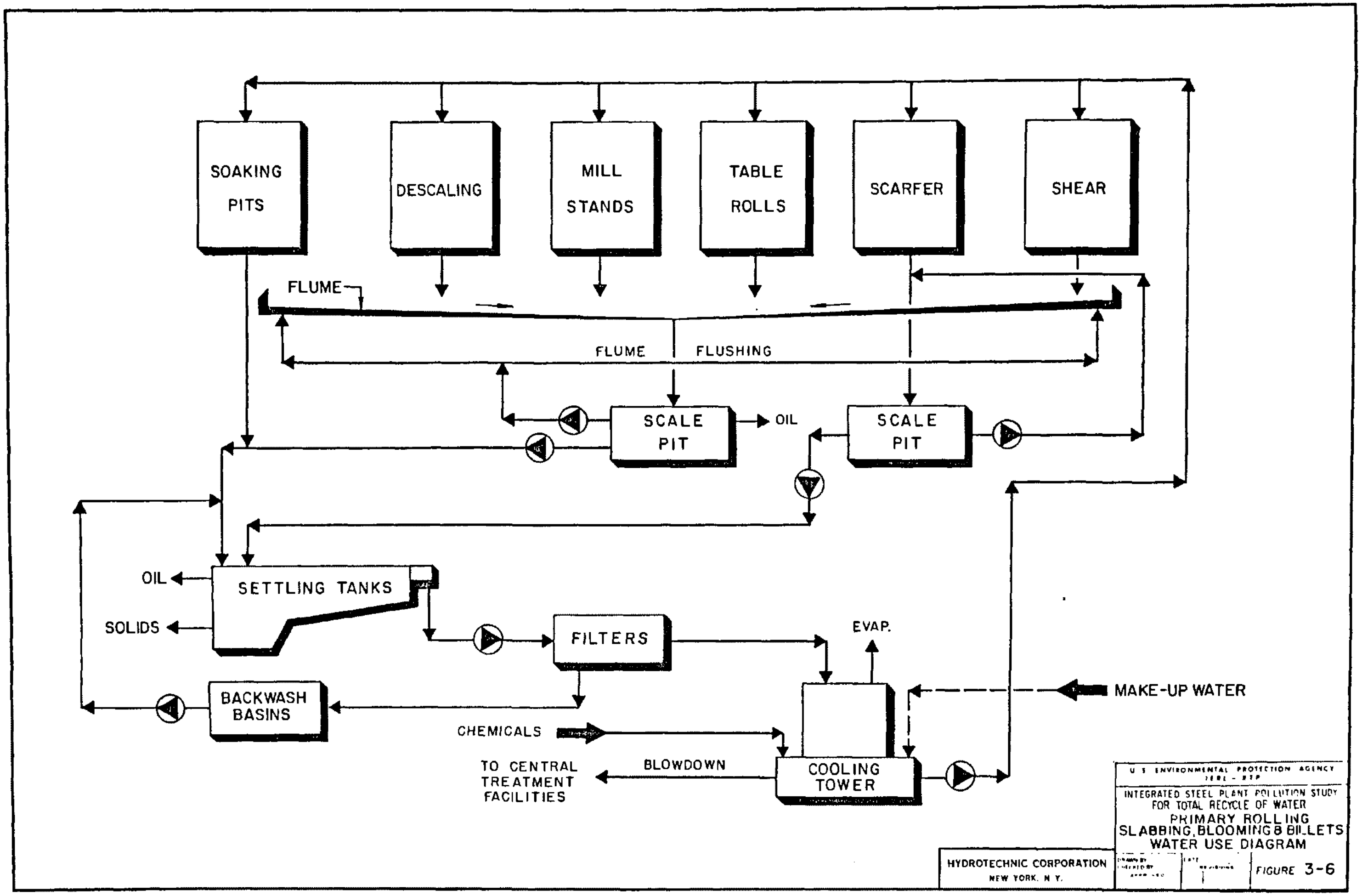
3.2.5.2 Primary Hot Rolling

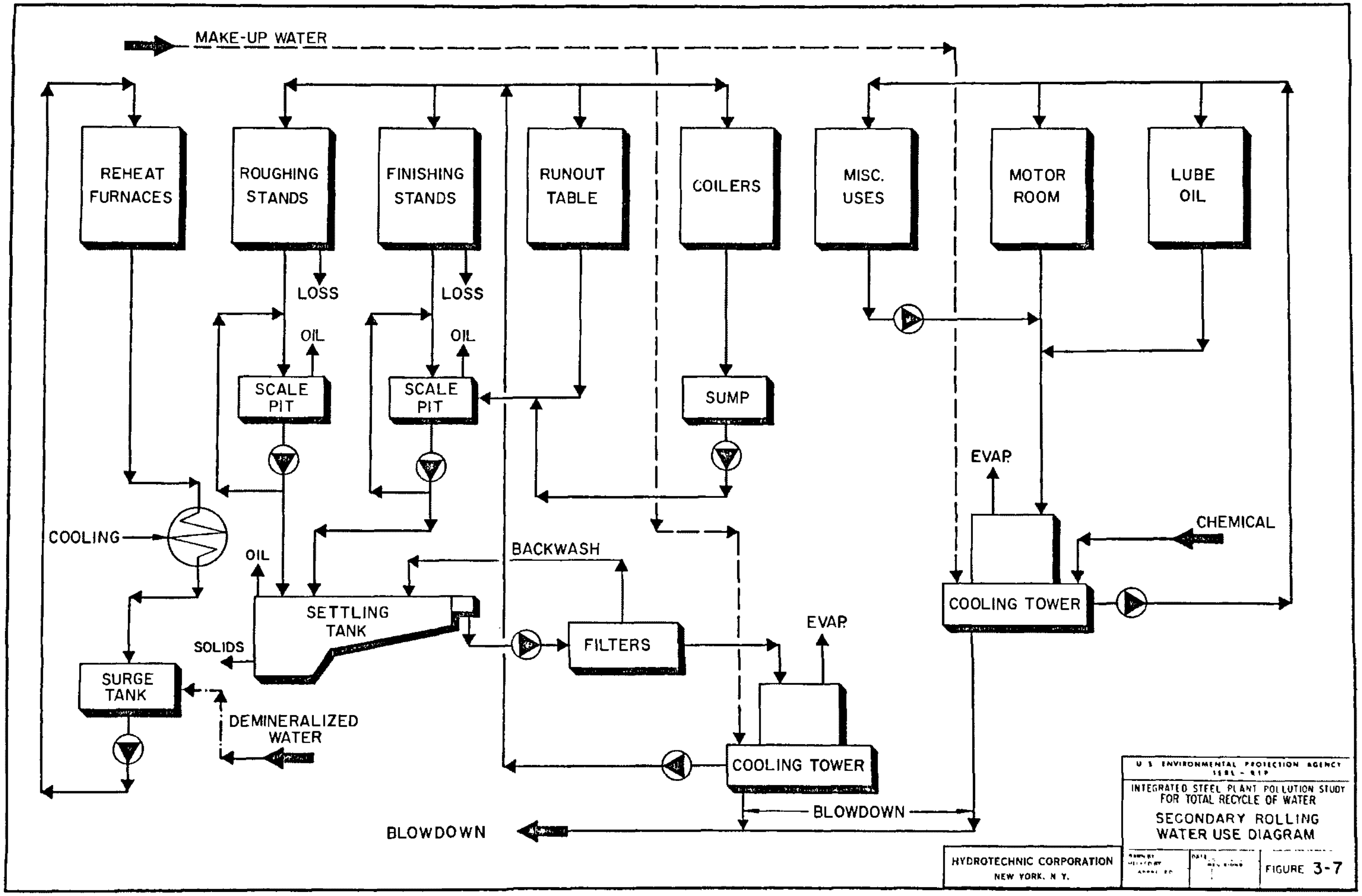
Contact water is used at the primary hot rolling mills for five basic purposes: descaling, table roll cooling, flume flushing, mill stand cooling and scarfer sprays and fume scrubbing. Water applications may range from 2,500 to 8,530 l/kkg (600-2,050 gal/t) for scarfing and from 1,250 to 8,775 l/kkg (300-2,110 gal/t) for other contact uses, excluding flume flushing.

A contact water system for a typical modern primary mill is shown on Figure 3-6. The water enters a flume running the entire length of the mill and discharges to a scale pit, often located outside of the mill building. The scarfers often have a separate water system. Large volumes of water must be recycled from the pit for flume flushing to maintain a high water velocity and prevent scale accumulation. The water is heavily laden with iron oxide mill scale and oils, most of which is removed in the scale pit. The clarified wastewater is then discharged to receiving waters at most mills while in other mills it is further treated by chemical coagulation or filtration prior to discharge or cooling for recycle at the mill.

Non-contact cooling water is used for reheat furnace cooling, motor room and lube cooling. These systems are usually once-through but in some mills are recycled, either totally or partially, as shown in the scheme for secondary hot rolling, Figure 3-7.


COOLING CHAMBER WALL COOLING
CASTER SPRAY COOLING
TORCH CUTTING MACHINE
TORCH CUTTING SLAG GRANULATION
RUNOUT TABLE ROLL COOLING
DESCALER
CASTER MACHINE COOLING
MOLD COOLING
FLUME
FLUME FLUSHING
FLUME FLUSHING
DEMINERALIZED WATER
SCALE PIT
OIL
SURGE TANK
HEAT EXCHANGER
OIL
SETTLING TANKS
SOLIDS
FILTERS
EVAP
CHEMICALS
BACKWASH BASINS
COOLING TOWERS
MAKE UP WATER
BLOWDOWN
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
CONTINUOUS CASTING WATER USE DIAGRAM
HYDROTECHNIC CORPORATION
NEW YORK, N.Y.
FIGURE 3-5


SOAKING PITS
DESCALING
MILL STANDS
TABLE ROLLS
SCARFER
SHEAR
FLUME
FLUME
FLUSHING
SCALE PIT
OIL
SCALE PIT
OIL
SETTLING TANKS
SOLIDS
FILTERS
EVAP.
MAKE-UP WATER
BACKWASH BASINS
CHEMICALS
TO CENTRAL TREATMENT FACILITIES
BLOWDOWN
COOLING TOWER
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
PRIMARY ROLLING
SLABBING, BLOOMING & BILLETS
WATER USE DIAGRAM
HYDROTECHNIC CORPORATION
NEW YORK, N. Y.
FIGURE 3-6



MAKE-UP WATER
REHEAT FURNACES
ROUGHING STANDS
FINISHING STANDS
RUNOUT TABLE
COILERS
MISC. USES
MOTOR ROOM
LUBE OIL
LOSS
LOSS
OIL
OIL
SCALE PIT
SCALE PIT
SUMP
EVAP.
CHEMICAL
COOLING
OIL
BACKWASH
SETTLING TANK
SOLIDS
FILTERS
EVAP.
COOLING TOWER
SURGE TANK
DEMINERALIZED WATER
COOLING TOWER
BLOWDOWN
BLOWDOWN
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY
FOR TOTAL RECYCLE OF WATER
SECONDARY ROLLING
WATER USE DIAGRAM
HYDROTECHNIC CORPORATION
NEW YORK, N. Y.
FIGURE 3-7

3.2.5.3 Secondary Hot Rolling

The various secondary rolling mills require water for the same general purposes as for the primary mills but in greater amounts increasing with mills producing more finished products. Contact water uses, as illustrated on Figure 3-7 for a hot strip mill, are for descaling, roll cooling, flume flushing and product cooling (9). These applications occur during the roughing, finishing and other stages of secondary hot rolling. The required water volumes are reported to range from 5,410 to 28,000 l/kkg (1,300-6,730 gal/t) for plates, and from 21,260 to 67,620 l/kkg (5,110-16,255 gal/t) for hot strip. Water used for roll cooling, descaling and flume flushing at the roughing stands and finishing stands usually flow to two separate scale pits, one for each type of operation. Runout table and coiler wastewater is usually discharged directly, but, as shown on Figure 3-7, it often is combined entirely or partially with finishing stand wastewater for treatment. In most mills the water is discharged without reuse but in many modern systems the water is further treated by filtration and cooling prior to reuse.

Most non-contact cooling water used at secondary hot rolling mills is for reheat furnace cooling. Reported water applications range from 5,200 to 23,900 l/kkg (1,250-5,750 gal/t). The furnace water systems are generally once-through but the water may be reused for flume flushing or, as in Figure 3-6, it may be cooled for reuse at the furnaces. There are smaller non-contact cooling systems for the motor room, lube oil and other applications; these systems are either one-through or recirculating.

3.2.6 Cold Finishing Water Use

In the cold finishing processes all water used comes in contact with the product, or processing material, except for water used in minor indirect cooling applications. The effluents have three distinct forms: acidic pickling wastes, spent oil emulsions from cold reduction and clean cooling water.

3.2.6.1 Pickling

In both continuous and batch pickling operations, water is used in two basic processes: pickling, and rinsing. Many installations, especially continuous picklers, also have wet fume scrubbing systems. In the case of continuous strip pickling, some water is also needed for the uncoilers, looping pit and coilers.

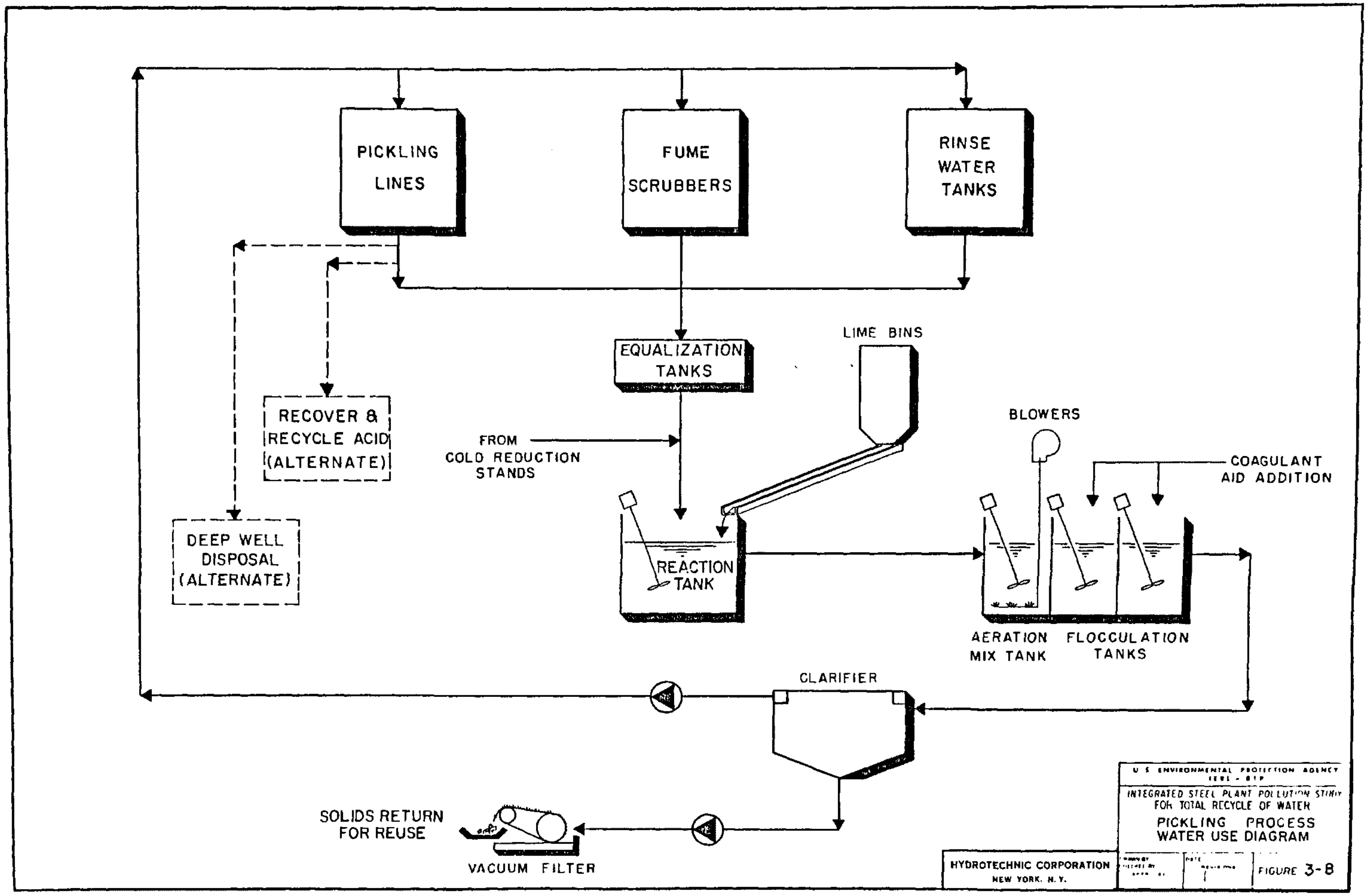
The effluent water from the pickling tanks (waste pickle liquor) consists of an acid solution, usually spent hydrochloric or sulfuric acid and iron salts. The waste hydrochloric liquor contains about 0.5% to 1% free HCl and 10% dissolved iron. The production of waste hydrochloric pickle liquor per unit product pickled is about 82 l/kkg (20 gal/t) or about 1 kg/kkg (2 lb/t) free HCl and 10 kg/kkg (20 lb/t) dissolved Fe. In waste sulfuric acid pickle liquor there is about 8% free acid and 8% dissolved iron, resulting in a production of about 10 kg/kkg each of free H_2SO_4 and dissolved Fe from the 103 l/kkg (25 gal/t) waste pickle liquor. Waste pickle liquor may also contain relatively small amounts of other metal sulfates, chlorides, lubricants, inhibitors, hydrocarbons, and other impurities. Rinse water contains the same pollutants in a diluted form. The reported rinse volumes range from 209 to 2,080 l/kkg (50-500 gal/t; the smaller volumes are for cascade rinse systems. The fume scrubbers have water applications ranging from 10 to 190 l/kkg (2.5-46 gal/t); the higher applications for the more volatile HCl pickling processes.

Generally, as shown on Figure 3-8, the waste pickle liquor dumps, the rinsing wastewaters and fume scrubber effluents are combined for treatment in an equalization tank, which discharges to reactors where the equalized wastes are mixed with lime or other alkaline agents to raise the pH to about 8.5. The water then flows to an aerator for oxidation followed by settling before discharge. In some plants the treated water may be recycled for fume scrubbing and some plants have systems to regenerate the waste pickle liquor and recover the iron as an oxide, sulfate or chloride.

3.2.6.2 Cold Reduction Mills

Water of good quality is mixed with rolling oil to form an emulsion which is used to lubricate and cool the steel as it passes through the reducing stands. Since the pickled product being rolled is free from rust, and no scale if formed, the contaminants added are oil, increased temperature, and suspended solids which may have accumulated on the steel in storage. The quantity of water used varies greatly depending on whether a once-through, a recycle system or a combination system is used. Water applications can vary from less than 100 l/kkg (24 gal/t to over 3,000 l/kkg (720 gal/t). Even total recycle systems have wastewater discharges from leaks, solution dumps and from the maintenance and roll finishing shops.

The high cost of rolling oils has increased the trend toward emulsion recycling and treatment of waste emulsions for oil recovery. Once-through or combination systems with continuous discharges may have an oil recovery facility. The basis of most oil recovery systems is the breaking of emulsions into separable oil and water phases. Emulsions are usually broken by a combination of heat and acid treatment. Oil content in the spent rolling solutions can be as high as 8 percent with sus-


PICKLING LINES
FUME SCRUBBERS
RINSE WATER TANKS
EQUALIZATION TANKS
LIME BINS
RECOVER & RECYCLE ACID (ALTERNATE)
DEEP WELL DISPOSAL (ALTERNATE)
FROM COLD REDUCTION STANDS
REACTION TANK
BLOWERS
COAGULANT AID ADDITION
AERATION MIX TANK
FLOCCULATION TANKS
CLARIFIER
SOLIDS RETURN FOR REUSE
VACUUM FILTER
U.S. ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
PICKLING PROCESS WATER USE DIAGRAM
HYDROTECHNIC CORPORATION NEW YORK, N.Y.
FIGURE 3-8

pended solids ranging from 100 to 1,000 mg/l. Figure 3-9 illustrates treatment or disposal methods practiced for waste emulsion dumps and continuous discharges.

3.3 SOLID WASTES

An integrated steel plant produces a variety of solid wastes; most are inorganic and can be reused within the plant or elsewhere, after suitable processing. The major tonnages of solid wastes are as slags, coke and raw material fines, iron oxide scale and dust, metal scrap and dewatered sludges. Much of the scale, the dust and sludges are solids from water and air pollution control systems. Table 3-3, summarizes the solid wastes generated at the different areas of production and their reuse destination. Solids removed from air emissions are not listed, but are included for discussion below. Most of the solid wastes are presently not reused but hauled to landfills. All solid wastes containing significant iron or iron oxides have a potential for reclamation and reuse (9, 10).

3.3.1 Coke Making

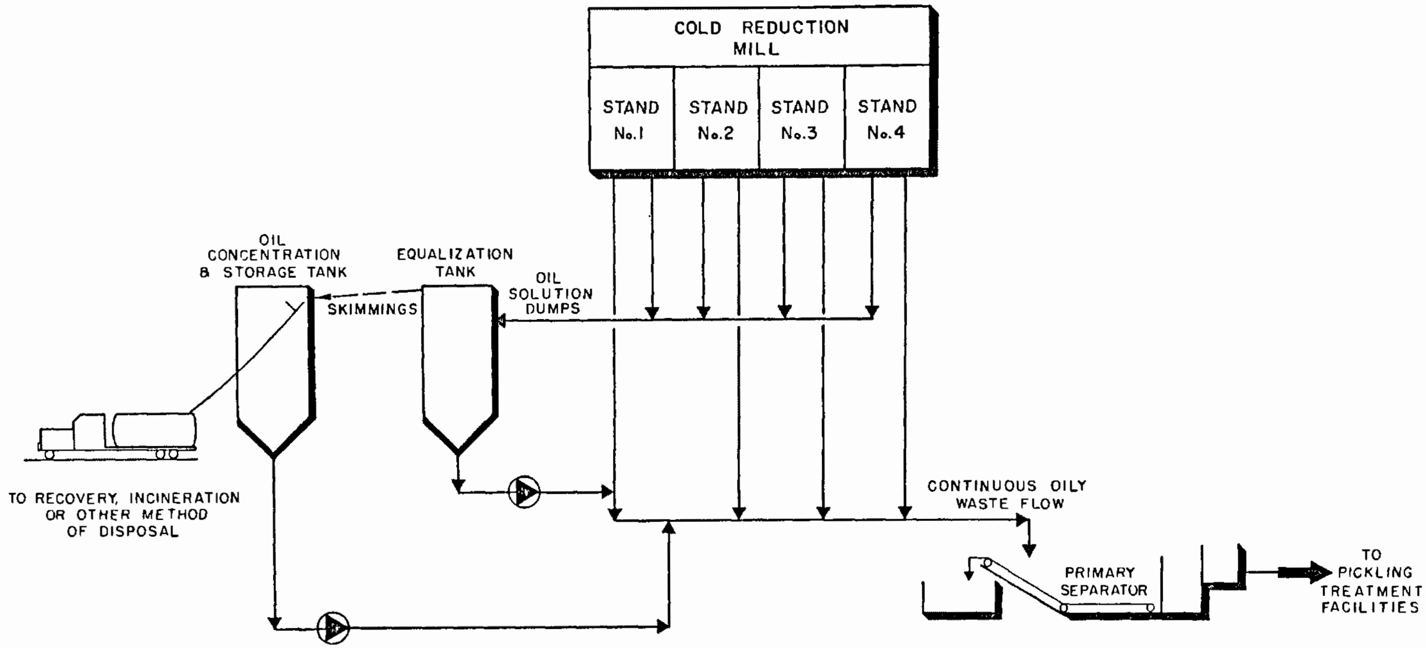
Coke which is too fine for direct use in blast furnaces is called "coke breeze". It contains more ash and moisture than blast furnace coke and is sent to the sintering plant for agglomeration or is used as fuel in boilers for steam generation. Minor amounts of solid wastes are from the by-products plant and include sludges from wastewater treatment and coal tar. The tar can be directly sold, processed within the plant or used as fuel in the open hearth furnaces.

3.3.2 Sintering

One function of a sinter plant is to recycle solid wastes, i.e., fines from raw material handling (ore and limestone), coke breeze, iron oxide dusts from blast furnace and steelmaking furnace emissions, and hot mill scale. The fines are agglomerated to a size suitable for blast furnace feed; any dust or fine product is resintered.

3.3.3 Iron Making

The blast furnace area generates large amounts of slag which consists of ore and coke mineral impurities (silicates and aluminates) combined with calcium oxide from the flux. The air-cooled, granulated or expanded slags each have different physical characteristics which, together with chemical composition, determine their eventual use. The processed slag is used mostly for road beds and landfill, but is also used as a component in paving material, concrete, cement, building blocks, tile, insulation, soil conditioning and even cooking ware.



U. S. ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP

INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

COLD REDUCTION MILL WATER USE DIAGRAM

HYDROTECHNIC CORPORATION
NEW YORK, N. Y.

FIGURE 3-9

TABLE 3-3

INTEGRATED STEEL PLANTS SOLID WASTE SOURCES*

Production Facility	Waste Description	Solids Reuse
Coke Plant		
Coke Screening	Coke Breeze	Sintering
By-Product Operation	Wastewater Sludge	None
Raw Material Handling	Fines	Sintering
Iron Making		
Blast Furnace	Slag	Construction, Road Beds, etc.
Steel Making		
Steelmaking Furnaces	Slag	Agriculture, Landfill, etc.
Hot Forming		
Hot Rolling	Scale	Sintering
	Scrap	Steelmaking
Acetylene Scarfing	Slag	Iron Recovery, Landfill
Pickling		
WPL Disposal	Iron Hydroxide Sludge	None
WPL Regeneration	Iron Oxide	Sintering
Cold Mill	Oil Skimmings	Oil Reclamation, Fuel

Note: *Particulate emissions which also generate solid wastes are listed in Table 3-1.

The cleaning of blast furnace gas produces from 70 to 250 kg/kkg of iron oxide wastes. About 60 percent of the total comes from dry dust catchers, the balance is dewatered sludge from wet scrubbing. These wastes are reclaimed by sintering or pelletization for reuse in the blast furnace. Some iron scrap is also reused in the BF.

3.3.4 Steelmaking

All furnaces in the steelmaking area generate considerable slag similar to the BF. Generally, electric arc furnaces produce the least slag and the BOF is the biggest producer. The cooled processed slag has more limited use than blast furnace slag; with its high lime and phosphorous content, and much is used as an agricultural soil conditioner.

Iron oxide is produced as dust and sludge from the dry and wet gas cleaning units at the steelmaking furnaces. Solids production ranges from 5 to 20 kg/kkg with the BOF the largest source. Zinc oxide (from galvanized scrap feed) and carbon dust (kish) are minor components of gas cleaning solids. The iron oxide wastes are sintered or pelletized for use in blast furnaces or in open hearth furnaces.

All steelmaking furnaces accept large amounts of steel scrap as normal components of the charge and some BOF units take mill scale in small portions.

3.3.5 Hot Forming

Iron oxide scale is the major solid waste from this area. Generally, mill scale production is from 8 to 10 percent of the steel product tonnage at the primary and secondary rolling operations. Continuous casting operations produce about 2% scale or 20 kg/kkg product. Most of this scale is sufficiently coarse to be removed by the scale pits and about 10-20 percent is recoverable from the sludge of further wastewater treatment processes. Oil and greases are also a significant waste associated with the mill scale. At each hot rolling operation, the waste oil and grease production is up to 0.5 kg/kkg. Most oil is skimmed off the wastewater and stored for periodic disposal or recovery, usually by an outside contractor.

Scarfing operations produce solid wastes from 2 to 3 percent of the steel product. Most of the waste is slag produced by the acetylene torches melting the hot steel. The slag is often processed to reclaim the metal.

Steel scrap is produced by cropping or shearing ends and sides of hot shapes. Casting wastes and rejects, are also recycled to the steelmaking furnaces. Generally, scrap production ranges from 8 to 12 percent of the product tonnage at each rolling stage with lesser amounts produced by continuous casting and hot strip production.

3.3.6 Pickling

Significant amounts of oxidized iron wastes, in different forms are produced in the treatment of waste pickle liquor and rinses. The pickling process removes from 0.2 to 2 percent of the metal from steel shapes, the loss depending on the surface area to volume ratio. Modern pickling lines incorporate pickle liquor regeneration facilities which generate iron oxide dust or granules which may be recycled at the sinter plant. Much pickle liquor and rinses are still being disposed of by neutralization and clarification to produce a sludge of iron hydroxides and sulfates which resists effective dewatering. Recovering of the iron for reuse is usually not feasible if iron oxide is not produced.

3.3.7 Cold Rolling

The largest source of organic waste from a steel plant is waste oil emulsions from the cold mills. The oily waste discharge is generally less than 3 kg/kkg steel product, but it can be more from mills using a once-through emulsion system with a reported loss of 25 kg/kkg from one mill.

3.3.8 Annealing

Solids wastes are not generated in significant amounts from the annealing process.

3.3.9 Coating

Except for cutoffs and some scrap, solids wastes are not generated in significant amounts in the coating processes.

3.4 ENVIRONMENTAL CONTROL CONSIDERATIONS

3.4.1 General Regulations for Discharges from Integrated Iron and Steel Plants.

This section presents existing state and federal discharge regulations which apply to integrated steel plants. For wastewater discharges federal regulations have been established but for air emissions only individual states have promulgated comprehensive regulations. No specific federal regulations have yet been established for disposal of industrial solid wastes.

3.4.1.1 Air Emission Regulations

Federal regulations have been established by the EPA for only a few specific steelmaking facilities and these are discussed below. Tables 3-4 and 3-5 present air pollution regulations established in states having integrated steel plants (5). As federal guidelines specific for steel plant emissions become established, they will augment these state regulations.

Michigan has established guidelines for specific sources of particulate emissions and are shown on Table 3-6.

In the EPA development document (1 and 2), some general conclusions have been made on the expected quality of treated emissions from various facilities. For the sinter plant, BOF, open hearth and electric furnaces, the particulate loadings are expected to be about 0.1 kg/kkg of exhaust gas. This loading is the same as the Michigan regulations for the steelmaking facilities but one-half that allowed for the sinter plant.

Federal regulations have been established by the EPA for treated emissions from electric art furnaces (11). A proposed limitation on BOF emissions is 50 mg/dscm (0.022 gr/dscf) and 10 percent opacity except for a maximum 20 percent opacity once per steel production cycle (12). It should be noted that the proposed particulate concentration from the BOF has the same value as similar limitations established by Colorado and Kentucky, while the Federal limitation for the relatively clean electric furnace emissions is significantly less than these state levels.

3.4.1.2 Wastewater Discharge Regulations

The federal regulations most relevant to this study are the effluent limitations guidelines (ELG's) according to the use of the Best Available Technology. These regulations were prepared for many industrial categories, including iron and steel manufacturing, and are to be implemented for new and existing facilities by 1984. The Federal Court has remanded certain of these limitations, which are presently under further study, but for the purposes of this report the present ELG's have been used as discussed in this section. They generally represent the effluent loadings attainable by the highest degree of treatment and water recycling deemed achievable industry-wide, using existing economical technology.

Tables 3-7 and 3-8 present a summary of the present BAT limitations for the various production subcategories established by the EPA for integrated steel plants. The limitations for the steelmaking facilities (13) are designated Phase I for the steel forming and finishing facilities (14), Phase II. The effluent limitations represent values not to be exceeded by any 30 consecutive day average. The maximum daily effluent loads per unit of production should not exceed the ELG values by a factor of more than 3. Most ELG's are presented on a gross basis. The ELG's do not specifically limit on discharge flow,

TABLE 3-4

AIR POLLUTION REGULATIONS FOR STATES HAVING INTEGRATED STEEL PLANTS

State	Allowable Particulate Emissions from Overall Plant (lbs/hr) Production Capacity--tons/hr 5	50	500	Particulate Concentration Grains per DSCF		Allowable Particulate Emissions from Combustion Sources (lbs/million BTU) Million BTU per hr. 1	10	100	1000		Allowable Sulphur Dioxide Emissions from Combustion Sources (lbs/million BTU) Million BTU per hr 1	10	100	1000
Alabama														
Class 1 County	9.7	32.2	46.7			0.5	0.5	0.18	0.12		1.8	1.8	1.8	1.8
Class 2 County						0.8	0.8	0.21	0.12					
Colorado	9.7	32.2	46.6	0.022		0.5	0.27	0.15	0.19	Liquid fuel	0.8	0.8	0.8	0.8
										Solid fuel	1.2	1.2	1.2	1.2
Illinois-														
New source	6.0	20.5	67.0			0.1	0.1	0.1	0.1	Liquid fuel	1.0	1.0	1.0	0.8
										Solid fuel	1.8	1.8	1.8	1.8
Indiana	12.0	44.6	69.0			0.6	0.6	0.42	0.29		6.0	6.0	1.7	1.7
											(1.2 above 3 mm BTU/hr)			
Kentucky	9.7	32.3	46.7	0.022	Region I	0.56	0.56	0.33	0.19	Liquid fuel	3.0	3.0	1.2	0.8
										Solid fuel	5.0	5.0	1.8	1.2
Michigan	12.0	44.6	69.0		Pulv. coal	0.6	0.6	0.6	0.36	Liquid fuel	1.7	1.7	1.7	1.1
					Other coal	0.65	0.65	0.65	0.45	Solid fuel	2.4	2.4	2.4	1.6
New York	15.3	50.0	71.1											
Ohio	12.0	44.6	69.0		Region I	0.4	0.4	0.2	0.1		1.0	1.0	1.0	1.0
					Region II	0.6	0.6	0.3	0.15					
Pennsylvania														
Iron making	9.6	25.5	74.0			0.4	0.4	0.27	0.1		1.0	1.0	0.9	0.66
Steel making	7.1	10.9	50.0								(0.6 above 2000 MBTU/hr)			
Sintering	5.3	10.4	38.0											
Texas	15.2	78.1	151.2			0.3 for solid fossil fuel								
West Virginia	10.0	33.0	50.0			0.05 for utility boilers 0.09 per other furnaces & boilers								

TABLE 3-5

AIR POLLUTION REGULATIONS FOR STATES HAVING INTEGRATED STEEL PLANTS

State	Carbon Monoide	Nitrogen Oxides	Mineral Oxides
Alabama	Blast furnace requires afterburner (0.3 seconds)	Boilers over 250 MBTU/hr Coal - 0.7 lb/MBTU Max. Oil - 0.3 lb/MBTU Max. Gas - 0.2 lb/MBTU Max.	-
Illinois	200 PPM max.	Same as Alabama	-
Indiana	Flares etc., required	Same as Alabama	-
Kentucky	-	Same as Alabama	-
Ohio	Same as Alabama	-	-
West Virginia	-	-	Sulphuric mist-35 PPM max. Nitric mist-70 PPM max. Hydrochloric mist-210 PPM max. Phosphoric mist-3 PPM max.

TABLE 3.6

STATE OF MICHIGAN
Particulate Emissions Limitations

Source of Particulates	kg/kkg (lbs/1000 lbs) Gas
Sintering	0.20
Steelmaking Furnaces	0.10
Blast Furnace	0.15
Heating Furnaces	0.30

TABLE 3-7

BAT - EFFLUENT LIMITATIONS GUIDELINES I

Production Facility (Sub-category)	BAT LIMITATIONS (kg/kkg or lb/1000 lb product) *										
	Suspended Solids	Oil & Grease	Cyanide	Ammonia	Sulfide	Phenol	Fluoride	Nitrate	Lead	Manganese	Zinc
By-Product Coke	104-4	42-4	1-4	42-4	12-5	21-5	-	-	-	-	-
Sintering	53-4	21-4	-	-	6-5	-	42-4	-	-	-	-
Blast Furnace (iron)	130-4	-	13-5	52-4	16-5	26-5	104-4	-	-	-	-
BOF (semi-wet APCS)**			No Discharge of Pollutants								
BOF (wet APCS)	52-4	-	-	-	-	-	42-4	-	-	-	-
Open Hearth	52-4	-	-	-	-	-	42-4	84-4	-	-	10.4
Electric (semi-wet APCS)			No Discharge of Pollutants								
Electric (wet APCS)	52-4	-	-	-	-	-	42-4	-	-	-	10.4
Vacuum Degassing	26-4	-	-	-	-	-	-	47-4	5-5	52-5	52-5
Continuous Casting	52-4	52-4	-	-	-	-	-	-	-	-	-

NOTE: * Limitations values in exponential notation, eg. 104-4 is 104 x 10^{-4} or 0.0104

** APCS is air pollution control system (gas cleaning system)

TABLE 3-8

BAT - EFFLUENT LIMITATIONS GUIDELINES II

Production Facility (sub-category)	BAT Limitations (kg/kkg or lb/1000 lb product)* Suspended Solids	Oil & Grease	Cyanide	Fluoride	Iron Diss.	Chromium Total	Chromium Hexavalent	Lead	Tin	Zinc	Chromium, Diss.	Copper, Dissolved	Nickel, Dissolved
Hot Forming-Primary	11-4	11-4	-	-	-	-	-	-	-	-	-	-	-
Hot Forming-Section			No Discharge of Pollutants										
Hot Forming-Strip			No Discharge of Pollutants										
Hot Forming-Plate	64-4	64-4	-	-	-	-	-	-	-	-	-	-	-
Pipe and Tube			No Discharge of Pollutants										
Pickling H_2SO_4 (Acid Recovery)			No Discharge of Pollutants										
Pickling H_2SO_4 (Acid Neutraliz.)	52-4	21-4**	-	-	21-5	-	-	-	-	-	-	-	-
Pickling-HCl***	83-4	34-4***	-	-	34-5	-	-	-	-	-	-	-	-
Cold Rolling													
- Recirculation	26-4	104-5	-	-	104-6**	-	-	-	-	-	-	-	-
- Combination	417-4	167-4	-	-	167-5**	-	-	-	-	-	-	-	-
- Direct Applic.	1042-4	417-4	-	-	42-4**	-	-	-	-	-	-	-	-
Galvanizing****	104-4	42-4	-	-	-	84-6	8-6	-	-	83-5	-	-	-
Terne Coating*****	104-4	42-4	-	-	-	-	-	104-6		83-5	-	-	-
Wire Coating & Pickling	1043-4	417-4**	10-4	626-4	42-4	-	-	-	-	-	21-4	10-4	10-4
Cont. Alk. Clean.	52-4	-	-	-	2-4	-	-	-	-	-	1-4	-	5-5

* Limitations values in exponential notation, e.g. 11-4 is 11×10^{-4} or 0.0011.

** Only when pickling wastes and cold rolling wastes are treated in combination.

*** If line has a fume hood scrubber, allow these additions: SS: 52-4, O. & G.: 21-4, Fe: 21-5.

**** If line has a fume hood scrubber, allow these additions: SS: 156-4, O. & G.: 63-4, Zn: 125-5, Cr(tot): 126-6, Cr(Hex) 13-5.

***** If line has a fume hood scrubber, allow these additions: SS: 156-4, O. & G.: 63-4, Lead: 156-6, Tin 125-6.

type of technology or concentrations to be achieved. However, they are generally based on a specified direct contact water discharge flow per unit product and concentrations of the various pollutant parameters achievable by BAT treatment technologies.

Tables 3-7 and 3-8 indicate that several production facilities are to operate on a basis of zero discharge of process pollutants. The discharge volume per unit production which were used to determine the ELG values (when multiplied by treated wastewater concentrations) are contained in Table 3-9.

These discharge rates are much less than the applied flows in each case and represent a high degree of water recycling after treatment. A goal of total recycle would be the design of integrated steel plant water systems to allow reuse of the blowdowns from these systems.

As an interim step toward total recycle, the U.S. EPA Effluent Limitations Guidelines for Best Available Technology Economically Achievable (BAT) for the Iron and Steel Industry proposed in 1976 were considered as standards for allowable discharges of water and waterborne contaminants. However, since the guidelines have been remanded by the courts and all are under study and review for possible revision, a brief review was made of the proposed guidelines to determine which technologies would be used as BAT for purposes of this report. The selection of technologies considers the original proposed BAT, technical points outlined in the court remand, and the authors' knowledge of alternate technologies. This is not meant, however, to be a complete technical review of proposed BAT Guidelines nor a recommendation for new proposed BAT Guildelines.

The information available for this review was limited but the evaluation does reflect the best engineering judgement of many individuals with years of iron and steel industry water and wastewater experience. In order to be consistent, the following review is in the same format as that presented in the Guidelines.

3.4.1.2.1 Coke Making - By-Product Operation

Alternate No. 2 which utilizes free and fixed ammonia stills, a dephenolizer and two stages of biological treatment, is selected because of its potential lower cost than Alternate No. 1, a physical/chemical treatment system.

3.4.1.2.2 Coke Making - Beehive Operation -

Not discussed since so few are in operation in integrated mills.

TABLE 3-9

BAT DISCHARGE VOLUMES FOR ELG DETERMINATION

Production Facility	Discharge l/kkg	Discharge gal/t
By-Product Coke	730	175
Sintering	209	50
BF (Iron)	522	125
BOF (semi-wet APCS)	0	0
BOF (wet APCS)	209	50
Open Hearth	209	50
Electric (semi-wet APCS)	0	0
Electric (wet (APCS)	209	50
Vacuum Degassing	104	25
Continuous Casting	522	125
Hot Forming - Primary	104	25
Hot Forming - Section	0	0
Hot Forming - Strip	0	0
Hot Forming - Plate	625	150
Pipe and Tube	0	0
Pickling - H_2SO_4 - (Acid Recovery)	0	0
Pickling - H_2SO_4 - (Acid Neutr.)	209	50
Pickling - HCl - (Recovery or Neutr.)	333	80
Cold Rolling - Recirculation	104	25
- Combination	1668	400
- Direct Appl.	4170	1000
Galvanizing	417	100
Terne Coating	417	100
Wire Coating & Pickling	4170	1000
Cont. Alk. Cleaning	209	50

3.4.1.2.3 Sintering Operations

The sintering model consisting of clarification chemical addition and sludge dewatering is selected.

3.4.1.2.4 Blast Furnace Operations

The settling, alkaline chlorination, pressure filtration and activated carbon system proposed is costly. The use of blast furnace gas washer water system blowdown as coke plant biological treatment plant dilution water should be investigated since this blowdown is similar to dilute coke plant wastewater. A two-fold benefit could be achieved, namely, treatment of the blast furnace system blowdown at basically no additional cost and the savings of dilution water. It is assumed that the use of blast furnace blowdown in the coke biological plant can be successfully developed and this technology is selected.

3.4.1.2.5 Steelmaking Operations

The model consisting of thickening, polymer addition, sludge dewatering and recycle is selected.

3.4.1.2.6 Continuous Casting

The model shown does not present the latest technology. Primary settling followed by filtration and cooling prior to recirculation with blowdown from the cooling tower "cold" side is selected.

3.4.1.2.7 Hot Forming Primary

The use of filters instead of clarifiers represents the latest technology since clarifiers, even with chemical treatment, cannot guarantee an effluent of 10 mg/l suspended solids and oil and grease. On new installations clarifiers are not required since filters can do the entire treatment job.

3.4.1.2.8 Hot Forming - Section

Filters should be used instead of clarifiers on new installations for the reasons stated in 3.5.1.2.7 above. In addition, a blowdown is required to control dissolved solids in the system. In the evaluation of the model, existing blowdowns must have been missed or the discharge to the sinter plant was low in percent solids which acted as a blowdown. In this report, it is assumed that a blowdown is required.

3.4.1.2.9 Hot Forming/Flat-Hot Strip and Sheet

Same comments as 3.4.1.2.7 and 3.4.1.2.8, above.

3.4.1.2.10 Hot Forming/Flat-Plate

Same comments as 3.4.1.2.7 and 3.4.1.2.8, above.

3.4.1.2.11 Pipe and Tubes - Integrated and Isolated

Same comments as 3.4.1.2.7 and 3.4.1.2.8, above.

3.4.1.2.12 Pickling - H_2SO_4 and HCl - Batch and Continuous

The models presented should produce the effluents desired.

3.4.1.2.13 Cold Rolling - Combination and Direct Application

The models presented should produce the effluents desired.

3.4.1.2.14 Hot Coating - Galvanizing and Terne

The models utilizing acid regeneration and/or neutralization with settling and sludge dewatering are selected.

3.4.1.2.15 Electroplating

The standards proposed for use in the steel industry are a transfer of technology from small plating shops. Since the integrated iron and steel industry plates steel mainly using continuous, high production operations the small shop electroplating guidelines may not apply. However, the proposed guidelines, which call for no discharge of water are selected for use in this report.

3.4.1.2.16 Miscellaneous Runoff

Each individual site must be considered.

3.4.1.2.17 Conclusions

The ELG's were remanded because such factors as: age of plant, makeup water quality, climatic conditions, difficulty in separating sewers, etc. were not considered. These factors are site specific and could significantly influence the allowable discharge rates in l/kkg and in the cost of facilities needed.

3.5 ENVIRONMENTAL CONTROL METHODS

3.5.1 Air Emissions

Discharges to the atmosphere can be classified into two basic categories: gases and particulate matter. Particulate matter may be further subclassified as smoke, dust, fumes and mists. Smoke consists of colloidal size solids, usually less than one micron resulting from incomplete combustion. Dusts are solid particles, larger than colloidal, formed by a physical disintegration process. Fumes are solid particles of submicron size generated by the sublimation of vapors or by chemical reactions. Mists are liquid particles created by vapor condensation or chemical reactions. Particulates and gases are produced during the different operations of iron and steelmaking and are to be controlled.

3.5.1.1 Particulate Matter Control Methods

Selection of the method for particulate removal depends upon the sizes and concentrations of the particles and the efficiency desired. Following is a brief discussion of the most common particulate air pollution control devices with particular emphasis upon those methods that require water for operation.

a. Settling Chambers

This device operates on the principle of gravitational settling of particulates when the velocity of the carrier gas is reduced, usually to less than 3 meters per second (10 ft/sec). The settling chambers' primary application is as the first stage of dust and fume recovery. Removal of smaller particulates requires subsequent treatment by high energy scrubbers or electrostatic precipitators.

b. Inertial Separators

Cyclone separators are the most common type of inertial separators and are basically composed of a cylinder with a tangential inlet and an inverted cone attached to a base. The gas stream enters the cyclone through the tangential inlet, and the resulting circular motion will cause the particles to impinge upon the cylinder wall. The particles then agglomerate and slide into the cone for discharge to a collecting device.

These separators can effectively remove particles 5-200 um in size, although high efficiency cyclones can remove particles as small as 2 um. Pressure drops range from 125 to 1500 Pa (0.5 - 6.0 inches of water).

c. Filters

There are two types of particulate filters in current use. Deep bed filters contain a fibrous medium, but due to their limitation for only light dust loads, they are not employed in the steel industry.

Cloth filters remove dust and fumes from gas steams by means of a fabric medium shaped as an envelope or tubular bag. The bag filters are very efficient devices, removing greater than 99 percent of all particulates, even submicron sizes, and must be cleaned periodically by shaking the bags to dislodge the dust into a collection hopper. Another method is by reversing the flow direction.

Bag filters have definite limitations with gas streams of high temperature or with very large dust loads and are also restricted from use on gases containing vapors which may condense on the bags. A sintering plant processing oily mill scale would produce such vapors.

d. Magnetic Collectors

If the air stream contains ferromagnetic or even weakly magnetic particulates in sufficient concentration, a magnetic device may be effective. A dry, high gradient magnetic separation device is under investigation by the EPA, Office of Research and Development. The magnetic fields utilized range 1,000 to 20,000 gauss (17). However, this device has not been used on a full scale installation in the steel industry.

e. Wet Collectors

These devices use a liquor medium, usually water, for removal of gases and particulate matter with spray chambers and assorted scrubbers being the most common. Collection efficiency varies widely with the design and except for the high energy scrubbers are generally ineffective when the particle size is less than 1 um.

Wet collectors all operate by passing the air stream through a fine spray of water droplets which dissolve the gases and collide with the particles and adhere to them. The droplets subsequently agglomerate until they drop out of suspension carrying particulates and soluble gases from the air stream. The resulting wastewater flow is then treated for disposal or product recovery and water recirculation.

The disadvantages inherent in all wet collectors include corrosion, scaling and plugging. Water mist, carrying gases and particulate matter, may escape the collectors and mist eliminators are usually required at the discharge.

f. Electrostatic Precipitators

Electrostatic precipitators remove particulates from gas streams by creating an electric field with high voltage electrodes. As the gas flow passes through the electric field, the particles precipitate on the positive electrode.

The electrostatic precipitation process is very efficient, achieving 80 - 99 percent removal in most cases, and at times achieving over 99.9 percent removal. The precipitators can remove a wide range of particle sizes, 0.1 um to 200 um, and generally operate best in the smaller size range.

Advantages of electrostatic precipitators are that the energy requirements are generally less than scrubbers, and they can be a dry operation, thereby avoiding a wastewater stream.

The chief disadvantages are their large sizes, high initial cost, and dependence upon particle resistivity for efficient operation. The resistivity problem is particularly serious on such applications as the collection of oil mists and the collection of particulates from the making of high flux sinter.

g. Mist Control Methods

Mists may be eliminated from gas streams by causing the droplets to coalesce by impingement on each other or on a surface. Various proprietary mist eliminator systems are essentially coarse filters for mist impingement. When enough droplets have coalesced, they are of sufficient weight to flow into a collector. Other mist eliminators are essentially solids separators removing mists by the same processes, i.e., inertial separators and electrostatic precipitators.

3.5.1.2 Gas Control Methods

Gases such as oxides of nitrogen, and sulfur are primarily controlled or stripped from the air stream by wet collectors such as spray chambers or scrubbers. Scrubbing may be simply by dissolving the gas in a water stream or by solution and reaction of the gas with additive chemicals. Examples of reaction processes are the use of alkaline agents such as limestone, ammonia, caustic or lime slurry to scrub sulfur dioxide from combustion stack emissions. In these processes, gases are collected by water streams and then treated as a water pollution problem for disposal or product recovery.

3.5.2 Wastewater Control

Water normally contains both dissolved and suspended impurities and any specific use of a water stream is dependent on the types and concentrations of impurities. For example, a high concentration of suspended matter may cause erosion or clogging of equipment, or a high concentration of chlorides may cause metal corrosion. Therefore, the removal of impurities where required is essential for the consideration of any water use or reuse. This section describes methods available for the treatment of wastewater streams from the operations of the iron and steel industry. Combinations of treatment methods will produce virtually any water quality; the products of ultimate treatment being soluble waste solids, reusable materials and demineralized water. However, costs can be prohibitive.

3.5.2.1 Suspended Solids Removal

Inorganic suspended solids constitute the major part of all contaminants in steel plant wastes. These solids are usually composed of iron oxide particles ranging from submicron sizes in gas scrubber effluent to coarse scale.

a. Sedimentation

Sedimentation, in general terms is a treatment method which reduces the water velocity and turbulence so that suspended matter may be removed by gravitational settling. Plain sedimentation is treatment without chemical addition, while coagulation or flocculation with sedimentation employs one or more chemical aids.

A sedimentation unit should allow a maximum detention time, a minimum horizontal velocity, and have an inflow distribution and outflow collection system design so that the solids have a sufficient settling time and not be subject to short-circuiting causing scour and resuspension. Overall basin size may be limited by factors such as area restrictions and subsurface conditions.

In some cases, sedimentation can produce, without chemical additions, treated water containing 50 mg/l or less of suspended matter depending upon the particle size distribution of the solids.

Sedimentation units are constructed in various configurations; they may be simple earthen basins or lagoons, lined basins or tanks of various shapes. Rectangular units, commonly settling basins, are used in the steel industry for plain sedimentation prior to water recycling. The settling may be the only treatment, e.g., coke quenching water, or an intermediate step, as in removal of scale from hot mill cooling water, before filtration or clarification. Scale pits are rectangular units with a short detention time to remove only coarse particles of hot mill scale. Lagoons are large settling basins with detention times of up to several days and may be used for final treatment of combined wastewaters.

In settling basins or rectangular tanks the flow is longitudinal from one end and the discharge is at the opposite end over weirs. Overflow conditions may be improved by use of finger weirs to increase the weir length. Depending on the amount and characteristics of the settled solids, various methods are utilized for their removal from the basin. If the solids are coarse and dense, they may be directly removed by overhead clamshell buckets, or may be dragged toward the influent end by an automatic scraper for removal by another scraper, bucket or pump. If the solids are light but compact, they may flow by gravity into a hopper at the bottom of the tank and be removed by a sludge pump. Where scraping mechanisms are used, they are usually constructed so that on their return they skim any floating oils and solids towards the effluent end for removal.

If the flows to be treated are large or extremely variable, multiple sedimentation units are constructed in parallel so that one cell can be taken out of service without a great reduction in solids removal efficiency.

Circular or square tanks are usually constructed with conical bottoms and are referred to as clarifiers or thickeners. They are typically used in the steel industry for sedimentation with or without chemical aids, such as treating gas cleaning wastewaters, or in clarification of treated coke plant by-products wastewater.

Clarifiers are usually designed with a central inlet and the clarified water discharges over v-notch weirs installed around the periphery of the basin. Constantly rotating rake mechanisms are employed to plow the settled solids toward a center well from where they are withdrawn by sludge pumps. There may also be a surface skimmer provided to remove floating oils and solids.

On some circular units the wastewater is introduced near the bottom, and allowed to rise in an upflow pattern. The change in cross-sectional area as the water disperses reduces its upflow velocity to a point where solids begin to settle. The settling solids contact with solids in the upflow water, agglomerate, and experience enhanced settling. The result is the formation of a sludge blanket or bed through which the wastewater must pass and undergo solids removal. In practice, chemicals or coagulants may be added to the wastewater to help produce an effective sludge blanket.

Coagulation and flocculation are employed with sedimentation to improve the removal of very fine suspended or colloidal solids which settle poorly, if at all, and cannot be effectively removed from wastewater by plain sedimentation or other physical treatment. Such methods are used in steel plants especially for treatment of blast furnace or steelmaking furnace gas cleaning effluents and to maximize solids removal from direct contact wastewaters prior to recycling.

Coagulation specifically is the addition of certain ionic chemicals to neutralize the repelling charges on the colloids in the wastewater which can then combine to form larger settleable solids aggregates. Flocculation, when employed, follows coagulation and involves the chemical bridging or physical enmeshment of the solids to form very large aggregates called "floc". The resulting floc mass has an enormous surface area and further adsorbs suspended solids, colloids and bacteria as it settled to the bottom of the clarifier. In the complete process, chemicals are added and rapidly mixed to insure thorough dispersal in the wastewater. The mixing time is short so that any initial floc is not broken or sheared. Flocculation then occurs by a gentle agitation of the wastewater over an extended period (10-30 minutes) to increase the number of contacts between solids particles and promote floc formation.

Coagulants are metal salts such as aluminum sulfate and iron chloride or organic polyelectrolytes which dissolve in the wastewater to form charged ions for destabilization of the colloidal dispersion. Coagulant aids such as silica, clay and organic polyelectrolytes stimulate coagulation and flocculation and improve solids settling. The most common coagulant is alum, but the newest and most versatile coagulants are organic polyelectrolytes which are water soluble, high molecular weight polymers which form ions of multiple charge in the water.

The metal salts and polyelectrolytes, when added in proper dosages, readily form large floc masses on gentle agitation. Each waste must have small-scale treatability tests performed to determine the most effective coagulant and optimum dosage. Preliminary tests are especially important when using the more costly polyelectrolytes. Small differences in the wastewater characteristics can determine the effectiveness of a given coagulant. For some wastes, addition of two or more chemicals may be required in a specific sequence.

Many clarifier designs combine coagulation, flocculation, and sedimentation in one tank. Designs of this type (often called flocculator-clarifiers) usually produce a better quality effluent than the conventional approach of using separate treatment units. The combined process is also more effective for the removal of emulsified or floating oils as well as suspended solids. In this case, a surface oil skimmer must be utilized either integral with, or following the flocculation/clarification step.

Where lack of space is a consideration or where wastewater flows are increased above the intial design capacity, there are devices that can be added to a settling unit. One design is multiple arrays of tilted plates or tubes that decrease particle settling distances to increase the efficiency of a small basin (18). Another is a wedge wire settler that employs parallel wire screens suspended below and parallel to the water surface so that wastewater must pass upward through the screen for improved solids settling. It thus acts like a mechanical sludge blanket (19). Prior to application of these devices, it should be determined whether clogging will take place on the plates or tubes when used with wastewater containing both oil and suspended solids or with a potentially heavy sludge production.

Hydrocyclones separate solids from fluids by use of centrifugal force and gravity. This method is especially useful for separating denser solids from water. There is no great reduction in flow velocity, instead separation is promoted by introducing the waste stream tangentially into an inverted cone-shaped vessel to allow the solids to migrate to the bottom and water to swirl out the top. One Steel Plant is reported to be using a hydrocyclone in the recycling of BOF gas scrubber water (94). These devices can also be used in solids classification by modification of the hydrocyclone structure and flow pattern to allow separation of solids of various densities and particle sizes (20). Effective oil removal with these devices is usually impossible.

Sedimentation is a process with low costs and very low energy requirements. Mechanical energy is required only for pumping, mixing and sludge collection. Proper designs can make use of gravity flow to minimize these energy requirements. For a given size, clarifiers will have a slightly higher power requirement than conventional settling basins. The total power required for a 1,600 m^3/hr (10 mgd) system using coagulation, flocculation and sedimentation will typically be 30-150 kw (17). For plain sedimentation, power requirements are reported to be 1.5 kw for 158 m^3/hr (1 mgd) to 31 kw for 15,800 m^3/hr (100 mgd) capacity (21).

b. Air or Gas Flotation

In the air or gas flotation process, suspended wastes are removed from a process stream by attachment to small air bubbles allowing the resultant buoyant mass to rise and separate under quiescent conditions. In some cases chemical flocculation or other chemical aids must be used to promote air attachment. The floating sludge is collected by skimming equipment; a bottom sludge collector is often required to remove grit and other dense solids.

Two basic methods are dispersed air and dissolved air flotation. In dispersed air flotation, bubbles are generated by either mechanical shear of mixers, diffusing air through a porous medium or by introduction of a homogenized air and liquid stream. Dissolved air flotation is accomplished by precipitating air out of the wastewater flow by first supersaturating the water under pressures of 1.8 to 4.2 kg/cm^2 (25-60 psig), and then releasing the pressure in the flotation tank and allowing the air to disperse into fine bubbles. Alternate schemes are to recycle a portion of the effluent, supersaturate it with air under pressure and mix with the pressurized or unpressurized influent just before admission to the flotation tank. Larger or more concentrated flows, including sludges, are usually more effectively treated by recycling.

Another method, more properly called vacuum flotation, is to introduce the wastewater into a closed flotation tank and apply a vacuum to cause the precipitation of air dissolved under atmospheric conditions. The vacuum flotation system is not in general use due to the limit of a one atmosphere pressure drop, the costs of constructing vacuum facilities and the oxygen depletion in the wastewater.

A new technique, actually a variant of electrolysis, uses electrode grids to generate a very uniform finely dispersed mixture of H_2 and O_2 in the water for flotation, however, there are safety problems inherent in the generation of free hydrogen and nitrogen. Pilot plant testing at 75 m_3/hr (0.5 mgd) has shown it effective in treating steel rolling mill wastes (22) (23).

Bubbles generated by dispersed air systems are in the order of 1,000 microns diameter, whereas, bubbles generated by dissolved air systems are only about 80 microns generally allowing more effective flotation of fine particles.

For optimum operation, the wastewater solids concentration and flow rate should remain constant, therefore, a flotation unit should be preceded by equalization facilities.

There are several advantages of air flotation over conventional gravity sedimentation. The flotation sludge has a greater dry solids content, yet has a lower density and is, in itself, amenable to thickening by air flotation or by gravity separation. Also the amount of chemical flocculants required is usually less than those for settling. Disadvantages are that the operating costs for power will generally be higher due to the need for recycle pumps or compressors and, where certain oily waters or detergents are present in the waste stream, frothing may occur which makes the sludge difficult to handle in subsequent steps.

Air or gas dissolved flotation can be applied to treat specific wastewater flows containing suspended solids of low specific gravity including chemical flocs and cold mill wastes. ((This method is being used in a 20 gpm pilot plant for treatment of coke plant wastewater (85).))

EPA estimates (2) of energy requirements in flotation treatment of cold mill wastes from recirculation or direct application emulsion system are as follows:

	Recirculation	Direct Application
Flow (m^3/hr)	12	160
Suspended Solids (mg/l)	200	80
Oil and Grease (mg/l)	600	200
Energy (kw/1,000^{3}m /day)	330	155
Energy (kw/mgd)	1,250	585

c. Filtration

Filtration is the passage of a fluid through a packed bed of granular or fibrous material (media) to remove particulate matter. The process of filtration is the retention of particles larger than the interstices, adsorption on the surface of the media at any depth, the coagulation, agglomeration, or coalescence of solids within the bed or any combination of these phenomena. Replaceable cartridge filters have not been considered due to the impracticality of handling the relatively large flows associated with steel plant water systems.

Generally, wastewater filtration follows treatment for coarser solids removal because the suspended solids loading on a filter should not be so high that it clogs rapidly and requires frequent cleaning (backwashing). The water discharging from a properly designed and operated high rate filter can consistently contain 10 mg/l or less of suspended solids. Water of this quality is suitable for recycle or reuse for direct contact uses.

There are three general types of filters in current use: granular media (GMF), flat bed filter and precoat filters.

Granular media filters may be of the gravity or pressure type; the former are open to the atmosphere and operate under the hydraulic head created by the influent. GMF can also be enclosed in pressure vessels and operate under pressure. Addition of coagulant aids into the filter influent stream can materially increase the efficiency of colloidal and suspended solids removal. A separate flocculation step may precede filtration or the chemically dosed and mixed wastewater may be directly filtered. These filters use granular media such as anthracite coal, sand and gravel, singly or in combination. Current trends are to use mixed media or multi-media which is graded coarse to fine in the direction of the water flow. The specific gravity of the media is selected so that backwashing does not upset the distinct layering of the multi-media in the bed. Multi-media filtration systems have certain inherent advantages (24).

1. Greater solids and flow rate capacity per unit of surface - flow rates of 20-60 m/hr (8-24 gpm/ft^2) are used in filtration of hot mill effluents.

2. Ability to handle a wider range of influent suspended solids concentrations - to 300 mg/l with relatively constant effluent concentrations.

3. Longer filter runs - 8 to 16 hour runs between backwashes are common in hot mill effluent treatment.

GMF are most commonly used in steel plants for treating descaled water from hot rolling mills for recycling. They also are used for polishing various treated and clarified effluents, such as from continuous casters and cold rolling mills. Careful selection of the type of filter used is imperative since a misapplication may prove extremely expensive to correct.

Energy requirements for gravity GMF (influent pumping and backwashing) are about 2.5 kw per 1,000 m^3/day capacity (10 kw/mgd capacity). For high rate pressure filters the energy requirements are higher but the pressure head available after the filters eliminates the need for pumping the effluent for further treatment (cooling) or reuse (24).

Filters are cleaned by backwashing when a specified head loss has been reached or on a predetermined time cycle. Backwashing is the operation of reversing the flow of water through the filter media at a high rate to remove the entrapped solids from the bed. The water that is used to backwash is usually filtered water. If dirty water is used, a short (forward) wash may be required before the filter goes back into the filtering mode. Backwashing is usually supplemented by mechanical, or air agitation to remove solids and other impurities lodged in the filter media by creating a scrubbing action. The amount of backwash water required to effect adequate cleaning may vary from 1 to 10 percent (3 percent average) of the filter throughput. The backwash water must be treated for solids removal, usually by discharging into a settling basin or thickener which then returns clarified overflow to the sedimentation basins or tanks that precede the filter. Although the backwash solids had originally passed through the sedimentation basins without being removed, they readily settle as a part of the backwash because they have been agglomerated in the filtration process.

Granual or media filters are widely used in steel plants. One Canadian Company has a 9,500 m^3/hr (60 mgd) filtration plant (98). Another plant has deep bed, dual media horizontal pressure filters capable of operating at 25 m/hr (10 gpm/ft^2) (99). Still another plant, using polyelectrolyte, treats 10,000 m^3/hr hot strip mill waste in a dual media filter system at 40 m/hr (16 gpm/ft^2) (100).

Flat bed filters use single, very shallow media, such as, paper or a fine screen. The influent may be under pressure or a vacuum applied at the discharge end. Flat beds generally are used for rough filtration of suspended solids and oils following coarse solids settling. They do not remove fine solids and are thus not used for final effluent polishing (1). They are used in steel plants for treatment of contact water from continuous casters or pressure slab molding units. A system to permit the recycling of coolant water in a continuous casting operation incorporates a 320 m^3/hr (1,400 gpm) flat bed filter system (101).

Precoat filters utilize a base or septum upon which is deposited a layer of fine filtering material such as diatomaceous earth (precoat). The fluid to be filtered is then passed through the filter, under vacuum or positive pressure. In some instances there is a constant feed of the filtering material (body feed) or filter aid to the fluid being filtered. When a specified head loss is reached, the filter is taken out of service and backwashed. During the backwash, the entire amount of filtering or precoat material is discarded. The low filtration rates and high costs of these types of filters preclude their use, in most cases, for large flows.

A moving bed filtration process shows potential for certain wastewaters and municipal sewage. Buoyant granular media is added with the influent to an upflow filter column. The media is removed from above the wastewater effluent port and washed for reuse. There are no operational systems at present. The main advantage of moving bed systems is continuous operation without backwash interruptions (25) but power costs would seem higher than for other filter systems.

d. Microstraining

The microstrainer has beem employed since 1950, principally in England. It was developed for potable water treatment as a mechanical "tertiary" treatment for the removal of algal growths before sand filtration. This process has been used to replace sand filters, in some cases, for treatment of industrial process water and wastewater.

In principle, the system consists of a revolving drum or disc with an attached micropore stainless steel mesh screen. The mesh pores range from 60 to 23 um (24-9 x 10^{-4} inches). The upstream side of the drum is open to receive wastewater. As the drum rotates on a horizontal axis, it collects solids on the mesh which are backwashed out of the pores at the top of its rotation cycle. Water for backwashing is taken from the downstream side of the drum and pumped by a row of self-cleaning adjustable jet nozzles through the back of the mesh. The backwash is discharged into a hopper attached to the hollow axle of the drum and is then handled similarly to filter backwash water. Since the backwash slurry is produced at a more uniform rate, intermittent storage requirements may not be as critical as is the case of filter backwash water.

The high cost and short life of the finer meshes precludes the use of this type of solids removal device for many steel mill applications. Energy requirements are low.

e. Magnetic Separation

In recent years there has been increasing interest in the use of magnetic methods to remove both ferromagnetic and weakly magnetic suspended solids from wastewater streams. Various proprietary methods of utilizing magnetics have been developed and they may be classified as three general types: magnetic flocculation, magnetic filtration and magnetic removal.

Magnetic flocculation is a well established method of increasing the size of particles to enhance settling by exposing the wastewater to a magnetic field to cause induced magnetism in the ferromagnetic solids and particle attraction for flocculation. The magnetic exposure is accomplished by passing a waste system through oppositely charged permanent magnets. The exposure of the stream to the magnetic field is very short and the velocity is high enough to scour attracted particles off the permanent magnets. The floc created by magnetic flocculation can trap non-magnetic material and thus provide effective settling of both magnetic and non-magnetic solids. Magnetic flocculation can be utilized in conjunction with chemical flocculation by adding a small amount of a flocculating agent such as a polyelectrolyte and by seeding the stream with a small amount of magnetic material so that the suspension would be amenable to magnetic flocculation.

With magnetically flocculated wastewater, due to the increased size of the particles, higher overflow rates can be used and thus decrease the size of settling facilities. In addition, magnetic flocculators are relatively low in price. This process is being used in steel plants for treatment of gas scrubber effluents from the steelmaking furnaces (26). It is especially useful, in conjunction with chemicals, for wastewaters from high energy scrubbers (102, 103). This method performs most efficiently with wastewaters containing high concentration of iron bearing materials.

Magnetic filtration, often called high gradient magnetic separation (HGMS), is a relatively new development which utilizes a high density electromagnetic field to remove particles as small as 1 um (4×10^{-4} inches) from the wastewater onto a magnetized filter medium. The core of the treatment device is generally a steel filtering media, such as steel wool, contained within the coils of a powerful electromagnet creating high intensity fields of 1,000 to 20,000 gauss (G). This intense field creates strong induced magnetic properties even in small, weakly magnetic particles which then adhere to the surface of the medium. Nonmagnetic solids can also be removed by filtration or physicochemical association with trapped magnetic floc. After the filtration cycle has reached a predetermined point (either time or pressure drop) the power is shut off and the magnetic field is reduced to zero. Water is flushed through the filter to wash off the entrapped solids. The solids, due to their induced magnetism, are flocculated and readily settle in a thickener for subsequent dewatering. The steel media are susceptible to corrosion and when oils are present difficulty may be experienced in thoroughly cleaning the media. No full-sized installation are presently in operation. However, high gradient magnetic separation has been tested on a bench scale in the United States (104) and Sweden (105).

HGMS has advantages especially with very fine iron oxide particles of low concentration and high flow rates (27). High installation cost and power consumption are definite disadvantages. An estimate of energy requirements for removal of erromagnetic material using a 10kG field is 50kW for 55 m^3/hr (0.35 mgd) capacity (17).

Magnetic separation utilizes a moving permanent magnet which is partially immersed in the waste stream to attract ferromagnetic particles from the waste stream. The magnet is often a rotating disc and as it emerges from the stream, the adhering particles are scraped off and removed to disposal. Magnetic fields are usually less than 1,000 G. Non-magnetic particles may be separated by use of flocculant, if necessary in combination with a magnetic seed. Units have been successfully tested in large flows from steel rolling mills (26). Rotating magnetic discs are in use at a hot rolling mill in Sweden (106, 107). Wear and anticipated high costs are disadvantages.

3.5.2.2 Oil Removal

Oily waste discharges from steel mills are a major treatment problem and can be classified into four categories:

1. Free oils, which usually are a mixture of gear oil, bearing oil, hydraulic leakage, some coating oil, and demulsified rolling oil.

2. Oil coated on solids, which consist of small particles of metal or oxide coated with an oil film.

3. Insoluble oil wastes, which consist primarily of various oils in the effluent from skimming tanks of rolling mills, plus small quantities of oily wastewater from dirty-water sumps. They may occur as free floating or settled oils or as unstable emulsions which are relatively easily broken.

4. Soluble oily wastes or stable emulsions are discharged from the tanks and sumps of the roll shops, electrostatic precipitators, chemical cleaning lines, oil skimming tanks underflow and rolling solution or oil coolant tanks of cold rolling mills.

These emulsions show no tendency to separate without treatment. Two basic types of chemical emulsifiers are used either separately or in conjunction with each other. These are anionic types which create emulsions that usually require special emulsion breaking techniques.

In general, the treatment of oily wastes is a specific problem for each manufacturing area or mill, and may be subject to change with variations in oil formulations, the state of repairs of the equipment, and the type of product produced. The removal of oil from wastewater can be effected by the following techniques used separately or in combination with each other, depending on the nature of the waste stream.

a. Gravity Separation

With the exception of filter techniques, all gravity oil removal processes are based on density separation. This process is applicable for the removal of both floatable (free oil and greases, fine oil coated solids) and non floatable substances. The choice of a particular type of separator could range from the simple API separator, in which floatable substances are removed, to the more complex dual function scale pits and clarifiers (with or without chemical treatment) in which both the floatable and heavier-than-water phases are removed.

Emulsions may be broken, physically, thermally or chemically to permit gravity separation. Physical emulsion breaking is more applicable to mechanically created emulsions such as might be created by high shear pumping of oily water. Chemical and thermal emulsion breaking are more applicable to chemically created emulsions.

The physical breaking of an emulsion is similar to filtration in that the water stream containing the emulsified oil is passed through a fine media (fiberglass, steel wool, synthetics) that permits water to pass but retain the very small (less than 10 um) oil globules. As the oil globules collect on the surface of the media they coalesce and when large enough they separate and float to the surface. In some coalescers the trapped oil is removed by flushing with a solvent or steam and the media must be periodically replaced (29 and 30).

Chemical breaking of emulsions is accomplished by the acidification of the wastewater to at least pH 2 and/or by addition of iron or aluminum salts to inactivate the emulsifying agent. The salts also increase the density of the water relative to the oil phase. The required dosages must be determined by testing the individual streams. Emulsions are broken thermally by heating in a tank to about 60^{o} C (140^{o} F). The tank may be heated or steam may be injected into the oily wastes. Heating is often combined with chemical methods.

After the oil and water are deemulsified, the floating oil may be removed by conventional physical means such as by skimming, and pumped to storage for eventual in-plant disposal in an incinerator, for use as a fuel or trucked away for reclamation or disposal.

Oil skimming of broken emulsions or simple gravity oil separation is accomplished mechanically in large installations or by manually in small installations. Devices for continuous oil skimming are:

i. Slotted pipes are devices with a lengthwise slot, installed partially submerged and parallel to the water surface of a gravity separation tank. As the pipe is rotated around its horizontal axis, the top layer of oil flows into the slot and drains into a collection tank. This device is for gross removal and the collected oil, mixed with water, usually requires further gravity separation. This separation may be in a holding tank with vertically oriented ports for drawing off the floating oil and removing the aqueous phase from the bottom.

ii. Belt, drum, or hose skimmers operate by continuously passing an oil layer for selective oil removal. The conveying material passes through a set of squeegees at the other end of the treatment loop and the removed oil flows into a collection container. At U.S. Steel's Loraine, Ohio plant (108), oil is recovered from lagoons by this method. Proper physical placement can markedly enhance the operation of these devices.

iii. Clarification skimming uses a skimming blade moving on the water surface to push floating oil into a container installed at water level. For clarifiers, the skimmer reaches from the tank center to the perimeter, rotating from the center axis. For settling basins, the skimmer reaches across the basin and moves down the length of the basin. This type of device is also for gross removal and the skimmings usually require further separation.

Free floating, non-emulsified oils from some steel plant facilities may be grossly removed by inertial separation in hydrocyclones. The wastewater is introduced tangentially into the circular tank and the oils will tend to swirl out the topmost discharge point with solids settling to the bottom (32).

b. Air Flotation

Removal of oil by air flotation is the same as described for suspended solids in Section 3.5.2.2.1b. Air flotation may be used with or without chemical aids but testing is required to determine whether chemical addition is required, and at what dosages.

c. Granular Media Filtration (GMF)

In general, granular media filtration, employing little or no chemical pretreatment, is applicable for the removal of all forms of oil and oil coated suspended solids from wastewater. While the removal efficiency will vary with the nature of the waste, variation of influent concentrations, within limits, will have little effect. The filter flux rates and operation between backwashes are as discussed in Section 3.5.2.1.c. Because of their limited waste holding capacity, filters should always be preceded by a gross solids and oil removal stage, such as primary and secondary scale pits, API separators and clarifiers, in which chemical treatment may or may not have been utilized.

Conventional granular media filters are sometimes subject to oil fouling of the filter media if proper backwashing techniques are not used and may have to be routinely cleaned with steam or hot water at the termination of the backwash cycle. New filters have been designed using a radial configuration (non-uniform gradient), synthetic (plastic) media, and an external regeneration or cleaning cycle. These units require approximately one-fourth the filter depth of conventional granular media filters, and have been shown to be effective in oil removal treatment.

Electrochemical coalescence of dilute oil emulsions has been proven effective in tests with porous media consisting of bimetallic or carbon-metal couples (32). The granules of carbon and an active metal such as aluminum or iron are intimately mixed in the treatment bed. As the emulsion enters the beds oil microdroplets, being negatively charged, are electro-deposited for coalescence on metal anodic surfaces. The aluminum or iron ions thus liberated are neutralized by hydroxyl ions liberated at the destabilization of the oil emulsion by promoting flocculation and filtration of the oil, metal and other solid material. In a test series, bed lives ranged from 8 to 20 hours at emulsion flux rates of 7 - 22 $m^3/hr/m^2$. The beds are not easily regenerated but large units are expected to operate up to several weeks between regenerations. Bed depths and porosity must be adjusted to provide optimal residence times.

Electrolytic processes have been patented for removal of oils along with heavy metals and organic matter at acid pH conditions (34).

d. Ultrafiltration

Systems are now in operation using ultrafiltration to reclaim floating and emulsified oils from rolling mill wastewaters (34) (35). It also is being used in such industries as chemicals and pharaceuticals, food processing and electronics (108, 110). The ultrafiltration process is described in Section 3.5.2.2.3 (g) along with the related reverse osmosis process for removal and concentration of dissolved solids. For oil reclamation, pretreatment is necessary to skim most floating oil and settle most suspended solids before passing the water through tubular ultrafiltration membranes. The treated (permeate) water may need further treatment before reuse to remove soluble organics. The oily filter concentrate can receive further treatment by acid-thermal cracking and the separated water and solids returned for treatment. Ultrafiltration is more flexible than most physical-chemical processes in treating variable oil wastewaters. Costs are relatively high. Capital costs for an Ultrafiltration system may be about \$1/liter/d (\$4/gpd) and operating costs may approach 0.26¢/l (1¢/gal) (17). However, these high costs can possibly be offset by the reuse of salvalged materials.

3.5.2.3 Inorganic Dissolved Solids Removal

A variety of chemical and physical processes are employed in individual process waste streams for the selective removal of dissolved inorganic species for recovery or to facilitate water treatment and reuse. Wastewaters from the coke plant, plating and pickling lines contain the greatest amounts of dissolved species that are selectively removed by combinations of the processes described below. Other processes described are non-selective in partial or complete removal of total dissolved solids from recycled water including non-contact cooling water.

a. Chemical Precipitation

There are several general methods used for selective removal of dissolved solids as insoluble precipitates easily separated from the water by sedimentation, filtration or flotation. Addition of chemicals may cause precipitation by; 1) direct combination with the dissolved species, 2) pH adjustment to the degree necessary to form precipitates or 3) oxidizing or reducing the dissolved species to an insoluble form. Electrolysis is a common method to precipitate metals by oxidation-reduction. Oxidation is promoted by high heat and/or pressure in the presence of air as in the processes for removal of iron oxides to regenerate hydrochloric acid pickling baths by spray roasting and other processes (36, 37, 38). Aeration is another method to induce oxidation of wastewater components (39). Ultrasonic wave treatment has been successfully tested to promote precipitation of metals in contaminated baths (40).

Crystallization is a useful method for selective removal when the dissolved species is in high concentration and may be caused to form crystals by further concentration or by changes in temperature or pressure. Methods to regenerate sulfuric acid pickling baths use vacuum or evaporative crystallization to remove the ferrous sulfate contaminant (41).

b. Neutralization

Neutralization is a basic treatment practice in which the pH of an acidic or caustic wastewater is adjusted to approximately 7, or any other desired value, in the range pH 6-9. As previously discussed, it is used to reduce the solubility of dissolved contaminants contained in caustic or, especially, acidic wastewaters so they can be removed by stripping, precipitation or other means. Wastewaters are generally neutralized before discharge. In steel plants, acidic wastewaters requiring extensive neutralization before discharge are pickling baths and rinses, metal finishing and plating wastewaters. Basic wastes include those from the by-product coke plant and some cleaning and plating operations. Lime or caustic soda is generally used for acid neutralization and sulfuric acid for alkaline neutralization and sulfuric acid for alkaline neutralization. Also, acidic and alkaline wastewaters may be combined for gross neutralization which is a form of wastewater equalization.

c. Equalization

A general unit operation in wastewater treatment is to collect one or more waste streams in a tank or basin sized for several hours or days detention. Equalization is often used to allow uniform treatment of intermittent or varying wastewater flows; the discharge from the equalization basin is controlled according to the demands of the treatment process. Use of equalization for direct wastewater treatment is an important method for removal of inorganic dissolved solids. Equalization of acidic and alkaline wastes, such as plating baths, pickle liquors and other metal finishing baths and rinses can allow neutralization and precipitation of inorganic solids, including metals for recovery (43). Cold rolling wastes are commonly equalized with pickling wastes for emulsion breaking and neutralization (2).

d. Gas Stripping

Dissolved gases may be separated or stripped from wastewaters within packed towers by mass transfer methods. An upward flowing carrier gas is passed through the down flowing water to strip the gases. A variant useful for high gas concentrations is stream stripping which is essentially a fractional distillation because of the high termperatures vaporizing many (organic) solutes. Species such as $NH_3$and H_2S in coke plant wastewater are dissolved in ionic and free forms and must be stripped after changes in pH, temperature and/or pressure to reduce gas solubility. Such mass transfer processes between a liquid and a liquid solution is better labelled a solvent extraction.

Energy requirements for air stripping of ammonia from treated sewage is reported to be 19 kw per 1,000 m^3/hr capacity (28 kw per mgd) (21).

e. Solvent Extraction

Certain inorganic species can be reacted, usually by formation of a complex, to become more soluble in solvents other than water and thus allow extraction. Frequently, the complexing chemical together with the solvent, which is immiscible in water, is mixed with the wastewater in a countercurrent flow within a vertical column. The dissolved inorganic species is complexed and passes from the water to the extracting solvent. A process has successfully been used for recovering nitric and hydrofluoric acid from spent pickling baths (43). The complexing agent, tributyl phosphate, is dissolved in kerosene to extract the acids while flowing upward through the extraction column. The acids are removed from the extractants by distillation and a secondary extraction. A similar process uses high molecular weight quaternary amines, dissolved in a carrier solvent, to complex and extract cyanide and metal cyanides from plating waste streams (44). Many new extractants are being developed to recover metals (45). Such processes are also called liquid ion exchange processes since they are similar to countercurrent ion exchange discussed below.

Energy costs for the extraction process are low, similar to ion exchange, since the driving force for the process is chemical and chemical costs are considerably below (about one half) the costs of ion exchange for the same treatment (17). Energy costs increase considerably with systems for recovery of the solvent and inorganic species.

Flotation processes for inorganic species extraction are still in the development stage. One process uses ferric ions to complex cyanide followed by flocculation with an organic surfactant (46). A similar process, has been successfully tested to remove small concentrations of chromium ions which attach to bubbles in the aerated wastewater. The concentrated floc is removed at the water surface (47, 48).

f. Ion Exchange

Ion exchange is the process of displacing one ion by another and can be used for selective ion removal or general demineralization of water. The source of the exchange ion is a solid exchange medium that readily exchanges certain ions in its structure with ions in the water. With certain types of exchange media, control of conditions in the water such as pH, will determine which type of ions will be removed from solution to attach to the solid medium.

The exchange medium may be a natural or synthetic zeolite, a carbonaceous exchanger or a synthetic resin. Three types of exchangers are in general use; cation exchangers which replace cations or positively charged ions, anion exchangers which replace anions or negatively charged ions and mixed bed exchangers which contain layers of cation and anion resins and are used for polishing or removing residual cations and anions. The operation of fixed bed ion exchangers is much the same as a filter, i.e., the liquid being treated is passed through a porous bed in which the exchange takes place. Since ion exchange is a surface phenomenon, the stream being treated must be essentially free of suspended matter that might coat the surface of the medium and render it ineffective.

Besides demineralization, for removal of dissolved solids, ion exchange processes are important in selective removal of contaminant cations or anions of individual process wastewaters. Metal cations from pickling and plating wastewaters may be removed for reuse of the baths and rinses and for recovery of the metal after regeneration of the exchange medium (49). Cooling tower blowdowns are treated for recovery of chromium and zinc ions (50). Ion exchange resins are being used to scavenge the contaminant cations in order to regenerate sodium dichromate solutions at one steel plant (111). It also finds extensive use in recovery of expensive materials, such as silver (112) and in treatment of mine wastes (113). Techniques have been developed for the selective removal of cyanide from wastewaters (51).

When the exchange medium is exhausted (it no longer contains ions to exchange) it is taken out of service and regenerated. Cation and hydrogen zeolite exchangers are regenerated by washing with an acid to replace the surface cations with hydrogen ions. Anion exchangers are regenerated with a caustic solution whereby the anions on the surface are replaced by hydroxide ions. Sodium zeolite exchangers are regenerated with brine as sodium replaces the cations to renew the sodium zeolite. In the regeneration process, wastewater of a smaller volume than the initial treated wastewater is generated which requires treatment. No sludge is produced directly during regeneration, however, further treatment processes may produce sludge.

The costs of regeneration are most significant in the ion exchange process. New resins are being developed to allow regeneration by weak electrolytes, including brackish water and even heated water (52). The most important advanced technique is continuous countercurrent regeneration (49) (53). Such systems create the lowest regeneration wastewater down to 1% of the original untreated volume. Since all portions of the exchange medium are used continuously for ion exchange, there is a much greater wastewater feed rate per volume of exchange resin. Continuous countercurrent systems are much more complicated and capital costs are higher than fixed bed systems.

Energy requirements are low for all types of ion exchange systems since only pumping is required and all other processes are chemical. Power costs are only 2-5 percent of total operating costs while regeneration chemical costs are about 50 percent of the operating costs (17).

g. Reverse Osmosis

Reverse osmosis is the application of a solution under pressure to one side of a semipermeable membrane whereby the natural osmotic pressure is overcome and there is a flow of water through the membrane from the concentrated solution to a dilute or pure water side. Various membranes and configurations of membranes have been in use since cellulose acetate was discovered to be applicable as a reverse osmosis membrane in the early 1950's. Although reverse osmosis has been primarily used to purify water for potable purposes and from production of ultra pure water, it has been shown to be applicable in many instances for the treatment of wastewater from metal finishing operations (54).

Reverse osmosis produces both high quality water suitable for reuse and a lower volume concentrated waste stream that may be reused or further treated in smaller subsequent treatment facilities. Pretreatment of the waste stream is necessary to prevent blinding of the membrane by suspended solids and the concentration of precipitable ions, especially Ca,Mg,Fe and Mn, should be monitored so that the solubility limit is not exceeded.

Reverse osmosis processes operate at feed side membrane pressures of 2,070 - 10,350 kPa (300-1,500 psi). Ultrafiltration is a similar membrane process operating at 70 - 690 kPa (10-100 psi) pressure range. Ultrafiltration can separate only larger molecules and colloids (2-10,000 nanometers) and the separation is based primarily on solute size. In reverse osmosis, separation of the smaller molecules (0.04-600 nanometers) is based on chemical and electrical forces as well as solute size (55).

The primary use of reverse osmosis today is in desalination of water for municipal and commercial use (114). The process is being used in wastewater treatment, primarily in the electroplating industry (115). It is seeing limited use in other industries (116).

Treatment units presently are generally quite small, less than 160 m^3/hr (1 mgd capacity). For reverse osmosis, energy requirements are estimated at about 250 kw for 160 m^3/hr (1 mgd) capacity and about 4 kw for 7 m^3/hr (10,000 gpd) capacity (17) (21).

h. Electrodialysis

Electrodialysis is the demineralizing of a waste stream by the use of a direct current to cause ions to migrate towards an oppositely charged electrode. An electrodialysis unit is composed of a series of cells separated by alternative membranes that permit the passage of either cations or anions. Alternate cells created by the membranes contain either fresh water or a concentrate. Electrodialysis units can be operated on either a batch or a continuous basis but in either system, as with reverse osmosis, the water being treated must be free of suspended matter to prevent blinding of the dividing membranes and care must be taken not to permit precipitation of solids that also might cause blinding. The continuous process may be operated with cells in parallel or in series. If the cells are in parallel the system can take proportionate increase in flow.

Electrodialysis has good potential in the removal and concentration of ionic contaminants. It is generally effective at a greater ionic concentration range than ion exchange or reverse osmosis processes. Testing has indicated some potential in treating metal finishing wastes and rinses (57) but more promise is in its use for treating cooling tower blowdown (57). Electrodialysis has been successfully tested in the laboratory for regeneration of spent sulfuric acid pickle liquor (118). Laboratory and pilot plant tests have been successful in a number of other industries (117). Energy consumption is significant; a rule of thumb is about 5 kw hr for each 1000 mg/l reduction of salt in each 3.78 m^3 (1,000 gal) of product water (17) excluding pumping.

i. Evaporation

Evaporation is the oldest method of separating dissolved solids and water. It is accomplished by vaporizing the water to be treated and then capturing and condensing the vapor in a separate container. Ideally, the water after returning to the liquid state will be free of dissolved solids and the residual solids will be dry. However, in practical use the liquid is not absolutely pure and the product residue is a concentrated liquid stream.

There are three general types of evaporators in use today; the multiple effect, the multistage flash and vapor compression. Each type is designed for maximum conservation of energy. The design of the heat transfer surfaces are the most important factor in efficient evaporators.

In the multiple effect evaporator the waste to be treated is heated in the initial effect or stage by an external source of steam to vaporize part of the wastewater. The steam is recovered and the vaporized water is used to heat the remaining wastewater in the next effect at a lower pressure; the vapor is the condensed. The wastewater that is not vaporized is transferred to the third effect for the same procedure and to as many effects as are required. After the last effect, the vapor is passed through a condenser and the concentrated waste is discharged. In each effect vaporization occurs at a lower temperature. There is a steam economy, to a limit, with increasing numbers of effects. Large evaporators of 6 to 10 effects are common, especially in the pulp and paper industry. Designs for seawater desalination consider 20 effects (17).

In multistage flash evaporation the wastewater is heated by an external source of steam in a heat exchanger and passed to a vessel that is kept at a pressure lower than atmospheric. A portion of the waste vaporizes and the balance of the water is passed to a vessel at a lower pressure where additional wastes vaporize. The vaporized water is used to preheat the raw waste before it enters the heat exchanger. This heat recovery or preheating serves to condense the vapor and permit it to flow out as demineralized water.

Vapor compression evaporation is the simplest but least energy conserving process and utilizes mechanical energy rather than steam to cause water to evaporate from the waste stream in a single effect. The waste is preheated by hot product water and enters the single vaporizing chamber. The vapor is drawn off and compressed thus raising its temperature to about 6°to 12°C (11 to 22°F) above that of the heated waste. The compressed vapor is then used to further heat the waste in the vaporizing chamber before it is discharged as product water through a heat exchanger where the raw waste is preheated.

Evaporation is also used in specific process flows to concentrate wastewaters for effective treatment and to recover purified solids and condensed vapors for recycling. The latter use is important in processes for regeneration of waste pickle liquors and metal plating baths (81).

Evaporation is a high energy consumer, mostly for generation of external steam for the initial heating. Annual steam costs are generally several times the initial capital investment for the evaporator unit and requirements range from 2×10^5 to 3×10^6 J (200-2,500 Btu) per kg of liquid evaporated, the lower range for multiple effect units (17).

j. Freezing

Freezing is another method of separating inorganic dissolved solids from water. In this operation the water containing dissolved solids is partially frozen and the ice crystals are separated from solution with solid-liquid separation equipment. These ice crystals are washed clean of impurities and melted, resulting in pure water. A concentrated solution remains for further treatment.

Three methods of freezing have been used successfully. In indirect contact freezing the transfer of heat takes place indirectly through a metal wall. The treated water is cooled until a slurry or mixture of ice crystals is formed. This slurry is then processed in a continuous centrifuge where ice crystals are separated from the slurry after which they are washed and sent to the melter tank. The heat for melting can be obtained by pre-cooling the incoming feed stream, thereby reducing the load on the refrigeration unit.

In the direct cooling process, the water comes directly in contact with a refrigerant, such as butane. After the feed water crystallizes in a direct contact unit, the slurry proceeds to a wash column where the ice crystals, due to their buoyancy, float and are skimmed off the surface. These ice crystals are then washed and melted by the compressed refrigerant to produce demineralized water.

In the hydrate process a solid hydrate (complexion) is formed between the water to be treated and a secondary refrigerant such as carbon dioxide or propane. After a slurry of hydrate crystals has been formed in the hydrate reactor, the slurry goes to a wash column, after which the crystals are melted. It should be noted that the hydrate crystals are mushy and therefore are difficult to separate from the mother solution.

Water purification by the freeze process has been successfully tested for waste streams ranging from 30 ppm to 100,000 ppm total dissolved solids. Pilot plant tests have investigated removal of heavy metals from plating rinses and treating cooling tower blowdown (59) (60).

Energy requirements for the freeze processes are estimated at 20 kwh/m^3 product water (17). This is generally less than evaporation requirements. Also freezing has advantage in avoidance of corrosion problems in heat transfer surfaces and needs little or no waste pretreatment. The capital cost of these systems is significantly higher than other methods.

k. Drying

All the above processes discharge the separated solids in a more or less concentrated wastewater stream. For the complete separation of the initial dissolved solids from the residual water, the waste must be completely evaporated to dryness.

There are two methods used in industry for complete solids-water separation, spray drying and freeze drying. In spray drying the concentrated stream is sprayed into a stream of hot gas in a tower which vaporizes the water and leaves the solids to drop to the bottom hopper. The spray can be counter to or concurrent with the stream flow of the hot gas. The vapor can be collected and condensed for reuse or allowed to pass into the atmosphere. The solids are collected for disposal or reclamation. This basic process is used in the spray roasting regeneration of spent hydrochloric pickling baths by recovering HCl from the vapor and iron oxide in the solids (61). Energy consumption is high but the process allows continuous recovery of pickling acids and iron and has been accepted by the steel industry. In freeze drying a thin film of liquid is frozen on a moving bed which passes into a vacuum chamber. The vacuum permits the water to evaporate from the frozen sheet and, at the end of the chamber, the residual on the tray is the dry solids. This method allows chemically reactive substances to be recovered in their original form by avoiding the high temperatures and oxidative (or reduction) conditions which occur in spray drying. Energy consumption is high and, in its present development, freeze drying is slow and batchwise; thus its use is confined to laboratories and commercial freeze drying of foods.

3.5.2.4 Organic Dissolved Solids Removal

Compounds that are found in some steel plant wastes, particularly in wastes emanating from coke and by-products plants and from blast furnace areas, contain dissolved organic compounds and other solids oxidizable by either chemical or biological means or a combination of both methods. These wastes contain, typically, phenols and inorganics, such as; cyanides, sulfides and ammonia.

a. Biological Treatment

Biological oxidation utilizes the metabolic processes of micro-organisms to oxidize these compounds and incorporate them into settleable solids or biological sludge. Biological treatment is commonly called secondary treatment when applied to mixed sewage.

However, not all biological organisms can utilize all organic compounds as they are applied. A period of acclimatization is required to generate biological species that can metabolize each of the specific compounds applied as a substrate. There must be a certain amount of basic nutrient substances, besides hydrocarbons, in the waste. Nitrogen (as in ammonia) and phosphorus are always required for biological action.

The organic compounds are oxidized first for the satisfaction of the first stage or carbonaceous biochemical oxygen demand (BOD) and then nitrogen compounds are oxidized in the second or nitrogenous stage for satisfaction of ultimate BOD. Denitrification may be required as an additional stage to convert nitrites and nitrates by anaerobic biological metabolism to nitrogen gas.

Typically, aerobic biological oxidation is used in one of several variations, described in the following sections. The biological systems must be protected, to some degree, against overloading and shock or toxic loads. Equalization basins or, for coke plant wastes especially, dilution of wastewaters is often necessary before effective biological oxidation.

1) Oxidation Ponds

Oxidation ponds, also referred to as lagoons or stabilization ponds, are designed to treat biologically oxidizable wastes by micro-organisms interacting with the natural forces of sunlight, algae and wind. In some instances, where there are toxic constituents present in a waste stream, pretreatment is necessary to prevent their entering the system and killing the active organisms.

Typically, the waste to be treated is introduced at one point into the ponds, which are deep enough to prevent weed growth but shallow enough to allow complete mixing by wind. The ponds are aerobic throughout the entire depth and anaerobic in the bottom sludge layer. They usually provide several days retention time to allow sufficient tratment. Mechanical aeration equipment is often provided to speed treatment, reduce the area required and to eliminate the complete dependence upon algae and wind mixing for free oxygen. Some ponds have a portion of the effluent recirculated to improve mixing.

Oxidation ponds are sometimes designed with several cells operating in parallel to permit better distribution of the waste, avoid localized zones of high oxygen demand caused by uneven deposits of sludge, and reduce problems that can be encountered by wave action in large single ponds. Ponds are sometimes placed in series to permit the first treatment pond to treat strong wastes, to improve satisfaction of BOD by separate stages and to permit the last pond to act as a final settling unit and thereby reduce the high suspended solids loads in the effluents that occur because of algae discharges.

Oxidation ponds are simple to construct, operate and maintain. They are low in construction costs and in some cases have no mechanical equipment to maintain. However, because of the relatively large space requirements for conventional ponds they are not often suitable for large industrial waste volumes. They have not been shown to be effective in the oxidation of ammonia.

2) Activated Sludge

The activated sludge process is the aerobic oxidation of organic compounds by a concentrated mass of micro-organisms. In this process air is constantly added by mechanical agitation or diffusers to maintain a residual concentration of dissolved oxygen and thus keep the system aerobic and well mixed. Additional suspended solids are created by the reproduction of the micro-organisms which are kept in a state of rapid growth.

After a controlled aeration period, the solids are removed in a settling tank and the clarified wastewater is discharged. Most of the settled solids are returned to the aeration unit to maintain the required mass of oxidizing organisms and the balance of the settled solids may be discharged to a digestor where the organic matter is broken down into simple stable compounds. Digestion can be accomplished under either aerobic or anerobic conditions, and the digested sludge can be incinerated or landfilled. Variations of the basic activated sludge process are used to attempt to improve treatment efficiency of specific wastes. The most commonly used variations are conventional, tapered aeration, contact stabilization, complete mix and extended aeration. The extended aeration variation is basically the same as oxidation pond treatment and does not produce sludge to be disposed of due to the autolysis and disintegration of the micro-organisms. The specific system to be used is dependent upon the characteristics wastes to be treated, the flexibility desired within the system, and the area available for installation of the system.

Energy requirements for a typical activated sludge plant, excluding digestion, are mainly for aeration, and are estimated at 26 kw for 160 m^3/hr (1 mgd) and 2,375 kw for 16,000 m^3/hr (100 mgd) capacity. Addition of a nitrification system is estimated to require another 26 kw per 160 m^3/hr and just 0.5 kw per 160 m^3/hr for dentrification (21). Although single stage bioxidation is relatively routine, multiple stage treatment has not been successfully demonstrated in the iron and steel industry.

3) Trickling Filters

A trickling filter is not a filter per se but a process where biological growths are built up on a bed of solid media and the nutrient containing wastes come into contact with the growths by trickling down the bed after an even distribution over the surface. Excess growths slough off and are settled in a succeeding settling facility. The settled solids exert an oxygen demand and must be digested.

In a high rate trickling filter a portion of the treated wastes are recirculated to maintain a required hydraulic loading and prevent clogging of the filter by the biological growth.

Trickling filters can withstand shock loads and overloads without breaking down and require a minimum of operator attention. However, removal rates for soluble industrial wastes are generally low and it is more suitable for biological pretreatment.

Energy requirements for a typical high rate unit are 9 kw for 160 m^3/hr (1 mgd) and 675 kw for 16,000 m^3/hr (100 mgd) capacity or less than one third of the requirements for the activated sludge process (21).

4) Rotary Biological Contactors

A recent development is the rotating biological contactor (RBC). This method of treatment is similar to the trickling filter in that the biota are allowed to grow on a medium that is exposed to a waste stream. However, in the RBC the medium with the attached growth moves through the wastes rather than the waste passing through the medium. The medium is a series of discs or porous cylinders attached to a shaft that rotates slowly and immerses approximately 40 percent of the medium area into the waste which continuously moves along the disc rows or through the cylinders. The turbulence caused by the rotation keeps the sloughed floc in suspension so that it is carried out and settled in a subsequent settling facility. The RBC surface area is often increased by corrugations or dimples on the discs or fillings the cylinders with various types of loosely spaced media.

The system is based on the hydraulic loading per unit media surface area and the treatment is staged so that carbonaceous BOD is removed closest to the influent and the nitrification and denitrification is accomplished at the latter stages.

Advantages of the RBC system are, similar to the trickling filter, low maintenance, lower power requirements and process stability, but it also shows potential for higher BOD removal rates.

5) Fluidized Bed

Another recent development is fluidized bed biological treatment. In this system sand or activated carbon is used as the medium for biological growth attachment within a reactor column. A large surface area is provided for bacterial growth which results in a high rate of reaction. The waste is introduced at the bottom of the column at a rate that will allow the upward flow to keep the medium with attached biological solids in suspension, thus allowing for maximum exposure of the biomass to the waste, and also alleviate the need for backwashing since the sloughed growths are flushed out the column top. This type of biological waste treatment has been successfully pilot tested to aerobically remove the carbonaceous and nitrogenous oxygen demand and in anaerobic wastewater denitrification (63) (119). If insufficient carbon compounds are present for denitrification, additional easily biodegradable organic carbon compounds such as methanol must be added.

This method of biological waste treatment is reported (63) to provide complete treatment in a fraction of the time required by other suspended growth systems and thus require a fraction of the area.

6) Anaerobic Filter

This biological treatment system uitlizes an upflow reactor column with a fixed bed of rock or synthetic medium. The anaerobic process has been successfully pilot tested on high temperature and high strength industrial wastes with little sludge production. It shows a capacity for shock loads and thus may be suitable as a pretreatment process ahead of another biological or chemical process (64). Other testing has demonstrated the feasibility of denitrification of wastewater in anerobic filters using autotropic bacteria which requires only additions of inorganic carbon and sulfide in the wastewater feed (65). Anaerobic filters also have been tested in combination with extra-cellular enzymes (120).

3.5.2.5 Chemical Oxidation

a) Ozonation

Ozone, although primarily considered a disinfectant, has been used to oxidize organic material and other compounds amenable to oxidation with varying degrees of success. It has been used to oxidize phenols, sulfides and cyanides but has not been demonstrated to oxidize ammonia efficiently (65) (121).

Ozone is produced by passing air or oxygen through a narrow gap separating high and low tension electrodes where a portion of the oxygen (O_2) is dissociated and forms ozone (O_3). The instability of ozone (a half life of approximately 30 minutes) necessitates onsite production so that it can be produced as it is required. Ozone has a low solubility in water and must therefore be utilized in specially designed contact chambers to maximize the reaction of the ozone with the compounds to be oxidized (66). These chambers may operate in various configurations such as bubbling ozone through porous diffusers, injecting ozone into a venturi throat or using a packed column with countercurrent flow of the ozone and water.

The main advantages of ozonation are its broad applicability, it is a continuous process and there is no residue added to the wastewater. It is reported to be a competitive process for polishing treated effluents such as from the coke plant. However, it has not been shown effective in nitrifying ammonia.

Ozonation is an energy intensive process, generally requiring 12-25 kwh per kg O_3 generation. For a system oxidizing 130 m^3/hr (0.8 mgd) wastewater with 0.38 mg/l phenol, total energy requirement was estimated at 160 kw (17).

b. Chlorination

When added in excess, chlorine may destroy, by oxidation, sulfide, cyanide, phenolic and ammonia compounds. The chlorine is supplied either as elemental gas, as a hypochlorite solution or as chlorine dioxide gas. Generally, the chemical reactions take place fairly rapidly in a turbulent alkaline atmosphere, however, careful pH control is important to optimize oxidation of specific contaminants (85). Alkaline chlorination is the most common method of cyanide destruction by either chlorine gas or hypochlorite (122 (123).

Very high dosages of chlorine must be used so that the breakpoint of ammonia chlorination is passed. A disadvantage to oxidation using chlorine is that there is a generation of chlorides which produces a residual in the treated wastewater stream with an increase in residual as more chlorine is added to reduce the phenol concentration. Methods are available to remove this residual chlorine but at additional cost.

Energy requirements are low for chlorination, required only for pumping the waste and oxidant and for mixing.

c. Activated Carbon Adsorption

Adsorption of organic compounds on the surface of carbon which has been activated (i.e., treated by steam or air to remove hydrocarbons and greatly increase the surface area and pore sizes) has been shown to be successful at steel plants as a final polishing treatment removing up 99 percent of organics present in pretreated coke plant wastes.

In the adsorption process, dissolved organics adhere to the surface of the carbon granules as wastewater passes through the carbon bed. The effluent, relieved of organic wastes frequently can be reclaimed or reused.

After the carbon can no longer adsorb the organics from the waste stream, it must be regenerated or reactivated, before reuse.

In general, carbon adsorption can operate in one of two modes: Fixed bed or moving beds. In the fixed bed method of operation the waste is passed through the stationary bed and the carbon must be removed from the bed for regeneration. In the moving bed, there is a continuous removal and replenishment of carbon and there are no inoperative periods.

When the fixed bed mode is used the carbon column will function as a filter and the carbon bed is subject to blinding due to the deposition of suspended matter. Therefore, the wastewater should be treated for suspended solids removal prior to application on the carbon bed. When the moving bed mode is used, the carbon bed is fluidized and suspended matter will freely pass through and no pretreatment for suspended solids removal is generally necessary.

Carbon is reactivated by several methods. Thermal regeneration in a furnace or kiln is most common. The adsorbent materials undergo pyrolysis and oxidation in a controlled atmosphere to minimize carbon oxidation and loss. If a thermal reactivation system were to be included as part of a carbon adsorption installation, air pollution control facilities might be required to prevent or minimize discharges of residual organics and particulate material.

Other carbon reactivation systems do not require the transfer of carbon and do not destroy the adsorbed material. These regeneration techniques include using a pH change to elute certain adsorbed chemicals including phenols. Steam is often used to nondestructively reactivate carbon, either alone or preceded by application of a solvent to desorb the material from the carbon. These in-place, non destructive reactivation techniques can be further modified to allow recycling of the regenerant solvent and/or to recover the adsorbed material (55).

Besides coke plant wastes, carbon adsorption polishing is applied to blowdowns, especially from blast furnace wastewater recycling. Testing for removal of cyanide and chromium from electroplating wastes has shown potential (67) (68).

Energy requirements for an activated carbon system treated sewage plant effluent are about 15 kw per 160 m^3/hr (mgd) capacity with another 0.75 kw for regeneration (21). These costs represent about 11% of total operating cost for the carbon system. Other system estimates are for 10-25% of total operation costs, especially if the wastes are concentrated. If non-thermal or no carbon regeneration is practiced, energy costs will be 5% or less of total operation costs (17). Carbon loss and replacement must also be considered.

Noncarbon adsorption systems are being tested using synthetic media or activated alumina for treating individual process wastewaters. Activated alumina most effectively adsorbs hydrophilic and strongly polar compounds which are types of compounds least effectively treated by activated carbon (69). Regeneration practices may, however, be extremely costly.

3.5.2.6 Combined Biological-Carbon Treatment

Several systems have been put into operation or tested which utilize activated carbon to aid biological oxidation by concentrating the biodegradable material on a fixed surface as well as adsorption removal of nonbiodegradable matter.

Biofilters with fixed beds of granular carbon loaded with micro-organisms have been tested to provide high rate biological oxidation similar to fluidized beds (70). Addition of powdered carbon to activated sludge units is used in several systems to stabilize and improve biological treatment of industrial wastewaters including those containing high concentrations of cyanides. The powdered carbon can be economically reactivated by systems which could include oxidation of the biological sludge (55) (71).

3.5.2.7 Solvent Extraction

Organic compounds, having a general low water solubility, are very amenable to separation from wastewaters by extraction into a nonaqueous solvent. The general process is similar to that described in Section 3.5.2.2.3 j, except with organic solids treatment, the alternate name is liquid-liquid extraction. Systems for recovery of phenols from coke plant wastes have been operational since 1940 (73). These systems include recovery of the solvent from the phenol and from the dephenolated wastewater so that it may be continually reused.

Energy costs are similar to ion exchange or liquid-ion extraction and less than steam stripping, a competing process. An estimate for a 20 m^3/hr (90 gpm) system treating concentrated phenol wastes is just 8 kw for the extraction (17).

3.5.2.8 Miscellaneous Oxidative Destruction

Oxidation is promoted in many cases by the action of various catalysts of which more are continuing to be discovered (124). Metals are often catalysts and tests have shown sulfides to be more readily oxidized by using iron, copper or nickel catalysts (73) (74). Iron salts have been shown to promote oxidation of phenolic wastes by hydrogen peroxide (75). There are several processes tested for the catalytic oxidation of cyanides. A process using copper as a catalyst has been proven to decompose cyanide in coke plant wastewaters. A copper-cyanide complex is absorbed on activated carbon and is decomposed by oxygen (76) (77). A Japanese plant is using a process for the catalytic decomposition of ammonia (125).

Electrolytic processes may use chemical intermediaries such as chloride to destroy cyanide by electrochlorination (78). A proven method for concentrated cyanide solutions is oxidation in an electrochemical cell packed with a steel wool catalyst (79). Such destructive electrochemical methods also allow recovery of heavy metals from plating baths. Electrolytical processes are very energy intensive with percentages of total direct operating costs ranging from 10 percent for high metal concentrations to 35 percent for dilute baths and cyanide destruction (17).

Incineration systems have been commercialized which burn liquids having high concentrations of compounds with significant calorific values. Wet air oxidation processes decompose larger molecules and cyclics by heat and pressure so that the products are more easily treated by biological or other treatment methods (80). Combustion systems are being used to completely decompose gases rich in ammonia and hydrogen sulfide which have been stripped from coke plant wastewaters (81).

3.5.3 Cooling

In the production of iron and steel numerous direct contact and indirect cooling processes are required. Water used for direct contact cooling process pick up other impurities in addition to heat. Indirect or non-contact cooling water receives only heat transferred through an intermediate wall as in heat exchangers, condensers and furnace walls. The water that has been heated is either discharged to a receiving stream in its heated state or is cooled for either reuse or discharged to meet regulations limiting thermal discharge.

Water cooling may be accomplished in a completely closed system using a liquid refrigerant or air or cooling may be in an open system. In an open system the cooling mechanism is evaporation, utilizing the latent heat of vaporization in the water. The degree of evaporative cooling is dependent upon the temperature of the water being cooled, the temperature of the air and the relative humidity of the air. Various methods are used to accomplish the required cooling.

3.5.3.1 Cooling Ponds

Where very large volumes of water require cooling, the heated water may be discharged into a shallow pond at one end and withdrawn from an opposite end. The pond must be designed so that there is thorough mixing and minimum short-circuiting between inlet and outlet. Water evaporates from the pond surface cooling the remaining water. Spraying some of the water will accelerate cooling and mixing and allow smaller pond areas, but will entail higher energy costs.

3.5.3.2 Cooling Towers

a. Induced draft towers are installations where air is mechanically forced into contact with the water being cooled by the creation of a partial vacuum. There are two types of induced draft towers. In the counter flow type, the water is introduced at the top and falls through the tower while a fan, mounted above the points of water distribution, draws air upward from the open sides of the tower. In the cross flow tower, the cool air flows across the entire area of water trickling down through the tower packing.

Energy requirements are for influent water pumping and fan operation. For cooling a 3,000 m^3/hr (19 mgd) flow from 38° (100°F) down to 32°C (90°F) at a wet bulb temperature of 24°C (75°F) a two cell induced draft tower would be required. Power for pumping with a 8 m (26 ft) hydraulic head would be 85 kw and fan power requirements 75 kw (82).

b. Forced draft towers are similar to the induced draft towers except that the cool air is blown into the tower. The forced draft tower may actually be a combination of cross flow and counter flow.

c. Natural draft or hyperbolic cooling towers do not use mechanical means for cool air contacting. Instead they use a chimney effect where heated air and water vapor rises and draws cool air in through the base of the tower. Of necessity these installations are very tall and occupy large land areas.

d. Dry cooling towers are installations where the water to be cooled does not come into direct contact with the air but is contained in finned pipes and cool air is drawn over the surface thereby dissipating the heat radiated from the fins. (As an alternate to dry cooling towers, the water can be pumped through a heat exchanger to be cooled by another water stream which, in turn, is either discharged or recirculated through an open (draft) cooling tower.) Dry cooling towers are closed systems and are limited to cooling relatively high temperature water producing cold water temperatures in excess of ambient dry bulb temperature. For a water/water heat exchanger with a 3,000 m^3/hr (13,000 gpm) capacity and a 17°C (30°F) temperature drop, power required for cold side water pumping is 280 kw. The energy required to cool this water, in an open cooling tower, would be an additional 75 kw (82).

e. Spray ponds are facilities where water is sprayed over a large surface area through many nozzles. A spray pond is, in effect, a combination of a cooling pond and a wet cooling tower.

f. Evaporation coolers are used on indirect cooling water systems where the water in the closed system must be cooled to a temperature approaching the wet bulb temperature.

The closed circuit water passes through finned tubes in a cooling tower and spray water is recirculated over the tubes. A fan is used to force air over the wetted tubes and evaporation of the spray water indirectly reduces the temperature of the water in the tubes. To cool a 3,000 m^3/hr (13,000 gpm) flow from 60°C to 50°C (140 to 120°F) at a 24°C (75°F) wet bulb would require about 400 kw in an evaporation cooler including spray water circulation (82). The example, however, utilizes a very large approach to the wet bulb temperature. Closer approaches would in all probability require more power.

3.5.3.3 Dissolved Solids Control

In the operation of a cooling system care must be taken that scale does not form on the interior of the cooling surfaces, the cooling surfaces do not corrode and that biological growth is accomplished by the addition of biocides to the circulating water. Biocides are fed to cooling tower systems on a continuous or shock basis to kill any growths that may have formed. The growths, if any, will slough off the surfaces within the system and settle in the cooling tower basin.

The tendency of circulating water to either form scale or cause corrosion are functions of the chemistry of the water within the system. With indirect cooling systems it is a function of the chemistry of the makeup water whereas for direct cooling systems it is a function of both the chemistry of the makeup water and the material which contacts the water. In addition, the chemical composition of the ambient air can affect the scaling and corrosion potential of the cooling water.

Due to the evaporation of water during the cooling process and during cooling treatment, dissolved solids such as chloride and sulfates in the water are concentrated to corrosive levels. In addition, bicarbonate alkalinity originally present is converted to the scaling carbonate form after the increase in pH caused by the loss of carbon dioxide during any aeration of the cooling water. Oxygen and other gases or vapors in the ambient air are dissolved into the water as it passes over a cooling tower. Examples of these corroding gases are sulfur dioxide and ammonia.

Control of scaling and corrosion is usually effected by discharging a portion of the circulating water (blowdown) and making up a quantity equal to the blowdown and other losses due to evaporation and cooling tower drift. Blowdowns control the cycles of concentration in the circulating water; one cycle is a 100% increase of makeup water dissolved solids concentration. The makeup water or circuit water side streams may receive a high degree of treatment including complete softening or partial demineralization to permit higher cycles of concentration.

To conserve water by reducing the required blowdown volume, chemicals may be added; acid to control scaling and pH and commercial inhibitors to control corrosion. The commercial chemicals often contain compounds which must be removed prior to discharge of the blowdown. Studies have indicated that certain brackish waters, when used for cooling circuit makeup, will need less chemical additives (83) and even blast furnace gas cleaning effluent, which has been treated, has potential for use as makeup water to cooling circuits (84). The ammonium salts in the makeup act in controlling scale and pH and thus problems caused by two wastewater discharges and a required water supply could be alleviated by one application.

The problem of discharges from cooling water circuits can only be solved by the ultimate treatment of the blowdowns. Solar ponds are an evaporative disposal method for blowdown but require an arid climate for significant blowdown volumes. The use of reverse osmosis, electrodialysis, or evaporation-condensation allow recovery of the water for reuse and a minimal amount of blowdown which may be evaporated in less arid climates (85).

3.5.4 Solids-Water Separation

Large quantities of sludge are produced in many of the water and wastewater treatment processes. Whether or not the solids content of the sludge has commercial value, the sludge should usually be dewatered to the maximum practical extent prior to disposal or reuse. If the sludge is to be hauled to a disposal point, the solids to water ratio should be maximized to reduce the dry weight cost of disposal, and to make the sludge more manageable (i.e., less liable to spills). If the solids are to be reused, reducing the water content conserves energy required for drying at the point of use.

Dewatering of sludge can be accomplished by either mechanical or natural means. Natural methods utilize sludge lagoons or drying beds where the water is removed by evaporation and/or seepage. Mechanical means are generally some form of filtration or centrifugation.

The optimum dewatering system to be used will depend on the characteristics of the sludge, the treatment space available and the final solids content achieveable or desirable at the least cost (87) (88). The greatest tonnage of sludges from steel plants is composed of inorganic materials, especially iron oxides, from descaling and gas cleaning operations. These sludges are relatively easy to dewater to a high solids content. Organic sludges, especially from biological treatment, and chemical sludges are more difficult to dewater and, in most cases, are disposed of by landfill or incineration.

3.5.4.1 Thickening

Prior to dewatering a sludge, it is commonly thickened to increase the solids to water ratio and reduce the load on the subsequent dewatering facility.

Thickening can be accomplished by allowing the solids to settle in a basin for a long period of time and the weight of the sludge surface layer will force out the water entrained in the lower layers. Another common method is to use a facility similar to a clarifier where a rake, often with horizontal members called pickets, moves very slowly and forces the solids to press horizontally to discharge air bubbles, prevent bridging, squeeze water out and move the sludge towards the center well from where the thickened solids are pumped to a dewatering facility. Chemical aids are often added to increase settling rates.

Power requirements for the gravity thickeners are related to thickener dimensions and increase slowly with volume treated. For a thickener treating 2 percent solids sludge at 5 m^3/hr (0.3 mgd), the power requirement is 0.9 kw. For a thickener handling 500 m^3/hr (30 mgd), the necessary power is only 3 kw (21).

Other methods of thickening are applicable to flocculant suspensions or lighter particles than would ordinarily be found in many steel plant waste sludges. These methods are air flotation and elutriation.

Air flotation has been described earlier (3.5.2.2.1b) and has similar advantages and higher power requirements than simple gravity treatment. Elutriation is more applicable to biological sludges where substances that interfere physically or economically with chemical conditioning (such as increasing the demand for acid in conditioners) and filtration (such as very fine solids) are washed out of the sludge and returned to the wastewater treatment facilities.

3.5.4.2 Sludge Digestion and Composting

Thickened biological sludges are especially unstable, odorous and difficult to dewater. They are usually treated by anaerobic or aerobic digestion before dewatering. These processes have been discussed in subsection 3.5.2.2.4c. Power requirements for anerobic digestion are approximately 50 kw for a 16 m^3/hr (70 gpm) unit (21). Power needs are higher, at least double, for aerobic units because of the requirements for an air supply.

Sludge composting has not been used to a great extent in the United States but it is in widespread use elsewhere in the world. The various methods have great potential for biological treatment of sludges and other organic solid wastes including degradation of many toxic or biologically resistant materials. The product, in many cases, can be used as a soil conditioner.

Dewatered sludges may be combined with other degradable solid wastes for composting. The materials are mixed together and placed in windrows (furrows), pits or containers for a digestion period of several days or weeks. Temperatures of up to 70°C (160°F) are achieved in rapid decomposition and the mass is kept aerobic by periodic or continuous mixing. The water content and carbon to nitrogen ratio are important factors. A final curing period of several weeks at lower temperatures completes the solids treatment.

Power requirements are low, associated mostly with preparing materials for composting, but overall costs are rather high and land requirements are extensive (88).

3.5.4.3 Drying Beds

The dewatering of solids on a drying bed is accomplished by surface evaporation and percolation into a bed below the sludge. The bed itself is composed of a sand layer underlain by a gravel layer. Percolating water is collected by a system of perforated tiles and pumped back to the treatment system. After a given accumulation of dewatered sludge in the bed, it is removed for disposal. Removal from the surface of the sand bed may be by scraping with a bulldozer or a front end loader or, if the bed has a short dimension, by a dragline. Of necessity, in the removal of the sludge, a portion of the uppermost sand layer is removed because this layer is usually saturated with sludge and must be replaced.

In some areas the drainage is allowed to percolate directly to the ground and it is not collected. This method of disposal of water is becoming increasingly more restrictive due to the application of more stringent requirements for the protection of ground water resources.

3.5.4.4 Sludge Conditioning

Thickened sludge often requires treatment to increase the efficiency of machanical dewatering. Various methods have been studied but chemical conditioning is most commonly practiced.

Chemical conditioners such as ferric chloride, lime or a polyelectrolyte are added in the dewatering feed system to improve filterability of biological sludges or increase the size of solids particles so the fines do not pass through the medium. There have been several pilot plant studies of electrolytic sludge conditioning (88). This process may be competitive with the chemical conditioning if power costs are low. Electrolytic treatment of 14 m^3 (3,650 gal) of sludge required 181 kwh. Artificial freezing techniques have been studied and determined to be technically effective for conditioning many kinds of sludges but not economically practical for most cases (88). Natural freezing for sludge dewatering is practiced in some areas with frigid winters.

Heat treatment is gaining acceptance as a feasible alternative to chemical conditioning of difficult sludges. Various processes are in operation using combinations of steam heat and pressure (100-210°C and 1,025 kg/cm^2) and generally produce sludges with much superior dewatering characteristics than chemical treatment (89) (90). Heat treatment systems are relatively complex and have higher power requirements. A unit of 25 m^3/hr (110 gpm) capacity treating waste activated sludge may have electrical requirements of 120 kw and boiler fuel requirements of 3.7×10^4 J/hr (3.5×10^6 Btu/hr) (82). Further digestion of sludge is, however, eliminated in most cases.

3.5.4.5 Vacuum Filtration

Vacuum filtration is accomplished by the application of a vacuum to a rotating, hollow, horizontal drum which is covered with a removable filter medium of cloth, metal mesh or tightly wound coil springs. There are three phases to the vacuum filtration cycle; forming, drying and discharging. The drum is initially partially immersed in a tank which contains the sludge to be dewatered. As the vacuum is applied sludge adheres to the drum and water is withdrawn from it (forming). As the drum rotates it emerges from the sludge with a reduced vacuum applied and additional water is removed from the formed sludge cake (drying). The medium with the dried cake separates from the drum and is rolled over a discharge bar where a portion of the dried cake drops off and the balance is scraped off into a conveyor or directly into a collection box. The medium is then reunited with the drum for a new cycle.

The parameters that must be considered in the design of a vacuum filtration system are: vacuum intensity, form time, drying time sludge characteristics and the filter medium. Chemical conditioners are usually added to biological sludges and significantly increase filtration costs. Power requirements for vacuum filtration of 5.75 m^3/hr (25 gpm), 4 percent solids sludge are 18 kw for the system (17).

3.5.4.6 Filter Presses

Pressure filtration is a batch process in which the sludge is fed into spaces between vertical media covered plates, then hydraulic pressure is applied to force the entrained water out through the media while retaining the solids. When the entire space is filled with dewatered solids and the flow of water from the filter is reduced, the pressure is released and the plates are separated to allow the caked solids to drop out onto a conveyor or directly into a truck. It is usually necessary to precoat the filter medium with a releasing agent such as lime to allow cake release. Some operations add a conditioning agent such as fly ash to the sludge to reduce the precoat stage requirements.

Filter presses are constructed in a series of interconnected plates which enables larger volumes of sludge to be dewatered during a filtering cycle. The plates are mechanically separated when the pressure is withdrawn, and usually the cake drops down onto a breaker bar. Periodically the filter medium must be washed to eliminate blinding and maintain efficiency.

Filter presses produce a drier cake than most other dewatering devices, often up to 40 percent sludge solids (86). This method generally requires more operator attention and maintenance than vacuum filtration and power requirements are the same or less.

3.5.4.7 Filter Belt Presses

Filter belt presses are relatively new dewatering devices. The filter belt press operates in three sections: feed, gravity dewatering and machanical dewatering. The sludge, which may or may not be chemically conditioned, is fed at a uniform rate onto a moving porous belt which acts as a filter medium. As the belt moves some water drains through the belt by gravity. The sludge then enters the two stage mechanical dewatering section. An impervious belt applied pressure to the top of the sludge layer to squeeze water out through the filtering belt. The sludge then passes to a shear stage where it is further dewatered by the application of shear forces. After the dewatered sludge exits from the mechanical dewatering section, it is scraped off the bottom belt for removal to a container.

Power requirements are reported to be about 4 kw for 5.5 m^3/hr (25 gpm) unit (90).

Another dewatering system consists of two separate rotating drums covered by a continuous filter. The sludge is thickened to the first cell, and is then carried over the separator into the second chamber where it is continuously rolled and formed into a cake. The weight of the cake presses additional water from the partially dewatered sludge and as the cake grows, excess quantities are discharged over the side of the cell onto a conveyor. This sludge can either be disposed of or can be further dewatered by a secondary rolling device. The secondary rolling device consists of dual endless belts on rollers and covered by special filter cloth. Sludge cake, concentrated by the continuous filter is fed by rotating blades to the space between the belts and graduated pressure is applied by the rollers to squeeze additional moisture through the cloth into the grooved support belt and thence into a drip pan. This dewatered cake is carried by the bottom cloth to the discharge point. This entire process reportedly does not require chemical conditioning or thickening prior to use (88). Power requirements are given as 8 kw for a 7 m^3/hr (30 gpm) and are significantly less than for conventional thickening and pressure filtration (91).

3.5.4.8 Centrifuges

Centrifuges utilize artificially increased acceleration forces for sludge dewatering or general solids-water separation. Various types of centrifuges are available but the most common one used for dewatering is the solid bowl which consists of a horizontal rotating bowl, tapered at one end, inside of which is a screw conveyor rotating at a slower speed. The sludge is introduced at one end and the centrifugal forces cause the solids to be deposited on the sides. The screw conveyor moves the solids toward the tapered discharge end where further solids dewatering takes place as the solids are moved up the taper (beach) above the liquid depth (pool) and discharged through solids outlet ports. The liquid level is maintained by allowing the clarified liquid (centrate) to overflow from ports at the end of the bowl. Solid bowl centrifuges are designed so that the direction of solids removal is either concurrent with or countercurrent to the flow of centrate.

Parameters that affect the efficiency of solids dewatering are bowl length/diameter ratio, beach angle, bowl speed, conveyor speed, pool volume, sludge feed rate and sludge characteristics. Sludge conditioning by chemicals or polymers may increase dewatering efficiency.

Power requirements are generally from 1 to 4.5 kw per m^3/hr influent sludge (0.33 to 1.2 HP per gpm) (17).

3.5.4.9 Screening

Various types of multistage screening devices have recently been developed for sludge dewatering. The screens are staged from coarse to fine in series and are vibrated in three dimensional motion at up to 1,200 rpm by electromagnets. A single stage unit has radial and tangential motion to move the sludge from a center feed point to the outer rim. Chemical conditioning is usually required for biological sludges but efficiency of fine solids capture remains low.

Screening units serve to thicken or to dewater sludge and are relatively simple devices, requiring little space and low power requirements (88).

3.5.4.10 Solvent Extraction

A new solvent extraction process, called the "Basic Extractive Sludge Treatment", uses an aliphatic amine solvent to extract essentially all of the water and oil from inorganic and organic sludges. The water extraction process is reversible with temperature, the solvent extraction from the solids (in centrifuges) occurring at about 10°C (50°F) and the solvent is freed from oils by side stream distillation and the solids are dryed to recover residual solvent. A mobile pilot scale system has demonstrated efficiencies of 99 percent in solids-water separation of digested anaerobic municipal sludge (92). Another similar solvent extraction process was determined impractical after testing at a municipal treatment plant (88).

3.5.4.11 Combustion

Incineration or pyrolysis is a viable alternative to land disposal for many types of dewatered sludges especially those with higher organic content. Various types of incineration equipment include multiple hearth furnaces, flash-drying incinerators, rotary kilns, fluidized sand bed incinerators, atomized spray units and conventional boiler furnaces. Wet combustion is being used in processes similar to that of heat conditioning but at higher temperatures and pressures. Each method of incineration has its advantages and optimal feed characteristics; many also accept municipal solid waste. Pyrolysis has advantages in the recovery of degradation by-products and better control of air emissions.

Energy requirements for combustion are high and depend greatly on contents of water and organics in the sludge. Sludges with solids contents greater than 35 percent and 60 percent organic material often can be incinerated without external fuel requirements other than for initial combustion (86). For a fluidized bed unit handling 25 m^3/hr (110 gpm) of lime sludge with 10 percent solids content, fuel requirements were 7.9×10^9 J/hr (7.5×10^6 Btu/hr) (17).

REFERENCES (Section 3)

1. Environmental Protection Agency. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Steel Making Segment of the Iron and Steel Manufacturing Point Source Category. EPA-440/1-74-024-a, E. L. Dulaney, Project Officer, U.S. EPA, Washington, D.C., 1974. 461 pp.

2. Environmental Protection Agency. Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Forming, Finishing and Specialty Steel Segments of the Iron and Steel Manufacturing Point Source Category. Volumes I and II. EPA-440/1-76/048-b, E.L. Dulaney, P.E. Williams, J.G. Williams, Project Officers, U.S. EPA, Washington, D.C., 1976. 819 pp.

3. United States Steel Corp., H.E. McGannon, ed. The Making, Shaping and Treating of Steel. Herbick and Held, Pittsburgh, Pennsylvania, 1971, 1,419 pp.

4. American Iron and Steel Institute. Source Data for Steel Facility Factors. (undated).

5. Task Group on "Steel Industry Impact on Air Quality". Report of meeting in Pittsburgh, Pa., January 13-18 to discuss preliminary draft of Control Program Guideline for Industrial Process Fugitive Particulate Emissions by PED Co., dated December 10, 1976.

6. American Wagner Biro Co., Inc. Economics of Dry Coke Cooling.

7. Voelker, F. A Contemporary Survey of Coke Over Air Emissions Abatement. Iron and Steel Engineer, 52(2):57-64, 1975.

8. Kulakov, N., et al. Kokschim. (1):22-28, 1975.

9. Akerlow, E.V. Economical Uses of Steel Plant Wastes. Iron and Steel Engineer. 52(2):39-41, 1975.

10. Mathias, W. M. and Dr. A. Goksel. Reuse of Steel Mill Solid Wastes. Iron and Steel Engineer. 52(12):49-51, 1975.

11. Environmental Protection Agency. Electric Arc Furnaces in the Steel Industry, Standards of Performance for New Stationary Sources.

12. Environmental Protection Agency. Basic Oxygen Process Furnaces. Standards of Performance for New Stationary Sources. March 2, 1977, Federal Register (42 FR 12130).

13. Environmental Protection Agency, Iron and Steel Manufacturing Point Source Category, Effluent Guidelines and Standars, Part II. June 28, 1974, Federal Register (39 FR 24114).

14. Environmental Protection Agency. Iron and Steel Manufacturing Point Source Category, Effluent Guidelines and Standards, Part III. March 29, 1976, Federal Register (41 FR-12990).

15. Dunlap, R.W. and F.C. McMichael. Reducing Coke Plant Effluent Environmental Science and Technology, 10(7):654-657, 1976.

16. Perl, L.J. How to Talk Business to the E.P.A. New York Times, January 29, 1979.

17. Arthur D. Little, Inc. Physical, Chemical and Biological Treatment Techniques for Industrial Wastes. Draft Report to U.S. EPA Office of Solid Waste Management Programs C-78950, dated November, 1976.

18. Forsell, B. The Lamella Separator, A. Definition and Result of Pilot Studies in the Pulp and Paper and Steel Industries. Proc. 26th Indust. Waste Conf. Purdue Univ., 1971. pp. 867-873.

19. Environmental Protection Agency. Process Design Manual for Suspended Solids Removal. EPA 625/1-75-003a. U.S. EPA Technology Transfer Office, Washington, D.C. January, 1975.

20. Zanker, A. Hydrycyclones: Dimensions and Performance. Chemical Engineering, 84(10): 122-125, 1977.

21. Smith, Robert. Electrical Power Consumption for Municipal Wastewater Treatment EPA-R2-73-281, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1973. 89 pp.

22. Kuhn, A. Electrochemical Treatment of Aqueous Effluent Streams. In: Electrochemistry of Cleaner Environments, J.O.M. Bockris, ed. Plenum Press, New York, 1972. Chap. 4.

23. Chambers, D., and W.R.T. Cottrell. Flotation: Two Fresh Ways to Treat Effluents. Chemical Engineering, 83(16):95-98, 1976.

24. Nebolsine, R., and G. San Roman. Ultra High Rate Filtration. Theory and Applications. In: Proceedings of the Proaqua-Provita, 1977, Basel, Switzerland, 1972.

25. Mixon, F. O. Moving Bed Filter Performance Studies. Chemical Engineering Progress, 71(12):40-46, 1975.

26. Bramer, H.C., and W.L. Gadd. Magnetic Flocculation of Steel Mill Waste Waters. Proc. 25th Indust. Waste Conf., Purdue Univ., 1970, pp. 154-165.

27. Oberteuffer, J.A., et al. High Gradient Magnetic Filtration of Steel Mill Process and Waste Waters. IEEE Transactions on Magnetics, 11(5): 1591-2, 1975.

28. Anon. Revolving Magnetic Disks Remove Particles from Steel Mill Effluent. Iron and Steel Engineer, 51(8):80-86, 1974.

29. Chieu, J.N., et al. Coalescence of Emulfified Wastes by Fibrous Beds. Texas Univ. Center Research Water Resources Tech. Report CRWR-126, 1975.

30. Shah, B. et al. Regeneration of Fibrous Bed Coalescers for Oil-Water Separation. Environmental Science and Technology, 11(2):167-170, 1977.

31. Ikehata, T. Treatment of Waste Oil at the Keihin Works-Nippon Kokan. Iron and Steel Engineer. 52(2):65-70.

32. Ghosh, M.M. and W.P. Brown. Oil Removal by Carbon-Metal Granular Beds. Jour. Water Pollution Control Federation 47:2101-2110, 1975.

33. Ayuzawa, S. Electrolysis of Oily Wastewater. Patent, Japan Kokai 75-151-772

34. Weinstein, N.J. Waste Oil Recycling and Disposal. U.S. Environmental Protection Agency. EPA 670/2-74-052, 1974.

35. Lisanti, A.F., and R. Helwick. Ultrafiltration Oil Reclamation Process. Iron and Steel Engineer 54(3):60, 1977.

36. Rupay, G.H. The Regeneration of HCl from WPL using the Keramechamiel Lurgi Fluidized Bed. Can. Mining Met. Bull. 68(754):89, 1975.

37. Grulke, C.A. Grulke Process. Patent, Can. 983,672, 1976.

38. Burtch, J.W. Hydrochloric Acid from Industrial Waste Streams - the PORI Process. Can. Mining Met. Bull. 68(753):96, 1975.

39. Krikau, F.G. Hydrochloric Waste Pickle Liquor Disposal - New Process. Iron and Steel Engineer, 46(1):71-73, 1969.

40. Takayasu, K. Ultrasonic Wave Treatment of Metal Surface Treating Liquor. Patent, Japan Kokai 75 98 440, 1975.

41. Reicher, H. Closed Loop Regeneration of Waste Pickle Liquor, Iron and Steel Engineer, 52(5):47-49, 1975.

42. Cochran, A.A. and L.C. George. Waste Plus Waste Process for Recovering Metals. Plating and Surface Finishing. 63(7):38-41, 1976.

43. Cochran, A.A. and L.C. George. Waste Plus Waste Process for Recovering Metals. Plating and Surface Finishing. 63(7):38-41, 1976.

44. Dempster, J.H. and P. Bjoerklund. Operating Experience in Recovery and Recycling of Nitric and HF Acid from WPL. Can. Mining Met. Bull. (68(754):94, 1975.

45. Anon, Cyanide Tamer Looks Promising. Chemical Week, April 14, 1976, p.44.

46. Bailes, P. et al. Liquid-Liquid Extraction:Metals. Chemical Engineering 83(183):86-94, 1976.

47. Grieves, R.B., D. Bhattacharya. Flotation of Complexed Cyanide. Proc. 24th Indust. Waste Conf., Purdue Univ., 1969, p. 989-997.

48. Environmental Protection Agency. Ion Flotation Separation of Chromium. Report 12010 EIF, March, 1971.

49. Rubin, A.J. et al. Comparison of Variables in Ion and Precipitate Flotation. Industrial and Engineering Chemistry. 5(4), 1966.

50. Higgins, I.R. Total Recycle System for Steel Pickle Liquor. In: Proc. 64th Meeting Am. Inst. Chem. Eng., San Francisco, 1971 U.S. Patent # 3,468,707.

51. Chemical Separations Corp. The Chromix Process. Oak Ridge, Tennessee, 1975.

52. Avery, N.L., and W. Fries, Ind. Eng. Chem., Prod. Res. Devel. 14(102), 1975.

53. Gold, H., and A. Todisco. Wastewater Reuse by Continuous Ion Exchange. In: Complete Water Reuse, AIChE Conference, ed. L.K. Cecil, April, 1973, p. 96.

54. Lake, M., and S. Melsheimer. Donnan Dialysis - A Continuous Exchange Membrane Process. In: Complete Water Reuse, AIChE Conference, 1973, p. 918.

55. Robinson, G.T. Plating Waste Treatment: In-Plant Ingenuity Pays Off. Product Finishing. August, 1975.

56. Mulligan, T., and R. Fox. Treatment of Industrial Wastewaters. Chemical Engineering, 83(22):49-66, 1976.

57. Leitz, F.B. Electrodialysis for Industrial Water Cleanup. Environmental Science & Technology, 10(2):136-139, 1976.

58. Jordan, D.R., et al. Blowdown Concentration by Electrodialysis, Chem. Engr. Progress, 71(7):89-94, 1975.

59. Obrzut, J. Climbing Film Evaporator. Iron Age, 218(7):30-32, 1976.

60. Campbell, R., and D. Emmermann. Freezing and Recycling of Plating Rinsewater. Industrial Water Eng., 9(4):38-39, 1972.

61. Frazer, J. and H. Davis. Laboratory Investigation of Concentrating Industrial Wastes by Freeze Crystallization. Report No. 13, AHCO Corporation.

62. Conners, A. Hydrotechnic Acid Regeneration as Applied to the Steel and Mineral Processing Industries. Can. Mining Met. Bull. 68(754):75, 1975.

63. Famularo, J. Rotating Biological Contactors. In: 21st Summer Institute on Biological Waste Treatment, Manhattan College, New York, 1976.

64. Jeris, J. Pilot Scale, High Rate Biological Dentrification. Jour. Water Pollution Control Federation, 47:2043-2050, 1975.

65. Mueller, J., and J. Mancini. Anaerobic Filter Kinetics and Application. In: Proc. 30th Industrial Waste Conf., Purdue Univ., 1975, pp. 423-447.

66. Rosen, H. Ozonation and Its Current Applications in Industrial Water and Wastewater Treatment. In: Water and Wastewater Equip. Manuf. Assoc. 3rd Pollution Control Conference, p. 145.

67. Mathieu, G. Film Layer Purifying Chamber Process to Destoy Cyanide in Wastewater. In: Int'l Symp. on Ozone for Water Wastewater Treatment, 1st Proc., 1975, p. 533.

68. Environmental Protection Agency. An Investigation of Techniques for Removing Cyanide From Electroplating Wastes. U.S. EPS Water Pollution Control Research Series No. 12010 EIE, November, 1971.

69. Smithson, G. An Investigation of Techniques for the Removal of Chromium from Electroplating Wastes. U.S. EPA Water Pollution Control Research Series No. 12010 EIE 03/71, 1971.

70. Eberle, S. et al. Study on the Adsorption Properties of Solid Aluminum Oxides. Conference on Special Problems of Water Technology, Karksruhe, W. Germany. EPA 600/9-76-030, 1976, p. 38.

71. Eberhardt, M. Experience with the Use of Biologically Effective Activated Carbon. Karlsrube, W. Germany, EPA-600/9-76-030, 1976, p. 331.

72. Anon. Putting Powdered Carbon in Wastewater Treatment. Environmental Science & Technology, 11(9):854-855. 1977.

73. Lauer, F., et al. Solvent Extraction Process for Phenols Recovery from Coke Plant Aqueous Wastes. Iron and Steel Engineer, 46(5):99-102, 1969.

74. Wilson, I. The Treatment of Chemical Wastes, Waste Treatment. Issac PCG Editor, Pergamon Press, London, 1969, p. 206.

75. Duffy, J. U.S. Patent 3,576,738, April 1971.

76. Eisenhauer, H., Oxidation of Phenolic Wastes. Jour. Water Poll. Control Fed. 36:1116, 1964.

77. Van Stone, G. Treatment of Coke Plant Waste Effluent. Iron and Steel Engineer Yearbook, 1972, pp.190-193.

78. Bernardin, F. Cyanide Detoxification Using Adsorption and Catalytic Oxidation on Granular Activated Carbon. Jour. Water Poll. Control Fed. 45:221, 1973.

79. Hillis, M. Treatment of Cyanide Wastes by Electrolysis. Trans. Inst. Metal. Finishing, Vol. 53, Summer 1975, p. 62.

80. Chin, D., and B. Ekert, Destruction of Cyanide Wastes with a Packed Bed Electrode. Plating and Surface Finishing, 63(10)38, 1976.

81. Kalinske, A. Handling of Solids and Liquid Sidestreams. In: Complete Water Reuse, AIChE Conference, 1973, p. 140-146.

82. Chemical Abstracts. 85, 166064d (1976)

83. Hydrotechnic Corp. estimates.

84. Roffman, H., and A. Roffman. Water that Cools but does not Pollute. Chemical Engineering, 83(13):167-174, 1976.

85. Chemical Abstracts. 84, 95447X (1976).

86. Westbrook, G. Coding Tower Salinity Optimization, Power Engineering, 81(8):64-69, 1977.

87. Jones, J., et al. Municipal Sludge Disposal Economics. Environmental Science & Technology, 11(10):968-972, 1977.

88. Nova, K.R. et al. How Sludge Characteristics Affect Incinerator Design. Chemical Engineering, 84(10):131-136, 1977.

89. Burd, R. A Study of Sludge Handling and Disposal. U.S. EPA, Water Pollution Control Research Series, Report No. WP-20-4, 1968. 369 pp.

90. Environmental Protection Agency. Process Design Manufal for Sludge Treatment and Disposal. EPA 625/1-74-006, U.S. EPA Technology Transfer Office, Washington, D.C., October 1974.

91. Beloit-Passavant Corporation. "Sludge-All" Filter Belt Press.

92. The Permutit Div. of Sybron Corporation. "DCG" for Gravity Sludge Dewatering, 1972.

93. Ames, R. K. Sludge Dewatering/Dehydration Results with Mini-B.E.S.T. In: Proc. 30th Industrial Waste Conference. Purdue Univ. 1975, p. 897.

94. Thompson, Ronald - Water Pollution Control Program at Armco's Middletown Works. Iron and Steel Engineers 49 (8), 43, 1972.

95. Schroeder, James N. & Naso. A. Charles - A New Method of Treating Coke Plant Waste Water. Iron and Steel Engineers 53 (12), 60, 1976.

96. Daniels Stacy L. - Chemical Treatment and Dissolved Air Flotation of Oxidation Pond Effluent AIChE Symp. Ser. 73,358, 1977.

97. Woodward, Franklin E., Hall, Millad W., Sproul, Otis J. & Ghosh, Mriganka M. - New Concepts in Treatment of Poultry Processing Wastes. Water Resources 11 (10), 873, 1977.

98. Air and Water Quality Control at Stelco's Hilton Works - Iron and Steel Engineers 53 (11), 75, 1976.

99. Patton, Richard S. Krikau, Fred G., and Wachowich, Richard J. Deep Bed Pressure Filtration of Hot Strip Mill Effluents - Iron and Steel Engineers 48 (3), 98, 1971.

100. Gravenstreter, James P. & Sanday, Rudolph J. - Waste Water Treatment Facilities at Gary's 84-Inch Hot Strip Mill - Iron and Steel Engineers 46 (5), 1969.

101. Filter System Features Simplified Design - Iron and Steel Engineers 45 (5), 149, 1968.

102. Bartnick, J.A. Magnetic - Chemical Flocculation Improves Operation Iron and Steel Engineers, 46 (3), 106, 1968.

103. Peck, D.F. & McBride, T.J. Treatment of Paramagnetic Slurries from Steel Mill Operations by Double Floccing - Iron and Steel Engineers 46 (10), 79, 1969.

104. McNallan, Michael J.,; Russell, Kenneth C.; Oberteuffer, John A. and Sec., J. Bruce - High Gradient Magnetic Filtration of Steel Plant Waste Water Iron and Steel Engineers 53 (1), 40, 1976.

105. Harland, J.R.; Nilsson, L. and Wallin, M. Pilot Scale High Gradient Magnetic Filtration of Steel Mill Wastewater. IEEE Trans. Magn. 12 (6), 904, 1976.

106. Revolving Magnetic Discs Remove Particles from Steel Mill Effluent - Iron and Steel Engineers - 5 (8), 80, 1974.

107. Hedwall, Per & Haggstrom, Aki. Magnadisc - A New Industrial Waste Water Treatment System for Use in the Iron and Steel Industry ASEA J. 50 (6), 141, 1977.

108. Hillyard, Harold E. Recovery of Waste Oil Using Floating-Type Skimmers - Iron and Steel Engineers - 45 (8), 77, 1968.

109. Connelly E.J. Cleaning Water by Ultrafiltration. Plant Eng. 31 (23), 145, 1977.

110. Rostain, Philippe, Le Procedi de Traitement des Huiveles Solubles per Ultrafiltration - Rev. Alum 467, 533, 1977.

111. Rupay, G.H. Operation of a Cold Mill Waste Treatment Plant-Proc. Ont., Ind. Waste Conf. 29th - p 155, 1977.

112. Marsh, Daniel G. Removal of Residual Silver from Processing Wastewaters by Ion Exchange - J. Appl. Photogs. Eng. 4 (1), 17, 1978.

113. Gott, Richard D. & Laferty, John, M., Jr.,; Development of Waste Water Treatment at the Climax Mine. Ind. Water Eng. 15 (2), 6, 1978.

114. Cruver, J.E. Reverse Osmosis - Where It Stands Today - Water and Sewage Works, 120 (10), 1973.

115. Robinson, G.T. Plating Waste Treatment: In-Plant Ingenuity Pays Off Product Finishing - August 1975.

116. Lightly, Fran S. Reverse Osmosis Utilized in the Zero Discharge System at Rock Island Arsenal, Illinois - Proc. Ont. Ind. Waste Conf. 63, 1975.

117. Korngold, E., Hocke, K. and Strathmann, H. - Electrodialysis in Advanced Waste Water Treatment - Desalination - 24 (1-3), 1978. Proc. Int. Symp. on Membr. Desal and Wastewater Treatment 129, 1978.

118. Heit, A. H. & Calman, C. - Electrodialytic Recovery of Sulfuric Acid and Iron Content from Spent Pickle Liquor - Proc. Symp. Membrane Process Ind. Biomed Plenum Press, New York 1971.

119. Weber, W.J., Jr., Integrated Biological and Physico-Chemical Treatment for Reclamation of Wastewater - Ind. Water Eng. 14 (7), 20, 1977.

120. El-Sayed, Nefaat (Sweden) Bilogically Active Filter Combined with Enzyme Treatment AIChE Symp. Sec. 73 (167), 1977.

121. Bollyky, L. Joseph, Ozone Treatment of Cyanide and Plating Wastes Int. Symp. on Ozone for Water and Wastewater Treatment 1, 522, 1973.

122. Ceresa, Myron and Lancy, Leslie E. Metal Finishing Waste Disposal Metal Finishing - 66 (6), 112, 1968.

123. Myatt, R.T., et al - The Treatment of Blast Furnace Gas Washing Effluent Iron Steel Int. 46 (5), 421, 1973. - Environ. Poll. Management 3 (43), 45, 1973.

124. Farha, F.G., Dunn, R.O.; Huerston, R.D. & Box E.O. Liquid Phase Catalytic Oxidation of Waste Water - Am. Chem. Soc. Div. Pet. Chem. Prep. 23 (1), 1978 - Gen. Pap. Am. Chem. Soc., Dev. Pet. Chem., Meet Anaheim, California 93, 1978.

125. Agawa, H., et al. Operation State of the Carl Still Ammonia Decomposition Plant - Aromatikkusu 29 (6), 224, 1977.

SECTION 4.0 - SUMMARY OF FIVE PLANTS STUDIED

4.1 PROCEDURE FOR SELECTION OF IRON AND STEEL PLANTS STUDIED

There are 50 or more steel plants in the United States which are characterized by the iron and steel industry as being integrated. For the purpose of this study an integrated steel plant was defined as one that has, as a minimum, the following facilities:

- blast furnace(s)
- coke and by-product plant(s)
- sinter plant(s)
- steelmaking (must include BOF)
- hot forming (primary and secondary)
- cold finishing (must include pickling and cold rolling)

Due to the absence of various production facilities, a great many plants had to be eliminated from consideration in this study of truly integrated steel plants as defined in this study.

Table 4-1 (four sheets) presents the initial list of plants considered with identification of the major production facilities incorporated in the individual plants. This listing of the integrated plants is based on a list as published by the Institute for Iron and Steel Studies. (1).

Based on the working definition various plants were eliminated from consideration, as shown on Fig. 4-1. One additional criterion was added in the process of elimination. It is anticipated that there will be required, to achieve the goal of total recycle, reuse of water by cascading wastes from one production facility to another. Therefore, it was determined that 3 or more integrated steel plant elements must be contiguous.

Of the listed plants, 14 were determined, using the definition established in the report, to be truly integrated. Selection of the plants, from the 14 remaining, for further study was based on a ranking procedure. This procedure consisted of establishing various criteria such as quantity of the production facilities known to be in place, number of processes for

TABLE 4-1

LIST OF POSSIBLE U. S. INTEGRATED STEEL PLANTS

SHEET 1 OF 4

NO.	COMPANY AND PLANT	PLANT LOCATION	RAW STEEL CAPACITY 10⁶ NET TON/YR	COKE PLANT	BY PRODUCT	SINTER PLANT	ORE STORAGE	BLAST FURNACE	B.O.F.	BASIC OPEN HEARTH FURNACE	ELECTRIC ARC FURNACE	VACUUM DEGASSING PLANT	CONTINUOUS CASTING	SLAB MILL	STRUCTURAL MILL	BILLET MILL	PLATE MILL	BLOOMING MILL	HOT STRIP MILL	PICKLING	COLD REDUCTION MILL	ANNEALING	OXYGEN PLANT	COATING LINES	COMMENTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	ARMCO STEEL CO. ASHLAND WORKS	P.O. BOX 191 ASHLAND, KY 41101	2.3	○	○	●	●	●	●	○	○	○	○	●	○	○	○	●	●	●	●	●	●	●	
2	ARMCO STEEL CO. HOUSTON WORKS	P.O. BOX 96120 HOUSTON, TEXAS 77015	1.5	●	●	●	●	●	○	●	●	●	○	●	●	●	●	●	○	○	○	○	○	○	
3	ARMCO STEEL CO. MIDDLETOWN WORKS	P.O. BOX 600 MIDDLETOWN, OHIO 45043	3.0	●	●	○	○	●	●	●	○	●	●	●	○	○	○	○	●	●	●	●	●	●	
4	BETHLEHEM STEEL CO. BETHLEHEM PLANT	BETHLEHEM, PA 18016	4.0	●	●	●	●	●	●	○	●	●	○	○	●	●	○	●	○	○	○	○	●	○	
5	BETHLEHEM STEEL CO. SPARROWS POINT	SPARROWS POINT, MARYLAND 21219	9.5	●	●	●	●	●	●	●	○	○	○	●	○	●	●	●	●	●	●	●	●	●	
6	BETHLEHEM STEEL CO. LACKAWANNA	LACKAWANNA, NY 14219	4.0	●	●	●	●	●	●	●	○	●	○	●	●	●	○	●	●	●	●	●	●	●	
7	BETHLEHEM STEEL CO. JOHNSTOWN	JOHNSTOWN, PA 15901	2.0	●	●	●	●	●	○	●	○	○	○	●	○	●	●	●	○	○	○	○	●	●	
8	BETHLEHEM STEEL CO. BURNS HARBOR PLANT	CHESTERTON, IND 46304	4.3	●	●	●	●	●	●	○	○	○	●	●	○	○	●	○	●	●	●	●	●	●	
9	C F & I STEEL CO. PUEBLO PLANT	PUEBLO, COLORADO 81002	1.91	●	●	●	●	●	●	●	●	○	●	○	●	○	○	●	○	○	○	○	○	○	
10	INLAND STEEL CO. INDIANA HARBOR WORKS	EAST CHICAGO, INDIANA 46312	9.2	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	○	●	
11	INTERNATIONAL HARVESTER CO. SOUTH CHICAGO	SOUTH CHICAGO, COOK CO., ILL	1.2	●	●	●	●	●	●	○	○	●	●	○	○	●	●	●	○	○	○	○	○	○	
12	JONES & LAUGHLIN STEEL CO. PITTSBURGH WORKS	2709 E. CARSON ST. PITTSBURGH, PA 15203	2.5	●	●	○	●	●	○	●	○	●	○	○	○	○	○	●	●	●	●	●	●	●	
13	JONES & LAUGHLIN STEEL CO. ALIQUIPPA WORKS	P.O. BOX 450 ALIQUIPPA, PA 15001	1.0	●	●	●	●	●	●	○	○	○	●	○	○	●	○	●	●	●	●	●	○	●	

LEGEND:

● FACILITY INSTALLED

○ FACILITY NOT INSTALLED

TABLE 4-1

(CONTINUED)

SHEET 2 OF 4

NO.	COMPANY AND PLANT	PLANT LOCATION	RAW STEEL CAPACITY 10^6 NET TON/YR	COKE PLANT	BY PRODUCT	SINTER PLANT	ORE STORAGE	BLAST FURNACE	B.O.F.	BASIC OPEN HEARTH FURNACE	ELECTRIC ARC FURNACE	VACUUM DEGASSING PLANT	CONTINUOUS CASTING	SLAB MILL	STRUCTURAL MILL	BILLET MILL	PLATE MILL	BLOOMING MILL	HOT STRIP MILL	PICKLING	COLD REDUCTION MILL	ANNEALING	OXYGEN PLANT	COATING LINES	COMMENTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
14	JONES & LAUGHLIN STEEL CO, CLEVELAND WORKS	P.O. BOX 6086 3342 JENNINGS RD, CLEVELAND, O. 44101	3.44	○	○	●	●	●	●	○	●	○	○	●	○	○	○	○	●	●	●	○	●	○	
15	KAISER STEEL CORP. FONTANA WORKS	P.O. BOX 217 FONTANA, CAL 92335	3.0	●	●	●	●	●	●	●	○	○	○	●	●	○	●	●	●	●	●	●	●	●	
16	MC LOUTH STEEL CORP. TRENTON WORKS	TRENTON, MICH TELEX 23 5286	3.9	○	○	●	●	●	●	○	●	○	●	●	○	○	●	●	●	●	●	●	○	○	
17	NATIONAL STEEL CORP. WEIRTON PLANT	WEIRTON, WEST VA 26062	3.5	●	●	●	●	●	●	○	○	●	●	○	●	○	○	●	●	●	●	●	●	●	
18	NATIONAL STEEL CORP. GRANITE CITY	20TH & STATE ST. GRANITE CITY, ILLINOIS 62040	2.2	●	●	●	●	●	●	○	○	○	○	●	○	○	●	○	●	●	●	●	●	●	
19	NATIONAL STEEL CORP. ECORSE DETROIT	DETROIT, MICH 48229	6.1	●	●	●	●	●	●	○	●	○	●	●	○	●	○	●	●	●	●	●	●	○	PLANT NOT CONTIGUOUS
20	REPUBLIC STEEL CORP. YOUNGSTOWN WORKS	YOUNGSTOWN, OHIO 44505	2.6	●	●	○	○	●	○	○	○	○	○	○	○	●	○	●	○	○	○	○	○	○	
21	REPUBLIC STEEL CORP. WARREN WORKS	WARREN & NILES, OHIO 44481	2.6	●	●	●	●	●	●	○	●	○	○	○	○	○	○	●	●	●	●	●	●	●	
22	REPUBLIC STEEL CORP. CLEVELAND PLANT	6100 TRISCON AVE. CLEVELAND, O. 44127	3.4	●	●	●	●	●	●	●	○	○	○	●	○	●	○	●	●	●	●	●	●	●	
23	REPUBLIC STEEL CORP. SOUTH CHICAGO WORKS	SOUTH CHICAGO, ILLINOIS 60617	2.0	●	●	○	●	●	○	●	●	○	○	○	○	●	○	●	○	○	○	○	●	○	
24	REPUBLIC STEEL CORP. GULFSTEEL WORKS	GADSDEN, ALA 35901	1.5	●	●	●	●	●	●	○	●	○	○	○	○	○	●	●	●	●	●	●	●	●	
25	REPUBLIC STEEL CORP. BUFFALO WORKS	1175 S. PARK AVE. BUFFALO, NY 14220	1.0	○	○	○	○	●	●	○	○	○	○	○	○	●	○	●	○	○	○	○	○	○	
26	REPUBLIC STEEL CORP. CENTRAL ALLOY DIST.	CANTON, OHIO 44701	1.8	●	●	○	●	●	○	○	●	●	●	●	○	●	○	●	●	●	●	●	●	○	PLANT NOT CONTIGUOUS
27	SHARON STEEL CORP. FARRELL PLANT	FARRELL, PA 16121	2.0	○	○	○	●	●	●	○	●	●	○	●	○	○	○	●	●	●	●	●	●	●	
28	U.S. STEEL CORP. CLAIRTON WORKS	CLAIRTON, PA 15025	0.6	●	●	○	○	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	

TABLE 4-1

(CONTINUED)

SHEET 3 OF 4

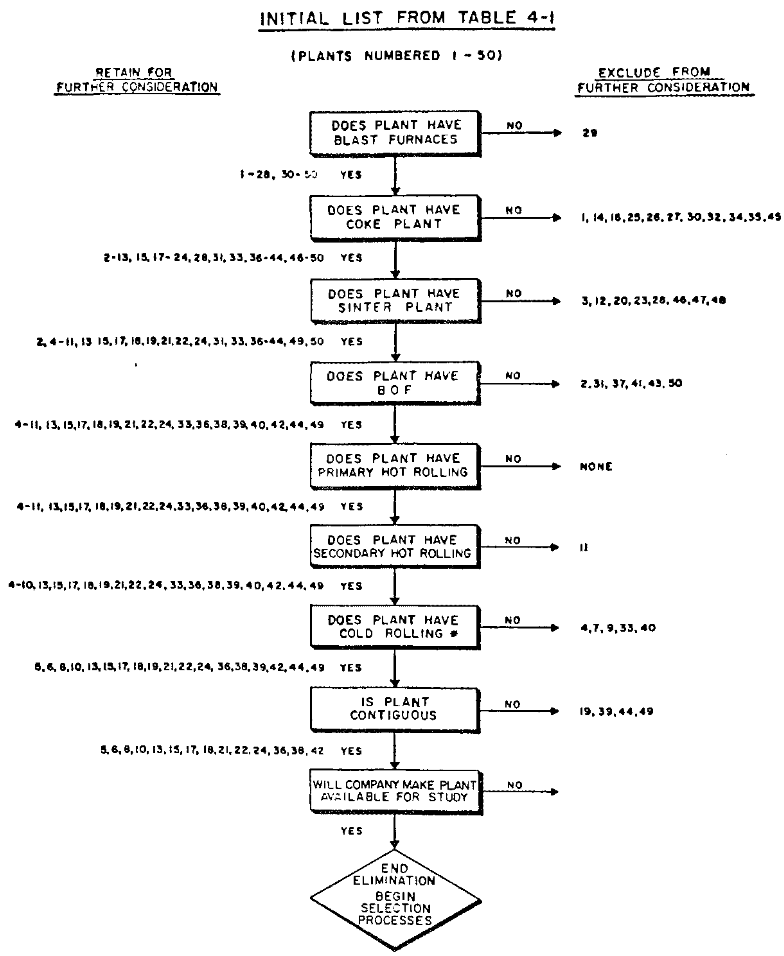
NO.	COMPANY AND PLANT	PLANT LOCATION	RAW STEEL CAPACITY 10⁶ NET TON/YR	COKE PLANT	BY PRODUCT	SINTER PLANT	ORE STORAGE	BLAST FURNACE	B.O.F.	BASIC OPEN HEARTH FURNACE	ELECTRIC ARC FURNACE	VACUUM DEGASSING PLANT	CONTINUOUS CASTING	SLAB MILL	STRUCTURAL MILL	BILLET MILL	PLATE MILL	BLOOMING MILL	HOT STRIP MILL	PICKLING	COLD REDUCTION MILL	ANNEALING	OXYGEN PLANT	COATING LINES	COMMENTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
29	U.S. STEEL CORP. HOMESTEAD WORKS	HOMESTEAD, PA 15120	4.0	○	○	○	○	●	○	●	○	○	○	●	●	○	●	●	●	●	●	○	○	○	PLANT NOT CONTIGUOUS
30	U.S. STEEL CORP. EDGAR THOMSON-IRVIN WORKS	BRADDOCK, PA 15104		○	○	●	●	●	●	○	○	○	○	●	○	○	○	○	●	●	●	●	○	●	PLANT NOT CONTIGUOUS
31	U.S. STEEL CORP. FAIRLESS WORKS	FAIRLESS HILLS, PENNSYLVANIA 19030	4.4	●	●	●	●	●	○	●	●	●	●	●	○	●	○	●	●	●	●	●	●	●	
32	U.S. STEEL CORP. NATIONAL-DUQUESNE WORKS	MC KEESPORT, PA	3.0	○	○	●	●	●	●	●	●	●	○	○	○	●	○	●	○	○	○	○	●	○	PLANT NOT CONTIGUOUS
33	U.S. STEEL CORP. LORAIN-CUYAHOGA WORKS	1807 EAST 28TH ST. LORAIN, OHIO 44055	3.0	●	●	●	●	●	●	○	○	○	○	○	○	○	○	●	●	●	●	●	●	●	PLANT NOT CONTIGUOUS
34	U.S. STEEL CORP. YOUNGSTOWN WORKS	912 SALT SPRINGS RD. YOUNGSTOWN, OHIO 44509	2.5	○	○	●	●	●	○	●	○	○	○	●	○	○	○	●	●	○	○	○	●	○	
35	U.S. STEEL CORP. SOUTH WORKS	3426 EAST 89TH ST. CHICAGO, ILL 60617	7.35	○	○	●	●	●	●	●	●	○	●	●	●	○	●	●	○	○	○	○	●	○	
36	U.S. STEEL CORP. GARY WORKS	GARY, INDIANA 46402	6.0	●	●	●	●	●	●	●	○	○	●	●	○	●	●	●	●	●	●	●	●	●	
37	U.S. STEEL CORP. GENEVA WORKS	P.O. BOX 510 PROVO, UTAH 84601	2.5	●	●	●	●	●	○	●	○	○	○	●	●	○	●	●	●	○	○	○	○	○	
38	U.S. STEEL CORP. FAIRFIELD WORKS	P.O. BOX 599 FAIRFIELD, ALA 35064	4.0	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	
39	WHEELING-PITTSBURGH STEEL CO. STEUBENVILLE	STEUBENVILLE, OHIO 43952	5.0	●	●	●	●	●	●	●	○	○	○	●	○	○	○	●	●	●	●	●	●	○	PLANT NOT CONTIGUOUS
40	WHEELING PITTSBURGH STEEL CO. MONESSEN, PA	MONESSEN, PA 15062	2.0	●	●	●	●	●	●	●	○	○	○	○	○	●	○	●	○	○	○	○	●	○	PLANT NOT CONTIGUOUS
41	YOUNGSTOWN STEEL SHEET & TUBE CO. CAMPBELL WORKS	CAMPBELL, OHIO 44501	3.0	●	●	●	●	●	○	●	○	○	○	○	○	●	○	●	●	●	●	○	○	○	
42	YOUNGSTOWN STEEL SHEET & TUBE CO. EAST CHICAGO	EAST CHICAGO, INDIANA 46312	6.0	●	●	●	●	●	●	●	○	○	○	●	○	●	○	●	●	●	●	●	○	●	
43	YOUNGSTOWN STEEL SHEET & TUBE CO. BRIER HILL WORKS	YOUNGSTOWN, OHIO 44501	[illegible]	●	●	○	○	●	○	●	○	●	○	○	○	●	○	●	○	○	○	○	○	○	

TABLE 4-1

(CONTINUED)

SHEET 4 OF 4

NO.	COMPANY AND PLANT	PLANT LOCATION	RAW STEEL CAPACITY 10^6 NET TON/YR	COKE PLANT	BY PRODUCT	SINTER PLANT	ORE STORAGE	BLAST FURNACE	B.O.F.	BASIC OPEN HEARTH FURNACE	ELECTRIC ARC FURNACE	VACUUM DEGASSING PLANT	CONTINUOUS CASTING	SLAB MILL	STRUCTURAL MILL	BILLET MILL	PLATE MILL	BLOOMING MILL	HOT STRIP MILL	PICKLING	COLD REDUCTION MILL	ANNEALING	OXYGEN PLANT	COATING LINES	COMMENTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
44	ALAN WOOD STEEL CO. CONCHOHOCKEN PLANT	CONSHOHOCKEN PA 19428	2.0	●	●	●	●	●	●	○	○	○	○	○	○	○	●	●	●	●	●	○	○	○	PLANT NOT CONTIGUOUS
45	ALLEGHENY LUDLUM STEEL CO. BRACKENRIDGE WORKS & WEST LEECHBURG WORKS	BRACKENRIDGE, PA & WEST LEECHBURG, PA		○	○	○	○	○	●	○	●	○	○	○	○	○	○	●	●	●	●	●	●	○	PLANT NOT CONTIGUOUS
46	CRUCIBLE INC. ALLOY & STAINLESS STEEL DIV.	P.O. BOX 226 MIDLAND, PA 15059	1.0	●	●	○	●	●	●	○	●	●	●	○	●	●	○	●	●	●	●	●	●	○	
47	CYCLOPS CORP. PORTSMOUTH PLANT	P.O. BOX 371 NEW BOSTON, OHIO 45662	1.5	●	●	○	●	●	○	●	○	○	○	●	○	●	○	○	●	●	●	○	○	○	
48	FORD MOTOR CO. STEEL DIVISION	MILLER ROAD DEARBORN, MICH 48121	3.75	●	●	○	●	●	●	○	●	○	○	●	○	●	○	●	●	●	●	●	○	○	
49	INTERLAKE INC. RIVERDALE PLANT & SOUTH CHICAGO WORKS	135TH & PERRY AVE, CHICAGO, ILL 60627	0.8	●	●	●	●	●	●	○	○	○	○	○	○	●	○	●	●	●	●	●	●	●	PLANT NOT CONTIGUOUS
50	LONE STAR STEEL CO. LONE STAR PLANT	LONE STAR, TEXAS 75668	1.5	●	●	●	●	●	○	●	○	○	○	●	○	○	○	○	●	○	○	○	○	○	



NOTE:

* ASSUMPTION - IF PLANT HAS SECONDARY HOT ROLLING AND COLD ROLLING IT ALSO HAS PICKLING

U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP

INTEGRATED STEEL PLANT POLLUTION STUDY FOR ZERO WATER AND MINIMUM AIR DISCHARGE

PLANT SELECTION PROCESS
LOGIC DIAGRAM

DRAWN BY A.S. DATE
CHECKED BY
APPROVED
REVISIONS

FIGURE 4-1

producing similar products (e.g., is steelmaking solely by BOF or by BOF plus open hearth), diversity of operations within the same area. Each criterion was assigned a weighting factor. As more information was received and evaluated, additional rankings were prepared so that a final selection could be made.

Each plant was ranked under each criterion in numerical order with the lowest number being the most desirable. Each ranking was then multiplied by the weighting factor and all weighted rankings summed for a final ranking.

Another consideration that affected the rankings was the desirability of there being at least two of each type of production facility such as electric arc furnaces and vacuum degassers. If a plant had a low ranking but had a required facility it may have been upgraded. Table 4-2 presents the ranking procedure and Table 4-3 lists the 14 plants in order of preference.

When this list was prepared a meeting was held with the AISI to discuss the final selection of the plants which would be studied further. Based on this meeting, five plants were selected:

Inland Steel Corp.	- Indiana Harbor Works
USSC	- Fairfield Works
Kaiser Steel Co.	- Fontana Plant
National Steel Corp.	- Weirton Steel Division
Youngstown Sheet & Tube Corp.	- Indiana Harbor Works

Figure 4-2 shows the geographic location of the plants. These were chosen based on additional reasons used by the AISI and Hydrotechnic Corp. to eliminate higher ranking plants and are as follows:

1. The desire not to burden any one corporation excessively by studying more than one of its plants.

2. The extensive use of salt water in a plant made it too atypical.

3. Production planning changes were such that modifications in progress would make it impossible to obtain up-to-date water use information.

4. Degree of cooperation that could be expected from each company.

The plants selected were then visited to obtain the following information:

TABLE 4-2

RANKING PROCEDURE

Corporation Plant / Basis of Ranking	No. of Production Facilities (From Table 1)	Production Facilities Less Oxygen Plant & Cont. Anneal.	No. of Types of Steelmaking Facilities	No. of Primary Rolling Facilities *	No. of Secondary Rolling Facilities	Is Continuous Caster in Place **	Is There Vacuum Degassing **	Points	Ranking Based on Points
Weight	1	3	2	2	2	2	1		
Inland - Indiana Harbor	1	1	1	1	1	1	2	14	1
USS - Fairfield	2	3	2	2	1	2	2	27	3
- Gary	1	2	2	2	1	1	1	20	2
Bethlehem - Sparrows Point	3	4	2	2	2	2	2	33	4,5,6
- Burns Harbor	5	6	3	3	2	2	2	45	11, 12
- Lackawanna	5	5	2	3	2	2	2	40	9
National - Weirton	4	5	3	3	2	1	1	38	7
- Granite City	7	8	3	4	3	2	2	57	14
Republic - Cleveland	4	5	2	2	3	2	2	39	8
- Gadsden	5	6	2	4	2	2	2	45	11, 12
- Warren	6	7	2	4	3	2	2	51	13
Kaiser - Fontana	3	4	2	3	1	2	2	33	4,5,6
Youngstown - Indiana Harbor	3	4	2	2	2	2	2	33	4,5,6
Jones & Laughlin - Aliquippa	6	6	3	2	3	1	2	44	10

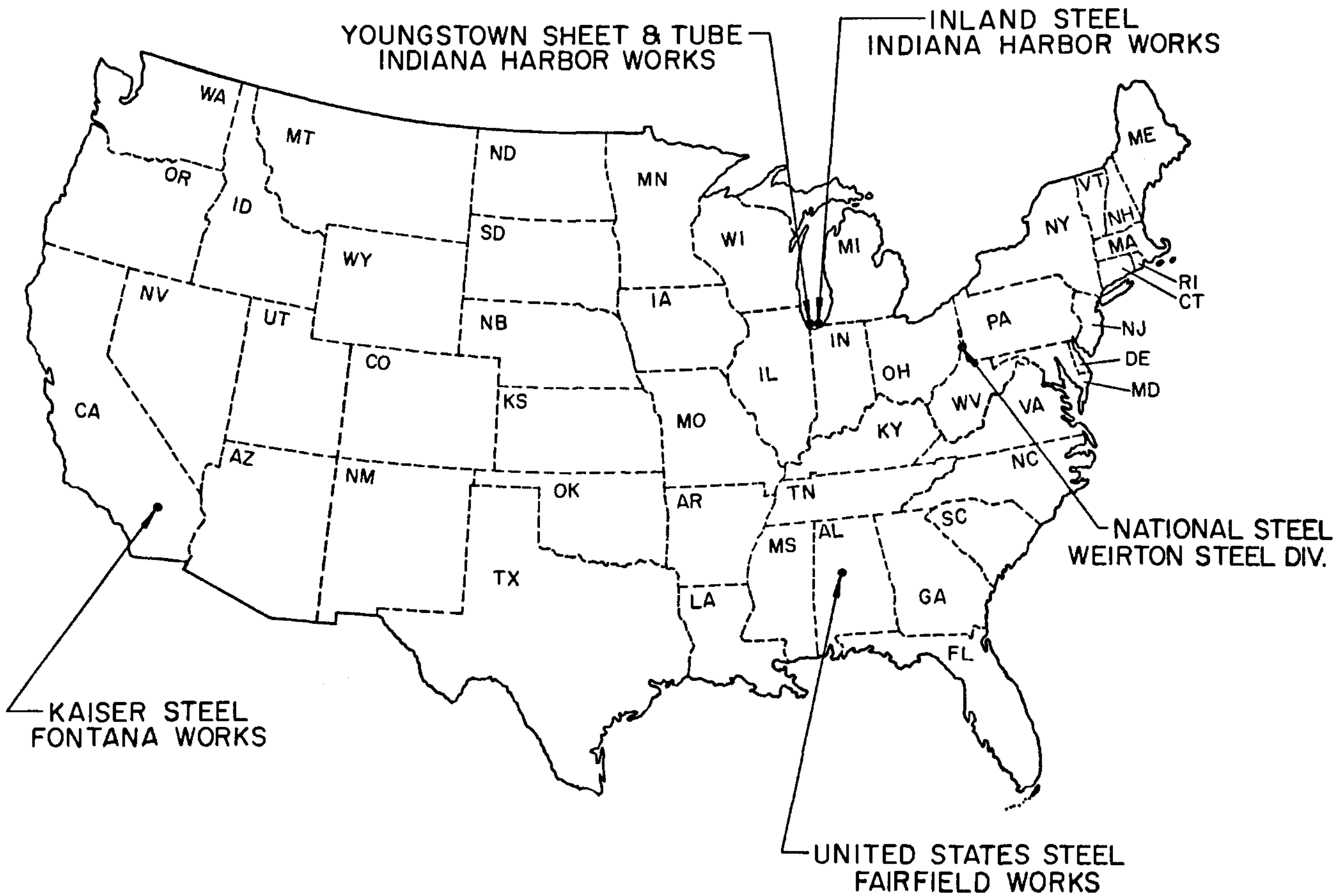
* Continuous Caster considered as primary rolling

** Yes = 1 No = 2

TABLE 4-3

FINAL LIST OF 14 PLANTS FOR POSSIBLE FURTHER STUDY

Order	Corporation	Plant
1	Inland Steel Company	Indiana Harbor
2	United States Steel	Gary Works
3	United States Steel	Fairfield Works
4	Bethlehem Steel	Sparrows Point Plant
5	Kaiser Steel	Fontana
6	Youngstown Sheet & Tube	Indiana Harbor Works
7	National Steel	Weirton Steel Division
8	Republic Steel	Cleveland Works
9	Bethlehem Steel	Lackawanna Plant
10	Republic Steel	Gadsden Works
11	Bethlehem Steel	Burns Harbor
12	Jones & Laughlin	Aliquippa
13	Republic Steel	Warren
14	National Steel	Granite City



LOCATIONS OF SELECTED INTEGRATED PLANTS

FIG. 4-2

- water, air and production process flow diagrams of each production facility

- plot plans of the plants on which would be indicated what areas would be available for the construction of pollution control facilities

- an indication of what facilities the plant has planned for future installation or deletion

- efficiencies of water pollution and air pollution control facilities presently installed

- any constraints that may be placed on future pollution control facilities

These visits were for a period of from one to three days. All requests for confidentiality were and are being respected.

After the initial visit, the data collected were analyzed and process water flow diagrams were prepared. Where data voids were identified, a listing of such voids was prepared and submitted to the plant personnel. In some cases the answers were provided by return letter and in other cases an additional visit was made to the plant or to the corporate offices. A short report was prepared for each plant using the final data and submitted to each plant or corporation inviting comments. After the comments were received the report was finalized and submitted to EPA. These finalized reports are incorporated in this report as Appendices A, B, C, D and E.

The primary purpose of the plant reports was to obtain factual data with respect to each plant. A second purpose was to get opinions from the industry on treatment processes that would be applicable for achieving BAT and total recycle of water. Another purpose of the individual plant studies was to determine areas of typicality (and atypicality) of the various plants.

4.2 SUMMARY OF THE FIVE PLANTS STUDIED

The five selected integrated steel plants were studied to determine: similarity of wastes and production processes between integrated steel plants, problems that would be encountered with respect to site specifics, water uses in various plants, degrees of treatment currently practiced and applicability of retrofit of treatment processes to plant production operations and plant waste treatment processes.

Detailed descriptions of the plants are included in the reports that were prepared for each plant studied and included in Appendices A through E.

4.2.1 Kaiser Steel Corporation - Fontana Works (Appendix A)

4.2.1.1 Processes and Facilities

The Kaiser Steel Corporation operates a completely integrated steel plant located in Fontana, California on approximately 607 hectares (1,500 acres). The production facilities as of December 1976 consisted of:

Production Facility	Average Daily Production kkg/t
- One by-products coke plant	3,720/4,100
- One sinter plant	3,493/3,850
- Four blast furnaces	6,386/7,040
- One-eight furnace open hearth shop (3 presently operating)	1,497/1,650
- One basic oxygen steelmaking shop (BOP)	3,480/3,836
- A slabbing mill	6,153/6,783
- A 46-inch blooming mill	not operational
- A 86-inch hot strip mill	4,997/5,508
- A merchant mill	not operational
- A structural mill	not operational
- A continuous weld pipe mill	447/ 493
- Two continuous pickling lines	2,831/3,120
- Three alkaline cleaning lines - one of which is contiguous with a continuous annealing line	1,637/1,805
- Four cold rolling mills, including tin plating and galvanizing	2,151/2,375

Since 1976 the blooming, merchant and structural mills have ceased operation. A second Basic Oxygen Steelmaking shop and a continuous caster presently are under construction. Plans are to operate only two of the three presently operating open hearth furnaces after the new BOP and caster are in operation.

4.2.1.2 Water Systems and Distribution

Water for the steel plant (KSP) is obtained from two sources: approximately 7.47×10^6 m^3 (two billion gallons) per year are purchased from the Fontana Union Water Company and the balance of the plant requirements, approximately 3.78×10^6 m^3 (one billion gallons) per year are obtained from two 245 meter (800 feet) deep wells located on KSP property. The purchased water and, when necessary, well water is stored in a main reservoir with a capacity of 17,000 m^3 (4.5 million gallons) or enough water to supply the plant with water for about 12 hours. Due to the average total dissolved solids of the water entering the plant (about 230 mg/l) and a hardness of about 150 mg/l (as $CaCO_3$) all water is softened in reactor-clarifiers. The water is then carbonated, chlorinated, and filtered and stored in domestic and industrial reservoirs.

The domestic water and fire protection systems use the same distribution network. This water is stored in a 1,890 m^3 (500,000 gallon) covered reservoir, and pumped to a distribution system with an elevated tower to supply domestic, fire, and other plant uses requiring high quality water.

The industrial water system as shown on Figures A-1 and A-2 (Appendix 4) has four quality levels and is supplied from an open 4,500 m^3 (1,200,000 gallon) reservoir. The general concept is that water cascades through a number of systems, with the blowdown of one system becoming the supply of the ensuing system. The systems are sequenced in order of quality requirements, with the first system having the highest quality and the last system the poorest.

The highest orders of use (highest quality) are the motor room systems, where electrical equipment is cooled, and in the reheat furnace cooling systems. These are recirculating non-contact cooling systems utilizing open cooling towers. KSP has three such non-contact systems equipped with cooling towers capable of handling 12,500 m^3/hr (55,000 gpm). Each system is equipped with an elevated storage tank to maintain a uniform pressure and provide an emergency supply in case of power failure. Steam or gasoline driven emergency pumps provide a minimum flow to protect the equipment in case of a long power outage.

The modernization program presently in progress will add two new high quality water systems. The new BOP will have a completely closed hood and lance cooling system with water-to-water heat exchangers. The hot side water in this enclosed system will be of boiler quality while the cold side heat exchanger water will be of the highest quality industrial water. The other high quality cooling water system will be for the continuous slab caster.

The second quality level systems provide water to the rolling mills for bearing cooling, roll cooling and some scale flushing. KSP has two of these systems equipped with cooling towers capable of handling 11,800 m^3/hr (52,000 gpm). Elevated storage tanks provide pressure control and reserve capacity. After the water is used in the rolling mills it is treated for reuse or recycle.

The third quality level systems supply cooling water to the Open Hearth steelmaking furnaces, Basic Oxygen steelmaking furnaces, a portion of the Coke Plant and the four Blast Furnaces. Water in these systems picks up heat and solids, mainly iron graphite. KSP has five of these systems which, when originally installed, were equipped only with cooling towers. In the past few years all but one have had clarifiers added to remove suspended solids. The rated capacity of the third level system is 13,400 m^3/hr (59,000 gpm) and is tied together through two elevated storage tanks.

The fourth and lowest quality level system serves the Blast Furnace gas washers. Large amounts of dust removed from the gas by the water is, in turn, removed in treatment facilities. After treatment the water is pumped over a cooling tower and returned to the blast furnace gas washers for reuse. Dissolved solids are controlled by blowing down a portion of the water to spray-cool molten slag. This blowdown is closely controlled to prevent excess water from accumulating in the slag cooling system. The rated capacity of the gas washer systems is 3,230 m^3/hr (14,200 gpm).

Sludge from the treatment system clarifiers is pumped to sludge beds, which are cleaned periodically and the sludge hauled to a dump site. Supernatant water is returned to the gas washer system.

Other cooling tower systems serve special functions in the plant. The power house water system uses 10,100 m^3/hr (44,300 gpm) and is equipped with cooling towers and a return pump station. Heat is the only contaminant involved so that only cooling is required. Three cooling tower systems are installed in the Coke Plant which indirectly cool the coke oven gas produced when coal is coked. The total rated capacity of these systems is 4,200 m^3/hr (18,500 gpm).

The total capacity of all of the cooling towers in the entire plant is between 54,540 and 54,800 m^3/hr (240,000 and 250,000 gpm).

4.2.1.3 Waste Treatment Facilities

KSP has three separate treatment facilities for wastewaters generated in the plant. These include: a sanitary sewage treatment plant, an acid neutralization plant and, a wastewater treatment plant for all non-acid, non-domestic wastewaters (WWTP).

The domestic sewage treatment plant has two stages consisting of a clarifier and a digester in the first stage and two pairs of trickling filters, a clarifier and a chlorine contact chamber in the second stage. The sewage plant effluent is returned for reuse in the plant to the first water quality level system.

Waste hydrochloric acid (HCl) pickle liquor is disposed of by sending the acid to an on-site contractor who converts it to ferric chloride for sale. HCl rinse water and waste sulfuric acid are neutralized with anhydrous ammonia in an acid neutralization plant. This neutralized waste is combined with excess wastes from the WWTP and discharged to the Chino Basin Municipal Water District for further treatment by the Los Angeles County Sanitation District before final discharge to the Pacific Ocean. The total discharge from the plant is approximately 402 m^3/hr (1,770 gpm).

The WWTP receives the major portion of its wastes from the cold rolling and plating mills and the balance from the hot strip mill sludge pond and furnace cooling water blowdown. When the new BOP is operational it will also discharge to the WWTP. The WWTP consists of an elevated surge tank, a two section float-sink separator and a clarifier. Mixing tanks are installed for chemical addition, but at present, are not being utilized. After addition of the new BOP wastes, the WWTP will treat approximately 285 m^3/hr (1,255 gpm). Approximately 63 m^3/hr (275 gpm) is recycled for use at the coke plant, the tin mill and the slag processor. The balance is discharged to the acid neutralization plant for combination with the neutralized acid rinse water for ultimate discharge to the Chino Basin Municipal Water District.

A temporary waste storage facility receives chromic acid and chromate wastes from the tinning lines. The purpose of the facility is to store the wastes until such time as a method of acceptable disposal or chrome recovery is developed. There is no discharge from this storage facility.

4.2.1.4 Discharge Qualities

The reported qualities of the various discharges to the WWTP and the Chino Basin Water District are shown on Table 4-4.

4.2.2 Inland Steel Company - Indiana Harbor Works

4.2.2.1 Processes and Facilities

Inland Steel Company operates a completely integrated steel plant on a 650 hectare (1,600 acre) site on a manmade peninsula stretching 3.2 km (2 miles) into Lake Michigan. The corporate disignation of the plant is the Indiana Harbor Works, East Chicago, Indiana. As of 1977 production facilities consisted of:

	Maximum Daily Production kkg	ton
- Two by-product coke plants:		
Plant No. 2	4,990	5,500
Plant No. 3	2,540	2,800
- One sinter plant	4,080	4,500
- Two blast furnace facilities:		
Plant No. 2 (6 furnaces)	11,340	12,500
Plant No. 3 (2 furnaces)	5,450	6,000
- One open hearth shop	6,800	7,500
- Two basic oxygen steelmaking shops:		
No. 2	5,900	6,500
No. 4	12,700	14,000
- One slab caster	4,170	4,600
- One billet caster	1,240	1,370
- One slabbing mill	9,700	10,700
- Two blooming mills:		
No. 2	3,900	4,300
No. 3	5,720	6,300
- Three hot strip mills:		
80-inch	12,700	14,000
76-inch	4,080	4,500
44-inch	3,630	4,000
- Four A.C. power stations (No. 1 A.C. not generating)	NA	
- A plate mill	1,080	1,200
- One electric arc furnace shop	1,630	1,800
- Four bar mills:		
10-inch	1,810	2,000
12-inch	1,900	2,100
14-inch	1,810	2,000
24-inch	900	1,000
- A 28" secondary mill	1,900	2,100
- A 32" secondary mill	1,900	2,100
- A spike mill	45	50
- Three cold strip mills:		
40-inch (No. 1 C.S.)	1,630	1,800
56-inch & 80-inch (No. 3 C.S.)	8,440	9,300
- A mold foundry	900	1,000
- Five pickling lines:		
No. 1 C.S.	4,540	5,000
No. 3 C.S.	8,530	9,400
44-inch sheet	900	1,000
12-inch bar	130	140
10-inch & 14-inch bar	725	800
- Five galvanizing lines:		
Plant No. 1 - Lines 1-4	1,810	2,000
Plant No. 2 - Line 5	900	1,000
- One alkaline cleaning line	900	1,000
- Miscellaneous shops	NA	

TABLE 4-4

KAISER STEEL CORPORATION - FONTANA WORKS

TREATED WASTEWATER DISCHARGES

All units, except pH, in mg/l

Parameter	Discharge from WWTP	Discharge to CBMWD
pH	9.8 - 11.2	6 - 9.5
P. Alkalinity (as $CaCO_3$)	112 - 390	0 - 280
M. O. Alkalinity (as $CaCO_3$)	276 - 810	24 - 2120
Total Solids	1250 - 2020	2010 - 28600
Suspended Solids	80 - 710	840 - 3850
Dissolved Solids	1000 - 1200	1160 - 24840
Total Hardness	16 - 112	18 - 168
Non-Carbonate Hardness	0	0 - 118
Chloride	16 - 200	60 - 10900
Sulfate	65 - 150	170 - 695
Sodium	150 - 455	110 - 480
Calcium	6 - 34	7 - 54
Magnesium	0 - 6	0 - 6
Phosphate	0.7 - 4.6	-
SiO_2	40 - 155	-
Nitrate	0.9 - 4.8	-
Oil & Grease	105 - 550	-

4.2.2.2 Water Systems and Distribution

The water for the plant is drawn from Lake Michigan through two intakes and is distributed through the plant by six pumping stations. The average daily quantities of water distributed through the plant during the first six months of 1977 were:

Pumping Station	Daily Average Flow	
	$m^3 \times 10^6$	gal. $\times 10^6$
1	0.400	105.7
2	0.543	143.4
3	0.789	208.6
4	0.594	156.9
5	0.290	76.6
6	0.629	166.3

All pumping stations, with the exception of No. 4 are interconnected and supply the entire plant with water. Pump Station No. 4 supplies one power station, one BOF shop, one open hearth shop and the mold foundry. Upon completion of the northward expansion the No. 4 pumping station will also supply the new coke plant, boiler house and blast furnace. No treatment other than screening at the intakes is provided. The distribution of the water in the plant is as shown on Figures B-1, B-2 and B-3 (Appendix B). A detailed discussion of the water uses within the plant is given in Appendix B.

4.2.2.3 Waste Treatment Facilities

The Inland Steel plant has installed facilities to treat wastewaters prior to discharge at some of its outfalls. Other treatment facilities are installed at the individual production facilities. Waste pickle liquor is disposed of by deep well injection. Biologically degradable wastes from the coke plants and partially treated sanitary wastes from two sanitary treatment plants are discharged to the East Chicago Sanitary District.

Extensive recycle systems are installed in the plant. Discharges to receiving waters consist of treated cooling tower blowdown from all the blast furnaces, the 12-inch bar mill, the electric furnace and the billet caster. The Slab Caster No. 1 blowdown is filtered prior to discharge.

Two combined waste treatment plants are installed for treating the discharge to three outfalls. One plant treats the wastewater from the hot forming mills, two cold strip mills and BOF No. 2 for the removal of oils and suspended solids prior to discharge at two outfalls. The second treatment plant treats the wastewater from the 80-inch Hot Strip Mill and Cold Strip

Mill No. 3 prior to discharge at one outfall. Detailed descriptions of the waste treatment facilities are included in Appendix B.

4.1.2.4 Discharge Qualities

The reported qualities of the various discharges from the Inland Steel Company plant are presented in Table 4-5.

4.2.3 National Steel Corporation - Weirton Steel Division

4.2.3.1 Manufacturing Processes and Facilities

The Weirton Steel Division, of National Steel Corporation, is a completely integrated steel plant located approximately 60 km (37 miles) west of Pittsburgh, Pennsylvania, on the east bank of the Ohio River in the Town of Weirton, West Virginia. It is at the confluence of the Ohio River and Harmon Creek and occupies a 142 hectare (350 acres) site oriented north-south. The integrated facilities located on the site to produce finished and semi-finished products consist of:

	Daily Capacities in kkg/ton
- Ore Coal and Flux Storage Areas	-
- Coal Washing Facilities	NA
- Two By-Product Coke Plants	7,516/8,275
- One Sinter Plant	6,690/7,375
- Four Blast Furnaces	8,948/9,864
- One BOP Shop	11,343/12,500
- Two Vacuum Degassers	5,983/6,595
- One Continuous Casting Shop	3,969/4,375
- A Blooming Mill	8,682/9,570
- A Hot Scarfer	NA
- A Structural Mill	Ceased Operations
- A 54-inch Hot Strip Mill	8,340/9,193
- Three Pickling Lines (Hydrochloric Acid)	8,499/9,369
- Five Tandem Mills (Cold Reduction)	9,918/10,933
- Two Weirlite Mills (Cold Reduction)	2,056/2,267
- Eight Temper Mills	NA
- One Sheet Mill Cleaning Line - Two Tin Mill Cleaning Lines - One Tin Mill Chemical Treatment Line - Three Tin Mill Continuous Annealing Lines	5,923/6,529
- A Strip Steel and Sheet Metal Batch Annealer	NA
- A Tin Mill Batch Annealer	NA
- Four Hot Dip Galvanizing Lines	1,714/1,889
- One Electrolytic Galvanizing Line - Three Electrolytic Galvanizing Line - One Electrolytic Plating Line (Chrome or Tin)	NA

TABLE 4-5

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

WATER DISCHARGE QUALITIES*

SOURCE	FLOW m^3/hr (gpm)	pH	T $^{\circ}C$ ($^{\circ}F$)	SS	OIL	TDS	ALK-M (as $CaCO_3$)	HARDNESS (as $CaCO_3$)	SO_4	Cl	NH_3	PHENOL	CN	F	REMARKS
LAKE	-	8.4		8	0	172	103	134	22	10	0.1	0.003	0.01	0.2	
OUTFALLS															
001	114 (500)			10	2.3				84	20				0.2	
002	20960 (92200)		5.5 (10)	8.2		185	100								
003	1300 (5700)	7.8		10	3.8				28	52	0.2	0.01	0	0.17	
005	1770 (7800)	8.2		14	4.3				26	11	0.1	0.004	0	0.18	
007	6182 (27200)		8.9 (16)												Lake Water Quality
008	9545 (42000)		4.4 (8)												-"-
011	25900 (114000)		6.7 (12)												-"-
012	3068 (13500)		19.4 (35)												-"-
013	13600 (60000)	8.1	3.9 (7)	18	3.3		90	140	31	16	0.6	0.017	0.01	0.2	
014	18200 (80000)	8.1	3.9 (7)	17	3.4		90	140	30	16	0.6	0.017	0.01	0.2	
015	5680 (25000)		12.2 (22)												Lake Water Quality
017	26820 (118000)	8.5		20	0.4				24	16				0	
018	18455 (81200)	8.5		8.2	0.1	185	105		35						
DISCHARGES TO EAST CHICAGO SANITARY DISTRICT FROM COKE PLANTS															
No.2	(200)			100-200							50-100	100-200	3-4		Estimated Quality
No.3	(160)			100-200							50-100	100-200	3-4		-"-
Battery 11	(400)	6-9		90	16	5050				2595	60	0.2	3		

* All concentrations except pH in mg/l

	Daily Capacities in kkg/ton
- A Boiler House	-
- A Power House	-
- A Hydrochloric Acid Recovery Plant	-
- A Palm Oil Recovery Plant	NA
- An Acetylene Plant	-

4.2.3.2 Water Systems and Distribution

Most of the water used at the plant is drawn from the Ohio River. A pump station on the river provides approximately 38,700 m^3/hr (170,300 gpm) of service water to the plant. Potable water, for sanitary purposes, is supplied by the City of Weirton or from the Weirton Steel Division potable water treatment plant. All sanitary wastewaters discharge to the City of Weirton Sewage Treatment Plant located south (downstream) of the steel plant.

The water use at the plant is shown on Figures C-1 and C-2 (Appendix C). Generally, a small portion of non-contact cooling water is recycled or reused. However, the plant will, in the near future, place in operation an extensive gas washer recycle system at the blast furnaces.

Discharges from the plant are through four outfalls, two to the Ohio River and one to Harmon Creek, a tributory of the Ohio River. The fourth outfall discharges the treated wastes from the Browns Island Coke Plant biological treatment plant. The discharges from "A" Outfall to the Ohio River are from the blast furnaces, the power and boiler houses, the sinter plant, a portion of the primary and secondary hot forming mills, some of the cleaning lines and the temper mill. The second outfall, to the Ohio River, identified as "B" Outfall, receives water from the demineralizer plant, the tin plating lines, the continuous annealing lines and the "Weirlite" (cold reduction) lines. The outfall to Harmon Creek ("C" and "E" Outfalls) receives all of the other plant discharges through two sewer systems (Sewers "C" and "E"). The flows to "C" sewer are from a major portion of the secondary hot forming mills, the rinse and fume scrubbing water from the continuous picklers, the acid regeneration plant, an oil recovery facility and the carbide and diesel shops. The flows to "E" sewer are from the balance of the cleaning lines, the BOP and vacuum degassing shop, the continuous caster, the detinning plant and the coal washing facility. The two sewers join for common treatment in two lagoons and then discharge to Harmon Creek.

Details of the water system are described in Appendix C.

4.2.3.3 Waste Treatment Facilities

The Weirton Steel Division treats most of its wastewater, to some degree, prior to discharge.

All flows from "A" Outfall will be from two parallel lagoons which are presently under construction for the removal of suspended solids and oil. The waters are treated, to some degree, prior to discharge to the lagoons. The blast furnace recirculation system discharges pass through suspended solids removal and cooling facilities. Boiler house waters, including the feed water softener discharge have suspended solids removal facilities. All of the contact water discharges from the primary and secondary hot forming mills, in the "A" sewer area, pass through scale pits prior to discharge to "A" sewer. Sinter plant wastes are treated for solids removal in rotoclones. Oil from the Temper Mill is collected and not discharged.

All flows to "B Outfall" pass through a lime neutralization facility and then through two parallel lagoons for the removal of suspended solids and oil. In addition, prior to discharge to "B" sewer wastes from the cold reduction "Weirlite" lines are treated for oil removal.

The flows to "C" sewer, from the hot forming mills, are treated in scale pits prior to discharge. The flows to "E" sewer, from the BOP and vacuum degassing facilities, are settled prior to discharge and the major portions of the solids from the continuous caster are removed in flat bed and pressure filters before blowdown. Coal washing solids are removed by settling.

Detailed descriptions of the water treatment facilities are given in Appendix C.

4.2.4 United States Steel Corporation - Fairfield Works

4.2.4.1 Processes and Facilities

United States Steel Corporation's, Fairfield Works is a completely integrated steel plant located on a 790 hectare (1,950 acres) site approximately 5 km (3 miles) southwest of Birmington, Alabama. The integrated facilities located on the site, which produce finished and semi-finished products, consist of:

Facility	Daily Production Capacity kkg/ton
- Ore, Coal and Flux Storage Areas	24 ha (60 acres)
- A Four Battery By-Products Coke Plant	5,960/6,570
- Four Blast Furnaces	9,767/10,766
- One Three-Vessel Q-BOP Shop	6,050/6,669
- A 46-inch Slab Mill	4,666/5,143
- A 45-inch Blooming and Slab Mill	3,418/3,768
- A 140-inch and 110-inch Plate Mill	1,666/1,836
- A 21-inch Billet Mill	1,241/1,368
- A 11-inch Merchant Mill	612/675
- A 24-inch Structural Mill	1,059/1,167
- A 68-inch Hot Strip Mill	5,051/5,568
- Two Strip Pickling Lines	4,049/4,458
- One Rod Batch Pickling	509/561
- Two Cleaning Lines	1,424/1,569
- One Continuous Annealing Line	822/906
- Three Cold Rolling Mills	4,812/5,307
- Three Temper Mills	NA
- One Wire Drawing Mill With Pickling	480/529
- Three Strip Tinning Lines	1,268/1,398
- Three Strip Galvanizing Lines	1,525/1,680
- One Wire Galvanizing Line	267/294
- One Paint Line	313/345

A sinter plant is located approximately 9.6 km (6 miles) away.

4.2.4.2 Water Systems and Distribution

Water for the plant is drawn from the City of Birmingham, Alabama water supply system. Approximately 3,955 m^3/hr (17,400 gpm) are required as makeup to the plant. Almost 80 percent of the water applied at the plant production processes is recirculated, 5 percent of the water used is discharged to Oppossum Creek and the balance is lost to evaporation or disposal of sludge.

All plant wastes are subjected to some degree of treatment prior to final discharge to Oppossum Creek. A detailed description of the water systems is presented in Appendix D, and is schematically shown on Figures D-1 and D-2.

Non-contact cooling water at the blast furnace is cooled and recycled in two cooling systems and the blowdowns are used for the makeup to the two gas cleaning recirculation systems. The Q-BOP system recirculates most of the gas cleaning water and the non-contact cooling water is used as makeup to one blast furnace non-contact cooling water recirculation system. The primary and secondary hot forming mills discharge their wastes, after passage through scale pits, to a two pond system for recirculation. Portions of the wastes from the cold reduction, plating and service facilities also are discharged to the two ponds. A portion of the blast furnace spray pond water is combined with the pond recirculation water. All other wastes are discharged to the final effluent control pond prior to discharge.

The sinter plant, located remotely from the plant, receives 77 m^3/hr (340 gpm) from the Birmingham City Water System for use in the sinter process and 53 m^3/hr (235 gpm) for sanitary uses. Approximately 55 percent of the water is recirculated water and the plant discharges approximately 125 m^3/hr (550 gpm) to Valley Creek.

4.2.4.3 Waste Treatment Facilities

All wastewaters from Fairfield Works are treated prior to discharge from the plant. Discharges from the blast furnaces (blowdowns from the gas cleaning system) are settled in three clarifiers for solids removal and the solids are sent to the sinter plant. A portion of the blowdown is used for slag quenching.

Solids are removed from the Q-BOP gas cleaning water in a desilter and a clarifier. Coke plant wastes are treated for removal of pollutants in a proprietary process followed by biological treatment, settling in two clarifiers and treatment in a final settling basin.

Approximately 40 percent of the wastewater from cold rolling finishing and plating operations is treated for oil and metal removal in lagoons followed by a chemical treatment system prior to discharge. Solids are dewatered and sent to a landfill. The remaining 60 percent of the wastewaters are discharged to a pond system together with all of the waste from the primary and secondary hot forming mills.

The wastes from each of the hot forming mills pass through scale pits prior to discharge to the primary and secondary settling ponds, which operate in series. Of the total wastes discharged to the ponds approximately 90 percent of the secondary settling pond effluent is recirculated back to the hot mills and the blast furnaces. The remaining ten percent is directed to the final effluent control pond prior to discharge to Opposum Creek. Waste pickle liquor is disposed of in a deep well.

Detailed descriptions of the waste treatment systems are given in Appendix D.

4.2.5 Youngstown Sheet and Tube Company - Indiana Harbor Works

4.2.5.1 Processes and Facilities

The Youngstown Sheet and Tube Company's, Indiana Harbor Works is a completely integrated steel plant located on a 525 hectare (1,300 acre) site on the southern shore of Lake Michigan in East Chicago, Indiana. Production facilities at the plant area:

	Daily Capacity kkg/ton
- One By-Product Coke Plant	3,629/4,000
- One Sinter Plant	3,625/4,000
- Four Blast Furnaces	9,525/10,500
- One Eight-Furnace Open Hearth Shop	6,895/7,600
- One 2-Vessel Basic Oxygen Furnace Shop	9,525/10,500
- A Slabbing Mill	8,165/9,000
- A Blooming Mill	3,810/4,200
- An 84-inch Hot Strip Mill	10,200/11,250
- A Seamless Tube Mill	635/700
- A Continuous Butt Weld Tube Mill	757/834
- Three Continuous Pickling Lines	8,400/9,260
- Two Cold Reduction Sheet Mills	3,295/3,630
- Two Tin Mills	2,295/2,530
- A galvanizing Shop	895/984

Support facilities at the plant include a boiler house and a power plant. The boiler house, in addition to supplying steam for the power plant operation, supplies steam for other in-plant uses.

4.2.5.2 Water Systems and Distribution

A water supply of approximately 38,300 m^3/hr (168,400 gpm) is drawn from Lake Michigan through three intakes for the Indiana Harbor Works. An additional 1,820 m^3/hr (8,000 gpm) is supplied, by the plant, to the nearby Sinclair Oil Company refinery. Four pumping stations distribute the water to the plant and to Sinclair Oil. Of the total 84,300 m^3/hr (371,000 gpm) water required approximately 52 percent is recycled within the plant. A flow diagram illustrating the Indiana Harbor Works water system is shown in Figure E-1, Appendix E.

Process wastes from the coke plant are pumped to the East Chicago treatment plant. Non-contact cooling water is cooled and recycled back to the coke plant and the cooling tower blowdown is used for coke quenching. Non-contact cooling water from the sinter plant and blast furnaces is on a once-through basis. Gas cleaning waters are recirculated at the blast furnaces and the system blowdown is used for slag quenching.

All other plant wastes, with the exception of waste pickle liquor and cooling water, pass through a treatment plant prior to discharge. Waste pickle liquor is trucked to a shallow well for disposal and cooling water is discharged to Indiana Harbor.

All water from the Seamless Pipe Mill is discharged to the intake of Pumping Station No. 2. All wastes from Cold Strip Mill No. 3 and Hot strip Mill No. 3 are recycled to Pumping Station No. 3.

Wastes from all other facilities are discharged after some treatment.

A detailed description of the water systems is given in Appendix E.

4.2.5.3 Waste Treatment Facilities

Waste treatment facilities are located at various points in the plant, at or near production facilities, to treat specific wastes or at outfalls to treat combined wastes prior to discharge or recycle.

Wastewater from the Flat Rolling Mills are treated chemically and physically for oil and metal removal. Blast furnace gas cleaning water is treated for solids removal and is cooled prior to recirculation. Wastewater from the Continuous Butt Weld Mill passes through a scale pit and is then filtered prior to discharge. The filter backwash is discharged to the main scale pit for further treatment. The wastewater from the open hearth shop is passed through grizzlies, classifiers and thickeners and then discharged to the main scale pit.

Wastewater from the Seamless Pipe Mill is discharged to a lagoon and then to No. 2 Pump Station intake where it is mixed with lake water and distributed to the plant via Pumping Station No. 2 and the low head pumping station. The wastewater from Cold Strip Mill No. 3 and Hot Strip Mill No. 3 are treated at a chemical treatment plant and a scale pit and then filtered. The filtered wastes, together with the non-contact cooling waters from both mills, are discharged to a lagoon and then discharged to Pump Station No. 3.

Detailed descriptions of the waste treatment facilities are given in Appendix E.

4.2.5.4 Discharge Qualities

The reported qualities of the various discharges from Youngstown Sheet and Tube Company's Indiana Harbor Works are presented in Table 4-6.

4.3 PROBLEMS EXPECTED TO BE ENCOUNTERED

4.3.1 Common Problems

Generally speaking, steel plants in the United States are from 40 to 80 years old and most were constructed on the basis of changing demand, requirements of wars and technological advances. As a technology became obsolete a facility was torn down and the new facilities were sometimes built upon the old foundations. Sewers are usually combined, mainline railroad tracks run through the centers of many plants and the plants usually occupy large tracts of land. Thus, in many cases, like production facilities are separated. In other cases plants are "shoe-horned" between a river and the cliffs of the river valley with very little room for expansion or installation of additional support facilities. The realities of steel plant site specific configurations cause considerable problems in a steel plant when major plant-wide programs are envisioned. At some plants storm water from residential areas outside of the plant is carried in through the plant and the plant storm water is added. In many cases, process waters are combined with storm flow and discharged through common plant outfalls.

Segregated sewers were basically unheard of until the 1950's when separate sanitary sewer construction was required of the plants. These sanitary sewers were small because of the small domestic flows, but their installation proved, even in 1950 dollars, to be extremely costly and the construction severely interfered with the normal production cycles in the mills. Envisioning the further segregation of industrial wastewater from storm sewers presents a picture which could indicate the complete shutdown of a mill during the segregation period. Alternately, construction of separate industrial wastewater force mains is also a tremendous task, for where will these force mains be located and how will obstructions of the normal production operations be avoided during their installation? If these force mains run above ground some means of freeze protection may also be necessary.

Infiltration of sewers and sumps by ground water is another problem. During shutdowns, due to strikes or other reasons, it has been noted that even though process water lines have been shut off sump pumps are continuously needed and sewers are never dry. The old sewers and sumps, and some of the new ones, are subject to groundwater infiltration and it would be

TABLE 4-6

YOUNGSTOWN SHEET AND TUBE COMPANY

INDIANA HARBOR WORKS

TREATED WASTEWATER DISCHARGES*

Parameter	Outfalls 001	002	009	010	011	To E. Chicago Treatment Plant
pH	7.6	7.7	8.0	8.2	8.1	9.0
Temp	65	65	70	64	60	
S.A.	15	10	6	10	15	55
Oil	6	4	4	4	5	43
TDS	641	272	243	253	344	
NH_3	2.2	1.8	1.5	1.9	2.5	195
CN	0.07	0.05	0.05	0.25	0.55	10
Cl	41	39	30	35	50	1650
SO_4	140	38	35	47	42	
Fl	0.5	0.4	0.3	0.3	0.4	
Tot Cr	0.01	-	-	-	-	
Zn	0.05	-	-	-	-	
Tin	0.2	-	-	-	-	
Phenol	0.006	0.005	0.006	0.006	0.006	80
Alk						940

* With the exception of discharges to East Chicago Sewage Treatment Plant all data are from plant computer printouts.

virtually an impossible task to restore infiltration free integrity to these installations.

Information availability is also a problem since many steel plant installations were and are partially "engineered" in the field and the existing drawings do not reflect the actual location and, in some cases, the size of pipelines and sewers. In many cases, drawings of any kind do not exist because they have been lost or were never made. Extensive investigatory excavation is needed for most plants just to find pipelines or sewer locations, sizes and elevations.

If recirculation and/or cascade of treated or untreated waste flows to the industrial water mains is contemplated, thorough hydraulic investigations are necessary to insure that pipeline capacities are adequate. In many cases large portions of the existing piping networks may have to be replaced.

4.3.2 Specific Plant Problems

During the course of this study of the five steel plants, as would be expected, specific problems were identified that would be encountered at each that may or may not be encountered at others. Some examples are:

1. The Inland Steel Company plant, at Indiana Harbor, is actually three steel plants that were constructed side by side as the needs arose. Due to this stepwise expansion similar production facilities producing like wastewater discharges are separated by many thousands of feet. The collection of these similar wastewaters for joint treatment at common treatment facilities would be extremely expensive and impractical. The plant also has the problem of infiltration into underground sumps and sewers. Although sumps may be reconditioned and made watertight it would be virtually impossible to create watertight integrity to the miles of the sewer networks in the plant. The age of the plant would preclude the availability of accurate up-to-date drawings of the sewer systems. In the older sections of the plant space for the construction of waste treatment facilities is at a premium either because of the close proximity of buildings to each other or the location of railroad tracks between buildings.

2. United States Steel's, Fairfield Works is located on a large site and all of the wastewaters eventually discharge into drainage ditches which also receive storm waters from the plant area and roof runoff. Segregation of storm water, process water and non-contact cooling waters for discharge and treatment would necessitate the installation of extensive flow diversion and collection systems. In addition, a separate storm water collection system would be required for runoff from material storage areas.

3. National Steel Corporation's, Weirton Steel Division occupies a long narrow compact site which is bisected by a main highway. Land is at a premium within the plant and land outside of the plant that may be available for purchase is located in topographically unfavorable areas, i.e., at a higher elevation than the plant. All sewers in the plant are combined and segregation would entail the construction of an extensive above ground piping network to transport wastes to and from treatment facilities. The segregation of wastes within the individual mills in the plant would require periods of mill shutdown for the installation of the required facilities.

4. Kaiser Steel Corporation's Fontana plant is located on a compact site which would make segregation of sewers difficult. Climatic conditions at Fontana favor solar evaporation of some wastes but this method of disposal is unique to Fontana. Fontana is also fortunate in having the presence of a contractor, on the plant site, who can use a waste (waste pickle liquor) that other plants have to undergo capital and operating expenses to dispose of. Due to the short intensive periods of precipitation experienced at Fontana disproportionately larger storm water storage ponds are required to retain material storage pile runoff.

Kaiser Steel has a contractual agreement with the Chino Basin Municipal Water District, whereby, they are to pay a standby user charge of approximately $41,000 per year for the sewer leading to the County of Los Angeles treatment plant. This charge is levied whether or not the sewer is used and, if the plant were to achieve total recycle and not discharge any wastes to the sewer, they would still be required to pay the charge. The contract extends to the year 2025.

5. Youngstown Sheet and Tube Company's Indiana Harbor Works occupies a large spread-out site where long runs of segregated sewers would be required to reach treatment facilities.

Although all of the plants studied have problems in common and problems specific to each, they do not all have the same types of production or waste treatment facilities. Therefore, in the evaluation of each plant, their specific production facilities over and above those that meet the basic definition of an integrated steel plant have to be evaluated with respect to treatment unit operations required to achieve the desired effluent goals. The existing waste treatment facilities also have to be evaluated to determine their compatibility with any system anticipated to meet the desired goals. Specifically, some of the differences between the plants are: all but one of the steel plants studied have electrolytic tinning lines; one plant has oil recovery and hydrochloric acid regenerations on its site; two plants discharge coke plant wastes to a municipal biological treatment plant and two plants operate their own biological treatment plants, all plants have galvanizing processes, either hot dip or electrolytic or both; two plants utilize water for air pollution control at the coke plant during pushing operations for a portion of the batteries.

SECTION 5.0 TECHNIQUES FOR ACHIEVING BAT AND TOTAL RECYCLE

In preparing this study, a basic question that had to be resolved was what could be considered proven technology and what was applicable or available technology. Applicable technology did not present as much of a problem as did proven technology. The definition of proven technology used in the analyses in this report was that if a full-sized system is operating or has operated successfully for a reasonable period of time under any circumstances, it was considered as proven. For example, if a two-stage biological oxidation system was operated treating coke plant water successfully by engineers and graduate chemists for a 24-hour a day basis for a month, it can be considered as proven. The fact that a routinely operated plant does not normally operate with engineers and graduate chemists is indicative of the training required of operators and the degree of instrumentation required to be incorporated in the plant design. In addition, proven technologies were not considered to be only those technologies that had operated successfully at steel plants, but those that operate successfully in other types of industries treating similar wastes.

5.1 RECYCLE AND REUSE

The primary method for conserving water and reducing the quantities to be discharged is by the recycle and reuse of as much water as possible. Recycle, within a steel plant, is the use of water more than once within a given production facility and reuse (also referred to as cascading) is the use of water discharged from one facility to another facility. The governing criterion is the minimum quality of water required at each facility.

Water cannot be indefinitely recycled at any facility because of the decrease in water quality in each passage through a process. Certain completely "bottled-up" systems do not have quality decreases but they represent a very small portion of water use in steel plants and are considered to be an exception. The quality may be degraded due to a pickup of contaminants by contact with the product, by concentration of contaminants due to evaporation of water, or both. An example of recycle is blast furnace gas cleaning recycle systems where, by contact with the blast furnace gases, both of the described phenomena occur. As the gas is cleaned, solids are scrubbed out and small amounts are dissolved when added to a solution of some gaseous constituents from the gas stream being cleaned in the water. In addition, as the gas is being cooled there is some evaporation loss which creates a concentration of dissolved solids that were initially present in the water and also loss of water droplets to the gas. The bulk of the suspended solids are separated from the stream and the water is recycled. When the concentration of dissolved solids has reached a level which is determined by the plant operator to be a maximum, a portion of the water is discharged and water is added (either continuously or intermittently) from another source which has a lower dissolved solids concentration. The quantity of makeup water is equal to the sum of the water lost through evaporation, tower windage, and intentionally discharged (blowdown) less the quantity of water condensed from the gas stream due to the moisture content of the burden.

Another example of recycle is the use of water at a hot rolling mill. Water applied for bearing and roll cooling and the descaling operation is usually partially recycled to flush the solids that are deposited in the flume to the scale pit (flume flushing). (21).

Examples of reuse can be seen in the blast furnace area where water is required for furnace cooling. The heated water is usually cooled in a cooling tower or spray pond. The increase in contaminant concentration is due to evaporative losses during cooling and dust pickup and the dissolved solids levels are controlled by discharging a portion of the water. Makeup is with water with a lower dissolved solids concentration. The water blown down from the furnace cooling facility may then be used as makeup to the gas cleaning system where a lower quality water can be tolerated.

It can be seen from the above discussion that the quality of water required at each facility is the factor that governs the degree of recycle and reuse. In some facilities, water with low suspended solids is required, in others low dissolved solids is the only basic requirement. (22).

Table 5-1 illustrates the procedures that may be required prior to use of water at various production facilities and the required uses of that water.

When the type of treatment to be utilized is being determined consideration must be given to the consequences of the treatment process used. If a system is designed with the goal of complete recycle, it must not include the addition to the water stream of any substance that would preclude the use of the water at some other point in the plant, and must assure that the consequences of the treatment will not place an added burden on other facilities that might be required further

TABLE 5-1

PROCEDURES TO MAXIMIZE WATER QUALITY FOR REUSE

Procedure	Facility or Type of Wastewater
Improve water recycle at production facility or reduce water use	Blast furnace gas cleaning Pickling rinse Hot forming
Regeneration	Acid at Pickling Chrome plating
Filtration, SS removal	Virtually all wastes
Ultra filtration	Preceding all membrane treatment processes
Cooling	All non-contact cooling waters and some contact waters
Biological Treatment	Coke Plant wastes Blast furnace gas cleaning wastes
Carbon Adsorption	Coke Plant wastes
Chemical Treatment	Oily wastes Between successive membrane processes Ash sluice recycle Blast Furnace gas cleaning wastes
Membrane Treatment	All wastes with high dissolved solids concentrations.

downstream of the reuse cycle.

When the goal of BAT is met, if total recycle is anticipated to be realized at some later date, some facilities that would be required to meet BAT may have to be abandoned at that time because treatment to effect complete recycle may require different unit operations to perform totally different functions. These unit operations for complete recycle may not be necessary or compatible with the unit operations required to achieve BAT. For instance, if lime precipitation is installed for BAT, then when total recycle is required and facilities must be installed to remove dissolved solids, the lime precipitation operation may no longer be required.

Guidelines established for the Iron and Steel industry consider pollutants that can be classified into various groups and sub-groups. Specifically these are: Suspended solids, dissolved solids, and oils and grease. The dissolved solids may be subclassified as: those amenable to biological treatment, those amenable to physical treatment, and those amenable to chemical treatment. Chemical treatment is used for breakage of oil emulsions, reduction of metals, precipitation of metals, and treatment of regulated compounds for conversion to a compound that is not regulated. For example, ammonia, a nitrogenous compound normally present in coke plant waste is a regulated parameter. Nitrites and nitrates are not regulated. Therefore, by oxidizing ammonia to nitrite or nitrate, an alternative, non-regulated compound of nitrogen would be formed and permitted to be discharged.

Biological treatment takes advantage of the metabolic activity of microorganisms to utilize pollutants as a food and oxidize organics and some inorganics to the energy required for existence and reproduction, and thereby effectively removes the pollutants.

In physical treatment, the waste stream is altered without chemical changes. Examples are the cooling of heated water and the removal of suspended solids or oils in filters or gravity separation facilities.

The basic unit operations required at each plant to maximize recycle and reuse of water are suspended solids removal facilities.

It is virtually impossible to hypothesize typical integrated steel plant operations unless a greenfield plant were built with the goal of total reuse of water integrated in the planning of production facilities. Existing steel plants each have their own unique production configurations which, at the time of individual production unit construction, may have been decided upon due to prior existing facilities, size of the new facility, existing production units relying on the facility being built, storage areas required, and transportation both existing and required. Therefore, a single integrated water use system may not be feasible at an existing individual integrated steel plant and two or more satellite systems may be required within the plant.

Of the integrated steel plants investigated in this study, the Kaiser Steel Plant at Fontana, CA. is the closest to maximizing the use of water both in original concept and actual application. The concept of the plant is to first use all incoming plant water where the highest quality is required, with subsequent users receiving water from a previous user, either treated or untreated, until the water is of a degraded quality, usually too high in dissolved solids, to preclude its further use without adversely affecting either product quality or the proper operation of equipment. When the water reaches this stage of degraded quality, it should be treated in more sophisticated operations to produce reusable water and to reduce the quantity of reject to a minimum. These operations will produce water with dissolved solids levels low enough for reuse, and a brine material which will require disposal.

A result of treating this brine is dry soluble solids requiring further disposal. Due to the wide variety of solids removed from the brine, a market for their disposal, at this time, cannot be envisioned.

Therefore, a complete investigation of a water system at an integrated steel plant, or any industrial water user must, of necessity, include determination of: the source(s) at the plant boundary, the users, the quantities of water required, the treatment required prior to use, the treatment required for reuse, the plant hydraulics, the unit operations for ultimate disposal of the final water stream, ground water protection, disposal of the solids remaining after the brine stream is eliminated, the power requirements, the fuel requirements and disposal of stormwater runoff from material storage areas. The investigation must be approached from the standpoint of technical applicability with regard to cost.

The following sections present the procedures used for the selection of treatment processes for the three types of waste streams in an integrated steel plant that may be the most controversial. These are: treatment of coke plant and blast furnace water, treatment for the removal of dissolved solids from a residual waste stream and disposal of the residual solids and the methods of cooling water prior to reuse.

All costs cited are based on quotes obtained from vendors of the equipment or processes cited, standard estimating procedures and in-house data.

5.2 TREATMENT OF ORGANIC COKE PLANT WASTES

Developing possible processes for the treatment of coke plant wastes to meet the provisions of BAT and total recycle required the investigation of various existing treatment systems and a thorough search of the available literature.

Removal of phenol by physical-chemical systems has not been reported to reliably reduce the phenol concentration to that required for discharge (2), however, properly acclimated biological systems can produce effluents with phenol concentrations of 0.025 ± 0.01 mg/l.

Removal of cycanide in biological treatment plants has been shown to be accomplished, but with a penalty. Destruction of cyanide and thiocyanate produce ammonia as a by-product which would be added to the initial ammonia loading to a biological system. However, some cyanide will not be destroyed in the treatment system but will be discharged in low concentrations of complexed cyanide which has been reported not to be toxic (4). Others have reported metal cyanide complexes, specifically zinc and cadmium complexes, which are toxic, whereas others, nickel and copper cyanide, are not. However, the most recent studies (2, 3) have shown that biological treatment will remove cyanide to the required BAT levels.

The consensus of the literature is that biological oxidation is the most promising route to follow to remove the regulated parameters not removed by physical-chemical means. Regulated parameters that can be treated biologically include cyanides, phenols and ammonia.

Ammonia appears to be the most difficult of the BAT regulated parameters to remove. Ozonation and activated carbon adsorption do not exhibit any appreciable removal of ammonia. Although biological treatment will remove ammonia from the waste stream, it has been reported that ammonia concentrations in excess of 2000 mg/l will inhibit the phenol oxidation rate (1). Other investigators also refer to the requirement for the pre-treatment of coke plant waste for ammonia removal prior to biological oxidation (2, 3).

In addition, unless biological systems are specifically designed to remove ammonia, an increase in the ammonia discharged over the ammonia entering the system will be experienced due to the cyanide and thiocyanate oxidation.

Therefore, pretreatment is necessary to permit sufficiently low loadings of ammonia to enter the biological system. This pretreatment should be applied to the weak ammonia liquor prior to combining this waste with benzol wastes and other wastes from the by-products coke plant.

Removal of ammonia from the weak ammonia liquor in ammonia stills is reported to produce effluents from free and fixed ammonia stills of from 50 to 460 mg/l of NH_3. A method of ammonia stripping has been developed to discharge 50 mg/l total ammonia (5). Another alternative is to prevent the ammonia from entering the waste stream initially and thereby eliminate the requirement for nitrification of ammonia. Such a method has reportedly been developed, in which ammonia and hydrogen sulfide are completely eliminated from coke oven gases, their condensates, desorption gases and vapors (6).

Biological nitrification has successfully been accomplished in operating municipal and industrial waste treatment facilities by activated sludge and extended aeration processes. Rotating biological contactors show promise and manufacturers claim that they are applicable to this type of treatment. In addition, laboratory studies have indicated that nitrification of ammonia can be accomplished and indications are that greater removal efficiencies are attainable (2, 3). Municipal wastes utilizing two stage biological treatment in which the nitrification efficiency approaches 100 percent under proper operating conditions has been documented (3).

Recently, an industrial waste treatment plant has demonstrated its ability to achieve nitrification of ammonia to less than 1 mg/l on a mean raw waste load of 75 mg/l in a single stage operation (8).

On the basis of the available data (and the in-house data of the contractor), ammonia stills followed by biological oxidation of coke plant wastes is the most feasible path to follow at this time.

Wastes discharged from Blast Furnace gas cleaning systems have the same potential pollutants as are present in coke plant wastes, i.e., ammonia, cyanide, phenol and sulfide, albeit in the lower concentrations. It is reasonable to assume, therefore, that these wastes would be amenable to biological treatment in the same facilities that are to be used for coke plant wastes (9). It must be pointed out, however, that blast furnace gas cleaning wastes may contain heavy metals which can be toxic to the biological organisms that would oxidize the wastes (10). Therefore, before instituting a program wherein blast furnace and coke plant wastes are combined for treatment, bench scale and pilot scale studies should be performed, preferably at each plant under consideration.

There is also a limitation on the discharges from blast furnaces with respect to fluoride. Lime precipitation is the recommended method to precipitate the relatively insoluble calcium fluoride. However, further studies are recommended to determine the effect of the increased pH due to the lime addition. These studies could determine if the pH increase will also precipitate the heavy metals, thus eliminating their toxic effect on the biological system, or if the increased pH inhibits the biological process.

In many biological systems presently treating coke plant wastes, dilution water is added to lower the concentration of substances that may be toxic or inhibitory to the functioning biomass in their natural high concentrations. Dilution in an equalization facility preceding the bio-plant aids in assuring the uniformity of wastes fed to the biological treatment system and, therefore, minimizes upsets. Blast furnace gas cleaning wastes, with their low concentration of similar pollutants, are a reasonable source of dilution water providing other constituents of the water would not prove toxic to the system, as discussed above.

In summary, biological oxidation with lowering of ammonia levels presently shows the greatest potential for the treatment of coke plant wastes and is also a possible alternative for the treatment of blast furnace wastes. The treatment methodologies are applicable for treatment to meet BAT guidelines. However, for total recycle, the biological treatment process may be considered as pre-treatment in that there must be a succeeding stage, i.e., removal of dissolved solids. In that event it may not be necessary to attempt to oxidize ammonia biologically since the ammonia would subsequently be removed physically in the succeeding stage.

5.3 SUSPENDED SOLIDS REMOVAL

The removal of suspended solids is required when water is to be reused directly at facilities, such as hot mills sprays, where abrasion and erosion would be a problem. Suspended solids removal is also necessary when the presence of suspended solids could inhibit the efficiency of a subsequent treatment step. Examples are ion exchangers, carbon absorption columns and membrane type facilities.

Suspended solids removal is a well established technology and is given minimal consideration in this study. Removal of suspended solids concentrations down to levels of 10 mg/l have been accomplished in many steel plants by proper use of removal facilities. If the waste water contains large particles of high specific gravity, plain sedimentation in properly designed sedimentation basins will accomplish the desired removal. An example of this type of treatment is a scale pit usually installed at a hot mill.

If, due to stricter treatment requirements, an increase of flow to an existing settling facility is to be experienced which would create excessive turbulence, reducing the efficiency of particulate settling, modifications may be made in most cases, to accomplish the desired removal. These modifications could be the installation of tilted tubes or plates to reduce the length of the path of the particulates' travel facilitating removal from the water. Modifications of this type would entail a capital cost with little operating costs if cleaning of the plates or tubes, due to adherence of oil and solids, is not a chronic problem.

Removal of suspended solids with a low specific gravity or very small solids of high specific gravity may be enhanced by the addition of chemical aids. The addition of polyelectrolytes may allow the use of existing settling facilities by permitting higher overflow rates due to the enhanced settling characteristics of agglomerated solids.

Filtration in either pressure retaining or gravity granular media filters is a well established and much used means of removal of suspended solids from wastes that arise at various mills in steel plants.

After water has been recycled and reused to a point where the concentrations of dissolved solids are so high that there is no point in the plant that it can be reused effectively, it must be treated to remove these dissolved solids.

5.4 DISSOLVED SOLIDS REMOVAL

After water has been used and reused to the point where it cannot be used any further without some detrimental effect on the water system, the product, or the production facilities, it must either be disposed of or treated in some ultimate treatment facility to upgrade it to a quality fit for reuse. The governing parameter is the removal of dissolved solids to a concentration which permits the water to be reused. An alternative to treatment for reuse is complete disposal. Since the objective of this study is the total recycle of water, disposal either via discharge or evaporation without recovery, is not considered further.

Various technologies which permit the reuse of water having high dissolved solids concentrations were considered. Not all technologies examined are presently being used in the iron and steel industry, but are considered here because, with adequate research and development, as well as transfer of technology from other industries, these technologies may be applicable.

Seventeen possible pretreatment and treatment processes were considered for application for the removal of dissolved solids from waste streams. Certain processes, because of their specificity for removing only certain types of dissolved solids, were eliminated, leaving only four processes to be considered in detail. In the detailed consideration, pretreatment requirements were included as a part of the total operation. Therefore, treatment systems, rather than individual unit operations, were compared. Comparisons were based on an assumed influent to the system of 2270 m^3/hr (10,000 gpm) with a dissolved solids concentration of 1500 mg/l. The water quality after treatment was assumed to contain a dissolved solids concentration of 175 mg/l.

5.4.1 Review of Possible Processes

The initial seventeen processes considered for pretreatment and treatment were:

Air Stripping

Biological Oxidation

Carbon Adsorption

Chemical Oxidation

Electrodialysis

Evaporation

Filtration

Flotation

Freeze Crystallization

Freeze Drying

High Gradient Magnetic Separation

Ion Exchange

Ozonation

Precipitation, Flocculation, Sedimentation

Reverse Osmosis

Steam Stripping

Ultrafiltration

Consideration has been given only to the removal of inorganic dissolved solids in this section. Removal of organic dissolved solids has been discussed in a previous section of this section. The removal of organic compounds will produce inorganic compounds which will, in turn, require removal using the methods studied.

Of the seventeen methodologies listed above - filtration, flotation, high gradient magnetic separation and ultrafiltration are applicable only for suspended solids removal and are discussed as a pretreatment operation. Chemical oxidation, biological oxidation, carbon adsorption and ozonation are primarily applicable to organics and are not further considered in the removal of inorganic dissolved solids.

Precipitation, flocculation and sedimentation, although actually three separate unit operations, are considered as one operation with respect to the removal of dissolved and suspended solids. Precipitation will remove some dissolved solids by virtue of selective chemical reactions, but there will always be a residual of excess reactants and ions not entering into the reactions. Therefore, the total dissolved solids concentration would not be appreciably reduced and would usually be increased. Flocculation and sedimentation are usually required for removal of fine particulate matter that may result from precipitation reactions.

Steam stripping or air stripping are methods that are applicable for the removal of some organic compounds and a few inorganic compounds. Since air and steam stripping are technologies that could not be universally useful for removal of all dissolved solids, they were not considered any further.

Freeze drying and freeze crystallization are exceedingly energy intensive and require high capital costs. Preliminary estimates have shown that the capital costs are in the order of five orders of magnitude higher (100,000 times) than other methodologies considered and were eliminated from further consideration.

Therefore, the technologies remaining for removal of inorganic dissolved solids are evaporation, electrodialysis, reverse osmosis and ion exchange. The latter three methodologies each require pretreatment for the removal of suspended solids to as close to zero concentration as is possible for protection of the system. The suspended solids removal systems considered were: sedimentation, high gradient magnetic separation, granular media filtration and ultrafiltration.

The efficiency of sedimentation is dependent upon the size and specific gravity of the particulate matter introduced into the system and is susceptible to upsets due to thermal effects, mechanical breakdown of equipment and the efficiency of the sludge removal process. While efficiencies can be increased by the use of chemicals, the same chemicals may place an added burden on the succeeding dissolved solids removal unit operations and add to the dried soluble solids disposal operations, which will be discussed later.

High gradient magnetic separation is a methodology which is applicable only to solids influenced by magnetic fields. Therefore, it cannot be relied upon to effectively or adequately pretreat all streams and has only been used on bench scale or pilot plant sized operations.

Granular media filtration is applicable as a pretreatment system for ion exchange facilities but does not appear applicable for pretreatment prior to membrane processes such as electrodialysis or reverse osmosis where zero suspended solids are required to prevent blinding of the membranes. However, granular media filtration is applicable as a first stage of pretreatment. Ion exchangers may act as filters and, by judicious selection of the granular media in filters preceeding ion exchange units difficulty with solids fouling of the ion exchangers should not be experienced. Total evaporation will not require pretreatment unless the suspended solids present will create erosion problems in the liquid injection system.

Of the four dissolved solids removal processes considered, three, namely; ion exchange, electrodialysis, and reverse osmosis, are concentrating processes producing waste streams with a high dissolved solids content, and product streams which are suitable for reuse within the plant (11, 12). The residual high dissolved solids stream must then be disposed of. The fourth dissolved solids removal process, evaporation, is, in fact, a stream disposal system producing both dried soluble solids for disposal, and steam. The steam has not been considered in the report as being recovered.

The four systems were evaluated on the basis of capital and operating costs including the necessary pretreatment steps required. In keeping with the national energy policy, coal has been considered as the source of heat for evaporation.

To produce water that is reusable within a plant by means prior to application on ion exchangers, the waste stream must first be filtered to remove suspended solids. The filtered waste stream is then passed through the appropriate anion and cation exchangers to remove sufficient ions other than hydroxide or hydroxyl. After the resin capacity to exchange ions is exhausted, the cation exchangers must be regenerated with acid and the anion exchangers with alkaline solutions. The regenerants are then mixed for equalization and, if necessary, the pH is further adjusted. Regenerative waste for disposal is approximately 15 percent of the total flow through, and would be evaporated to dryness. Capital costs include filters, exchange columns, exchange resins, chemical storage, dilution and feed facilities, equalization, evaporators, fuel storage, and solids collection equipment.

Operating costs include power fuel, labor, chemicals, maintenance, amortization, and solids disposal.

If ion exchange is used for demineralization, the quantity of dried soluble solids to be disposed of, based on a waste stream of 2273 m^3/hr (10,000 gpm), is 121,000 kkg (133,000 tons) per year. Of this amount 94,300 kkg (104,000 tons) per year is due to the chemicals added to the system for regeneration, pH adjustment, etc. Only 26,900 kkg (29,600 tons) per year would be removed from the waste stream containing the original 1,500 mg/l of dissolved solids. The average quantity of regenerant water to be evaporated would be approximately 340 m^3/hr (1500 gpm).

The capital cost of a complete system to treat 2273 m^3/hr (10,000 gpm) would be approximately $27,330,000 and the annual cost would be approximately $45,600,000 per year. Of the annual cost approximately $17,600,000 would be due to the hauling of solids. If the solids were to be stored on site, the capital cost would be increased by approximately $27,800,000 and the annual hauling costs reduced by $1,340,000. The dried solids to be disposed of for a twenty year period would require a lined storage area 3 meters (10 feet) deep and occupying approximately 83 ha (205 acres).

Power requirements for a total ion exchange facility would be 12.2 x 10^{13} Joules (34 x 10^6 kWh) per year and annual fuel requirements would be approximately 7.6 x 10^{15} Joules (7.2 x 10^{12} BTU) which translates into 476,000 kkg (525,000 tons) per year of coal. An additional 67 ha (170 acres) would be required for ash storage, plus sludges produced due to flu gas desulfurization, if required. If natural gas were to be used approximately 3.4 x 10^8 m^3 (1.2 x 10^{10} ft^3) per year would be required with no ash disposal problems.

The use of electrodialysis and/or R/O is predicated on membranes that are not subject to deterioration or disintegration due to contact with low concentrations of organic compounds. The pretreatment requirement selected for each of these methods is ultrafiltration to prevent the blinding of the semi-permeable membranes by suspended or colloidal particles. To reduce the gross solids loading to protect the ultrafiltration stage the suspended solids must be removed for consistency of product stream using granular media filters. The total residual waste stream from the ultrafiltration and reverse osmosis stages of treatment is expected to be approximately 25 percent of the total throughput. When electrodialysis is used, the residual waste stream is expected to be approximately 20 percent of the total throughput.

The capital costs of these membrane processes include granular media filtration, ultrafiltration, the reverse osmosis or electrodialysis facilities, evaporators, fuel storage, and solids collection. Annual operating costs include power, fuel, labor, maintenance, chemicals, amortization and solids disposal.

The dried solids from the reject stream to be disposed of would amount to approximately 27,000 kkg (29,800 tons) per year from electrodialysis, or 27,200 kkg (30,000 tons) per year from reverse osmosis, and the water to be evaporated would be 455 m^3/hr (2,000 gpm) and 568 m^3/hr (2500 gpm), respectively.

It is estimated that the capital cost would be $34,430,000 for electrodialysis and $39,017,000 for reverse osmosis, with respective annual operating costs of $36,890,000 and $44,530,000.

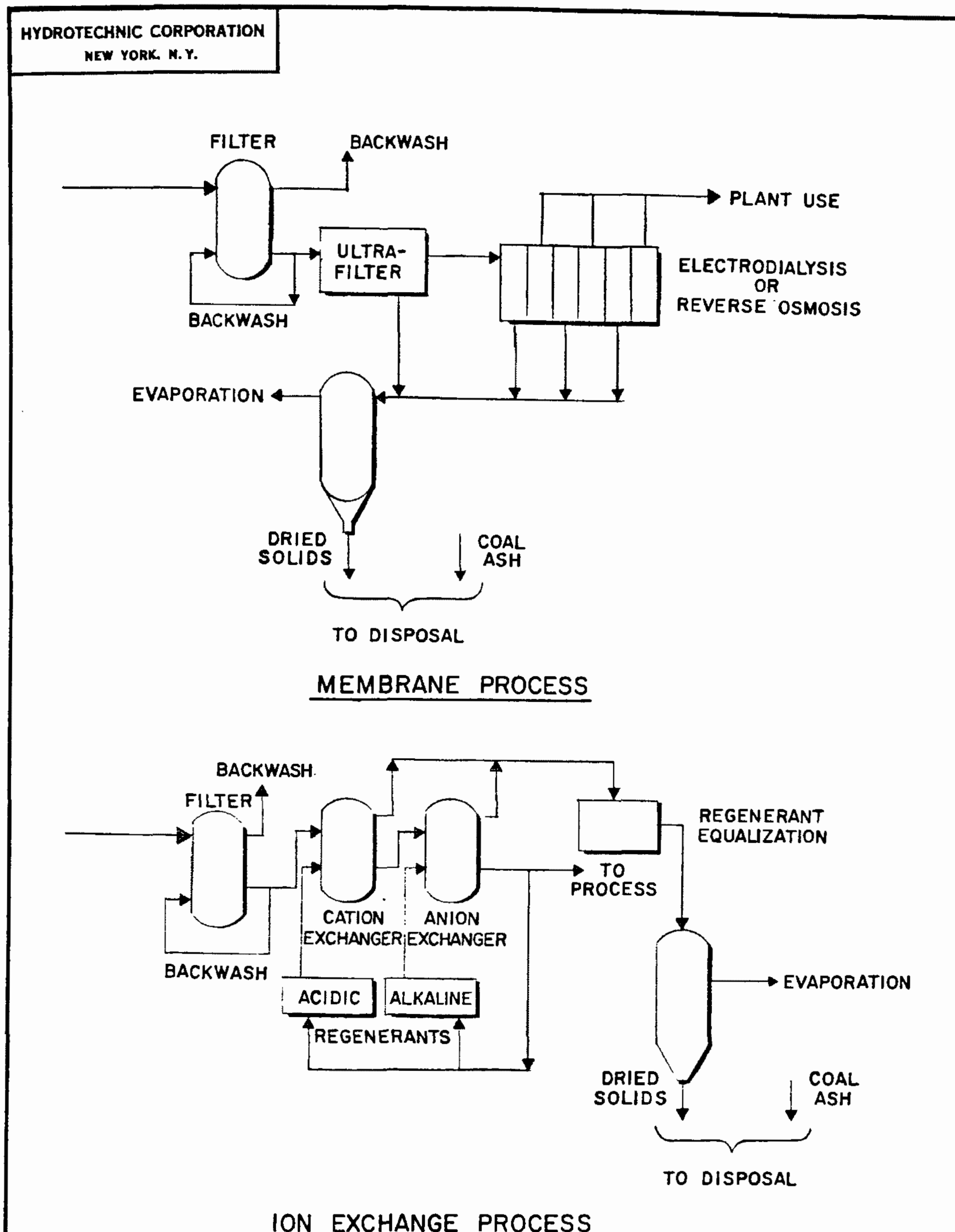
Flow Diagrams of the three systems are shown on Figure 5-1.

Table 5-2 summarizes a comparison of the capital and operating costs and the energy requirements of the three systems.

In addition, a system for total evaporation of the entire 2,273 m^3/m (10,000 gpm) waste stream is presented. It should be pointed out here that none of the comparisons include facilities for condensing the water evaporated for possible reuse. Such facilities would require additional condensing equipment and a condenser cooling water system. These facilities would add significantly to the already high capital and operating costs and add to the volume of wastes requiring treatment due to the cooling system blowdown. The possibility of utilizing the steam for power generation has not been considered because of the unknown purity of the steam produced and its possible effect on turbines.

The major portion of the operating cost associated with all the systems is the ultimate disposal of the dried soluble solids and, when coal is used as a fuel, the cost of bottom ash, fly ash, and flue gas desulfurization sludge disposal. In this analysis coal has been assumed as the heat source.

Figure 5-2 presents, graphically, the costs of the three systems over six years of operation. For comparison, the costs using gas as a heat source has been shown. This comparison vividly shows the effects of coal handling, flue gas desulfurization and excess costs of coal ash disposal on the costs of dissolved solids removal systems.



DISSOLVED SOLIDS REMOVAL PROCESSES

FIGURE 5-1

TABLE 5-2

SUMMARY OF COSTS AND ENERGY REQUIREMENTS

	Pretreatment Costs ($\$ \times 10^6$)		Treatment Costs ($\$ \times 10^6$)		Evaporation Costs* ($\$ \times 10^6$)		Solids Disposal Costs** ($\$ \times 10^6$)		Total System Costs ($\$ \times 10^6$)		Annual Energy Requirements	
	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual	$J \times 10^{13}$ ($kWh \times 10^6$)	$J \times 10^{15}$ ($BTU \times 10^{12}$)
Ion Exchange	1.15	0.25	14.0	8.78	12.18	18.99	-	17.6	27.33	45.62	12.24 (34)	7.635 (7.23)
Reverse Osmosis	9.95	1.83	10.1	2.63	19.12	29.87	-	10.2	39.17	44.53	18.97 (52.7)	12.776 (12.1)
Electrodialysis	9.95	1.83	9.0	3.08	15.48	23.53		8.45	34.43	36.89	11.41 (31.7)	10.18 (9.64)
Total Evaporation					73.29	103		40.8	73.29	143.8	9.4 (26.1)	511.104 (484)

* Includes cost of flue gas desulfurization.

** Assumption is that land would not be available on site and that solids would be hauled 5 miles off site.

Annual costs include amortization at 10 percent over 15 years plus operations and maintenance.

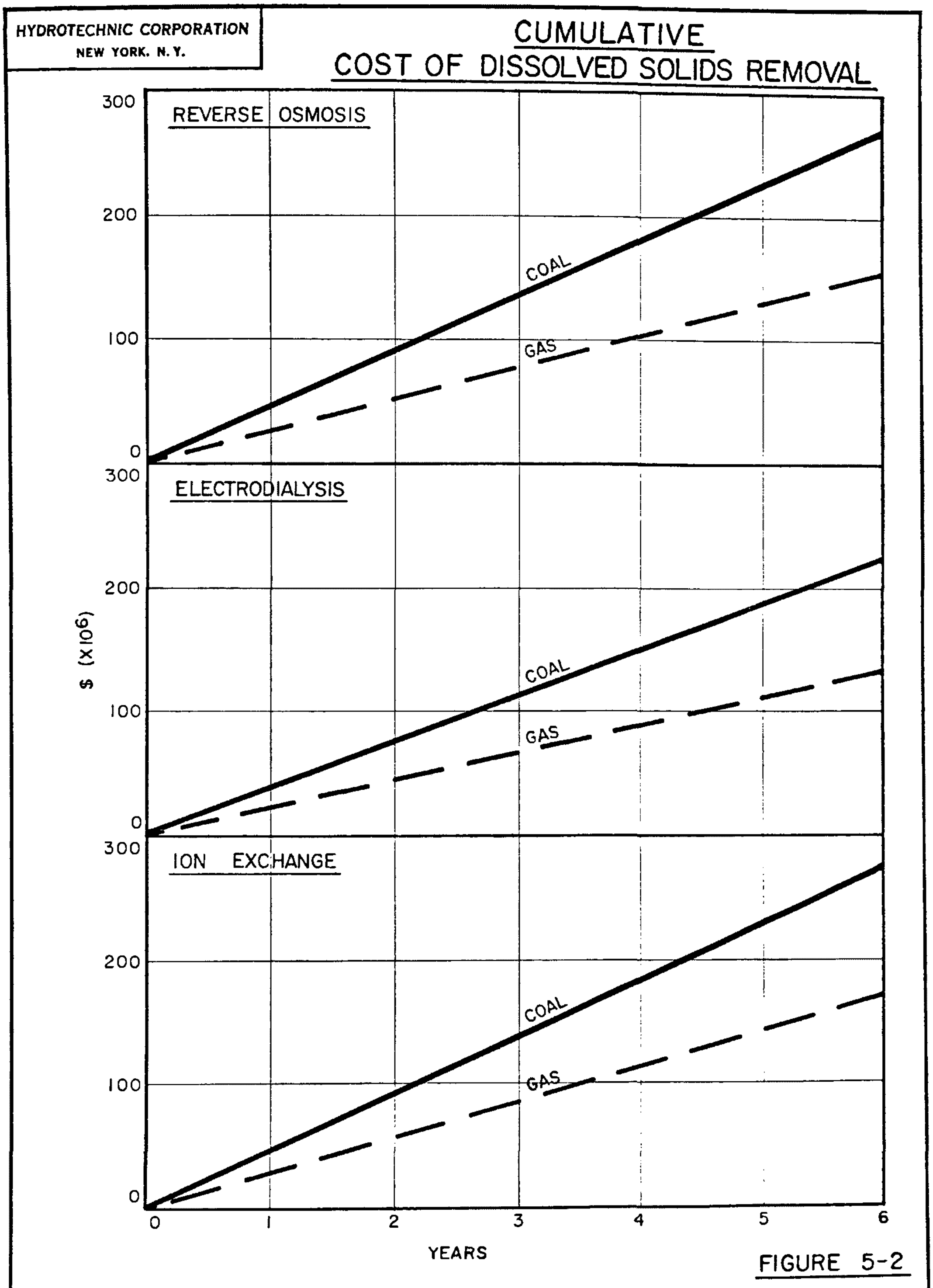

HYDROTECHNIC CORPORATION
NEW YORK, N. Y.
CUMULATIVE
COST OF DISSOLVED SOLIDS REMOVAL
REVERSE OSMOSIS
ELECTRODIALYSIS
ION EXCHANGE
COAL
GAS
$ (X10^6)
300
200
100
0
0
1
2
3
4
5
6
YEARS

FIGURE 5-2

Although the capital costs of installing a membrane process system is significantly higher than an ion exchange system, the operating costs are lower. Operating costs of reverse osmosis is marginally lower and those for electrodialysis is significantly lower. However, the solids disposal costs for an ion exchange system is significantly greater. Although not included in the estimated costs, the availability and cost of land for the solids disposal should be considered. Less than one quarter of the area required for ion exchange dissolved solids disposal is required for membrane process dissolved solids disposal.

Ion exchange was eliminated from further consideration on the bases of annual costs and off-site land requirements. Thus only reverse osmosis and electrodialysis remain for further consideration. At this time, reverse osmosis enjoys a broader technological base (13, 14, 15) and has been used in more applications than electrodialysis. Reverse osmosis has, therefore, been selected as the possible dissolved solids removal treatment unit operation for our analyses, in spite of the considerably higher capital and operating costs.

5.5 COOLING

There are many places in steel plants where water is presently used on a once-through basis for cooling, either contact or non-contact, and then discharged. To meet the goal of total recycle these waters would have to be reused after cooling.

Three types of cooling systems were compared using the following assumptions:

Flow rate: 2,273 m^3/hr (10,000 gpm)

Temperature drop ΔT: 11.1 C^o (15 F^o)

Dissolved solids in makeup water: 175 mg/l

Dissolved solids in blowdown: 600 mg/l*

*Maximum to be tolerated in cooling system.

Included in the comparisons are reverse osmosis systems for treating any blowdown to permit further recycle and to minimize the quantities for evaporation.

The three cooling systems compared were:

1. Open cooling towers (wet)
2. Closed air cooling systems (dry)

3. Wet/dry cooling systems.

Flow diagrams of these systems are shown on Figure 5-3.

The costs of construction and operation of these three types of cooling systems were evaluated on the basis of cost of the cooling system itself plus the cost of blowdown treatment systems where required. These costs are illustrated graphically on Figure 5-4. Various references (16, 17) indicate that the capital cost of a dry cooling system is from two to four times that of a wet cooling tower and that the operating cost of a dry system is approximately twice that of a wet tower. However, these analyses did not account for the cost of makeup water or the treatment of wet and semi-wet tower blowdowns that would be required when striving for total recycle. When these treatment costs, including the costs of hauling the dried solids and ash are included, it can be seen that the operating costs of wet and semi-wet systems increase significantly and thus, after approximately 2-1/2 years, the total cost of a dry system has a cost advantage over a wet or semi-wet system and, after approximately 6-1/2 years, the semi-wet system has a cost advantage over the wet system.

Wet cooling towers were considered to be the applicable cooling method to be used in the analysis due to the fact that additional cooling systems required would have to be retrofitted. Dry systems require more area than do wet ones and, in most cases small areas of land are available for retrofitting, usually between existing structures; Therefore on the basis of universal applicability wet cooling systems were used.

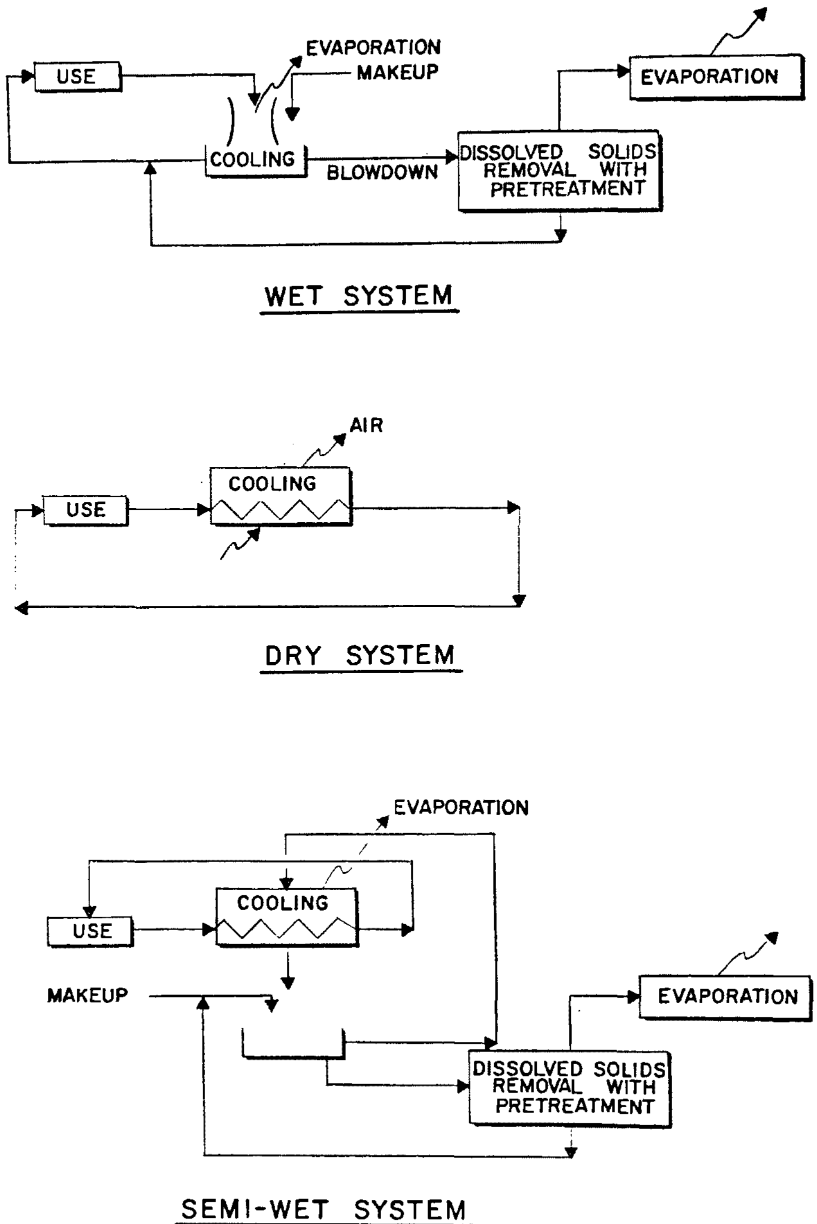
Care must be taken, however, in the selection of the system to be used at any plant. The cooling requirements to be met by any system is dependent upon the ambient dry-bulb and/or wet bulb temperatures. Any analysis made by a plant must include the seasonal variation to reliably reach the required temperatures in the cooling water system.

5.6 FINAL SOLIDS DISPOSAL

A search of the available literature reveals that the subject of disposal of solids resulting from the ultimate evaporation of a final residual waste stream presents a problem that has not been studied to any degree.

The basic problem in their disposal is that these solids are, by virtue of their source, soluble. Initially disposal of the brine streams by cooling molten slag or incandescent coke was considered which would leave the solids on the cooled slag or coke. However, it has been reported (18) that the use of water with high dissolved solids for quenching

HYDROTECHNIC CORPORATION
NEW YORK, N. Y.



COOLING METHODS

FIGURE 5-3

HYDROTECHNIC CORPORATION
NEW YORK, N.Y.

A COMPARISON OF CUMULATIVE ANNUAL COSTS OF COOLING SYSTEMS

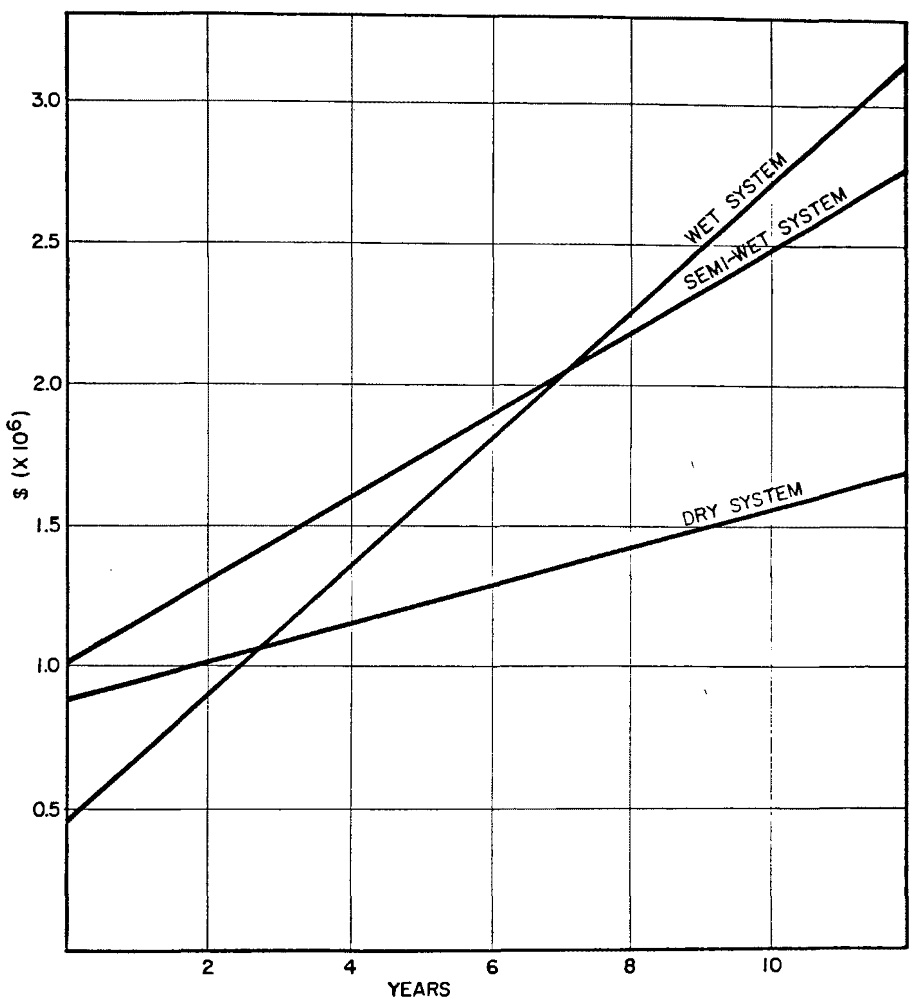


FIGURE 5-4

results in high particulate emission rates. Conversations with EPA, IERL at Research Triangle Park have indicated that the cooling or quenching of hot material with water containing high dissolved solids may not be permitted in the future due to this particulate emission potential.

Other means were then sought for disposal of these solids. Discharge of dried solids into molten slag was considered and eliminated due to the possibliity that the soluble solids would leach from the slag during and after precipitation. Disposal of the solids in concentrated solutions into receiving bodies of water was eliminated as an alternative because of potential adverse environmental effects by creating "hot spots" of concentrated solids.

The only apparent reliable method of disposal of the solids is perpetual storage in waste storage ponds which would have to be lined to prevent leaching into the ground, since the solids would all be soluble and create a potential for ground water contamination.

Salt (NaCl) stored on unlined ground areas for snow removal purposes in municipalities has been reported to contaminate domestic well water supplies (19). Covering the dry, soluble solids storage areas should also be given consideration for two reasons; first, in areas of storage where precipitation exceeds evaporation rate provisions would have to be made to return the excess water to the treatment facilities for re-removal of the solids from the waste stream and second, the dried solids would be fine particulates and be susceptible to being blown off the surface of the stored areas by winds. Capital costs for lined and covered storage areas would be approximately $15 per ton stored (19) and uncovered lined storage ponds would be approximately $10.50 per ton stored. The lined areas would also require the installation of monitoring wells to determine if the integrity of the linings was being maintained (20).

5.7 POSSIBLE PLANS FOR PLANTS TO MEET BAT AND TOTAL RECYCLE

Studies were prepared for the five plants under consideration and plans were developed to achieve the objectives of both BAT and total recycle for each. These plans are conceptual and should not be taken as definitive. At each plant, physical constraints may exist which will preclude the suggested systems as presented. In addition, various mixes of wastes were conceptualized for concurrent treatment. It is strongly suggested that, if implementation of any of the programs presented is planned, comprehensive bench scale tests followed by pilot tests should be undertaken prior to detail design of the systems. In addition, after design and construction, the operators of the facilities should be of a competence level that will ensure proper operation of the facilities. These operators need not necessarily be engineers, but they would have to have some scientific training, as well as training for operation of the specific facilities. This would enable them to recognize not only malfunctions of the waste water treatment systems, but also to determine the causes of these malfunctions. They would then be able to institute corrective measures independently of plant engineering departments.

For each of the systems described seven basic items were considered which contribute to the plans developed; these are:

1. All non-contact cooling water and storm water must be segregated from process flows to minimize the process flows to be treated.

2. Non-contact cooling water would be permitted to be discharged under BAT conditions. For total recycle, except in the case of Kaiser-Fontana, two steps were used, one allowing the non-contact cooling water to discharge as under BAT and the other that the non-contact water would be cooled and totally recirculated under total recycle conditions.

3. Storm water runoff from material storage piles would be collected and stored in lined ponds and gradually discharged to receiving waters under BAT conditions and to treatment facilities under total recycle conditions.

4. Water with high levels of dissolved solids would not be permitted for use to quench coke and slag.

5. Scrubber cars would be utilized at the pushing side of the coke ovens.

6. The discharge of wastes to municipal treatment plants would be discontinued necessitating their treatment at the plant under total recycle conditions.

7. General area runoff and treated or untreated sanitary wastes would continue to be discharged from the plant to either receiving waters or municipal treatment plants.

In the preparation of cost estimates, broad assumptions had to be made as to the costs of yard piping, both underground and aboveground, since detailed knowledge of interferences that might be encountered were not available. Capital and operating costs are based on the use of purchased electrical power and on the use of gas as the energy source for the evaporation of residual waste streams. Equipment costs were obtained from manufacturers, from in-house data, and personal correspondence with knowledgeable persons and companies.

Following are summaries of the conceptual waste treatment systems for the five plants studied. For more detailed discussions of each of the systems and flow diagrams illustrating the systems, refer to appendices A, B, C, D and E.

5.7.1 Kaiser Steel Plant - Fontana, CA

The Kaiser Steel Plant is presently collecting and treating all of their wastes to a degree that, with some modifications and additions, would meet the BAT requirements. However additional facilities and practices are needed for the purposes of minimizing air pollution. Scrubber cars could be installed at each of the three quench towers at the coke plant to eliminate pushing emissions. The scrubber cars would operate on a recirculating system with a blowdown of approximately 54.5 m^3/hr (240 gpm) which would be treated with the balance of the coke plant wastes.

In addition, disposal of contaminated wastes from the coke plant by quenching of coke would also be discontinued.

Coke plant wastes would be collected and treated in a biological treatment plant. The wastes would consist of the wastes presently being disposed of by quenching of the incandescent coke and, in addition, blowdown from the suggested pushing scrubber system. The total waste flow would be 98 m^3/hr (430 gpm). An additional 92 m^3/hr (400 gpm) of blast furnace gas washer system blowdown would be combined with this coke plant wastewater for concurrent treatment. The coke plant wastewater treatment system suggested is a two-stage biological system using rotating biological contactors followed by filters to meet the BAT requirements and, for total recycle, a reverse osmosis system to treat the effluent from the biological plant and filters with evaporation of the brine concentrate. The product water would be returned to the industrial water reservoir for reuse in the plant.

Treatment of the wastes from the balance of the plant would be at the existing wastewater treatment plant.

Storm water runoff from all coal and ore piles would be collected and stored in a lined storage pond for subsequent pumping at a controlled low rate into the wastewater collection system. The system would include modification of the facilities at the existing wastewater treatment plant and the addition of some new facilities. The new facilities would consist of scalping tanks to skim non-emulsified oils from the cold rolling mills and tinning mills wastewater in one tank and the oils from the cleaning lines in a separate tank. The total waste flow would be 267 m^3/hr (1,175 gpm). Acid and heat, if required, would be added in a subsequent tank to demulsify the emulsified oils. The flow would then have lime and polyelectrolyte added in a second mixing tank. Additional flows to the second mixing tank would be 9 m^3/hr (40 gpm) of chrome wastes which have been treated with acid and sodium metabisulfite to reduce the hexavalent chrome to trivalent chrome, 11 m^3/hr (50 gpm) of wastes from the BOP shop, 7 m^3/hr (30 gpm) of wastewater from the hot strip mill decant pond, and, when necessary, 7 m^3/hr (30 gpm) from the material storage pile runoff collection pond.

The existing wastewater treatment plant float-sink separators would be modified by the installation of flocculation paddles and would receive the wastes from the second mixing tank. The 308 m^3/hr (1,355 gpm) of flocculated wastes would then flow to the existing clarifier and, with the exception of 17 m^3/hr (75 gpm) which would be sent to the coke plant, then directed to filters. The filtrate would then be treated in an ultrafiltration and reverse osmosis facility for the removal of dissolved solids. The 218 m^3/hr (960 gpm) of product water would be recycled to the industrial water system as highest quality water. The 73 m^3/hr (320 gpm) of reject brine would be evaporated to dryness in evaporators and the dried solids disposed of in a lined pond.

A more detailed discussion of the facilities described here is presented in Chapter 2 of Appendix A of this report. The capital cost of these facilities including non-contact cooling water are estimated to be approximately $17,717,000 and the annual costs are estimated to be approximately $9,762,000.

5.7.2 Inland Steel Company - Indiana Harbor Works, East Chicago, IN

Plans have been developed to permit the Inland Steel Company to meet total recycle of water in stages by first meeting BAT requirements and then progressing to total recycle. Maximum use was made of the existing treatment systems presently in place at the Inland Steel Plant.

It was assumed that the planned scrubber cars will be in place at the coke ovens. Wet electrostatic precipitators are presently planned for the hot scarfers at the No. 4 Slabbing Mill and at the No. 2 and No. 3 Blooming Mills and were assumed to be in place. The blowdowns from these planned recirculating precipitator systems would be 45 m^3/hr (180 gpm), which has been included in the treatment systems described below.

5.7.2.1 BAT Systems

The systems to meet BAT requirements have been described utilizing the outfall numbers to which the flows presently discharge.

Approximately 99 percent of the flow to Outfall 002 is non-contact cooling water and the remaining 1 percent is the discharge from the plant No. 3 blast furnace gas cleaning system. The gas cleaning system wastes, after segregation from the non-contact cooling water flow, can be treated by lime precipitation followed by chlorination for the removal of fluorides and nitrification of ammonia. This process would then be followed by filtration and activated carbon absorption for final polishing.

The 1200 m^3/hr (5300 gpm) of non-contact cooling water presently flowing to Outfalls 003 and 005 would be segregated from the total flow and discharged separately. This would result in only 1,860 m^3/hr (8,200 gpm) of contaminated waste-water flow to the two existing lagoons. Approximately 307 m^3/hr (1,350 gpm) would be filtered and the filtrate pumped to the plant No. 3 blast furnace cooling system as make-up, and the balance recycled to the mills.

The non-contact cooling waters that discharge to Outfalls 013 and 014 would be segregated from the terminal treatment plant, thus reducing the flow to the terminal treatment plant from 31,818 m^3/hr (140,000 gpm) to 25,159 m^3/hr (111,000 gpm). The flow from the treatment plant would then be further treated in filters, cooled in cooling towers and discharged to the intake of pumping station No. 6. The 5,841 m^3/hr (25,700 gpm) of non-contact cooling water from Cold Strip Mill No. 3 would discharge to Outfalls 017 and 24N, as is the present practice, as would the non-contact cooling water flow of 7,955 m^3/hr (35,000 gpm) from the 80-inch Hot Strip Mill.

The treated wastes from the Industrial Waste Treatment Plant would be further treated by filtration in filters, cooled and recirculated. Chemical additions at the Industrial Waste Treatment Plant could then be discontinued.

Storm water runoff from the ore and coal piles would be collected and contained in lined storm water retention ponds and pumped at a low rate to the Indiana Harbor Ship Canal.

If quenching of coke using coke plant wastes is eliminated, the flow to the East Chicago Sanitary District would increase by 95 m^3/hr (420 gpm). The total flow of wastes to the East Chicago Sanitary District would then be, from all areas of the Inland Steel Company Plant, 370 m^3/hr (1,630 gpm) which should be acceptable.

Detailed descriptions of the above systems are presented in Appendix B.

It is estimated that the capital cost of the facilities described would be approximately $36,300,000 and the annual costs would be approximately $18,823,000.

5.7.2.2 Total Recycle

In order to meet the requirements of total recycle criteria the facilities installed under BAT must be expanded and new facilities must be added to provide for the treatment and elimination of waters that can no longer be treated for reuse.

The cooling tower blowdowns, presently flowing to Outfall 001, would be pumped to the Plant No. 3 Blast Furnace gas cleaning system cooling towers as makeup, thus eliminating all plant water discharges from Outfall 001.

Almost 99 percent of the water discharged to Outfall 002 is non-contact cooling water. The balance is blowdown from the Blast Furnace gas cleaning system. This blowdown of 59 m^3/hr (260 gpm) can be treated with the wastes from Coke Plant No. 3. The non-contact cooling water can also be cooled and recirculated. The blowdown would be used as makeup to the gas cleaning system. To reduce the amount of water required for gas cleaning the cycles of concentration within the gas cleaning system would be increased and, therefore, reduce the amount of blowdown.

The wastes from the Coke Plant No. 3 would no longer be sent to the City of East Chicago under the total recycle criteria and treatment would be necessary. Biological treatment is proposed with the required dilution water coming from the lime precipitation stage of the Blast Furnace gas cleaning system BAT treatment. After biological treatment the wastes would be filtered and demineralized in a reverse osmosis facility. Additional wastes discharging to this reverse osmosis system would be boiler blowdown from Power Station No. 3. Approximately 83 m^3/hr (364 gpm) of the R.O. unit product water would be returned to the non-contact cooling water cooling tower described above. The brine concentrate would be evaporated to dryness.

Process wastes presently discharging to Outfalls 003 and 005 were eliminated under the system described for BAT. The only changes required under total recycle would be to discharge the filtrate from the lagoons to Pump Station No. 3 Blast Furnace gas cooling water cooling tower, and install another cooling tower to cool and recycle the 1205 m^3/hr (5,300 gpm) of non-contact cooling water from the 24-inch Bar Mill, Plant No. 1 Galvanizing Lines, the Plate Mill, and the Spike Mill to Pump

Station No. 3. The blowdown would be to the Plant No. 3 Blast gas cooling water cooling tower.

The total non-contact cooling water flow of 12,500 m^3/hr (55,000 gpm) from Plant No. 2 Blast Furnaces presently flowing to Outfalls 007 and 011 would be cooled in a new cooling tower and recycled. A blowdown of 76 m^3/hr (355 gpm) would be demineralized in the reverse osmosis facility described under Coke Plant No. 2.

The 29,091 m^3/hr (128,000 gpm), presently discharged to Outfalls 008 and 011, would be cooled and recycled with the blowdown directed to the reverse osmosis facility described under Coke Plant No. 2.

The non-contact cooling water flows from Power Station No. 2 and Plant No. 2 Blast Furnaces would be cooled as described under Outfalls 007 and 008. The non-contact cooling water flow of 93 m^3/hr (410 gpm) would be cooled in one of two new Coke Plant No. 2 cooling towers. The boiler blowdown from Power Station No. 2 would discharge directly to the reverse osmosis facility described under Coke Plant No. 2.

The flows to Outfall 012 would be eliminated by installing two new cooling towers. One of the cooling towers would cool and recycle 2,841 m^3/hr (12,500 gpm) of non-contact cooling water from Coke Plant No. 2 and the second would cool and recycle 227 m^3/hr (1,000 gpm) of non-contact cooling water from BOF No. 2. This latter cooling tower would also cool approximately 4,090 m^3/hr (18,000 gpm) of non-contact cooling water presently flowing to the Terminal Treatment Plant at Outfalls 013 and 014.

The wastes from Coke Plant No. 2 presently sent to the City of East Chicago would be treated in a biological treatment plant. With the use of contaminated wastes from Coke Plant No. 2 for the quenching of coke discontinued, and with the installation of pushing scrubber cars, a total flow of 198 m^3/hr (810 gpm) to the biological treatment plant would result. Approximately 143 m^3/hr (630 gpm) of dilution water would be from the Plant No. 2 Blast Furnace gas cleaning system. Subsequent to biological treatment, the waste flow would be combined with the Plant No. 2 Blast Furnace non-contact cooling tower blowdown, Power Station No. 2 cooling tower and boiler blowdowns, to be treated in a reverse osmosis facility. A reject flow of 136 m^3/hr (600 gpm) would be evaporated to dryness and the product water distributed for reuse and possible coke quenching.

Flows that presently discharge to Outfalls 013 and 014 from the Terminal Treatment Plant would be treated in a filtration plant and cooled prior to recirculation to Pump Station No. 6. The wastes from Cold Strip Mills 1 and 2 would be treated in a filtration-reverse osmosis system to remove approximately 75 percent of the dissolved solids present. They would then be treated in a second stage reverse osmosis unit with a portion of the flow from the Terminal Treatment Plant for recirculation to Pump Stations 2 and 5.

The non-contact cooling water which was segregated from the flow to the Industrial Waste Treatment Plant under BAT would be cooled and recirculated and the blowdown would be discharged as makeup to the contact water cooling tower. The segregated non-contact cooling water from the 80-inch Hot Strip Mill would be cooled and recycled to the intake of Pumping Station No. 6. The cooling tower blowdown would be used as makeup to the contact water system cooling tower.

The total flow from the Industrial Waste Treatment Plant which was partially discharged via a new cooling tower under BAT conditions would have a portion demineralized in a reverse osmosis facility and recirculated to Pump Stations 5 and 6. Approximately 824 m^3/hr (3,625 gpm) would be evaporated to dryness and 2,474 m^3/hr (10,900 gpm) of product water would be returned.

At Outfall 015, 114 m^3/hr (500 gpm) of treated sanitary wastes would still discharge under the definition of total recycle, but the non-contact cooling water flow of 5,680 m^3/hr (25,000 gpm) from Open Hearth No. 3 would require cooling in a cooling tower and 5,505 m^3/hr (24,200 gpm) would be recycled. The blowdown would then be discharged to the final treatment system installed for Outfall 018 wastes.

Of the flows discharged to Outfall 018 under BAT conditions, 18,180 m^3/hr (80,000 gpm) is non-contact cooling water which could be cooled and returned to Power Station No. 4. A blowdown of 61 m^3/hr (270 gpm), together with the boiler blowdown of 45 m^3/hr (200 gpm), the 227 m^3/hr (1,000 gpm) from the BOF No. 4 and the Slab Caster No. 1 system, and the 52 m^3/hr (230 gpm) from proposed Open Hearth No. 3 cooling tower, would be treated in a reverse osmosis facility. Approximately 227 m^3/hr (1,000 gpm) of product water would be returned for cooling tower makeup and 62 m^3/hr (275 gpm) returned to BOF No. 4. A reject flow of 97 m^3/hr (425 gpm) would be evaporated to dryness. The fly ash sluicing system at Power Station No. 4 could be replaced by a dry fly ash handling system.

The "Northward Expansion" slag quenching system using alkaline chlorination system treated water from Blast Furnace No. 7 would be discontinued and this water discharged, after lime treatment and settling, to the biological treatment plant. The 57 m^3/hr (250 gpm) from Coke Battery 11 used to quench slag would also discharge to the biological treatment plant. With these two flow additions, the biological treatment plant would be increased in size by 50 percent and would require two new clarifiers. The discharge from the four clarifiers would then be filtered and treated further in a two-stage reverse osmosis facility. A reject stream of 71 m^3/hr (315 gpm) would be evaporated to dryness and 215 m^3/hr (945 gpm) would be returned to Coke Battery 11.

All the rainfall runoff from the material storage piles, as described under BAT requirements, would be pumped to the nearest pumping station intake instead of being discharged.

Detailed descriptions of the above systems are included in Appendix B.

The cost of the proposed systems were estimated for total recycle without including non-contact cooling water and total recycle including non-contact cooling water and are presented on Table 5-3.

5.7.3 <u>National Steel Corporation - Weirton Steel Division, Weirton, WV</u>

5.7.3.1 BAT Systems

The systems for the Weirton Steel Division are described by the outfall designations to which the wastes are presently discharged. The blast furnace recirculation system should be reevaluated to determine if the blowdown can be reduced from 175 m^3/hr (770 gpm) to approximately 57 m^3/hr (250 gpm). If this modification is possible, then a fluoride precipitation system would be installed and the blast furnace wastes sent to the Browns Island Biological treatment plant for use as dilution water. If it is not feasible to reduce the blowdown quantity, then treatment by fluoride precipitation, alkaline chlorination, settling, pH adjustment, filtration, and carbon adsorption would be required prior to discharge to Outfall "A". Non-contact cooling water would by-pass the treatment system and discharge directly to Outfall "A".

The 836 m^3/hr (3,680 gpm) flow from the power house and boiler house thickener and decant tank would be treated by additional settling or filtration using polyelectrolytes. The Blooming Mill and scarfer should have water recirculation systems installed. Treatment facilities required to permit recirculation would be additional settling possibly utilizing polyelectrolytes, a filtration system, and a cooling tower. Periodic blowdown, after filtration, would be necessary to control dissolved solids.

The wastes from the Tin Mill cleaning lines should be diverted from Outfall "A" to Outfall "B". A terminal treatment

TABLE 5-3

Summary of Costs for BAT and Total Recycle

Inland Steel Company - Indiana Harbor Works

	Capital Cost	Total Annual Cost
BAT	$ 36,300,000	$ 18,823,000
Total Recycle w/o non-contact cooling water	96,924,000	106,051,000
Total Recycle w/ non-contact cooling water	162,079,000	139,875,000

plant should be constructed at Outfall "B". Wastes from the various production facilities would be segregated and the chrome wastes treated separately for chrome recovery in an ion exchange facility. The excess regenerants would then be used as chemical reagents at the terminal treatment plant. Heavy metals would be precipitated, dewatered and hauled away.

A portion of the Hot Strip Mill scale pit water should be recirculated for flume flushing and the balance settled, in an additional settling facility, filtered, cooled and returned to the mill for reuse. A blowdown of approximately 840 m^3/hr (3,700 gpm) would be discharged to control dissolved solids.

An additional terminal waste treatment plant is proposed at C & E sewers. This plant would receive the rinse and fume scrubbing water from the continuous picklers, the carbide and diesel shop wastes, wastes from the acid regeneration plant and the "PORI" oil recovery plant, wastes from the sheet mill galvanizers and cleaning lines, and the detinning plant wastes. In order to be in compliance with the present BAT zero discharge requirements for plating wastes and detinning plant wastes, a portion of the treatment plant flow would be further treated in a reverse osmosis facility. The treatment of the wastes at the C & E treatment plant would consist of chemical treatment utilizing portions of the waste discharges as chemical reagents, then clarification, filtration and discharge. System blowdown should be from the continuous caster deep bed filter discharge rather than from the flat bed filter discharge.

More detailed descriptions of the above facilities are in Appendix C.

It is estimated that a capital investment of \$24,051,000 would be required and annual costs of approximately \$10,298,000 would be incurred.

5.7.3.2 Total Recycle

To meet a total recycle requirement, Weirton Steel Division would require facilities in addition to those described under BAT.

Cooling towers to cool and recirculate all of the non-contact cooling water would be required at the Mainland Coke Plant. A blowdown of 270 m^3/hr (1,190 gpm) would be discharged to the Blast Furnace gas cleaning system. Two other additional cooling towers are proposed, one for the Blast Furnace non-contact cooling water system and one for the Power House, which would discharge blowdowns of 334 m^3/hr (1470 gpm) and 140 m^3/hr (620 gpm), respectively, to the Blast

Furnace gas cleaning system. Additional makeup water to the Blast Furnace gas cleaning system would be from the Boiler House treatment plant installed under BAT. With the excess makeup provided, the quantity of the blowdown from the Blast Furnace treatment facilities would be increased. Approximately 155 m^3/hr (680 gpm) would be discharged to the Browns Island Biological Treatment Plant for use as dilution water and the balance treated in a filtration-activated carbon-reverse osmosis system. Approximately 438 m^3/hr (1,930 gpm) would be returned to the plant supply water system and 145 m^3/hr (640 gpm) would be evaporated to dryness. The discharge from the Browns Island Biological Treatment Plant would also require filtration and demineralization prior to return to the plant water system. At the Brown Island Coke Plant a cooling tower to cool the non-contact cooling water is proposed with the blowdown treated in the reverse osmosis facility.

Non-contact cooling waters from the Blooming Mill and Scarfer would be cooled and returned to the mills. A blowdown of 102 m^3/hr (450 gpm) would be used as makeup at the Blooming Mill and Scarfer contact water treatment plant proposed under BAT. The Treatment Plant cooling tower blowdown would be discharged to the "C" sewer system.

The treated wastes from the "C" Terminal Treatment Plant, proposed under BAT conditions, would have a high concentration of dissolved solids and require demineralization prior to reuse. Approximately 2,114 m^3/hr (9,300 gpm) would be returned to the Plant water system after demineralization and 765 m^3/hr (3,100 gpm) of reject water would be evaporated to dryness. Non-contact cooling water from the Temper Mill would be cooled and recirculated back to the Mill. The blowdown would be used as a portion of the makeup at the Tin Mill Cleaning Lines.

Non-contact cooling water from the Tandem Mills should be cooled and recirculated. The blowdown would be used as a portion of the makeup to the Hot Strip Mill contact water system. The non-contact water from the Hot Strip Mill presently discharged should be cooled and recirculated with the blowdown used as a portion of the makeup at the contact water system. The 1,786 m^3/hr (7,860 gpm) of blowdown from the contact water system would join with the 83 m^3/hr (365 gpm) from the Blooming Mill and Scarfer blowdown and the 131 m^3/hr (575 gpm) blowdown from the BOP and Vacuum Degassing and Continuous Caster and be demineralized in a reverse osmosis facility located near the C & E Chemical Treatment Plant installed for BAT compliance. The discharges from the C & E Chemical Treatment Plant would also be demineralized in an expanded reverse osmosis facility.

Approximately 1,834 m^3/hr (8,070 gpm) would be returned to the plant water system from the reverse osmosis system and 611 m^3/hr (2,690 gpm) would be evaporated to dryness.

Rainfall runoff from material storage areas would be collected in the lagoon presently used for "A" outfall wastes and the collected water pumped at a low rate to the Plant Water Intake.

More detailed descriptions of the systems described above are included in Chapter 2 of Appendix C.

The cost of the proposed systems were estimated for BAT, total recycle without including non-contact cooling water and total recycle including non-contact cooling water and are presented on Table 5-4.

5.7.4 United States Steel Corporation - Fairfield Works

5.7.4.1 BAT Systems

Since Fairfield Works has only one major outfall, the treatment of the wastes produced are discussed by area source.

The flows from the finishing facilities would be segregated. The 264 m^3/hr (1,160 gpm) of wastes from Galvanizing Line No. 4, Tinning Lines 1, 3 and 4 and from Wire Galvanizing would flow directly to the Tin Mill Treatment Plant Lagoons. The other flows presently flowing to the Tin Mill Treatment Plant would continue to flow to the Tin Mill Ditch where acid would be added, and the wastes would then be pumped directly to two of the three existing clarifiers for settling and oil skimming, by-passing the existing chemical treatment. The flows to the lagoons would continue to be treated in the treatment plant. However, after clarification in the one remaining clarifier, the treated wastes would be filtered and demineralized in a reverse osmosis facility with the product water returned to the Tin Mills and the brine reject stream evaporated to dryness.

The Q-BOP's 123 m^3/hr (540 gpm) discharge would be diverted from the Final Effluent Control Pond and used at the blast furnaces as makeup. Blowdown from blast furnaces 5, 6 and 7 would be limited to 136 m^3/hr (600 gpm) and treated with lime to precipitate the fluorides. The treated flow would then be pumped to the Coke Plant biological treatment plant for phenol, cyanide and ammonia removal. The blowdown from blast furnace 8 would not be used to quench slag but would be discharged to the Final Effluent Control Pond.

TABLE 5-4

Summary of Costs for BAT and Total Recycle

National Steel Corporation - Weirton Steel Division

	Capital Cost	Total Annual Cost
BAT	$ 24,051,000	$ 10,298,000
Total Recycle w/o non-contact cooling water	96,582,000	115,297,000
Total Recycle w/ non-contact cooling water	129,814,000	129,933,000

The prime industrial water presently used as dilution water at the Coke Plant should be replaced by treated blast furnace gas washer water blowdown and coke pushing scrubber car blowdown after the "CY-AM" stills. The Biological Treatment plant should be expanded and modified to provide two stage biological treatment. Two additional clarifiers should be added, two serving each stage. After final settling, filtration of 477 m^3/hr (2,100 gpm) is proposed to assure suspended solids compliance with BAT requirements. Prime industrial water would be replaced by 80 m^3/hr (350 gpm) from the final settling basin for coal dust control.

Runoff from the ore and coal storage piles would be collected and stored in existing Settling Pond No. 4 near the sheet mills. The Sinter Plant, although remote from the main body of the plant requires a separate treatment facility. All process wastes from the sinter plant should be collected in Pond No. 1 and treated by aeration and lime precipitation, with final pH adjustment, prior to discharge to Pond No. 2, together with the treated sanitary wastes and storm water runoff for final settling and discharge to Outfall 029.

More detailed descriptions of the above systems are in Appendix D.

It is estimated that the capital cost of the systems proposed would be approximately \$7,760,000 and the annual costs would be approximately \$5,559,000.

5.7.4.2 Total Recycle

To effect total recycle of water it would be necessary to segregate all process waste and cooling water flows from all storm water, after which the proposals put forth below can be implemented.

The 170 m^3/hr (750 gpm) discharged to the Blast Furnace 5,6 and 7 spray pond from the Q-BOP would be returned for use at the Q-BOP and additional make-up requirements drawn from the prime industrial water line.

The dissolved solids level in the Blast Furnace gas cleaning system would be increased so that the blowdown from Blast Furnaces 5, 6 and 7 is 43 m^3/hr (190 gpm) and the blowdown from Blast Furnace 8 is 25 m^3/hr (110 gpm). These blowdowns would then discharge to the Coke Plant Wastewater Treatment Plant to replace the prime industrial water that is presently used for dilution. No additions would be required at the Coke Plant but the filtration of the final settling basin effluent would no longer be required.

Since all flows, other than those from the Sinter Plant, ultimately flow through the Final Effluent Control Pond, one terminal treatment plant would be required to treat the water discharged to a quality sufficient for reuse at the plant. The wastes from the Final Effluent Control Pond would be filtered and demineralized in a two-stage reverse osmosis facility with intermediate lime softening. Approximately 1,877 m^3/hr (8,250 gpm) would be returned to the prime industrial water system and approximately 625 m^3/hr (2,750 gpm) would be evaporated to dryness.

A filtration and reverse osmosis facility would be installed at the Sinter Plant to treat approximately 18 m^3/hr (80 gpm) of the wastes from the pond described under BAT and the product stream combined with the raw settled wastes and returned to the Sinter Plant for reuse. Approximately 4.5 m^3/hr (20 gpm) would be evaporated to dryness.

Detailed descriptions of the systems are in Appendix D.

The cost of the proposed systems were estimated for BAT, total recycle without including non-contact cooling water and total recycle including non-contact cooling water are presented on Table 5-5.

5.7.5 Youngstown Sheet & Tube Company - Indiana Harbor Works

5.7.5.1 BAT Systems

To meet the requirements of BAT at the Indiana Harbor Works various additional treatment and recycle facilities will be needed. A treatment facility consisting of a gravity filtration plant is presently under construction at the outfall that discharges the largest quantity of water (Outfall 011).

Proposals are presented below to modify the flow to Outfall 011 and recirculate a portion of the treated wastes from the new filter plant and reduce the volume discharged. The total flow to the filtration plant should be segregated to eliminate the unnecessary filtration of non-contact cooling water which would reduce the flow of contact water to be filtered to 6300 m^3/hr (27,000 gpm). The remaining 10,300 m^3/hr (45,500 gpm) of non-contact water would be discharged to nearby Pump Station No. 1. This volume would eliminate the intake of water from Lake Michigan to the plant to that pumping station. The excess capacity of this new filter plant would then be redundant.

The discharges from the Central Treatment Plant would be treated in a reverse osmosis and evaporation facility to eliminate all contact water discharges from the Flat Roll Mills and the product water would be recirculated back to the mills. Therefore, Outfall 001 would no longer discharge waste water other than non-contact cooling water and storm water runoff.

Outfall 010 discharges consist of non-contact cooling water and filtered wastes from the Continuous Butt Weld Pipe Mill. The filtrate would be returned to the pipe mill for reuse. System blowdown would consist of the filter backwash water discharges to the main scale pit near Outfall 011. The balance of the non-contact cooling water flow would be discharged.

The blast furnace recirculation system disposes of blowdown by quenching slag. However, due to air pollution requirements this would no longer be permitted. The gas cleaning system would operate at higher dissolved solids concentrations and the blowdown would be reduced to 108 m^3/hr (475 gpm) which would be treated by alkaline-chlorination followed by settling, filtration and activated carbon treatment prior to discharge. Additional wastes flowing to the blast furnace gas cleaning system would be from a high energy scrubber installed at the Sinter Plant.

The Coke Plant would require additional water for the control of pushing emissions. A new scrubber car system is assumed, with a discharge of 45 m^3/hr (200 gpm) which would be sent to the City of East Chicago Sanitary Treatment Plant.

More detailed descriptions of the proposed systems are in Appendix E.

It is estimated that the capital costs of the systems proposed would be approximately $19,580,000 with annual costs of approximately $23,648,000.

5.7.5.2 Total Recycle

To meet total recycle, the plant would require additional facilities for either recirculation of flows presently discharged or for the elimination of these waste waters.

Four additional cooling towers would be required to cool and recirculate non-contact cooling water from Open Hearth No. 2 and the BOF, the Power House and the Boiler House, the Flat Roll Mills and the four Blast Furnaces. The discharge from the Continuous Butt Weld Mill filters would be used as makeup to the Boiler-Power House and Blast Furnace cooling towers.

TABLE 5-5

Summary of Costs for BAT and Total Recycle

United States Steel Corporation - Fairfield Works

	Capital Cost	Total Annual Cost
BAT	$ 7,760,000	$ 5,559,000
Total Recycle w/o non-contact cooling water	-	-
Total Recycle w/ non-contact cooling water	59,192,000	69,344,000

When cooling towers are installed the wastes treated at the Outfall 011 filters would be reduced to 5,250 m^3/hr (23,100 gpm) from the mills.

To eliminate the flows discharged to the City of East Chicago, a biological treatment plant would be installed at the Coke Plant and the discharges from the biological plant would be to the Outfall 011 filters. Wastes flowing to the biological treatment plant would consist of the Coke Plant wastes and the Blast Furnace gas cleaning wastes. The treatment facilities installed for BAT for the Blast Furnace gas cleaning wastes would retain the lime precipitation and settling stages but all other stages would not be utilized.

The filtered wastes from the Outfall 011 filters would be treated in a reverse osmosis facility with approximately 236 m^3/hr (1,040 gpm) being evaporated to dryness and the product water discharged to Pump Station No. 1.

Since varying qualities of water are actually required at various mills, Pump Station No. 1 would be divided into two sections; one section to pump higher quality lake water to areas where high quality water is needed, such as at the Flat Roll Mills, for cooling tower makeup and as boiler feed water.

The rinse tanks at the pickling lines would be modified to utilize a counter-current cascade rinse system to reduce the volume of waste requiring treatment. An acid regeneration plant would be constructed to recover the 36 m^3/hr (161 gpm) of acid presently disposed of in the shallow well.

Detailed descriptions of the proposed systems are in Appendix E.

The cost of the proposed systems were estimated for BAT, total recycle without including non-contact cooling water and total recycle including non-contact cooling water and are presented on Table 5-6.

TABLE 5-6

Summary of Costs for BAT and Total Recycle

Youngstown Sheet & Tube Company - Indiana Harbor Works

	Capital Cost	Total Annual Cost
BAT	$ 19,580,000	$ 23,648,000
Total Recycle w/o non-contact cooling water	46,300,000	35,524,000
Total Recycle w/non-contact cooling water	74,350,000	64,571,000

REFERENCES (SECTION V)

1. Kostenbader, P.D., and Flecksteiner, J.W., Biological Oxidation of Coke Plant Weak Ammonia Liquor. Journal of the Water Pollution Control Federation, 41(2): 199-209, 1969.

2. Wong-Chong, G.M., et al., Treatment and Control Technology for Coke Plant Wastewaters. 84th National Meeting AICHE, February 1978.

3. Luthy, R.G., and Jones, L.D., Biological Treatment of Coke Plant Wastewater. Submitted to the Environmental Engineering Division, ASCE, December 1978.

4. Doudoroff, P., Some Experiments on the Toxicity of Complex Cyanides to Fish. Sewage and Industrial Wastes, 28(8), 1020-1040.

5. Schroeder, J.W., and Naso, A.C., U.S. Patent 3,920,419, November 1975, Assigned to Republic Steel Corporation.

6. Wunderlich, G., et al., U.S. Patent 3,822,337, July 1974.

7. EPA Process Design Manual for Nitrogen Control, October 1975.

8. Bridle, T.R., et al., Operation of a Full Scale Nitrification and Denitrification Industrial Waste Treatment Plant. Proceedings of Tenth Mid-Atlantic Industrial Waste Conference, June 1978.

9. Hydrotechnic in-house memoranda.

10. Discussions with British Steel Corporation (H.J. Kohlmann).

11. Morlin, O.J., Membrane Processes for Water Treatment, Power Engineering, July 1977.

12. Gregor, H.P., and Gregor, C.D., Synthetic Membrane Technology, Scientific American, July 1978.

13. Hauck, A.R., and Sauririajan, S., Reverse Osmosis Treatment of Diluted Nickel Plating Solutions, Journal of the Water Pollution Control Federation, 44(7) 1372-1383.

14. Wiley, A.J., et al., Concentration of Dilute Pulping Wastes by Reverse Osmosis and Ultra Filtration, Journal of the Water Pollution Control Federation, 42(8) Part 2, R279-R289.

15. Williams, R.H., and Richardson, J.L., Complete Water Reuse with Membranes - Reverse Osmosis for Dissolved Solids Concentration. Proceedings Second National Conference on Complete Water Reuse, 1975.

16. A Power Plant Even Environmentalists Like, Business Week, July 3, 1978.

17. Larinoff, M.W., Performance and Capital Costs of Wet/Dry Cooling Towers in Power Plant Service, Combustion, May 1978.

18. Sommerer, D., Laube, A.H., Organic Material from a Coke Quench Tower, Proceedings of the Fifth National Conference on Energy and Environment, 1977.

19. The American City and County, November 1978.

20. Kim, K.B., Hofstein, H., and Brogard, J.N., Handling and Disposal of Solid Wastes from Steam Power Plants. Proceedings Second National Conference on Complete WateRe-use, 1975.

21. Kohlmann, H.J. and MacKay, T., Cooperation for Conservation Yields Success in Hot Strip Mill Water Systems Design. Iron and Steel Engineer, 56(3): 35-40, 1979.

22. Danzberger, A.H. and Kohlmann, H.J., Modality of Water Reuse by Industry. Proceedings of the Third National Conference on Complete Water Reuse, AICHE and EPA Technical Transfer, 1976.

SECTION 6.0 - SUMMARY AND CONCLUSIONS

Five large integrated American steel plants were studied to determine the requirements for reaching total recycle of water. As an interim step, the facilities required to achieve the present requirements of the U.S. E.P.A.'s Best Available Technology (BAT) were also studied. The term "total recycle" is defined as the elimination of all water discharges from a steel plant to receiving bodies of water either directly or through municipal sewerage systems. Water consumed in the preparation of the product, water evaporated, and water lost to the ground are considered non-recyclible.

One of the first basic conclusions reached was that there is a lack of typicality between steel plants. No simplified solutions can be developed that would be applicable throughout the entire industry. Certain systems are similar but variations exist due to configuration, space limitations or, conversely, spread out site, locality, plant age, and other factors too numerous to list. It is safe to conclude that there are no typical steel plants. The atypical nature of the plants studied, and other differences throughout the entire industry, makes it difficult to assign standard numbers to water flows, costs, and various other factors that would prove extremely convenient for determining restrictions on contaminant levels and the cost of complying with these restrictions.

The total capacity of the five plants studied was approximately 19.3 kkg (21.2 million tons) per year which represents 13.5 percent of the total present integrated steel plant capacity in the United States. (Approximate current integrated steel plant capacity is 142.7 x 10^6 kkg (157 million tons) per year.) Based on this rather small sampling, the diversified nature of the integrated steel plants is probably more pointed since additional plant studies would provide further dissimilarities.

The BAT compliance step study presented the most differences in the facilities needed as well as their construction and operating costs. This was due to the great variety in the in-place wastewater treatment and recycle systems presently installed. These differences are mainly due to the age of the plants studied, the availability of water for use in the plants and, in some cases, the States in which the plants are located.

Plant age is an important consideration since the newer plants, due to the technology not previously available and to recent concerns for protecting the environment, installed facilities to treat their wastewater to a degree which usually meets the BPT requirements and, in some cases, even the BAT limitations. Plant locality also has a great effect since plants located near abundant supplies of water were more apt to exclude facilities for wastewater treatment and reuse. On the other hand, some plants were constructed in water scarce areas making it mandatory to conserve as much water as possible which has the effect of considerably reducing the amount of untreated wastewater that is discharged.

The State in which a plant is located also has an effect since, prior to the formation of the U.S. E.P.A., the States were the sole governing bodies which determined the extent to which a particular plant had to reduce its discharge of contaminants. In some States the restrictions were stricter, thus resulting in steel plants with more treatment facilities than those required in other States.

This "Summary and Conclusion" chapter sets forth the findings of approximately two years of intensive study and presents the findings only to a degree of accuracy which was permitted by the data received and conditions observed. Although certain minor water systems may have been omitted, all underground interferences most probably have not have been identified, and new emerging technologies may have been overlooked, the study should still serve as a guide to the scope and ramifications of the goal of attaining total recycle of water in an integrated steel plant.

6.1 IN-PLANT EFFECTS

As will be seen, the goals of BAT and total recycle would result in large expenditures for the construction of water treatment and reuse systems. These large construction projects, if implemented, will most probably have a disrupting effect on the operations of the steel plants during construction and, in some of the more crowded plants, even after the construction is completed. The level of education and competence of operators and supervisory personnel will have to be increased considerably even though there exist today many skilled personnel associated with water facilities in steel plants. Difficulties may be encountered in obtaining these personnel due to agreements between the industry and unions and government agencies.

The transportation of chemicals, sludges, oils, etc..., within the plants would increase with inherent increased traffic problems. Safety requirements would require broadening to encompass the use of different chemicals and the use of new types of water treatment process equipment. Monitoring of water systems would be expanded so that water qualities of the tightly "bottled-up" systems are not upset causing outages of production facilities. This monitoring would require increased staffs to handle the samples, perform the analyses, analyze the results, and make reports with recommendations for rapid corrective action. Contingency plans would have to be developed if a water system had to be "dumped".

The management of sophisticated water systems in well diversified integrated steel plants would in itself be an extremely complex problem.

6.2 EXTRA-PLANT EFFECTS

Whenever extensive and ambitious projects are undertaken in an industrial plant or in an industry as a whole, effects of these projects are felt not only within the plant or industry itself but also external to the plant. Certain of these effects produce beneficial results and others produce results which are detrimental. Following is a discussion of the results that may be expected to affect off-site considerations.

6.2.1 Power Generation

It has been assumed that the electric power required to operate the facilities for attaining BAT and total recycle would be generated off-site. The electric power and thermal requirements for the five plants are presented in Table 6-1. It should be noted that these requirements are additive. An average of the KW hours required for BAT and total recycle for the four most "typical" plants is 57.5×10^6 j per kkg (14.5 kWh per ton) and 262 j per kkg (66 kWh per ton), respectively. If this average is applied to the total U.S. steel industry, a total of 260 MWe and 1,183 MWe of new generating capacity will be required for BAT and total recycle, respectively. The present forecasts for increased power generation are estimated to be an average of 22,500 MWe per year over the next ten years and this, if it is assumed that BAT and total recycle are implemented within the next ten years, represents an increase in generation needs of 0.5 percent over these predictions for the steel industry alone and would account for 0.8 percent of the total industrial use of electricity by the year 1987 (1).

These new offsite generating facilities will in all probability be either nuclear or coal-fired with the additional impact of desulfurization, ash handling, air pollution control, and nuclear waste disposal, all of which must be considered.

TABLE 6-1

SUMMARY OF ENERGY REQUIREMENTS TO MEET BAT AND TOTAL RECYCLE

Plant	Phase	Electrical Energy kWh/yr x 10^6	Electrical Energy Joules/yr x 10^{12}	Thermal Energy BTU/yr x 10^{12}	Thermal Energy Joules/yr x 10^{15}	Equivalent to ft^3 gas/yr x 10^9 @1000BTU/ft^3	Equivalent to m^3 gas/yr x 10^6	Equivalent to ton of coal/ year @13000BTU/#	Equivalent to kkg of coal/ year x 10^6
Kaiser-Fontana	Total Recycle	32.0	115.4	3.027	3.2	3.027	85.72	116,100	105,600
Inland Steel	BAT	110.5	397.8	--	-	-	-	-	-
	Add for Total Recycle	611.4	2,201.0	47.93	50.55	47.93	1,357	1,944,000	1,764,000
	Total Recycle*	721.9	2,598.8	47.93	50.55	47.93	1,357	1,944,000	1,764,000
National Steel - Weirton	BAT	98.1	353.2	-	-	-	-	-	-
	Add for Total Recycle	462.9	1,666.4	53.98	56.93	53.98	1,528.7	2,076,000	1,884,000
	Total Recycle*	561.0	2,019.6	53.98	56.93	53.98	1,528.7	2,076,000	1,884,000
United States Steel - Fairfield	BAT	18.1	65.1	2.018	2.13	2.018	57.15	77,600	70,400
	Add for Total Recycle	238.3	857.9	30.270	31.9	30.270	857.24	1,164,200	1,056,500
	Total Recycle*	256.4	923.00	32.288	34.03	32.288	914.39	1,242,000	1,127,000
Youngstown Sheet & Tube Indiana	BAT	84.9	305.6	10.85	11.44	10.85	307.3	417,300	378,700
	Add for Total Recycle	194.4	699.8	14.63	15.43	14.63	414.3	562,700	510,600
	Total Recycle*	279.3	1,005.4	25.48	26.87	25.48	721.6	980,000	889,300
Total (less Kaiser)	BAT	311.6	1,121.7	12.868	13.57	12.868	364.42	494,900	449.100
	Add for Total Recycle	1,507.0	5,425.1	146.81	154.85	146.81	4,157.6	5,647,000	5,124,300
	Total Recycle*	1,818.6	6,546.8	159.678	168.42	159.678	4,504.02	6,141,900	5,573.400

* NOTE: Energy and fuel requirements include non-contact cooling water and BAT

6.2.2 Water Loss

The majority of the present steel industry water systems either are once-through or utilize minimal recycle. This results in a minimal loss of water to evaporation. However, increasing the amount of recycle will require cooling which will increase the amount of water lost to evaporation. This loss is necessitated by the evaporative cooling effects required to lower the temperature of the water recycled and, in the case of certain systems for BAT and for total recycle, to dispose of the waste streams from dissolved solids removal systems. The estimated quantities of water for the five plants studied for makeup, blowdown and consumption for existing conditions, BAT requirements and possible total recycle are presented in Table 6-2. This table indicates the wide variations in makeup, blowdown and consumption for existing conditions with lesser degrees of variation for BAT and total recycle.

The m^3/kkg (gal/ton) figures for water consumption for the five plants have been averaged and are presented in Table 6-3. Since the present water systems at Kaiser-Fontana and USSC-Fairfield are considered atypical, their rates per unit of production have been eliminated from the averages for the existing and BAT stages. The average increase in water consumption between existing conditions and BAT is approximately 10 percent while the increase from existing conditions to total recycle is approximately 100 percent. If this is applied to the total U.S. integrated steel production of 142.7 x 10^6 kkg (157 million tons) the increase in water consumption between existing conditions and BAT will be 38.5 x 10^6 m^3/yr (10,170 x 10^6 gal/year). The increase from existing conditions to total recycle will be 364 x 10^6 m^3/yr (196,500 x 10^6 gal/year).

This additional water will be lost to users in the immediate area of the steel plants, and recovery of the water and at what locale cannot be predicted.

6.2.3 Meteorological Effects

In Section 6.2.2, the water consumption was predicated on advancing from existing conditions to BAT, thence to total recycle. Huge amounts of additional water will be consumed under the requirements of total recycle. The loss to the atmosphere of the additional amount of water may have detrimental effects on the meteorology of the areas in question and those areas nearby. However, these effects have not been studied in this report. Prior to implementation of total recycle, a thorough study should be made of this aspect.

TABLE 6-2

WATER REQUIREMENTS OF FIVE PLANTS STUDIED

Plant	Level of Compliance	Water Use: Makeup m^3/kkg (gal/ton)	Makeup m^3/yrx10^6 (gal/yrx10^6)	Blowdown m^3/kkg (gal/ton)	Blowdown m^3/yrx10^6 (gal/yrx10^6)	Consumption m^3/kkg (gal/ton)	Consumption m^3/yrx10^6 (gal/yrx10^6)
Kaiser Steel Corp.- Fontana Works	Existing (BAT)	4.08 (1,075) *	14.7 (3,870) *	1.0 (248)	3.4 (892)	3.0 (827)	11.3 (2,979)
	Total Recycle	3.2 (839)	11.4 (3,018)	0	0	3.2 (839)	11.4 (3,018)
Inland Steel Corp. - Indiana Harbor Works	Existing	124 (32,660)	1,345 (355,250)	119 (31,400)	1,294 (341,530)	5 (1,260)	51 (13,720)
	BAT	87 (23,039)	949 (250,600)	81 (21,423)	883 (233,023)	6 (1,616)	66 (17,577)
	Total Recycle	9 (2,487)	102 (27,056)	0	0	9 (2,487)	102 (27,056)
National Steel Corp. - Weirton Steel Division	Existing	66 (17,550)	287 (75,675)	65 (17,145)	280 (73,930)	1 (405)	7 (1,745)
	BAT	51 (13,380)	219 (57,700)	48 (12,560)	205 (54,155)	3 (820)	14 (3,545)
	Total Recycle	16 (4,215)	69 (18,176)	0	0	16 (4,215)	69 (18,176)
United States Steel Corp. - Fairfield Works	Existing	18.2 (4,370)	40 (10,650)	12.1 (2,820)	26 (6,860)	6.1 (1,550)	14 (3,790)
	BAT	15 (3,925)	36 (9,553)	10.5 (2,515)	23 (6,120)	4.5 (1,410)	13 (3,433)
	Total Recycle	12.2 (2,930)	27 (7,130)	0	0	12.2 (2,930)	27 (7,130)
Youngstown Sheet & Tube - Indiana Harbor Works	Existing	51 (13,460)	337 (88,900)	45 (11,980)	300 (79,135)	6 (1,480)	37 (9,765)
	BAT	36 (9,635)	241 (63,655)	29 (7,638)	191 (50,458)	7 (1,997)	50 (13,197)
	Total Recycle	7 (1,680)	42 (11,100)	0	0	7 (1,680)	42 (11,100)

* Maximum theoretical use which has never been attained

TABLE 6-3

WATER REQUIRED M3/KKG (GAL/TON) - AVERAGES OF FIVE PLANTS STUDIED

Level of Compliance	Water Use: Makeup m^3/kkg (gal/ton)	Blowdown m^3/kkg (gal/ton)	Consumption m^3/kkg (gal/ton)
Existing*	80 (21,223)	76 (20,175)	4 (1,048)
BAT	58 (15,351)	53 (13,873)	5 (1,478)
Total Recycle	11 (2,794)	0	11 (2,794)

* Do not include Kaiser-Fontana and USSC-Fairfield since the present level of water recycle approaches or betters the BAT requirements.

6.2.4 Energy Consumption

Aside from the high construction costs of the systems suggested, it is also quite apparent that the goal of total recycle is highly energy intensive. Huge amounts of energy will be expended to comply with this goal either by using fuel within the plants or at power generating stations at off-site locations. We have assumed the primary fuel would be natural gas due to its relatively clean burning nature. However, recent Government regulations have mandated the use of coal in new facilities so, in addition, the costs of using coal have been estimated.

An estimate of 145 m^3/kkg (4,630 ft^3/ton) of natural gas would be required for total recycle with a cost per kkg of steel produced of $7.66 ($6.95/ton). If coal were used, approximately 0.18 kkg (0.18 ton) of coal would be required throughout the U.S. per kkg (ton) of steel produced at cost of $12.90/kkg or $11.91/ton. The increase in the cost of coal over gas is due to extra handling (stocking, stoking, ash) and pollution control facilities.

If these fuel requirements are expanded to the entire integrated steel industry, 20.69 x 10^9 m^3 (726.9 x 10^9 ft^3) of natural gas or 25.7 x 10^6 tons) of coal will be required per year for total recycle.

6.3 SUMMARY OF COSTS

Cost estimates were prepared for the proposed systems to accomplish total recycle with the interim step of reaching the BAT requirements. Both capital and annual costs were estimated using 1978 prices. Since only general designs were prepared, certain site specific considerations, such as the need for piling, obstructions, railroad crossing, etc., may not have been taken into consideration. However, contingency factors were added in an attempt to compensate for unknown and unforeseen items which would cause cost increases.

Table 6-4 presents the estimated costs for both BAT and total recycle. As stated above, natural gas was assumed as the fuel, and capital and annual costs are given for gas. In addition, costs per kkg (ton) of steel produced to achieve both BAT and total recycle are presented based on the use of coal as a fuel.

It would be expected that the costs to achieve both BAT and total recycle for each plant on the basis of cost per unit of production of steel would be approximately the same. However, noticeable differences are evident. Following is a discussion on the possible reasons for these cost variations.

TABLE 6-4

SUMMARY OF PLANT COSTS TO MEET BAT AND TOTAL RECYCLE

Plant	Phase	Capital Costs $	Annual Costs $	Plant Capacity kkg/yr (ton/yr)	Addl Annual Cost $/kkg(ton)
Kaiser-Fontana	BAT	-	-		-
	Total Recycle w/o NCCW	-	-	3,267,000 (3,600,000)	-
	Total Recycle w/ NCCW	17,717,000	9,762,000	-	2.99 (2.71)
Inland Steel Corp. - Indiana Harbor Works	BAT	36,300,000	18,823,000		1.91 (1.73)
	Total Recycle w/o NCCW	94,172,000	75,235,000	9,866,000 (10,877,000)	7.63 (6.92)
	Total Recycle w/ NCCW	162,079,000	139,875,000		14.18 (12.86)
National Steel - Weirton Steel Division	BAT	24,051,000	10,298,000		2.63 (2.39)
	Total Recycle w/o NCCW	120,633,000	125,595,000	3,912,000 (4,312,000)	32.11 (29.13)
	Total Recycle w/ NCCW	129,814,000	129,933,000		33.21 (30.13)
United States Steel - Fairfield Works	BAT	7,760,000	5,559,000		2.52 (2.28)
	Total Recycle w/o NCCW	-	-	2,208,000 (2,434,000)	-
	Total Recycle w/ NCCW	59,192,000	69,344,000		31.41 (28.49)
Youngstown Sheet & Tube - Indiana Harbor Works	BAT	19,580,000	23,648,000		3.95 (3.58)
	Total Recycle w/o NCCW	65,880,000	59,172,000	5,993,000 (6,606,000)	9.87 (8.96)
	Total Recycle w/ NCCW	74,350,000	64,571,000		10.77 (9.77)
Totals*	BAT*	79,931,000	52,769,000		2.67 (2.42)
	Total Recycle w/o NCCW	280,685,000	260,002,000	19,771,000 (21,795,000)	13.15 (11.93)
	Total Recycle w/ NCCW	366,243,000	334,379,000		16.91 (15.34)

* NOTES:

1. Costs shown for total recycle with and without non-contact cooling water include costs of BAT
2. *Totals do not include Kaiser Fontana and USSC-Fairfield.
3. NCCW is non-contact cooling water.

6.3.1 BAT Costs

The following costs per unit of production were estimated to achieve the BAT requirements.

	Cost per kkg (ton)
Kaiser-Fontana	No Costs Estimated
Inland-Indiana Harbor	$1.91 (1.73)
National-Weirton	$2.63 (2.39)
USSC- Fairfield	$2.52 (2.28)
Y.S. & T.-Indiana Harbor	$3.95 (3.58)

The costs for Kaiser-Fontana were not estimated for the BAT step because this plant has facilities which, with some modifications, would bring it into compliance. Of the costs for the four remaining plants Fairfield, Weirton and Y.S. & T. - Indiana Harbor are basically in agreement. The cost for Inland Steel, however, is approximately half that of the other three plants and this is probably due to two factors. The main factor is that Inland does not have tinning facilities which require high cost treatment facilities and high operating costs, since zero discharge is required for BAT. Another reason could be the size of this plant which produces almost twice as much steel as the next largest plant studied, namely Y.S. & T. - Indiana Harbor Works. The large plant would, in all probability, have treatment facilities with lower unit capital and operating costs.

6.3.2 Total Recycle Costs

The following costs per unit of production for facilities to achieve total recycle, with and without the inclusion of non-contact cooling water were estimated. These costs include the costs for the BAT step as shown in Section 6.3.1.

	Cost per kkg (ton)	
	Without Non-Contact Cooling Water	With Non-Contact Cooling Water
Kaiser-Fontana	-	$ 2.99 (2.71)
Inland-Indiana Harbor	$ 7.63 (6.92)	14.18 (12.86)
National-Weirton	32.11 (29.13)	33.21 (30.13)
USSC-Fairfield	-	31.41 (28.49)
Y.S. & T.-Indiana Harbor	9.87 (8.96)	10.77 (9.77)

The low cost per unit of production for the Kaiser-Fontana plant can be attributed to their presently installed system which produces the lowest blowdown amount per unit of production of any of the plants studied and is probably one of the lowest in the world

6.3.3 Increase in the Cost of Steel

Presently (1978) steel products range in cost from approximately \$385 to \$440 per kkg (\$350 to \$400 per ton). This variation is due basically to the wide range of products offered. If a figure of \$413 per kkg (\$375 per ton) is used as an average, the added cost due to BAT will be approximately \$2.67 per kkg (\$2.42 /ton). Total recycle excluding non-contact cooling water will be approximately \$13.15 per kkg (\$11.93 per ton) and including non-contact cooling water will be approximately 16.91 per kkg (\$15.34 per ton). This represents an increase of 0.65 percent in the cost of raw steel produced for BAT, 3.2 percent for total recycle excluding non-contact cooling water and 4.1 percent for total recycle including non-contact cooling water.

6.4 SUGGESTED RESEARCH

In the formulation of the various possible means of attaining the BAT and total recycle, wastewater treatment processes have been shown in this report which have not been tested on a full scale basis and, in some cases, bench scale tests have not been performed. Use of these processes, however, was necessary because existing proven technology within the steel industry to attain this goal does not exist for total recycle and, although it is available for BAT in the main, certain areas such as the tin plating process do not possess this proven technology.

Whenever technology is suggested for application to an industry where it has not been previously proven, there is great and justified concern expressed. These concerns are justified by the fact that industry cannot spend large amounts of money to build facilities which they feel may never operate successfully. It is, therefore, mandatory that extensive research programs be initiated prior to any decision to impose the requirement of total recycle. The areas of needed research are mainly in the multi-step biological treatment of by-product coke plant wastewaters, in the treatment of blast furnace gas washer system blowdown, and in the treatment of wastewaters to remove dissolved solids. It is assumed that the zero discharge requirement for tinning operations will be changed in the present review of the guidelines. If this is not accomplished, research in this area will be needed.

6.4.1 By-product Coke Plant Wastewaters

To date, treatment of coke plant wastewater has been limited to single stage biological treatment plants which have had varying degrees of success in producing the desired effluent qualities. It is safe to say, however, that a properly designed and operated single stage biological treatment plant with ammonia removal preceding it can successfully treat by-product coke plant wastewaters to meet certain specified criteria of BPCTCA. The BAT treatment models generally do not represent tried and true proven steel industry technology. While, in theory, the proposed treatment processes should produce the desired effluent qualities, there are no known plants of this type operating in the U.S. steel industry.

Prior to implementation of multi-stage biological treatment, extensive pilot plant tests should be performed on the effluents of the plant under consideration. This is necessary since it is extremely difficult not only to transfer technology from one industry to another, but from one steel plant to another due to the different nature of the wastewaters under consideration.

At present, EPA Contract No. 68-02-2671 is being executed for the treatment of by-product coke plant and blast furnace wastes. When completed, the information obtained should be valuable in establishing parameters for plant specific pilot studies on this type of wastewater.

Concurrent treatment of blast furnace gas washer system blowdown with coke plant wastes is suggested in this report. This suggestion is made since the blast furnace blowdown is similar to, although more dilute in quality, than the coke plant wastewater. However, there are objections to combining these two wastewaters. The only valid objection appears to be the possible presence of known and unknown compounds in the blast furnace blowdown which could impede the biological treatment process. Certain compounds could be treated prior to the combined treatment suggested.

6.4.2 Blast Furnace Gas Washer Blowdown Treatment

In the previous section, the combined treatment of blast furnace gas washer blowdown with by-product coke plant wastewater was suggested. This combined treatment should be researched because of the possibility of large saving in construction and operating cost possible. This is especially so since the coke plants are usually in relative close proximity to the blast furnaces at most plants. This combined treatment is also desirable due to the extremely high cost of the recommended alkaline-chlorination treatment process for the removal of cyanide.

6.4.3 Dissolved Solids Removal

Chapter 5, deals with various methods for the removal of dissolved solids from wastewater and the disposal of the brines generated. The suggested teechnology has not been demonstrated on the treatment of the volumes and types of wastewater to be encountered. A thorough research project should be undertaken to determine if the suggested technology is feasible and to substantiate the estimated costs.

6.5 POSSIBLE IMPLEMENTATION PROGRAM

If a total recycle program is put forth for an integrated steel plant, certain steps will be necessary from the inception of the project to its final completion and operation. These steps include the implementation of research projects, the reporting of results of these projects, preparation of designs and specifications for construction of the facilities, construction of the facilities, and start-up and operator training.

The following is a brief description of the steps envisioned in a program to implement total recycle in a typical integrated steel mill:

A. Install facilities to meet BPT requirements. - It is assumed for the purposes of the program that the facilities to meet BPT have been installed. However, at some plants the facilities are not in place and the time for this additional work may have to be added to the total time of the program.

B. Install facilities to meet BAT requirements. - This step, in the program, will have the following sub-steps:

   1. Prepare report with cost estimate on BAT facilities required to form a basis for design.

   2. Construct and operate pilot plant on facilities to reach zero discharge from plating facilities.

   3. Prepare report on plating facilities pilot plant studies.

   4. Obtain appropriations for construction of BAT facilities.

   5. Design BAT facilities.

   6. Prepare request for bids and issues.

   7. Preparation of bids by contractors.

   8. Review of bids and award of contract.

9. Construction - It was assumed, for simplicity, that the construction of facilities for BAT could take place throughout the entire plant. However, in order to avoid the disruption of production as much as possible staged construction may be required which would extend the period of construction.

10. Startup and operator training including producing effluents that are acceptable under the BAT requirements.

C. Perform test work including pilot plant studies for facilities to meet total recycle.

1. Perform analyses on BAT effluents and prepare report on pilot plant requirements.

2. Design pilot plants.

3. Construct pilot plants.

4. Operate pilot plants and prepare report including results and recommendations.

D. Install facilities to meet requirements of total recycle.

1. Prepare designs of facilities recommended in total recycle pilot plant study including further segregation and retrouting of water and wastewater flows.

2. Prepare hydraulic study of plant water systems to insure that pipe and pump sizings are adequate or make recommendations for changes and modifications.

3. Prepare request for bids and issue.

4. Preparation of bids by contractors.

5. Review of bids and award of contract.

6. Construction - It is assumed, for simplicity, that the construction of facilities for total recycle could take place throughout the entire plant. However, in order to avoid the disruption of production as much as possible staged construction may be required which would extend the period of construction.

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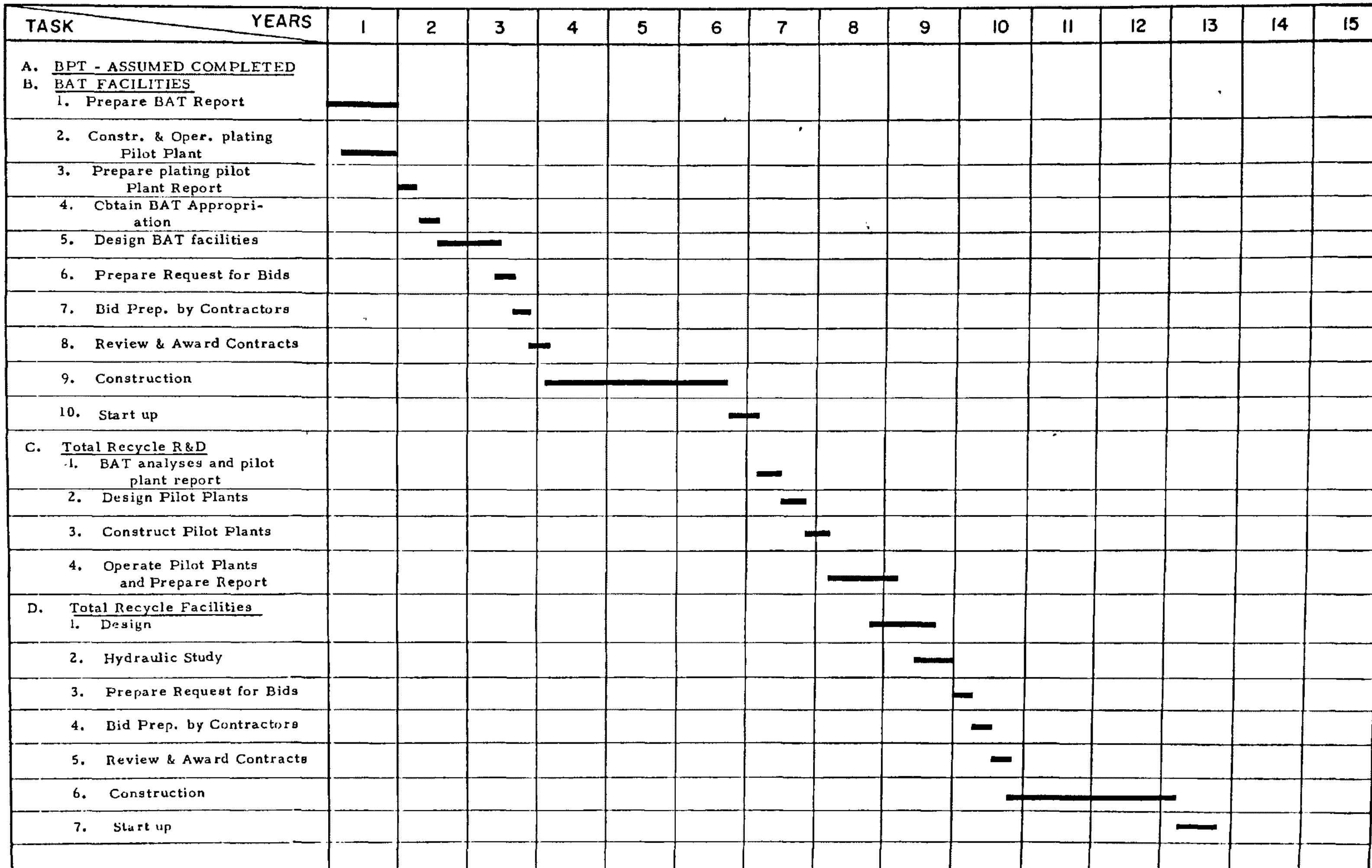
FIGURE 6-1

SCHEDULE FOR TOTAL RECYCLE PROJECT



7. Startup and operator training including bringing the facilities in compliance with the total recycle requirements.

Figure 6-1 has been prepared to graphically indicate the various steps required and the estimated time to complete each step.

A period of approximately 13 years is estimated from the time a commitment is made to implement total recycle until plants are constructed and properly operating. This schedule does not, however, take into consideration the possible failure of a process during the research period and the necessity to reassess other technologies for consideration with the subsequent research that will be needed. If research must be repeated on other processes, then the time of completion will be lengthened. Therefore, more than one process should be researched at a time to assure that the required results are achieved within a reasonable time frame.

<u>REFERENCE</u> (SECTION VI)

(1) Electric World, September 15, 1978, McGraw Hill Publications.

APPENDIX A

KAISER STEEL CORPORATION

FONTANA WORKS

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This appendix addresses itself specifically to the Kaiser Steel Corporation plant at Fontana, California. It includes preliminary engineering designs based on conclusions reached from data supplied by the Kaiser Steel Corporation. It does not include the identification of all environmental control technologies considered, the evaluation of other steel plants studied or cost estimates.

1.2 METHODOLOGY

Kaiser Steel's existing recirculation systems are so extensive that no attempt was made to investigate in detail the qualities of water used at the in-plant water systems, unless a potential resultant air pollution problem was indicated.

Air quality control systems were also evaluated with respect to existing emissions and local air quality requirements. Local air quality control agencies were contacted and data and regulatory requirements were obtained. The plants also provided summaries of their emissions inventories.

1.3 DESCRIPTION OF THE STEEL PLANT

1.3.1 Processes and Facilities

The Kaiser Steel Corporation operates a completely integrated Steel Plant located in Fontana, California, on approximately 607 ha (1500 acres). The production facilities as of December 1976 consisted of:

	Capacity - kkg/yr (ton/yr)
- One by products coke plant	3,609 (3,798)
- One sinter plant	2,109 (2,325)
- Four blast furnaces	6,087 (6,710)
- One eight furnace open hearth shop	3,099 (3,416)
- One basic oxygen steel-making shop (BOSP)	3,449 (3,802)
- A slabbing mill	5,002 (5,514)

	Capacity - kkg/yr (ton/yr)
- A 46-inch blooming mill	362 (399)
- An 86-inch hot strip mill	3,708 (4,087)
- A merchant mill	66 (73)
- A structural mill	147 (162)
- A continuous weld pipe mill	265 (292)
- Two continuous pickling lines	2,143 (2,362)
- Three alkaline cleaning lines - one of which is contiguous with a continuous annealing line.	1,467 (1,617)
- Four cold rolling mills, including tin plating and galvanizing.	2,173 (2,395)
- A 148-inch plate mill	1,129 (1,245)

Since 1976 the blooming, merchant and structural mills have ceased operating. A second Basic Oxygen Steelmaking shop and a continuous caster are presently under construction. Plant plans are to operate only two of the three retained open hearth furnaces after the new BOP and caster are in operation.

1.3.2 Water Systems and Distribution

In this report the flows reported and indicated on the flow diagram were estimates by plant personnel and have not been substantiated by measurements. They reflect the values used for pipe sizing and can vary widely depending upon plant operations. KSC has stated that "...the only reliable flow meters are located at the plant raw water treatment plant and at the plant's discharge to the non-reclaimable waste water line. What happens in between is largely conjecture." Additionally, some of the water qualities supplied by KSC for the preparation of this report are KSC plant estimates and judgements.

Water for the steel plant is obtained from two sources; presently approximately 7.57 x $10^6 m^3$ (two billion gallons) per year is purchased from the Fontana Union Water Company and the balance of the plant requirements, approximately 3.78 x $10^6 m^3$ (one billion gallons) per year, are obtained from two 245 meter (800 feet) deep wells located on Kaiser property with a water table approximately 120 meters (400 feet) below ground. The purchased water and, when necessary, well water is stored in a main reservoir that has a capacity of 17,000 m^3 (4.5 million gallons) which is enough to supply the plant with water for about 12 hours. Due to the average total dissolved solids of the water entering the plant (about 230 mg/l) and a hardness of about 150 mg/l (as $CaCO_3$) all water is softened in reactor clarifiers. The water is then carbonated, chlorinated, filtered and then stored in domestic and industrial reservoirs.

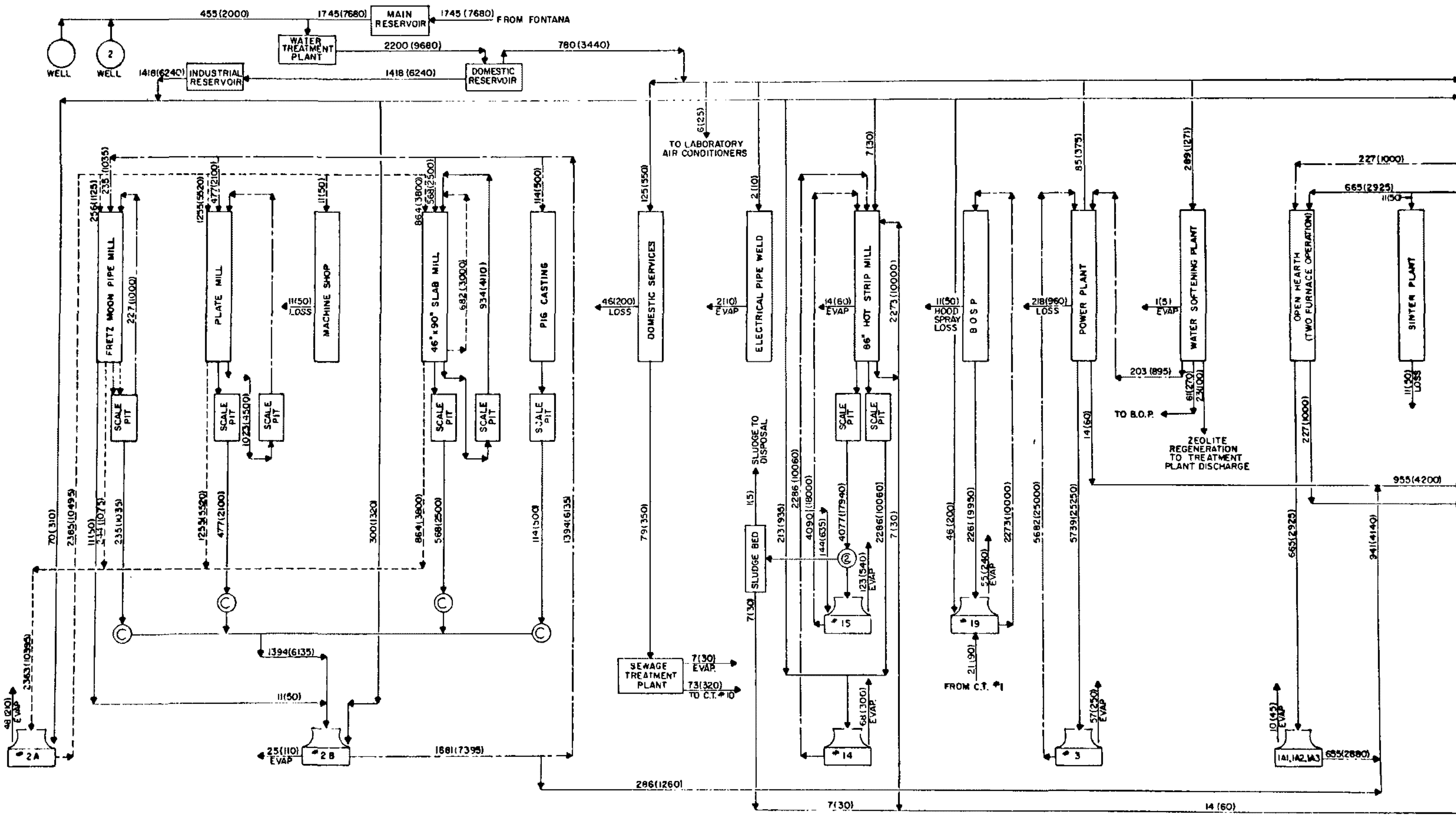
The domestic water and fire protection systems use the same distribution network. The water is stored in a 1890 m^3 (500,000 gallon) covered reservoir, and then pumped to an elevated tower from where it is distributed to domestic, fire, and other plant uses requiring high quality water.

The water system, as shown on Figures A-1 and A-2, has four quality levels and is supplied from an open 4500 m^3 (1,200,000 gallon) reservoir. The general concept is that water cascades through a number of systems, with the blowdown of one system becoming the supply of the following system. The systems are sequenced in order of quality requirements, with the first systems having the highest quality and the last system the poorest. A diagram of the system is shown on Fig. A-3.

The highest order of use is the motor room systems, where electrical equipment is cooled, in the lube cooling systems, and the reheat furnace cooling systems. These are recirculating non-contact cooling systems utilizing open cooling towers. KSP has three such non-contact systems equipped with cooling towers capable of handling 12,500 m^3/hr (55,000 gpm). Each system is equipped with an elevated storage tank to maintain a uniform pressure and provide an emergency supply in case of a power failure. Steam or gasoline driven emergency pumps provide for a minimum flow to protect the equipment in case of a long power outage.

The modernization program presently in progress will have two additions to the high quality water systems. The new B.O.F. will have a completely closed hood and lance cooling system with water to water heat exchangers. The water in this enclosed system will be of boiler quality, while the cold side heat exchanger water will be similar in quality to that described above. The other cooling water system will be for the continuous slab caster.

The second quality level systems provide water to the rolling mills for bearing cooling, roll cooling and some scale flushing. Water in these systems picks up heat, oil, grease and some mill scale from the rolling mills. KSP has two of these systems equipped with cooling towers capable of handling 11,800 m^3/hr (52,000 gpm). Elevated storage tanks provide pressure control and reserve capacity. After the water is used in the rolling mills it flows to adjacent scale pits where the heavy scale particles settle out. The water is then pumped to clarifiers where fine scale and other solids are removed and the oil skimmed off. Effluent from the clarifiers is pumped over the cooling towers for heat removal and then back to the mills for reuse. The clarifier effluent is satisfactory for all mill purposes except high pressure descaling. There it has been necessary to provide additional cleaning by automatic



NOTES:

1 BLAST FURNACE CLARIFIER UNDERFLOW TO SLUDGE BED SUPERNATANT RETURNED TO LEVEL 4 SYSTEM

2 HOT MILLS CLARIFIERS UNDERFLOW TO SLUDGE BED SUPERNATANT RETURNED TO COOLING TOWER 2B

* EXCESS DISCHARGE OVER SUPPLY AT COKE PLANT DUE TO WASTE AMMONIA LIQUOR.

LEGEND:

FLOWS 000 — M^3/Hr (000) — GPM

RECYCLED WATER

COOLING WATER (NON-CONTACT)

PROCESS WATER

CLARIFIER (S)

ELEVATED TOWER

COOLING TOWER (CT)

SLAG QUENCH

WATER COOLED-HEAT EXCHANGER

U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP

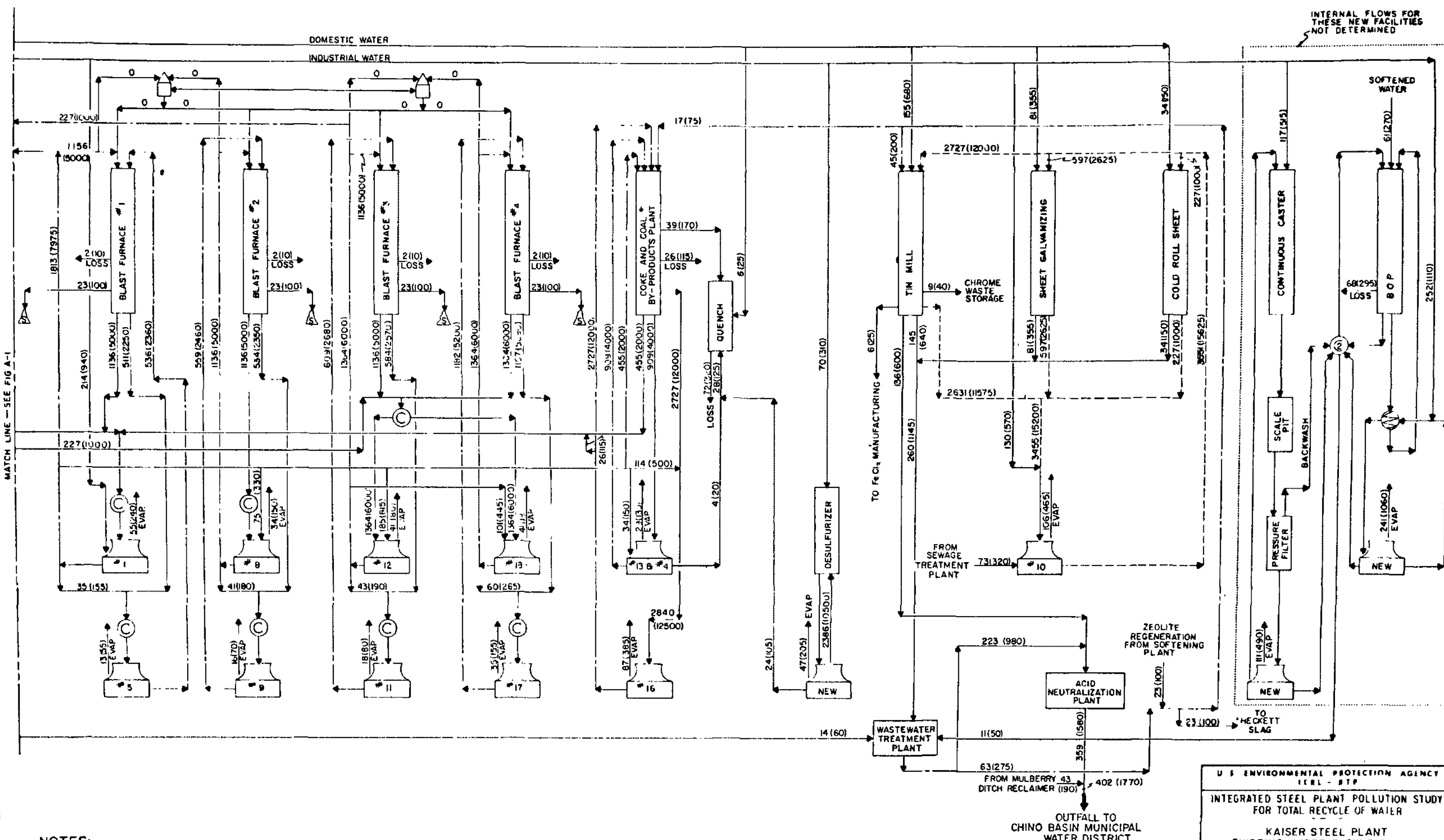
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

KAISER STEEL PLANT
EXISTING WATER FLOW DIAGRAM

HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK, N.Y.

DRAWN BY M
CHECKED BY H.H.
APPROVED H.J.K.
DATE
REVISIONS

FIGURE A-1



NOTES:
FOR NOTES AND LEGEND SEE FIG A-1

U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP

INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

KAISER STEEL PLANT
EXISTING WATER FLOW DIAGRAM

HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y

FIGURE A-2

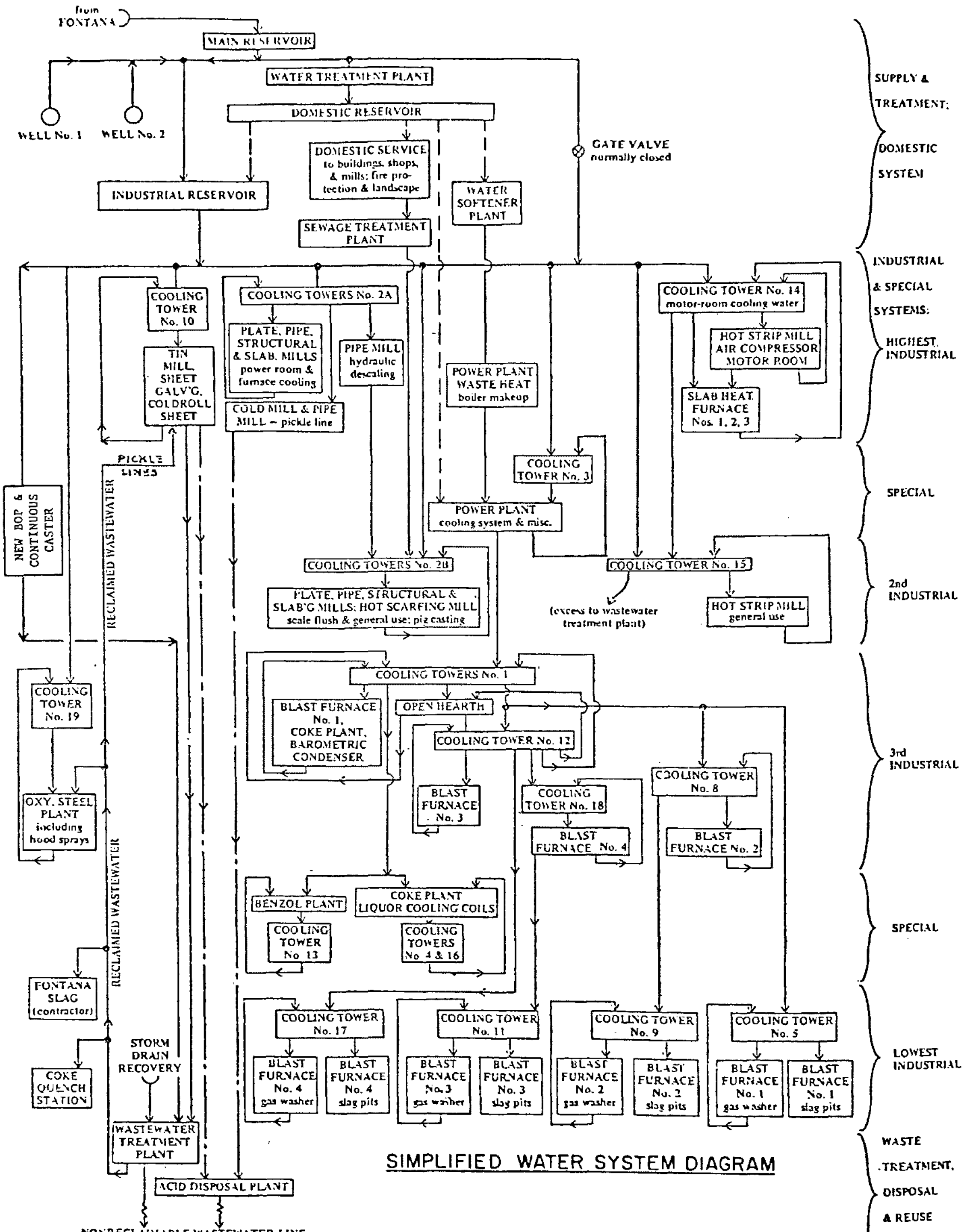


FIGURE A-3

AFTER ARTICLE BY ROBERT W. WIGHT "HOW IT'S DONE AT KAISER" strainers with a fine mesh. It has been reported that this water is of not a high enough quality and that difficulties have been encountered in spray nozzle wear and clogging and maintenance of the descale pumps.

Sludge underflow is pumped from the clarifiers to sludge beds. When full, these beds are allowed to dewater and dry. A clam shell crane then removes the sludge for haulage to a disposal site. Supernatant from the hot strip mill sludge bed is pumped to the wastewater treatment plant (WWTP).

The third quality level system supplies cooling water to the Open Hearth steelmaing furnaces, the Basic Oxygen steelmaking furnaces, a portion of the Coke Plant and the four Blast Furnaces. Water in these systems picks up heat and dirt, mainly iron graphite. KSC has five of these systems which, when originally installed, were equipped only with cooling towers. During the past few years all but one have had clarifiers added to remove the iron graphite and coke breeze. Problems with plugging of some of the internal coolers made the addition of the clarifiers necessary. Sludge from the clarifiers is handled in sludge beds. The rated capacity of the third level system is 13,400 m^3/hr (59,000 gpm). These five, third quality level, systems are all tied together through two elevated towers. System balancing is difficult but due to the potential of loss in equipment and production it is necessary to have system back-up so that complete loss of water is practically impossible. Emergency steam driven pumps are installed at each cooling tower to continue water circulation in the event of power failure.

The fourth and lowest quality level system serves the Blast Furnace gas washers. Orifice scrubbers and gas washers are used to scrub and cool the flue gas. Large amounts of dust are removed from the gas by the water which then flows to clarifiers where the solids settle and are removed as sludge. After clarification the water is pumped over a cooling tower and then pumped back to the Blast Furnace gas washers for reuse. Dissolved solids build up quite rapidly in these systems and are controlled by blowing down a portion of the water to spray-cool the molten slag which runs into open pits each time a Blast Furnace is tapped. The application of this water is closely controlled to prevent excess water from accumulating. In this way, all of soluble salts in the water combine with the Blast Furnace slag which is hauled away by a contractor. The rated capacity of the gas washer systems is 3,230 m^3/hr (14,200 gpm).

The soluble salts combined with the slag is moved to many off-site areas and used for many purposes which prevents or minimizes entry of the soluble salts into ground water supplies.

Sludge from the clarifiers is pumped to sludge beds, which are cleaned periodically and the sludge hauled to a dump site. The water in these beds would be in violation of the discharge requirements and the beds are, therefore, lined to prevent contamination of the ground water. Supernatant water is returned to the gas washer system.

Other cooling tower systems serve special functions in the plant. The power house system, with a capacity of 10,100 m^3/hr (44,300 gpm) is equipped only with cooling towers and a return pump station. Heat is the only contaminant involved so treatment other than by cooling towers is not required. The Coke Plant has three cooling tower systems which indirectly cool the Coke Oven gas. The total rated capacity of these systems is 4,200 m^3/hr (18,500 gpm).

The total capacity of all of the cooling towers in the entire plant is between 54,540 and 54,800 m^3/hr (240,000 and 250,000 gpm).

A summary of water uses, qualities, quantities and cooling tower systems is shown on Table A-1.

1.3.3 Waste Treatment Facilities

Kaiser Steel Corporation has three separate treatment facilities for wastewaters generated in the plant. These include: (a) A sanitary sewage treatment plant, (b) An acid neutralization plant, and (c) A treatment plant for all non-acid, non-domestic wastewaters. The last plant is generally referred to as the Wastewater Treatment Plant (WWTP).

(a) The sewage treatment plant has a primary treatment stage consisting of a clarifier and a digester and a secondary stage consisting of two pairs of trickling filters, a clarifier and a chlorine contact chamber.

The sewage is generally very dilute with a low BOD loading due to the fact that most of the water originates from the showers during shift changes. Because of the low BOD loading, it is sometimes difficult, because of a lack of nutrients, to keep the trickling filters with an adequate algae growth.

The chlorine residual of the effluent of the sewage treatment plant is kept at a minimum of 1 mg/l and the typical BOD is 1-5 mg/l. Sewage plant effluent is returned to the plant for reuse in the first water quality level systems and is discharged into the makeup line of No. 10 Cooling Tower. An algae growth inhibitor is necessary in the cooling tower

TABLE A-1

SUMMARY OF WATER USES, QUALITIES AND QUANTITIES

CT#	Quality Level	Rated Capacity m^3/hr	Rated Capacity gpm	Present Qualities: Total Hard. as $CaCO_3$	Total Alk	TDS	SS	Cl	Na	SO_4	pH	Data Source	Water Used At
2A	1	5340	23,500 (total)**	108	51	283	23	53	32	49	7.4	Received from Kaiser	Plate and Pipe Mills, cooling, Machine Shop
10	1	5680	25,000	83	25	263	53	71	45	55	7.2	Received from Kaiser	Tin Mill, Sheet galvanizing, Cold Roll Sheet cooling
14	1	2730	12,000	126	36	408	96	94	60	84	7.1	Received from Kaiser	Hot Strip Mill cooling
2B	2	3770	16,600 (total)**	115	64	284	28	37	36	69	7.7	Received from Kaiser	Pipe Mill process, Slab Mill flume flush, Plate Mill cooling and descale
15	2	5455	24,000	132	82	412	100	79	78	104	7.4	Received from Kaiser	Hot Strip Mill process
1	3	7270	32,000 (total)**	149	39	473	39	144	81	79	7.3	Received from Kaiser	Coal Chemicals, Blast Furnace No. 1, open hearth cooling, Sinter Plant applic.
18	3	2045	9,000	174	43	551	29	179	96	84	7.5	Received from Kaiser	Blast Furnace No. 4 cooling
8	3	1365	6,000									Similar to CT#18	Blast Furnace No. 2 cooling
12	3	2045	9,000									Similar to CT#18	Blast Furnace No. 3 cooling, open hearth
19	3	3410	15,000	80	180	699	58	95	103	61	7.6	*	BOSP cooling and hood sprays
17	4	1180	5,200	902	219	3092	52	1123	577	368	7.1	Received from Kaiser	Blast Furnace No. 4 gas washing
5	4	680	3,000									Similar to CT#17	Blast Furnace No. 1 gas washing
9	4	680	3,000									Similar to CT#17	Blast Furnace No. 2 gas washing
11	4	680	3,000									Similar to CT#17	Blast Furnace No. 3 gas washing

TABLE A-1

SUMMARY OF WATER USES, QUALITIES AND QUANTITIES

(Continued)

CT#	Quality Level	Rated Capacity m^3/hr	Rated Capacity gpm	Present Qualities: Total Hard. as $CaCO_3$	Total Alk	TDS	SS	Cl	Na	SO_4	pH	Data Source	Water Used At
3	Special System	10080	44,340	381	375	831	38	81	106	113	8.2	*	Power Plant cooling
4	"	568	2,500	1118	293	3548	293	1080	608	593	7.5	*	Coal Chemicals cooling
13	"	909	4,000									*	Coal Chemicals cooling
16	"	2730	12,000	641	168	2034	168	619	348	340	7.5	*	Coal Chemicals cooling
30, 31, 32	To be constr.											Not presently known	

* Calculated by determining cycles of concentration and multiplying that by the quality of make up.

** A total of more than one tower unit.

systems involved. Sewage effluent has been used in the plant without problems since start-up in 1943.

Since this water is completely recoverable, mill operators divert the effluents from evaporative coolers, seal water sources, steam traps, etc., to the domestic sewerage system, rather than divert these flows to the more contaminated system flowing to the WWTP.

(b) The acid neutralization plant was originally designed for neutralization of spent sulfuric acid with lime. The resulting sludge was stored in lagoons and the decanted liquid reused for rinse water on the pickle line. This water caused scaling of the pipe lines and sludge deposits in the rinse tanks. As soon as a connection to the non-reclaimable wastewater line was complete this rinse water was discharged and replaced with the effluent from the wastewater treatment plant.

The decanted liquid from the acid neutralization process, containing partially soluble calcium sulfate, began to form scale in the non-reclaimable wastewater line and a different neutralizing agent was necessary. KSP now uses anhydrous ammonia for neutralization which forms completely soluble ammonium sulfate. The cost of anhydrous ammonia is considerably higher than that of burnt line but the savings from reductions in operating and maintenance costs resulted in slightly reduced overall neutralization costs per gallon of waste pickle liquor. In 1969 KSP converted its pickling processes to hydrochloric acid (HCl) and the only other users of sulfuric acid remaining are the three electrolytic plating lines.

KSP has contracted with a company located on plant property to take the concentrated waste HCl pickle liquor and use it to manufacture marketable ferric chloride, therefore, only HCl rinse waters and waste sulfuric acid - a total of 136 m^3/hr (600 gpm) flow to the acid neutralization plant. Presently, the ferric chloride manufacturer has a market demand which exceeds KSP's capabilities to supply him with his raw feedstock (waste pickle liquor).

Wastewater from the WWTP that is not recirculated back to various parts of the plant passes through the neutralization plant in addition to the rinse and acid wastes. Discharges from the acid neutralization plant are directed to the non reclaimable wastewater line and then to the Chino Basin Municipal Water District (CBMWD) for further treatment by the Los Angeles County Sanitation District before final discharge to the Pacific Ocean. The current contract with the CBMWD is for the discharge of 30 capacity units (one capacity unit is 10.2 m^3/hr (45 gpm)). Because of the modernization of the steel plant it is expected that the amount of wastewater generated at the plant will increase and KSP has, therefore, submitted an application to the CBMWD for the purchase of an additional 13 capacity units. The design of an additional sewer line which would be required has been completed.

(c) The Wastewater Treatment Plant consists of an elevated surge tank, a two section float-sink separator, and a clarifier. Some mixing tanks are available to give additional treatment at various stages of the process but, at present, are not used. Water flowing through this plant is high in suspended solids and oils. The suspended material is mainly free oils, greases, very fine mill scale, oil emulsions and colloidal suspensions of silicates. The pH varies from 9.5 to 11.5.

The suspended solids originate in the Tin Mill, Cold Roll and Sheet Galvanizing from such processes as electrolytic cleaning and cold reduction overflow, and from the hot strip mill sludge pond.

KSP has installed "Brill" oil skimmers, at both the scale pits and the one operating sludge bed, which remove floating oils which are then stored and removed by a contractor for processing and subsequently sold back to the plant as lubricants and fuel.

At the WWTP sludge is produced in the float-sink separator and in the clarifier due to gravity separation of solids and oils. The design flow rate of the float-sink separator was 170.5 m^3/hr (750 gpm) per section but discussions with KSP personnel indicate that the design capacity per section should actually be 114 m^3/hr (500 gpm). Before the diversion of Mulberry Ditch the float-sink separator had operated occasionally at 227 m^3/hr (1,000 gpm) per section. Sludge is collected in hoppers and vacuumed out for disposal at a Class I dump site. The sludge consists of 8 to 15 percent metallic solids, 65 to 70 percent water and the balance various oils and greases consisting mainly of tallow from the cold reduction mills. KSP is studying the effects of oily sludge on coke oven operations and on the quality of the coke and by products. If successful, the oily sludge may be metered on to the coal stocker belt when coal unloading operations are in progress.

The quality of liquid effluent from the WWTP varies widely and at times has a milky appearance. The disposition of the water from the WWTP has been estimated by the plant to be as follows with the caution that the figures given are <u>only</u> estimates: Approximately 62.5 m^3/hr (275 gpm) of the total 278 m^3/hr (1,225 gpm) discharged from the WWTP is recycled back to the Coke Plant (17 m^3/hr (75 gpm)) and to the Tin Mill

Pickling Lines (45 m^3/hr (200 gpm)). An additional 216 m^3/hr (950 gpm) is discharged to the acid neutralization plant together with the pickle rinse waters for subsequent discharge to the CBMWD. In the recent past an additional 34 m^3/hr (150 gpm) was recirculated back to the BOSP for cooling but problems of scaling due to the reuse of this water was encountered and its use was discontinued and replaced by blowdown from Cooling Towers 19 and 2.

(d) An additional temporary waste disposal system is located on the landfill area near the Waste Pickle Liquor evaporative ponds. This system consists of two 26,500 m^3 (seven million gallons) lined ponds which were constructed to store waste chromic acid and sodium dichromate which originates as dragout from the tinning lines. These ponds receive an average of 3.2 m^3/hr (14 gpm) of chromic acid wastes and will, in the near future, receive an additional 5.9 m^3/hr (26 gpm) of sodium dichromate wastes. At the total rate of 9.1 m^3/hr (40 gpm), and allowing for net evaporation, KSC estimates that the ponds would be sufficient to contain the wastes produced during a two-year period. No treatment is provided other than evaporation. The purpose of the ponds is to store the wastes until such time as a method of acceptable disposal or chrome recovery is developed.

1.3.4 Water Discharges and Qualities

The major portion of the water supplied to the steel plant is lost through consumptive and evaporative processes in the various recycle systems described in Section 1.3.2 above. By far the greatest losses occur at the numerous cooling towers. This loss is conservatively estimated to be 1,216 m^3/hr (5,350 gpm). Other estimated identifiable losses are or will be: steam production and discharge of 218 m^3/hr (960 gpm), slag cooling at the blast furnaces - 91.0 m^3/hr (400 gpm), the BOSP - 11.4 m^3/hr (50 gpm), coke quenching - 51 m^3/hr (225 gpm), domestic uses such as lawn watering and food preparation - 45 m^3/hr (200 gpm), miscellaneous mill losses such as runout table spray evaporation, machine shop losses, and water retained in sludges and 23 m^3/hr (100 gpm) which is sent to Heckett Slag Co. for their slag quenching operation.

The volume of liquid wastes discharged to the CBMWD, after the plant modifications are complete may be as high as 432 m^3/hr (1900 gpm). It is not anticipated that, if present treatment and recirculation practice are to continue, the quality will vary from that presently discharged.

Data was obtained for the month of April 1977 showing the range of water quality discharged from the WWTP to the reclaimed wastewater line and the wastes as discharged from the

WTP and the acid neutralization plant to the CBMWD. These data are shown in Table A-2.

Wastewaters produced at material storage piles are due to rainfall runoff. Literature pertaining to coal storage indicates that the runoff would require treatment prior to discharge or reuse at a steel plant. Runoff also occurs from ore storage and flux storage piles. The quantity of runoff is highly specific with respect to the porosity of the material storage pile and antecedent conditions. In the area of the Kaiser Steel Plant the average total annual rainfall of 381 mm (15 inches) is not distributed over a 12-month period but is concentrated over a short period of the 3 months of January, February and March. The quality of the runoff from coal piles is specific to the source of the coal. The average effluent drainage concentration is shown in Table A-3.

No data has been available as to the characterization of the runoff from limestone and ore storage piles. It has been assumed that runoff from the limestone and ore storage areas may be high in suspended solids.

KSC has reported that heavy metals or sulfides have not been found in the discharges through the plant drainage system which includes material storage pile runoff. The conductivity is reported as 500 uS/cm indicating low dissolved solids.

1.3.5 Air Pollution Control Facilities

Because of the air quality control requirements imposed upon KSP at the open hearth shop, a decision was made, after an economic analysis, to construct the new BOP and continuous caster and shut down operations at six of the eight open hearth furnaces. Steel will be produced at the remaining open hearths without the use of oxygen injection. Equipment will be included in the new system for the external desulfurization of molten iron.

The new BOP shop, presently under construction, will use suppressed combustion, a closed hood and a wet scrubber and the clean gas will be flared. Facilities will also be provided for the full control of fugitive emissions including "Pecor" doghouses around the vessels. Softened water will be used for cooling the lance and the hood and will be supplied from the power house boiler system without steam generation.

The existing BOSP utilizes dry electrostatic precipitators, and conditioning water at the top of the furnace is adjusted so that gases to the precipitator are not overheated and no water runs into the furnace.

TABLE A-2

TREATED WASTEWATER DISCHARGES

(All units, except pH, in mg/1)

Parameter	Discharge from WWTP	Discharge to CBMWD
pH	9.8 - 11.2	6 - 9.5
Phenolphthalein Alkalinity	112 - 390	0 - 280
Methyl Orange Alkalinity	276 - 810	24 - 2120
Total Solids	1250 - 2020	2010 - 28600
Suspended Solids	80 - 710	840 - 3850
Dissolved Solids	1000 - 1200	1160 - 24840
Total Hardness	16 - 112	18 - 168
Non-Carbonate Hardness	0	0 - 118
Chloride	16 - 200	60 - 10900
Sulfate	65 - 150	170 - 695
Sodium	150 - 455	110 - 480
Calcium	6 - 34	7 - 54
Magnesium	0 - 6	0 - 6
Phosphate	0.7 - 4.6	-
SiO_2	40 - 155	-
Nitrate	0.9 - 4.8	-
Oil & Grease	105 - 550	-

TABLE A-3

AVERAGE EFFLUENT DRAINAGE CONCENTRATIONS(1)

Parameter	Source of Coal		
	Southwestern 83 Percent	Western 17 Percent	Average
Total Suspended Solids	1538	2486	1700
Total Dissolved Solids	356	1900	618
Sulfate	190	240	198
Iron	5.5	8.2	6.0
Manganese	0.04	0.4	0.1
Free Silica	NDL (2)	NDL	NDL
Cyanide	NDL	NDL	NDL
BOD$_5$	7.5	2.5	6.6
COD	769	1826	949
Nitrate	0.16	1.8	0.44
Total Phosphate	NDL	NDL	NDL
Antimony	6.5	14.0	7.8
Arsenic	4.1	5.6	4.4
Beryllium	NDL	NDL	-
Cadmium	NDL	0.005	-
Chromium	NDL	0.04	-
Copper	0.02	NDL	-
Lead	0.05	0.07	0.05
Nickel	0.03	0.05	0.03
Selenium	21.5	15.0	20.4
Silver	NDL	NDL	-
Zinc	0.04	0.15	0.06
Mercury	0.002	0.005	0.002
Thallium	NDL	NDL	-
pH	6.60	7.24	6.7
Chloride	NDL	NDL	-
Total Organic Carbon	158.7	318.4	185.8

(1) All concentrations except pH expressed as g/m^3.

(2) No detectable level.

Water Pollution from Drainage and Runoff from Coal Storage Areas; Wachter, R.A.; NCA/BCR Conference 1977

Gas scrubbers and coolers are utilized at the four blast furnaces to clean the blast furnace gas prior to its use as a fuel. The solids laden water is clarified and the water is reused. Solids are disposed of in a dump site and stored for possible recycle.

Emissions from the sinter plant windbox are controlled by a baghouse and the catch recycled to the sinter plant feed. Discharge end emissions are controlled by water sprays which also serve to cool the sinter. There are no water discharges from sinter plant air cleaning systems.

The ingot mold foundry is equipped with a wet fume control system using "Rotoclones." The "Rotoclone" underflow discharges to one of the clarifiers in the second quality level of the water systems.

The hot scarfer at the 46" x 90" slab mill is equipped with a wet electrostatic precipitator for fume control. This water is also discharged to one of the clarifiers in the second quality level of the water systems.

Fumes from the pickle and plating lines are cleaned by scrubbers. The discharges of the scrubber waters are directed to the respective production line wastewater streams.

A "TRW-CDS" unit had been installed to control emissions from one of the coke oven stacks. Its operation is not successful and it has been abandoned.

1.3.6 Air Emissions

Observations at the plant indicated relatively few emissions from leaking doors at the coke ovens.

The plant personnel have investigated dry and wet electrostatic precipitators, as well as bag filtration at the coke oven stacks and, as a result, KSC has committed itself to the installation of baghouses at four coke oven stacks.

The air quality management district, in February, 1977, conducted a test of emissions from the quench tower and reported that emissions were 43.02 mg/m^3 (0.0188 grains per SCF) and 0.12 kg/hr (20.12 lbs/min).

The personnel at Kaiser stated that they had no other test results at any of the other air pollution control facilities. The original data sheets for these facilities may not be valid since most of the pollution control facilities have been modified or amended to suit changing process requirements. It was difficult to obtain a visual evaluation of emissions from various sources in the plant because of the prevailing smog and haze. It did appear, however, that emissions from the various sources were not severe.

Piles of sludge were observed in the slag disposal area which appeared to be quite dry. There are no provisions for watering the piles and, at certain times of the year when the winds in the area are high, dusting from the piles create fugitive emissions.

1.3.7 Solid Wastes Produced and Methods of Disposal

Solid wastes are produced as a by-product of the manufacturing processes or remain as a residual of the air or water cleaning processes. Table A-4 presents the sources of these solid wastes, the quantities produced and the present means of disposal.

TABLE A-4

SOLID WASTE PRODUCTION AND DISPOSAL

Source	Quantity Produced (1)	Ultimate Disposal
Coke Plant	399 kkg (440 tons) per day (4)	Sinter Plant
Blast Furnaces -		
From Dry Dust Catchers	109 kkg (120 tons) per day	Sinter Plant
From Scrubbers	32 kkg (35 tons) per day	Slag Pile
Slag	(2)	Sold to Slag Contractor
External Desulfurization	28 kkg (31 tons) per day (4)	Slag Pile
BOSP -		
Dust	86 kkg (95 tons) per day	Sinter Plant
Slag	(2)	Sold to Reclaimer
Open Hearth -		
Dust	10.6 kkg (11.7 tons) per day	Sold or to Slag Pile
Slag	(2)	Sold to Reclaimer
New BOP		
From Scrubber	183 kkg (202 tons) per day	Sinter Plant
Slag	(2)	Sold to Reclaimer
New Continuous Caster	54 kkg (60 tons) per week	Stockpiled (3)
Plate Mill Scale Pits	231 kkg (255 tons) per week	Stockpiled (3)
46 x 90 Slab Mill Scale Pits	1615 kkg (1780 tons) per week	Stockpiled (3)
86" Hot Strip Mill Scale Pits	757 kkg (835 tons) per week	Part Stockpiled (3) - Part to Sinter Plant
Fretz Moon Pipe Mill Scale Pit	0.8 kkg (0.9 tons) per year	Stockpiled (3)
Pig Casting Scale Pit	Negligable	-
Mill Sludge Beds	726 kkg (800 tons) per year (wet)	Slag Pile
Water Treatment Plant	No record	Slag Pile
Waste Water Treatment Plant	No record	Sprayed on Coal Pile
Acid Neutralization Plant	3.6 kkg (4 tons) per day (5)	To CBMWD with Water
Sewage Treatment Plant	Negligable	-

(1) Quantities Based on 1976 Plant Production Data
(2) No Records Available
(3) Stockpiled for possible future reclaim of metallics
(4) Estimated by Hydrotechnic
(5) Based on Flow of 386 m^3/hr (1700 gpm) @ 400 mg/l Suspended Solids

2.0 PROPOSED PROGRAM

2.1 GENERAL

Although the Kaiser Steel Plant has achieved the highest degree of water recirculation of any integrated steel plant within the United States, the purpose of this report is to study methods to achieve total recycle of water. It is recognized that to achieve total recycle of water, methods must be used for the disposal of water that cannot be further recirculated. Presently, disposal of the waters is by one of five methods: evaporation by quenching incandescent coke, quenching of molten slag, discharge of waste pickle liquor to an on-site ferric chloride manufacturer, retention of water in sludges produced during the treatment of water and wastewater, and discharge through the non-reclaimable wastewater line to the CBMWD. Water is also consumed by the evaporation from cooling towers, cooling of product such as on the runout table and in the generation of steam at power plants. The latter consumptive uses produce concentrate waste streams, whereas the disposal processes consume the water and the contained wastes.

If total recycle is shown to be impractical the plant may still have to provide some degree of treatment even though the waste flows to an off-site waste treatment facility. The off-site treatment facility, in the case of KSC, is operated by the county of Los Angeles, which is presently permitted to establish its own pretreatment standards. In the interest of conservatism, Hydrotechnic has assumed that future pretreatment standards will be identical to BAT. Waters that are discharged by the plant directly, even though meeting current NPDES permit requirements, are assumed to have to meet BAT limitations after expiration of the present permits. See Table A-5 for the allowable discharges under BAT. Table A-6 presents the present plant water quality.

If zero discharge is to be achieved, all water, with the exception of rainfall runoff from areas other than raw material storage, must be recycled. In this study the flow quantities described are plant estimates, based on pipe and pump sizing, and are, therefore, conservative and may vary widely. The methods of treatment determined and areas required should not be considered as the optimum until flows are firmly established.

TABLE A-5

ALLOWABLE DISCHARGES AS PERMITTED UNDER BATEA LIMITATIONS

Production Facility	Average Daily Production	Daily Allowable Discharges kg/day lbs/day												
		Susp. Solids	Oil & Grease	Cyanide	Ammonia	Phenol	BOD_5	Fluoride	Sulfide	Nitrate	Dissolved Iron	Dissolved Chromium	Nickel	Zinc
Coke Plant	3720/4100	15.6 34.4	15.6 34.4	0.37 0.82	15.6 34.4	0.78 1.72	30.9 68.1		0.45 0.99					
Sinter Plant	3493/3850	18.5 40.8	7.3 16.2					14.7 32.4	0.21 0.46					
Blast Furnaces	6386/7040	33.2 73.2		0.83 1.83	33.2 73.2	1.66 3.66		66.4 146	1.02 2.25					
Open Hearths	1497/1650	7.8 17.2						6.3 13.9		14.1 31.1				1.5 3.3
BOSP	3480/3836	18.1 39.9						14.6 32.2						
Slab Mill	6153/6783	6.8 14.9	6.8 14.9											
86" Hot Strip Mill	4997/5508	0 0	0 0											
148" Plate Mill	2193/2417	14.0 30.9	14.0 30.9											
Tin Mill Cleaning	937/1033	4.9 10.7									0.19 0.42	0.09 0.20	0.05 0.11	
Cont. Clng. & Annealing	595/656	3.1 6.8									0.12 0.26	0.06 0.13	0.03 0.07	
Cold Sheet Cleaning	1042/1149	5.4 11.9									0.21 0.46	0.10 0.22	0.05 0.11	
62" Pickle	719/792	9.8 21.4	4.0 9.7								0.40 0.87			
50" Pickle	2112/2328	28.8 62.9	11.7 25.6								1.17 2.56			

TABLE A-5

ALLOWABLE DISCHARGES AS PERMITTED UNDER BATEA LIMITATIONS

(Continued)

Production Facility	Average Daily Production	Daily Allowable Discharges kg/day / lbs/day												
		Susp. Solids	Oil & Grease	Cyanide	Ammonia	Phenol	BOD_5	Fluoride	Sulfide	Nitrate	Dissolved Iron	Dissolved Chromium	Nickel	Zinc
Cold Reduction 3 Stand dbl red	812/896	2.1 4.7	0.8 1.8								0.08 0.18			
Tin Mill 5 Std.	1358/1500	3.5 7.8	1.4 3.1								0.14 0.31			
Galv. Sht Mill	793/875	2.1 4.5	0.8 1.8								0.08 0.18			
Continuous Weld Pipe Mill	447/493	0	0											

NOTE: New BOP and Continuous Caster must be added.
Open Hearth should be reduced to reflect the shut down of four furnaces.
BOSP data should be revised to reflect changes in plant production split.

TABLE A-6

PLANT WATER QUALITY*

Parameter	Domestic Water	Industrial Water	Final Plant Discharge
Flow m^3/hr (gpm)	748 (3291)	1355 (5960)	336 (1480)
pH (units)	8.2	7.2	6.0-9.5
Total Alkalinity (as $CaCO_3$)	60	145	24-2120
Total Dissolved Solids	133	201	1160-24840
Suspended Solids	6	29	840-3850
Total Hardness (as $CaCO_3$)	61	146	18-168
Chloride	13	13	60-10900
Sodium	17	17	110-480
Sulfate	18	19	170-695

* All parameters unless otherwise indicated in mg/l.

Five flows presently enter the wastewater treatment plant for treatment: the BOP - 11.3 m^3/hr (50 gpm), Tin Mill - 155 m^3/hr (680 gpm), Sheet Galvanizing - 81 m^3/hr (355 gpm), and the Hot Strip Mill sludge decant - 6.8 m^3/hr (30 gpm) for a total of 254 m^3/hr (1115 gpm). Of the treated effluent 96 m^3/hr (425 gpm) is recycled and the remaining 158 m^3/hr (690 gpm) together with the Mulberry ditch flow of 43 m^3/hr (190 gpm) flows to the Acid Neutralization Plant where it combined with 136 m^3/hr (600 gpm) pickle rinse water. This total combined flow of 337 m^3/hr (1480 gpm) then discharges to the CBMWD.

The first step toward total recycle was to see if this discharged water could be reused without additional treatment in the mill.

If the total outfall flow were combined with Industrial Water Reservoir or Domestic Water Reservoir, the dilution would result in a combined water quality containing almost 900 mg/l of total dissolved solids.

Since the Industrial Reservoir makes up water to level 1 and 2 systems this water would be too high in dissolved solids (4 times that presently utilized) and would adversely affect the quality of water in the mills. Therefore, specific points of application were investigated in the level 4 systems and possibly level 3 systems.

Cooling Tower #1 was investigated because it is the only cooling tower in level 3 which receives make-up from the Industrial Water Reservoir System. The present make-up is 214 m^3/hr (940 gpm) with a TDS of 473 mg/l. To dilute the outfall wastewater to meet the present water quality in the tower only 10 percent of outfall discharge (less than 23 m^3/hr (100 gpm)) could be used. Since the present make-up to the tower is of higher quality an inordinately high blowdown would be required. It was determined that the extra blowdown would not be a worthwhile alternate. Therefore, possibilities of reuse were restricted to the level 4 water systems.

The coke plant was the next area examined. Make-up to cooling towers #4, 13 and 16 using plant effluent was eliminated because the present makeup is from cooling tower #1. Using the water by coke quenching was also eliminated because the water presently used for quenching is of very poor quality and nothing would be gained. The new desulfurizer was also studied and it was determined that the quality requirements for make-up to the desulfurizer are too high to consider using outfall wastewater. Replacing blowdown from this desulfurizing system, which is directed to the quench towers, with outfall discharge was eliminated because of the poor outfall water quality. Therefore, the coke plant has no areas for application of wastewater from the non-reclaimable water line.

The level 4 system also consists of gas scrubbing systems for the blast furnaces. Since the make-up to these systems is cascaded from cooling tower #1, application of outfall water here was also eliminated.

Recycling the outfall at the new BOF and continuous caster was also a possibility. Since these facilities require a large make-up (over 364 m^3/hr (1600 gpm)) it is possible to add wastewater in a diluted form. But if a lower quality water is added to the BOF a larger quantity will have to be blown down. This blowdown will increase the wastewater quantity and defeat the original purpose.

It was therefore concluded that there is no reasonable way to recycle the discharging wastewater without additional treatment.

2.2 RECOMMENDED MODIFICATIONS TO AIR QUALITY CONTROL TO ACHIEVE MINIMUM AIR DISCHARGE

The coke plant is the area at the Kaiser Steel Plant where improvements to air quality control are required.

At the coke plant three scrubber cars are recommended, one for each quench tower. The quench cars would require water applied at a total rate of 157 m^3/hr (690 gpm). This value is based on an application requirement of approximately 0.88 m^3 of water per kkg of coke produced (211 gal per ton). Of this, approximately 54.5 m^3/hr (240 gpm) would be blown down and the balance recirculated.

To achieve minimum air pollution, the present use of contaminated wastewater from the coke plant to quench incandescent coke should be discontinued. Reference to the EPA tests indicate that this conversion of water source for coke quenching will reduce emissions to approximately 2.1 pounds per ton of coke. The application of a spray tower to the steam and gases from quenching would effect an additional 50 percent reduction yielding an emission factor of 1.0 pound per ton of coke.

Two alternatives, considered to minimize air discharges from coke quenching operations were spray towers and dry quenching of coke. Neither of these appear to be entirely satisfactory on the basis of being proven technology or economically justified. Dry quenching would completely eliminate emissions. However, its development in the United States has been impeded by questions of economics. Spray towers, although still considered to be an emergent technology, are sometimes used to minimize air discharges with lesser economic impact.

2.3 WATER TREATMENT AND RECYCLE FACILITIES

To achieve BAT or total recycle and also minimize air discharges three separate sources of wastes were considered: 1) rainfall runoff from material storage piles, 2) Coke plant waste, and 3) flows discharged to the existing Wastewater Treatment Plant. Since the Fontana Plant recycles most of this water in integrated systems a BAT step and a step without including non-contact cooling water have not been prepared.

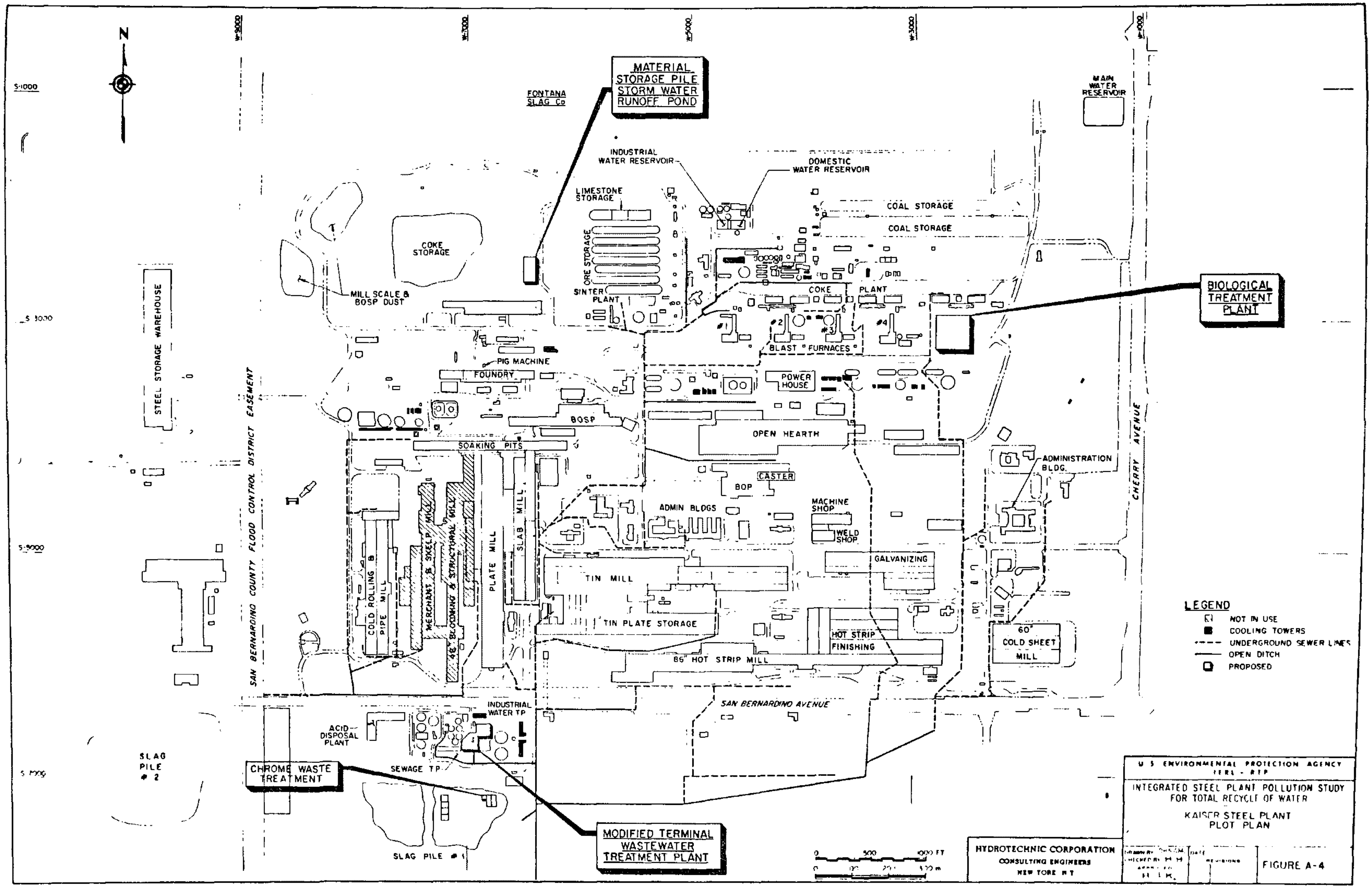
The wastes that are presently being treated and the methods of disposal have been described in Section 1.3.3. In order to maximize the quantity of water recycled and the amount treated and minimize the amount fo ultimate disposal and, at the same time, not create additional air pollution problems, certain in-plant modifications are recommended. It is recognized that some of these modifications, as well as treatment methods have been previously considered by Kaiser Steel in the past and rejected for various reasons. They are recommended herein on the basis of applicability to minimizing pollutants or totally eliminating discharges from the Kaiser Steel Plant.

It must be pointed out that each of the treatment systems recommended herein should be subject to treatability testing on the actual waste streams where required.

2.3.1 Rainfall Runoff

Although the guidelines have not been specific with respect to the intensity and durations of rainfall runoff from material storage piles that require treatment, Hydrotechnic has used as a basis for the treatment of runoff that quantity that would result from a once in ten years, 24-hour storm. Since the total annual rainfall occurs over a relatively short period of time (approximately three months), it has been assumed that, when the maximum rainfall would occur, the storage piles would be saturated and the coefficient of runoff would be 0.95 (i.e., 95 percent of all of the rainfall would run off as a waste stream).

The runoff prior to disposal would be contained in a storage pond located as shown on Figure A-4, where settling of some suspended solids would take place. In view of the fact that little is known about the dissolved solids from the ore and limestone storage piles, two methods were considered for the reuse of these storm waters for total recycle. Most



N
MATERIAL STORAGE PILE STORM WATER RUNOFF POND
FONTANA SLAG Co
MAIN WATER RESERVOIR
INDUSTRIAL WATER RESERVOIR
DOMESTIC WATER RESERVOIR
LIMESTONE STORAGE
COAL STORAGE
COAL STORAGE
COKE STORAGE
ORE STORAGE
SINTER PLANT
COKE PLANT
MILL SCALE & BOSP DUST
BIOLOGICAL TREATMENT PLANT
STEEL STORAGE WAREHOUSE
BLAST FURNACES
PIG MACHINE
FOUNDRY
POWER HOUSE
BOSP
OPEN HEARTH
SOAKING PITS
ADMINISTRATION BLDG.
CASTER
BOP
ADMIN BLDGS
MACHINE SHOP
WELD SHOP
CHERRY AVENUE
SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT EASEMENT
COLD ROLLING & PIPE MILL
MERCHANT & SKELP MILL
46" BLOOMING & STRUCTURAL MILL
PLATE MILL
SLAB MILL
TIN MILL
GALVANIZING
TIN PLATE STORAGE
HOT STRIP FINISHING
86" HOT STRIP MILL
60" COLD SHEET MILL
LEGEND
NOT IN USE
COOLING TOWERS
UNDERGROUND SEWER LINES
OPEN DITCH
PROPOSED
SAN BERNARDINO AVENUE
INDUSTRIAL WATER TP
ACID DISPOSAL PLANT
SLAG PILE # 2
CHROME WASTE TREATMENT
SEWAGE TP
SLAG PILE # 1
MODIFIED TERMINAL WASTEWATER TREATMENT PLANT
0 500 1000 FT
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U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
KAISER STEEL PLANT
PLOT PLAN
FIGURE A-4

conservatively the disposal of the semi-clarified supernatant was considered to be by one of three methods. Evaporate by spraying over surrounding land during periods of zero rainfall. This method was eliminated on two bases. One was that the total season rainfall would require retention before the dry season and would, therefore, require too large a retention pond. If the pond were to be made smaller and the runoff were to be sprayed over the land during the entire year, pollutants that might be present in the runoff such as heavy metals, would be transferred to overland runoff and enter receiving streams. If it were to be sprayed only during dry periods, they would redissolve and possibly enter the ground water when the rainy season returned. The second method considered was discharging the settled water to the main reservoir. This method was eliminated because of the high dissolved solids in the water and because toxic materials may be introduced into the drinking water source.

Therefore, the third method of disposal, that of metering the water to the wastewater treatment plant for treatment and reuse, over a three-month period, was selected. The three-month period was chosen so that, in one day's time, sufficient volume would be available in the retention basin to accommodate the runoff from an additional 17 mm (0.66 inches) of rain.

However, if the contained storm water is of high enough quality and if the conservative assumption that there would be contamination of drinking water is found to be groundless, then the water would be pumped directly to the main reservoir to serve as an additional source of water.

2.3.2 Coke and By-Products Plant and Blast Furnaces

Wastes produced at the Coke and By-Products plant have high concentrations of phenols, cyanides and ammonia. These compounds are toxic and are oxidizable with varying degrees of difficulty by biological or chemical means to innocuous compounds and elements. The proposed scrubber car wastes would also contain these contaminants. Wastes from the blast furnace gas washer cleaning system contain the same contaminants but in much lower concentrations.

The flows that would require treatment were arrived at by estimating the blowdown flow from the proposed scrubber car, would be 56 m^3/hr (245 gpm). The coke plant flow of 38.6 m^3/hr (170 gpm) and the blast furnace slag quench water flow of 91 m^3/hr (400 gpm) was obtained from KSC.

To protect the biological system from the possibly toxic heavy metals from the blast furnaces, alkaline precipitation would be required before the coke plant and blast furnace wastes are introduced into the biological system.

Treatment with activated carbon was considered and eliminated because experience has shown that both capital and operating costs are usually high for a raw waste stream.

Chemical treatment by use of ozone was considered and eliminated because of the ineffectiveness of ozone in the destruction of ammonia. Chemical treatment by use of chlorine was eliminated because of the high volumes of chlorine that would be required and problems that might be generated by the creation of residual chlorinated phenols.

The only viable treatment was therefore by biological means. Several options were considered: oxidation ponds, trickling filters, rotating biological contactors, and the various forms of the activated sludge process (i.e., conventional, contact stabilization, tapered aeration and extended aeration).

Oxidation ponds, which would operate under most favorable climatic conditions in the Fontana area, were eliminated from consideration because of the possibility of algae and/or spores entering the extensive cooling tower systems at the plant when the water was to be reused and oxidation ponds have not been shown to be effective in the reduction of ammonia.

Trickling filters generally require high capital costs for the installation of the "filters," recirculation facilities and final settling facilities. For low flows they are generally not economical. Their advantage is that they can generally handle high shock load, but would require two stages for reduction of the high ammonia concentrations.

Rotating biological contactors (RBC) are a viable alternative. Here too, however, a second stage would be required for nitrification of the ammonia present and, due to the high concentration, nutrient addition would be required between the first and second stages.

Of the various activated sludge treatment processes presently in use the extended aeration system has minimum operator attention and the second step, that of handling sludge produced as a result of biological metabolism, is eliminated. Virtually no sludge is produced because of the autolytic consumption of the organisms.

A biological oxidation system consisting of RBC's has been selected to treat the flow of 189 m^3/hr (830 gpm). A flow diagram showing wastewater requiring oxidation is presented on Fig. A-5 and a general arrangement of the system is shown on Fig. A-6 with a proposed location plan on Fig. A-4.

In addition, the wastes from the coke oven pusher scrubber cars would require a clarifier prior recycling and blowdown to the biological treatment plant because of the high suspended solids content.

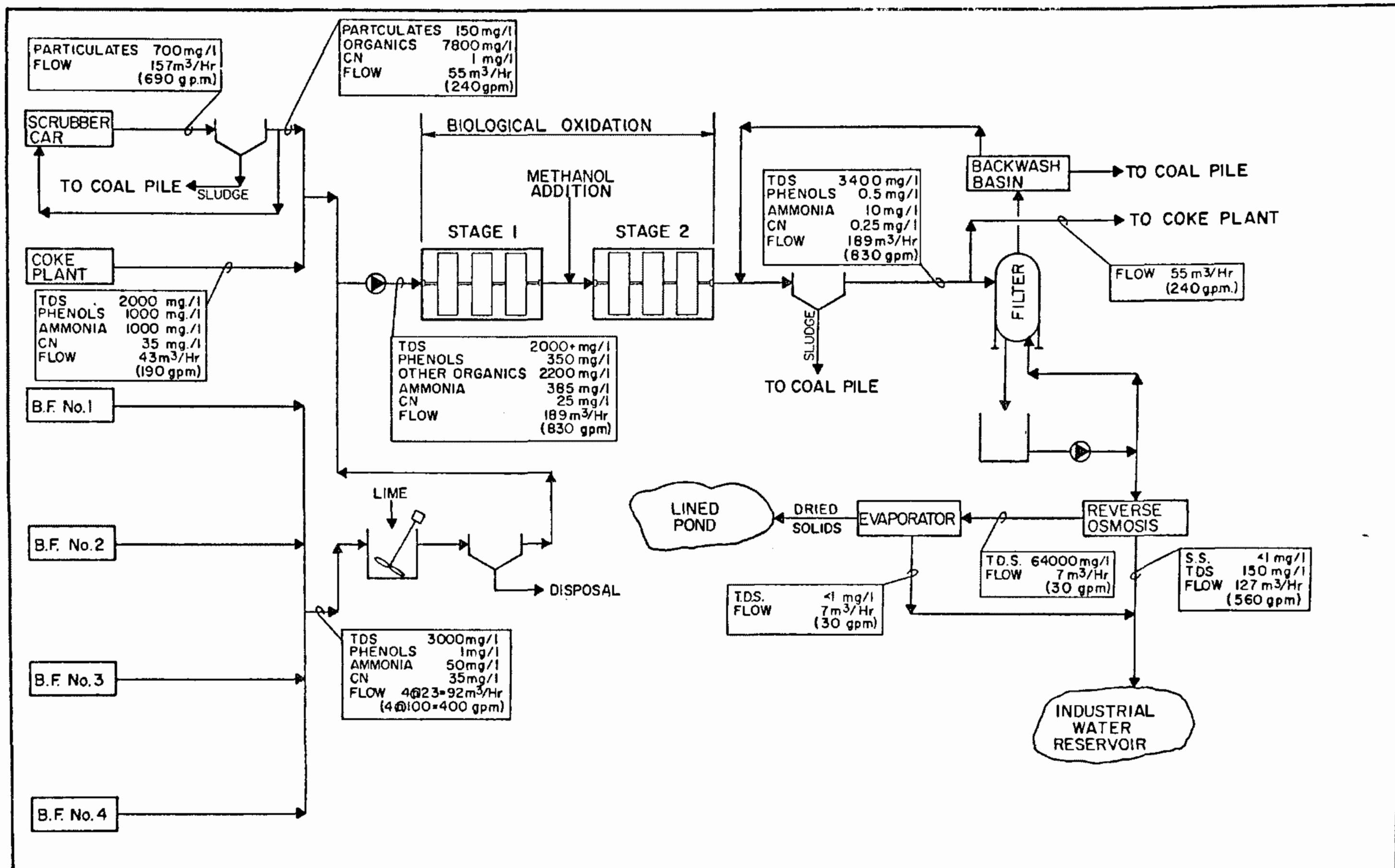
2.3.3 Cold Reduction and Plating Wastes

The wastes from these facilities that require treatment consist of discharges of rolling and cleaning solutions in an amount of 80.7 m^3/hr (355 gpm) which is presently being discharged to the existing wastewater treatment plant. Information from KSP personnel indicates that the flow from the Cold Rolled Sheet Mill is 34 m^3/hr (150 gpm). Based on the tonnage rolled, Hydrotechnic has estimated that 26.1 m^3/hr (115 gpm) of this flow is oily wastewater and the balance of 7.9 m^3/hr (35 gpm) is cleaning solution waste. KSP Drawing HO-5426-1 (Rev. 4) shows 154.5 m^3/hr (680 gpm) being discharged from the Tin Mill. Information from KSP personnel indicate that of this; 3.2 m^3/hr (14 gpm) is chromic acid waste and 5.9 m^3/hr (26 gpm) is sodium dichromate wastes. Of the remaining 145.4 m^3/hr (640 gpm), Hydrotechnic has approximated that 109 m^3/hr (480 gpm) is oily wastes and 36.4 (160 gpm) is cleaning solution.

The Hot Strip Finishing Mill has an intermittent discharge of 40 m^3/hr (175 gpm) and an average flow of 6.8 m^3/hr (30 gpm) has been assumed from this facility which consists primarily of oily wastes with no cleaning solutions.

The wastes requiring treatment are those containing oils, suspended solids and dissolved metals. The primary source of dissolved metals is from the chrome wastes presently being stored in the ponds on top of slag pile No. 1. Consideration was given to treatment of the wastes by reduction and precipitation or recovery of the chrome solutions. Recovery of chrome solutions by the use of the ion exchange process is feasible by the selective removal of chromate ions and chrome ions in anion and cation exchanges. However, although resin manufacturers have indicated that the process is feasible, some system manufacturers hesitate to guarantee recoveries from a complete system. Therefore, reduction and precipitation is recommended to be the method used for treatment of chrome bearing wastes. The installation of the facilities can be delayed, however, until such time that there is no longer storage capacity in the collection ponds and some other means of disposal or a guaranteed system is available. The reduction and precipitation unit operation is included herein.

If a chrome recovery system is found to be feasible, the regenerated wastes would still contain dissolved chrome and chromate that would require removal prior to discharge.



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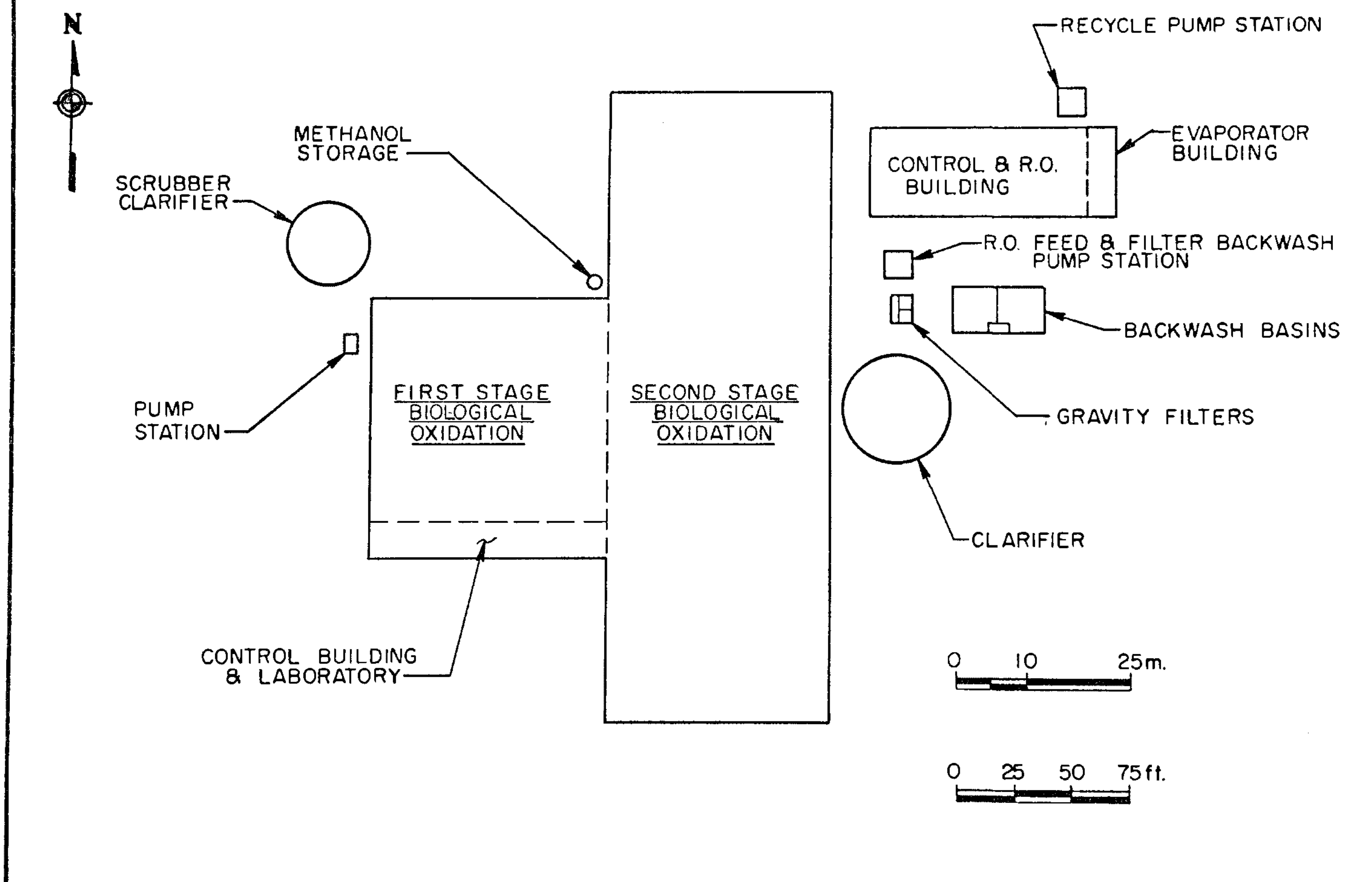
ORGANIC WASTE TREATMENT - FLOW & QUALITY DIAGRAM

FIGURE A-5



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NEW YORK, N. Y.

PROPOSED BIOLOGICAL TREATMENT PLANT
GENERAL ARRANGEMENT

FIGURE A-6

For these regenerant wastes reduction and precipitation would also be required; however, operating costs would be drastically reduced.

It is recommended that all of the rinse water discharges from the pickling lines be first reduced by installing cascade counter-current rinse systems. The total discharge could be reduced to approximately 6.8 m^3/hr (30 gpm) and the acid concentration would be approximately two percent. The concentration is reportedly too dilute to be discharged to the ferric chloride manufacturer. Dependent upon testing results, two methods of disposal are possible; one would be to use the waste in the breaking of oil emulsions, and the second would be to evaporate it to a concentration similar to the waste pickle liquor presently delivered to the ferric chloride manufacturer. Discharge to the mixed oily wastes to serve as a pH depressor and a source of iron salts is recommended.

Location of the new segregated waste treatment plant at the existing wastewater treatment plant site or in the vicinity of the sources of the waste was studied. KSP has indicated that the costs of segregating the wastes to bring them together at a separate location in the Tin Mill area would be the same as bringing them together at the WWTP. It is, therefore, more advisable to have all waste treatment performed at the WWTP.

The treatment process, as shown on Figure A-7, would consist of:

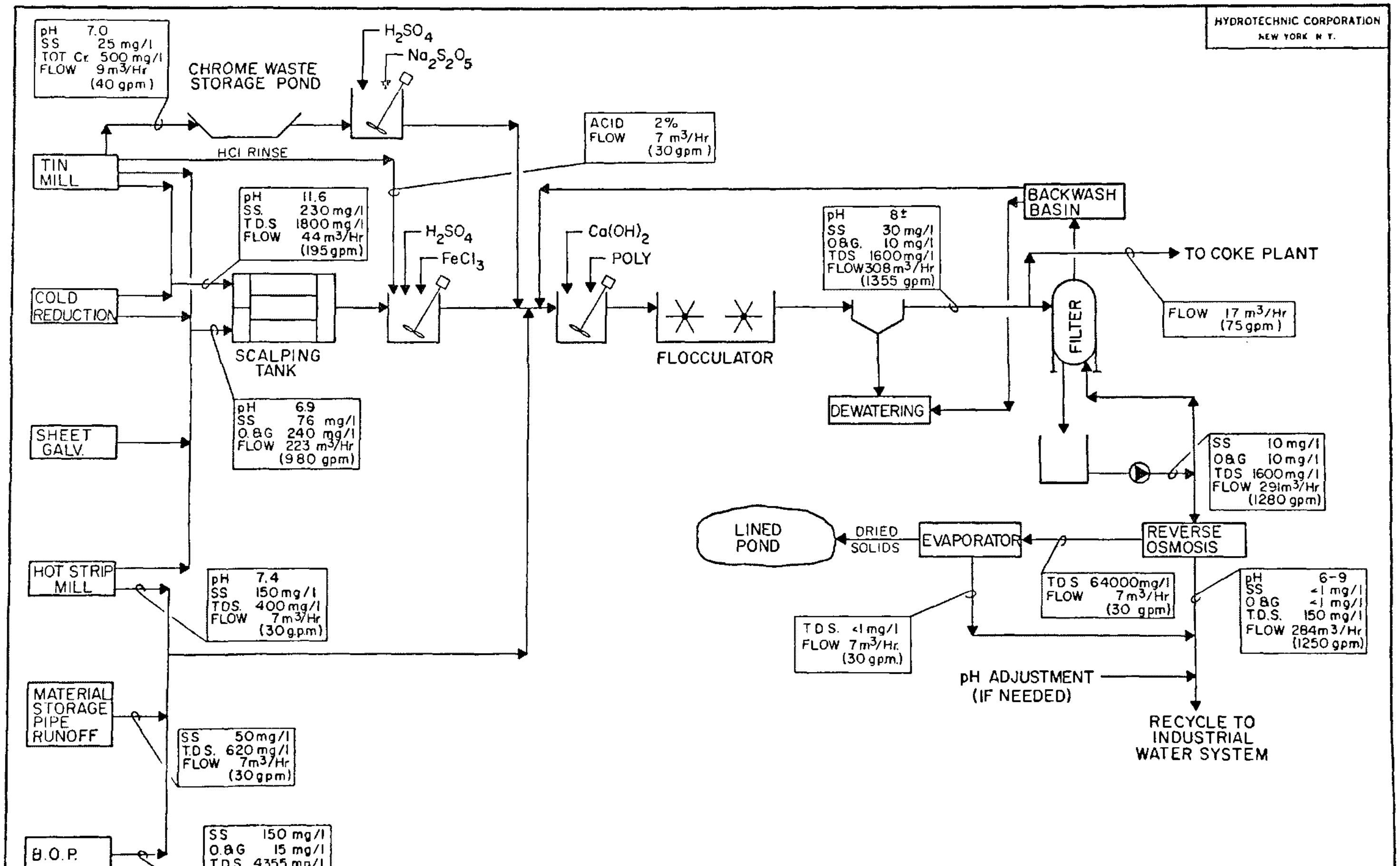
- preliminary skimming of non-emulsified oils from the cold rolling, galvanizing and tin mills wastewater in one scalping tank and oils from cleaning solutions in a separate tank;

- combination of the skimmed wastes in a mixing tank and the addition of acid and ferric chloride to demulsify the oils;

- addition of calcium hydroxide and polyelectrolytes (if needed) in a second mixing tank;

- continue to pump the chrome waste to the chrome storage ponds, and then to a mixing tank where sulfuric acid and sodium metabisulfite would be added to reduce the hexavalent chrome to the trivalent state. Overflow by gravity to the second mixing tank at the WWTP where the calcium hydroxide would be added;

- additional wastes discharged into the second mixing



INORGANIC WASTE TREATMENT – FLOW & QUALITY DIAGRAM

FIGURE A-7

tank would be the Hot Strip Mill decant, new BOP waste and flow from the storm water collection system, if necessary;

- the combined wastes would then flow to the existing float-sink separators which would be modified to function as flocculating basins by the addition of flocculating paddles;

- the flocculated wastes would then flow to the existing clarifier where oils would be skimmed off and precipitated solids would settle;

- the overflow from the clarifier would be to a new gravity filtration system. The filtered effluent would satisfy BAT requirements with respect to suspended solids, oils and metals, and the filtrate could be discharged;

- for zero discharge, the treated wastes would require additional treatment for the removal of the dissolved solids prior to reuse. In this instance a reverse osmosis system is proposed with the product water returned to the industrial water system. The level of treatment can be controlled so that the quality can be adjusted to return the permeate to any level desired. The reject stream would require disposal.

Alternatives considered for the elimination of this final reject waste stream were: total evaporation to dryness in either a solar pond or a thermal evaporator; using it to quench the incandescent coke and quenching of molten slag. If a solar evaporation pond were to be used, a lined pond of approximately 23 ha (55 acres) would be required and there would be an accumulation of approximately 4,750 m^3 (6200 cubic yards) per year of dried soluble solids. Storage for the solids accumulated would also be required if the stream is evaporated in a thermal or mechanical evaporator. This storage area, however, would be smaller in size.

Disposal by using the waste to quench coke was eliminated because of the increased particulate emissions that could be created. Use of the stream to quench slag was also eliminated because of leaching problems that might be encountered at the point of final slag use. Pumping of the concentrated stream to a solar evaporation pond was eliminated from further consideration because of the scaling problems that might be encountered in the line because of the high concentration of dissolved solids.

An evaporator is recommended to evaporate the relatively small reject stream to dryness. The dried solids from the reject stream would be deposited in a lined and covered pond to prevent solution of the solids in rainwater and percolation into the ground.

2.3.4 Modification to the Wastewater Treatment Plant

The existing wastewater treatment plant would require the installation of two scalping tanks, activation of the existing mixing tank, addition of another mixing tank, provision of chemical storage (i.e., sulfuric acid, ferric chloride, polymer and rebuilding of the lime facilities), modification of the float-sink separator by installation of flocculators, installation of gravity filters complete with backwash facilities, new reverse osmosis facilities and evaporative dryers.

The wastewater treated at the modified wastewater treatment plant would be composed of the following:

- Discharge 223 m^3/hr (980 gpm) of oily rolling solutions to one section of the new scalping tank. The 44 m^3/hr (195 gpm) of alkaline cleaning wastes would discharge to the other section. Scalping tank sludges would be pumped to the second mixing tank.

- The combined flow of 267 m^3/hr (1,175 gpm) would then be discharged to a mixing tank for addition of pickle rinse wastes, additional acid and ferric chloride.

- The 9 m^3/hr (40 gpm) of chrome storage pond waste would be treated with sodium metabisulfite and sulfuric acid to reduce hexavalent chrome.

- The treated oily wastes, and chrome wastes, together with 11 m^3/hr (50 gpm) of new BOP blowdown, 7 m^3/hr (30 gpm) from the Hot Strip Mill sludge pond and 6.8 m^3/hr (30 gpm) from the storm water pond (if necessary) would be discharged to a second mixing tank where hydrated lime and coagulant aid would be added.

- The 300 m^3/hr (1,325 gpm) of treated combined wastes would then flow to the float-sink separator where newly installed flocculator paddles would flocculate the wastes.

- The flocculated wastes would overflow to the existing clarifier where solids would settle and oil would be skimmed.

- The wastes would be directed to a three-cell gravity filter. The filtrate would be collected in a clean water basin for use as filter backwash water. The overflow would be pumped to a reverse osmosis unit for total recycle requirements or discharged to the existing non-reclaimable wastewater line for BAT requirements.

- For total recycle the reverse osmosis reject stream would be dried and the product stream would be recycled.

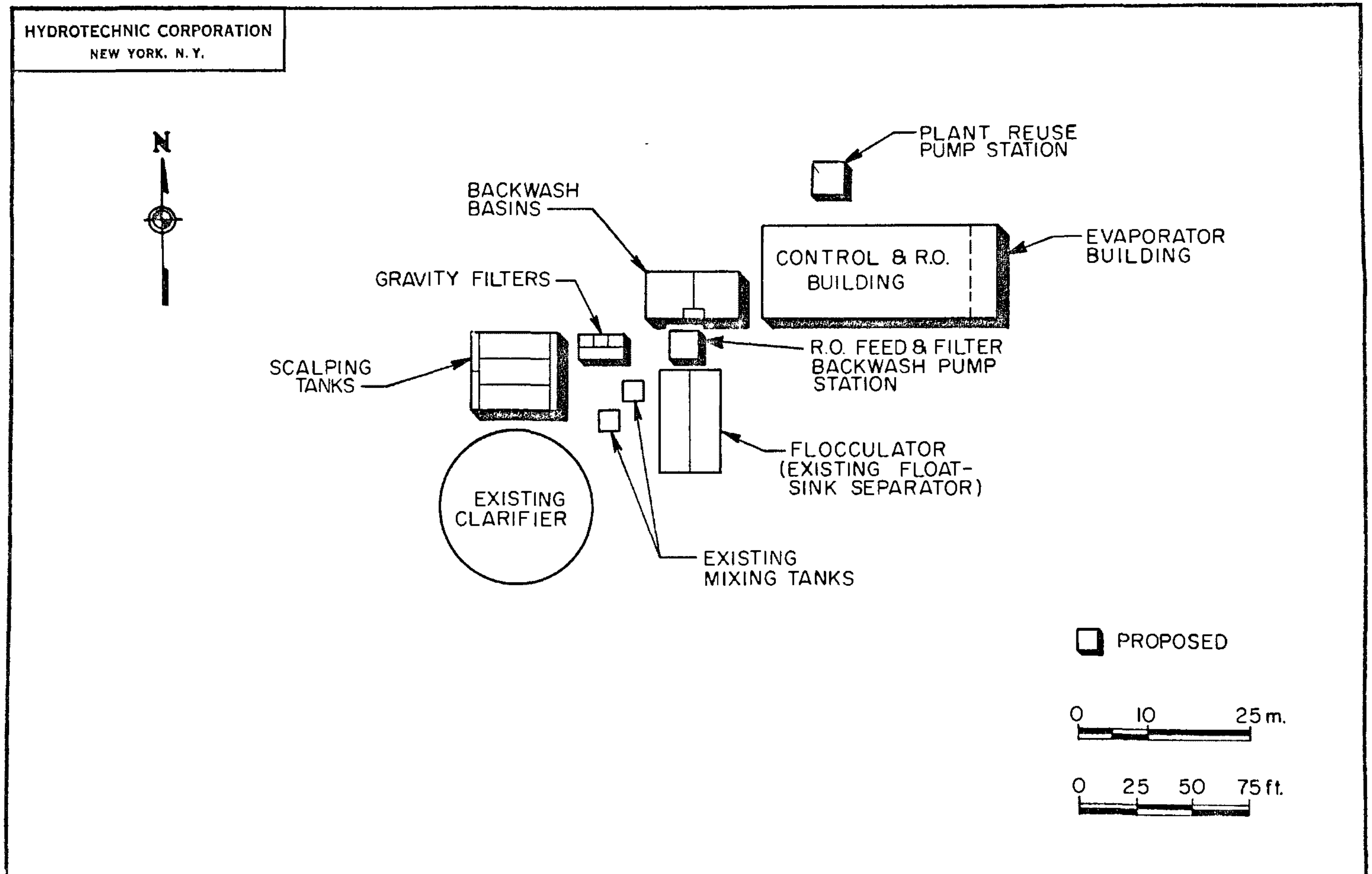
The modified terminal waste treatment facility is shown schematically on flow diagram Fig. A-7 and in general arrangement on Fig. A-8. The qualities of the wastewaters treated and the final effluent qualities are shown on Fig. A-7. The overall plant flow diagram showing the modified flows including new sources treatment facilities and points of reuse are shown on Figs. A-9 and A-10.

Solids Production

Solids to be disposed of at the WWTP would consist of clarifier sludge, filter backwash, and the reverse osmosis dried soluble solids. The clarifier underflow and the filter backwash would be dewatered and disposed of at an acceptable landfill facility. Approximately 9.2 m^3/day (12 cubic yards per day) would require disposal. The reverse osmosis solids would be produced at an evaporator at a rate of approximately 13 m^3/day 17 cy/day) and, since they are all soluble, would require disposal in a lined and covered area.

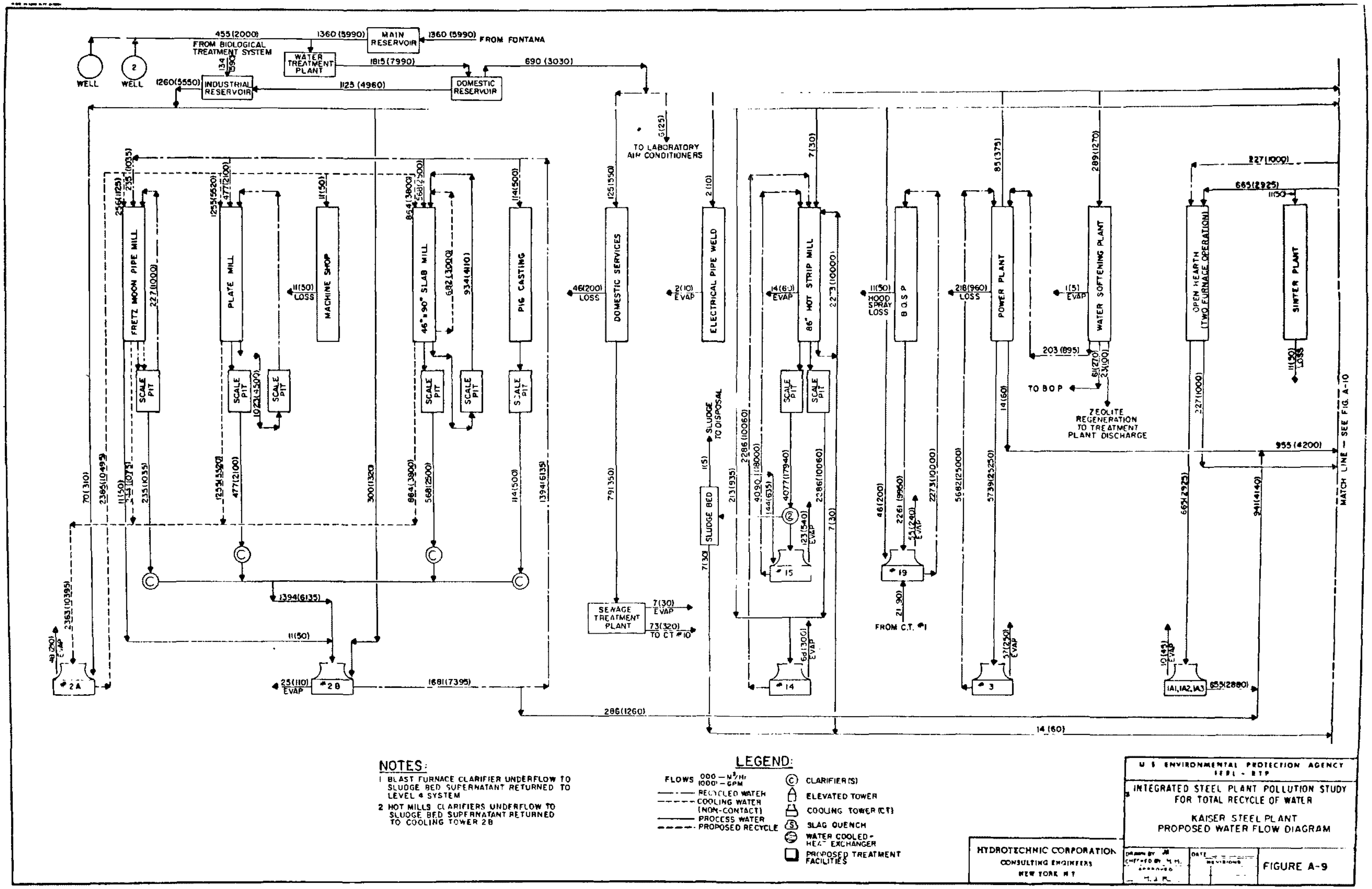
Assuming a 20-year life and at a depth of 3 meters (10 ft), an area of 3 hectares (7.5 acres) would be required.

Biological treatment plant solids would be produced at the final settling facility, the scrubber car clarifier and the reverse osmosis drying facility. An estimated additional 13 m^3/day (17 cy/day) of solids will be produced at the reverse osmosis facility. An additional 3 ha (7.5 acres) would be required for disposal of these solids. The solids from the biological system would be mostly volatile and should be disposed of on the coal pile. The solids from the scrubber cars clarifier consist of coke fines and could also be disposed of on the coal pile.



MODIFIED TERMINAL WASTEWATER TREATMENT PLANT GENERAL ARRANGEMENT

FIGURE A-8



FROM FONTANA
MAIN RESERVOIR
WATER TREATMENT PLANT
FROM BIOLOGICAL TREATMENT SYSTEM
DOMESTIC RESERVOIR
INDUSTRIAL RESERVOIR
WELL
WELL
TO LABORATORY AIR CONDITIONERS
FRETZ MOON PIPE MILL
PLATE MILL
MACHINE SHOP
46" x 90" SLAB MILL
PIG CASTING
DOMESTIC SERVICES
ELECTRICAL PIPE WELD
86" HOT STRIP MILL
B O S P
POWER PLANT
WATER SOFTENING PLANT
OPEN HEARTH (TWO FURNACE OPERATION)
SINTER PLANT
SCALE PIT
SEWAGE TREATMENT PLANT
SLUDGE BED
SLUDGE TO DISPOSAL
ZEOLITE REGENERATION TO TREATMENT PLANT DISCHARGE
TO BOP
FROM C.T. #1
TO CT #10
MATCH LINE - SEE FIG. A-10
NOTES:
1 BLAST FURNACE CLARIFIER UNDERFLOW TO SLUDGE BED SUPERNATANT RETURNED TO LEVEL 4 SYSTEM
2 HOT MILLS CLARIFIERS UNDERFLOW TO SLUDGE BED SUPERNATANT RETURNED TO COOLING TOWER 2B
LEGEND:
FLOWS 000 — M³/Hr (000) — GPM
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
CLARIFIER(S)
ELEVATED TOWER
COOLING TOWER (CT)
SLAG QUENCH
WATER COOLED HEAT EXCHANGER
PROPOSED TREATMENT FACILITIES
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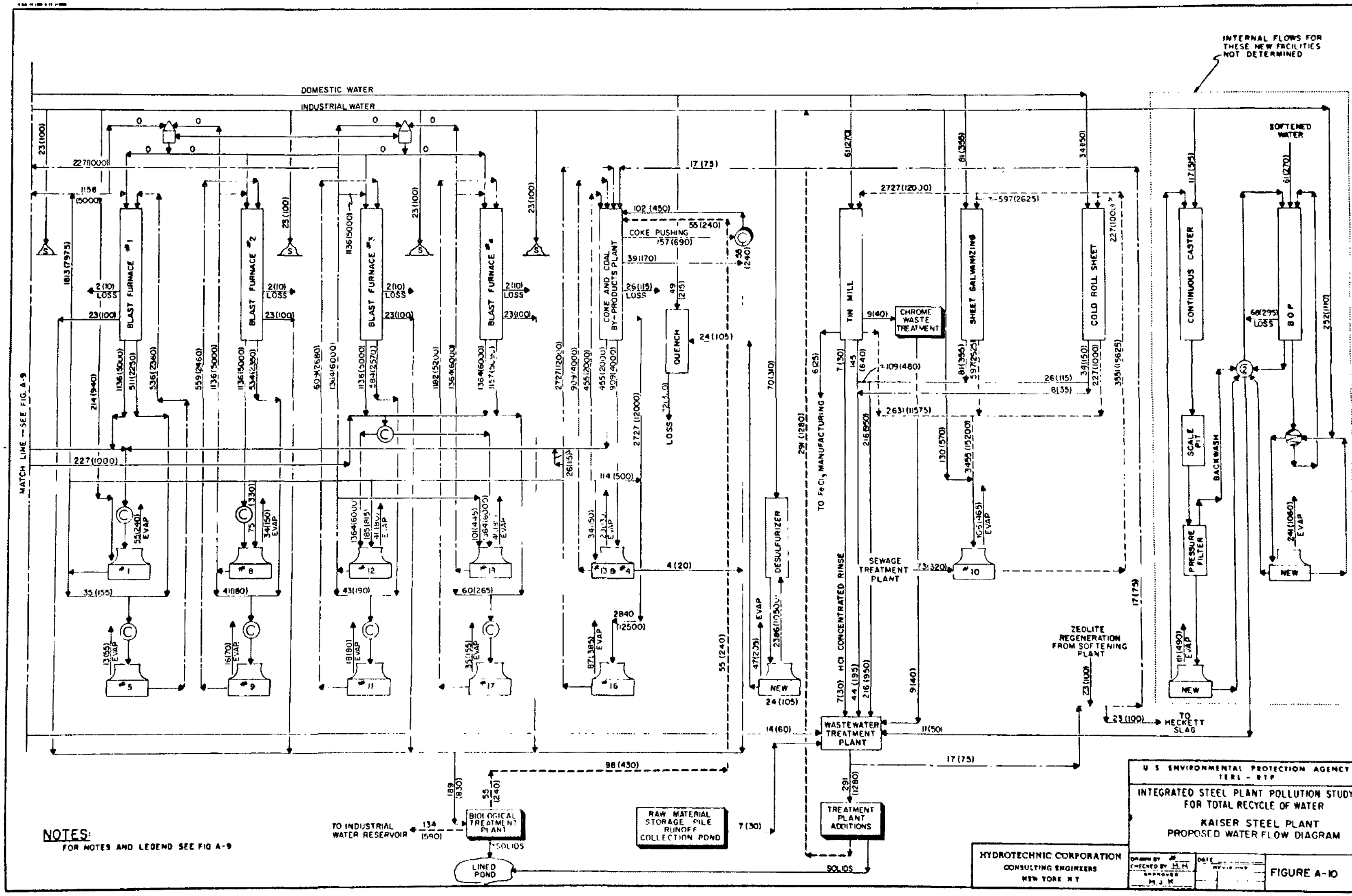
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
KAISER STEEL PLANT
PROPOSED WATER FLOW DIAGRAM
FIGURE A-9



DOMESTIC WATER
INDUSTRIAL WATER
INTERNAL FLOWS FOR THESE NEW FACILITIES NOT DETERMINED
SOFTENED WATER
BLAST FURNACE #1
BLAST FURNACE #2
BLAST FURNACE #3
BLAST FURNACE #4
COKE AND COAL BY-PRODUCTS PLANT
COKE PUSHING
QUENCH
TIN MILL
CHROME WASTE TREATMENT
SHEET GALVANIZING
COLD ROLL SHEET
CONTINUOUS CASTER
BOP
SCALE PIT
BACKWASH
PRESSURE FILTER
DESULFURIZER
MATCH LINE — SEE FIG. A-9
TO FeCl3 MANUFACTURING
HCl CONCENTRATED RINSE
SEWAGE TREATMENT PLANT
ZEOLITE REGENERATION FROM SOFTENING PLANT
TO HECKETT SLAG
WASTEWATER TREATMENT PLANT
TREATMENT PLANT ADDITIONS
BIOLOGICAL TREATMENT PLANT
TO INDUSTRIAL WATER RESERVOIR
RAW MATERIAL STORAGE PILE RUNOFF COLLECTION POND
LINED POND
SOLIDS
LOSS
EVAP
NEW
NOTES:
FOR NOTES AND LEGEND SEE FIG A-9
U S ENVIRONMENTAL PROTECTION AGENCY
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INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
KAISER STEEL PLANT
PROPOSED WATER FLOW DIAGRAM
HYDROTECHNIC CORPORATION
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NEW YORK N Y
FIGURE A-10

APPENDIX B

INLAND STEEL COMPANY

INDIANA HARBOR WORKS

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This appendix addresses itself to Inland Steel Company's, Indiana Harbor Works at East Chicago, Indiana. Preliminary engineering designs are included based on conclusions reached from data supplied by the Inland Steel Company. It does not include the identification of all environmental control technologies considered, the evaluation of other steel plants studied, cost estimates, practicality or possible environmental impacts. Therefore, it should be looked on only as a vehicle to present a possible scheme to attain total recycle but not necessarily one that is practical, feasible or one that will not generate, with its implementation, an environmental impact in other segtors which is intolerable.

1.2 DESCRIPTION OF THE STEEL PLANT

1.3.1 Processes and Facilities

The Inland Steel Company operates a completely integrated steel plant located in East Chicago, Indiana. The plant occupies a 650 hectare (1,600 acre) site located on a man made peninsula stretching two miles into Lake Michigan. The corporate designation of the plant is Indiana Harbor Works. Production facilities at the Indiana Harbor Works as of 1977 consisted of:

	Maximum Daily Production	
	KKG	Tons
- Two by product coke plants:		
Plant No. 2	4,990	5,500
Plant No. 3	2,540	2,800
- One sinter plant	4,080	4,500
- Two blast furnace facilities:		
Plant No. 2 (6 furnaces)	11,340	12,500
Plant No. 3 (2 furnaces)	5,450	6,000
- One open hearth shop	6,800	7,500
- One electric arc furnace shop	1,630	1,800
- Two basic oxygen steelmaking shops:		
No. 2	5,900	6,500
No. 4	12,700	14,000
- One slab caster	4,170	4,600

	Maximum Daily Production	
	KKG	Tons
- One billet caster	1,240	1,370
- One slabbing mill	9,700	10,700
- Two Blooming Mills:		
No. 2	3,900	4,300
No. 3	5,720	6,300
- Three hot strip mills:		
80 inch	12,700	14,000
76 inch	4,080	4,500
44 inch	3,630	4,000
- Four A.C. power stations (No. 1 A.C. not generating)	not available	
- A plate mill	1,090	1,200
- Four bar mills:		
10 inch	1,810	2,000
12 inch	1,900	2,100
14 inch	1,810	2,000
24 inch	900	1,000
- A 28" secondary mill	1,900	2,100
- A 32" secondary mill	1,900	2,100
- A spike mill	45	50
- Three cold strip mills:		
40 inch (No. 1 C.S.)	1,630	1,800
56 inch & 80 inch (No. 3 C.S.)	8,440	9,300
- A mold foundry	900	1,000
- Five pickling lines:		
No. 1 C.S.	4,540	5,000
No. 3 C.S.	8,530	9,400
44 inch sheet	900	1,000
12 inch bar	130	140
10 inch & 14 inch bar	725	800
- Five galvanizing lines:		
Plant No. 1 - Lines 1-4	1,810	2,000
Plant No. 2 - Line 5	900	1,000
- One alkaline cleaning line	900	1,000
- Miscellaneous shops	not available	

In addition to these facilities, an expansion program taking place in the north end of the plant in which the following facilities are under construction:

	KKG	Tons
- A by-product coke plant	2,720	3,000
- A blast furnace	6,800	7,500
- A boiler house (steam)	132 kg/sec.	525 tons/hr.

1.3.2 Water Systems and Distribution

The water supply for Indiana Harbor Works is drawn from Lake Michigan through two intakes which supply pump stations 1 through 6. All pump stations are interconnected except for No. 4 A.C. Station Pumphouse which is essentially independent. There is a 20-inch interconnection line from the No. 5 Pumphouse, but in the event of a power failure at the No. 4 A.C. Station, there would be insufficient water to supply some mills and they would have to be shut down.

The No. 4 Pumphouse supplies: the No. 4 A.C. Station, the No. 4 BOF, the No. 3 open hearth and the mold foundry. Upon completion of the Northward Expansion, No. 4 Pumphouse will also supply: the No. 11 coke battery, the No. 7 blast furnace, and the No. 5 boiler house.

Water supplied from the six pumping stations based on the first six months of 1977 was as follows:

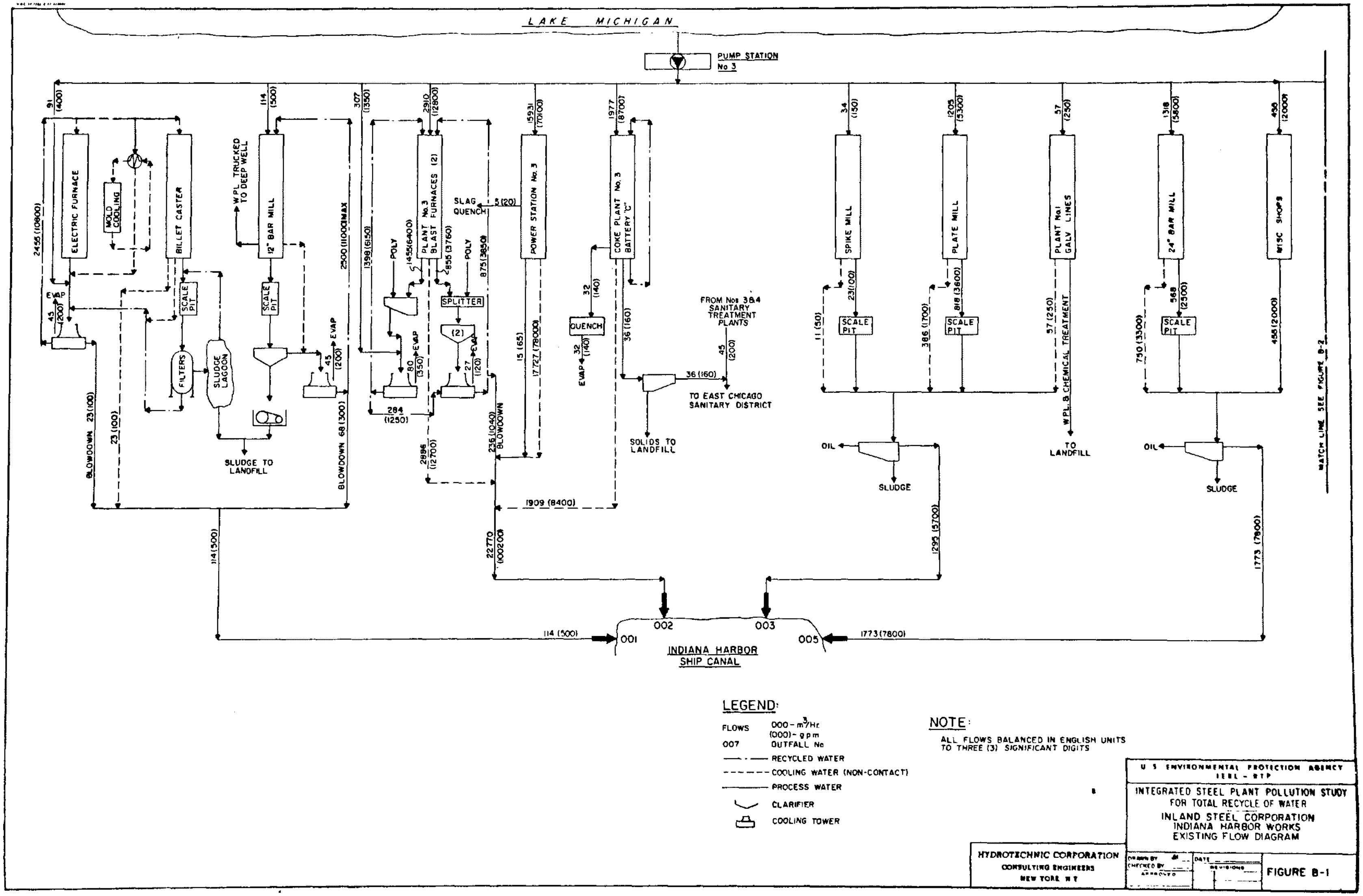
Pumphouse	GPD Average *	M^3/Hr.	GPM
1	105,749,000	16,700	73,400
2	143,405,000	22,600	99,600
3	208,610,000	32,900	144,900
4	156,960,000	24,800	109,000
5	76,563,000	12,100	53,200
6	166,346,000	26,300	115,500

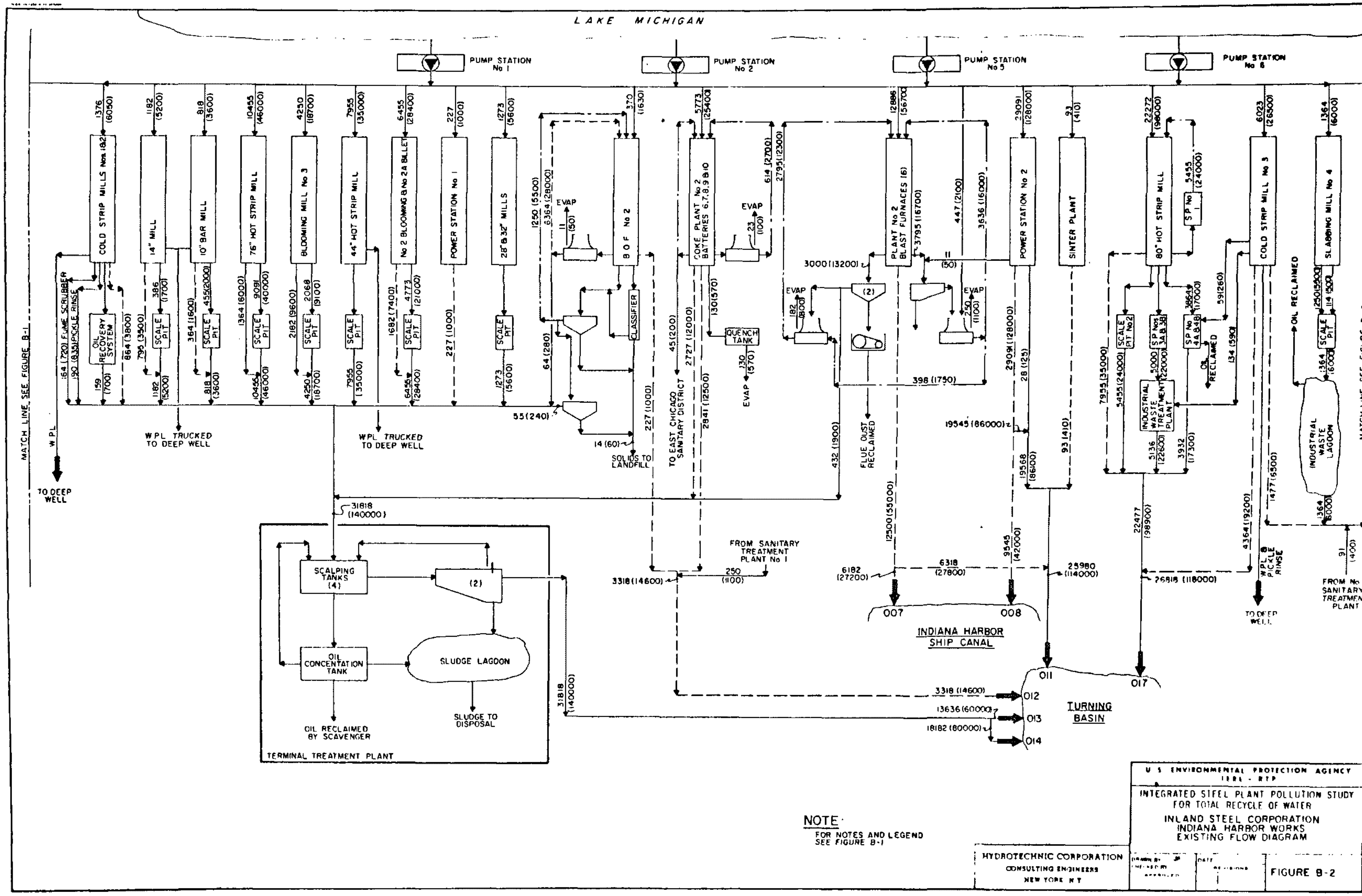
* Data received from Inland Steel

There are, at present, sixteen points of discharge from the Indiana Harbor Works. Figures B-1, B-2, and B-3 illustrate the existing water distribution, use and discharge systems. Table B-1 tabulates the qualities of water discharged from the plant by outfalls. The plant facilities that discharge to these outfalls are discussed below.

Outfall 001

The discharge from Outfall 001 consists of blowdowns from the recycle systems of the Electric Arc Furnace, the Billet Caster, and the 12-inch Bar Mill. Approximately 23 m^3/hr (100 gpm) of non-contact cooling water discharges directly from the Billet Caster. This combines with 23 m^3/hr (100 gpm) which is blown down from a cooling tower common to both the Elctric Furnace and Billet Caster. In addition, 68 m^3/hr (300 gpm) is blown down from the 12-inch Bar Mill cooling tower. The total discharge from Outfall 001 to the Indiana Harbor Ship Canal is approximately 114 m^3/hr (500 gpm).


LAKE MICHIGAN
PUMP STATION No 3
ELECTRIC FURNACE
MOLD COOLING
BILLET CASTER
SCALE PIT
FILTERS
SLUDGE LAGOON
SLUDGE TO LANDFILL
WPL TRUCKED TO DEEP WELL
12" BAR MILL
EVAP
BLOWDOWN 23 (100)
BLOWDOWN 68 (300)
2500 (11000) MAX
PLANT No.3 BLAST FURNACES (2)
POLY
SPLITTER
SLAG QUENCH
5 (20)
POWER STATION No. 3
COKE PLANT No. 3 BATTERY "C"
QUENCH
FROM Nos 3 & 4 SANITARY TREATMENT PLANTS
TO EAST CHICAGO SANITARY DISTRICT
SOLIDS TO LANDFILL
1909 (8400)
22770 (100200)
SPIKE MILL
PLATE MILL
PLANT No. 1 GALV LINES
WPL & CHEMICAL TREATMENT
TO LANDFILL
24" BAR MILL
MISC SHOPS
OIL
SLUDGE
1293 (5700)
1773 (7800)
MATCH LINE SEE FIGURE B-2
114 (500)
INDIANA HARBOR SHIP CANAL
001
002
003
005
LEGEND:
FLOWS 000 - m³/Hr
(000) - gpm
007 OUTFALL No
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
CLARIFIER
COOLING TOWER
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO THREE (3) SIGNIFICANT DIGITS
U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION
INDIANA HARBOR WORKS
EXISTING FLOW DIAGRAM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE B-1


LAKE MICHIGAN
PUMP STATION No 1
PUMP STATION No 2
PUMP STATION No 5
PUMP STATION No 6
MATCH LINE SEE FIGURE B-1
COLD STRIP MILLS Nos 1&2
164 (720) FUME SCRUBBER
190 (835) PICKLE RINSE
OIL RECOVERY SYSTEM
864 (3800)
14" MILL
10" BAR MILL
76" HOT STRIP MILL
BLOOMING MILL No 3
44" HOT STRIP MILL
No 2 BLOOMING & No 2A BILLET
POWER STATION No 1
28" & 32" MILLS
SCALE PIT
WPL
TO DEEP WELL
WPL TRUCKED TO DEEP WELL
BOF No 2
CLASSIFIER
EVAP
SOLIDS TO LANDFILL
TO EAST CHICAGO SANITARY DISTRICT
COKE PLANT No 2 BATTERIES 6,7,8,9 & 10
QUENCH TANK
PLANT No 2 BLAST FURNACES (6)
FLUE DUST RECLAIMED
POWER STATION No 2
SINTER PLANT
80" HOT STRIP MILL
SCALE PIT No 2
SP Nos 3A & 3B
SP No 4A & 4B
SP No 1
INDUSTRIAL WASTE TREATMENT PLANT
OIL RECLAIMED
COLD STRIP MILL No 3
SLABBING MILL No 4
INDUSTRIAL WASTE LAGOON
MATCH LINE SEE FIGURE B-3
WPL & PICKLE RINSE
FROM No 2 SANITARY TREATMENT PLANT
FROM SANITARY TREATMENT PLANT No 1
SCALPING TANKS (4)
OIL CONCENTATION TANK
SLUDGE LAGOON
OIL RECLAIMED BY SCAVENGER
SLUDGE TO DISPOSAL
TERMINAL TREATMENT PLANT
31818 (140000)
INDIANA HARBOR SHIP CANAL
007
008
011
012
013
014
017
TURNING BASIN
NOTE
FOR NOTES AND LEGEND SEE FIGURE B-1
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION
INDIANA HARBOR WORKS
EXISTING FLOW DIAGRAM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE B-2

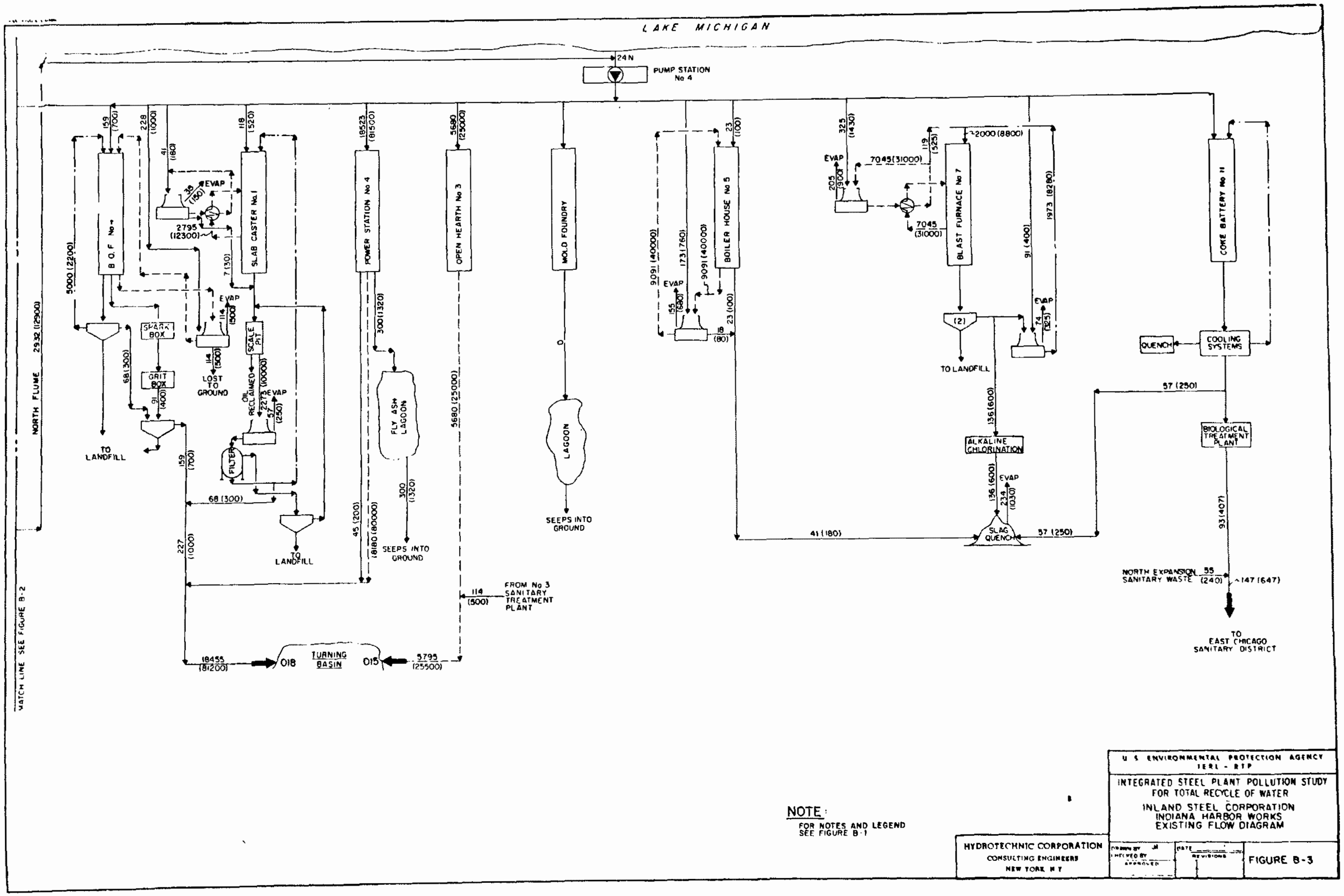

LAKE MICHIGAN
PUMP STATION No 4
24 N
B.O.F. No 4
SLAB CASTER No 1
POWER STATION No 4
OPEN HEARTH No 3
MOLD FOUNDRY
BOILER HOUSE No 5
BLAST FURNACE No 7
COKE BATTERY No 11
NORTH FLUME
SPARK BOX
GRIT BOX
SCALE PIT
FILTER
OIL RECLAIMED
LOST TO GROUND
TO LANDFILL
FLY ASH LAGOON
LAGOON
SEEPS INTO GROUND
EVAP
ALKALINE CHLORINATION
SLAG QUENCH
QUENCH
COOLING SYSTEMS
BIOLOGICAL TREATMENT PLANT
NORTH EXPANSION SANITARY WASTE
TO EAST CHICAGO SANITARY DISTRICT
FROM No 3 SANITARY TREATMENT PLANT
TURNING BASIN
018
015
18455 (81200)
5795 (25500)
MATCH LINE SEE FIGURE B-2
NOTE:
FOR NOTES AND LEGEND SEE FIGURE B-1
U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION
INDIANA HARBOR WORKS
EXISTING FLOW DIAGRAM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE B-3

TABLE B-1

EXISTING DISCHARGE QUALITIES CONCENTRATIONS*

SOURCE	FLOW m^3/hr (gpm)	pH	T ^oC(^oF)	SS	OIL	TDS	ALK-M (as $CaCO_3$)	HARDNESS (as $CaCO_3$)	SO_4	Cl	NH_3	PHENOL	CN	F	REMARKS
LAKE	-	8.4		8	0	172	103	134	22	10	0.1	0.003	0.01	0.2	
OUTFALLS															
001	114 (500)			10	2.3				84	20				0.2	
002	20960 (92200)		5.5 (10)	8.2		185	100								
003	1300 (5700)	7.8		10	3.8				28	52	0.2	0.01	0	0.17	
005	1770 (7800)	8.2		14	4.3				26	11	0.1	0.004	0	0.18	
007	6182 (27200)		8.9 (16)												Lake Water Quality
008	9545 (42000)		4.4 (8)												-"-
011	25900 (114000)		6.7 (12)												-"-
012	3068 (13500)		19.4 (35)												-"-
013	13600 (60000)	8.1	3.9 (7)	18	3.3		90	140	31	16	0.6	0.017	0.01	0.2	
014	18200 (80000)	8.1	3.9 (7)	17	3.4		90	140	30	16	0.6	0.017	0.01	0.2	
015	5680 (25000)		12.2 (22)												Lake Water Quality
017	26820 (118000)	8.5		20	0.4				24	16				0	
018	18455 (81200)	8.5		8.2	0.1	185	105		35						
DISCHARGES TO EAST CHICAGO SANITARY DISTRICT FROM COKE PLANTS															
No.2	(200)			100-200							50-100	100-200	3-4		Estimated Quality
No.3	(160)			100-200							50-100	100-200	3-4		-"-
Battery 11	(407)	6-9		90	16	5050				2595	60	0.2	3		

* All concentrations except pH in mg/l

Outfall 002

The discharge from Outfall 002 is a combination of process and cooling water. Plant No. 3 Blast Furnace discharges 2,886 m^3/hr (12,700 gpm) of once-through non-contact cooling water and approximately 236 m^3/hr (1,040 gpm) which is blown down from the gas cleaning systems. Power Station No. 3 contributes 17,727 m^3/hr (78,000 gpm) of non-contact cooling water with 15 m^3/hr (65 gpm) of boiler blowdown. These flows combine with 1,910 m^3/hr (8,400 gpm) of non-contact cooling water from Coke Plant No. 3. The total discharge from Outfall 002 to the Indiana Harbor Ship Canal is approximately 22,800 m^3/hr (100,200 gpm).

Outfall 003

The discharge from Outfall 003 is a combination of process and cooling waters from the Spike Mill, the Plate Mill and Plant No. 1 Galvanizing Lines. All of the non-contact cooling water is on a once-through basis and totals 454 m^3/hr (2,000) gpm) from Plant No. 1 Galvanizing Lines, 386 m^3/hr (1,700 gpm) from the Plate Mill, 11 m^3/hr (100 gpm) from the Spike Mill scale pit and 818 m^3/hr (3,600 gpm) from the Plate Mill scale pit combine with the cooling water in a settling basin and discharge to the Indiana Harbor Ship Canal. This total discharge from Outfall 003 is approximately 1,300 m^3/hr (5,700) gpm).

Outfall 005

The 24-inch Bar Mill discharges 568 m^3/hr (2,500 gpm) of process water from its scale pit and approximately 750 m^3/hr (3,300 gpm) of non-contact cooling water. This combines with approximately 455 m^3/hr (2,000 gpm) from the miscellaneous shops in a settling basin which discharges to the Indiana Harbor Ship Canal. The total discharge from Outfall 005 is approximately 1,770 m^3/hr (7,800 gpm).

Outfall 007

The 6,182 m^3/hr (27,200 gpm) discharge from Outfall 007 is composed entirely of once-through, non-contact cooling water from Plant No. 2 Blast Furnaces. This outfall discharges into the Indiana Harbor Ship Canal.

Outfall 008

The flow of water from this outfall to the Indiana Harbor Ship Canal consists entirely of 9,545 m^3/hr (42,000 gpm) of non-contact cooling water from Power Station No. 2.

Outfall 011

The discharge from Outfall 011 is comprised of non-contact water from the Sinter Plant, Power Station No. 2, and Plant No. 2 Blast Furnaces. Power Station No. 2 discharges 19,545 m^3/hr (86,000 gpm) of non-contact cooling water along with 28 m^3/hr (125 gpm) of boiler blowdown. Combined with these flows are 93 m^3/hr (410 gpm) of non-contact bearing cooling water from the Sinter Plant and 6,318 m^3/hr (27,800 gpm) of non-contact cooling water from Plant No. 2 Blast Furnaces. The total discharge to the Turning Basin is approximately 25,900 m^3hr (114,000 gpm).

Outfall 012

The discharge from Outfall 012 is approximately 3,068 m^3/hr (13,500 gpm) of non-contact cooling water; 227 m^3/hr (1,000 gpm) from BOF No. 2 and 2,840 m^3/hr (12,500 gpm) from Coke Plant No. 2 and 250 m^3/hr (1,100 gpm) from No. 1 Sanitary Treatment Plant. This outfall discharges into the Turning Basin.

Outfalls 013 and 014

The effluent from the Terminal Treatment Plant discharges through Outfalls 013 and 014 to the Turning Basin. The average total discharge is approximately 31,818 m^3/hr (140,000 gpm); 13,600 m^3/hr (60,000 gpm) through Outfall 013, and 18,200 m^3/hr (80,000 gpm) through Outfall 014. Plant facilities contributing to these flows are:

- Discharge from the gas cleaning recycle system of the Plant No. 2 Blast Furnaces amounting to 432 m^3/hr (1,900 gpm).

- Non-contact cooling water of approximately 2,730 m^3/hr (12,000 gpm) from Coke Plant No. 2.

- Blowdowns amounting to 118 m^3/hr (520 gpm) from the gas cleaning and cooling recylce systems of BOF No. 2.

- A total discharge, from Cold Strip Mills 1 and 2, of approximately 1,380 m^3/hr (6,060 gpm); 864 m^3/hr (3,800 gpm) of non-contact cooling water, 190 m^3/hr (835 gpm) of pickle rinse water, 164 m^3/hr (720 gpm) of fume scrubber water, and 159 m^3/hr (700 gpm) from the oil recovery system.

- The 14-inch Bar Mill discharges approximately 386 m^3/hr (1,700 gpm) from the scale pit and 795 m^3/hr (3,500 gpm) of non-contact cooling water.

- The flows from the 10-inch Bar Mill include 445 m^3/hr (2,000 gpm) from the scale pit and 364 m^3/hr (1,600 gpm) of non-contact cooling water.

- Approximately 9,090 m^3/hr (40,000 gpm) of process water is discharged from the 76-inch Hot Strip Mill Scale Pit. An additional 1,360 m^3/hr (6,000 gpm) is discharged but bypasses the scale pit and is composed of both process and non-contact cooling water.

- Blooming Mill No. 3 discharges approximately 2,070 m^3/hr (9,100 gpm) from the Scale Pit and 2,182 m^3/hr (9,600 gpm) which bypasses the scale pit.

- The 44-inch Hot Strip Mill discharges 7,950 m^3/hr (35,000 gpm) from the scale pit.

- The flows from the No. 2 Blooming Mill and No. 2A Billet Mill include 4,770 m^3/hr (21,000 gpm) from the scale pit and 1,683 m^3/hr (7,400 gpm) of non-contact cooling water.

- Approximately 227 m^3/hr (1,000 gpm) of non-contact cooling water is discharged from Power Station No. 1 which is used for equipment cooling only.

- The 28-inch and 32-inch Mills discharge about 1,270 m^3/hr (5,600 gpm) from the scale pit.

Outfall 015

The discharge from Outfall 015 is composed of 5,680 m^3/hr (25,000 gpm) of non-contact cooling water from Open Hearth No. 3 and 114 m /hr (500 gpm) from the No. 3 Sanitary Treatment Plant. This outfall discharges into the Turning Basin.

Outfall 017

The discharge of 26,820 m^3/hr (118,000 gpm) from Outfall 017 is a combination of process and cooling water from the 80-inch Hot Strip Mill and Cold Strip Mill No. 3. This flow is comprised of 12,300 m^3/hr (54,100 gpm) of non-contact cooling water, 5,450 m^3/hr (24,000 gpm) of process water from Scale Pit No. 2, 5,130 m^3/hr (22,600 gpm) from the Industrial Waste Treatment Plant, and 3,920 m^3/hr (17,300 gpm) from skimming pits 4A and 4B. Outfall 017 discharges into the Turning Basin.

Outfall 018

Outfall 018 discharges approximately 18,455 m^3/hr (81,200 gpm) from BOF No. 4, Slab Caster No. 1 and Power Station No. 4. BOF No. 4 and Slab Caster No. 1 have extensive recycle systems from which they blow down 159 m^3/hr (700 gpm) and 68 m^3/hr (300 gpm), respectively. Approximately 18,180 m^3/hr (80,000 gpm) of non-contact cooling water and 45 m^3/hr (200 gpm) boiler blowdown discharge from Power Station No. 4. The total flow from Outfall 018 of about 18,455 m^3/hr (81,200 gpm) discharges to the Turning Basin.

Outfall 24N

Approximately 2,932 m^3/hr (12,900 gpm) of both process and non-contact cooling water empties to Outfall 24N which discharges to the intake flume for the No. 4 A.C. Station. This flow is composed of 114 m^3/hr (500 gpm) of non-contact cooling and 1,250 m /hr (5,500 gpm) of process water which is used at Slabbing Mill No. 4 and jointly passes through a scale pit and the Industrial Waste Lagoon. This stream combines with approximately 1,480 m^3/hr (6,500 gpm) of non-contact cooling water from Cold Strip Mill No. 3 and 91 m^3/hr (400 gpm) of sanitary plant No. 2 effluent.

East Chicago Sewage Treatment Plant

Coke Plant No. 2 and Coke Plant No. 3 blowdown 45 m^3/hr (200 gpm) and 36 m^3/hr (160 gpm), respectively, of still waste liquor to the City of East Chicago Sewage Treatment Plant and 45 m^3/hr (200 gpm) of sanitary wastes from plants 3 and 4. Upon completion of the Northward Expansion, Coke Battery No. 11 will increase the flow of still waste liquor by 93 m^3/hr (407 gpm) and Sanitary wastes by 55 m^3/hr (240 gpm) to the East Chicago Treatment Plant.

Deep Well

Waste pickle liquor from Cold Strip Mills Nos. 1, 2 and 3, as well as, concentrated pickle rinse water from Cold Strip Mill No. 3 and waste pickle liquor from the 12-inch Bar Mill, the 10-inch and 14-inch Bar Mill PC Docks and 44-inch sheet mill pickler are injected into a deep well which discharges into the Mt. Simon geological formation.

1.3.3 Waste Treatment Facilities

There are, at present, waste treatment facilities located at various points in the plant, either at or near production facilities to treat specific wastes or at outfalls to treat combined wastes prior to discharge. These treatment facilities are discussed below in relation to the outfalls to which they discharge. The sanitary treatment plant wastes which discharge through these outfalls are omitted from discussion because they are not included in this study.

Outfall 001

Outfall 001 discharges a combination of process and non-contact cooling water from the 12-inch Bar Mill treatment facilities and the Electric Furnace and Billet Caster water systems. The Electric Furnace and Billet Caster have three water systems: an open recirculating process loop, an open recirculating non-contact cooling water system and a closed recirculating non-contact cooling water loop.

The process water system handles all contaminated water that is generated by the mills. These contaminants result from contact with the hot steel and various oils and greases. This water is directed into flumes located under the casting machine which, in turn, flow into a twin cell scale pit. The floating oils are skimmed off at the pit into an oil collection system. The oil is then trucked away to be recovered at the Terminal Treatment Plant. The heavy mill scale that has settled in the scale pit is removed by an overhead crane and the water from the scale pit is then filtered in three high rate sand filters. The filtered water flows to the hot well of a two cell cooling tower. Two hot well pumps lift the water to the top of the cooling tower. The cooled water, in the cold well, is then pumped back to the mill, by two pumps, for reuse.

The filter backwash water is discharged to a pair of lagoons where the solids are settled out. The water then slowly returns to the scale pit for reuse. Approximately 23 m^3/hr (100 gpm) is blown down from the hot well to the Indiana Harbor Ship Canal via Outfall 001 to control the level of dissolved solids in the system. Chemicals used in the system are dispersants, inhibitors, and chlorine.

The open recirculating cooling system is used to cool the main furnaces, air compressors, mold water heat exchangers and other miscellaneous cooling applications. All uses involve indirect contact and no water contamination. This water is then cooled in the cooling tower described above. In addition to the blowdown from the cooling tower, 23 m^3/hr (100 gpm) is blown down directly from the Billet Caster to the Indiana Harbor Ship Canal.

The third system operates as a closed loop which cools the copper casting molds. Since clean heat transfer surfaces are required, this water is zeolite softened. The mold water pumps circulate this water through the molds and through the mold water heat exchangers. The heat exchanger is cooled by the open recirculating system discussed above.

A 38 m /hr (10,000 gallon) storage tank acts as a surge tank for the mold water pumps. Makeup water is provided from a zeolite tank which feeds into the surge-storage tank. The quantity of makeup is based on tank water level. Chemicals added to this system consist of chlorine for biological control and chromate for corrosion control. In the event of a power failure a stand-by diesel generator provides power to run the key pumps in the water system. An elevated water tank supplies the water needs of the system for the short period of time required to start the emergency generator.

The 12-inch Bar Mill operates on a complete recirculation system which produces two types of wastewaters: process water at 35°C (95°F), with several hundred mg/l suspended solids, and non-contact cooling water with a temperature of about 43°C (110°F). The clean, hot water, consisting of cooling waters from air compressors, lubrication oil systems, motor rooms, the annealing furnace and the billet reheat furnace flows to the cooling tower pumping station hot well.

Contaminated hot waters from the pinch rolls, hydraulic descaling units, roll cooling units, coiler coolers, roll shop, mechanical work area and cobble baler are collected in flumes and discharged to a scale pit. The scale pit consists of one primary cell and two secondary cells each capable of handling 100 percent of the flow. In the primary cell, the coarsest scale particles (greater than 1 mm) settle out, while smaller particles from 1 mm. to 0.1 mm. are removed in the secondary cells. Floating oils and greases are removed from the secondary cells by rotating pipe skimmers and a continuous belt unit.

The effluent from the scale pit is pumped to a chemical wastewater treatment plant where suspended solids and oil are removed. Spent pickling acid and lime are used for coagulation and polyelectrolyte is used as a settling aid. The treatment units consist of two clarifiers each capable of handling 100 percent of the flow. Sludge which collects at the bottom of the clarifiers is pumped to vacuum filters for dewatering.

The clarified effluent then flows to the cooling tower hot well and is mixed with the clean hot water. The mixed water (43°C or 110°F) is pumped to a two-cell cooling tower and cooled to about 30°C (85°F). A cold well receives the cooled water and pumps return it to the mill for reuse. Fresh water is added to the cold well to make-up for evaporation, drift losses and necessary blowdown. A blowdown of approximately 68 m^3/hr (300 gpm) is discharged to the Indiana Harbor Ship Canal via Outfall 001.

Outfall 002

Both process and non-contact cooling water from Plant No. 3 Blast Furnaces, Power Station No. 3, and Coke Plant No. 3 discharge to the Indiana Harbor Ship Canal through Outfall 002. The Plant No. 3 Blast Furnaces recycle both the gas cooling and gas cleaning water but discharge 2,886 m^3/hr (12,700 gpm) of untreated non-contact cooling water, which has a temperature increase of 2.8C° (5F°), to the Indiana Harbor Ship Canal.

Plant No. 3 Blast Furnace Recirculation System is, in effect, two separate recirculation systems: one system for the gas cooler water and one for the gas cleaning system, stove seals and separator water. The gas cooler cools the cleaned blast furnace gases and the heated water is sent to a settling basin where suspended matter is removed by chemically aided settling. The water is then pumped over a 3-cell cooling tower and the cooled water is pumped back to the Blast Furances for reuse. To prevent dissolved solids build-up the system, approximately 284 m^3/hr (1,250 gpm) is blown down to the gas cleaning water system as makeup. Service water is added, at the cold well, to make up for system losses.

The gas cleaning system water washes the solids from the gas in two venturi scrubbers. Solids laden water is then pumped to two 189 m^3 (50,000 gallon) clarifiers where the solids settle aided by a feed of polyelectrolyte solution. Sludge removed from the system is trucked away. The cleaned water is then pumped over a fill-less, 3-cell cooling tower. To prevent dissolved solids buildup in the system, approximately 236 m^3/hr (1,040 gpm) is blown down to the Indiana Harbor Ship Canal.

The gas cleaning water is then pumped back to the venturi scrubbers for reuse and for maintaining the water seals on the blast furnaces.

Provisions for adding chemicals are provided in both of the above water systems to condition the water as required in a recirculating system. There chemicals include; sulfuric acid for pH control, an anti-foulant chemical, and a scale controlling chemical.

Power Station No. 3 has no treatment facilities and discharges approximately 16,090 m^3/hr (70,800 gpm) of once-through non-contact cooling water with a temperature rise of 5.6C° (10F°). In addition, the Power Station discharges approximately 15 m^3/hr (65 gpm) of boiler blowdown.

No. 3 Coke Plant discharges approximately 1,910 m^3/hr (8,400 gpm) of non-contact cooling water to the Indiana Harbor Ship Canal. This water is primarily used for cooling in the coal chemicals plant, the barometric condenser and, minimally, in the sulfur recovery boiler. The temperature increase of this water is approximately 8.9C° (16F°).

All process water in the Coke Plant is recycled except for 68 m^3/hr (300 gpm) which is blown down. Approximately 32 m^3/hr (140 gpm) of this blowdown water (shed scrubber blowdown) is used for coke quenching and is evaporated. The remaining 36 m^3/hr (160 gpm) of still waste liquor passes through a settling basin and is then sent to the City of East Chicago Sanitary Treatment Plant. The sludge from the settling basin in trucked to a landfill.

Outfall 003

The total wastes, amounting to approximately 1,300 m^3/hr (5,700 gpm), from the Spike Mill, the Plate Mill and the Plant No. 1 Galvanizing Lines are treated in a settling basin prior to discharge to the Ship Canal. The floating oils and greases are skimmed off into an oil collection system. This oil is then transported to the Terminal Treatment Plant for recovery. The sludge which collects in the bottom of the settling basin is pumped out for dewatering, off site.

The 23 m^3/hr (100 gpm) of process water from the Spike Mill passes through a scale pit prior to the settling basin. The scale from the pit is reclaimed. This water then combines with about 11 m^3/hr (50 gpm) of non-contact cooling water with an unknown, but assumed minimal, temperature increase. The Plate Mill also has both contact and non-contact water, totaling 818 m^3/hr (3,600 gpm) and 386 m^3/hr (1,700 gpm), respectively. Process water passes through a scale pit in which the larger particles settle out. The scale from the scale pit is reclaimed as is the skimmed oil. This process water mixes with the non-contact cooling water and increases in temperature approximately 3.3C° (6F°).

The remaining flow of non-contact cooling water discharging to the settling basin is 57 m^3/hr (250 gpm) from Plant No. 1 Galvanizing Lines. Temperature elevation is not known. The Galvanizing Lines also discharge Waste Pickle Liquor and chemical treatment wastes which are trucked to a landfill.

Outfall 005

Approximately 1,770 m^3/hr (7,800 gpm) of wastewater discharges from the 24-inch Bar Mill and the Miscellaneous Shops passes through a settling basin and then discharges to the Indiana Harbor Ship Canal via Outfall 005. The floating oils are skimmed, collected and trucked to the Terminal Treatment Plant for reclaiming. The sludge which collects in the basin is dewatering. All process water from the 24-inch Bar Mill (568 m^3/hr or 2,500 gpm) passes through a scale pit where the major portion of suspended solids and oils are removed and reclaimed. The water then combines with 750 m^3/hr (3,300 gpm) of non-contact cooling water which has a temperature rise of 14.4C° (26F°).

In addition to the Bar Mill wastewater, approximately 455 m^3/hr (2,000 gpm) of process water from the Miscellaneous Shops in the area enters the settling basin without previous treatment.

Outfall 007

The total discharge from Outfall 007 is 6,190 m^3/hr (27,200 gpm) of non-contact cooling water from the Plant No. 2 Blast Furnaces. This water is not treated and the only change it experiences is a temperature rise of 8.9C° (16F°).

Outfall 008

Approximately 9,540 m^3/hr (42,000 gpm) of non-contact cooling water from Power Station No. 2 discharges to the Indiana Harbor Ship Canal through Outfall 008. This water is not cooled prior to discharge and the temperature elevation is about 4.4C° (8F°).

Outfall 011

Approximately 25,900 m^3/hr (114,000 gpm) of non-contact cooling water is discharged through Outfall 011 and this water is not treated prior to discharge. Approximately 93 m^3/hr (410 gpm) of Sinter Plant non-contact bearing cooling water and 28 m^3/hr (125 gpm) of boiler blowdown from Power Station No. 2 is discharged.

The balance of the discharged water is 19,500 m^3/hr (86,000 gpm) and 6,310 m^3/hr (27,850 gpm) of non-contact cooling water from Power Station No. 2 and the Plant No. 2 Blast Furnaces, respectively. The cooling water from both of these facilities has a temperature increase of 6.7C° (12F°).

Outfall 012

The total discharge through Outfall 012 is composed of approximately 3,068 m^3/hr (13,500 gpm) of non-contact cooling water and 250 m^3/hr (1,100 gpm) of sanitary waste treatment plant effluent. BOF No. 2 discharges 227 m^3/hr (1,000 gpm) with a temperature rise of 6.1C° (11F°). This water combines with 2,840 m^3/hr (12,500 gpm) of ammonia liquor cooling water from

Coke Plant No. 2 which has a temperature rise of 22.8C° (41F°). These waste streams are not cooled, and the temperature rise of the stream is 21.4C° (38.6F°).

Outfalls 013 and 014

All 31,818 m^3/hr (140,000 gpm) discharges to Outfalls 013 and 014 are presently treated by passing the combined wastes through the Terminal Treatment Plant. The treatment facility consists of an interceptor system, four scalping tanks with oil removal facilities, a low lift pumping station, two terminal settling basins and a sludge lagoon. Floating oils are automatically skimmed from the surface of the scalping tanks and conveyed into a heated collection trough by reciprocating bridge skimmers. A screw conveyor moves the skimmed oil from the trough, into a heated sump. The two identical oil separation systems consist of sumps, concentration tanks, storage tanks and pumps. The scalping tanks are 7.3 m (24 ft.) wide by 35 m (115 ft.) long, each with a retention time of 8 minutes. The scalping tanks are cleaned when the sludge depth is 0.6 m (2 ft.).

The low lift pumping station is designed to have an adequate capacity for both dry and wet weather flows. Pumping units consist of four 3,410 m^3/hr (15,000 gpm) pumps and four 13,600 m^3/hr (60,000 gpm) pumps with the provision for the installation of two additional 13,600 m^3/hr (60,000 gpm) pumps in the future. The discharge from the low lift pumps enters the inlet flumes of the two terminal settling basins. Each basin is 64.6 m (212 ft.) wide and 152 m (500 ft.) long with a depth of 4 m (13 ft.). The retention time is 2¼ hours. A sludge lagoon is used for storing and drying sludge dredged from the scalping tanks and terminal basins.

BOF No. 2, Coke Plant No. 2 and the Plant No. 2 Blast Furnaces have extensive recycle systems and therefore warrant a more detailed discussion. BOF No. 2 has four recirculation systems: two process water loops and two non-contact cooling water loops.

The first process water loop is for cooling and scrubbing the off-gas from the two steelmaking furnaces. The water is first pumped to high energy P.A. Venturi scrubbers. Contaminated scrubber effluent water is then collected in a quencher feed tank where it is repumped to the quenchers. These quenchers remove the solids from the most heavily laden gases. The solids laden water then flows to the treatment plant by way of the quencher seal tanks and enters a head tank at the treatment plant where it is then diverted to two of three inertial type cyclones. These cyclones separate the fines from the water and send them to two spiral classifiers which then discharge for disposal in a landfill. The partially cleaned water next enters two 30.5 m

(100 ft.) diameter thickeners where most of the remaining solids settle out with the aid of a polyelectrolyte. The flow then enters a holding tank for recycling to the scrubber feed pumps. The settled solids are then pumped as a sludge from the bottom of the thickeners and trucked as a liquid slurry for use as landfill.

Water is blown down constantly to control the dissolved solids in the system. The blowdown enters a small clarifier, 6.1 m (20 ft.) in diameter, where most of the remaining suspended solids settle out. Sludge from the thickener is also used as landfill. The total sludge flow amounts to approximately 14 m^3/hr (60 gpm). Clean blowdown, which totals approximately 55 m^3/hr (240 gpm), is then discharged to the terminal water treatment plant.

The second process water loop is a scrubbing loop for the secondary gas collection system. Building fumes are collected by ducts and cleaned by this process water which is recirculated through a high energy Venturi scrubber. The solids laden water is constantly being blown down to the thickeners of the first system for solids removal. Water is made up from the first system although service water can be used if needed.

The third system is an open non-contact cooling system. A two-cell filled cooling tower cools 6,360 m^3/hr (28,000 gpm) of cooling water. This water is then pumped to the membrane-type furnace hoods, lance water heat exchangers, and vessel trunnion cooling. The water then returns to the cooling tower. Approximately 64 m^3/hr (280 gpm) is blown down to the Terminal Treatment Plant by a conductivity control which regulates the system dissolved solids. Makeup is with service water and chemical treatment is used.

The second non-contact cooling water system is an enclosed, indirect contact type. The furnace lances are cooled by recirculating water which is cooled in a bank of shell and tube heat exchangers. The heat exchanger bank is cooled by the third water system described above. The makeup for this system is service water that has been filtered and softened by standard sodium zeolite softeners. This water is then chemically treated for corrosion control, there is no blowdown except for incidental leakage. In addition to these four recycle systems, approximately 227 m^3/hr (1,000 gpm) of once-through non-contact cooling water is discharged to Outfall 012.

Each of the six blast furnaces of Plant No. 2 has two recirculated water systems: one for gas cooling and one for gas cleaning. The gas cooler water is heated by the gas being cooled and then sent to the gas cooler water settling basin. Suspended solids in the water are removed by gravity with the aid of a chemical polyelectrolyte, if needed. This water is then pumped over a 3-cell cooling tower and the cooled water flows to the gas cooler cold well for pumping back to the gas coolers. System blowdowns of approximately 398 m^3/hr (1,750 gpm) are discharged to the Gas Cleaning Water System. Service water is added at the gas cooler cold well to make up for system losses.

Venturi pumps, pump the gas cleaning water to Venturi scrubbers at each furnace and to the gas water seals of the furnace system. This solids laden water is then sent to two clarifiers where solids are removed from the water with chemical assistance. The resulting sludge is either removed by trucks or pumped to vacuum filters. The process water then flows to the hot well of the main recirculation pump station and is pumped to thermal rotors. These devices cool the water by fine spraying at the gas cleaning water basin. In this large basin, most suspended solids that remain in the water settle out. Finally, the water enters the main recirculation pump station cold well and is pumped by the Venturi pumps to the scrubber. Dissolved solids build up in this system is limited by blowing down approximately 432 m^3/hr (1,900 gpm) to the Terminal Treatment Plant.

Both water systems have chemical conditions added. Chemicals used include: sulfuric acid for pH control, an antifoulant and a scale control chemical.

In addition to these recycle systems, the blast furnaces discharge approximately 12,500 m^3/hr (55,000 gpm) of once-through non-contact cooling water to Outfalls 007 and 011. Plant No. 2 Coke Plant discharges approximately 2,730 m^3/hr (12,000 gpm) of non-contact cooling water to the Terminal Treatment Plant. This water is used for cooling in: the steam condenser, wash oil cooler, water heater, light oil condenser and ammonia liquor cooler. The water increases in temperature, 7.8C^o (14F^o). There is also approximately 2,840 m^3/hr (12,500 gpm) of non-contact water which discharges to Outfall 012.

The Coke Plant recirculates its' process water but blowdowns are necessary because of water pickup from the distillation. The 45 m^3/hr (200 gpm) of still wastes blowdown is sent to the East Chicago Sanitary Treatment Plant after passing through three settling basins for the removal of suspended solids. Sludge which collects on the bottom of the basin is transported to a landfill. The balance of the blowdowns from the final cooler, the benzol plant and the scrubber car are sent to coke quenching. Approximately 130 m^3/hr (570 gpm) evaporates from the quench tanks and additional raw service water is needed for makeup to the coke quenching system.

The discharges from all the mills to the Terminal Treatment Plant amount to approximately 37,300 m^3/hr (164,000 gpm). According to Inland Steel Company, this value is a high estimate because of the normal downtime experienced at the mills. The actual discharge is closer to 31,800 m^3/hr (140,000 gpm). This effluent from the Treatment Plant discharges to the Turning Basin through Outfalls 013 and 014 and totals approximately 13,600 m^3/hr (60,000 gpm) and 18,200 m^3/hr (80,000 gpm), respectively.

Outfall 015

The entire discharge from Outfall 015 is approximately 5,680 m^3/hr (25,000 gpm) of once-through indirect cooling water from the No. 3 Open Hearth Shop. The temperature elevation of this water is 12.2C^o (22F^o).

Outfall 017

Outfall 017 discharges approximately 26,800 m^3/hr (118,000 gpm) of both contact and non-contact wastewater from the 80-inch Hot Strip Mill and Cold Strip Mill No. 3.

All process water from the 80-inch Hot Strip Mill passes through scale pits for removal of mill scale and other suspended solids and oil is skimmed. The process water from the first half of the roughing stands flows into scale pit No. 1 and is pumped back to the mill for flume flushing and then discharges to scale pit No. 2. Therefore, the effluent from scale pit No. 2 is composed of wastes from both the front and back of the roughing stands and totals approximately 5,450 m^3/hr (24,000 gpm) which discharges to Outfall 017. The process wastewaters from the finishing stands and part of the run-out table are captured in flumes and flow to scale pits 3A and 3B. The effluents from these scale pits totalling approximately 5,000 m^3/hr (22,000 gpm) combine with 134 m^3/hr (590 gpm) from the Cold Strip Mill No. 3 in a mixing distribution chamber. Waste Pickle Liquor and lime are added in the distribution chamber to aid in settling. This waste splits and enters two rapid mixing chambers for aeration. Following rapid mixing, a polyelectrolyte is added in a distribution chamber to further aid settling in four flocculator-clarifiers. The effluent from the clarifiers totals approximately 5,130 m^3/hr (22,600 gpm) and discharges to Outfall 017. The sludge is pumped to two vacuum filters and the dewatered solids are trucked away to a landfill.

The wastes from the coilers and part of the run-out tables are sent to Skimming Pits 4A and 4B, where they combine with 59 m^3/hr (260 gpm) of oily waste from Cold Strip Mill No. 3. The oil is reclaimed from the skimming pits and the 3,930 m^3/hr (17,300 gpm) of effluent is discharged to Outfall 017.

In addition to the process water, about 12,300 m^3/hr (54,100 gpm) of non-contact cooling water discharges to Outfall 017. This is a combination of 795 m^3/hr (35,000 gpm) from the Hot Strip Mill and 4,350 m^3/hr (19,100 gpm) from the Cold Strip Mill. The temperature elevations of these indirect cooling flows are 2.9C° (7F°) and 1.1C° (2F°), respectively. The total discharge from Outfall 017 to the Turning Basin is approximately 26,800 m^3/hr (118,000 gpm). Cold Strip Mill No. 3 also discharges Waste Pickle Liquor and Pickle Rinse to the Deep Well and 80 m^3/hr (6,500 gpm) of non-contact cooling water to Outfall 24N at Pump Station no. 4 intake.

Outfall 018

The total discharge from Outfall 018 is a combination of both process and cooling water from Power Station No. 4, BOF No. 4 and Slab Caster No. 1. This total discharge to the Turning Basin is approximately 18,455 m^3/hr (81,200 gpm).

Power Station No. 4 discharges 18,200 m^3/hr (80,000 gpm) of non-contact cooling water with a temperature elevation of approximately 5.5C° (10F°). This combines with approximately 45 m^3/hr (200 gpm) of Boiler Blowdown. Power Station No. 4 also discharges 273 m^3/hr (1,200 gpm) of Fly Ash Slurry Water, approximately 27 m^3/hr (120 gpm) of lime pretreatment waste and a small amount of boiler water pretreatment backwash to a Fly Ash Lagoon. This 300 m^3/hr (1,320 gpm) of wastewater is disposed of by percolation into the ground and by evaporation.

Slab Caster No. 1 utilizes three water systems to maximize recirculation of its wastewaters.

The first system is an open-recirculating system for handling the process water that comes in direct contact with oils, grease, mill scale, etc. This water is used to spray hot steel slabs and picks up considerable solids. The slab spray water enters a large 2-cell scale pit with a 2,840 m^3 (750,000 gallons) capacity. Heavier scale is settled out in this scale pit and is removed by bucket and crane. Floating oils are also removed by an adjustable trough. The oil collected is then pumped to portable oil dumpsters for final removal. The scale pit effluent is then pumped over a 2-cell cooling tower by scale pit hot well pumps. A portion of the cooled water is used on the final run-out table sprays for slab cooling and the remainder flows by gravity to high rate water filters. The filter effluent flows to the caster surge tank. Mill pumps then distribute this water to the various water systems including, slab cooling sprays, torch cutting machines, descaling sprays and machine cooling water systems. Water losses in this system are made up from the second water system described below. To control the buildup of dissolved solids in the system, approximately 68 m^3/hr (300 gpm) is blown down to Outfall 017 after passing through the high rate filters.

The Second System is an open-recirculating, indirect contact cooling water system which supplies cooling water to the caster machine and mold water shell and tube heat exchangers. Cooling water is pumped to the exchangers and after use the warm water returns directly to the caster cooling tower, eliminating the need for hot well pumps. The blowdown from this system serves as makeup to the process system described above. Makeup to this system is service water. Both system No. 1 and No. 2 are chemically treated with; acid to control pH, a scale inhibitor, an anti-foulant chemical and chlorine for biological growth control.

The third system is an emergency system which is capable of providing water to various areas for about 50 minutes at 680 m^3/hr (3,000 gpm). Service water is filtered, softened and pumped up to an elevated water tank with a 500 m^3/hr (150,000 gallons) capacity. Two booster pumps can fill this tower at a rate of approximately 51 m^3/hr (225 gpm) when needed. During non-emergency periods water is drawn from this tank to makeup losses that occur in the mill mold water system. Since the mill mold water system is a closed indirect contact system, very little makeup water is normally used. The emergency tower system is chemically treated with chromate for corrosion protection.

BOF No. 4, as well as, Slab Caster No. 1 have tight recirculation systems. BOF No. 4 has two process water systems and two cooling water systems.

The first process water system is a gas cleaning system in which water flows to thickeners to remove the solids and is recycled back to the quench tower scrubbers and the moisture separator. The sludge which accumulates in the thickeners is trucked to a landfill and the blowdown is to the thickener of the second system.

The second system is a once-through process system for the spark box. This water passes through a grit box, where the grit is removed, and then to a thickener where the majority of suspended solids are removed. The process water from the spark box is combined with the blowdown from the first system in the thickener, and the effluent of approximately 159 m^3/hr (700 gpm) is discharged to Outfall 018. The sludge from the thickener is trucked to a landfill.

The third system is an open-recirculating, non-contact cooling system. It supplies cooling water to the spark box, hood cooling panels, and to the heat exchangers. Approximately 114 m^3/hr (500 gpm) is lost from the system into the group which serves as a blowdown to control dissolved solids buildup.

The fourth system is a closed-recirculating indirect cooling system which provides cooling water for the oxygen lance. Since this system is completely closed, neither a blowdown nor a makeup is normally necessary.

Outfall 24N

Approximately 2,932 m^3/hr (12,900 gpm) discharges to Outfall 24N which discharges to the intake flume for No. 4 A.C. Station. Approximately 1,480 m^3/hr (6,500 gpm) of non-contact cooling water discharges to Outfall 24N from Cold Strip Mill No. 3. The temperature elevation of this water is not known, but it is assumed low.

Wastewater from Slabbing Mill No. 4 contributes the majority of the discharge to Outfall 24N and amounts to approximately 1,360 m^3/hr (6,000 gpm). This water is composed of approximately 1,250 m^3/hr (5,500 gpm) of process water and 114 m^3/hr (500 gpm) of cooling water. The combined stream passes through a scale pit to remove the coarse solids and then flows to the Industrial Waste Lagoon for further settling and oil skimming. The effluent from the lagoon mixes with the cooling water from the Cold Strip Mill and is recycled to No. 4 Pump Station. The remaining discharge is 91 m^3/hr (400 gpm) of effluent from the No. 2 sanitary treatment plant.

Deep Well

Waste pickle liquor from Cold Strip Mill Nos. 1, 2 and 3, as well as, concentrated pickle rinse water from Cold Strip Mill No. 3 and waste pickle liquor from the 12-inch Bar Mill, the 10-inch and 14-inch Bar Mill PC Docks and the 44-inch Hot Strip Mill Sheet Pickler is injected into a deep well.

The equipment at this disposal area consists of two 378 m^3/hr (100,000 gallon) storage tanks, truck unloading facilities, filters, a precoat system, a buffer tank, injection pumps, a filter sludge disposal system, booster pumps, and annulus water pumps. Treatment of buffer water and annulus water is provided to prevent bacterial growth in the disposal strata.

The system is automated to collect, filter and inject waste pickle liquor into the deep well and is designed to filter the waste pickle liquor at a rate of 34 m^3/hr (150 gpm) and inject it into the deep well with a temperature of approximately 10°C (50°F) with a maximum pressure of 1,725 kPa (250 psig). The waste acid and buffer water are filtered to remove particles above 0.6 micrometers. A complete backup facility for each major piece of equipment is installed to insure continuous operation of the deep well. Filtered water is injected constantly in the annulus around the injection tube to prevent waste pickle liquor from coming into contact with the steel casing. Electrical conductivity probes are attached to the fiber-cast injection tube to detect the presence of pickle liquor in the annulus, which would indicate a crack in the injection tube. The waste material being injected into the well has a specific gravity of 1.1 to 1.2.

The water in the Mt. Simon formation, where the deep well is located, has a salt content of about 20,000 mg/l at the 800 m (2,600 ft.) level (near the top of the formation).

1.3.4 Air Pollution Control Facilities

Air pollution control facilities are installed at the various production facilities at the Inland Steel Company's plant that utilize water for air or gas cleaning. These facilities are installed at the coke plant, sinter plant, blast furnaces, hot scarfers, continuous pickling lines and the 80-inch hot strip mill.

At "C" Coke Battery, pipeline charging has been installed to prevent charging emissions. Plans for other batteries, are to purchase new larry cars for staged charging. Pushing emissions at "C" Coke Battery are currently captured in a shed and discharged through a scrubber system. Gases produced at "C" Coke Battery are desulfurized by a vacuum carbonate system followed by a "Claus" sulfur recovery unit. The new No. 11 Battery will have a similar system but plans for the remaining batteries, at the present time, do not include H_2S removal.

Gases at the blast furnaces are cleaned by venturi scrubbers. Hot scarfers at the No. 4 slab mill, the No. 2 blooming mill and the No. 3 blooming mill use only sprays to control dust.

Nos. 2, 3, 4 and 5 continuous strip pickling lines, use hydrochloric acid and have fume scrubbers which discharge scrubber water to the terminal treatment plant. Plans are to return the scrubber waters to the pickling line for reuse. Both of the BOF shops employ scrubbers for cleaning of gases.

2.0 PROPOSED PROGRAM

2.1 General

The Inland Steel Plant treats virtually all contaminated wastewaters prior to discharge. Non-contact cooling water, however, is not generally recirculated or treated. Of the thirteen outfalls that discharge to either the turning basin or the Indiana Harbor Ship Canal only one is composed entirely of process water, three only discharge non-contact cooling water, two contain non-contact cooling water with treated sanitary wastes and the balance discharge process water with non-contact cooling water.

Two factors are essential when considering total recycle of water from any industrial facility. First, the segregation of storm runoff from all process and cooling streams must be considered including the minimizing of or elimating infiltration into buried gravity wastewater lines and below ground sumps. The second consideration is removal of excess dissolved solids that are concentrated due to circulation of water and the ultimate disposal of these solids.

The Inland Steel Corporation Plant is essentially four different plants located along a 5.8 km (3.6 mi) strip of land. Although similar production and service facilities are at each of the plants, the problem of combining and treating wastes from similar facilities at common waste treatment facilities appears to be insurmountable due to the piping runs that would be required, the power required to pump the water to and from the treatment facility and the heating of these pipes during the periods of extreme cold encountered in the plant area during the winter months.

The facilities proposed and recommended, herein, were developed in two stages; first to achieve discharges that will be in compliance with the BAT limitations and then reaching total recycle as an extension of the facilities proposed for BAT.

2.2 Water Related Modifications for Air Quality Control

At the Coke Plants some controls which impact on water use that will reduce present emissions are currently being implemented or plans have been formulated to reduce these emissions. These are scrubber cars at all batteries for the control of pushing emissions, except C Battery which has a shed scrubber system. Additional controls or operational modifications described below are at the coke plant, the hot scarfers and the No. 1, 2 and 3 cold strip mills.

Particulate emissions from coke quenching operations could be reduced by the use of spray towers following quenching. In addition, at batteries 6, 7, 8, 9 and 10, the water used for quenching should be changed from the present use of Wheeler Cooler and Light Oil Plant discharges to service water or some other water with a lower dissolved solids concentration. Prior to using water from the scrubber shed for quenching at "C" Battery, the water should be further clarified to reduce the suspended solids concentration in the water presently used, to below the 1,052 mg/l.

Improvements to emissions control are recommended at the hot scarfer at the No. 4 Slabbing Mill, the No. 2 and 3 Blooming Mills. Wet electrostatic precipitators are recommended. At these mills, the respective recirculating water uses are expected to be 227 m^3/hr (1,000 gpm), 182 m^3/hr (800 gpm) and 205 m^3/hr (900 gpm). Blowdowns are anticipated to be 20 percent of this use.

Oil vapors could be controlled at the No. 1, 2 and 3 cold strip mills by the use of impingement baffles.

2.3 Requirements for the Plant to Meet BAT

Effluent limitations have been prescribed by the United States Environmental Protection Agency for each type of production facility at iron and steel plants. These limitations were established on the basis of mass loading per unit of production for each facility. Inland Steel's allowable discharges are shown on Table B-2. The treatment recommendations in this section are generally presented by outfall number. However, when a possibility exists for redirecting flows, to reach the objective, from one outfall system to another this procedure has been followed.

Outfall 001

The combined flows to Outfall 001, with all facilities in operation, presently meet BAT limitations since adequate treatment is provided at the billet caster. Therefore, no additional facilities have to be added or operational changes be made for facilities discharging to Outfall 001.

TABLE B-2

ALLOWABLE DISCHARGES AS PERMITTED UNDER BAT LIMITATIONS

Daily Allowable Discharges (kkg/day) (lb/day)

Production Facility	Daily Production kkg/tons	S.S.	O&G	CN	NH_3	S^-	Phenol	BOD_5	F-	Zn	Mn	NO_3	SN	Pb	Fe (diss)	Cr^{+6}	Cr (tot)	Cr (diss)	Ni (diss)	Cu (diss)
#2 Coke	4990/5500	21.0 46.2	21.0 46.2	0.50 1.10	21.0 46.2	0.60 1.32	1.05 2.31	41.4 91.3												
#3 Coke	2540/2800	10.7 23.5	10.7 23.5	0.25 0.56	10.7 23.5	0.30 0.67	0.53 1.18	21.1 46.5												
#11 Coke	2720/3000	11.4 25.2	11.4 25.2	0.27 0.60	11.4 25.2	0.33 0.72	0.57 1.26	22.6 49.8												
#2 Blast Furnace	11340/12500	59.0 130.0		1.47 3.25	59.0 130.0	1.8 4.0	2.95 6.50		117.9 260.0											
#3 Blast Furnace	5450/6000	28.3 62.4		0.71 1.56	28.3 62.4	0.87 1.92	1.42 3.12		56.7 124.8											
#7 Blast Furnace	6800/7500	35.4 78.0		0.88 1.96	35.4 78.0	1.09 2.4	1.77 3.90		70.7 156.0											
Sinter Plant	4080/4500	21.6 47.7	8.6 18.9			0.24 0.54			17.1 37.8											
#2 BOF	5900/6500	30.7 67.6							24.8 54.6											
#4 BOF	12700/14000	66.0 145.6							53.3 117.6											
#3 Open Hearth	6800/7500	35.4 78.0							28.6 63.0	6.8 15.0		63.9 141.0								
#1 Elec. Arc	1630/1800	0							0	0										
#2 Blooming	3900/4300	4.3 9.5	4.3 9.5																	
#3 Blooming	5720/6300	6.3 13.9	6.3 13.9																	
#5 Boiler	132/1050000																			

(continued on B-28)

TABLE B-2

ALLOWABLE DISCHARGES AS PERMITTED UNDER BAT LIMITATIONS

(continued)

Production Facility	Daily Production kkg/tons	Daily Allowable Discharges (kkg/day) (lb/day) S.S.	O & G	CN	NH_3	$S^=$	Phenol	BOD_5	F -	Zn	Mn	NO_3	SN	Pb	Fe (diss)	Cr^{+6}	Cr (tot)	Cr (diss)	Ni (diss)	Cu (diss)
#4 Slabbing	9700/10700	10.7 23.5	10.7 23.5																	
#1 Slab Caster	4170/4600	21.7 47.8	21.7 47.8																	
#1 Billet Caster	1240/1370	6.4 14.2	6.4 14.2																	
44" HSM	3630/4000	0	0																	
76" HSM	4080/4500	0	0																	
80" HSM	12700/14000	0	0																	
Mold Foundry	900/1000																			
100" Plate	1090/1200	7.0 15.4	7.0 15.4																	
10" Bar)) 14" Bar)	1810/2000	0	0																	
12" Bar	1900/2100	0	0																	
Spike *	45/50	0	0																	
24" Bar	900/1000	0	0																	

Note: * Hot Forming Sect

(continued on B-29)

TABLE B-2

ALLOWABLE DISCHARGES AS PERMITTED UNDER BAT LIMITATIONS

(continued)

Production Facility	Daily Production kkg/tons	S.S.	O & G	CN	NH_3	S^-	Phenol	BOD_5	F -	Zn	Mn	NO_3	SN	Pb	Fe (diss)	Cr^{+6}	Cr (tot)	Cr (diss)	Ni (diss)	Cu (diss)	
		Daily Allowable Discharges (kkg/day) (lb/day)																			
28" Mill)) 32" Mill)	1900/2100	0	0																		
#2 Billet	2720/3000	0	0																		
40" CR #1	1630/1800	169.8 375.1	68.0 150.1												6.85 15.1						Direct Applic.
80"CR #3	8440/9300	21.9 48.4	8.8 19.3												0.88 1.93						Recirc.
CR # 1 Pickling	4540/5000																				Deep Well
CR #3 Pickling	8530/9400																				Deep Well
44" Sheet Pickler	900/1000																				Deep Well
12" Bar Pickling	130/140																				Deep Well
#5 Galv.	900/1000	9.36 20.6	3.78 8.3							.75 1.65						.0072 .016	.076 .168				
Alk. Cleaning	900/1000	4.68 10.3													0.18 0.40		0.09 0.20				
#1 Galv. Lines	1810/2000	18.8 41.4	7.6 16.8							1.5 3.3						.0145 .032	.152 .335				
10"-14" Pickler	235/261																				Deep Well

(continued on B-30)

TABLE B-2

ALLOWABLE DISCHARGES AS PERMITTED UNDER BAT LIMITATIONS

(continued)

Production Facility	Daily Production kkg/tons	Daily Allowable Discharges (kkg/day) (lb/day) S.S.	O&G	CN	NH_3	$S^=$	Phenol	BOD_5	F^-	Zn	Mn	NO	SN	Pb	Fe (diss)	Cr^{+6}	Cr (tot)	Cr (diss)	Ni (diss)	Cu (diss)
Power Sta. #2																				
28 m^3/hr (125 gpm)																				
Boiler Blowdown		20.4	10.2												0.7					0.7
		45	22.5												1.5					1.5
Power Sta. #3																				
15 m^3/hr (65 gpm)																				
Boiler Blowdown		10.6	5.3												0.35					0.35
		23.4	11.7												0.8					0.8
Power Sta. #4																				
45 m^3/hr (200 gpm)																				
Boiler Blowdown		32.6	16.3												0.4					0.4
		72	36												0.9					0.9
300 m^3/hr (1320 gpm)																				
& Lime Pretreatment		215.6	107.8																	
		475.2	237.6																	
Boiler #5																				
23 m^3/hr (100 gpm)																				
Boiler Blowdown		16.3	8.2												0.54					0.54
		36	18												1.2					1.2

Outfall 002

The major flows to Outfall 002 are non-contact cooling waters from Plant No. 3 blast furnaces, Power Station No. 3 and Coke Plant No. 3. The non-contact cooling water accounts for 98 percent of the total flow to the outfall. Of the remaining 2 percent 236 m^3/hr (1,040 gpm) or approximately 1.1 percent is a discharge from the blast furnace gas cleaning system. This blowdown contains ammonia, fluorides and suspended solids in excess of BAT limitations. To meet the limitations, this gas cleaning blowdown should be segregated from the other flows and treated for discharge. The recommended treatment is lime precipitation and settling for removal of fluorides followed by break point chlorination for nitrification of the ammonia, filtration for suspended solids removal and activated carbon adsorption for final polishing.

Outfall 003 and Outfall 005

Outfalls 003 and 005 are considered under one heading due to the similarity of their wastes and their proximity to each other. The 1,200 m^3/hr (5,300 gpm) of non-contact cooling water should be segregated from the total flows and discharged separately, allowing only 1,860 m^3/hr (8,200 gpm) to pass through the two lagoons. The effluent from the lagoons should then be recycled back to the mills and 307 m^3/hr (1,350 gpm) blown down to a filtration system. The filtrate should then be pumped to Plant No. 3 blast furnace cooling system to replace the present service water makeup. Recycling will minimize the quantity of water requiring treatment and reduce the amount of service water needed. The mills that have a zero discharge limitation will then be in compliance with the BAT requirements. Additionally, the plate mill, although permitted a blowdown, will have the equivalent of zero discharge.

Outfalls 007, 008, 011, 012 and 015

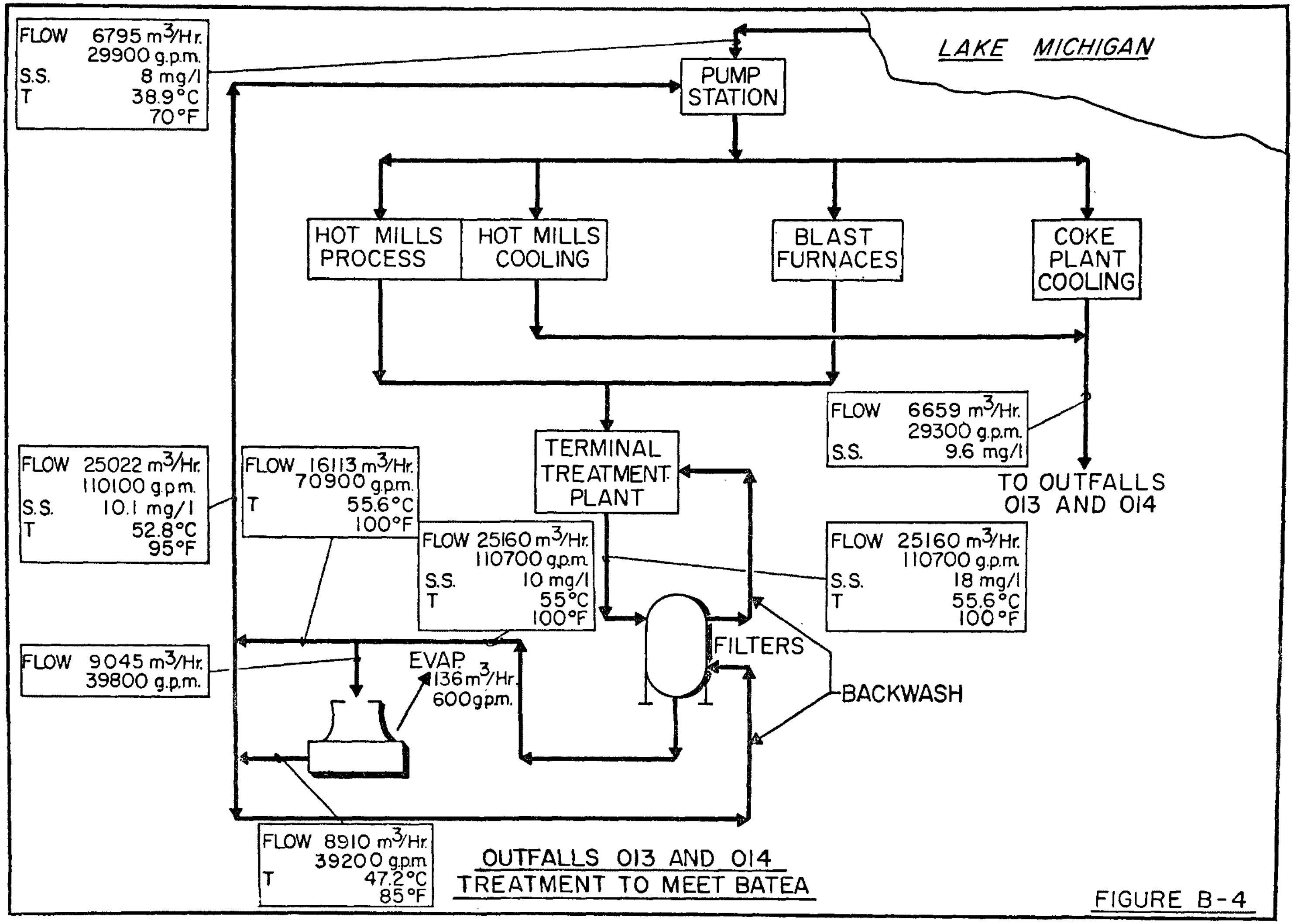
Outfalls 007, 008, 011, 012 and 015, discharge only non-contact cooling water and treated sanitary wastes and are not in violation of BAT limitations. However, in the near future, thermal regulations are anticipated and may be imposed on heated water discharges. Consideration should be given to the possibility of installing cooling towers to cool the water prior to reuse. The temperatures of the water discharged are increased by 8.9C^o (16F^o), 4.4C^o (8F^o), 6.8C^o (12.2F^o), 19.4C^o (35F^o) and 12.2C^o (22F^o) for Outfalls 007, 008, 011, 012 and 015, respectively.

Outfalls 013 and 014

Outfalls 013 and 014 discharge treated waste from the terminal plant. The suspended solids allowable, under BAT, from all the wastewater treated in the terminal treatment plant is 285 kg (627 lbs) per day. At a flow of 31,818 m^3/hr (140,000 gpm) and a reported increase of suspended solids over intake quality of 10 mg/l, the actual discharge is 7,627 kg (16,800 lbs) per day. To reduce the quantity of suspended solids discharged, two steps are recommended: first - segregate all non-contact cooling water from the influent to the terminal treatment plant and discharge this flow directly to the turning basin and, second - recirculate all of the water from the terminal treatment plant back to the mills and coke plant for reuse. Blowdown from the system would be via the non-contact cooling water discharges. However, prior to recirculation, additional treatment in addition to the existing wastewater treatment plant will be required.

The waste blowdown from the blast furnace recirculation system was studied to determine if any pre-treatment was necessary prior to combination with other waste. It was found that the discharges are in accordance with limitations for most parameters, (i.e., fluoride, sulfide, phenol, cyanide and ammonia) but suspended solids levels are higher than the BAT recommendations. Pre-treatment was not deemed necessary, however.

With the non-contact cooling water diverted from the terminal treatment plant, the flow to the facility would be reduced from 31,818 m^3/hr (140,000 gpm) to approximately 25,159 m^3/hr (111,000 gpm). This volume also includes an estimated 77.3 m^3/hr (350 gpm) from Blooming Mill No. 3 and Billet Mill No. 2A scarfer electrostatic precipitators discharge. After the terminal plant, the wastewater should be filtered, using 40 - 4.6 m (15 ft.) diameter, pressurized, granular media filters operating at a flux rate of 39 m/hr (16 gpm per sq.ft.), then cooling in cooling towers and directed to the intake of Pumping Station No. 6. Filters have been demonstrated to satisfactorily treat and consistently discharge effluents with suspended solids of 10 mg/l or less. The backwash water for the filters would be drawn from the cooling tower cold well and the solids laden backwash water would be discharged to the two existing terminal lagoons from where the solids would settle and be dredged to the sludge lagoon. A flow diagram showing the distribution and quality of the recirculation system water with respect to temperature and solids is shown on Figure B-4. The blowdown from this recirculation system would be via the non-contact cooling water discharged. The solids discharged would be approximately 256 kg (568 lbs) per day as opposed to the allowable limit of 285 kg (627 lbs) per day.



OUTFALLS 013 AND 014
TREATMENT TO MEET BATEA

FIGURE B-4

Outfall 017 and 24N

The wastes discharging through Outfall 017 consist of 7,955 M^3/hr (35,000 gpm) of non-contact cooling water from the 80-inch Hot Strip Mill and 4,364 m^3/hr (19,200 gpm) from Cold Strip Mill No. 3. Of the remaining flow, 5,136 m^3/hr (22,600 gpm) has been treated in the Industrial Waste Treatment Plant, 5,455 m^3/hr (24,000 gpm) is discharged directly from the 80-inch Hot Strip Mill Scale Pit No. 2 and 3,932 m^3/hr (17,300 gpm) is from the 80-inch Hot Strip Mill and Cold Strip Mill No. 3 which is discharged from skimming pits Nos. 4A and 4B. The net suspended solids discharged are approximately 9,534 kg (21,000 lbs) per day as compared with the allowable (under BAT) 35.9 kg (79.3 lbs) per day.

Outfall 24N is not, in the strictest sense, an outfall since it discharges wastes to the intake of Pumping Station No. 4 and only a portion of Pumping Station No. 4 water discharges to the receiving waters via Outfall 015. The allowable discharge under BAT for No. 4 Slabbing Mill is 10.7 kg (23.5 lbs) per day. The total present flow required by Pumping Station No. 4 is 26,977 m^3/hr (118,700 gpm) and, of this, 5,860 m^3/hr (25,000 gpm) is discharged untreated through Outfall 015. However, for the suspended solids to be limited to the allowable 10.7 kg (23.5 lbs) per day, the gross suspended solids concentration is Outfall 015 would have to be 8.13 mg/l and the gross concentration from the Slabbing Mill No. 4 lagoon would have to be no greater than 10.57 mg/l. A lagoon system is not capable of providing this degree of treatment. Therefore, Slabbing Mill No. 4 scale pit effluent should be treated with the 80-inch Hot Strip Mill wastes, as described below. The additional flow to be treated would be 1,409 m^3/hr (6,200 gpm) which includes the existing flow plus the additional flow due to the electrostatic precipitator at the scarfer.

The non-contact cooling water from Cold Strip Mill No. 3 should discharge to Outfalls 017 and 24N, as is the present practice. The non-contact cooling water flow of 7,955 m^3/hr (35,000 gpm) from the 80-inch Hot Strip Mill should be cooled in an open cooling tower and recirculated via a new non-contact cooling water supply main. Blowdown from the cooling tower would be 605 m^3/hr (2,660 gpm) and should be directed to the contact water system as makeup. Makeup of 1,000 m^3/hr (4,400 gpm) to the non-contact cooling water system would be from Pumping Station No. 6.

To enable the reuse of this contact water together with the water from Scale Pit No. 2 and the Skimmings Pits some further treatment would be required to reduce the suspended solids level in order to reduce nozzle wear and line plugging. The effluent from the Industrial Waste Treatment Plant, Scale pit No. 2 and the Skimmings Pits should be collected and pumped to pressure containing filters and cooling towers prior to return to the various facilities.

If this scheme is adopted, chemical addition at the Industrial Waste Treatment Plant could be discontinued because this facility would only be used for secondary settling and the filters would reduce the suspended solids and oils to acceptable levels. Twenty-six 4.6 m (15 ft.) diameter filters would be required, operating at a flux rate of 39 m/hr (16 gpm per sq.ft.).

The treated water would be returned to the various facilities as follows: 1,364 m^3/hr (6,000 gpm) to Slabbing Mill No. 4 and 14,284 m^3/hr (62,800 gpm) to the 80-inch Hot Strip Mill. Makeup to the system would be from the non-contact system as discussed above.

Utilizing the procedure outlined above, the following benefits are realized:

(1) The plant will meet the BAT limitations for suspended solids and oils;

(2) Lake water use will be decreased by 22,636 m^3/hr (99,600 gpm);

(3) Chemical use and associated excess sludge producing procedures will be eliminated;

(4) Addition of dissolved chemicals will be reduced.

Material Storage Runoff

The BAT limitations for runoff from material storage areas is 25 mg/l of suspended solids. Material storage areas are defined in this report as areas where raw materials are stored without cover. At the plant approximately 11 ha (27 acres) are dedicated to ore storage at two locations. Plant No. 2 has 7.2 ha (17.5 acres) of storage northwest of the blast furnaces and at Plant No. 3 there are 3.8 ha (9.5 acres) of storage northwest of the blast furnaces. At Plant No. 2, between the blast furnaces and the coke plant, 3.8 ha (9.3 acres) are used for coal storage. Considering a once-in-10-year, 24-hour storm, 14,200 m^3 (3.75 x 10^6 gallons) would require retention. Using an effective depth of storage of 3 m (10 ft.), a total area of 0.47 ha (1.15 acres) would be required. However, due to the location of the production facilities, at Plant No. 1, which occupy the entire area between Plants 2 and 3, it is not practical to collect all of the storm water runoff at one location.

Portions of the material storage areas at each of the three locations, described above, should be set aside for the construction of storm water retention and settling basins. At Plant No. 3, 0.13 ha (0.32 acres) would be required for collection of runoff from the ore storage, and two areas would be required at Plant No. 2: one, 0.24 ha (0.59 acres) for retention of ore storage runoff and another, 0.13 ha (0.31 acres) for retention of coal pile runoff. These areas represent a reduction in storage of approximately three percent.

The basins should be of earth construction and not be lined. The collected waters would be pumped at a rate of 22.7 m^3/hr (100 gpm) to the Indiana Harbor Ship Canal.

Collection of storm water from the basins would be by either drainage ditches around the areas or by a new storm sewer collection system. Drainage ditches are recommended.

Discharges to East Chicago Sanitary District

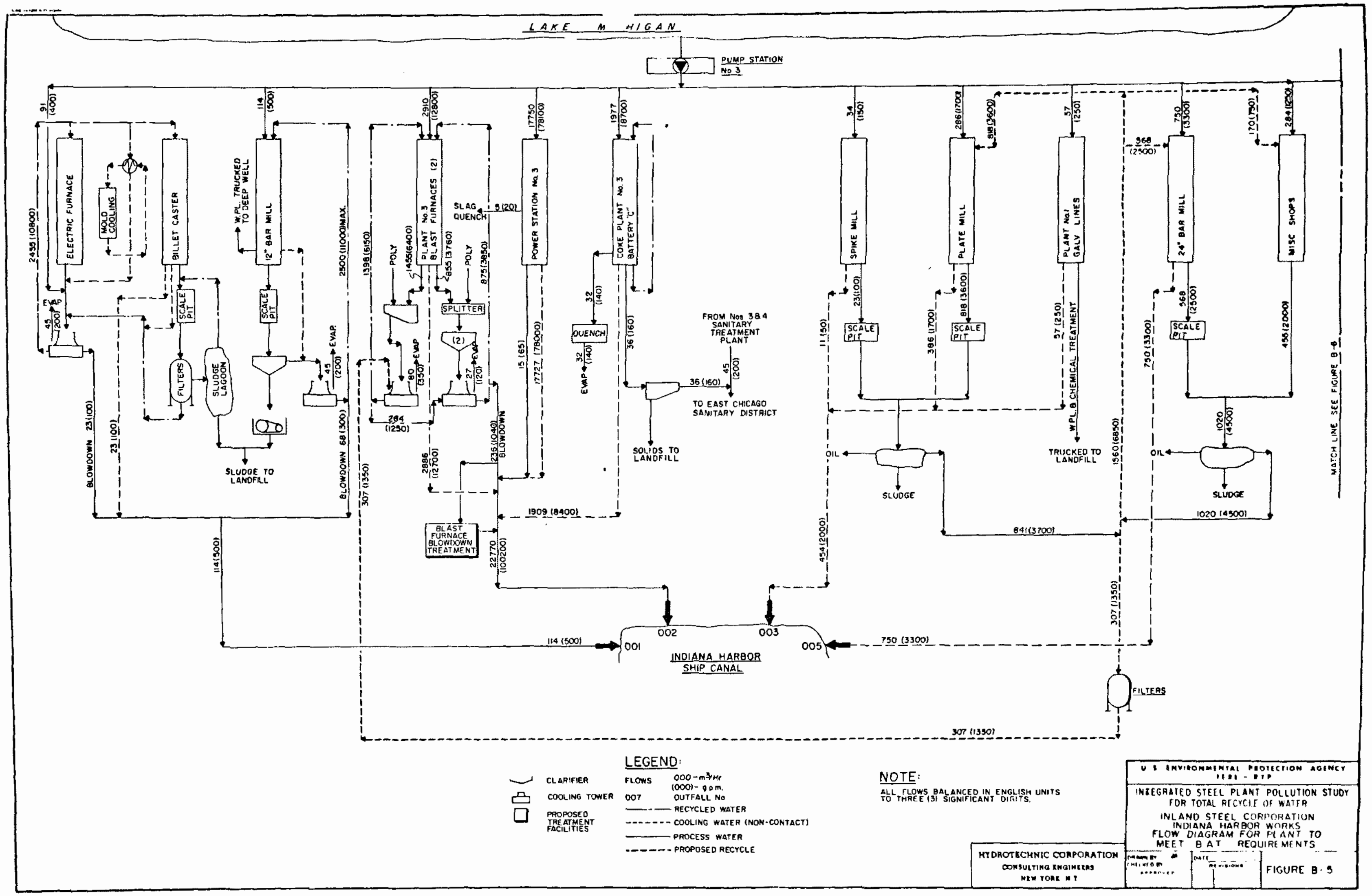
Present or planned flows to the East Chicago Sanitary District for the treatment of coke plant wastes are 45 m^3/hr (200 gpm) from Coke Plant No. 2, 36 m^3/hr (160 gpm) from Coke Plant No. 3, 93 m^3/hr (407 gpm) from Coke Battery 11, 55 m^3/hr (240 gpm) sanitary wastes from the North Expansion area and 45.5 m^3/hr (200 gpm) sanitary wastes from Plants 3 and 4. Due to the elimination process in disposing of 95 m^3/hr (420 gpm) in coke quenching operations for air quality purposes at Coke Plant No. 2, this flow would have to be increased by 95 m^3/hr (420 gpm).

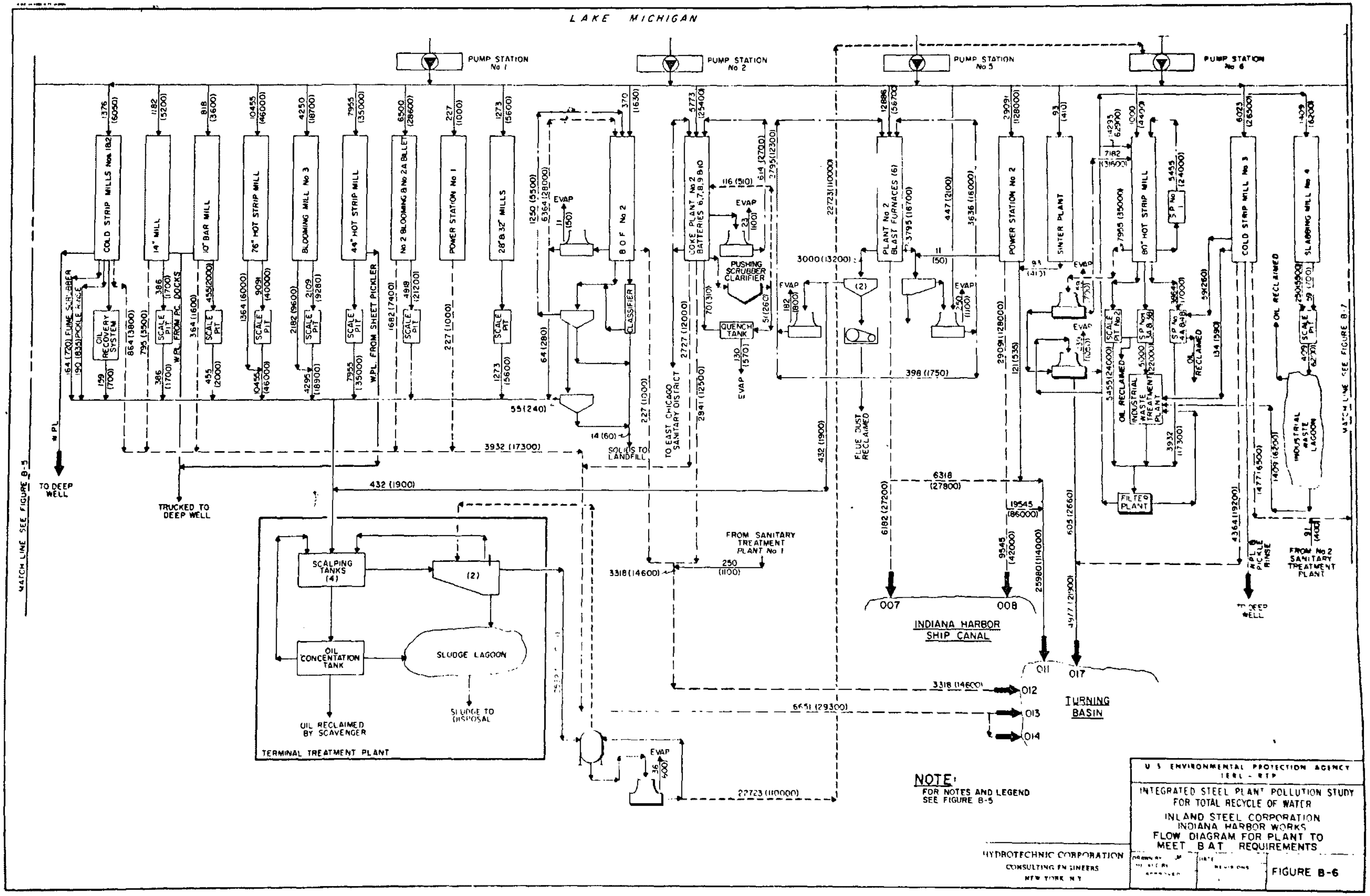
Summary

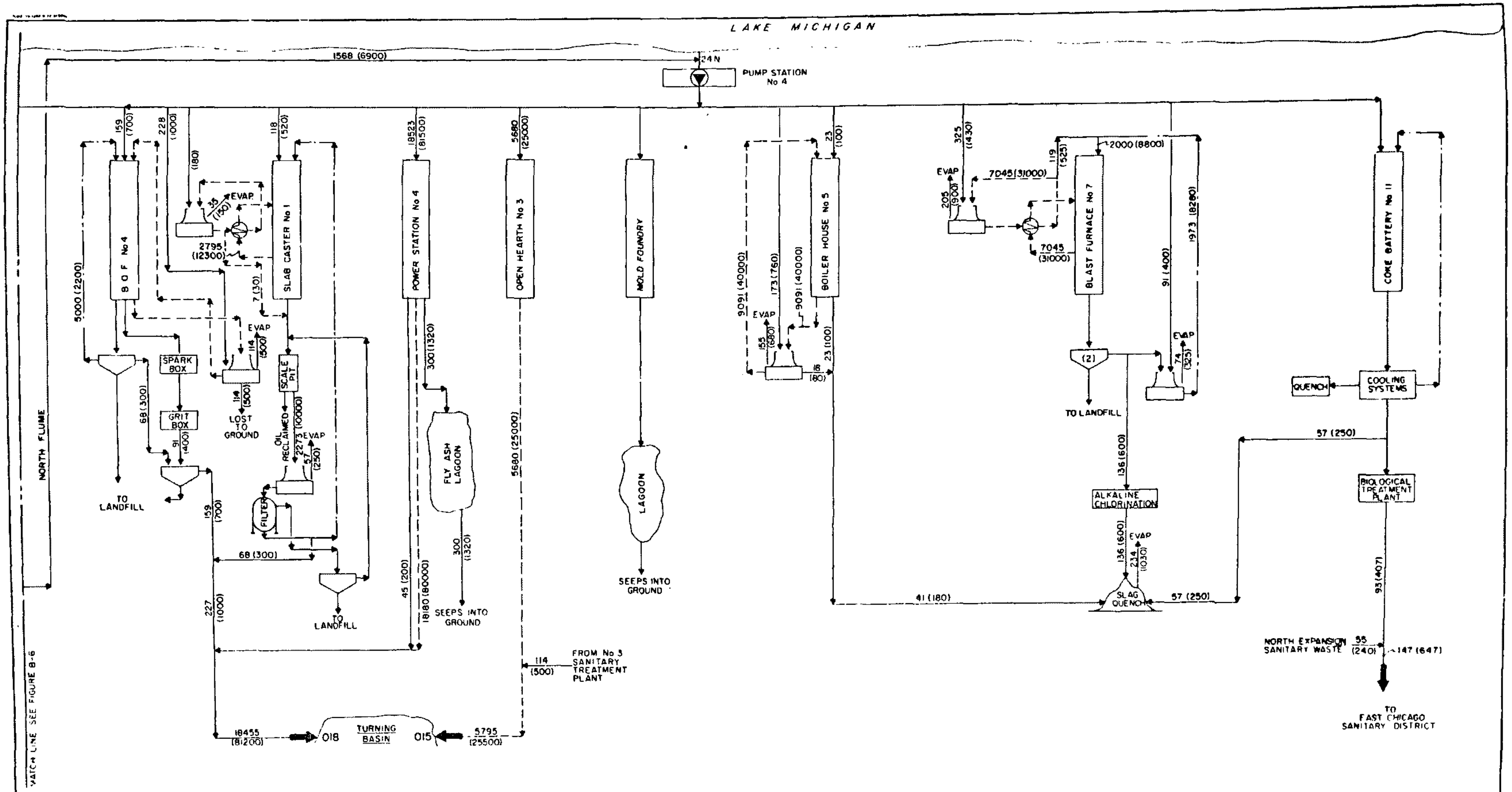
A plant flow diagram illustrating water distribution and uses under BAT conditions is shown as Figures B-5, B-6 and B-7.

2.4 Requirements for Plant to Meet Total Recycle

This section addresses itself to the manner in which all discharges of water from the Inland Steel Company Plant can be eliminated. The recommendations made in Section 2.3 are considered to be in place with new facilities added, whereby, all water discharges, with the exception of sanitary sewage and area runoff, are eliminated. In the preparation of this section, it must be realized that the practicality of the concept of total recycle has not been addressed. However, the best judgment of the engineers was used in recommending the systems presented.


LAKE MICHIGAN
PUMP STATION No 3
ELECTRIC FURNACE
MOLD COOLING
BILLET CASTER
SCALE PIT
FILTERS
SLUDGE LAGOON
SLUDGE TO LANDFILL
EVAP
45 (200)
91 (400)
2435 (10800)
BLOWDOWN 23 (100)
23 (100)
114 (500)
W.P.L. TRUCKED TO DEEP WELL
12" BAR MILL
2500 (11000) MAX.
BLOWDOWN 68 (300)
PLANT No. 3 BLAST FURNACES (2)
2910 (12800)
1398 (6150)
POLY
1455 (6400)
855 (3760)
875 (3850)
SPLITTER
80 (350)
27 (120)
284 (1250)
2886 (12700)
307 (1350)
SLAG QUENCH
5 (20)
POWER STATION No. 3
17750 (78100)
15 (65)
17727 (78000)
236 (1040) BLOWDOWN
BLAST FURNACE BLOWDOWN TREATMENT
22770 (100200)
1909 (8400)
COKE PLANT No. 3 BATTERY "C"
1977 (8700)
QUENCH
32 (140)
36 (160)
SOLIDS TO LANDFILL
FROM Nos 3 & 4 SANITARY TREATMENT PLANT
TO EAST CHICAGO SANITARY DISTRICT
SPIKE MILL
34 (150)
23 (100)
11 (50)
PLATE MILL
286 (1700)
818 (3600)
386 (1700)
PLANT No. 1 GALV. LINES
57 (250)
W.P.L. & CHEMICAL TREATMENT
TRUCKED TO LANDFILL
24" BAR MILL
730 (3300)
568 (2500)
750 (3300)
1560 (6850)
MISC SHOPS
170 (750)
284 (1250)
456 (2000)
OIL
SLUDGE
1020 (4500)
841 (3700)
454 (2000)
MATCH LINE SEE FIGURE B-6
INDIANA HARBOR SHIP CANAL
001
002
003
005
FILTERS
LEGEND:
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
FLOWS 000 - m³/hr (000) - gpm.
007 OUTFALL No
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO THREE (3) SIGNIFICANT DIGITS.
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION
INDIANA HARBOR WORKS
FLOW DIAGRAM FOR PLANT TO MEET B A T REQUIREMENTS
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE B-5


LAKE MICHIGAN
PUMP STATION No 1
PUMP STATION No 2
PUMP STATION No 5
PUMP STATION No 6
COLD STRIP MILLS Nos 1&2
14" MILL
10" BAR MILL
76" HOT STRIP MILL
BLOOMING MILL No 3
44" HOT STRIP MILL
No 2 BLOOMING & No 2A BILLET
POWER STATION No 1
28"&32" MILLS
B O F No 2
COKE PLANT No 2 BATTERIES 6,7,8,9 & 10
PLANT No 2 BLAST FURNACES (6)
POWER STATION No 2
SINTER PLANT
80" HOT STRIP MILL
COLD STRIP MILL No 3
SLABBING MILL No 4
OIL RECOVERY SYSTEM
SCALE PIT
CLASSIFIER
PUSHING SCRUBBER CLARIFIER
QUENCH TANK
EVAP
FUME SCRUBBER
PICKLE RINSE
W.P.L. FROM P.C. DOCKS
W.P.L. FROM SHEET PICKLER
INDUSTRIAL WASTE TREATMENT PLANT
INDUSTRIAL WASTE LAGOON
FILTER PLANT
OIL RECLAIMED
FLUE DUST RECLAIMED
TO DEEP WELL
TRUCKED TO DEEP WELL
SOLIDS TO LANDFILL
TO EAST CHICAGO SANITARY DISTRICT
FROM SANITARY TREATMENT PLANT No 1
FROM No 2 SANITARY TREATMENT PLANT
SCALPING TANKS (4)
OIL CONCENTRATION TANK
SLUDGE LAGOON
OIL RECLAIMED BY SCAVENGER
SLUDGE TO DISPOSAL
TERMINAL TREATMENT PLANT
INDIANA HARBOR SHIP CANAL
TURNING BASIN
007
008
011
012
013
014
017
3932 (17300)
432 (1900)
6318 (27800)
19545 (86000)
3318 (14600)
6651 (29300)
22723 (110000)
MATCH LINE SEE FIGURE B-5
MATCH LINE SEE FIGURE B-7
NOTE:
FOR NOTES AND LEGEND SEE FIGURE B-5
U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION
INDIANA HARBOR WORKS
FLOW DIAGRAM FOR PLANT TO MEET B A T REQUIREMENTS
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
FIGURE B-6



NOTE:
FOR NOTES AND LEGEND SEE FIGURE B-5

U S ENVIRONMENTAL PROTECTION AGENCY
(IERL - RTP)

INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

INLAND STEEL CORPORATION
INDIANA HARBOR WORKS
FLOW DIAGRAM FOR PLANT TO MEET BAT REQUIREMENTS

HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y

FIGURE B-7

The average flow rates used in this section, and in the previous section, are based on data supplied by Inland Steel Company. Prior to the design and consideration of any waste treatment facility, an infiltration-inflow analysis should be made of all gravity sewers and below grade sumps and, when seepage is found, it should be eliminated if possible. This procedure will materially reduce the flows to be treated and the size of associated treatment facilities.

Outfall 001 and 002

Almost all of the water is cooled prior to discharge through Outfall 001. The present 114 m^3/hr (500 gpm) from Outfall 001 should be pumped to the Plant No. 3 blast furnace cooling system as makeup for cooling tower losses. Assuming a dissolved solids concentration of 400 mg/l in the discharge from Outfall 001, the blast furnace gas cooling tower should operate so that the blowdown would limit the dissolved solids in the recirculating water to 600 mg/l. At that concentration the blowdown would be 102 m^3/hr (450 gpm) and this water could be used for slag quenching at a rate of 0.46 m^3/kkg (110 gallons per ton).

Approximately 22,500 m^3/hr (99,100 gpm) of the discharge through Outfall 002 is non-contact cooling water from the coke plant, Power Station No. 3 and the Plant No. 3 Blast Furnaces. The water should be collected and cooled in an open cooling tower prior to recycle. If the water is cooled 5.5C^o (10F^o) and the dissolved solids concentration in the blowdown is slightly above 600 mg/l, the blowdown would be 86 m^3/hr (380 gpm). This blowdown could be used as makeup to the blast furnace gas cleaning water system.

The cycles of concentration at the blast furnace gas cleaning system can be increased so that the dissolved solids level is 3,500 mg/l, resulting in a blowdown of 59 m^3/hr (260 gpm). This blowdown could then be used as dilution water at the coke plant biological treatment plant described below.

To attain the goal of total recycle, the 36 m^3/hr (160 gpm) of coke plant wastes could no longer be discharged to the East Chicago Sanitary District and a treatment system for this wastewater would be required. Since the raw coke plant wastes are too high in ammonia, either ammonia removal or dilution water is required. Assuming adequate ammonia removal cannot be achieved we have used dilution water. This dilution water would be the 59 m^3/hr (260 gpm) blowdown from the blast furnace gas washer system. The wastewater would be treated biologically in an extended aeration system with a residence time of approximately 18 hours. After removal of the biologically degradable compounds, the waste would be filtered and combined with the boiler blowdown from Power Station No. 3 for dissolved solids removal. Removal of dissolved solids is assumed to be by reverse osmosis to a level of 175 mg/l. The product stream of 83 m^3/hr (367 gpm) would be used as makeup at the proposed cooling tower and the brine reject stream of 27 m^3/hr (121 gpm) would be evaporated to dryness. Approximately 17.2 kkg (19 tons) of dry solids per day would require disposal, and the volume would be approximately 18.2 cubic meters (24 cubic yards) per day.

Outfalls 003 and 005

The non-contact cooling water flow of 1,205 m^3/hr (5,300 gpm) from the Spike Mill, the Plate Mill, Plant No. 1 Galvanizing Lines and the 24-inch Bar Mill must be eliminated. This water should be collected and cooled and will have a blowdown of 68 m^3/hr (300 gpm) which would discharge to the blast furnace gas cooling system. The cooling tower effluent would be combined with the filtered and non-filtered process waters from the mills (as described in Section 2.3) and recycled back to Pump Station No. 3.

Outfall 007

The flows to Outfalls 007 are all non-contact cooling water should be collected and cooled in an open cooling tower and returned to the Plant No. 2 blast furnace cooling system for reuse. A blowdown of 76 m^3/hr (335 gpm) would be sent to the dissolved solids removal unit following the biological treatment plant described under Outfall 012. This flow also includes 6,318 m^3/hr (27,800 gpm) presently being discharged to Outfall 011 for a total cooling tower capacity of 12,500 m^3/hr (55,000 gpm).

Outfall 008

The only flow to Outfall 008 is non-contact cooling water from Power Station No. 2. This flow of 29,091 m^3/hr (128,000 gpm) should be cooled in an open cooling tower and recycled to Power Station No. 2. The blowdown of 98 m^3/hr (430 gpm) would be sent to the dissolved solids removal unit following the biological treatment described under Outfall 012.

Outfall 011

The non-contact cooling water from Power Station No. 2 presently discharging to Outfall 011, would be diverted and cooled in the cooling tower described under Outfall 008 and the non-contact cooling water from Plant No. 2 blast furnaces would be cooled in the cooling tower described under Outfall 007.

The sinter plant flow of 93 m^3/hr (410 gpm) would be pumped to the Coke Plant No. 2 cooling towers, described below.

Boiler blowdown from Power Station No. 2 would be transferred to the final treatment stage of the Coke Plant No. 2 treatment system, described below.

Outfall 012 and Coke Plant No. 2

All discharge to Outfall 012, with the exception of the treated sanitary wastes, would be eliminated when cooling towers are installed for various non-contact cooling water streams. The 227 m^3/hr (1,000 gpm) of non-contact cooling water from BOF No. 2 should be collected and combined with the following waters. The non-contact cooling water from the following sources should be segregated from the contaminated wastewaters which presently discharge to the Terminal Treatment Plant to eliminate unnecessary treatment:

Cold Strip Mill Nos. 1 & 2	864 m^3/hr (3,800 gpm)
14-inch Plate Mill	795 m^3/hr (3,500 gpm)
10-inch Bar Mill	364 m^3/hr (1,600 gpm)
No. 2 Blooming & No. 2A Billet Mill	1,682 M^3/hr (7,400 gpm)
Power Station No. 1	227 m^3/hr (1,000 gpm)

The total cooling tower capacity would be 4,160 m^3/hr (18,300 gpm) and the cooled water would be recirculated back to BOF No. 2 and Pump Station No. 1. A blowdown of 19 m^3/hr (85 gpm) would be used for quenching coke at Coke Plant No. 2.

Two additional cooling towers, to cool non-contact cooling waters from Coke Plant No. 2, would also be required. The first would cool 2,841 m^3/hr (12,500 gpm) with a 22.7C^o (41F^o) temperature increase and the second to cool 2,727 m^3/hr (12,000 gpm) with a 7.8C^o (14F^o) temperature increase. In addition, 93 m^3/hr (410 gpm) from the sinter plant would be cooled in these towers. Blowdown from the two towers, 48.9 m^3/hr (215 gpm) and 15.9 m^3/hr (70 gpm), respectively, would be used for coke quenching.

The discontinuation of coke quenching using wastewater from the final cooler and benzol plant, due to air pollution control requirements, will result in 95.5 m^3/hr (420 gpm) of additional wastes requiring treatment. The blowdown of 56.8 m^3/hr (250 gpm) from the pushing scrubber car system would also be added. Therefore, the total coke plant waste requiring treatment, on site, would be 198 m^3/hr (870 gpm). Treatment would be by biological means as at Plant No. 3, Coke Plant. Due to the strength of the wastes from coke plant sources, other than the pushing operation, dilution is required. The dilution water would be blowdown from the Plant No. 3 blast furnace gas cleaning system which presently flows to the terminal treatment plant. Additional recirculation of gas cleaning water should be practiced so that the blowdown is reduced to 145 m^3/hr (630 gpm). This blowdown would then be treated with the coke plant wastes.

The total flow through the Plant No. 2 biological system would be 341 m^3/hr (1,500 gpm). The system would use the extended aeration process with a residence time of approximately 18 hours. Two parallel basins should be provided and, after removal of the biologically degradable compounds, the waste would be filtered and combined with the 28 m^3/hr (125 gpm) boiler blowdown from Power Station No. 2, cooling tower blowdowns of 98 m^3/m (430 gpm) from Power Station No. 2 and 76 m^3/hr (335 gpm) from Plant No. 2 blast furnaces. This waste would have the dissolved solids removed by a reverse osmosis system. The product stream, treated to a dissolved solids concentration of 600 mg/l would be distributed as follows: 11.4 m^3/hr (50 gpm) to coke quenching, 93.2 m^3/hr (410 gpm) to the sinter plant, 212 m^3/hr (935 gpm) as makeup to the Plant No. 2 blast furnace gas cleaning system and 90 m^3/hr (395 gpm) to Pump Station No. 2. The reject stream of 136 m^3/hr (600 gpm) would be evaporated to dryness. It is estimated that approximately 25.8 kkg (28.4 tons) of dry solids per day would require disposal with a volume of 26.8 m^3 (35.1 cubic yards) per day.

Outfalls 013 and 014

If the flow modifications recommended for Outfall 012 are implemented, the flow to Outfalls 013 and 014 via the Terminal Treatment Plant would be reduced by the following amounts:

Source	Flow Reduction	
	m^3/hr	gpm
Plant No. 2 blast furnace cleaning system	432	1,900
Coke Plant No. 2 non-contact cooling water	2,727	12,000
Power Station No. 1 non-cooling water	227	1,000
No. 2 Blooming and No. 2A Billet Mill non-contact cooling water	1,682	7,400
10-inch Bar Mill con-contact cooling water	364	1,600
14-inch Mill con-contact cooling water	795	3,500
Cold Strip Mills 1 & 2 non-contact cooling water	864	3,800
Total	7,090	31,200

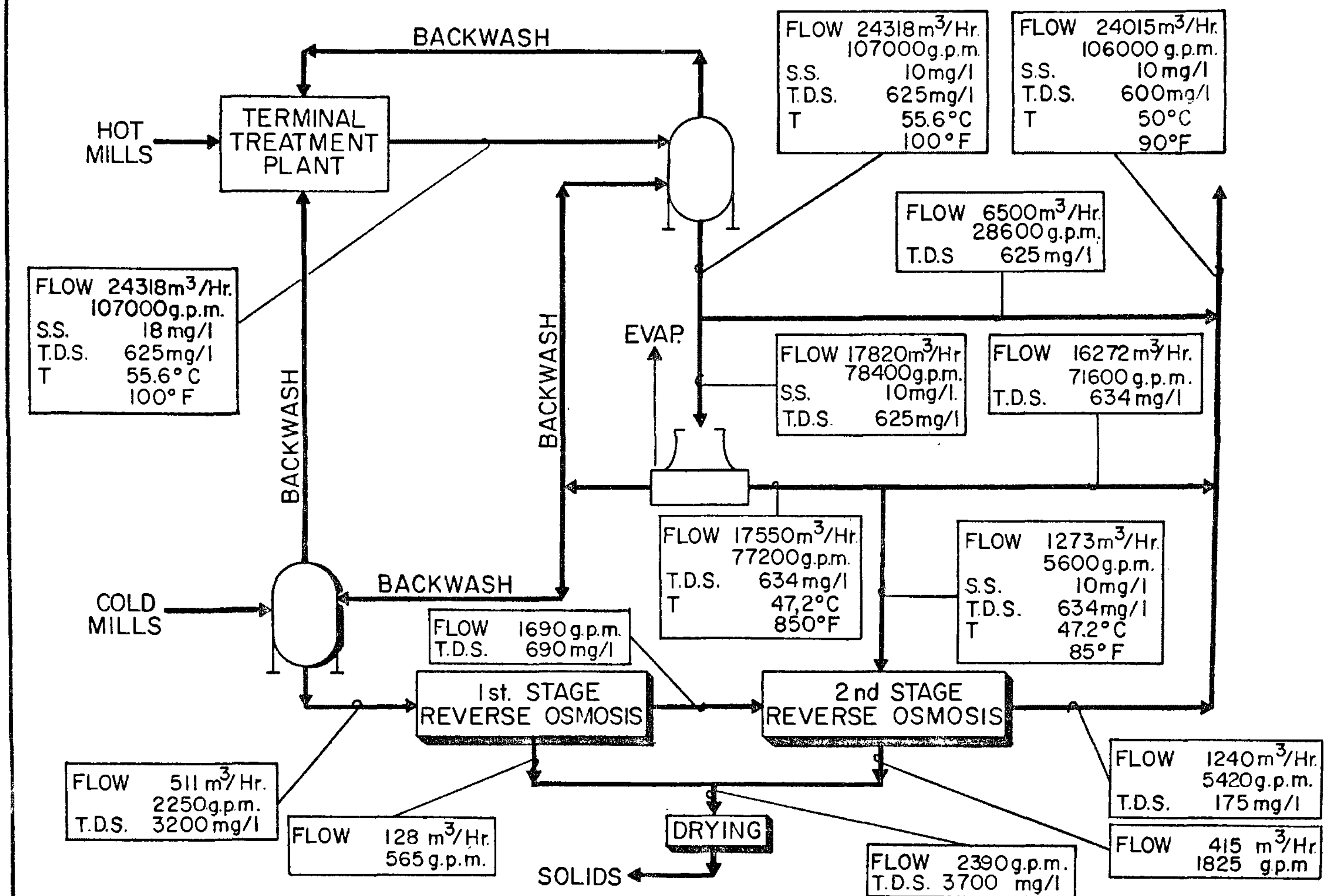
The total quantity of wastewater remaining, that would require treatment would then be approximately 24,772 m^3/hr (109,000 gpm). Assuming a total water recycle system with a dissolved solids level of 600 mg/l in the water recirculated back to the mills, the system described below and shown on Figure B-8 should be installed. In developing the system, the following assumptions were made: maximum temperature usable at the mills contributing wastes to these outfalls is 50°C (90°F), the temperature of the wastes from the hot mills is 55.5°C (100°F), the dissolved solids increase in the water discharged from the hot mills is 25 mg/l and the dissolved solids increase in the water from the cold strip mills is 2,600 mg/l.

As indicated in Section 2.3, treatment of the discharge from the Terminal Treatment Plant is required. In this proposed system, the wastes that would continue to be treated in the Terminal Treatment Plant are all from hot mill contact cooling usage. Cold mills wastes would be segregated for separate first stage treatment. The total wastewater flow of 24,772 m^3/hr (109,000 gpm) would be reduced by the cold mill flow of 500 m^3/hr (2,200 gpm) for a total of 24,270 m^3/hr (106,800 gpm). After cooling, a portion of the wastes would be demineralized in a reverse osmosis facility to a level of 175 mg/l dissolved solids and combined with the balance so that the resultant dissolved solids level would be 600 mg/l.

Wastes from the cold mills would be collected separately, treated for oil removal, filtered and passed through a first stage reverse osmosis unit to remove 75 percent of the dissolved solids. The product stream would then be combined with the flow from the hot mills system and passed through the hot mills reverse osmosis unit. Using a reject stream of 25 percent from each unit, a total of 543 m^3/hr (2,390 gpm) would have to be evaporated to dryness. The dried solids produced would be approximately 49.4 kkg (54.4 tons) per day with a volume of approximately 51.4 m^3 (67.2 cubic yeards). Evaporation would be in a spray dryer.

Outfall 017

Utilizing the same facilities described in Section 2.3 for treatment of wastes for discharge, modification and additions would be required to meet the total recycle requirements. Assuming that the dissolved solids level in the non-contact cooling water would be maintained at 600 mg/l, a cooling tower would be required to cool this water from both the 80-inch Hot Strip Mill and Cold Strip Mill No. 3. The cooling tower would blow down 26.1 m^3/hr (115 gpm) to the process water cooling tower which follows filtration.



OUTFALLS 013 AND 014 TREATMENT FOR TOTAL RECYCLE

FIGURE B-8

A dissolved solids increase in the mills and the industrial waste treatment plant of 100 mg/l should be experienced and, in turn, the dissolved solids level in the circulating water used in the mills would be 600 mg/l. A demineralizing facility with brine evaporation would then be required and the demineralizing facility would have to treat approximately 3,300 m^3/hr (14,500 gpm) and reject approximately 824 m^3/hr (3,625 gpm) for evaporation. The final waste to be disposed of would be 42.6 kkg (47 tons) per day and the solids accumulation would be 44.3 m^3 (58 cubic yards) per day. The system is illustrated on Figure B-9.

Outfall 015

The 114 m^3/hr (500 gpm) of treated sanitary wastes would continue to be discharged through Outfall 015, but the non-contact cooling water flow of 5,680 m^3/hr (25,000 gpm) would require cooling and recirculation. To maintain a dissolved solids level of 600 mg/l, a blowdown of 56.3 m^3/hr (230 gpm) would be pumped to the final treatment system described below under Outfall 018.

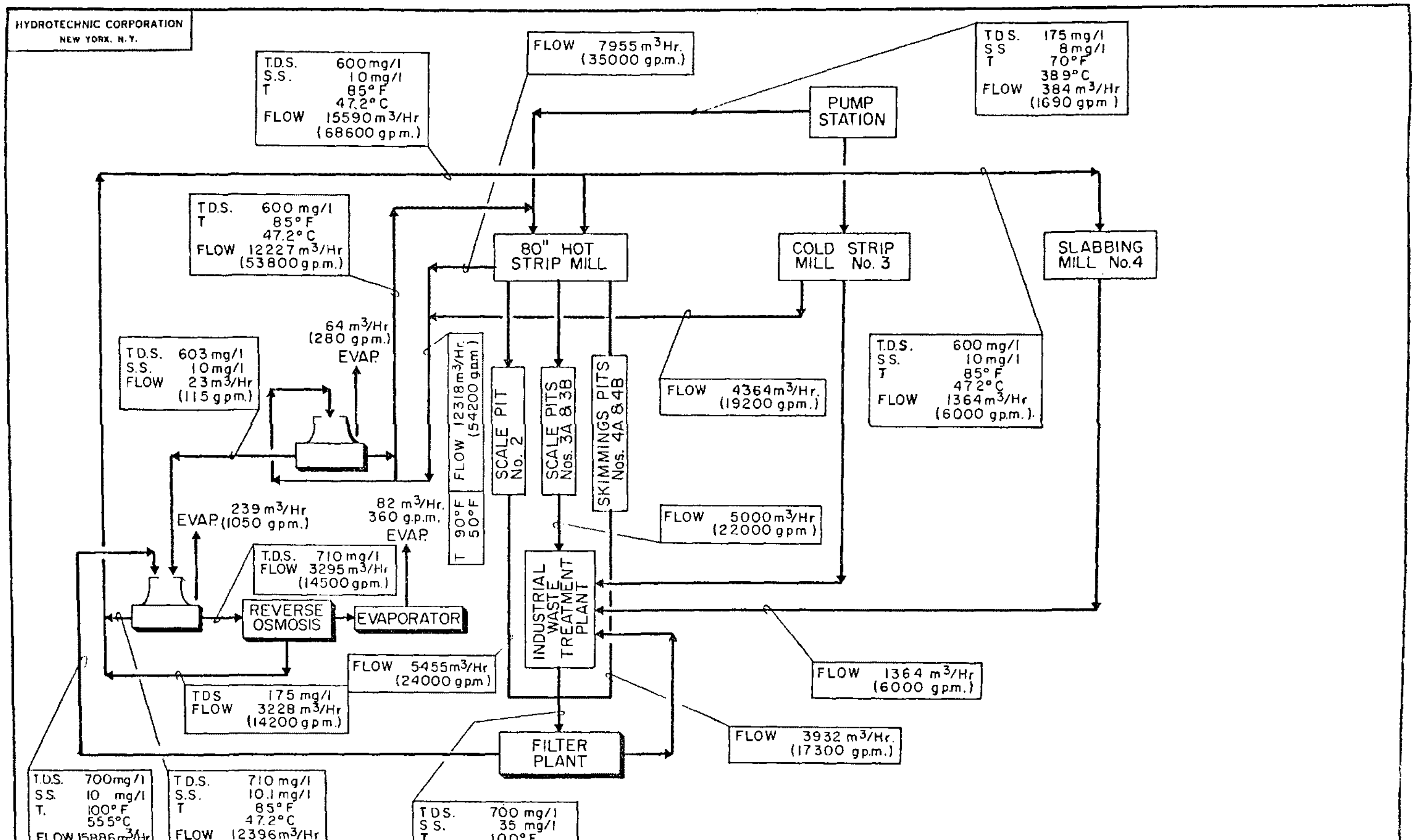
Outfall 018

Of the flows that discharge to Outfall 018, 18,180 m^3/hr (80,000 gpm) is non-contact cooling water. This water should be cooled and returned to the power station No. 4. A 61 m^3/hr (270 gpm) blowdown from this recirculation system would be combined with the boiler blowdown flow of 45 m^3/hr (200 gpm) and treated with the 227 m^3/hr (1,000 gpm) blowdown from BOF No. 4 and Slab Caster No. 1 system in a reverse osmosis unit prior to return to the BOF and Slab Caster. Approximately 97 m^3/hr (425 gpm) of reject would be evaporated to dryness. An additional waste flow from Power Station No. 4 seeps into the ground at the fly ash lagoon. This flow should be eliminated by using a dry fly ash collection system and hauling the ash rather than sluicing.

Northward Expansion

The northward expansion biological treatment plant effluent is being sent to the East Chicago Sanitary District with other plant sanitary wastes. Under the total recycle criterion, this would no longer be permitted and the wastes would require further on-site treatment prior to reuse.

The treatment would consist of filtration, demineralization, return of product water to the plant and evaporation of the reject stream.



OUTFALL 017 TREATMENT
FOR TOTAL RECYCLE

FIGURE B-9

Additional wastes from the coke plant and the blast furnace gas washer system at the northward expansion are currently used to quench slag. It is assumed that this practice would be discontinued due to air pollution considerations and these flows would have to be treated in the biological treatment plant. The gas cleaning system blowdown would serve as dilution water in the biological treatment plant and the total flow to the biological plant would be approximately 286 m^3/hr (1,260 gpm) with a resulting retention time of approximately 12 hours. For adequate treatment the biological treatment plant should be increased in size by 50 percent and two additional clarifiers installed. Further treatment would consist of collection of the wastes from the four clarifiers and pumping this wastewater to two 3 m (10 ft.) diameter filters. The filtrate would be collected and a portion would be used to backwash the filters and the balance pumped to a two-stage reverse osmosis facility for demineralization. The filter backwash would be collected in a backwash collection basin and allowed to settle. The supernatant would be returned to the clarifiers and the sludge would be pumped to the air flotation thickeners.

The brine reject stream from each stage of the reverse osmosis facility would total approximately 71 m^3/hr (315 gpm) which would be evaporated to dryness and approximately 32.6 kkg (36 tons) per day of dried solids would be produced with a volume of approximately 33.9 m^3 (44.4 cubic yards).

Precipitation Runoff

All runoff collected, as described in Section 2.3, would be pumped to the closest pumping station intake for use at the plant.

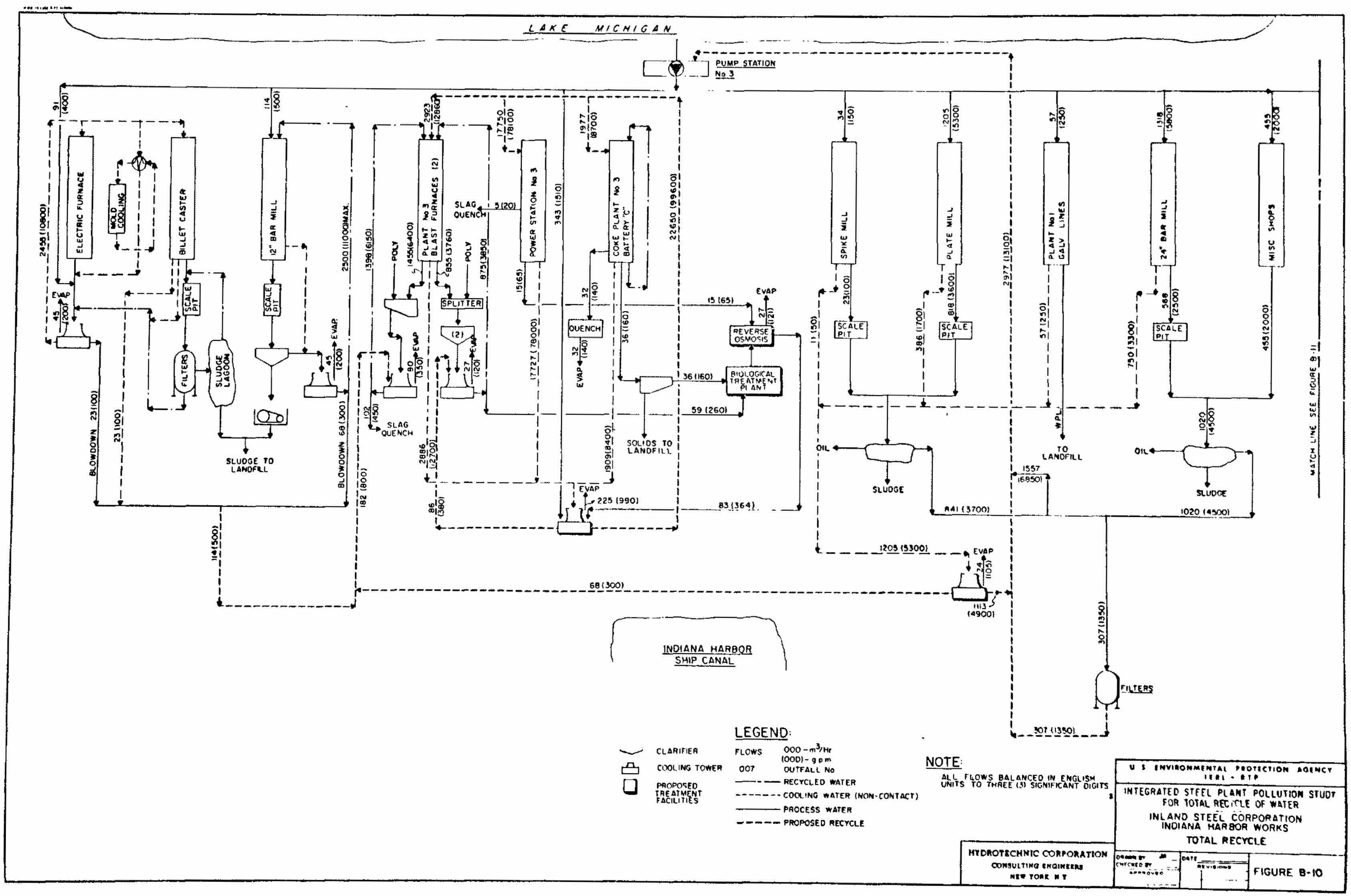
Solids Disposal

The treatment of wastes, as described above, at the Northwest Expansion and at Outfalls 001, 002, 012, 013, 014, and 017, will result in the production of considerable quantities of soluble dried solids. The total quantities would be 138 kkg (152 tons) per day with a volume of 143.5 m^3 (187.8 cubic years).

Assuming a twenty year storage of these solids in an area which would be lined to prevent leaching into the ground during periods of precipitation, and assuming a useable depth of 3 meters (10 ft.), a minimum area of 34.3 ha (85 acres) would be required.

Summary

A flow diagram illustrating water distribution and uses under zero discharge conditions is shown as Figure B-10, B-11 and B-12 and the location of in-plant facilities are shown on Figures B-13 and B14.


LAKE MICHIGAN
PUMP STATION No 3
ELECTRIC FURNACE
MOLD COOLING
BILLET CASTER
12" BAR MILL
PLANT No 3 BLAST FURNACES (2)
POWER STATION No 3
COKE PLANT No 3 BATTERY "C"
SPIKE MILL
PLATE MILL
PLANT No 1 GALV LINES
24" BAR MILL
MISC SHOPS
SCALE PIT
FILTERS
SLUDGE LAGOON
SLUDGE TO LANDFILL
SLAG QUENCH
SPLITTER
QUENCH
REVERSE OSMOSIS
BIOLOGICAL TREATMENT PLANT
SOLIDS TO LANDFILL
EVAP
BLOWDOWN
OIL
SLUDGE
TO LANDFILL
INDIANA HARBOR SHIP CANAL
MATCH LINE SEE FIGURE B-11
LEGEND:
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
FLOWS 000 - m³/Hr (000) - gpm
007 OUTFALL No
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO THREE (3) SIGNIFICANT DIGITS
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION INDIANA HARBOR WORKS
TOTAL RECYCLE
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE B-10

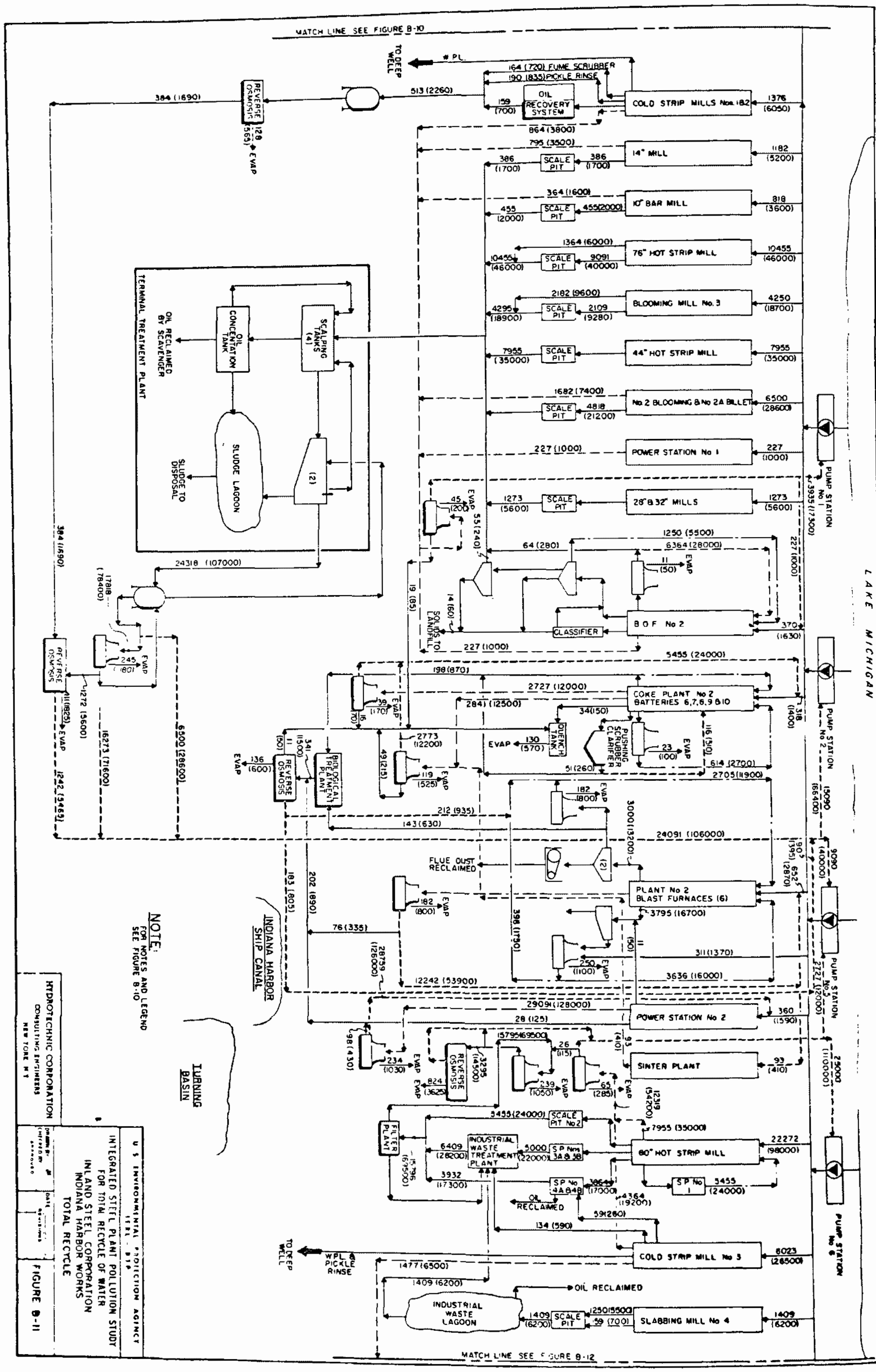
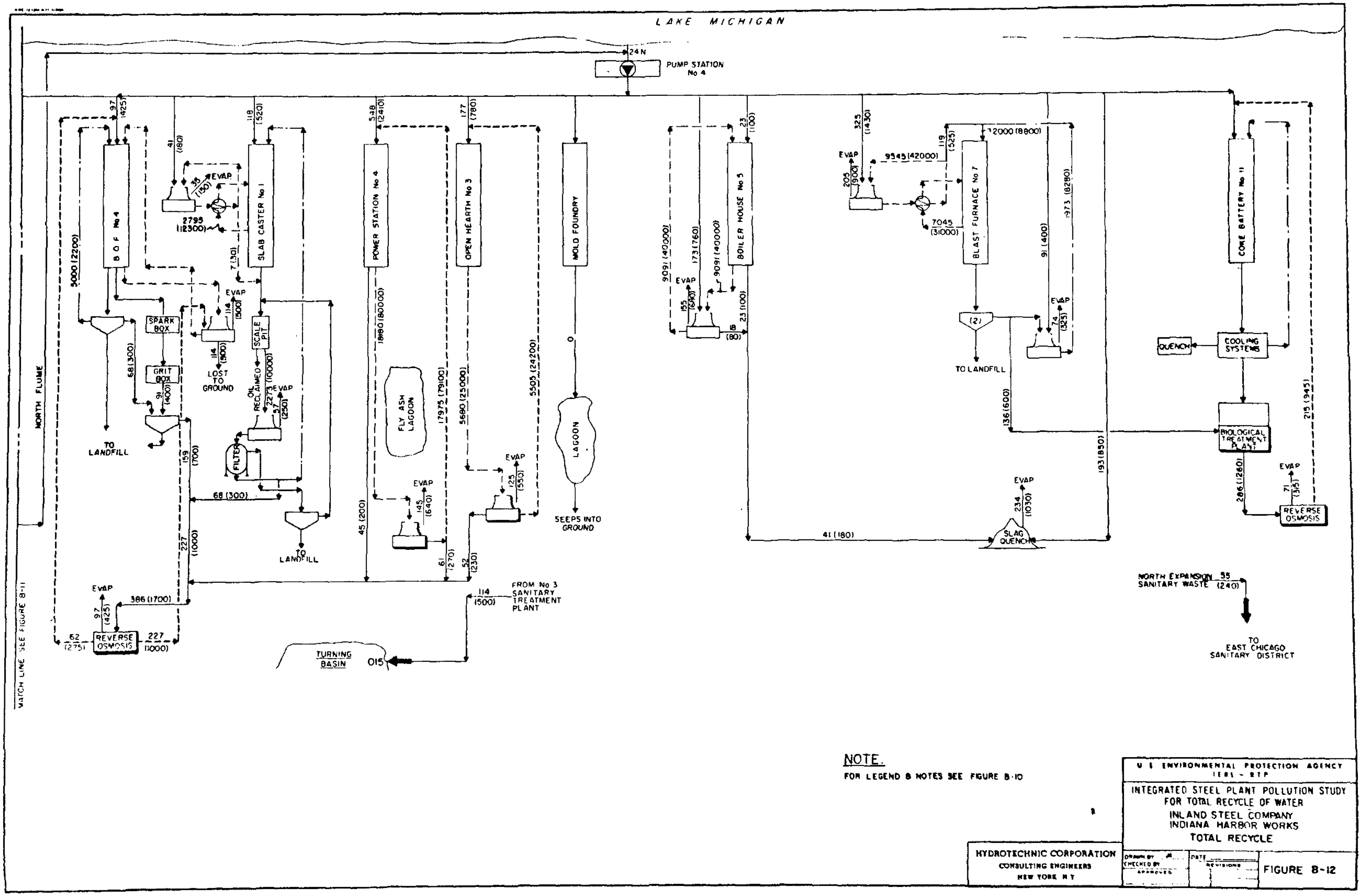
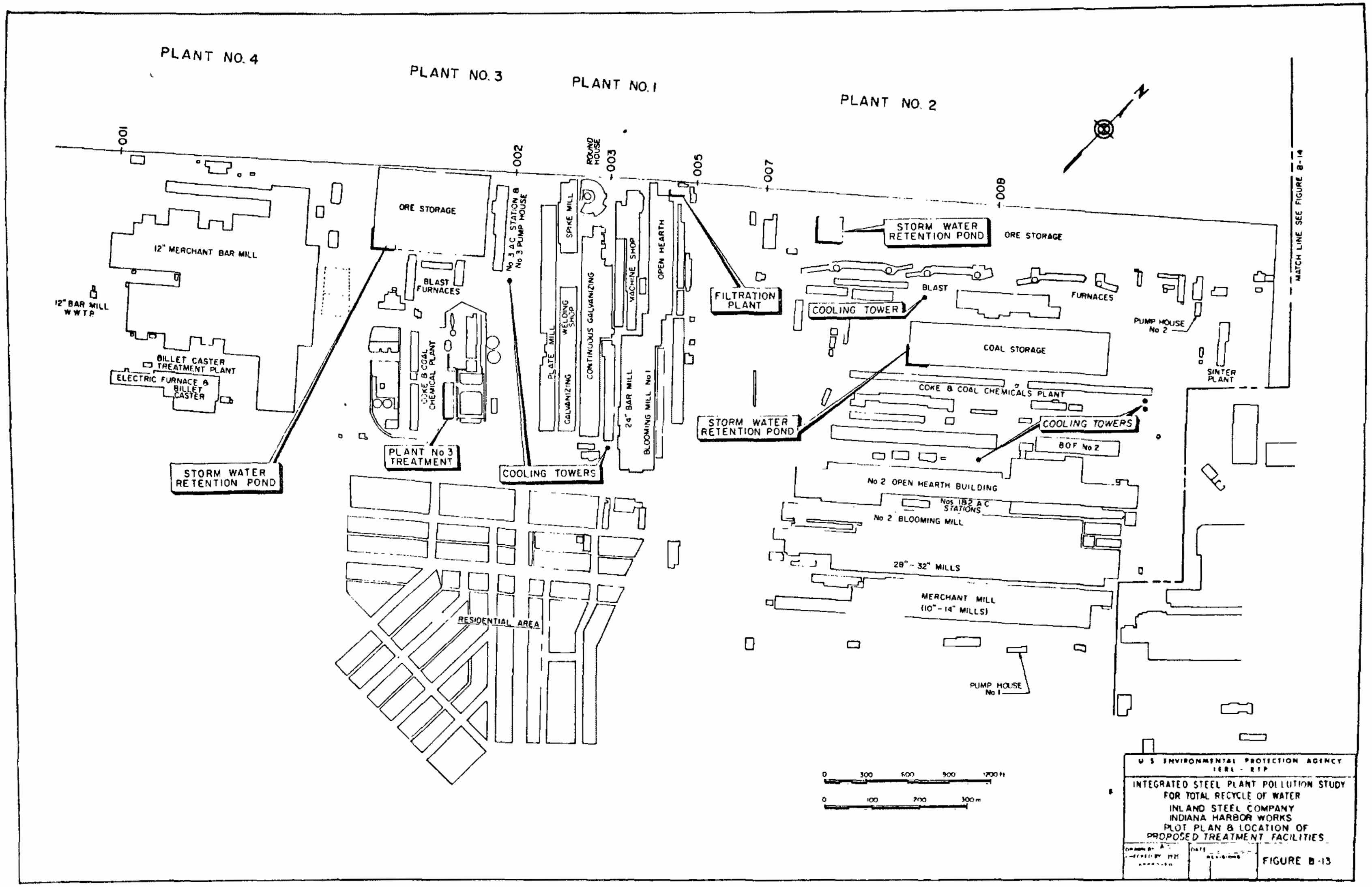
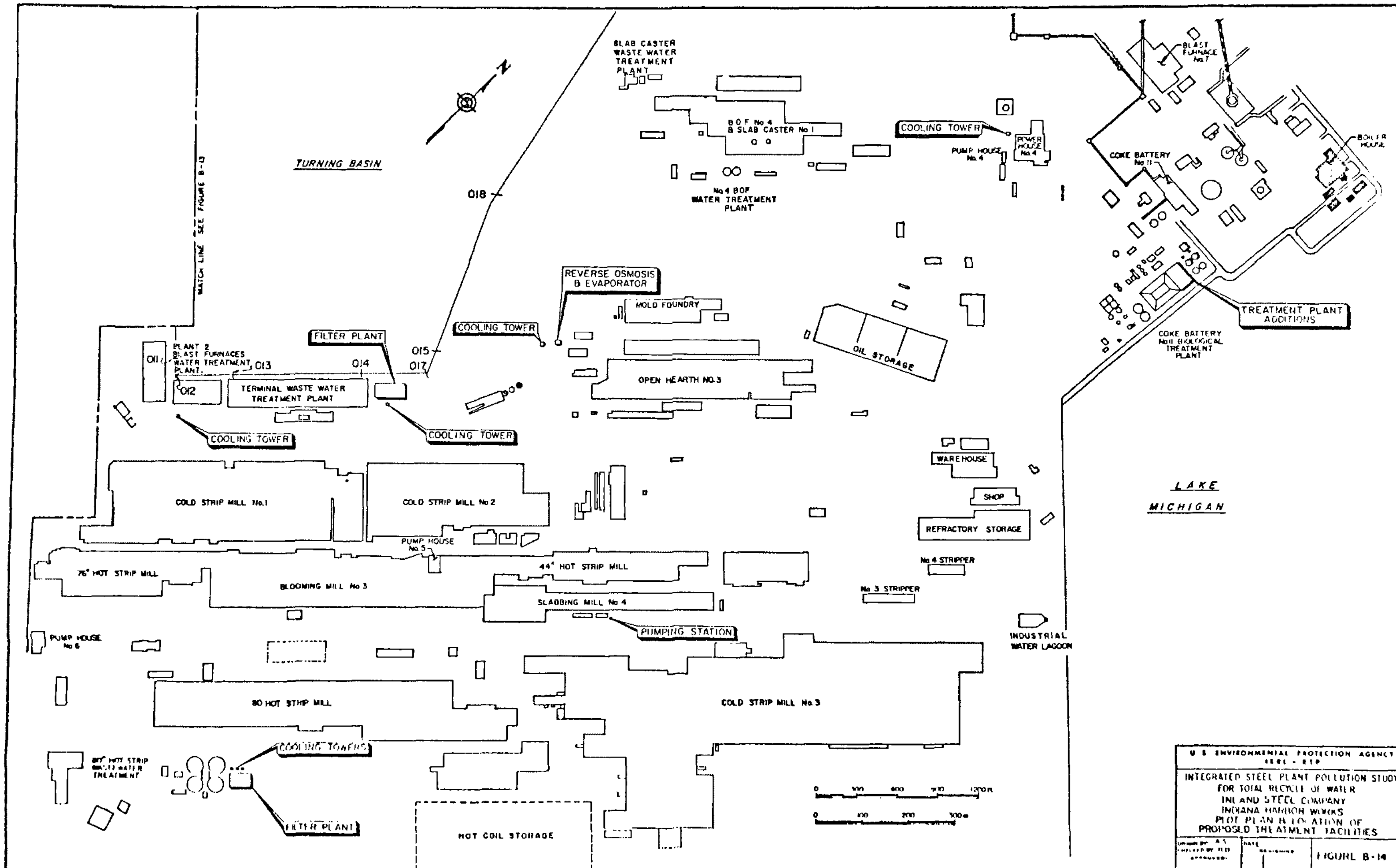

MATCH LINE SEE FIGURE B-10
TO DEEP WELL
COLD STRIP MILLS Nos. 1&2
OIL RECOVERY SYSTEM
164 (720) FUME SCRUBBER
190 (835) PICKLE RINSE
REVERSE OSMOSIS
14" MILL
10" BAR MILL
76" HOT STRIP MILL
BLOOMING MILL No. 3
44" HOT STRIP MILL
No 2 BLOOMING & No 2A BILLET
POWER STATION No 1
28" & 32" MILLS
SCALE PIT
TERMINAL TREATMENT PLANT
SCALPING TANKS (4)
OIL CONCENTRATION TANK
OIL RECLAIMED BY SCAVENGER
SLUDGE LAGOON
SLUDGE TO DISPOSAL
B O F No 2
CLASSIFIER
SOLIDS TO LANDFILL
COKE PLANT No 2 BATTERIES 6,7,8,9 & 10
QUENCH TANK
PUSHING SCRUBBER CLARIFIER
BIOLOGICAL TREATMENT PLANT
FLUE DUST RECLAIMED
PLANT No 2 BLAST FURNACES (6)
POWER STATION No 2
SINTER PLANT
FILTER PLANT
INDUSTRIAL WASTE TREATMENT PLANT
SCALE PIT No 2
SP Nos 3A & 3B
SP No 4A & 4B
SP No 1
60" HOT STRIP MILL
OIL RECLAIMED
COLD STRIP MILL No 3
WPL & PICKLE RINSE
INDUSTRIAL WASTE LAGOON
SLABBING MILL No 4
MATCH LINE SEE FIGURE B-12
PUMP STATION No 1
PUMP STATION No 2
PUMP STATION No 5
PUMP STATION No 6
LAKE MICHIGAN
INDIANA HARBOR SHIP CANAL
TURNING BASIN
EVAP
NOTE: FOR NOTES AND LEGEND SEE FIGURE B-10
HYDROTECHNIC CORPORATION CONSULTING ENGINEERS NEW YORK N Y
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL CORPORATION INDIANA HARBOR WORKS
TOTAL RECYCLE

FIGURE B-11



LAKE MICHIGAN
PUMP STATION No 4
NORTH FLUME
BOF No 4
SLAB CASTER No 1
POWER STATION No 4
OPEN HEARTH No 3
MOLD FOUNDRY
BOILER HOUSE No 5
BLAST FURNACE No 7
COKE BATTERY No 11
SPARK BOX
GRIT BOX
SCALE PIT
FILTER
OIL RECLAIMED
LOST TO GROUND
TO LANDFILL
FLY ASH LAGOON
LAGOON
SEEPS INTO GROUND
SLAG QUENCH
QUENCH
COOLING SYSTEMS
BIOLOGICAL TREATMENT PLANT
REVERSE OSMOSIS
EVAP
FROM No 3 SANITARY TREATMENT PLANT
TURNING BASIN
015
NORTH EXPANSION SANITARY WASTE 55 (240)
TO EAST CHICAGO SANITARY DISTRICT
MATCH LINE SEE FIGURE B-11
NOTE.
FOR LEGEND & NOTES SEE FIGURE B-10
U.S. ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY
FOR TOTAL RECYCLE OF WATER
INLAND STEEL COMPANY
INDIANA HARBOR WORKS
TOTAL RECYCLE
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
FIGURE B-12


PLANT NO. 4
PLANT NO. 3
PLANT NO. 1
PLANT NO. 2
001
002
003
005
007
008
ROUND HOUSE
ORE STORAGE
12" MERCHANT BAR MILL
12" BAR MILL WWTP
BILLET CASTER TREATMENT PLANT
ELECTRIC FURNACE & BILLET CASTER
BLAST FURNACES
COKE & COAL CHEMICAL PLANT
PLANT No 3 TREATMENT
STORM WATER RETENTION POND
No 3 A.C. STATION & No 3 PUMP HOUSE
COOLING TOWERS
SPIKE MILL
PLATE MILL
WELDING SHOP
GALVANIZING
CONTINUOUS GALVANIZING
MACHINE SHOP
OPEN HEARTH
24" BAR MILL
BLOOMING MILL No 1
FILTRATION PLANT
COOLING TOWER
STORM WATER RETENTION POND
ORE STORAGE
BLAST
FURNACES
PUMP HOUSE No 2
COAL STORAGE
SINTER PLANT
COKE & COAL CHEMICALS PLANT
COOLING TOWERS
BOF No 2
No 2 OPEN HEARTH BUILDING
Nos 1&2 A.C. STATIONS
No 2 BLOOMING MILL
28" - 32" MILLS
MERCHANT MILL (10" - 14" MILLS)
RESIDENTIAL AREA
PUMP HOUSE No 1
MATCH LINE SEE FIGURE B-14
N
0 300 600 900 1200 ft
0 100 200 300 m
U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL COMPANY
INDIANA HARBOR WORKS
PLOT PLAN & LOCATION OF PROPOSED TREATMENT FACILITIES
FIGURE B-13


TURNING BASIN
MATCH LINE SEE FIGURE B-13
N
018
015
017
SLAB CASTER WASTE WATER TREATMENT PLANT
B O F No 4 & SLAB CASTER No 1
No 4 BOF WATER TREATMENT PLANT
COOLING TOWER
PUMP HOUSE No 4
POWER HOUSE No 4
BLAST FURNACE No 7
COKE BATTERY No 11
BOILER HOUSE
REVERSE OSMOSIS & EVAPORATOR
MOLD FOUNDRY
OIL STORAGE
TREATMENT PLANT ADDITIONS
COKE BATTERY No 11 BIOLOGICAL TREATMENT PLANT
FILTER PLANT
COOLING TOWER
PLANT 2 BLAST FURNACES WATER TREATMENT PLANT
011
012
013
014
TERMINAL WASTE WATER TREATMENT PLANT
OPEN HEARTH No 3
COOLING TOWER
COOLING TOWER
WAREHOUSE
SHOP
REFRACTORY STORAGE
LAKE MICHIGAN
COLD STRIP MILL No 1
COLD STRIP MILL No 2
PUMP HOUSE No 5
76" HOT STRIP MILL
BLOOMING MILL No 3
44" HOT STRIP MILL
SLABBING MILL No 4
No 4 STRIPPER
No 3 STRIPPER
PUMPING STATION
INDUSTRIAL WATER LAGOON
PUMP HOUSE No 6
80 HOT STRIP MILL
COLD STRIP MILL No 3
80" HOT STRIP MILL
COOLING TOWERS
FILTER PLANT
HOT COIL STORAGE
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
INLAND STEEL COMPANY
INDIANA HARBOR WORKS
PLOT PLAN & LOCATION OF PROPOSED TREATMENT FACILITIES
FIGURE B-14

APPENDIX C

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

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1.2.3	Existing Waste Treatment Facilities	C-7
1.2.4	Water Related Aspects of Air Quality Control Systems	C-10
2.0	Proposed Program	C-11
2.1	General	C-11
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2.3	Requirements for the Plant to Meet BAT	C-12
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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This appendix addresses itself specifically to National Steel Corporation's Weirton Steel Division in Weirton, West Virginia. It includes the preliminary engineering designs based on conclusions reached from data supplied by the Weirton Steel Division. It does not include the identification of all environmental control technologies considered, the evaluation of other steel plants studied or cost estimates, practicality or possible environmental impacts. Therefore, it should be looked on only as a vehicle to present a possible scheme to attain total recycle but not necessarily one that is practical, feasible or one that will not generate, with its implementation, an environmental impact in other sectors which is intolerable.

1.2 DESCRIPTION OF THE PLANT

1.2.1 Manufacturing Processes and Facilities

The Weirton Steel Division of the National Steel Corporation is a completely integrated steel plant located approximately 60 km (37 miles) west of Pittsburgh, Pennsylvania, on the east bank of the Ohio River in the town of Weirton, West Virginia. It is at the confluence of the Ohio River and Harmon Creek and occupies a 142 hectare (350 acres) site oriented north-south. The integrated facilities located on the site to produce finished and semi-finished products consist of:

	Capacity where applicable in kkg/day/TPD
- Ore Coal and Flux Storage Areas	N.A.
- Coal Washing Facilities	N.A.
- Two By-Products Coke Plants	7516/8278
- One Sinter Plant	6690/7375
- Four Blast Furnaces	8948/9864
- One BOP Shop	11343/12500
- Two Vacuum Degassers	5983/6595

	Capacity where applicable in kkg/day/TPD
- One Continuous Casting Shop	3969/4375
- A Blooming Mill	8682/9570
- A Hot Scarfer	N.A.
- A 54-inch Hot Strip Mill	8340/9193
- Three Pickling Lines (Hydrochloric acid)	8499/9369
- Five Tandem Mills (Cold Reduction)	9918/10933
- Two Weirlite Mills (Cold Reduction)	2056/2267
- Eight Temper Mills	N.A.
- One Sheet Mill Cleaning Line) - Two Tin Mill Cleaning Lines) - One Tin Mill Chemical Treatment Line) - Three Tin Mill Continuous Annealing Lines)	6380/7018
- A Strip Steel and Sheet Mill Batch Annealer	N.A.
- A Tin Mill Batch Annealer	N.A.
- Four Hot Dip Galvanizing Lines	1714/1889
- One Electrolytic Galvanizing Line	N.A.
- Three Electrolytic Tin Plating Lines	N.A.
- One Electrolytic Plating Line (Chrome or Tin)	N.A.
- A Boiler House	N.A.
- A Power House	N.A.
- A Hydrochloric Acid Recovery Plant	N.A.
- A Palm Oil Recovery Plant	N.A.
- An Acetylene Plant	N.A.

1.2.2 Water Systems and Distribution

Water used at the plant is drawn from the Ohio River. A pump station on the river provides approximately 38,700 m^3/hr (170,300 gpm) of service water to the plant. Potable water for sanitary purposes is supplied by the City of Weirton or from the Weirton Steel Division potable water treatment plant. All sanitary wastewaters discharge to the City of Weirton Sewage Treatment Plant located south (downstream) of the steel plant.

The uses of water at the plant are shown on Figures C-1 and C-2. Generally, the only water that is recycled or reused is non-contact cooling water. However, the plant will place in operation in the near future an extensive recycle system at the blast furnaces gas washer system. For the purposes of this report it has been assumed that the blast furnace system is installed and operating. This recycle system will reduce the gas washer discharges from 3260 m^3/hr (14,340 gpm) to 175 m^3/hr (770 gpm).

The water uses at the plant are discussed below and grouped in relation to the outfalls through which they discharge.

"A" Outfall

The by-products coke plant discharges approximately 3070 m^3/hr (13,500 gpm) to the outfall. Other flows from the coke plant are approximately 40 m^3/hr (175 gpm) which discharge to the Brown's Island biological treatment plant and approximately 115 m^3/hr (500 gpm) of clean blowdown is used for coke quenching. The latter flow is lost through evaporation.

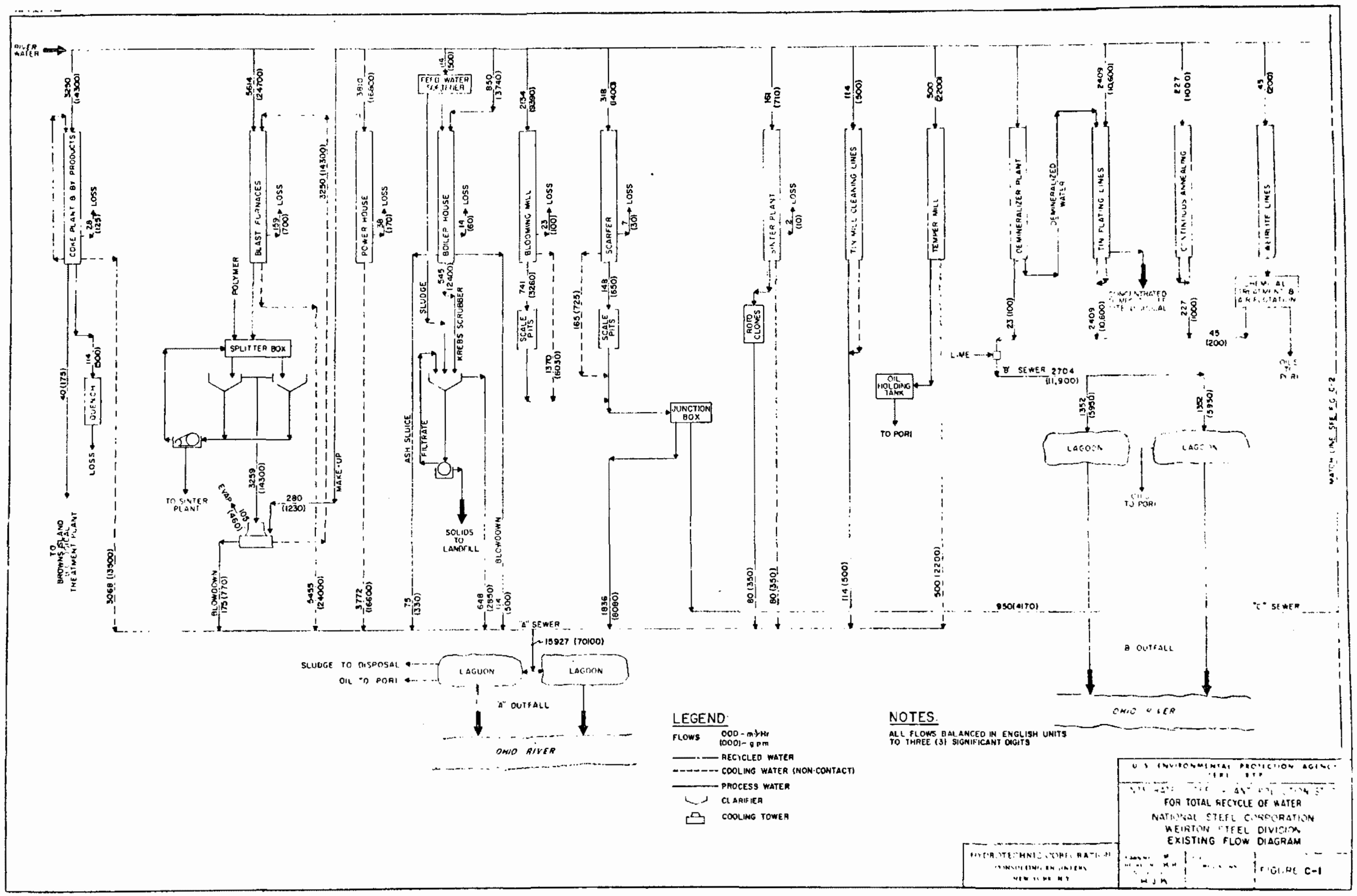
There are two flows to "A" outfall from the Blast Furnaces, a non-contact cooling water flow of approximately 5440 m^3/hr (24,000 gpm) and the new gas washer system blowdown of 175 m^3/hr (770 gpm). Solids removed from the treated water are sent to the sinter plant. The power house discharges approximately 3775 m^3/hr (16,600 gpm) of condenser cooling water to "A" outfall.

The boiler house produces steam for use at the power house. It receives water from the plant water supply system either as it is drawn from the river after softening in a feed water softener. Approximately 545 m^3/hr (2400 gpm) are utilized in the "Krebs" scrubber and discharge after treatment together with the water removed from the water softening wastes totaling 648 m^3/hr (2850 gpm).

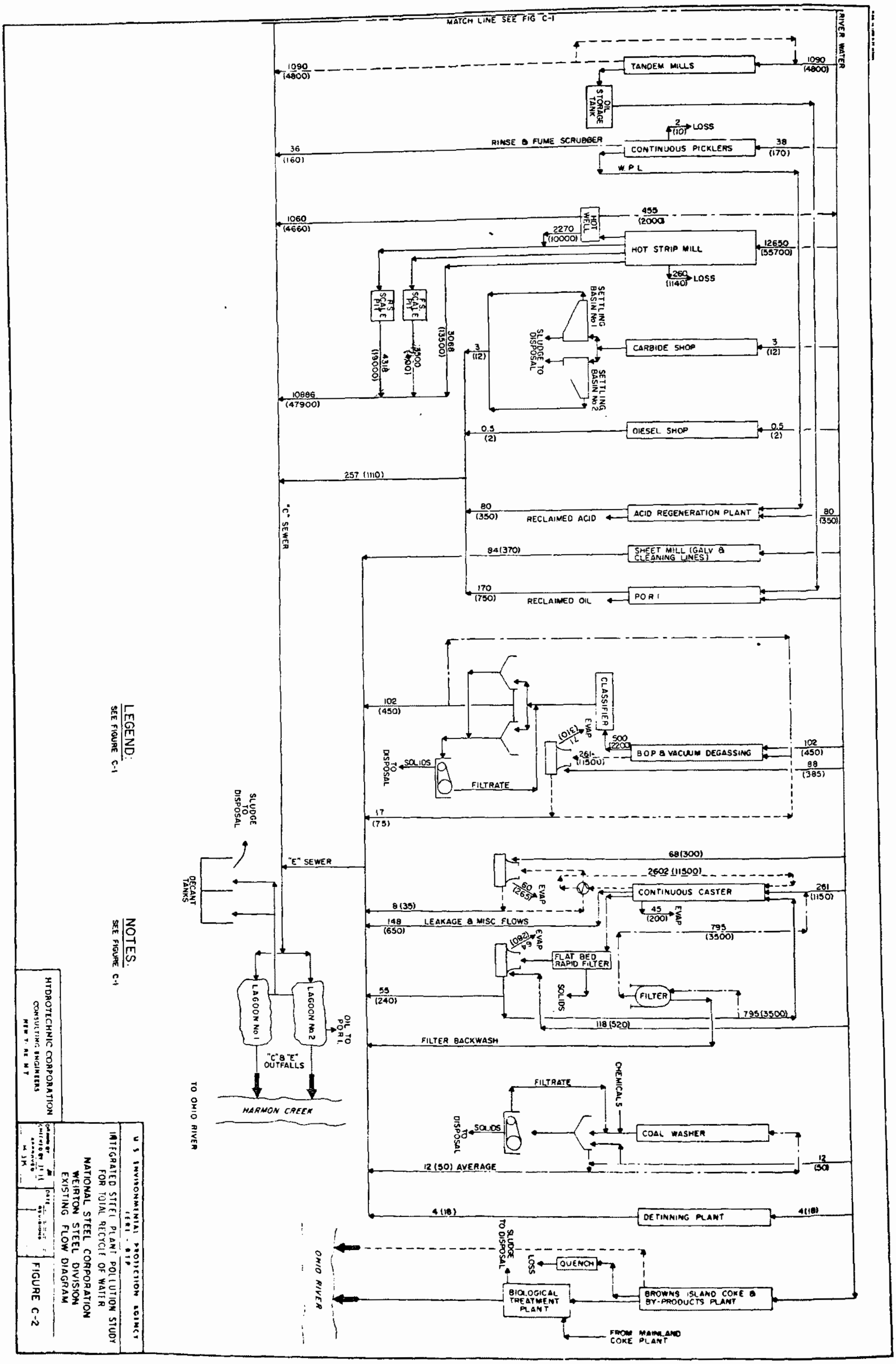
Approximately 115 m^3/hr (500 gpm) of boiler blowdown is discharged from the Boiler House to "A" sewer. An additional 75 m^3/hr (330 gpm) is used for sluicing ash and the settled water is also discharged to "A" sewer.

Water use at the Tin Mill Cleaning Line is estimated to be approximately 114 m^3/hr (500 gpm). It is used for cleaning solution makeup, spraying and rinsing operations. The Temper Mill discharges 500 m^3/hr (2200 gpm).

The Blooming Mill and Scarfer discharge both process and non-contact cooling waters to both "A" outfall and "C and E" outfall through a junction box. Approximately 1836 m^3/hr (8080 gpm) is to "A" outfall and 950 m^3/hr (4170 gpm) is to "C and E" outfall. Of these flows approximately 1535 m^3/hr (6755 gpm) is non-contact cooling water



RIVER WATER
COKE PLANT & BY PRODUCTS
QUENCH
LOSS
TO BROWNS ISLAND CHEMICAL TREATMENT PLANT
BLAST FURNACES
POLYMER
SPLITTER BOX
TO SINTER PLANT
BLOWDOWN
MAKE-UP
POWER HOUSE
FEED WATER SOFTENER
BOILER HOUSE
SLUDGE
ASH SLUICE
FILTRATE
KREBS SCRUBBER
SOLIDS TO LANDFILL
BLOOMING MILL
SCALE PITS
SCARFER
JUNCTION BOX
SINTER PLANT
ROTO CLONES
TIN MILL CLEANING LINES
TEMPER MILL
OIL HOLDING TANK
TO PORI
DEMINERALIZER PLANT
DEMINERALIZED WATER
TIN PLATING LINES
CONCENTRATED
CONTINUOUS ANNEALING
LIME
"B" SEWER 2704 (11,900)
LAGOON
OIL TO PORI
"A" SEWER
15927 (70100)
SLUDGE TO DISPOSAL
OIL TO PORI
"A" OUTFALL
OHIO RIVER
"C" SEWER
B OUTFALL
OHIO RIVER
LEGEND:
FLOWS 000 - m³/Hr (000) - gpm
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
CLARIFIER
COOLING TOWER
NOTES:
ALL FLOWS BALANCED IN ENGLISH UNITS TO THREE (3) SIGNIFICANT DIGITS
U.S. ENVIRONMENTAL PROTECTION AGENCY
FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
EXISTING FLOW DIAGRAM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK, N.Y.
FIGURE C-1


MATCH LINE SEE FIG C-1
RIVER WATER
TANDEM MILLS
1090 (4800)
OIL STORAGE TANK
2 (10) LOSS
RINSE & FUME SCRUBBER
CONTINUOUS PICKLERS
36 (160)
38 (170)
W P L
HOT WELL
455 (2000)
1060 (4660)
2270 (10000)
HOT STRIP MILL
12650 (55700)
260 (1140) LOSS
R.S. SCALE PIT
F.S. SCALE PIT
4318 (19000)
3068 (13500)
10886 (47900)
SETTLING BASIN No 1
SETTLING BASIN No 2
SLUDGE TO DISPOSAL
CARBIDE SHOP
3 (12)
DIESEL SHOP
0.5 (2)
257 (1110)
"C" SEWER
ACID REGENERATION PLANT
80 (350)
RECLAIMED ACID
SHEET MILL (GALV & CLEANING LINES)
84 (370)
P O R I
170 (750)
RECLAIMED OIL
CLASSIFIER
102 (450)
500 (2200)
261 (1150)
BOP & VACUUM DEGASSING
88 (385)
SOLIDS TO DISPOSAL
FILTRATE
17 (75)
"E" SEWER
SLUDGE TO DISPOSAL
DECANT TANKS
68 (300)
2602 (11500)
60 (265) EVAP
CONTINUOUS CASTER
261 (1150)
8 (35)
45 (200) EVAP
148 (650)
LEAKAGE & MISC FLOWS
795 (3500)
FLAT BED RAPID FILTER
FILTER
SOLIDS
55 (240)
118 (520)
795 (3500)
FILTER BACKWASH
LAGOON No 1
LAGOON No 2
OIL TO P.O.R.I.
"C" & "E" OUTFALLS
HARMON CREEK
TO OHIO RIVER
FILTRATE
CHEMICALS
COAL WASHER
12 (50) AVERAGE
DETINNING PLANT
4 (18)
OHIO RIVER
QUENCH
LOSS
BIOLOGICAL TREATMENT PLANT
BROWNS ISLAND COKE & BY-PRODUCTS PLANT
FROM MAINLAND COKE PLANT
LEGEND: SEE FIGURE C-1
NOTES: SEE FIGURE C-1
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
EXISTING FLOW DIAGRAM
FIGURE C-2

and the balance of 889 m^3/hr (3910 gpm) is process water that has passed through scale pits.

The Sinter Plant utilizes approximately 80 m^3/hr (350 gpm) for air cleaning and an equal volume for non-contact cooling.

The total flow to outfall "A" is approximately 15,927 m^3/hr (70,100 gpm).

"B" Outfall

The flows to the Ohio River through "B" outfall are approximately 2700 m^3/hr (11,800 gpm). All flows pass through a lime neutralization manhole and then through two lagoons operating in parallel prior to discharge.

The demineralizer plant discharges an average of 23 m^3/hr (100 gpm) which consists of regenerant wastes that are collected and equalized prior to discharge.

The continuous annealing lines have cleaning sections associated with them. Water is used for cleaning solution makeup, strip quenching and a small amount for non-contact cooling. The process wastes discharged to "B" sewer are estimated to be approximately 227 m^3/hr (1000 gpm).

Of the two cold reduction Weirlite lines one is on recycle and the other on direct application of rolling solutions. Continuous discharges from the Weirlite lines in the amount of approximately 45 m^3/hr (200 gpm) are discharged to a chemical treatment plant and then to "B" sewer.

The electrolytic (tin) plating lines discharge approximately 2409 m^3/hr (10,600 gpm) to "B" sewer. The wastes consist of cleaning solution, occasional pickle liquor dumps, rinse tank overflows, and plating bath rinse overflows.

"C and E" Outfalls

The flows from the facilities that discharge to "C" Sewer and "E" Sewer are combined and, the combined flows discharge through two parallel lagoons to Harmon Creek, a tributary of the Ohio River.

"C" Sewer

Approximately 14,200 m^3/hr (62,600 gpm) are discharged to "C" Sewer. Approximately 891 m^3/hr (3940 gpm) are from the hot mills via the junction box described under "A" outfall above.

When all of the pickling lines have been converted to counter current rinses and when plate scrubbers are installed, the design discharge will be 30 m^3/hr (160 gpm). An average of 11.4 m^3/hr (50 gpm) waste pickle liquor is sent to the acid regeneration plant for the recovery of hydrochloric acid.

There are four separate flows to "C" sewer from the 54-inch Hot Strip Mill. Contact cooling water is discharged to a hot well from which 1060 m^3/hr (4660 gpm) flows to "C" sewer. A flume flushing flow of 2270 m^3/hr (10,000 gpm) is used which is directed to the roughing stands scale pit and 455 m^3/hr (2000 gpm) is recycled to the service water line. A total of 3500 m^3/hr (15,400 gpm) discharges from the finishing stands scale pit, 4320 m^3/hr (19,000 gpm) from the roughing stands scale pit and 3070 m^3/hr (13,500 gpm), directly from the runout table. All discharge to "C" sewer. Other flows are 1090 m^3/hr (4800 gpm) from the Tandem Mills and 252 m^3/hr (1110 gpm) from miscellaneous shops.

"E" Sewer

A flow of 102 m^3/hr (450 gpm) is discharged from the water treatment facilities and 17 m^3/hr (450 gpm) from cooling tower blowdown. A recycle flow of 3114 m^3/hr (13,700 gpm) is directed to these facilities from the cooling tower and waste treatment system. Makeup to these facilities is 190 m^3/hr (835 gpm) from the plant service water system of which 88 m^3/hr (385 gpm) is directly to the cooling tower.

The continuous caster discharges its wastewater to "E" Sewer. This facility has extensive recirculation facilities and virtually all of the discharges are blowdowns from treatment facilities. The closed system cooling tower blows down 8 m^3/hr (35 gpm) and the open system blows down 55 m^3/hr (240 gpm) to "E" Sewer. Leakage and evaporative losses from the casting process and cooling towers amount to 232 m^3/hr (1020 gpm). An additional discharge from the open system occurs as large, short duration flows from the backwashing of the deep bed filters. The total daily flow is 606 m^3 (160,000 gals).

The coal washing facilities discharge a total of 246 m^3/day (65,000 gpd) and the detinning plant discharges an average 15 m^3 (4000 gal) per 8 hour turn.

1.2.3 Existing Waste Treatment Facilities

The Weirton Steel Division treats all waste to some degree prior to discharge. Each of the outfalls with the exception of the Brown's Island biological treatment plant has lagoons just before discharge where solids are settled and oil is skimmed. Upstream of the lagoons, at some of the production and service facilities, some treatment is provided before discharge to the main sewers.

The blast furnaces, as described in Section 1.2.2 have had a gas cleaning water recirculation system installed. Gas cleaning water discharges into a splitter box where polymer is added prior to flow to two clarifiers. Clarified water is then pumped to a cooling tower and then recirculated to the gas washer system. The underflow from the clarifiers is dewatered and the solids sent to the sinter plant. A cooling tower blowdown of approximately 175 m^3/hr (770 gpm) is used to control the dissolved solids level in the system. Makeup to the system is from the service water line to the cooling tower.

Power House waste from hot lime softening of boiler feed water and from the "Krebs" scrubber are treated in a "Lamella" separator system. The sludge underflow from the "Lamella" separator is dewatered and the overflow is discharged to "A" sewer.

The only treatment provided at the Blooming Mill and Scarfer is a scale pit. No recirculation is practiced at these facilities and the scale pit effluent together with non-contact cooling water combines and is discharged to the junction box of "C and E" sewer.

No waste treatment facilities are provided at the Tin Mill cleaning line, Temper Mill or Sinter Plant; however, sintering wastes are treated at the Blast Furnace.

The above flows are to the "A" outfall lagoons where the oil is skimmed off and sent to the "PORI" outfall lagoons where the oil is skimmed off and sent to the "PORI" plant for processing. The sludge is bucketed out and hauled away by contractors to disposal.

Wastes from the Weirlite lines consist of emulsified oils, free oils, scale and dirt. The flows from both lines pass thorugh a treatment plant where oils are skimmed after chemical treatment and air flotation. The oil is then sent to the "PORI" plant and the treated wastes combine with the flows from the tin plating lines, the continuous annealing lines and the regenerants from the demineralizer plant. The combined flows pass through a manhole where lime is added and then flow to the "B" outfall lagoon. Oils, gravity separated in the lagoon, are skimmed and sent to the "PORI" plant.

Oil solutions from the Tandem Mills are pumped directly to the "PORI" plant.

Waste Pickle Liquor from the three pickling lines (Nos. 3, 4 & 5) are pumped directly to the acid regeneration plant.

The Hot Strip Mill discharges wastes from the roll stands into one of four scale pits. The roughing stands discharge into one pit and the finishing stands flows are divided into three pits. The gross scale particles are removed and the settled wastes are discharged. A portion of the cooling water from a hot well is used for flume flushing under the roughing stands and is discharged into the roughing stands scale pit, a portion is returned to the service water line and a portion is discharged to the sewer.

The Carbide Plant discharges its waste slurry through two settling pits where the solids are kept in suspension and discharged with the supernatant.

The acid regeneration plant and the "PORI" plant are considered as waste treatment facilities although they, as a result of operations, discharge wastes to "C and E" outfalls.

From the gas cleaning system at the BOP, the water is discharged to two clarifiers, via a splitter box, where most of the solids are removed. The clarifier overflow is recirculated with a portion blown down to the sewer for dissolved solids control. The clarifier underflow is dewatered in one of two vacuum filters.

The continuous caster open system has a waste treatment system that permits recycle of most of the water used. The water first passes to a flat bed filter for solids removal and then to a cooling tower. A portion of the return water from the cooling tower is passed through four deep bed filters for further solids removal. Each filter is backwashed three times a day and the solids are discharged to the sewer. The closed water system recycles all of its water with the exception of cooling tower blowdown required for dissolved solids control.

The coal washing facilities discharge solids laden water to a clarifier where settling aids are added. The clarified water is recycled back to the washing facilities and the sludge is dewatered on a vacuum filter. However, at the end of each day operation approximately 227-246 m^3 (60-65,000 gals) are pumped to the sewer. This water contains suspended and dissolved solids.

All of the wastewaters that flow to "C and E" sewers flow through two lagoons where additional solids are settled and oil skimmed off. The skimmed oil is sent to PORI. The settled solids in the lagoon are periodically pumped by a floating dredge to two decant tanks. The supernatant from the decant tanks is returned to the lagoons and the settled sludge is periodically hauled away to a land disposal site.

1.2.4 Water Related Aspects of Air Quality Control Systems

Water related air pollution control facilities are presently installed at the two coke plants, the blast furnaces, the boiler house, the BOP shop, the tandem mills, the pickle lines and at the scarfer.

The Brown's Island Coke Plant pusher cars are equipped with venturi scrubbers. An underground continuous quenching system has been installed which is equipped with a scrubber but the mainland coke batteries have no controls for pushing. A Claus vacuum carbonate system for the production of elemental sulfur from hydrogen sulfide was installed but was destroyed by corrosion due to the inadequacy of the cyanide removal system. Improvements are being made and it is expected that it will be fully operative. Ammonia is removed in an ammonia still and incinerated. By 1980 Weirton will desulfurize coke oven gases at the mainland Coke Plant.

At each of the blast furnaces there are two trains used for cleaning of gas, depending upon where the gas is to be used. The gas that is to be used at the coke plant passes through a dry dust catcher, a venturi, a wet electrostatic precipitator, a disintegrator and a second wet electrostatic precipitator. Gas to be used at the boiler house and the soaking pits passes through a venturi scrubber and a wet electrostatic precipitator.

BoilersNos. 1 & 2 can fire coal and coke oven gas and No. 3 is capable of firing blast furnace gas, coke oven gas, No. 6 fuel oil and coal. Because of the coal firing the boilers are tied into a common, low energy, "Krebs" scrubber which is used to remove fly ash from the gas stream.

Weirton originally had two sinter machines, No. 1 rated at 2270 kkg/day (2500 TPD), and No. 2, rated at 4535 kkg/day (5000 TPD). No. 1 was shut down in 1975 and is not expected to start up again. At the discharge end of machine No. 1, the emissions are controlled by means of Rotoclones.

All of the steel is produced in two basic oxygen furnaces, rated 354 kkg (390 tons) each. One vessel is blown at a time and produces 32 heats per day. The exhaust hood is arranged as a waste heat boiler which fires No. 6 oil when the vessel is not being blown. The gases then go to a quencher and venturi scrubbers which operate at a 7.5 kPa (30 inches of water) pressure drop.

2.0 PROPOSED PROGRAM

2.1 GENERAL

The Weirton Steel Division is presently practicing some degree of recirculation at the continuous caster and at the blast furnace and provides some degree of treatment for all wastes prior to discharge. However, none of the flows discharged to either the Ohio River or Harmon Creek are meeting the requirements established under BAT although most do meet the NPDES permit limitations.

Discharges containing quantities of regulated substances are permitted from most facilities under the requirements of BAT. However, in the case of total recycle no water could be discharged, and all water must be recycled or evaporated. Before water can be indefinitely recycled some constituents present must be removed to protect plant equipment and product quality. Total recycle of water is interpreted, in this report, to be no discharge of water to any body of water be it surface, ground or off-site treatment where the water is not returned to the plant. Exceptions to this are sanitary sewage which may be discharged after treatment at the plant or at a municipality and storm water runoff from areas other than material storage (i.e., coal, coke, flux and ore).

In view of the above, additional treatment facilities will be required to recycle treated water at the production facilities or from one or more terminal waste treatment plants. At areas where treatment is presently performed, the facilities will have to be upgraded or additions provided to first meet BAT and then additional facilities provided to permit complete recirculation and ultimate disposal of wastes to meet the total recycle criterion.

2.2 WATER RELATED MODIFICATIONS TO AIR QUALITY CONTROL

There are five areas at the Weirton Steel Division where water may be required for air quality control. These are at the Mainland Coke Plant (Batteries 4 through 9), the Sinter Plant, the blast furnace cast houses, the basic oxygen furnaces and the blooming mill hot scarfer.

At the mainland coke plant three scrubber cars are proposed for the pushing of coke. The pushing control systems would require a water application rate of 0.8 m^3 of water per kkg of coke produced (186 gals per ton). The average rate at the mainland coke batteries would be 150 m^3/hr (660 gpm) and the power requirement would be 6.43×10^6 j/kkg (1.62 kWh/t). A coke oven gas desulfurization system is scheduled for installation at the mainland coke plant by 1980.

Fugitive emissions due to charging will be controlled and minimized when the stage charging cars which have been purchased are in operation. A second stage of scrubbing has been provided at the BOP to reduce the present outlet loading of from 68.6 mg/m^3 (0.03 gr/SCF) to 45.8 mg/m^3 (0.02 gr/SCF).

Emissions from the hot scarfer at the blooming mill are presently not in compliance with opacity regulations for short periods of time and should be controlled by the installation of a wet electrostatic precipitator.

2.3 REQUIREMENTS FOR PLANT TO MEET BAT

To develop a plan for the Weirton Steel Division to meet BAT, certain assumptions were made. These are:

1. Guidelines for plating operations have been established for the metal finishing segment of the Electroplating Point Source Category (EPA-440/1-75/040a). These guidelines call for zero discharge of water and are applicable to steel plant plating operations. Guidelines were also established for pickling and cleaning operations in iron and steel manufacturing. For electroplating operations zero discharge of pollutants (suspended solids, oil and grease, soluble iron, tin and chrome) were used.

2. In the absence of guidelines in the regulations covering iron and steel making with respect to boiler houses and power houses, the guidelines established by the EPA for Steam Electric Power Generating Point Source Category, as published in the Federal Register October 8, 1974 (Vol. 39, No. 196, Part III) were used. The limitations with respect to low volume waste sources are suspended solids - 30 mg/l, and oil and grease - 10 mg/l. Criteria as published in 40 CFR 48830 (Coal Mining Point Source Category) were used as limitations for the coal washing facilities at Weirton.

3. All non-contact cooling waters would be permitted to be discharged in that there is no product contact and,

therefore, as long as there is no mixing with product contact water, no limitations are to be set.

4. Modifications would be required at the mainland coke plant to reduce pushing emissions.

5. The dissolved solids content of makeup water at all intakes is assumed to be 350 mg/l.

6. It is assumed that both the blast furnace recirculation system and the addition to the biological treatment plant on Brown's Island to treat mainland coke plant water are in operation.

7. In the absence of more recent analytical data, waste concentrations of various individual waste streams were obtained from the EPA publication "Combined Steel Mill and Municipal Wastewaters Treatment" dated February 1972.

A summary of discharges allowable under BAT requirements is shown on Table C-1.

The treatment requirements or modifications to existing treatment facilities are discussed below with respect to the outfalls that each production facility discharges to.

2.3.1 "A" Sewer & Brown's Island Outfall

Blast Furnace

The blast furnace recycle system planned to have a blowdown of 175 m^3/hr (770 gpm); however, the system should be re-evaluated to see if a blowdown of from 41 to 73 m^3/hr (180 to 320 gpm) could be achieved through tighter control. If this smaller blowdown is achievable, then the blowdown from the blast furnace recycle system could be sent to the Brown's Island Biological Treatment Plant. However, to meet the BAT requirements with respect to fluorides, a lime precipitation step should be added after the recirculation system and before biological treatment.

If it is not feasible to treat the Blast Furnace blowdown at the Brown's Island Biological Plant, then this blowdown will require treatment by alkaline chlorination, settling, pH adjustment, filtration and carbon adsorption prior to discharge through "A" outfall.

All non-contact cooling water would be discharged. A flow diagram illustrating the treatment proposed is shown on Fig. C-3 and a general arrangement of facilities is shown on Fig. C-4.

TABLE NO. C - 1

BAT ALLOWABLE DISCHARGES

Production Facility	Daily Production kkg/tons	Allowable Discharge (kg/day) / (lbs/day)																
		SS	O & G	CN	NH_3	$S^=$	Phen.	BOD_5	F	Zn	Mn	NO_3	Pb	Fe (Diss.)	Cr^{+6}	Cr (Tot.)	Cr (Diss.)	Ni (Diss.)
Coke Plant	7516/8278	30.9	30.9	0.73	30.9	0.88	1.5	61										
		68	68	1.62	68	1.9	3.3	134										
Blast Furnaces	8948/9864	47	-	1.2	46	1.4	2.3	-	93									
		102	-	2.6	103	3.2	5.1	-	205									
BOF (Wet AQCS)	11343/12500	56	-	-	-	-	-	-	45									
		123	-	-	-	-	-	-	99									
Sinter Plant	6690/7375	35	14	-	-	0.40	-	-	28									
		78	31	-	-	0.88	-	-	62									
Vacuum Degassing	5983/6595	16								3.1	3.1	28	0.3					
		34								6.8	6.8	62	0.68					
Continuous Casting	3969/4375	21	21															
		46	46															
Blooming Mill	8682/9570	9.6	9.6															
		21	21															
Pickling Lines HCl w/recov.	8499/9369	114												4.7				
		251												10.3				
Cold Rolling (Direct Applic.)	3126/3446	326	130											13				
		718	287											29				
Cold Rolling (Recirculating)	6792/7487	18	7.1											0.71				
		39	16											1.6				
Weirlite (CR) (Direct Applic.)	1026/1131	107	43											4.3				
		235	94											9.5				

Coke Plant

The Brown's Island Biological Treatment Plant is two single stage aeration plants with capacities of 212 m^3/hr (1.5 mgd) each with final settling facilities. Although the plant has reported that it is meeting the NPDES permit limitations, these are higher than allowable under BAT with respect to ammonia and cyanide. To allow the wastes presently discharged to meet BAT limitations, a second stage biological treatment plant will be required with an additional settling facility.

Fresh water that is used to dilute the Coke Plant wastes for treatment could be eliminated and substituted with water from the Mainland Coke Plant pushing scrubber system and the Blast Furnace recycle system blowdown. The substitute dilution water contains the same compounds as the coke plant water, only much more diluted; and can be treated although not specifically required to be done, in the same facilities as the Coke Plant water. Excess solids from the Biological Treatment Plant are volatile and could be disposed of on the coal pile. The solids will then burn when the coal is coked.

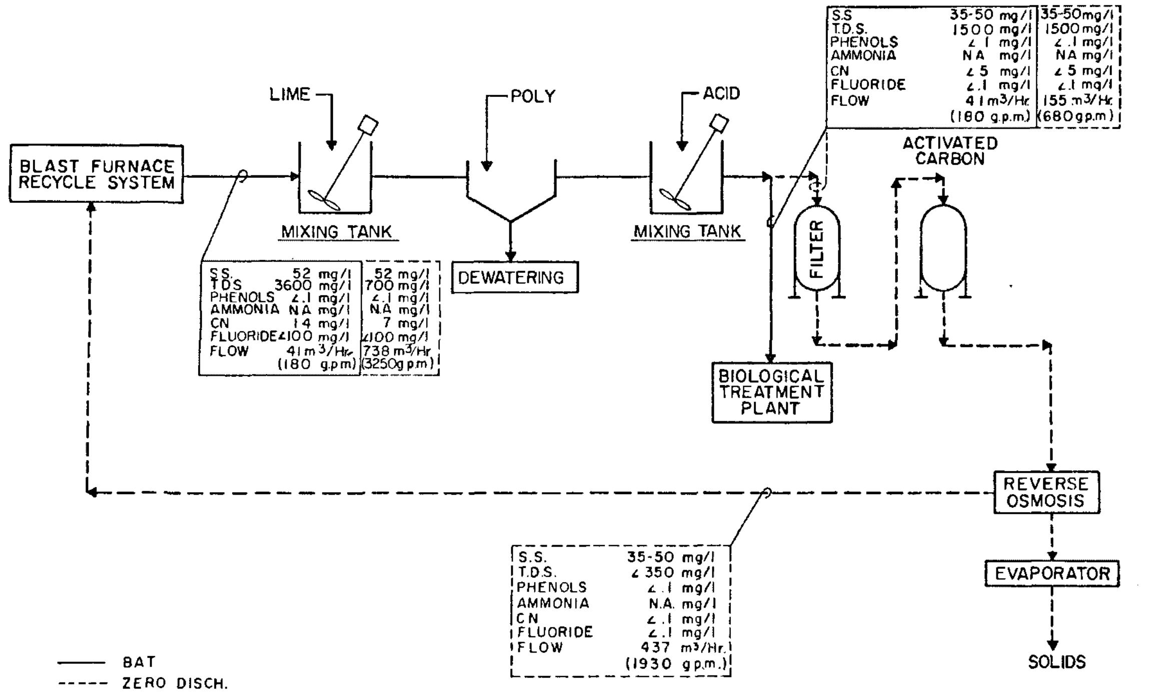
Sinter Plant

Non-contact cooling water from the Sinter Plant would continue to be discharged. The 80 m^3/hr (350 gpm) discharged from the rotoclones would continue to be discharged to the Blast Furnace recirculation system thickeners splitter box and thickeners which will serve to remove suspended solids and also provide a source of makeup water.

Power House and Boiler House

Only non-contact cooling water is discharged from the Power House and its discharge is permitted under BAT.

Water being discharged from the Boiler House is composed of fly ash scrubber water, bottom ash sluice water, boiler blowdown and water softening sludges. The scrubber water and the water softening wastes are discharged to a thickener. However, the suspended solids concentration in the thickener effluent are estimated to be in the order of 80 to 100 mg/l which is above the BAT guidelines limitation of 30 mg/l. It is suggested that polyelectrolyte be added to the thickener to improve settling or that the discharge be further treated in a filter to reduce the solids concentration to below the 30 mg/l required. The bottom ash decant water is estimated to be above the 30 mg/l limitation and should also be treated. The combined flow to new filters would be 836 m^3/hr (3680 gpm). A backwash holding tank would be required and the solids settled in that tank would be dewatered in an expanded dewatering facility, together with the existing



BLAST FURNACE AREA TREATMENT PLANT
QUALITY & FLOW DIAGRAM

FIG. C-3

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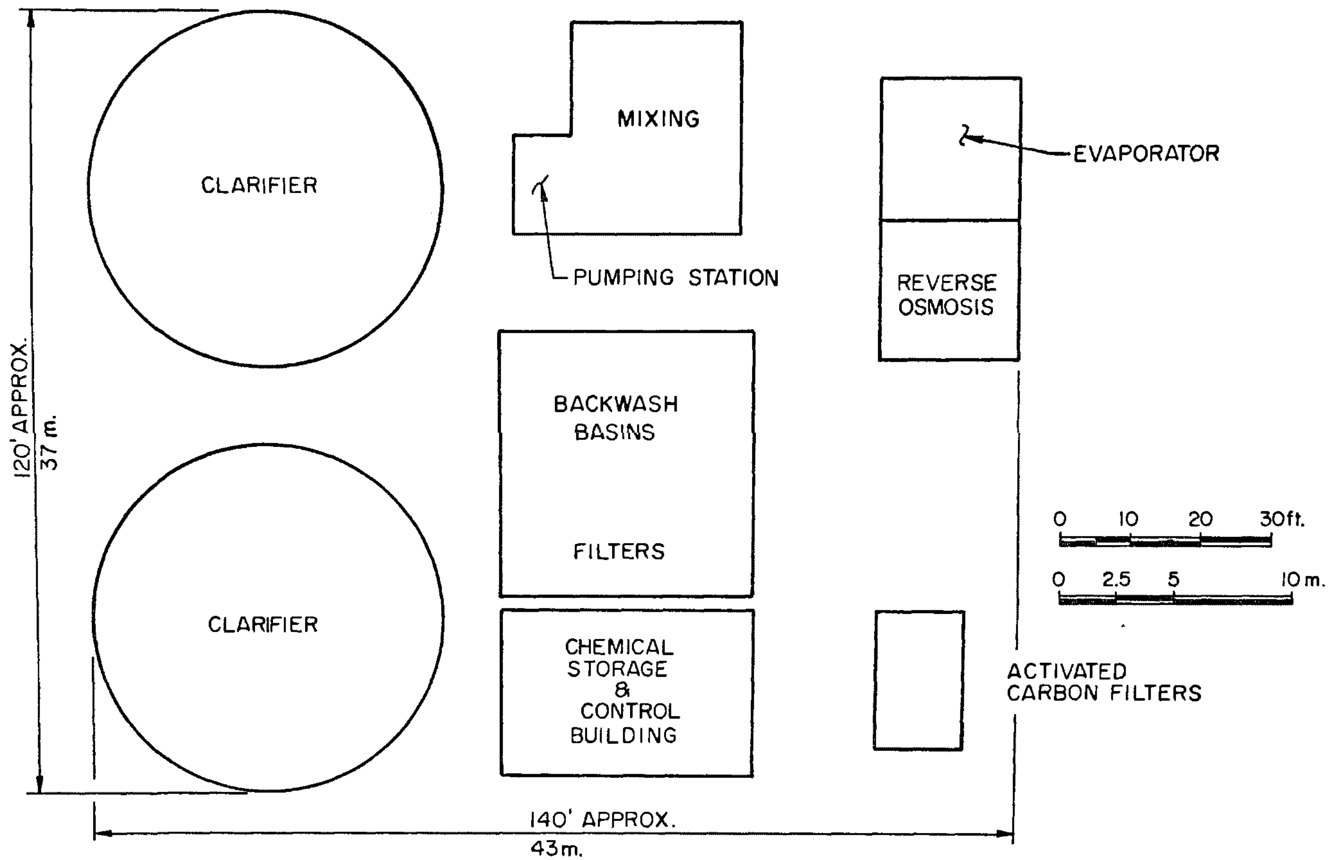


GENERAL ARRANGEMENT
BLAST FURNACE TREATMENT PLANT

FIG. C-4

HYDROTECHNIC CORPORATION
NEW YORK, N. Y.

thickener solids. An additional 1540 kg (3400 pounds) per day (dry basis) would be produced.

The boiler blowdown of 114 m^3/hr (500 gpm) is assumed to be in compliance with the guidelines.

Blooming Mill and Scarfer

Each of these facilities utilizes water for both contact and non-contact purposes. To meet the limitations under BAT and minimize the sizes of treatment facilities, the non-contact cooling water should be segregated from any combined wastes and discharged separately. The contact waters at the mills limited under BAT would then be limited to contact discharges from the Blooming Mill and Scarfer only.

Three scale pits are provided at these facilities for gross solids removal. After the scale pits the suspended solids discharged are 1030 kg (2280 lbs) per day from the Blooming Mill and 200 kg (440 lbs) per day from the scarfer, which are above the BAT limitations of 9.5 kg (21 lbs) and 4.5 kg (10 lb) per day, respectively. To achieve BAT limitations, flume flushing water should be taken from the scale pit discharge to reduce the total flow from the scale pits to 1032 m^3/hr (4540 gpm). The scale pit effluent water contains suspended solids in the range of 75 to 100 mg/l. Assuming a waste treatment facility which would be capable of discharging a suspended solids concentration of 10 mg/l, and a maximum permissible suspended solids discharge of 9.6 kg (21 lbs) per day, only 39 m^3/hr (175 gpm) could be discharged. A recirculation system is proposed for this mill complex which would consist of an additional settling facility, possibly with the addition of settling aids, a filtration system and a cooling tower. Oil skimming would be provided at both the settling and backwash facilities. The only discharge would be a cooling tower blowdown.

Due to evaporation losses in the mill, makeup water would be required and a buildup of dissolved solids will be experienced in the system. A blowdown would, therefore, be necessary and the quality of the blowdown would have to be equal to river water quality with respect to suspended solids and oils. Although this would not satisfy the criterion of total recycle, it would satisfy a criterion of zero additional discharge of suspended solids and oils. A flow diagram graphically describing the treatment is shown on Figure C-5 and a general arrangement of the facilities is shown on Figure C-6.

Temper Mill

The Temper Mill discharges non-contact cooling water and process wastes containing lubricating oils. The process wastes discharge to a holding tank and are hauled away by an outside contractor for processing. The non-contact cooling water would be allowed to be discharged under BAT limitations.

Tin Mill Cleaning

The Tin Mill cleaning lines presently discharge wastes that exceed the BAT limitations with respect to suspended solids, dissolved nickel and dissolved chrome, and have a high alkalinity. These wastes should be diverted from "A" outfall to "B" outfall and treated in combination with the wastes described there.

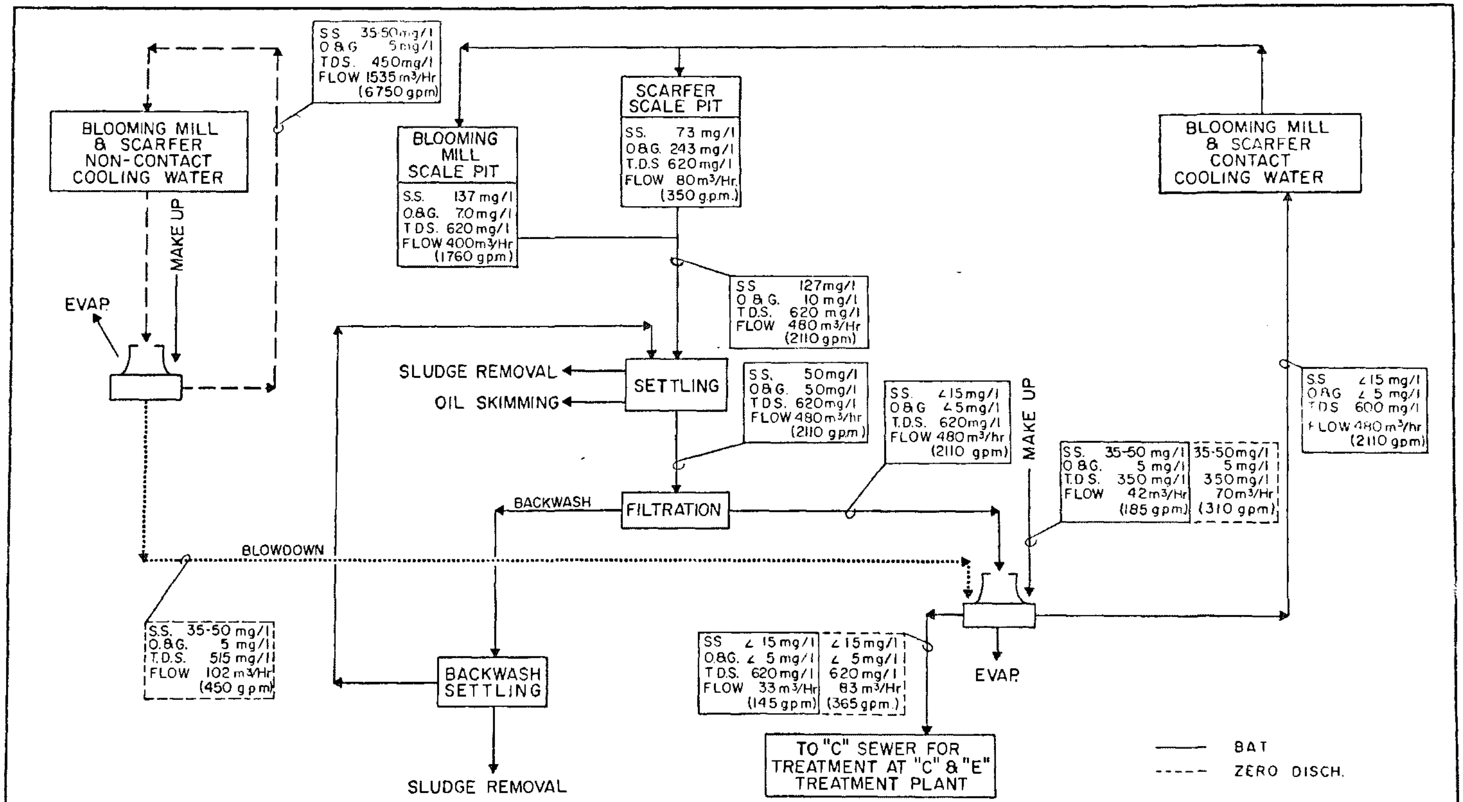
2.3.2 "B" Outfall

The production and service facilities that discharge to "B" sewer are the Weirlite Lines, the Continuous Annealing Lines, the Tin Plating Lines and the Demineralizer plant.

A chemical and physical treatment plant to remove emulsified oils is installed at the Weirlite lines. However, effluent oil concentrations are above the allowable limits, necessitating additional treatment. After skimming, the waste water should be filtered to remove additional emulsified oils, and then flow to a treatment plant described below. The plant is referred to as the B-terminal treatment plant.

The tin lines discharge wastes from various treatment tanks. Cleaning and pickling section wastes should be collected and treated separately at different sections of the B-terminal treatment plant. The wastes from the plating and brightening sections, in accordance with the electroplating industry guidelines, should not be discharged. Therefore, the chrome wastes should be passed through an ion exchange chrome recovery system and reused. The excess regenerants would be directed to the B-terminal treatment plant and the throughput of the chrome recovery ion exchangers can be recycled back to the plating lines to be used as makeup water.

The B-terminal treatment plant would consist of facilities for acid and ferric chloride addition to break any additional oil emulsions and to reduce any hexavalent chrome to the trivalent state. In a second tank the alkaline cleaning wastes would be added and flocculated together with the acidified wastes. The flow would then be to a third mixing tank where lime and available caustic would be added to raise the pH of the totally mixed waste and precipitate heavy metals present as hydroxides. The flow would then be to the flocculator clarifier where sludge would settle and the freed oils would be skimmed off.



BLOOMING & SCARFER TREATMENT PLANT
QUALITY & FLOW DIAGRAM

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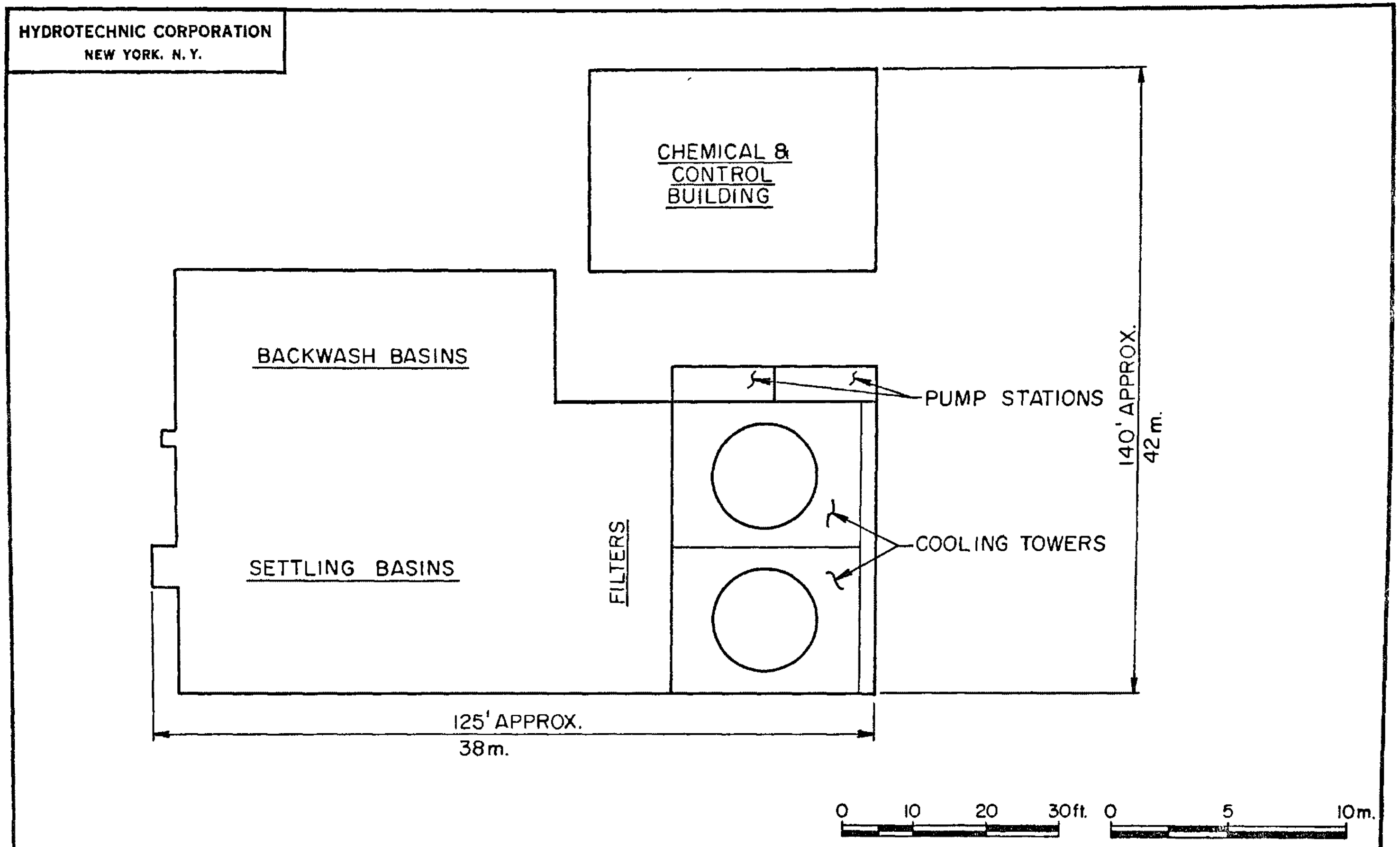
FIG. C-5



GENERAL ARRANGEMENT
BLOOMING MILL & SCARFER TREATMENT PLANT

FIG. C-6

The sources of reagents would be:

Acid would be obtained from the demineralizer plant cation exchangers regenerants, the first stage chrome recovery system cation exchangers regenerants, the pickling section of the plating lines. Any additional requirements would be from storage.

Alkalinity required at the third mixing tank would be obtained from the demineralizer plant anion exchangers regenerants, the throughput from the chrome recovery system cation exchangers, and the chrome recovery systems strong anion exchangers regenerants. Additional alkalinity would be caustic or lime from storage. The effluent from the treatment plant should then meet BAT requirements.

Sludge from the underflow of the flocculator clarifier would be dewatered and disposed of at an acceptable landfill site. Skimmed oils would be hauled away for processing. A flow diagram showing the treatment system is appended as Figure C-7 and a general arrangement of the facilities is shown on Figure C-8.

2.3.3 "C" Sewer

Tandem Mills

Tandem Mills 6, 7 and 9 operate with recirculating rolling solution. When the solution becomes ineffective it is dumped to the "PORI" plant. These mills utilize non-contact cooling water for solution cooling which is the only discharge and, under BAT limitations, is permitted. Mill 8 operates on a once-through rolling solution. Contaminants consist of oily wastes, dirt and scale. No non-contact water is used at 8 and 9 mills. The oily rolling solution wastes from all mills are stored in a collection tank which is discharged to the "PORI" plant for treatment.

Continuous Picklers

The continuous pickling lines discharge rinse and spray waters along with fume scrubber water to "C" Sewer. Waste acid is discharged to holding tanks for pumping at the acid regeneration plant. The rinse spray and fume scrubber waters which discharge to "C" sewer do not meet the limits set under BAT guidelines. Presently the discharge of the Nos. 2 and 3 pickle lines fume scrubber water is 156 kg (344 lbs) per day of suspended solids which is above the guidelines set at 114 kg (251 lbs) per day. To comply with BAT guidelines all wastes from the picklers should discharge to the proposed chemical treatment plant for treatment and also to provide a a source of acidity. Installation of more efficient equipment to reduce all leaks at the picklers to increase concentration of contaminated flows is also suggested.

Hot Strip Mill

Wastes from the hot strip mill consist of non-contact and contact cooling water. The non-contact water is used for cooling of the motor room and lube systems and reheat furnaces. This non-contact water would be allowed to discharge under BAT limitations.

The contact waters which are used at the roughing and finishing sections, run out table and coilers are not in compliance with the limitations set forth under BAT which limits discharge of contact waters to zero discharge. Hot strip mill discharges should follow similar guidelines.

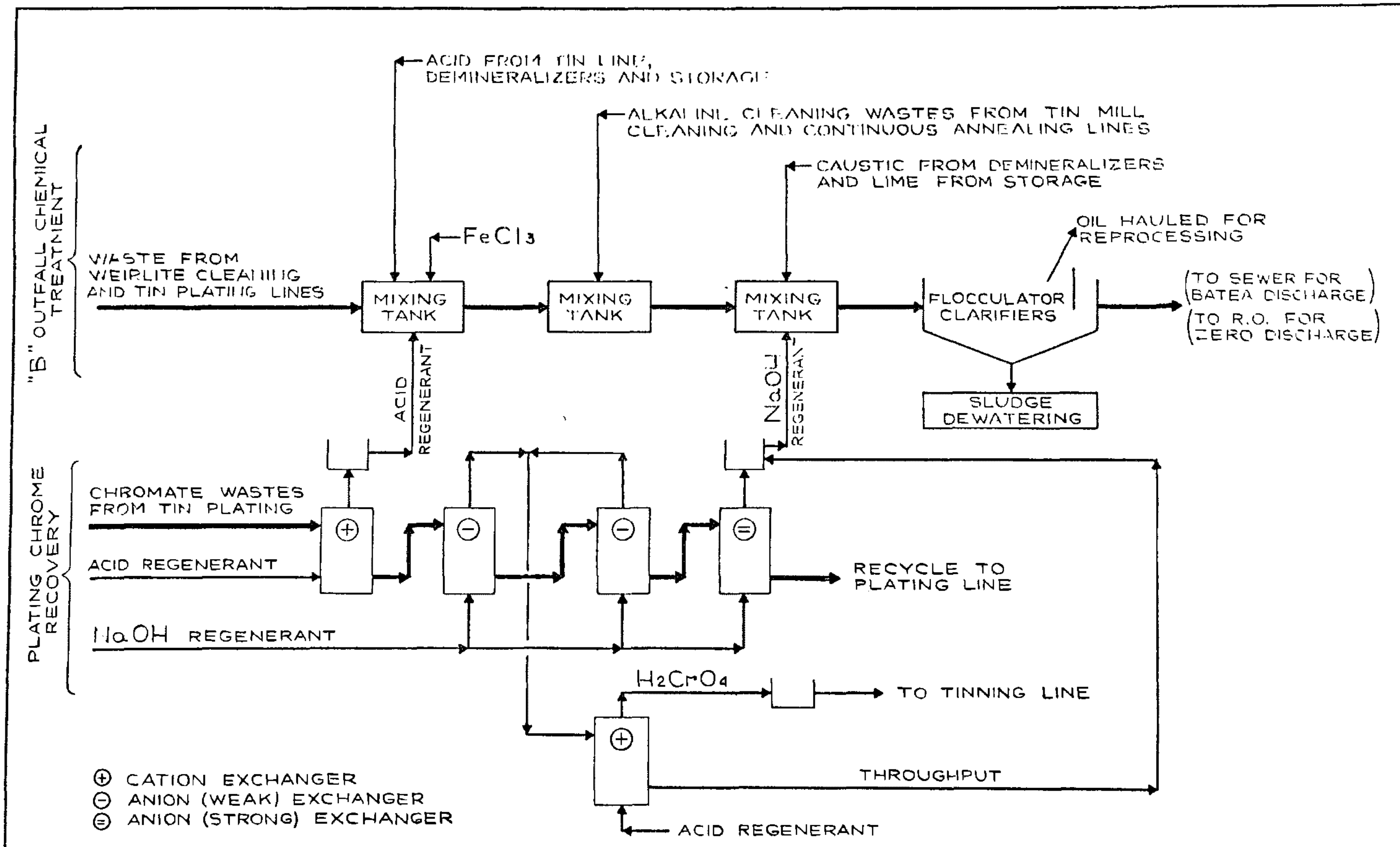
To achieve reasonable BAT limits, all contact wastewaters should be collected and discharged into a settling basin for further removal of oils and suspended solids. Prior to this, a portion of the flow would be used for flume flushing at the roughing section. This would conserve approximately 2270 m^3/m (10,000 gpm) of the non-contact furnace water which is presently being used for this purpose. Following settling the wastes would be filtered to reduce solids to 15 mg/l and oil and greases to less than 10 mg/l. The filtered water would then be cooled and returned to the mill for reuse. This system would require a blowdown of approximately 840 m^3/hr (3700 gpm) for the control of dissolved solids. The discharge of the blowdown water should be permitted under the previously described zero discharge limitations. A flow diagram describing the treatment and a general arrangement of the facilities is shown as Figures C-9 and C-10.

Carbide Shop

The carbide shop produces approximately 10,400 kg (23,000 lbs) of acetylene lime per day. Presently the lime is discharged into a modified settling tank which is equipped with air sparging equipment to prevent the lime from settling. This could be used as a source of lime in the C and E chemical treatment plant.

Diesel Shop

Maintenance services are performed at this shop and only small volumes of water containing slight traces of oil are discharged. Approximate discharge is 0.5 m^3/m (2 gpm).



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TIN MILL WASTES AND "B" OUTFALL CHEMICAL TREATMENT PLANT QUALITY & FLOW DIAGRAM

FIG. C-7

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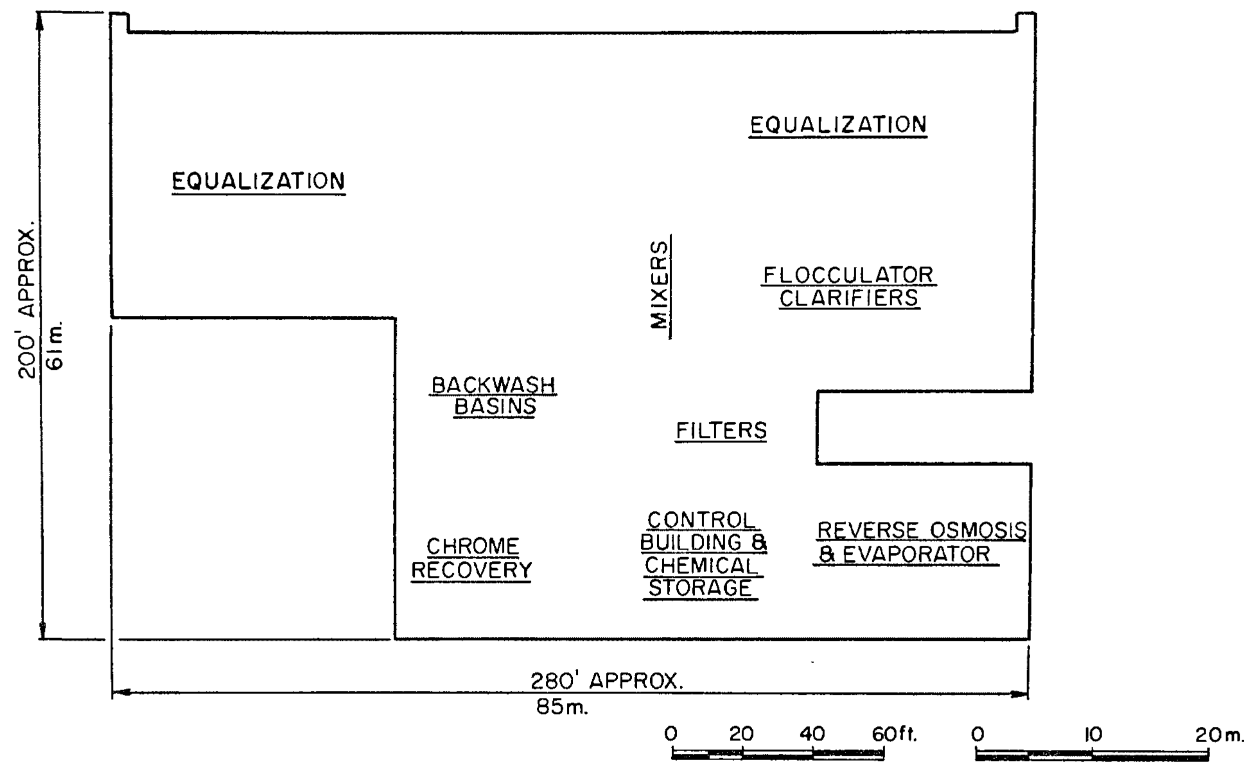
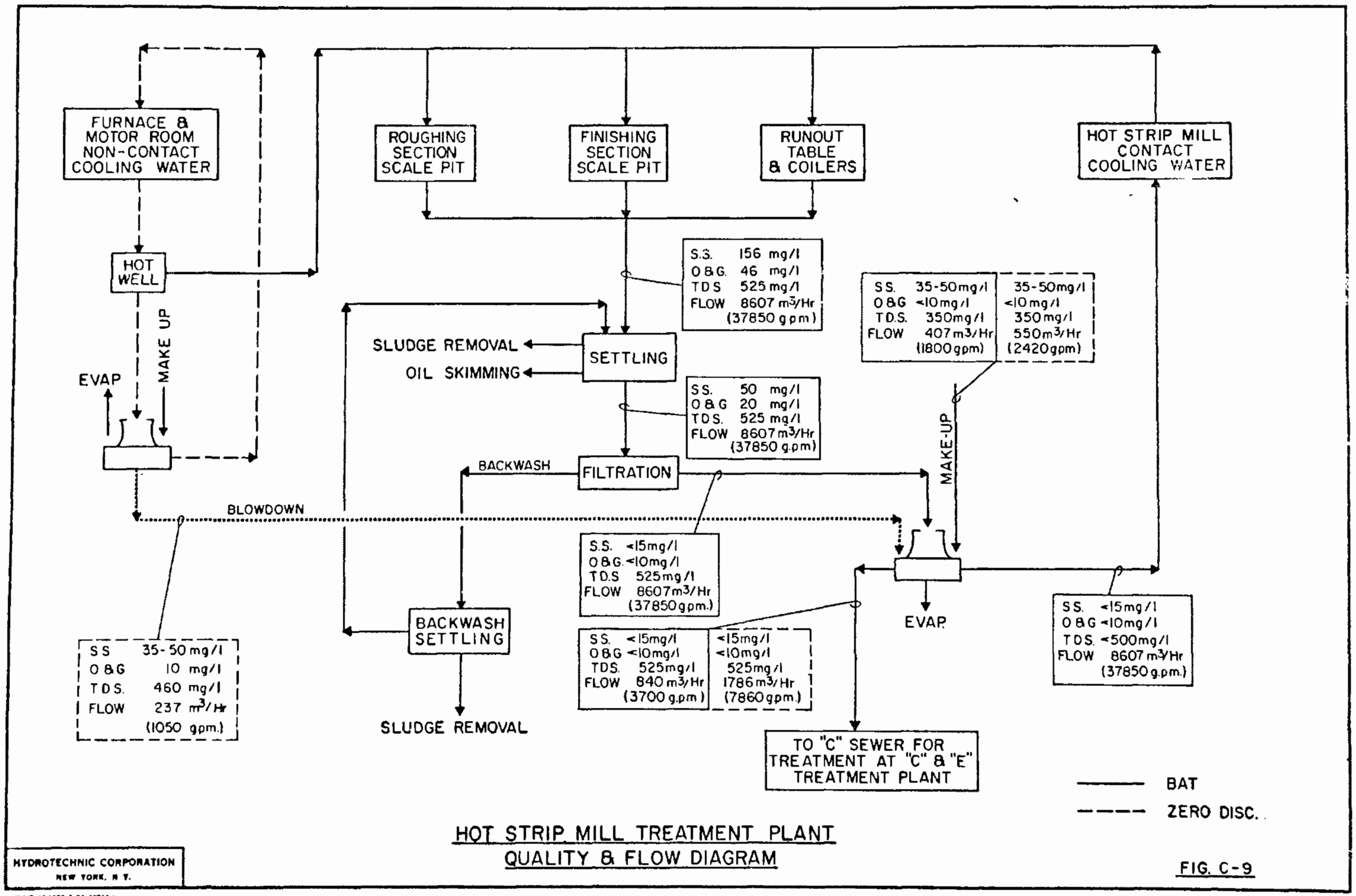


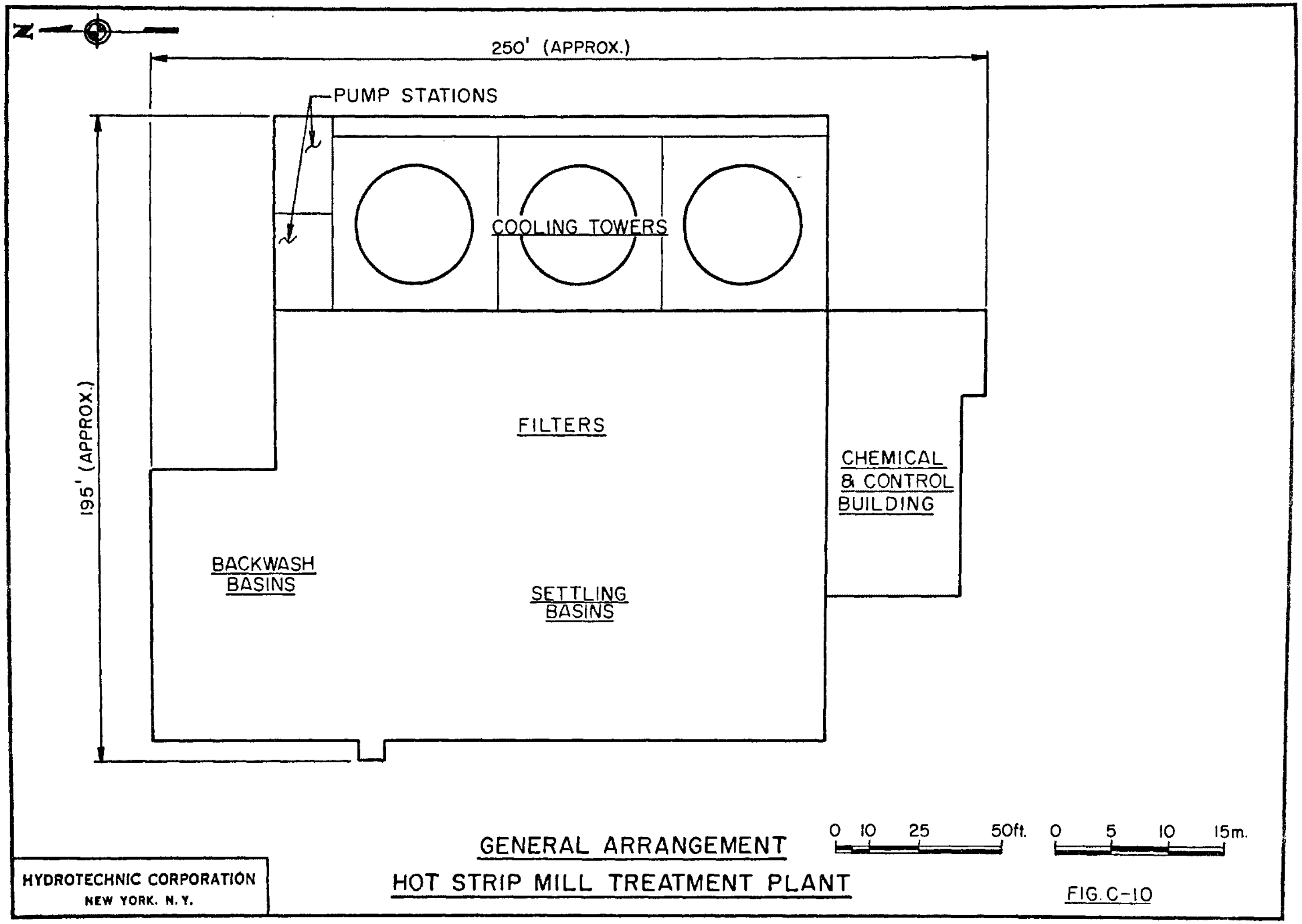
GENERAL ARRANGEMENT
TIN MILL WASTES &"B" OUTFALL CHEMICAL TREATMENT PLANT

FIG. C-8



HOT STRIP MILL TREATMENT PLANT
QUALITY & FLOW DIAGRAM

FIG. C-9



GENERAL ARRANGEMENT

HOT STRIP MILL TREATMENT PLANT

FIG. C-10

Under BAT guidelines no limitations have been set; however, this small flow be collected and periodically pumped to the waste treatment plant. All separable waste oils are collected in drums and are not discharged.

Acid Regeneration

Wastewater from the acid regeneration plant is mainly from the fume scrubber and is discharged into the "C" sewer at a rate of 80 m^3/m (350 gpm). Discharges are 695 kg (1530 lbs) per day of suspended solids, 28 kg (62 lbs) per day of oil and grease and 11 kg (24 lbs) per day of iron. These contaminants when combined with pickling operations are above the limits under BAT guidelines for pickling operations. This waste stream should be treated in the "C and E" chemical treatment plant, to be discussed later.

"PORI"

Palm Oil Recovery Incorporated is an outside contractor who treats the oily wastes and recovery of oils for reuse. Discharges from the "PORI" system are from overflows from the oil skimming tanks and they are discharged to the "C" sewer. Contaminants are high in oils and suspended solids and further treatment should be considered. The discharge under BAT will be approximately 227 m^3/hr (1000 gpm). This oily waste should be treated at the "C and E" chemical treatment plant.

Sheet Mill (Galvanizing Line and Cleaning Lines)

Prior to coating, the strip is cleaned, annealed, coated, and cooled. Wastes from the galvanizing line originate from the cleaning and rinsing processes, solution dumps and cooling rinses. The cleaning stage discharges are high in phosphorous and alkalinity which should serve as a suitable reagent in the "C and E" chemical treatment plant. The discharge from the final rinse stages contains traces of hexavalent chrome which will require reduction prior to precipitation in the treatment plant.

The cleaning lines operate similarly to the galvanizing line cleaning stage and, similarly, all discharges should be sent to the "C and E" chemical treatment plant.

BOP and Vacuum Degassing

Water use at the BOP is for non-contact cooling and gas scrubbing. Presently both systems recycle. The gas scrubber water flow of 101 m^3/hr (445 gpm) is treated in a thickener prior to recycle. BAT guidelines limit the discharge of suspended solids to 56 kg (123 lbs) per day and fluorides of 45 kg (99 lbs) per day. Since present discharges contain 61 kg (135 lbs) per day of suspended solids and 62 kg (137 lbs) per day of fluorides further treatment is required. The contact cooling water system should have its blowdown reduced to 40 m^3/hr (175 gpm). Non-contact waters do not fall under BAT guidelines and discharge is permitted.

Continuous Caster

Wastewaters from the continuous casters consist of blowdown from the non-contact and contact system cooling towers. Both streams are discharged to the "E" sewer at a rate of 7.3 m^3/hr (32 gpm) for non-contact and 55 m^3/hr (240 gpm) for contact waters. No limits are placed on non-contact waters, thus discharge is allowed under BAT guidelines. The contact water limitations are 21 kg (46 lbs) per day of suspended solids and 21 kg (46 lbs) per day of oil and grease. Assuming the flat bed filters are operating with an effluent suspended solids concentration of 25 mg/l, these limitations would be exceeded. To meet the BAT limits, blowdown from the system should be from the pressure filter effluent, rather than the influent. This would bring suspended solids and oil levels to less than 14 kg (30 lbs) per day each.

Detinning

Batch overflow wastes from the treatment settling tanks are discharged from the detinning plant. Average flows are estimated at 4.1 m^3/hr (18 gpm) which discharge to "E" sewer. Contaminants in the waste stream consist mainly of suspended solids and metals such as tin, iron and chrome. The batch dumps from the detinning line should be discharged to the "C and E" treatment plant to precipitate the heavy metals. The caustic tank rinses should also be discharged to the caustic stage of the treatment plant.

Coal Washer

Coal washing water is discharged to a clarifier for treatment. Overflow from the clarifier is recycled to the system for reuse. Blowdown from the system is estimated at 246 m^3/d (65,000 gpd) as an average and is discharged to "E" sewer. Contaminants discharged are at concentrations of 331 mg/l of suspended solids and 52 mg/l of total iron which are both above the limitations for BAT guidelines listed under coal preparation in the category of coal mining. It is therefore suggested that, if this blowdown cannot be eliminated, it should be treated in the "C and E" chemical treatment plant for the removal of iron and suspended solids.

2.3.4 "C and E" Treatment Plant

Most wastes from the "C and E" sewer sections require chemical treatment to meet the limits set forth under BAT guidelines. The proposed treatment system would be a multi-stage chemical treatment plant. The first stage of this plant will be an acidification stage, where wastes from the pickling, galvanizing lines, acid regeneration, "PORI", and coal washer wastes would be discharged. Here additional acid will be fed if necessary to reduce any hexavalent chrome to its trivalent stage and to crack any oils which may be in emulsion. Following this stage the acidified wastes would enter the second stage where caustic is applied to gradually adjust the pH and to precipitate the dissolved metals. At this stage the alkaline and phosphorous waste of the galvanizing and cleaning line would be added, along with the caustic rinses from the detinning plant. The lime slurry from the carbide shop would also discharge to this stage to serve as a source of alkalinity along with an emergency lime system in the event of shutdown of the carbide shop. The waste stream would then be settled in a clarifier. The overflows would then be filtered. The sludge would be removed, dried and disposed of in a landfill. This plant would produce approximately 1140 kg (2500 lbs per day) of sludge (dry basis). Filtration would produce an effluent containing 15 mg/l of suspended solids, 10 mg/l of oils and small traces of metals. The effluent water is suitable for discharge under BAT guidelines with the exception of the water used at the detinning lines which falls under zero discharge. This volume of water if discharged to a reverse osmosis (R.O.) or other dissolved solids removal facility and evaporation system would return an average of 5 m^3/hr (18 gpm) of product water and meet the BAT guidelines as mentioned. This system could later be expanded to meet zero discharge requirements.

The "C and E" treatment plant flow diagram is shown on Figure C-11 and a general arrangement of the facilities is shown on Figure C-12.

A revised plant flow diagram showing the flows as they would exist under BAT criteria is shown on Figure C-13 and C-14.

2.4 REQUIREMENTS FOR THE PLANT TO MEET TOTAL RECYCLE

The various treatment areas of the plant, as described below with logical combinations to achieve a practical operating system.

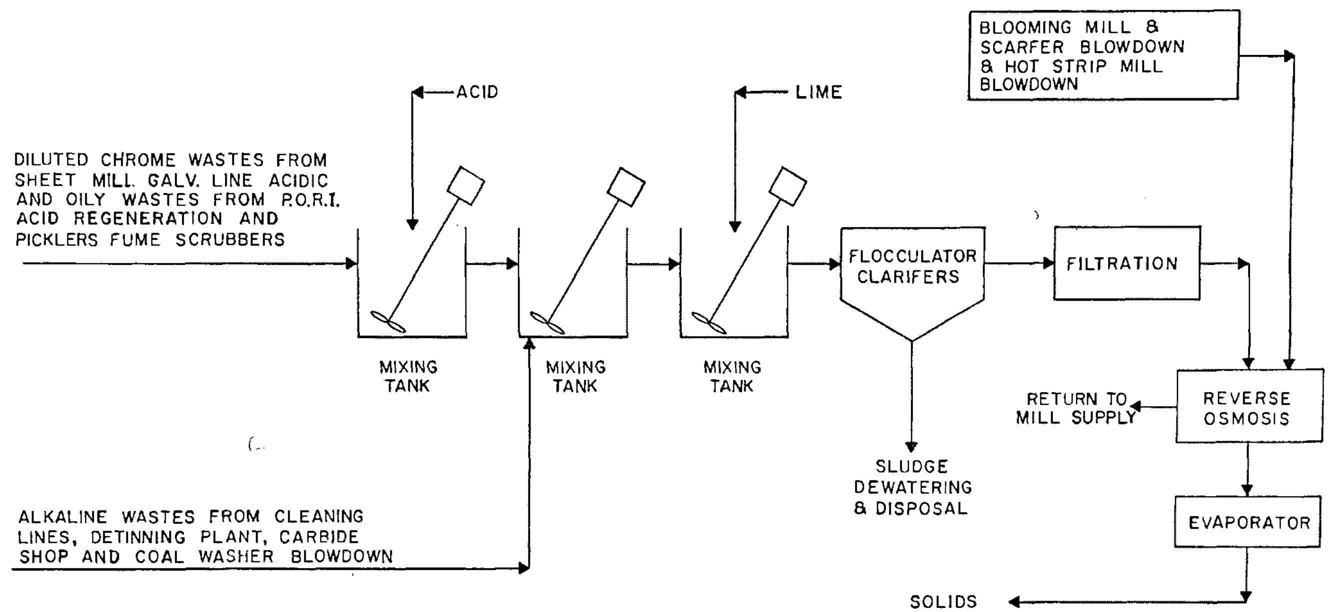
Two steps toward total recycle have been assumed, namely: total recycle of non-contact waters and total recycle of both contact and non-contact waters. The drawings and text discusses both steps but the cost estimates presented in the main body of the text show cost differences.

Blast Furnace and Coke Plant

To achieve total recycle, all of the non-contact cooling water from the Blast Furnace and Coke Plant areas must be recirculated. At the mainland Coke Plant, cooling towers would require a blowdown of approximately 270 m^3/hr (1190 gpm) which would be used as a part of the makeup to the Blast Furnace gas washing recycle system. At the Blast Furnaces cooling of non-contact cooling water would also be required and the cooling tower blowdown would also be sent to the Blast Furnace gas washing recycle system. The blowdown would be approximately 334 m^3/hr (1470 gpm). A third cooling tower installation that would discharge blowdown to the Blast Furnace recycle system is the Power House system which would blow down approximately 140 m^3/hr (620 gpm).

The Blast Furnace gas washer recycle system would receive makeup water from the above cooling towers, from the Sinter Plant rotoclone (if it continues to operate) and blowdown from the "Krebs" scrubber recirculation system described in Section 2.3. Incorporating all of these flows into the Blast Furnace gas washer system will increase the makeup volume over that which is presently required and also increase the blowdown from the gas washer system. However, due to the increased volume, the blowdown would be diluted and the quality improved. The purpose of having all of the wastes discharged to the gas washer system is to centralize all of the wastes and minimize operating problems in the washer system. As the blowdown from the gas washer system would have to be further treated to attain total recycle, there would be only one source of waste. To be able to reuse the water the dissolved solids concentration must be reduced to service water quality of 350 mg/l. A portion of the blowdown would be sent to the Coke Plant biological treatment system to be used as dilution water and the balance of 584 m^3/hr (2570 gpm) treated at a system for removal of dissolved solids.

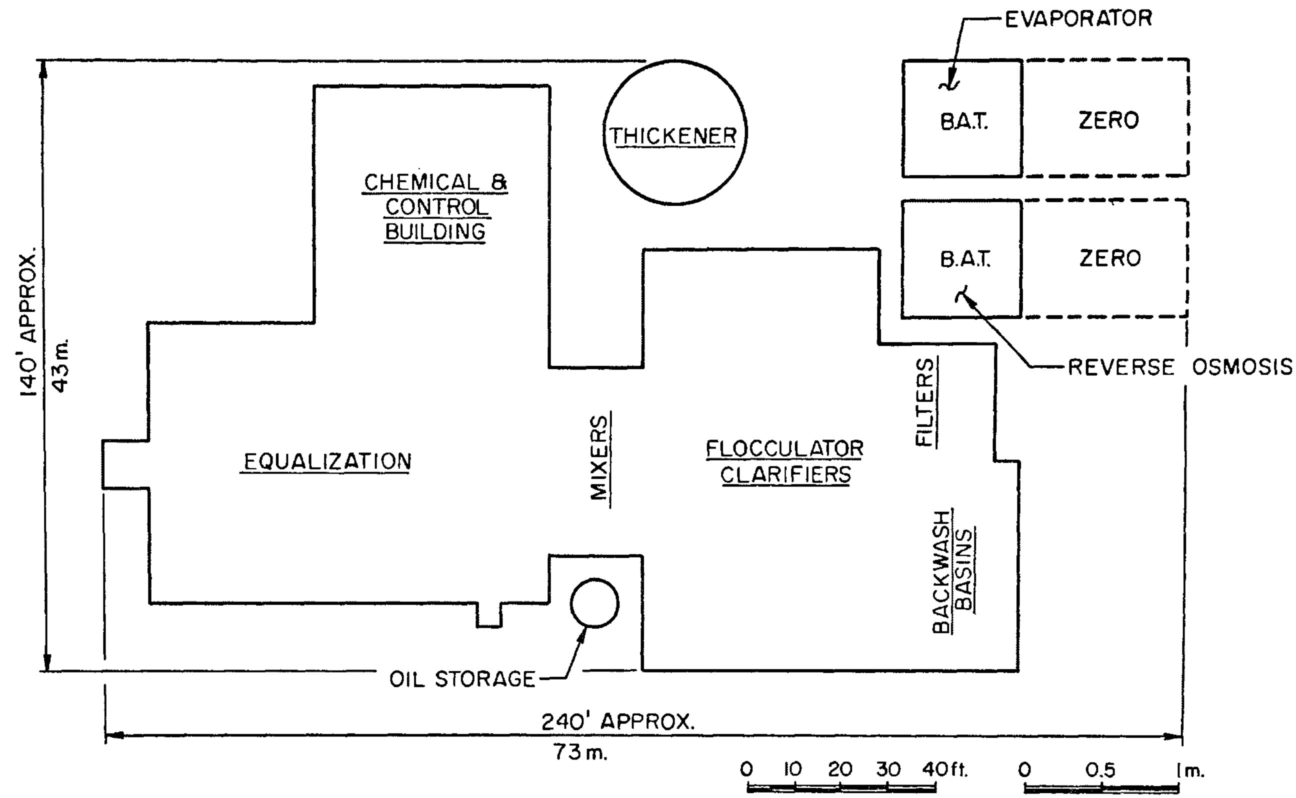
The entire flow would not have to pass through the system. Since a water of very high quality will be produced the quantity passing through the system can be reduced and a portion can by-pass the unit and be blended with the product water to produce any quality desired for reuse in the plant. The flow to the unit must be filtered and the pH adjusted. The brine reject steam would have to be further treated for total elimination. It is estimated that there will be 7.1 m^3 (9.2 cubic yards) per day of dried soluble solids to be



"C" & "E" CHEMICAL TREATMENT PLANT
QUALITY & FLOW DIAGRAM

HYDROTECHNIC CORPORATION
NEW YORK, N. Y.

FIG. C-11



HYDROTECHNIC CORPORATION
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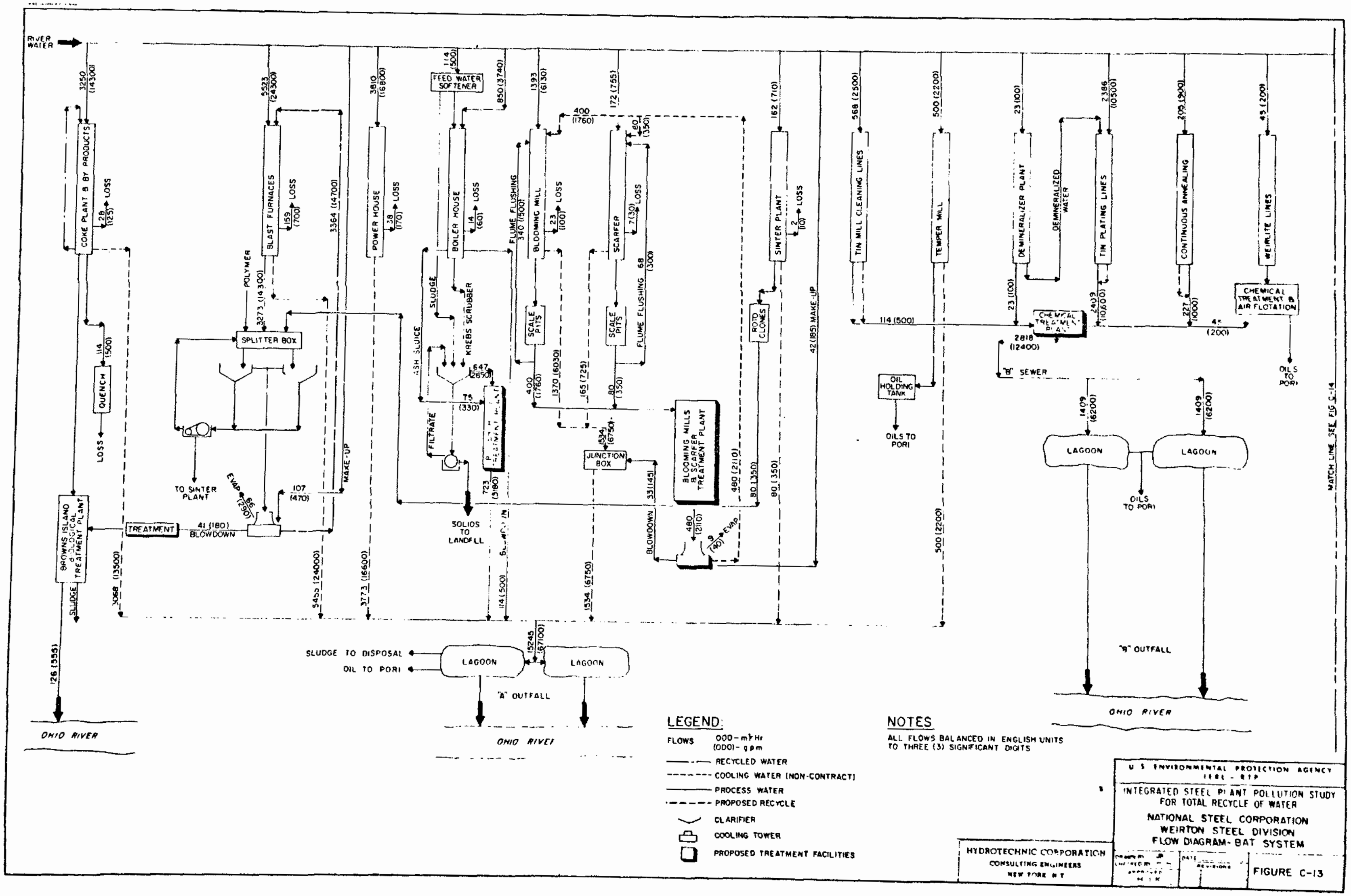
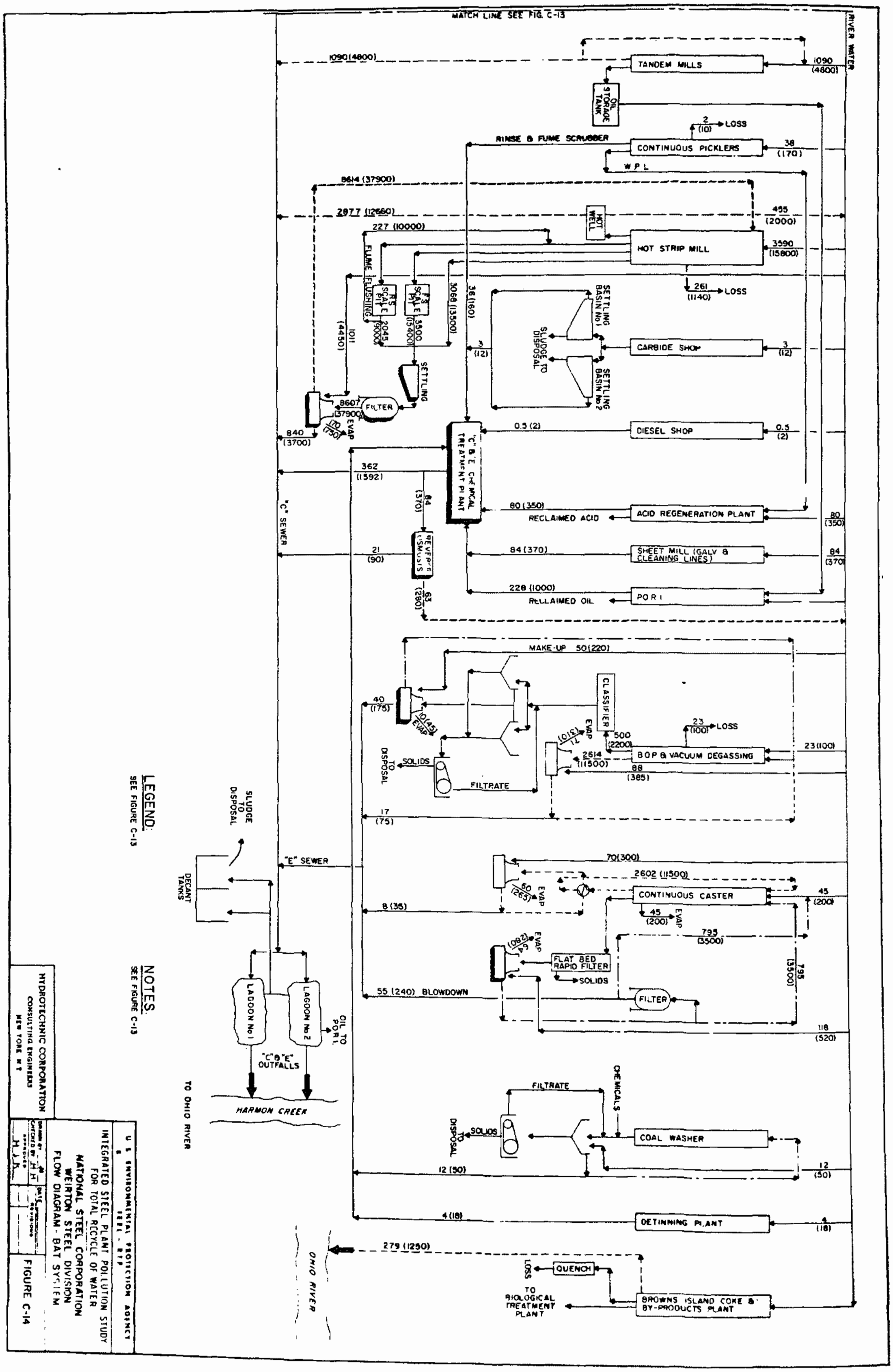
GENERAL ARRANGEMENT
"C" & "E" TREATMENT PLANT

FIG. C-12


RIVER WATER
COKE PLANT & BY PRODUCTS
QUENCH
BLAST FURNACES
SPLITTER BOX
POLYMER
TO SINTER PLANT
EVAP.
TREATMENT
BLOWDOWN
MAKE-UP
POWER HOUSE
FEED WATER SOFTENER
BOILER HOUSE
KREBS SCRUBBER
ASH SLUICE
SLUDGE
FILTRATE
SOLIDS TO LANDFILL
BLOOMING MILL
FLUME FLUSHING
SCALE PITS
SCARFER
JUNCTION BOX
BLOOMING MILLS & SCARFER TREATMENT PLANT
SINTER PLANT
ROTO CLONES
TIN MILL CLEANING LINES
TEMPER MILL
OIL HOLDING TANK
OILS TO PORI
DEMINERALIZER PLANT
DEMINERALIZED WATER
TIN PLATING LINES
CHEMICAL TREATMENT PLANT
CONTINUOUS ANNEALING
WEIRLITE LINES
CHEMICAL TREATMENT & AIR FLOTATION
"B" SEWER
LAGOON
"B" OUTFALL
OHIO RIVER
BROWNS ISLAND BIOLOGICAL TREATMENT PLANT
SLUDGE TO DISPOSAL
OIL TO PORI
"A" OUTFALL
MATCH LINE SEE FIG C-14
LOSS
LEGEND:
FLOWS 000 - m³/Hr (000) - gpm
RECYCLED WATER
COOLING WATER (NON-CONTRACT)
PROCESS WATER
PROPOSED RECYCLE
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
NOTES
ALL FLOWS BALANCED IN ENGLISH UNITS TO THREE (3) SIGNIFICANT DIGITS
U.S. ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
FLOW DIAGRAM - BAT SYSTEM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
FIGURE C-13


MATCH LINE SEE FIG. C-13
RIVER WATER
TANDEM MILLS
1090 (4800)
OIL STORAGE TANK
CONTINUOUS PICKLERS
2 (10) LOSS
38 (170)
RINSE & FUME SCRUBBER
W.P.L.
8614 (37900)
2877 (12660)
HOT WELL
455 (2000)
227 (10000)
HOT STRIP MILL
3590 (15800)
261 (1140) LOSS
FLUME FLUSHING
R.S. SCALE PIT
F.S. SCALE PIT
2045 (9000)
3500 (15400)
3068 (13500)
36 (160)
1011 (4450)
SETTLING
SETTLING BASIN No 1
SETTLING BASIN No 2
SLUDGE TO DISPOSAL
CARBIDE SHOP
3 (12)
FILTER
8607 (37900)
170 (750) EVAP
840 (3700)
DIESEL SHOP
0.5 (2)
"C" & "E" CHEMICAL TREATMENT PLANT
362 (1592)
84 (370)
"C" SEWER
ACID REGENERATION PLANT
80 (350)
RECLAIMED ACID
REVERSE OSMOSIS
21 (90)
SHEET MILL (GALV & CLEANING LINES)
84 (370)
PORI
228 (1000)
RECLAIMED OIL
63 (280)
MAKE-UP 50 (220)
CLASSIFIER
40 (175)
10 (45) EVAP
72 (315) EVAP
500 (2200)
23 (100) LOSS
BOP & VACUUM DEGASSING
23 (100)
2614 (11500)
88 (385)
SOLIDS TO DISPOSAL
FILTRATE
17 (75)
SLUDGE TO DISPOSAL
DECANT TANKS
"E" SEWER
70 (300)
2602 (11500)
60 (265) EVAP
CONTINUOUS CASTER
45 (200)
45 (200) EVAP
8 (35)
795 (3500)
65 (280) EVAP
FLAT BED RAPID FILTER
SOLIDS
55 (240) BLOWDOWN
FILTER
118 (520)
LAGOON No 1
LAGOON No 2
OIL TO PORI
"C" & "E" OUTFALLS
HARMON CREEK
TO OHIO RIVER
FILTRATE
CHEMICALS
SOLIDS TO DISPOSAL
COAL WASHER
12 (50)
DETINNING PLANT
4 (18)
OHIO RIVER
279 (1250)
LOSS
QUENCH
TO BIOLOGICAL TREATMENT PLANT
BROWNS ISLAND COKE & BY-PRODUCTS PLANT
LEGEND: SEE FIGURE C-13
NOTES: SEE FIGURE C-13
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
U.S. ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
FLOW DIAGRAM - BAT SYSTEM
FIGURE C-14

disposed of from this system. The solids would have to be placed in a lined and covered area to prevent percolation into the ground during periods of precipitation or spreading due to wind.

The biologically treated wastes from the Coke Plant would also have to be treated to remove dissolved solids prior to reuse. A dissolved solids removal system is recommended for installation which would produce approximately 14 m^3 (18 yd^3) of dried solids per day.

Blooming Mill, Scarfer

To achieve total recycle at these mills, the non-contact cooling water should be cooled and recirculated. The necessary blowdown from the non-contact cooling water system could be used as makeup to the contact system cooling tower. The blowdown from the contact water cooling system could not be discharged and would not be of a quality usable for reuse. Therefore, the system blowdown should be discharged to the "C" sewer system for ultimate treatment, together with other wastes discharging to the "C" sewer.

"B" Sewer

The discharges from the "B" sewer will require recirculation under the total recycle criteria. The treated water discharged from the "B" terminal treatment plant proposed in the BAT section will have a high concentration of the dissolved solids due to the process contaminants and the treatment additions which would negate its possible reuse for contact or non-contact cooling water at other portions of the plant. Therefore, this water should also be demineralized. It is estimated that approximately 38 cubic meters (50 cubic yards per day) of dried solids would be produced from a demineralizer and evaporator system and require disposal.

"C and E" Sewer

To achieve total recycle at the "C and E" sewer system various modifications will be necessary and some additional treatment will be required. Basically the modifications are:

- Cooling towers will be required to permit recycle of the non-contact cooling water at the Tandem Mills and the Hot Strip Mill.

- All stormwater runoff should be diverted to "E" sewer. "C" sewer would be retained strictly as a wastewater and blowdown sewer.

The facilities that are recommended to treat wastes to BAT levels, as described in Section 2.3, will continue to operate. However, additional treatment will be required to achieve total recycle. The dissolved solids removal unit at the discharge of the treatment system should be expanded to treat an additional portion of the discharge so that, when blended with a by-passed portion, will produce a water of suitable quality for reuse in the plant.

As described above, the "C" sewer will be retained to bring all blowdowns to the "C and E" Treatment Plant.

Hot Strip Mill and Tandem Mill non-contact cooling water should be cooled in a cooling tower and the blowdown discharged as makeup to the contact process water, at the Hot Strip Mill. The total blowdown from the Hot Strip Mill would increase to 1786 m^3/hr (7860 gpm) and would be discharged to the "C" sewer.

BOP and Vacuum Degassing

The non-contact cooling systems at the BOP presently recycle water with a blowdown of 80 m^3/hr (350 gpm) from the cooling tower to the "E" sewer. Since non-contact blowdown water is a higher quality, then the water in the gas-scrubber system can be utilized for makeup water to that system. Under BAT recommendations, the proposed gas scrubber recycle system would have a blowdown of 40 m^3/hr (175 gpm) with service water used as makeup. The addition of the non-contact blowdown water of the BOP system, as well as the contact blowdowns of the continuous caster system, would necessitate a higher volume of blowdown to maintain a low enough dissolved solids level. The blowdown would be approximately 132 m^3/hr (575 gpm). These blowdowns should be diverted to the "C" sewer.

Continuous Caster

Non-contact water at the Continuous Caster is presently recycled with a cooling tower blowdown of 8 m^3/hr (35 gpm). Under total recycle this water cannot be discharged. This blowdown should be utilized as makeup water to the contact water system since its quality would be higher. Under BAT it was recommended to discharge the blowdown from the contact system from the filter plant effluent. Under total recycle this would not be permitted and should be discharged to the BOP gas scrubber system for makeup. Following these recommendations, no wastes will be discharging directly from the continuous casters thus complying with total recycle.

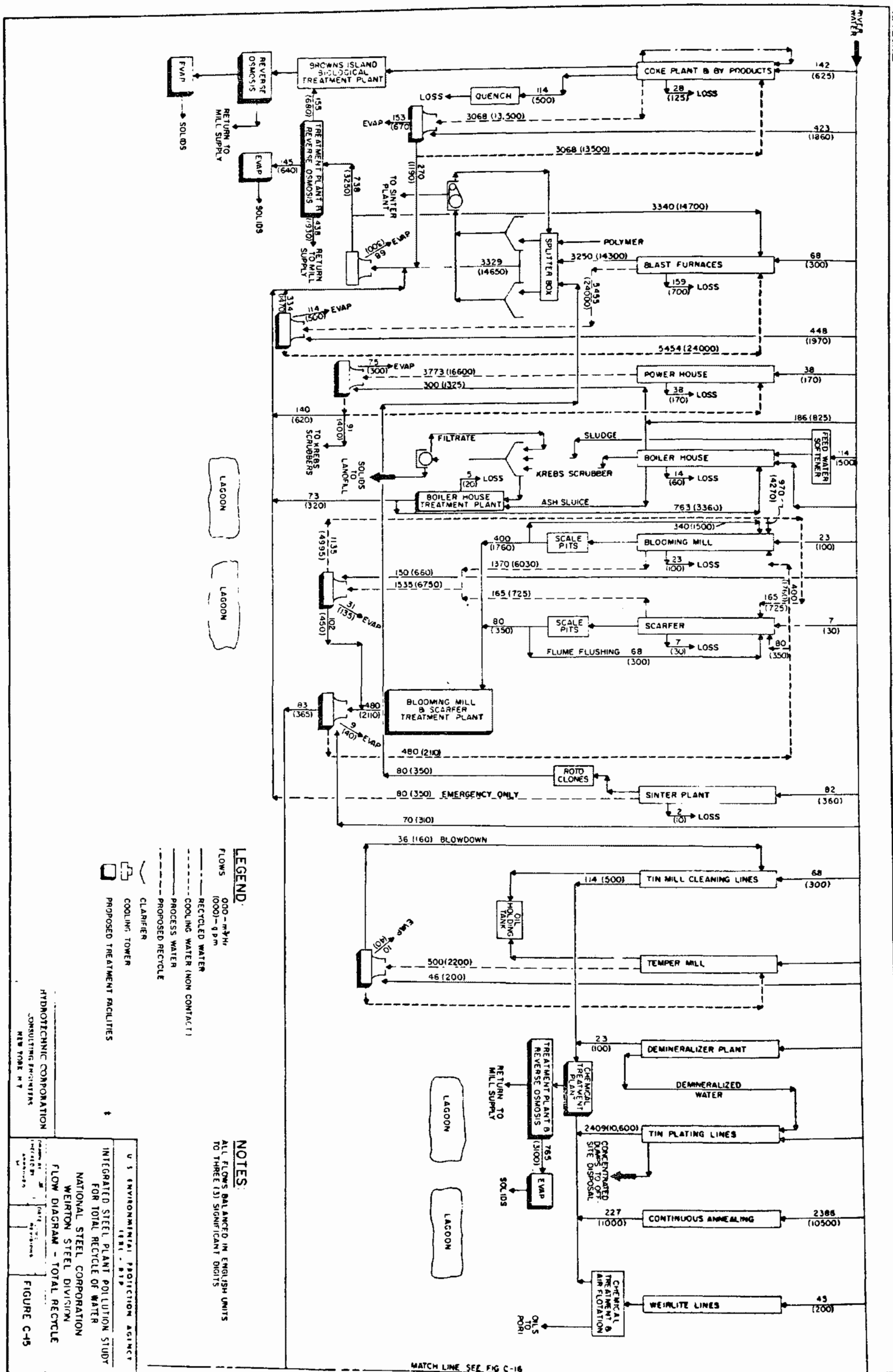
The connection between "C and E" sewers near the lagoons should be blocked off and the storm water collected in "E" sewer discharged. At the terminus of "C" sewer a pumping station should be installed to pump the collected wastes directly to the expanded R.O. facility which would follow the "C and E" sewer area chemical waste treatment plant.

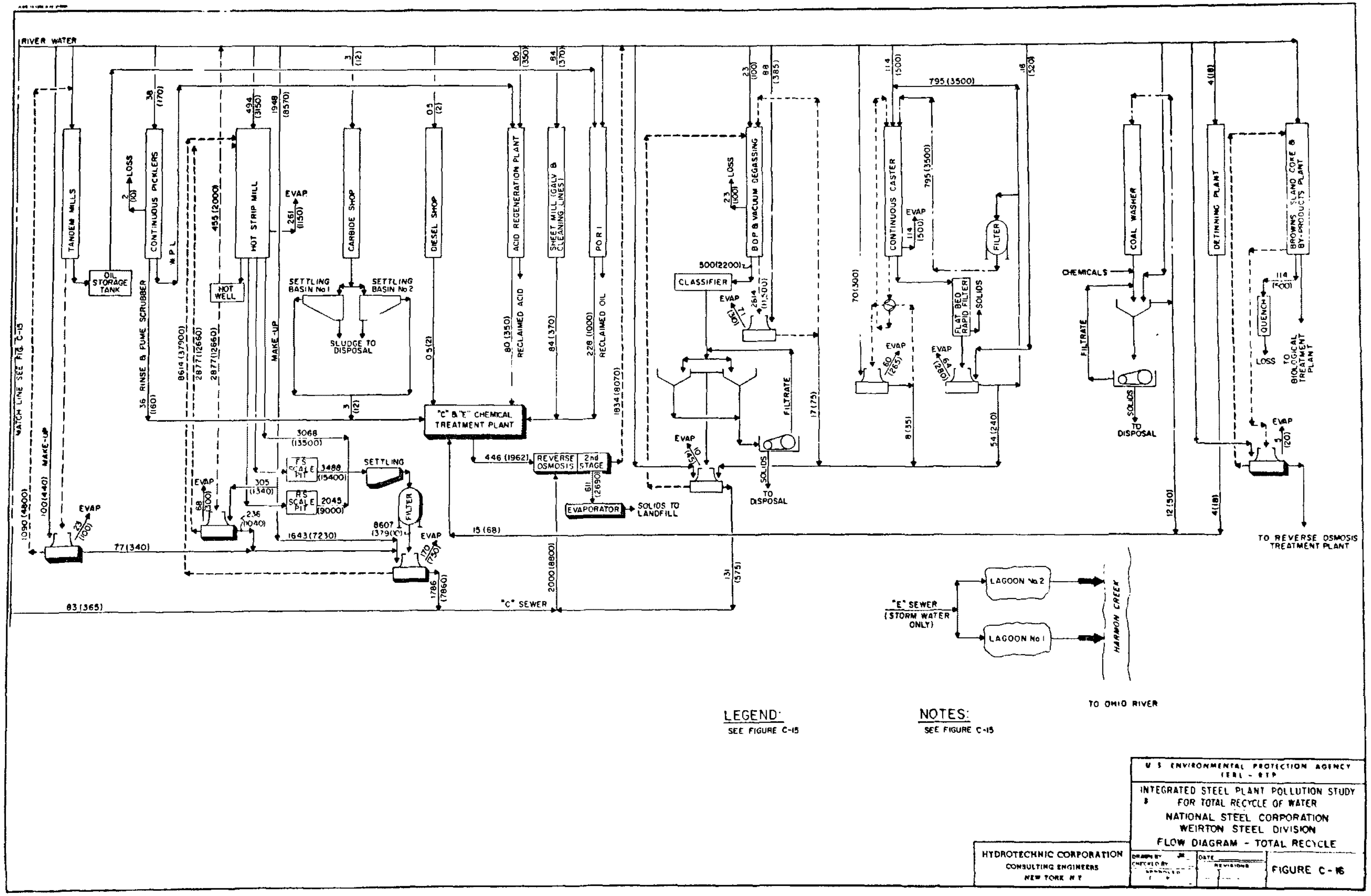
Under the total recycle criteria as defined, precipitation runoff from material storage areas would not be permitted. The areas around the coal, flux and ore piles should be drained and the runoff sent to the lagoon presently in place for the collection of wastes at "A" outfall. The water should then be pumped at a low rate to the plant water intake. It is anticipated that infrequent dredging of the lagoons would be necessary to remove suspended solids that are collected. Since all of the water in the plant would eventually end up at one of the treatment facilities, there will be no discharge of material storage area runoff.

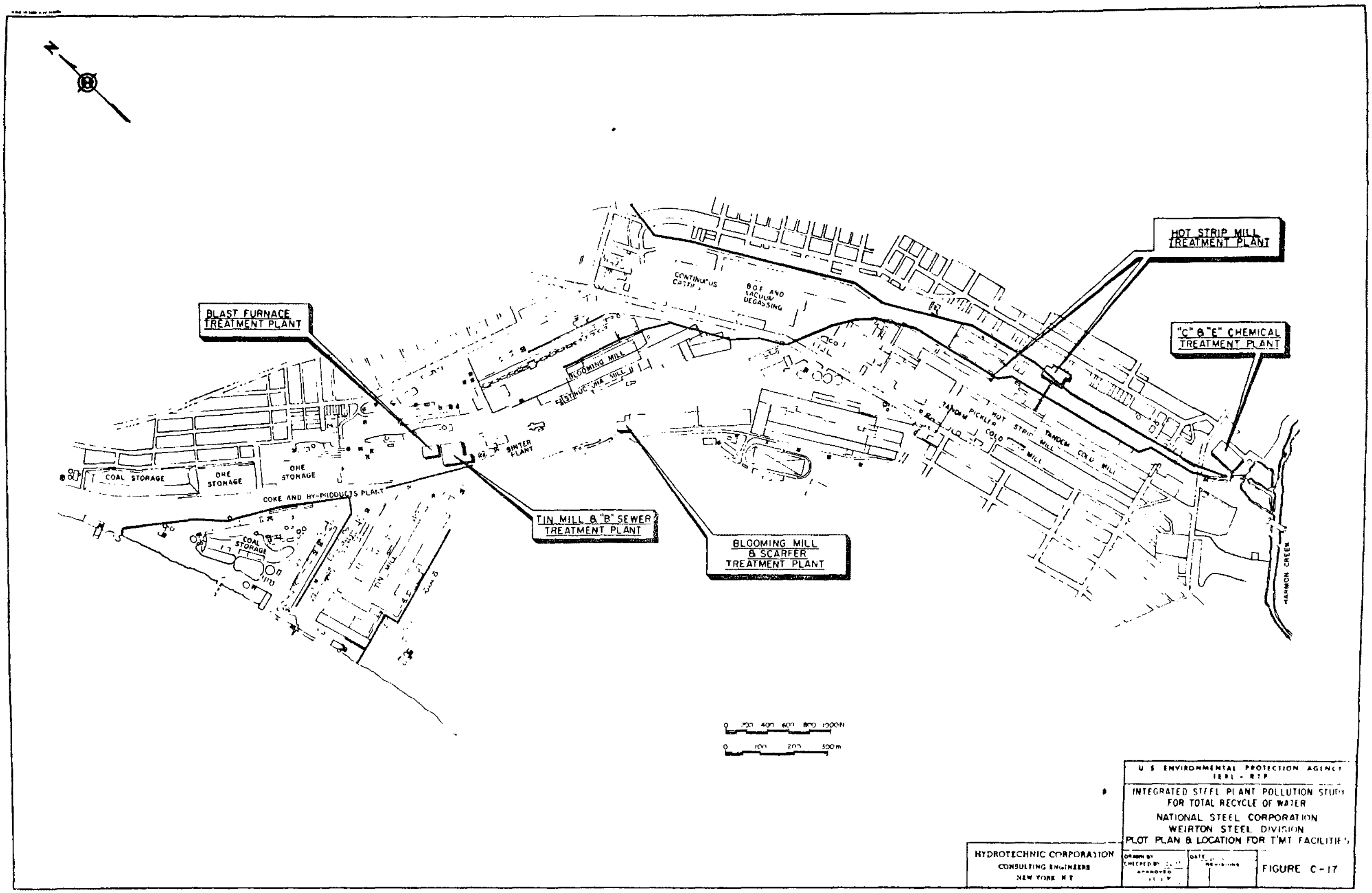
It is strongly recommended that, prior to the design of the waste treatment facilities proposed, treatability studies be performed to more accurately determine the sizes required and to assure the quality of water that would be discharged under the BAT guideline or recirculated under total recycle.

A revised plant flow diagram showing the plant flows as they would be under the zero discharge criteria is shown on Figure C-15 and C-16.

The locations of all of the waste treatment facilities recommended herein are shown on Figure C-17.


RIVER WATER
COKE PLANT & BY PRODUCTS
BROWNS ISLAND BIOLOGICAL TREATMENT PLANT
REVERSE OSMOSIS
EVAP
SOLIDS
RETURN TO MILL SUPPLY
QUENCH
LOSS
TREATMENT PLANT A REVERSE OSMOSIS
TO SINTER PLANT
SPLITTER BOX
POLYMER
BLAST FURNACES
POWER HOUSE
TO KREBS SCRUBBERS
SOLIDS TO LANDFILL
FILTRATE
SLUDGE
KREBS SCRUBBER
BOILER HOUSE
FEED WATER SOFTENER
BOILER HOUSE TREATMENT PLANT
ASH SLUICE
LAGOON
SCALE PITS
BLOOMING MILL
SCARFER
FLUME FLUSHING
BLOOMING MILL & SCARFER TREATMENT PLANT
ROTO CLONES
SINTER PLANT
EMERGENCY ONLY
BLOWDOWN
TIN MILL CLEANING LINES
OIL HOLDING TANK
TEMPER MILL
DEMINERALIZER PLANT
DEMINERALIZED WATER
CHEMICAL TREATMENT PLANT
TREATMENT PLANT B REVERSE OSMOSIS
TIN PLATING LINES
CONCENTRATED DUMPS TO OFF SITE DISPOSAL
CONTINUOUS ANNEALING
CHEMICAL TREATMENT & AIR FLOTATION
WEIRLITE LINES
OILS TO PORT
MATCH LINE SEE FIG C-16
LEGEND
FLOWS 000 – m³/hr (000) – gpm
RECYCLED WATER
COOLING WATER (NON CONTACT)
PROCESS WATER
PROPOSED RECYCLE
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
NOTES:
ALL FLOWS BALANCED IN ENGLISH UNITS TO THREE (3) SIGNIFICANT DIGITS
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
U.S. ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
FLOW DIAGRAM - TOTAL RECYCLE
FIGURE C-15


RIVER WATER
TANDEM MILLS
OIL STORAGE TANK
CONTINUOUS PICKLERS
HOT STRIP MILL
CARBIDE SHOP
DIESEL SHOP
ACID REGENERATION PLANT
SHEET MILL (GALV & CLEANING LINES)
POR I
SETTLING BASIN No 1
SETTLING BASIN No 2
SLUDGE TO DISPOSAL
HOT WELL
"C" & "E" CHEMICAL TREATMENT PLANT
REVERSE OSMOSIS
2nd STAGE
EVAPORATOR
SOLIDS TO LANDFILL
FS SCALE PIT
RS SCALE PIT
SETTLING
FILTER
BOP & VACUUM DEGASSING
CLASSIFIER
FILTRATE
SOLIDS TO DISPOSAL
CONTINUOUS CASTER
FLAT BED RAPID FILTER
COAL WASHER
CHEMICALS
DETINNING PLANT
BROWNS ISLAND COKE & BY-PRODUCTS PLANT
QUENCH
TO BIOLOGICAL TREATMENT PLANT
TO REVERSE OSMOSIS TREATMENT PLANT
"C" SEWER
"E" SEWER (STORM WATER ONLY)
LAGOON No 2
LAGOON No 1
HARMON CREEK
TO OHIO RIVER
LEGEND: SEE FIGURE C-15
NOTES: SEE FIGURE C-15
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
FLOW DIAGRAM - TOTAL RECYCLE
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE C-16


BLAST FURNACE TREATMENT PLANT
TIN MILL & "B" SEWER TREATMENT PLANT
BLOOMING MILL & SCARFER TREATMENT PLANT
HOT STRIP MILL TREATMENT PLANT
"C" & "E" CHEMICAL TREATMENT PLANT
COAL STORAGE
ORE STORAGE
ORE STORAGE
COKE AND BY-PRODUCTS PLANT
COAL STORAGE
SINTER PLANT
CONTINUOUS CASTING
B.O.F. AND VACUUM DEGASSING
BLOOMING MILL
STRUCTURAL MILL
TANDEM PICKLER
HOT STRIP MILL
COLD MILL
TANDEM COLD MILL
TIN MILL
HARMON CREEK
U.S. ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY
FOR TOTAL RECYCLE OF WATER
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
PLOT PLAN & LOCATION FOR T'MT FACILITIES
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
FIGURE C-17

APPENDIX "D"

UNITED STATES STEEL CORPORATION

FAIRFIELD WORKS

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This appendix addresses itself to the United States Steel Corporation's Plant at Fairfield, Alabama. It includes the preliminary engineering concepts based on data supplied by the United States Steel Corporation and other sources. It does not include the identification of all environmental control technologies considered, the evaluation of other steel plants studied, cost estimated, practicality or possible resultant environmental impact. Therefore, it should be looked on only as a vehicle to present a possible scheme to attain total recycle but not necessarily one that is practical or feasible or that with its implementation will not have an intolerably adverse environmental impact in other sectors.

1.2 DESCRIPTION OF THE STEEL PLANT

1.2.1 Processes and Facilities

United States Steel Corporation's Fairfield Works is a completely integrated steel plant located approximately 5 km (3 miles) southwest of Birmingham, Alabama and occupies 790 hectares (1950 acres). The integrated facilities located on the site, which produce finished and semi-finished products, consist of:

Facility	Daily Production Capacity kkg (ton)
- ore, coal and flux storage areas	24 ha (60 acres)
- a four battery by-products coke plant	5960 (6570)
- four blast furnaces	9767 (10766)
- one three-vessel Q-BOP shop	6050 (6669)
- a 46-inch slab mill	4666 (5143)
- a 45-inch blooming and slab mill	3418 (3768)
- a 140-inch and 110-inch plate mill	1666 (1836)
- a 21-inch billet mill	1241 (1368)
- an 11-inch merchant mill	612 (675)
- a 24-inch structural mill	1059 (1167)
- a 68-inch hot strip mill	5051 (5568)
- two strip pickling lines	4049 (4458)

Facility - (Cont'd)	Daily Production Capacity kkg (ton)
- one rod batch pickling	509 (561)
- two cleaning lines	1424 (1569)
- one continuous annealing line	822 (906)
- three cold rolling mills	4812 (5307)
- three temper mills	NA
- one wire drawing mill with pickling	480 (529)
- three strip tinning lines	1268 (1398)
- three strip galvanizing lines	1525 (1680)
- one wire galvanizing line	267 (294)
- one paint line	313 (345)

A sinter plant is approximately 9.6 km (6 miles) away which, for the purpose of this report, will be considered separately.

1.2.2 Water Systems and Distribution

Water required for the plant (approximately 3955 m^3/hr (17,400 gpm) is referred to as Prime Industrial Water (PIW) and is drawn from the city of Birmingham, Alabama, water supply.

For the purposes of description, the plant has been divided into six major water systems and one minor system and the water use is described below by system.

a. Steel Making Water System

Although three Q-BOP vessels are installed at the Fairfield Works, under normal operating conditions only two would be in use at any time. Each vessel is supplied continuously with 90 m^3/hr (395 gpm) of PIW; approximately 57 m^3/hr (250 gpm) is used for non-contact cooling and the balance used for gas cleaning. The non-contact cooling water that is not directly recirculated, is blown down to the Blast Furnace spray pond for further use. An additional non-contact cooling system recirculates approximately 2730 m^3/hr (12,000 gpm) through air cooled heat exchangers. Gas cleaning water is treated in a recirculation system, described in Section 1.2.3

below, and a 123 m^3/hr (540 gpm) blowdown from this system is sent to the final effluent control pond (FECP). An additional 68 m^3/hr (300 gpm) of PIW provides makeup to the gas washer system, as well as to other miscellaneous uses.

b. Finishing Facilities Water System

Approximately 2020 m^3/hr (8900 gpm) of PIW is supplied to the finishing facilities as shown on Figure D-1. The cold mills, discharge 1230 m^3/hr (5400 gpm) to the upper dolomite pond (UDP) for primary settling. Wastes, in the amount of 750 m^3/hr (3300 gpm), requiring a higher degree of treatment, are discharged to the tin mill treatment plant which, after treatment, are still not suitable for reuse and are discharged to the FECP.

The minor water system (labeled wire mill) is shown on Figure D-1 and is a part of the cold mills and plating area. Wastewaters from rod pickling are treated, then combined with the nail galvanizing discharge and a portion of wire galvanizing water, and discharged directly to the Opossum Creek. The total flow is 45 m^3/hr (200 gpm).

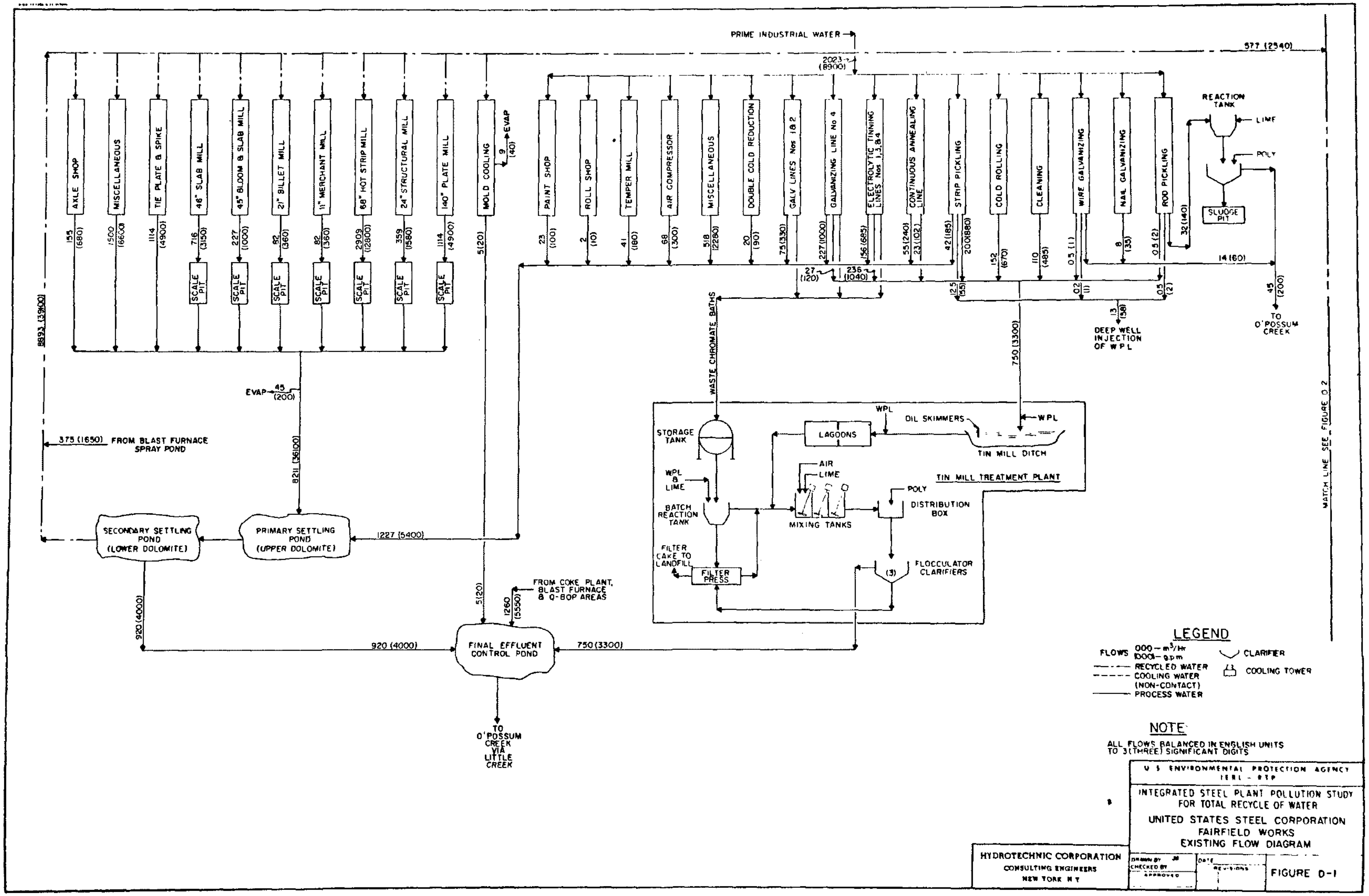
c. Hot Mills System

Virtually all of the water used is recycled from the secondary settling, or lower dolomite pond (LDP). Wastes from the 46-inch slab mill, the 45-inch blooming mill, and 21-inch billet mill, the 11-inch merchant mill, the 68-inch hot strip mill, the 24-inch structural mill and the 140-inch plate mill are treated in scale pits for gross solids removal and discharged to the UDP together with wastes from the axle shop, the tie plate and spike mill and other miscellaneous wastes. The total flow from these facilities is approximately 45 m^3/hr (200 gpm) is reported. Mold cooling receives approximately 13.6 m^3/hr (60 gpm) from the LDP of which 9 m^3/hr (40 gpm) is lost through evaporation and the balance of 4.5 m^3/hr (20 gpm) is discharged to the FECP.

The recycle line from the LDP combines with approximately 375 m^3/hr (1650 gpm) of cooled water from the blast furnace non-contact cooling system spray pond and provides 386 m^3/hr (1700 gpm) back to the blast furnace cooling system. Approximately 202 m^3/hr (890 gpm) is discharged, as makeup, to the blast furnace gas cleaning system and 920 m^3/hr (4050 gpm) is blown down to the FECP.

d. Blast Furnace Cooling and Boiler House System

This water system is composed of non-contact cooling waters from furnace cooling for blast furnaces 5,6,7 and 8, blast furnaces 5,6 and 7 boiler house and blast furnace 8



PRIME INDUSTRIAL WATER
577 (2540)
2023 (8900)
AXLE SHOP
MISCELLANEOUS
TIE PLATE & SPIKE
46" SLAB MILL
45" BLOOM & SLAB MILL
21" BILLET MILL
11" MERCHANT MILL
68" HOT STRIP MILL
24" STRUCTURAL MILL
140" PLATE MILL
MOLD COOLING
EVAP
PAINT SHOP
ROLL SHOP
TEMPER MILL
AIR COMPRESSOR
MISCELLANEOUS
DOUBLE COLD REDUCTION
GALV LINES Nos 1 & 2
GALVANIZING LINE No 4
ELECTROLYTIC TINNING LINES Nos 1, 3, & 4
CONTINUOUS ANNEALING LINE
STRIP PICKLING
COLD ROLLING
CLEANING
WIRE GALVANIZING
NAIL GALVANIZING
ROD PICKLING
REACTION TANK
LIME
POLY
SLUDGE PIT
SCALE PIT
TO O'POSSUM CREEK
DEEP WELL INJECTION OF W P L
WASTE CHROMATE BATHS
375 (1650) FROM BLAST FURNACE SPRAY POND
8893 (39100)
8211 (36100)
1227 (5400)
SECONDARY SETTLING POND (LOWER DOLOMITE)
PRIMARY SETTLING POND (UPPER DOLOMITE)
920 (4000)
750 (3300)
FINAL EFFLUENT CONTROL POND
FROM COKE PLANT, BLAST FURNACE & Q-BOP AREAS
1260 (5550)
TO O'POSSUM CREEK VIA LITTLE CREEK
STORAGE TANK
LAGOONS
OIL SKIMMERS
WPL
TIN MILL DITCH
TIN MILL TREATMENT PLANT
WPL & LIME
AIR
LIME
POLY
BATCH REACTION TANK
MIXING TANKS
DISTRIBUTION BOX
FILTER CAKE TO LANDFILL
FILTER PRESS
FLOCCULATOR CLARIFIERS
MATCH LINE SEE FIGURE D-2
LEGEND
FLOWS 000 – m³/Hr (000) – gpm
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
CLARIFIER
COOLING TOWER
NOTE
ALL FLOWS BALANCED IN ENGLISH UNITS TO 3 (THREE) SIGNIFICANT DIGITS
U S ENVIRONMENTAL PROTECTION AGENCY IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION FAIRFIELD WORKS EXISTING FLOW DIAGRAM
HYDROTECHNIC CORPORATION CONSULTING ENGINEERS NEW YORK N Y
FIGURE D-1

turboblower compressor. Approximately 5360 m hr (23,600 gpm) of non-contact cooling water from blast furnaces 5,6 and 7 is discharged to a spray pond for cooling. Of this, 4980 m^3/hr (21,900 gpm) is recirculated directly back to the blast furnaces and 375 m^3/hr(1650 gpm) is combined with LDP discharge. A combined LDP flow of 386 m^3/hr (1700 gpm) is returned to blast furnaces 5,6 and 7. Blast furnace 8 has its own cooling tower which receives 325 m^3/hr (1430 gpm) of PIW as makeup. Evaporative losses are 123 m^3/hr (540 gpm) from blast furnace 8 cooling tower and 182 m^3/hr (800 gpm) from the spray pond. A blowdown of 202 m^3/hr (890 gpm) from the blast furnace 8 cooling tower serves as makeup to the blast furnaces gas cleaning system. Additional makeup at the spray pond is 170 m^3 hr (750 gpm) blown down from the Q-BOP.

The boiler house and turboblower condenser loses approximately 550 m^3/hr (2460 gpm) through evaporation in the cooling system and blows down 455 m^3/hr (2000 gpm) to the FECP. These facilities receive 1020 m^3/hr (4460 gpm) of make-up water from the PIW system.

e. Blast Furnaces Gas Cleaning System

Approximately 3850 m^3/hr (16,930 gpm) is utilized for cleaning the blast furnace gas prior to use. Most of the water is reused and approximately 257 m^3/hr (1130 gpm) is blown down to the FECP and approximately 23 m^3/hr (100 gpm) is used for slag quenching at blast furnace 8. There is a system evaporative loss of approximately 114 m^3/hr (500 gpm). A make-up of 393 m^3/hr (1730 gpm) is provided from the LDP and from blast furnace 8 cooling tower blowdown.

f. Coke Plant

The sixth water system at Fairfield Works is the system at the coke plants where water is used for contact and non-contact cooling. All water supplied to the coke plant is PIW and the requirements are 630 m^3/hr (2770 gpm). Approximately 125 m^3/hr (550 gpm) is lost to coke quenching, 75 m^3/hr (330 gpm) is lost to cooling tower evaporation, 2.3 m^3/hr (10 gpm) goes out with the product and 427 m^3/hr (1880 gpm) is discharged to the FECP via the waste treatment plant.

g. Ultimate Disposal

Water is lost or discharged from the Fairfield Works by evaporation through cooling and quenching processes, with the product, by disposal in deep wells and by discharge to receiving bodies of water. The total treated wastewater discharged from the plant is reported to be 2936 m^3/hr (12900 gpm) discharged to Little Creek, and 45 m^3/hr (200 gpm), to Opossum Creek. See Figures D-1 and D-2.

1.2.3 Existing Wastewater Treatment Facilities

Wasterwater treatment facilities are installed at Fairfield Works for each of the systems described above for the purpose of recirculating water or for treatment prior to discharge. The treatment facilities are described below in the same order as the water systems previously described.

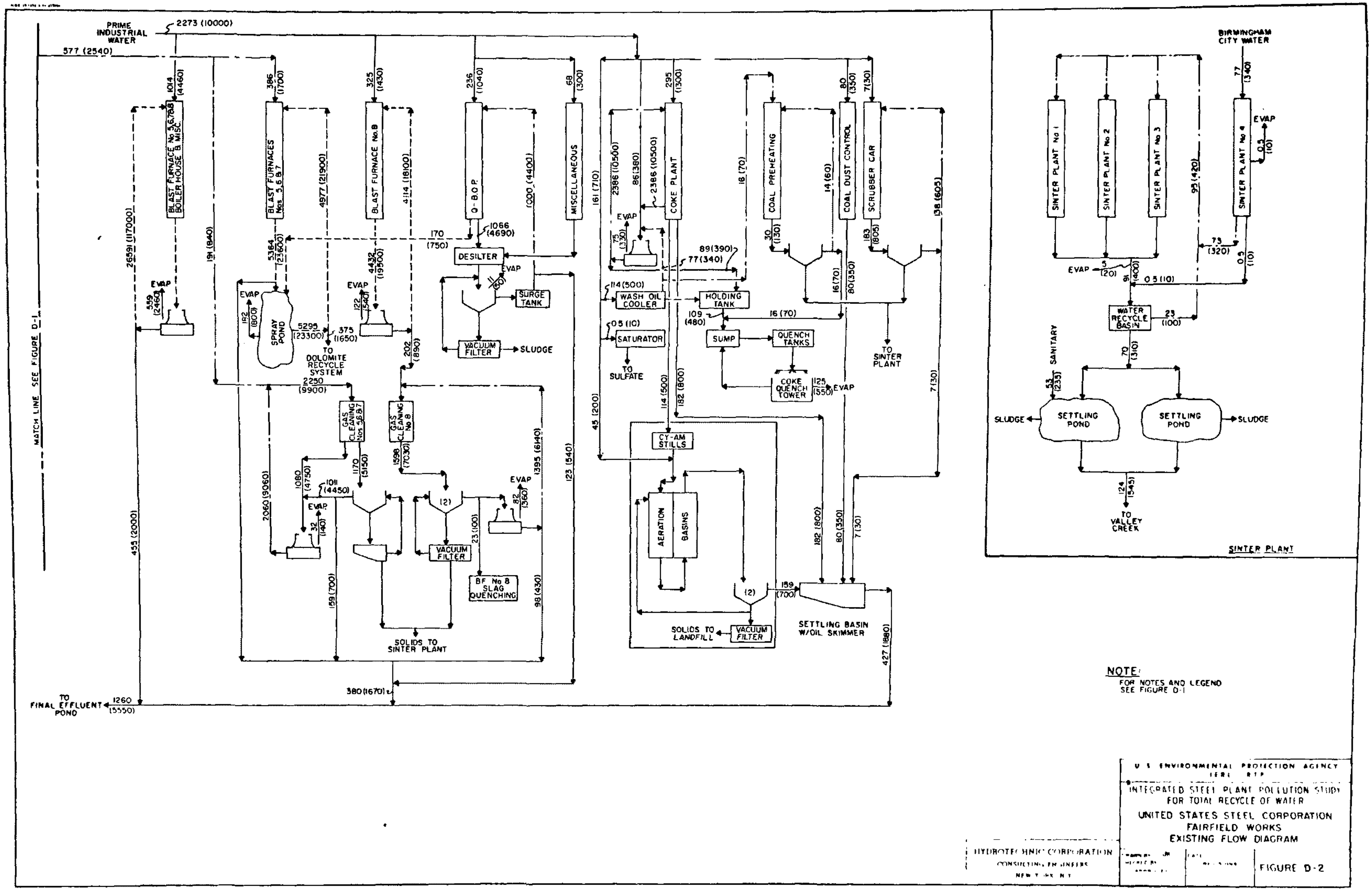
a. Steel Making

Water is used at the steel making facilities for equipment cooling and gas cleaning. Each of the Q-BOP vessels has an identical system. Skirt seals, quencher jackets and bell dampers use clean PIW on a once-through basis and discharge to the blast furnace spray pond. For hood cooling, the water is recirculated through an air cooled heat exchanger, PIW is used for trunnion cooling and maintaining quencher seals, and is discharged to the gas quencher-scrubber system. Miscellaneous contact water users, such as pump seals, receive PIW on a once-through basis and also discharge to the quencher system. The quencher-scrubber treatment system is unified for the three Q-BOP vessels. Approximately 1500 m^3/hr (6600 gpm) from the quencher and 68 m^3/hr (330 gpm) of miscellaneous wastes is discharged to a 7.6 m (25 ft) diameter desilter and then to a 36.5 m (125 ft) diameter clarifier for removal of suspended solids. The overflow from the clarifier flows to a surge tank from which 100 m^3/hr (4400 gpm) is recycled back to the quenching system and 123 m^3/hr (540 gpm) is blown down to the FECP. Evaporative losses in the Q-BOP systems are approximately 11.4 m^3/hr (50 gpm). Sludge drawn from the bottom of the clarifier is dewatered by one of the two vacuum filters and the dewatered solids are disposed of at landfills.

b. Finishing Facilities

Of the 16 facilities shown as part of the Finishing Facilities area of the Fairfield Works, eleven of these facilities discharge approximately 1230 m^3/hr (5400 gpm) directly to the UDP. The 32 m^3/hr (140 gpm) of rod pickling wastes are neutralized by lime in a reaction tank and then settled, with the aid of polymers, in a clarifier. The clarifier underflow is concentrated in a sludge pit and the clarifier overflow is discharged to Opossum Creek. Approximately 14 ^{3}/hr (60 gpm) of untreated water from the wire galvanizing and nail galvanizing mills combine with the clarifier overflow and discharge to Opossum Creek.

The balance of the wastes are discharged to the tin


PRIME INDUSTRIAL WATER
2273 (10000)
577 (2540)
BLAST FURNACE No. 5,6,7&8 BOILER HOUSE & MISC.
BLAST FURNACES Nos 5,6 & 7
BLAST FURNACE No. 8
Q-BOP
MISCELLANEOUS
COKE PLANT
COAL PREHEATING
COAL DUST CONTROL
SCRUBBER CAR
SPRAY POND
TO DOLOMITE RECYCLE SYSTEM
DESILTER
SURGE TANK
VACUUM FILTER
SLUDGE
GAS CLEANING Nos 5,6,&7
GAS CLEANING No. 8
BF No 8 SLAG QUENCHING
SOLIDS TO SINTER PLANT
WASH OIL COOLER
SATURATOR
TO SULFATE
HOLDING TANK
SUMP
QUENCH TANKS
COKE QUENCH TOWER
TO SINTER PLANT
CY-AM STILLS
AERATION
BASINS
SOLIDS TO LANDFILL
SETTLING BASIN W/OIL SKIMMER
EVAP
TO FINAL EFFLUENT POND
1260 (5550)
380 (1670)
MATCH LINE SEE FIGURE D-1
BIRMINGHAM CITY WATER
SINTER PLANT No 1
SINTER PLANT No 2
SINTER PLANT No 3
SINTER PLANT No 4
WATER RECYCLE BASIN
SANITARY
SETTLING POND
TO VALLEY CREEK
SINTER PLANT
NOTE:
FOR NOTES AND LEGEND SEE FIGURE D-1
U.S. ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION
FAIRFIELD WORKS
EXISTING FLOW DIAGRAM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK, N.Y.
FIGURE D-2

mill treatment plant via one of two routes. Chrome wastes from Galvanizing Lines 1,2 and 4 and from Electrolytic Tinning Lines 1,3 and 4 are discharged to a 38 m^3 (10,000 gal.) storage tank from tanks at the line. Periodically, the storage tank is dumped to a 38 m^3/hr (10,000 gal) batch reaction tank where waste pickle liquor and lime are added to precipitate the chrome hydroxide. The supernatant is then discharged to the tin mill treatment plant mixing tanks.

The balance of the flows from the cold mills and plating facilities are discharged to Tin Mill Ditch. Oil skimmers are installed at the effluent end of the ditch to remove free oils. At the head end of the ditch a small amount of waste pickle liquor from the paint line is added. The wastewater from the ditch then flows to two lagoons arranged in series. An additional 0.5 to 0.9 m^3/hr (2-4 gpm) of waste pickle liquor is added between the ditch and the lagoons. The flow from the lagoons is measured and discharged to a series of three mixing tanks. Air and lime are added to the first mixing tank. The treated flow from the third mixing tank is pumped to a distribution box where coagulant aid is added. The flow is then divided into one 30.5 m (100 ft) diameter and two 21.3 m (70 ft) diameter clarifiers. The 750 m^3/hr (3300 gpm) of combined clarifier overflow is then discharged to the FECP. The clarifiers' sludge underflow and the batch raction tank solids are dewatered in a filter press. Dewatered solids are disposed of at a landfill. Waste pickle liquor is disposed of in the deep well and an emergency storage lagoon, with a capacity of 3800 m^3 (1 million gallons), is provided in the event of well malfunction.

c. Blast Furnace Gas Cleaning

The water used for gas cleaning is recirculated through a solids removal and cooling treatment system. The gas cleaning waters first pass through spiral classifiers where the gross solids are separated prior to treatment in thickeners. Blast furnace 8 utilizes two thickeners and blast furnaces 5,6 and 7 are on a combined system utilizing one thickener. Approximately 23 m^3/hr (100 gpm) of the overflow from blast furnace 8 thickeners is used for slag quenching and the balance of 1570 m^3/hr (6930 gpm) is pumped to cooling towers. Blast furnaces 5,6 and 7 discharge approximately 1170 m^3/hr (5150 gpm) to their thickener and 1011 m^3/hr (4450 gpm) to their thickener and 1011 m^3/hr (4450 gpm) of the overflow is pumped to the cooling towers. The thickener blowdown of 159 m^3/hr (700 gpm) is directed to the FECP.

Gas cooling water at blast furnaces 5,6 and 7 is divided and 1170 m^3/hr (16900 gpm) is circulated to the gas cleaning systems. Required makeup, of 393 m^3/hr (1730 gpm), is from the LDP and blowdown of the blast furnace 8 furnace cooling tower. Underflow from the No.8 blast furnace thickeners is vacuum filtered and the solids are sent to the sinter plant with the dry dust collected in the dust catchers.

d. Blast Furnace Cooling

Furnace cooling water at blast furnaces 5,6 and 7 is discharged to a spray pond for cooling and recirculation. The water recirculation rate is 5360 m^3/hr (23600 gpm) of which approximately 182 m^3/hr (800 gpm) is evaporated. Makeup to the system is 170 m^3/hr (750 gpm) from the Q-BOP directly to the spray pond and 386 m^3/hr (1700 gpm) from the LDP recirculation system. A spray pond blowdown of 318 m^3/hr (1400 gpm) is directed to the LDP recirculation system.

Blast furnace 8 uses 4430 m^3/hr (19500 gpm) which is cooled in cooling towers and recirculated. An estimated 123 m^3/hr (540 gpm) is lost through evaporation and 202 m^3/hr (890 gpm) is blown down to the blast furnace gas cleaning system. The 325 m^3/hr (1430 gpm) makeup is from the PIW system.

c. Coke Plant

All coke plant wastewaters are treated prior to discharge and all non-contact gas cooling water is cooled and recycled. The blowdown is used as makeup for the coke quenchers.

The coke plant waste treatment facilities treat 34 m^3/hr (150 gpm) of excess ammonia liquor and 80 m^3/hr (350 gpm) of miscellaneous wastewaters. The treatment facilities consist of oil removal in gravity separators and removal of ammonia and other gases at free and fixed ammonia stills. The bottom stream from the stills is settled in a clarifier for the removal of excess lime and other suspended solids. Clarifier underflow is pumped to a thickener and the overflow is directed to a 3800 m^3 (1 million gallon) equalization tank. A flow of 114 m^3/hr (500 gpm) is pumped from the equalization tank and blended with 45 m^3/hr (200 gpm) of PIW dilution water. This diluted wastewater is then treated in two 3800 m3 (1 million gallon) aeration basins operated in series for biological degradation. The effluent from the aeration basins flows to two clarifiers where the solids are settled out. A portion of the sludge is recycled to the aeration basins to maintain a mixed liquor suspended solids level adequate for the biological treatment. The excess sludge is discharged to the thickener which also receives the lime sludge clarifier underflow. The overflow from the biological system clarifiers is discharged to the FECP via a final settling basin.

This final settling basin installed after the clarifier receives 161 m^3/hr (700 gpm) from the biological treatment system, 80 m^3/hr (350 gpm) from coal handling dust control, 136 m^3/hr (600 gpm) from miscellaneous cooling, 45 m^3/hr (200 gpm) of condensate and 6.8 m^3/hr (30 gpm) of pusher scrubber car discharge from the new coke oven battery. Oil is skimmed off the surface and a total of 427 m^3/hr (1880 gpm) is discharged to the FECP.

Coal preheating facilities are utilized at the new coke battery which require 29.5 m^3/hr (130 gpm) for scrubbing and sealing. The flow is discharged to a clarifier from which 13.6 m^3/hr (60 gpm) is recirculated and the remaining 15.9 m^3 (70 gpm) is discharged to the biological treatment plant. A makeup of 15.9 m^3/hr (70 gpm) is from the PIW system.

1.2.4 Air Pollution Control Facilities

Air pollution emanating from the processes at the various production facilities at Fairfield Works is controlled by facilities installed at the coke ovens, iron making, steel making, tin mills, wire mill and at the galvanizing line.

At the coke plant area a new coke battery, designed No. 2 coke battery, is equipped with coal preheating facilities, hot larry cars, stage charging, a scrubber car to control pushing emissions, and a conventional quench tower with baffles. Existing coke batteries, Nos. 5 and 6 have no problems at the stacks, since they are presently in compliance with regulations and it is anticipated that, after the rebuilding of battery No. 9, it too, will be in compliance. Battery No. 2 will also have pushing controls, but there are no provisions at the other two batteries for the control of fugitive pushing emissions.

The blast furnaces' gases are cleaned prior to use in the stoves and boiler houses. The gas cleaning facilities consist of dry dust catchers and high energy scrubbers.

The steelmaking Q-BOP facilities gases are cleaned using high energy scrubbers which are reported to be 99.8 percent efficient and the plant meets particulate stack emission regulations. In order to control the significant fugitive emissions during charging and tapping of the vessels, the plant is developing improvements to the sealing arrangements for the vessels, including the provision of a secondary collection system. Facilities to control emissions at the hot metal mixers are also being installed. The pollution control flux handling system at the Q-BOP consists of a bag house which is reported to be more than 99 percent efficient.

At the tin mills there are gravity collectors for removal of particulates which result from shot blasting operations and wet scrubbers over the cleaning section for alkaline removal, over the pickling lines for acid mist removal and over the cold reduction lines for oil mist removal. At the wire mill there is a vapor recovery system installed at the vapor degreasing operations. The No. 4 galvanizing line has a scrubber installed at the strip cleaning section.

All of the above are reportedly operating satisfactorily.

2.0 PROPOSED PROGRAM

2.1 GENERAL

Fairfield Works is presently discharging one of the lowest quantities of water, based on m^3/kkg (gal/ton) of steel produced, of any of the integrated steel plants in the United States. The ultimate objective of this study is to determine the means by which the plant could possibly arrive at total recycle of water with the exception of area runoff and sanitary sewage. It is recognized that to reach this objective there must be methods of disposal or regeneration of water that can no longer be recirculated. The total recycle objective is aproached in a stepwise manner, whereby, recommendations are made to meet the quality requirements of BAT and then, by addition, to meet the total recycle criteria.

The plant presently disposes of water by discharge to Opossum Creek and by evaporation. A large portion of the process and cooling water is presently recirculated and the existing facilities needed for the recirculation systems, whenever possible, are incorporated in the expanded systems for BAT and total recycle. In some cases recommendations for additional facilities are made, in others different modes of water use are recommended, causing the quality of water used for processes to be lowered.

2.2 WATER RELATED MODIFICATIONS TO AIR QUALITY CONTROL

Analysis of the Fairfield Works air emissions indicates that the plant is, at virtually all sources, either meeting emission regulations or has instituted programs to meet or exceed regulations.

At the coke plant, scrubber cars will be used at coke batteries No. 2 and No. 9 to control fugitive pushing emissions. It is recommended that an additional scrubber car be installed at Nos. 4 and 6 batteries to control their fugitive emissions. The use of water is estimated to be 112 m^3/hr (495 gpm) with a blowdown of 37.5 m^3/hr (165 gpm). This blowdown would be combined with the No. 2 battery blowdown of 6.8 m^3/hr (30 gpm).

2.3 PLANT MODIFICATIONS TO MEET BAT

2.3.1 General

The Fairfield Works presently provides treatment for all wastewater prior to discharge. Plant data indicates that when each production source is considered individually, some do not meet the BAT discharge requirements. However, in the combined discharge from the FECP, the data provided shows that the plant meets the requirements for suspended solids and oils and grease.

The approach taken in this section of this report is based on point sources as described in the Effluent Limitations Guidelines because of the mass limitations described for specific plant areas such as the coke plant, blast furnaces and electroplating. BAT limitations were used without regard to existing permitted discharges.

The allowable BAT discharges from Fairfield Works, based on production, are shown on Table D-1.

The effluent water from the coke plant wastwater treatment plant apparently does not meet the discharge requirements for suspended solids, ammonia and cyanide. Data is not available on blast furnaces discharges of ammonia, cyanide, fluoride, phenols or sulfide. It is assumed that, for Blast Furnaces 5,6 and 7, the required levels for these parameters are not being met. Fairfield has stated that the treated discharges for new Blast Furnace 8 will meet the BAT chemistry for discharge. The treated discharge from the Q-BOP facilities apparently exceeds the required level for suspended solids and it is assumed fluorides may also be in excess, although data is not available. The Tin Mill Treatment Plant does meet discharge requirements for suspended solids, oils and grease but the treatment facilities appear to be adequate for meeting all BAT requirements if there is proper operation and maintenance.

2.3.2 Finishing Facilities

The finishing facilities consist of cold reduction, cleaning, annealing, pickling and plating operations. Wastes from galvanizing, electrolytic tinning, cleaning, continuous annealing, pickling and cold reduction facilities are presently treated at the Tin Mill Treatment Plant. However, there are different allowable discharges for each of these process

TABLE D-1

ALLOWABLE DISCHARGES AS PERMITTED UNDER BATEA LIMITATIONS

Production Facility	Daily Production kkg/tons	Daily Allowable Discharges (kkg/day) (lb/day) S.S.	O&G	CN	NH_3	S^-	Phenol	BOD_5	F^-	Zn	Mn	NO	SN	Pb	Fe (diss)	Cr^{+6}	Cr (tot)	Cr (diss)	Ni (diss)	Cu (diss)
By-Product Coke	5960/6570	62.1 137.	24.9 55.	0.59 1.3	24.9 55.	0.73 1.6	1.27 2.8													
Blast-Furnaces	9767/10766	127. 280	- -	1.27 2.8	50.8 112.	1.54 3.4	2.54 5.6	- -	102. 224.											
Q-BOP	6050/6669	31.3 69.							25.4 56.											
45-inch Blooming	3418/3768	3.8 8.4	3.8 8.4																	
46-inch Slab	4666/5143	5.1 11.2	5.1 11.2																	
21-inch Billet	1241/1368	1.4 3.1	1.4 3.1																	
Plate Mill	1666/1836	10.7 23.5	10.7 23.5																	
68-inch Hot Strip	5051/5568	No Discharges Permitted																		
Structural Mill	1059/1167	No Discharges Permitted																		
Merchant Mill	612/675	No Discharges Permitted																		
48-inch Pickling	1744/1923	9.1 20.0	3.7 8.1												0.37 0.81					
56-inch Pickling	2300/2535	12.0 26.4	4.8 10.6												0.48 1.1					
Rod Pickling	509/561	4.2 9.3	1.7 3.8												0.17 0.38					
38-inch Cleaning	629/693	3.3 7.2													0.13 0.28			0.06 0.14	0.03 1.07	

TABLE D-1

ALLOWABLE DISCHARGES AS PERMITTED UNDER BATEA LIMITATIONS
(continued)

Production Facility	Daily Production kkg/tons	Daily Allowable Discharges (kkg/day) (lb/day) S.S.	O&G	CN	NH_3	S^-	Phenol	BOD_5	F^-	Zn	Mn	NO	SN	Pb	Fe (diss)	Cr^{+6}	Cr (tot)	Cr (diss)	Ni (diss)	Cu (diss)
43-inch Cleaning	795/876	4.1 9.1													0.16 0.35			0.08 0.18	0.04 0.09	
38-inch Cont. Annealing	822/906	4.3 9.4													0.16 0.36			0.08 0.18	0.04 0.09	
54-inch Tandem	2218/2445	231. 510.	92.5 204												9.3 20.5					
52-inch Tandem	1976/2181	206. 455.	82.4 182.												8.3 18.3					
48-inch Double Cold Reduction	618/681	64.4 142.	25.8 56.8												2.6 5.7					
38-inch Tinning No. 1	457/504	No Discharges Permitted																		
35-inch Tinning No. 3	357/393	No Discharges Permitted																		
38-inch Tinning No. 4	454/501	No Discharges Permitted																		
Galvanizing No. 1	278/306	7.2 15.8	2.9 6.4							0.58 1.3						0.006 0.013	0.6 0.13			
Galvanizing No. 2	411/453	10.7 23.6	4.3 9.5							0.85 1.9						0.009 0.02	0.09 0.2			
Galvanizing No. 4	836/921	21.7 47.8	8.8 19.4							1.74 3.8						0.017 0.037	0.17 0.37			
Galvanizing Wire	267/294	27.8 61.3	11.1 24.5	0.3 0.6					16.7 36.8	0.22 0.49					1.1 2.5	0.002 0.005	0.02 0.05	0.56 1.2	0.3 0.6	0.3 0.6

operations. The electroplating point source category, under BAT requires zero discharge. The justification for this requirement is questionable since the guideline data is based on small plating operations rather than the massive plating lines associated with steel plants. However, to meet this goal, modifications to the existing Tin Mill Treatment Plant would be required with respect to the wastes that are treated and additional unit processes that would be needed.

Flows to the plant should be segregated so that the wastes from Galvanizing Line No. 4, Tinning Lines 1,3 and 4 and Wire Galvanizing, totaling 264 m^3/hr (1160 gpm) flow directly to the treatment plant lagoons. The flows from continuous annealing, strip pickling, cold rolling, cleaning and rod pickling (486 m^3/hr (2140 gpm) should be segregated and continue to flow to the Tin Mill Ditch. After acid addition and oil skimming in the ditch these flows should by-pass the chemical treatment portion of the treatment plant and be pumped to two of the clarifiers for settling before discharge to the FECP.

The flows to the lagoons should be treated in the treatment plant. However, after clarification the flow should be filtered and demineralized and the product water returned to the tinning lines for use as solution makeup water or for other high quality water requirements. The brine reject stream should be evaporated to dryness and the 9.6 m^3 (12.5 cu. yd.) of dried solids produced per day disposed of in a lined and covered storage area.

2.3.3 Q-BOP Area

The direct contract wastewater discharge of 123 m^3/hr (540 gpm) from the three Q-BOP units should be diverted from the FECP and used as makeup at the blast furnace gas cleaning systems. This modification is suggested because the treated discharge from the Q-BOP area is of adequate quality for blast furnace system makeup and, since the same restriction with respect to fluoride applies to both blast furnace and Q-BOP wastes, it would be advisable to treat both together.

2.3.4 Blast Furnaces

Blast Furnaces 5,6 and 7 gas cleaning systems, under BAT point source discharges, have a blowdown limitation of 141 m^3/hr (622 gpm). A flow of 136 m^3/hr (600 gpm) has been assumed in this discussion to be the limiting value. The Q-BOP blowdown of 123 m^3/hr (540 gpm) can be used for a portion of the makeup requirements with the balance of 45.5 m^3/hr (200 gpm) drawn from the LDP recycle line. Under these conditions the dissolved solids in the blowdown would be 1330 mg/l. This flow should be treated with lime to precipitate the fluorides present and then pumped to the coke plant biological treatment plant for phenol, cyanide and ammonia removal.

The allowable discharge at blast furnace 8, under BAT, is 71 m^3/hr (312 gpm) as opposed to the present flow of 120 m^3/hr (530 gpm) which includes the water used to quench slag. However, due to the dissolved solids concentration in the water and anticipated air pollution restrictions, it is suggested that the quenching of slag with blast furnace gas cleaning water be discontinued and replaced with boiler house cooling tower blowdown. At a discharge rate of 68 m^3/hr (300 gpm) to the FECP the suspended solids are anticipated to be 14 mg/l and the dissolved solids approximately 1300 mg/l. No further treatment is suggested prior to discharge to the FECP. Makeup requirements to blast furnace 8 gas cleaning system will be reduced to 150 m^3/hr (660 gpm) and blast furnace 8 furnace cooling water blowdown should be reduced to that amount.

2.3.5 Coke Plant

The present practice of using PIW for dilution at the Coke Plant waste treatment plant should be altered to use other sources. Suggested sources for this dilution water are the 136 m^3/hr (660 gpm) blowdown from blast furnaces 5,6 and 7 gas washer system and the 44 m^3/hr (195 gpm) from the coke pushing scrubber car blowdown. If these two flows enter the treatment system after the CY-AM stills the discharge from the treatment plant to the final settling basin would be approximately 294 m^3/hr (1300 gpm) with a dissolved solids concentration of 2330 mg/l. The total flow from the settling basin would then be 557 m^3/hr (2450 gpm) with a dissolved solids concentration of 1470 mg/l. Coal dust control could use 80 m^3/hr (350 gpm) to replace PIW and the balance discharged to the FECP.

If the coke plant wastewater treatment plant is to meet the BAT requirements at a flow rate of 477 m^3/hr (2100 gpm) the concentration of ammonia and cyanides would have to be 5.2 and 0.1 mg/l, respectively. To accomplish this, the existing facilities would have to be upgraded by either adding additional treatment facilities and/or by modifying the present operation.

The existing facilities should be modified and expanded by providing an additional 1890 m^3 (500,000 gal) of aeration capacity and adding two additional clarifiers. The system should then be operated in two stages for both carbonaceous and nitrogenous BOD removal. Aeration time in each stage should be a minimum of 16 hours with settling and sludge return to the influent of each stage.

Alternatively, the existing basins could be modified to accommodate two stages of rotating biological contactors or a fluidized biological reactor could be provided to nitrify the excess ammonia.

A detailed testing and treatability program would have to be undertaken prior to the implementation of any treatment modification for this system.

Since the suspended solids discharged are in excess of those permitted under BAT the effluent from the final settling basin may have to be filtered prior to the discharge to the FECP. Backwash facilities would then be required with the filtration operation. See Figure D-3.

2.3.6 Blast Furnace Boiler House and Turboblowers

Although consideration had been given to replacing the source of water used at the boiler house and turboblowers from PIW to recycled LDP water to reduce the quantity of water discharged, the plant has informed us that they had also considered this modification. It was rejected by them due to anticipated scaling problems and also, their heat exchangers would not be capable of operating because of the elevated temperatures of the LDP water.

2.3.7 Material Storage Pile Runoff

Effluent guidelines have set, as a limit of material storage pile runoff, 25 mg/l suspended solids. To meet this limit, while minimizing the amount of treatment to be provided a collection pond should be installed that will contain the runoff from a "once in ten years 24-hour storm." The storage volume required, using a runoff coefficient of 0.95, would be 35000 m^3 (1,235,000 ft^3). With an effective storage depth of 3 m (10 ft), an area of 1.1 ha (2.8 acres) would be required. Most of the solids carried off the storage piles should settle in the pond. The retained water would then be pumped at a nominal rate of 23 m^3/hr (100 gpm) to the FECP, thus allowing for each day's pumping, a sufficient volume to retain an additional 2.4 mm (0.09 inches) of rainfall.

Settling Pond No. 4 near the sheet mills is apparently sufficient to contain the storm flows.

2.3.8 Sinter Plant

There are two alternative methods available for the Fairfield Works to meet the requirements of BAT at the sinter plant, one of which also accomplishes total recycle.

The first method is to return all of the water from the water recycle basin. At the present time only 23 m^3/hr (100 gpm) is returned to sinter plants, 1,2 and 3. The remaining 70 m^3/hr (310 gpm) would be recycled back for use in ore and flue dust blending. In addition to the above it is suggested that the storm water runoff from the material storage piles be collected and piped to the settling ponds and all other storm water from the plant area by bypassed around the pond. However, the plant states that it would be impossible for them to use the quantity of water proposed for recyle back for use as bland water.

The second alternative provides for treatment of the process wastes. The present degree of treatment provides for removal of suspended solids and oils but there is no provision for the removal of other regulated contaminants, i.e., sulfide and fluoride.

To provide for treatment to lower concentrations than those permitted under BAT, the following modifications and additions should be provided at the existing ponds:

1. Pipe all of the process flows presently being discharged from the sinter plant to Pond No. 1.

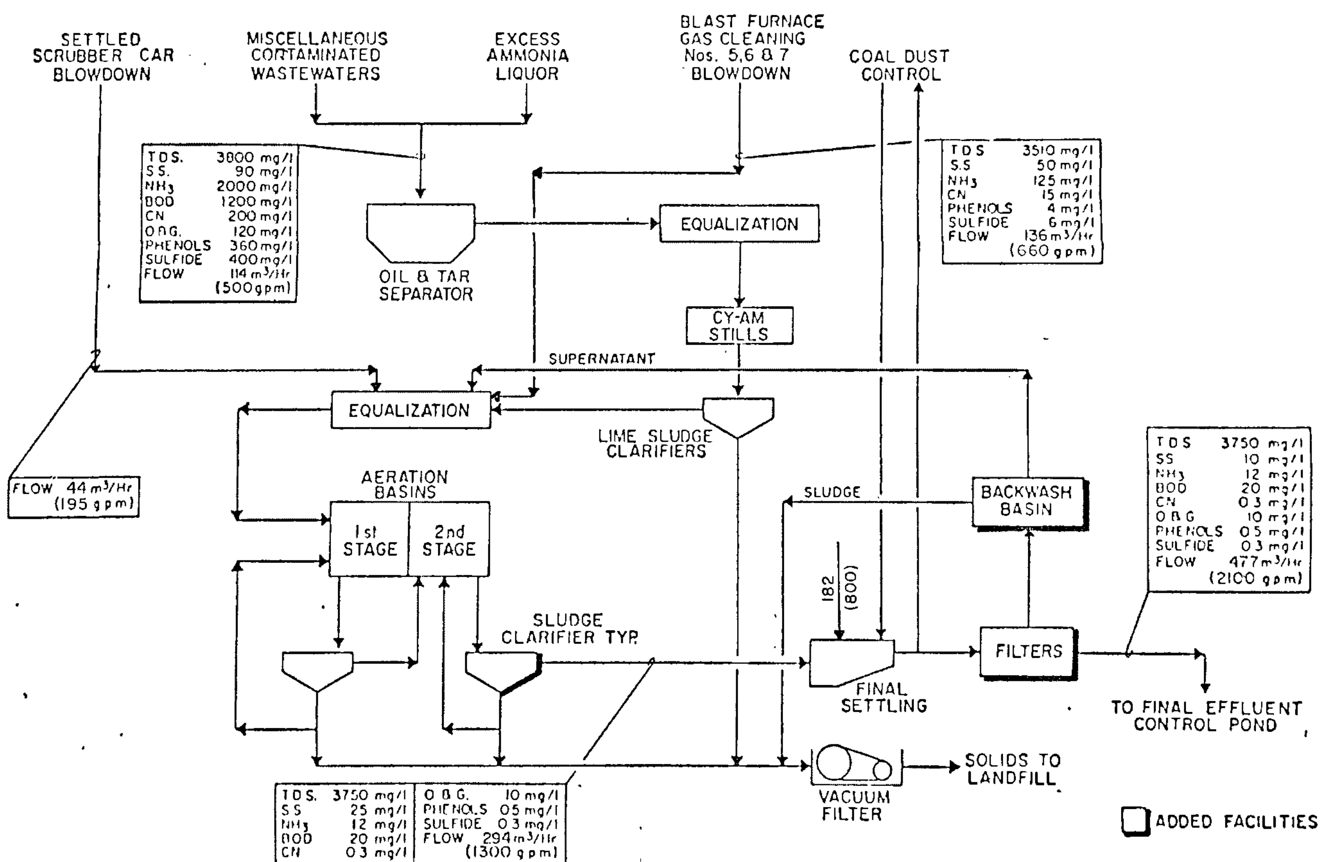
2. Pipe all of the treated sanitary wastes to Pond No. 2.

3. Collect storm water runoff from the material storage areas and pipe it to Pond No. 2.

4. Divert all other area storm runoff around the settling ponds and discharge it directly to the ditch at Outfall 029.

5. Collect the effluent from Pond No. 1 and pump it to a treatment facility.

6. Install a two stage treatment facility consisting of an aeration basin and a lime mixing basin. The effluent from the lime



HYDROTECHNIC CORPORATION
NEW YORK, N.Y.

PROPOSED COMBINED COKE PLANT AND BLAST FURNACE WASTE TREATMENT

FIGURE D-3

mixing basin would have the pH adjusted with acid and discharged to Pond No. 2 for final settling. Final discharge would be to Outfall 029.

At an anticipated once-in-ten-year 24 hours rainfall from the material storage areas it is anticpated that the overflow rate and detention time in one pond would be sufficient to provide a suspended solids effluent of 25 mg/l as required.

2.3.9 Final Effluent Control Pond

With the additions of the in-plant modification recommended no additional treatment will be required at the FECP since each production area will meet the respective BAT requirements.

2.4 TOTAL RECYCLE

2.4.1 General

To achieve total recycle of water in the most efficient and cost effective manner, maximum reuse of water must be accomplished prior to any ultimate treatment. Water from one process must be cascaded to another. In view of the minimum water quality requirements at the Fairfield Works, as supplied by the U.S. Steel Corporation, large quantities of water must be treated. It is recommended that first a detailed survey of the plant processes and materials of construction be made to establish more firmly what minimum quality of water is acceptable at each process. The analyses and recommendations presented in this section are based on the minimum quality requirement as provided by U.S. Steel and upon the judgment of Hydrotechnic, where qualities were not provided.

In the previous section various recommendations were made to reuse water prior to discharge to achieve a discharge quality suitable to meet BAT with the anticipation that zero discharge would be a following step. In this section further reduction in water use is recommended to effect minimal ultimate treatment in the achievement of total recycle of water.

A major plant modification that will be required to achieve total recycle of process water will be to segregate all flows that are due to precipitation from the existing plant sewer systems and collect only those waters discharged as a result of plant manufacturing processes and runoff from material storage piles for ultimate treatment. With this accomplished the following recommendations are made:

2.4.2 Q-BOP Area

Presently approximately 170 m^3/hr (750 gpm) is discharged to blast furnace 5,6 and 7 spray ponds. This quantity should be returned to the Q-BOP area and 68 m^3/hr (300 gpm) used for miscellaneous purposes and 102 m^3/hr (450 gpm) utilized for purposes other than non-contact cooling. Water would continue to be drawn from the PIW system for the additional makeup of 134 m^3/hr (590 gpm). The blowdown from the surge tank should be used for makeup to the blast furnaces gas cleaning systems described below.

2.4.3 Blast Furnaces

The dissolved solids level in the gas cleaning systems should be increased to 3500 mg/l. If the Q-BOP blowdown of 75 m^3/hr (330 gpm) is used as makeup water at blast furnaces 5,6 and 7 this level of dissolved solids can be maintained by blowing down 43 m^3/hr (190 gpm).

At blast furnace 8, 48 m^3/hr (210 gpm) of blowdown from the Q-BOP and a reduced blowdown of 59 m^3/hr (260 gpm) from No. 8 furnace cooling tower can be used for makeup water. Dissolved solids levels of 3500 mg/l can be maintained by blowing down 25 m^3/hr (110 gpm).

Blowdown flows from both blast furnace gas cleaning systems should be combined and sent to the coke plant wastewater treatment plant for use as dilution water.

2.4.4 Coke Plant

The systems described in Section 2.3.5 would be required prior to discharge to the FECP with the following differences: the flow passing through the biological systems would be reduced to 250 m^3/hr (1100 gpm) and filtration would not be required for the 432 m^3/hr (1800 gpm) discharged from the settling basin before discharge to the FECP.

2.4.5 Blast Furnace Boiler House and Turboblowers

No changes in the blast furnace boiler house and turboblowers other than those described in Section 2.3.5 are recommended under total recycle conditions.

2.4.6 Material Storage Pile Runoff

No additional facilities other than those described in Section 2.3.6 are suggested for material storage pile runoff.

2.4.7 Sinter Plant

The consumptive use of water at the sinter plant cannot be reduced by reuse of the process water presently being discharged. The material storage pile runoff should, therefore, be exempted from the zero discharge provision. Under the total recycle concept the following provisions should be added to the treatment system prepared under Section 2.3.7.

A dissolved solids removal facility complete with filter should be installed and approximately 18 m^3/hr (80 gpm) of the total discharge treated. The balance of the flow (52 m^3/hr (230 gpm) should be combined with the treated water and recycled back to the sinter plant for reuse. This system would replace the chemical treatment system described in Section 2.3.7. The reject stream, estimated to be 4.5 m^3/hr (20 gpm), would have to be evaporated to dryness.

2.4.8 Final Effluent Control Pond (FECP)

The total flows to the FECP, under total recycle conditions, would be:

Source	Flow m^3/hr	Flow gpm	Estimated TDS (mg/l)
Coke Plant and Material Storage Pile Runoff Pond	477	2100	1500
Blast Furnace 5, 6 & 7 Boiler House	420	1850	65
Finishing Facilities	502	2340	1200
LDP	1102	4850	200
Mold Cooling	5	20	200
Total	2536	11200	630 ave.

The dissolved solids concentration in the FECP water would then be 630 mg/l. If the plant requires water with a maximum of 125 mg/l dissolved solids a reverse osmosis or similar unit would be required. A two-stage reverse osmosis system with filtration, intermediate lime softening and drying would be required. An estimated 33.6 tons per day of dried soluble solids would be rejected by the system. To provide for disposal of these and 10 tons per day of solids from the finishing mills, a lined and covered pond would be necessary so that leaching into the ground would be prevented during periods of precipitation. Assuming a bulk density of 961 kg per m^3 (60 pounds per cubic foot) and assuming storage capacity for 10 years of solids production a lined area of 4.92 hectares (12.2 acres) 3 meters (10 feet) deep would be required.

Figures D-4 and D-5 show the flows under BAT conditions and Figures D-6 and D-7 show the flows under total recycle conditions.

Figure D-8 shows the locations of the proposed facilities. The sinter plant is not shown due to its remoteness from the main body of the plant.

2.4.9 Feasibility

Proposals made in Section 2.3 and 2.4 of this report, of necessity, require that there be considerable segregation of flows, i.e., process waters, non-contact cooling water and storm water. It is recognized that there are technical and economic problems that will be associated with this separation process, but without specific knowledge of the in-plant and in-mill sewer systems quantification at this stage is impossible. Difficulties may include:

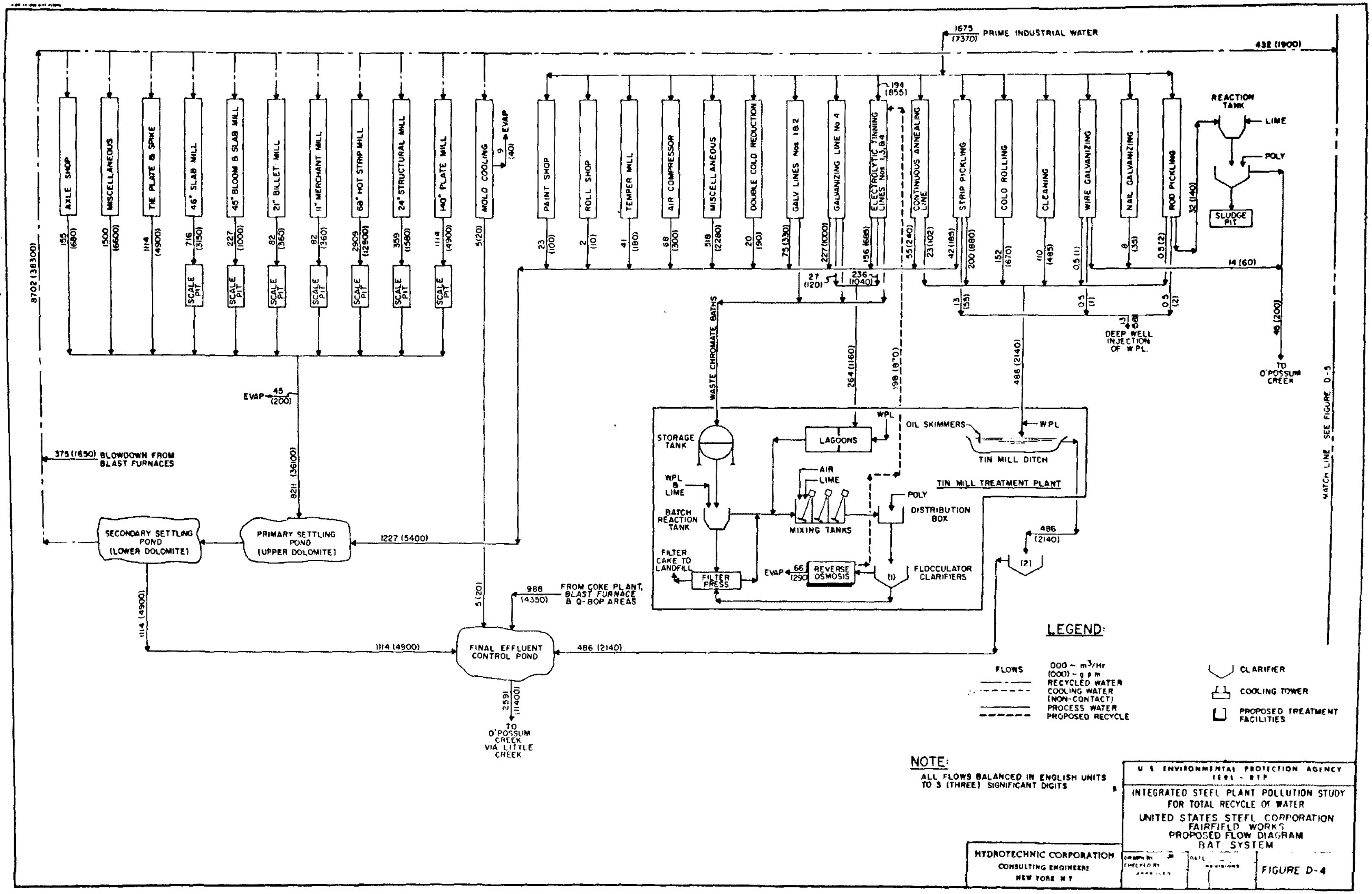
1. Shutdown of a mill during the period that waters are segregated and divided.

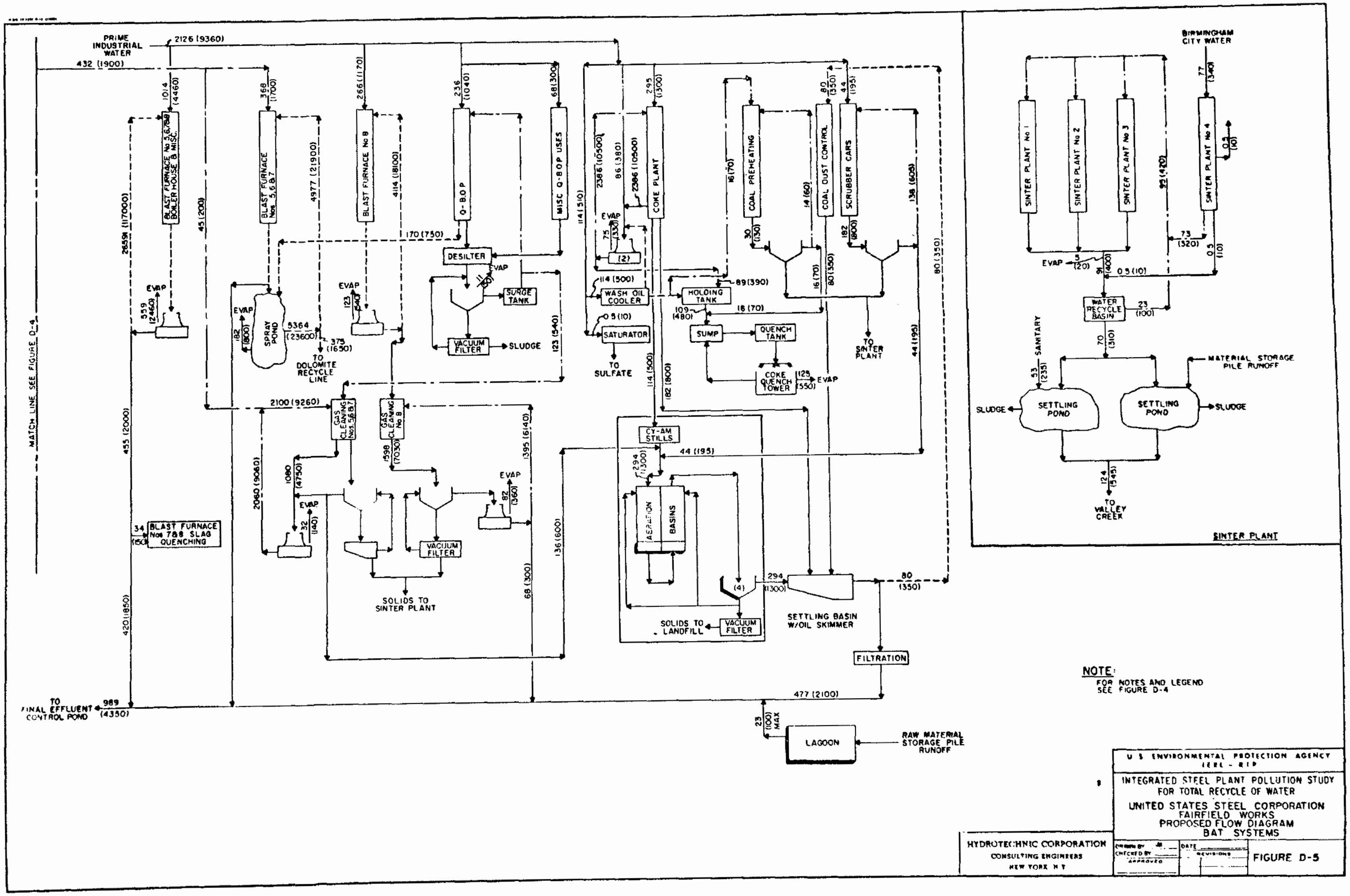
2. Space availability for pumping stations that may be required to divert process and cooling waters.

3. Diversion of process flows directly to treatment facilities from the open ditches they now flow in.

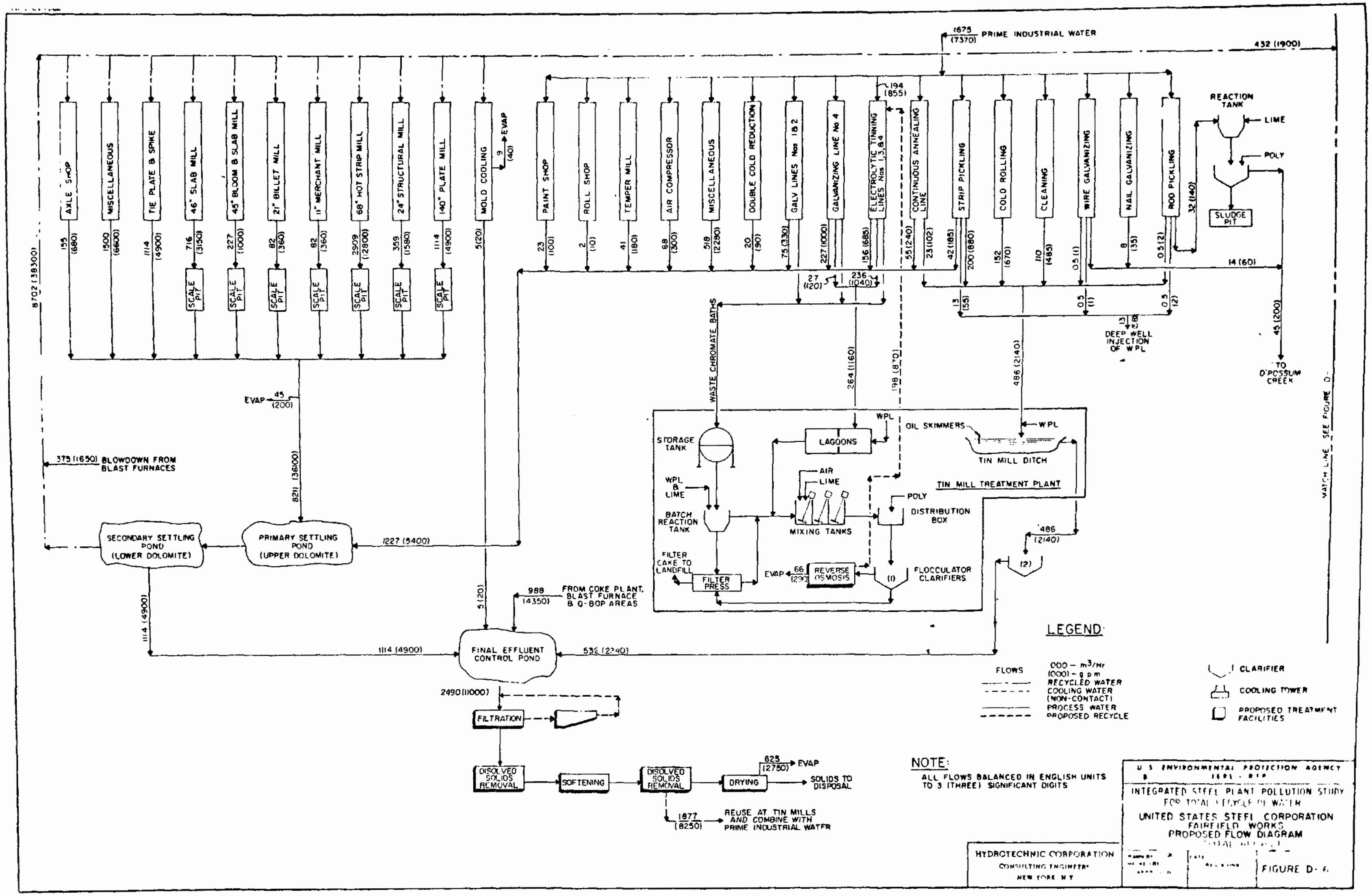
4. Diversion of storm flows around treatment facilities.

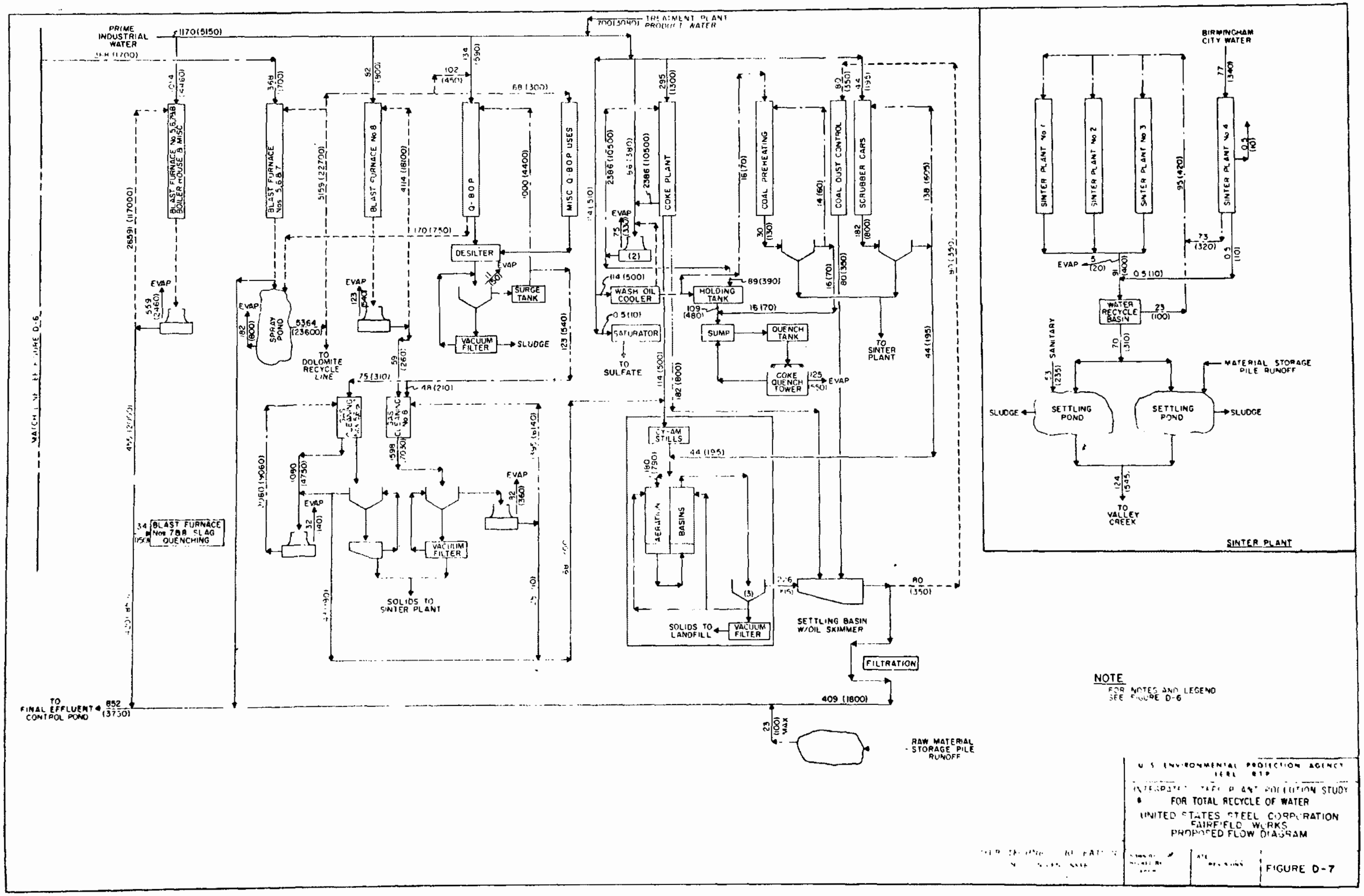
It must be stressed that, prior to considering the possibility of implementing any of the plans indicated in this report, a detailed analysis of each mill's water and wastewater system must be performed. In addition a testing program must be conducted to establish the design parameters for the systems suggested.


1675 (7370) PRIME INDUSTRIAL WATER
432 (1900)
AXLE SHOP
MISCELLANEOUS
TIE PLATE & SPIKE
46" SLAB MILL
45" BLOOM & SLAB MILL
21" BILLET MILL
11" MERCHANT MILL
68" HOT STRIP MILL
24" STRUCTURAL MILL
140" PLATE MILL
MOLD COOLING
EVAP 9 (40)
PAINT SHOP
ROLL SHOP
TEMPER MILL
AIR COMPRESSOR
MISCELLANEOUS
DOUBLE COLD REDUCTION
GALV LINES Nos 1 & 2
GALVANIZING LINE No 4
ELECTROLYTIC TINNING LINES Nos 1,3 & 4
CONTINUOUS ANNEALING LINE
STRIP PICKLING
COLD ROLLING
CLEANING
WIRE GALVANIZING
NAIL GALVANIZING
ROD PICKLING
194 (855)
REACTION TANK
LIME
POLY
SLUDGE PIT
SCALE PIT
8702 (38300)
EVAP 45 (200)
8211 (36100)
379 (1650) BLOWDOWN FROM BLAST FURNACES
SECONDARY SETTLING POND (LOWER DOLOMITE)
PRIMARY SETTLING POND (UPPER DOLOMITE)
1227 (5400)
1114 (4900)
5 (20)
988 (4350) FROM COKE PLANT, BLAST FURNACE & Q-BOP AREAS
FINAL EFFLUENT CONTROL POND
486 (2140)
2591 (11400)
TO O'POSSUM CREEK VIA LITTLE CREEK
27 (120)
236 (1040)
14 (60)
DEEP WELL INJECTION OF W.P.L.
48 (200)
TO O'POSSUM CREEK
WASTE CHROMATE BATHS
264 (1160)
198 (870)
486 (2140)
STORAGE TANK
LAGOONS
WPL
OIL SKIMMERS
TIN MILL DITCH
TIN MILL TREATMENT PLANT
WPL & LIME
BATCH REACTION TANK
AIR
LIME
MIXING TANKS
POLY
DISTRIBUTION BOX
FILTER CAKE TO LANDFILL
FILTER PRESS
EVAP 66 (290)
REVERSE OSMOSIS
FLOCCULATOR CLARIFIERS
MATCH LINE SEE FIGURE D-5
LEGEND:
FLOWS 000 – m³/Hr (000) – g p m
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO 3 (THREE) SIGNIFICANT DIGITS
U S ENVIRONMENTAL PROTECTION AGENCY IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION FAIRFIELD WORKS
PROPOSED FLOW DIAGRAM BAT SYSTEM
HYDROTECHNIC CORPORATION CONSULTING ENGINEERS NEW YORK N Y
FIGURE D-4

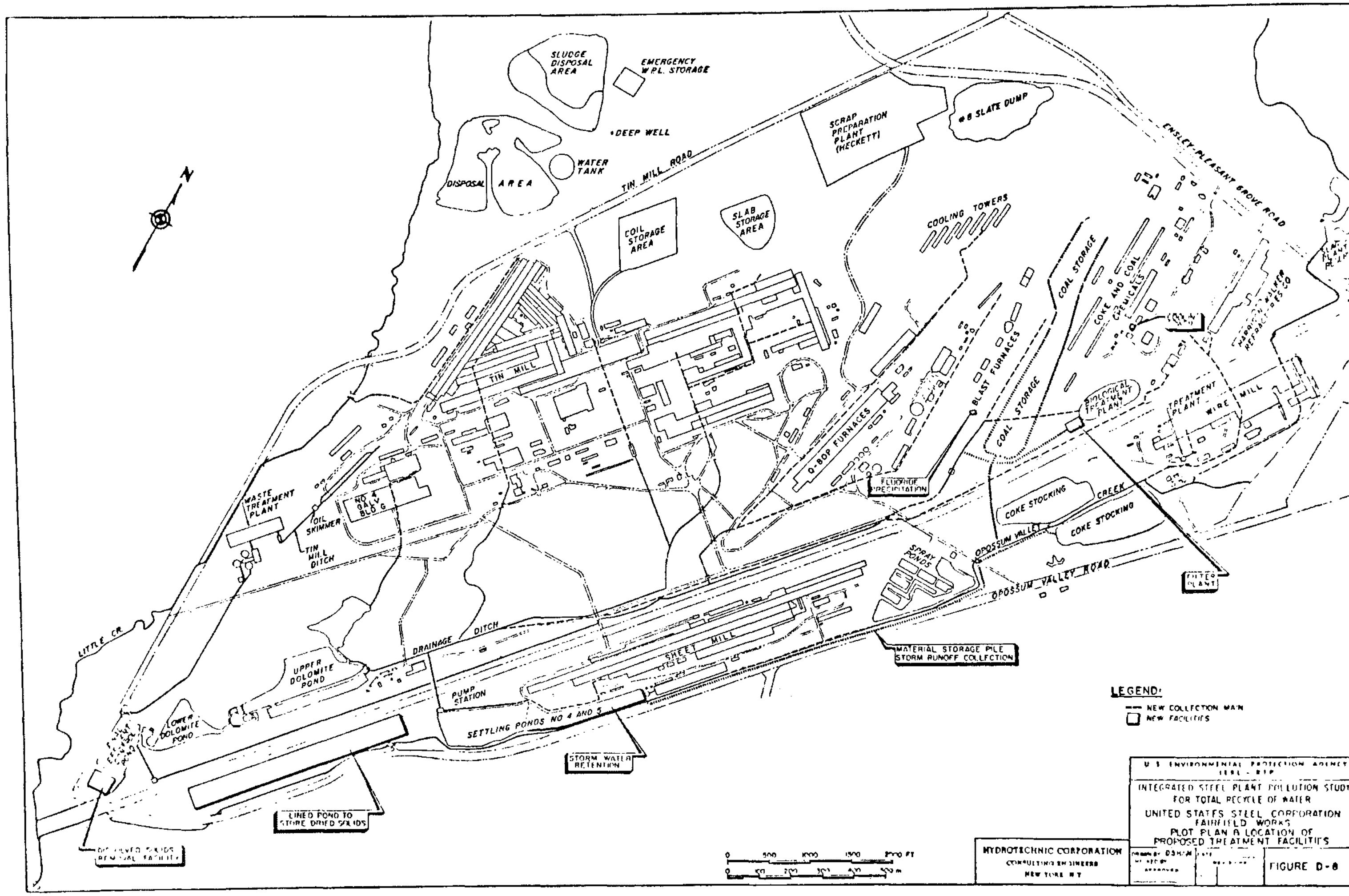


PRIME INDUSTRIAL WATER
2126 (9360)
432 (1900)
MATCH LINE SEE FIGURE D-4
BLAST FURNACE No 5,6,7&8 BOILER HOUSE & MISC.
BLAST FURNACE Nos 5,6,& 7
BLAST FURNACE No 8
Q-BOP
MISC Q-BOP USES
DESILTER
SURGE TANK
VACUUM FILTER
SLUDGE
SPRAY POND
TO DOLOMITE RECYCLE LINE
GAS CLEANING Nos 5,6,& 7
GAS CLEANING No 8
SOLIDS TO SINTER PLANT
BLAST FURNACE Nos 7&8 SLAG QUENCHING
TO FINAL EFFLUENT CONTROL POND
989 (4350)
COKE PLANT
WASH OIL COOLER
SATURATOR
TO SULFATE
COAL PREHEATING
COAL DUST CONTROL
SCRUBBER CARS
HOLDING TANK
SUMP
QUENCH TANK
COKE QUENCH TOWER
TO SINTER PLANT
CY-AM STILLS
AERATION BASINS
SOLIDS TO LANDFILL
SETTLING BASIN W/OIL SKIMMER
FILTRATION
477 (2100)
LAGOON
RAW MATERIAL STORAGE PILE RUNOFF
EVAP
BIRMINGHAM CITY WATER
SINTER PLANT No 1
SINTER PLANT No 2
SINTER PLANT No 3
SINTER PLANT No 4
WATER RECYCLE BASIN
SANITARY
MATERIAL STORAGE PILE RUNOFF
SETTLING POND
SETTLING POND
TO VALLEY CREEK
SINTER PLANT
NOTE:
FOR NOTES AND LEGEND SEE FIGURE D-4
U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION
FAIRFIELD WORKS
PROPOSED FLOW DIAGRAM
BAT SYSTEMS
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE D-5


1675 (7370) PRIME INDUSTRIAL WATER
432 (1900)
194 (855)
AXLE SHOP
MISCELLANEOUS
TIE PLATE & SPIKE
46" SLAB MILL
45" BLOOM & SLAB MILL
21" BILLET MILL
11" MERCHANT MILL
68" HOT STRIP MILL
24" STRUCTURAL MILL
140" PLATE MILL
MOLD COOLING
9 (40) EVAP
PAINT SHOP
ROLL SHOP
TEMPER MILL
AIR COMPRESSOR
MISCELLANEOUS
DOUBLE COLD REDUCTION
GALV LINES Nos 1 & 2
GALVANIZING LINE No 4
ELECTROLYTIC TINNING LINES Nos 1,3,&4
CONTINUOUS ANNEALING LINE
STRIP PICKLING
COLD ROLLING
CLEANING
WIRE GALVANIZING
NAIL GALVANIZING
ROD PICKLING
REACTION TANK
LIME
POLY
SLUDGE PIT
32 (140)
155 (680)
1500 (6600)
1114 (4900)
716 (3150)
227 (1000)
82 (360)
82 (360)
2909 (12800)
359 (1580)
1114 (4900)
5 (20)
23 (100)
2 (10)
41 (180)
68 (300)
518 (2280)
20 (90)
75 (330)
227 (1000)
156 (685)
55 (240)
23 (102)
42 (185)
200 (880)
152 (670)
110 (485)
0.5 (1)
8 (35)
0.5 (2)
14 (60)
SCALE PIT
27 (120)
236 (1040)
13 (55)
0.5 (1)
0.5 (2)
13 (58)
DEEP WELL INJECTION OF WPL
45 (200)
TO O'POSSUM CREEK
8702 (38300)
WASTE CHROMATE BATHS
264 (1160)
198 (870)
486 (2140)
EVAP 45 (200)
375 (1650) BLOWDOWN FROM BLAST FURNACES
8211 (36100)
STORAGE TANK
WPL
LAGOONS
OIL SKIMMERS
WPL
TIN MILL DITCH
TIN MILL TREATMENT PLANT
WPL & LIME
AIR
LIME
POLY
BATCH REACTION TANK
MIXING TANKS
DISTRIBUTION BOX
486 (2140)
(2)
FILTER CAKE TO LANDFILL
FILTER PRESS
EVAP 66 (230)
REVERSE OSMOSIS
(1)
FLOCCULATOR CLARIFIERS
SECONDARY SETTLING POND (LOWER DOLOMITE)
PRIMARY SETTLING POND (UPPER DOLOMITE)
1227 (5400)
988 (4350) FROM COKE PLANT, BLAST FURNACE & Q-BOP AREAS
5 (20)
1114 (4900)
1114 (4900)
FINAL EFFLUENT CONTROL POND
532 (2340)
2490 (11000)
FILTRATION
DISOLVED SOLIDS REMOVAL
SOFTENING
DISOLVED SOLIDS REMOVAL
DRYING
625 (2750) EVAP
SOLIDS TO DISPOSAL
1877 (8250) REUSE AT TIN MILLS AND COMBINE WITH PRIME INDUSTRIAL WATER
WATCH LINE SEE FIGURE D-
LEGEND
FLOWS
000 – m³/Hr
(000) – g p m
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO 3 (THREE) SIGNIFICANT DIGITS
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION
FAIRFIELD WORKS
PROPOSED FLOW DIAGRAM
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE D-



PRIME INDUSTRIAL WATER
1170 (5150)
TREATMENT PLANT PRODUCT WATER
BLAST FURNACE Nos 5,6,7&8 BOILER HOUSE & MISC
BLAST FURNACE Nos 5,6,8,7
BLAST FURNACE No 8
Q-BOP
MISC Q-BOP USES
COKE PLANT
COAL PREHEATING
COAL DUST CONTROL
SCRUBBER CARS
DESILTER
SURGE TANK
VACUUM FILTER
SLUDGE
SPRAY POND
TO DOLOMITE RECYCLE LINE
EVAP
WASH OIL COOLER
HOLDING TANK
SATURATOR
TO SULFATE
SUMP
QUENCH TANK
COKE QUENCH TOWER
TO SINTER PLANT
GAS CLEANING No 8
AMMONIA STILLS
AERATION BASINS
SOLIDS TO SINTER PLANT
SOLIDS TO LANDFILL
SETTLING BASIN W/OIL SKIMMER
FILTRATION
BLAST FURNACE Nos 7&8 SLAG QUENCHING
TO FINAL EFFLUENT CONTROL POND
852 (3750)
409 (1800)
RAW MATERIAL STORAGE PILE RUNOFF
BIRMINGHAM CITY WATER
SINTER PLANT No 1
SINTER PLANT No 2
SINTER PLANT No 3
SINTER PLANT No 4
WATER RECYCLE BASIN
SANITARY
MATERIAL STORAGE PILE RUNOFF
SETTLING POND
SETTLING POND
TO VALLEY CREEK
SINTER PLANT
NOTE
FOR NOTES AND LEGEND SEE FIGURE D-6
U.S. ENVIRONMENTAL PROTECTION AGENCY
FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION
FAIRFIELD WORKS
PROPOSED FLOW DIAGRAM
FIGURE D-7


SLUDGE DISPOSAL AREA
EMERGENCY W.P.L. STORAGE
DEEP WELL
WATER TANK
DISPOSAL AREA
TIN MILL ROAD
SCRAP PREPARATION PLANT (HECKETT)
#8 SLATE DUMP
ENSLEY-PLEASANT GROVE ROAD
COIL STORAGE AREA
SLAB STORAGE AREA
COOLING TOWERS
TIN MILL
COAL STORAGE
COKE AND COAL CHEMICALS
BLAST FURNACES
Q-BOP FURNACES
FLUORIDE PRECIPITATION
BIOLOGICAL TREATMENT PLANT
TREATMENT PLANT
WIRE MILL
COKE STOCKING
CREEK
OPOSSUM VALLEY
OPOSSUM VALLEY ROAD
FILTER PLANT
WASTE TREATMENT PLANT
OIL SKIMMER
NO 4 GALV BLDG
TIN MILL DITCH
SPRAY PONDS
LITTLE CR.
DRAINAGE DITCH
SHEET MILL
MATERIAL STORAGE PILE STORM RUNOFF COLLECTION
UPPER DOLOMITE POND
LOWER DOLOMITE POND
PUMP STATION
SETTLING PONDS NO 4 AND 5
STORM WATER RETENTION
LINED POND TO STORE DRIED SOLIDS
LEGEND:
NEW COLLECTION MAIN
NEW FACILITIES
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
UNITED STATES STEEL CORPORATION FAIRFIELD WORKS
PLOT PLAN & LOCATION OF PROPOSED TREATMENT FACILITIES
HYDROTECHNIC CORPORATION
FIGURE D-8

APPENDIX E

YOUNGSTOWN SHEET AND TUBE COMPANY

INDIANA HARBOR WORKS

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This appendix addresses itself specifically to the Youngstown Sheet and Tube Company's Indiana Harbor Works at East Chicago, Indiana. It includes the preliminary engineering designs based on conclusions reached from data supplied by the Youngstown Sheet and Tube Company. It does not include the identification of all environmental control technologies considered, the evaluation of other steel plants studied, cost estimates, practicality or possible environmental impacts. Therefore, it should be looked on only as a vehicle to present a possible scheme to attain zero discharge but not necessarily one that is practical, feasible or one that will not generate, with its implementation, an environmental impact in other sectors which is intolerable.

1.2 DESCRIPTION OF THE STEEL PLANT

1.2.1 Processes and Facilities

The Youngstown Sheet and Tube Company operates a completely integrated steel plant located in East Chicago, Indiana. A small portion of the plant is located in Whiting, Indiana and the total plant occupies a 525 hectare (1300 acre) site located on the southern shore of Lake Michigan at Indiana Harbor. The corporate designation of the plant is the Indiana Harbor Works. Production facilities at the Indiana Harbor Works as of 1977 consisted of:

	Capacity in kkg/day/TPD
- One by-products coke plant	3629/4000
- One sinter plant	3625/4000
- Four blast furnaces	9525/10500
- One eight-furnace open hearth shop	6895/7600
- One 2-vessel basic oxygen furnace shop	9525/10500
- A slabbing mill	8165/9000
- A blooming mill	3810/4200
- An 84-inch hot strip mill	10200/11250
- Two Merchant Mills	N.A.

	Capacity in kkg/day/TPD
- A billet mill	N.A.
- A seamless tube mill	635/700
- A continuous butt weld tube mill	757/834
- Three continuous pickling lines	8400/9260
- Two cold reduction sheet mills	3295/3630
- Two tin mills	2295/2530
- A galvanizing shop	895/984

Of the above facilities the two merchant mills and the billet mill have been closed and will not resume operation. The galvanizing shop, although not presently operating is assumed to be operational in the future.

Support facilities at the plant are a boiler house and a power plant. The boiler house, in addition to supplying steam for the power plant operation, supplies steam for other in-plant uses.

1.2.2 Water Systems and Distribution

The water supply for the Indiana Harbor Works is drawn from Lake Michigan through three intakes, supplying four pumping stations. Intake No. 1 supplies Pump House No. 1; Intake No. 2 supplies Pump House No. 2 and the Low Head Pumping Station; and Intake No. 3 supplies Pump House No. 3.

Although Pump Houses 1, 2 and 3 are nominally interconnected, each station supplies specific facilities within the plant and the low head pumping station supplies water to a separate group of plant faciliteis and also supplies water to the adjacent Sinclair Plant. The uses of water from each pumping station are discussed below:

Intake No. 1 is located at the northeast corner of the plant at the entrance to the Indiana Harbor Ship Canal. Water flows to Pump House No. 1 which is located west of the north ore yard and east of the No. 1 Warehouse. Pump House No. 1 supplies 500 m^3/hr (2200 gpm) to the No. 1 Blooming Mill, 455 m^3/hr (2000 gpm) to the No. 2 Continuous Butt Weld Mill, 2320 m^3/hr (10,200 gpm) to the No. 2 Cold Reduction Mill and the No. 1 and No. 2 Tin Mills and 4890 m^3/hr (21,500 gpm) to Blast Furnaces 3 and 4.

Pump House No. 1 is equipped with 6 pumps: 2 at 5680 m^3/hr (25,000 gpm), 1 at 4320 m^3/hr (19,000 gpm), 2 at 3410 m^3/hr (15,000 gpm) and 1 at 2270 m^3/hr (10,000 gpm).

Intake No. 2 draws its water from Lake Michigan through an intake flume located in the north central area of the plant. Water is supplied through this flume to Pump House No. 2 and additional water is transported through a water intake tunnel to the Low Head Pump House. Pump House No. 2 equipped with 2 - 5680 m^3/hr (25,000 gpm), 1 - 3410 m^3/hr (15,000 gpm) and 2 - 2380 m^3/hr (10,400 gpm) pumps and is located at the end of the intake flume, north of the slab yard. This pump station supplies 2318 m^3/hr (10,200) to the BOF, 6020 m^3/hr (26,500 gpm) to Slabbing Mill No. 2, 3230 m^3/hr (14,200 gpm) to Open Hearth No. 2 and 1950 m^3/hr (8600 gpm) to the Seamless Pipe Mill. The Low Head Pump House provides 225 m^3/hr (1050 gpm) to the Coke Plant, 180 m^3/hr (800 gpm) to the Sinter Plant, 2730 m^3/hr (12,000 gpm) to Blast Furnaces 1 and 2 and 14,200 m^3/hr (62,600 gpm) to the Power House and Boiler House. In addition 1820 m^3/hr (8,000 gpm) is pumped to the Sinclair Company for their in-plant use. The Low Head Pump House has 1 - 15,900 m^3/hr (70,000 gpm) and 1 - 11,400 m^3/hr (50,000 gpm) pumps.

Pump House No. 3 has 3 - 11,400 m^3/hr (50,000 gpm) pumps and is located at the extreme north end of the plant, north of the 84-inch Hot Strip Mill. It supplies 23,800 m^3/hr (104,800 gpm) to the 84-inch Hot Strip Mill and the 80-inch Cold Reduced Sheet Mill No. 3.

The following is a list of the seven points of water discharge from the Indiana Harbor Works:

Discharge Point	Source of Waste
Outfall 001	Tin Mills 1 & 2, Sheet Mill 2 and Sheet Mill 2 Galvanizing Line
Outfall 002	Non-contact cooling water from Sheet Mill 2 and Sheet Mill 2 Galvanizing Line
Outfall 009	Non-contact cooling water from the Sinter Plant, Boiler House and Power House
Outfall 010	Process water from Continuous Butt Weld Mill No. 2, non-contact cooling water from the Power House and Blast Furnaces 1 & 2 and emergency overflow from the Blast Furnace recycle system
Outfall 011	Terminal Lagoon Blowdown
East Chicago Treatment Plant	Coke Plant
Sinclair	Seamless Pipe Mill via Low Head Pump Station
Shallow Well	Waste pickle liquor from Flat Roll Mills, and Cold Strip Mill No. 3

Figure E-1 illustrates the existing water distribution, use and discharge systems. Table E-1 tabulates the qualities of water discharged from the outfalls for which NPDES permits have been issued. The discharges are discussed below with the uses of water from the plant facilities that contribute to these outfalls. The locations of the outfalls are shown on Fig. E-2.

Outfall 001

Discharge from Outfall 001 contains process water from Tin Mill 1, Tin Mill 2, Sheet Mill 2 and Sheet Mill 2 Galvanizing Lines. Approximately 1750 m^3/hr (7700 gpm) of process water flows from these mills and are treated in the Central Treatment Plant. An additional 340 m^3/hr (1500 gpm) combines with the treated water prior to discharge. The total discharge from Outfall 001 to the Indiana Harbor Ship Canal is approximately 2090 m^3/hr (9200 gpm).

Outfall 002

The flow of water from this outfall to the Indiana Harbor Ship Canal consists of only 227 m^3/hr (1000 gpm) of non-contact cooling water from Sheet Mill No. 2. The outfall is located north of the Dickey Place Bridge.

Outfall 009

Outfall 009 discharges non-contact cooling water from the Sinter Plant (68 m^3/hr (300 gpm)), the Boiler House (273 m^3/hr (1200 gpm)) and the Power House (7730 m^3/hr (34,000 gpm)) to the Indiana Harbor Ship Canal just north of the ore yard for a total of 8070 m^3/hr (35,500 gpm).

Outfall 010

The discharge of 8640 m^3/hr (38,000 gpm) to the Indiana Harbor Ship Canal through Outfall 010 is primarily non-contact cooling water; 2730 m^3/hr (12,000 gpm) from Blast Furnaces 1 and 2 and 5450 m^3/hr (24,000 gpm) from the Power House. The remaining 455 m^3/hr (2000 gpm) is process water from Continuous Butt Weld Mill No. 2 which has passed through a scale pit and filters. Outfall 010 is located south of the ore yard just north of Outfall 009.

Outfall 011

Approximately 16,600 m^3/hr (73,100 gpm) is discharged to Lake Michigan through Outfall 011. Plant facilities contributing to this flow are:

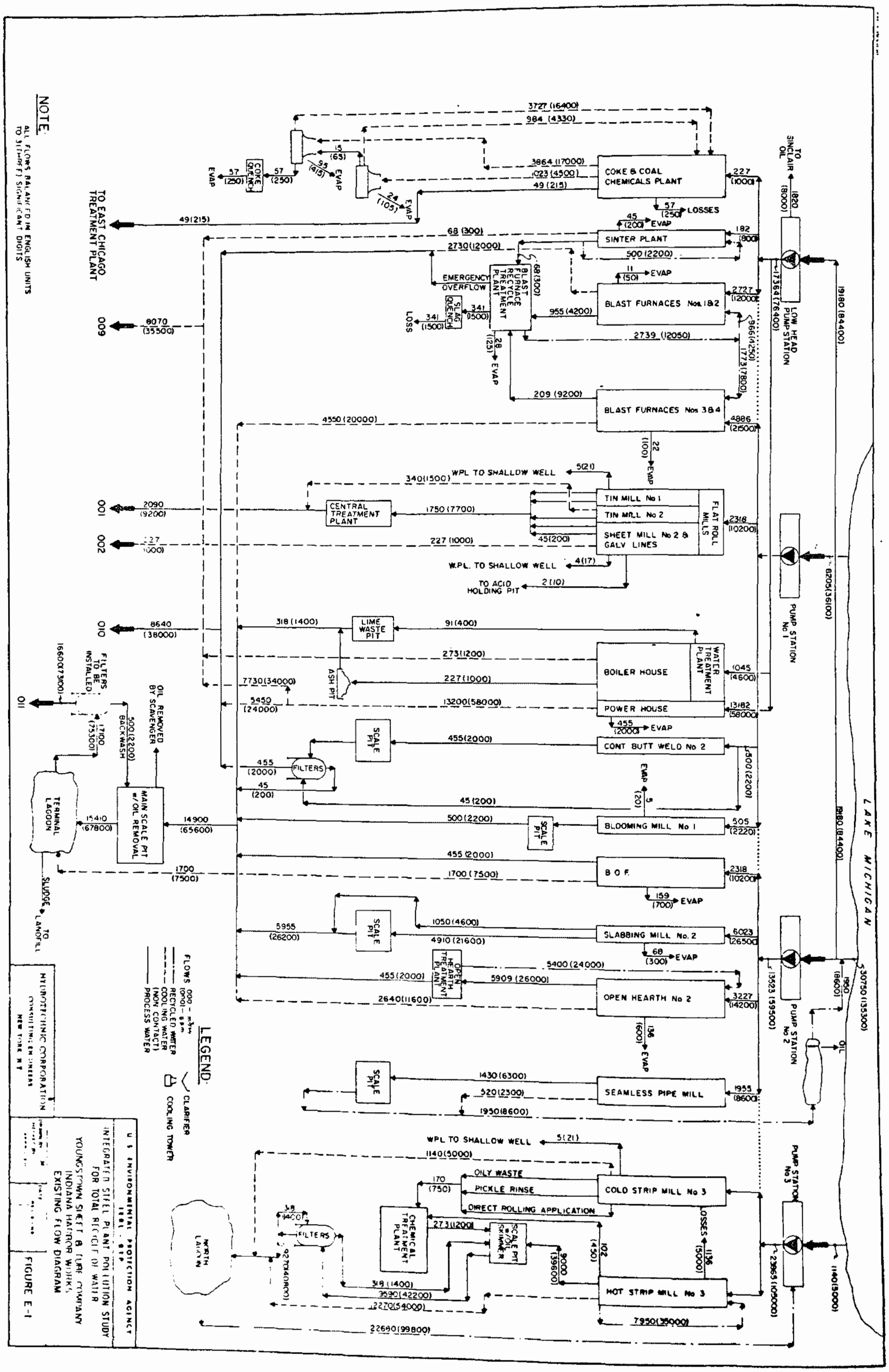
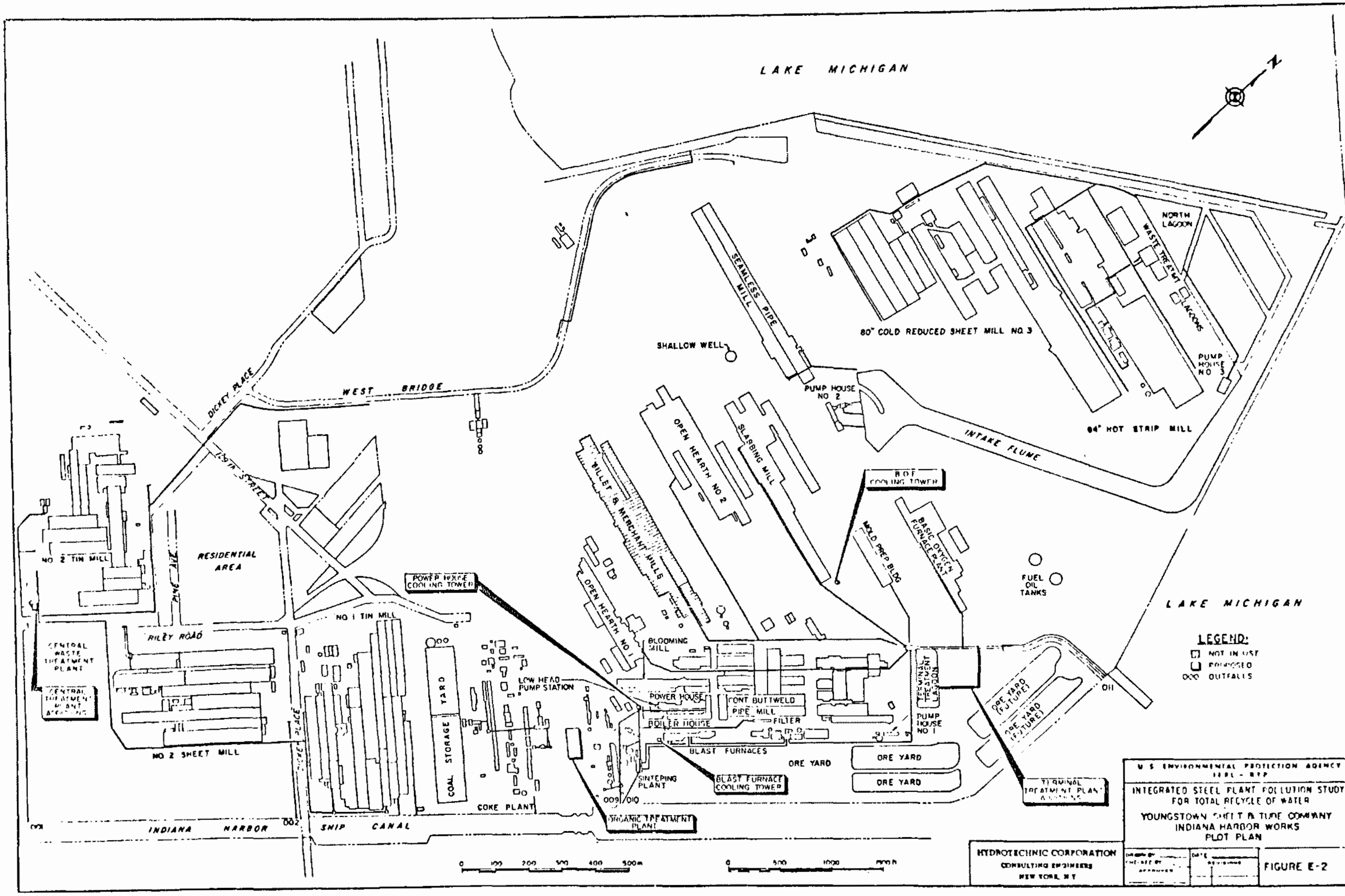

NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO SIGNIFICANT DIGITS
LEGEND:
FLOWS 000 - m³/hr (000) - gpm
RECYCLED WATER
COOLING WATER (NON CONTACT)
PROCESS WATER
CLARIFIER
COOLING TOWER
LAKE MICHIGAN
TO SINCLAIR OIL
LOW HEAD PUMP STATION
PUMP STATION No 1
PUMP STATION No 2
PUMP STATION No 3
COKE & COAL CHEMICALS PLANT
COKE QUENCH
SINTER PLANT
BLAST FURNACES Nos 1&2
BLAST FURNACE RECYCLE TREATMENT PLANT
SLAG QUENCH
EMERGENCY OVERFLOW
BLAST FURNACES Nos 3&4
TIN MILL No 1
TIN MILL No 2
SHEET MILL No 2 & GALV LINES
FLAT ROLL MILLS
CENTRAL TREATMENT PLANT
W.P.L. TO SHALLOW WELL
TO ACID HOLDING PIT
LIME WASTE PIT
WATER TREATMENT PLANT
BOILER HOUSE
POWER HOUSE
ASH PIT
CONT BUTT WELD No 2
FILTERS
SCALE PIT
BLOOMING MILL No 1
B O F
SLABBING MILL No. 2
OPEN HEARTH PLANT
OPEN HEARTH No 2
SEAMLESS PIPE MILL
COLD STRIP MILL No 3
OILY WASTE
PICKLE RINSE
DIRECT ROLLING APPLICATION
CHEMICAL TREATMENT PLANT
SCALE PIT W/OIL SKIMMER
HOT STRIP MILL No 3
NORTH LAGOON
MAIN SCALE PIT W/OIL REMOVAL
TERMINAL LAGOON
OIL REMOVED BY SCAVENGER
FILTERS TO BE INSTALLED
BACKWASH
SLUDGE TO LANDFILL
TO EAST CHICAGO TREATMENT PLANT
009
001
002
010
011
EVAP
LOSSES
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
YOUNGSTOWN SHEET & TUBE COMPANY INDIANA HARBOR WORKS
EXISTING FLOW DIAGRAM
FIGURE E-1
HYDROTECHNIC CORPORATION CONSULTING ENGINEERS NEW YORK N.Y.

TABLE NO. E-1

TREATED WASTEWATER DISCHARGES *

Parameter	Outfalls 001	002	009	010	011	To E. Chicago Treatment Plant
pH	7.6	7.7	8.0	8.2	8.1	9.0
Temp	65	65	70	64	60	
S. S.	15	10	6	10	15	55
Oil	6	4	4	4	5	43
TDS	641	272	243	253	344	
NH_3	2.2	1.8	1.5	1.9	2.5	195
CN	0.07	0.05	0.05	0.25	0.55	10
Cl	41	39	30	35	50	1650
SO_4	140	38	35	47	42	
Fl	0.5	0.4	0.3	0.3	0.4	
Tot Cr	0.01	-	-	-	-	
Zn	0.05	-	-	-	-	
Tin	0.2	-	-	-	-	
Phenol	0.006	0.005	0.006	0.006	0.006	80
Alk						940

* With the exception of discharges to East Chicago Sewage Treatment Plant all data are from computer printouts.


LAKE MICHIGAN
LEGEND:
NOT IN USE
PROPOSED
OUTFALLS
SEAMLESS PIPE MILL
80" COLD REDUCED SHEET MILL NO 3
NORTH LAGOON
WASTE TREATMENT LAGOONS
PUMP HOUSE NO 3
84" HOT STRIP MILL
SHALLOW WELL
PUMP HOUSE NO 2
INTAKE FLUME
WEST BRIDGE
DICKEY PLACE
OPEN HEARTH NO 2
SLABBING MILL
BILLET & MERCHANT MILLS
B.O.F. COOLING TOWER
MOLD PREP BLDG
BASIC OXYGEN FURNACE PLANT
FUEL OIL TANKS
RESIDENTIAL AREA
NO 2 TIN MILL
POWER HOUSE COOLING TOWER
OPEN HEARTH NO 1
BLOOMING MILL
NO 1 TIN MILL
RILEY ROAD
CENTRAL WASTE TREATMENT PLANT
LOW HEAD PUMP STATION
POWER HOUSE
CONT BUTTWELD PIPE MILL
FILTER
BOILER HOUSE
TERMINAL TREATMENT LAGOON
PUMP HOUSE NO 1
ORE YARD (FUTURE)
ORE YARD (FUTURE)
BLAST FURNACES
ORE YARD
ORE YARD
ORE YARD
COAL STORAGE YARD
SINTERING PLANT
BLAST FURNACE COOLING TOWER
NO 2 SHEET MILL
COKE PLANT
ORGANIC TREATMENT PLANT
TERMINAL TREATMENT PLANT
009
010
001
002
INDIANA HARBOR SHIP CANAL
0 100 200 300 400 500m
0 500 1000 1500ft
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
YOUNGSTOWN SHEET & TUBE COMPANY
INDIANA HARBOR WORKS
PLOT PLAN
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK, N Y
FIGURE E-2

- Blowdown and water treatment plant wastes from the Boiler and Power House amounting to approximately 318 m^3/hr (1400 gpm).

- Discharge of approximately 500 m^3/hr (2200 gpm) from the Blooming Mill scale pit.

- Continuous Butt Weld filter backwash flow of 45 m^3/hr (200 gpm).

- A non-contact cooling water discharge of approximately 4550 m^3/hr (20,000 gpm) from Blast Furnaces 3 and 4.

- Mold preparation and cooling facilities at the BOF discharge approximately 455 m^3/hr (2000 gpm).

- BOF non-contact cooling water discharges amount to approximately 1700 m^3/hr (7500 gpm).

- Slabbing Mill No. 2 discharges approximately 4910 m^3/hr (21,600 gpm) from the scale pit and 1050 m^3/hr (4600 gpm) of non-contact cooling water from motor-room cooling.

- The flows from Open Hearth No. 2 including 2640 m^3/hr (11,600 gpm) of non-contact cooling water and 455 m^3/hr (2000 gpm) of discharge from the gas cleaning recycle systems.

Recycled Water

Hot Strip Mill No. 3 and Cold Strip Mill No. 3 located at the north end of the plant discharge all their process and non-contact cooling water through the North Lagoon to the intake of No. 3 Pump House. Approximately 22,680 m^3/hr (99,800 gpm) is recycled and 1140 m^3/hr (5000 gpm) is drawn from Lake Michigan to make up for process losses.

The Seamless Pipe Mill discharges its entire flow of 1950 m^3/hr (8600 gpm) to Pump House No. 2 Intake.

Wastes from the Coke Plant (49 m^3/hr (215 gpm)) are sent to the City of East Chicago sewage treatment plant.

Waste pickle liquor from the three pickling lines is transported to a "shallow well" located south of the Seamless Tube Mill and east of the Blooming Mill. These wastes percolate into the ground.

1.2.3 Waste Treatment Facilities

There are, at present, waste treatment facilities located at various points in the plant, either at or near a production facility to treat a specific waste or at outfalls to treat combined wastes prior to discharge. These treatment facilities are discussed below in relation to the outfalls that they discharge to.

Outfall 001

All process wastes discharging through Outfall 001 are treated at the Central Treatment Plant, which is located at the extreme southern end of the plant. The 1750 m^3/hr (7700 gpm) of wastes treated are those arising from cold rolling, pickling, tinning line, chrome line and galvanizing operations. The wastes contain rolling solutions, contact cooling water, pickle rinse water and galvanizing wastes. These combined wastes flow through the treatment plant with a series of unit operations consisting of: aeration and oil scalping, lime and additional air addition, clarification and oil skimming prior to discharge. Solids are collected in the clarifier and dewatered by a centrifuge. The dewatered solids are hauled to an off-site landfill. The treated effluent is then combined with 340 m^3/hr (1500 gpm) of non-contact cooling water from the No. 2 Tin Mill and discharged to the Indiana Harbor Ship Canal.

Sulfuric acid waste pickle liquor from the three pickling lines at Sheet Mill No. 2, Tin Mill No. 1 and No. 3 Cold Strip Mill amounting to a total flow of approximately 11.8 m^3/hr (52 gpm) is trucked to a shallow well located in a slag pile west of the Blooming Mill and the waste pickle liquor percolates into the ground. The plant has reported that there are no noticeable adverse effects on the ground water due to this percolation.

Outfalls 002 and 009

The only waters that discharge through Outfall 002 and Outfall 009 are 227 m^3/hr (1000 gpm) and 8070 m^3/hr (35,500 gpm) of non-contact cooling water, respectively. There is no cooling of this water prior to discharge and the temperature increases are approximately 5.5 to 8.3C^o (10 to 15F^o) and 10 to 10.5C^o (18 to 19F^o) for outfalls 002 and 009, respectively.

Outfall 010

Outfall 010 discharges a combination of treatment process water and non-contact cooling water. Cooling is not provided for the 2730 m^3/hr (12,000 gpm) of non-contact cooling water from Blast Furnaces 1 and 2 and the 5450 m^3/h (24,000 gpm) of non-contact cooling water from the Power House. These non-contact cooling waters combine with treated process water from the Continuous Butt Weld Mill and emergency overflows from the gas washer recycle system for the four Blast Furnaces.

The Blast Furnace gas washer recycle system consists of three thickeners and a three cell cooling tower at Furnaces 1, 2, 3 and 4 gas washers. The total cooled water flow from the cooling towers, less blowdown which is used for slag quenching, is recycled. After use the gas cooler water is collected in a sump and a major portion is recycled to the venturi gas washers on furnaces 1, 2 and 4. Blast Furnace No. 3 utilizes cooling tower effluent directly for both the venturi gas washer and gas cooling. The total gas washer and cooler water is collected from the four furnaces and directed to the three thickeners. Evaporation losses from the recycle system are approximately 28 m^3/hr (125 gpm). System blowdown to maintain water quality is approximately 341 m^3/hr (1500 gpm) and is used to quench molten slag. Underflows from the thickeners are dewatered in vacuum filters with the filter cake conveyed to the Sinter Plant and the filtrate returned to the thickeners.

Make-up to the system is from the service water line to the cooling tower cold well and blowdown from the Sinter Plant scrubber systems to the thickener distribution box.

Although there are provisions at each of the gas washer sumps, the distribution box, the wash water sump between the thickeners and the cooling tower, and at the cooling towers for emergency overflows, the plant has reported that these overflows rarely occur.

All of the process water from the Continuous Butt Weld Mill (455 m^3/hr (2000 gpm)) is first passed through a scale pit where the gross solids are removed. It is then pumped to three deep bed sand filters, each 16 feet in diameter. The filtrate is discharged to Outfall 010. Filter backwash volume has been reported to be approximately 10 percent of the throughput (an average of 45 m^3/hr (200 gpm)) which is discharged to the main scale pit at the Outfall 011 treatment facilities. Backwash water is drawn from the mill water supply.

Outfall 011

All of the discharges to Outfall 011 are presently treated by passing the combined wastes through the main scale pit and a terminal lagoon. It is assumed that the total flow will also be passed thorugh a gravity filter installation presently under construction near the main scale pit. Oil removed at the main scale pit is hauled away by a scavenger. Sludge removed from the terminal lagoon is hauled to an in-plant landfill area.

Scale pits treat process wastes from the Blooming Mill No. 1, Slabbing Mill No. 2, and the Open Hearth Shop. At Blooming Mill No. 1, before they discharge to the main scale pit, the total flow of 500 m^3/hr (2200 gpm) passes through the main scale pit. At Slabbing Mill No. 2, 4910 m^3/hr (21,600 gpm) of mill process and scarfer water is passed through one scale pit for solids removal. The water discharged from the scale pit is combined with 1050 m^3/hr (4600 gpm) of motor room non-contact cooling water which flows to the main scale pit.

The open hearth shop treats the scrubber gas cleaning water for recycle in two grizzlys (large solids removal units), four classifiers, and four thickeners. Thickener sludge is hauled to an evaporation and percolating lagoon. Gas cooling water is cooled in evaporative cooling towers. Blowdown from the cooling tower and leakage from the gas cleaning system, in the amount of 455 m^3/hr (2000 gpm), is discharged to the main scale pit sewer. Non-contact cooling water that is not used for make-up to the gas cleaning cooling system (approximately 2640 m^3/hr (11,600 gpm)) is also discharged to the main scale pit.

Discharge to East Chicago Sewage Treatment Plant

The Indiana Harbor Works Coke Plant has a recycle and treatment system for non-contact water. Blowdown from both of the non-contact cooling water cooling towers is used to quench coke. The 50 m^3/hr (215 gpm) of wastes from the by-product plant that have been treated in dephenolizers and ammonia stills (free and fixed) are sent to the City of East Chicago, Indiana, for treatment with their municipal wastes.

Discharges to Intake No. 2

The Seamless Pipe Mill has a process flow of approximately 1430 m^3/hr (6300 gpm) which is passed through a scale pit and then combines with a non-contact cooling water flow of approximately 520 m^3/hr (2300 gpm). The combined flow is discharged to a small lagoon which is equipped with an oil skimmer. The overflow is discharged to the No. 2 Intake. Oil is removed by a scavanger.

Discharges to Intake No. 3

Virtually all water used at Hot Strip Mill No. 3 and Cold Strip Mill No. 3 is recycled back to Intake No. 3 for reuse at these facilities.

Process waste discharges from Cold Strip Mill No. 3 consists of direct application rolling solution, pickle rinse water and miscellaneous oily wastes. The total waste flow of 170 m^3/hr (750 gpm) is discharged to a chemical treatment plant. In addition, approximately 102 m^3/hr (450 gpm) of oily wastes from Hot Strip Mill No. 3 also flows to the chemical treatment plant.

At the chemical treatment plant the wastes first flow to an 80-foot diameter clarifier where sulfuric acid is added to crack the oil-water emulsion and the oil is skimmed off in the clarifier. The flow then enters a 40-foot diameter air flotation tank where caustic is added to adjust the pH and oil is also skimmed. The effluent from the air flotation tank is discharged to the Hot Strip Mill 5-cell dragout scale pit which contains additional oil skimming facilities. The scale pit also receives approximately 9000 m^3/hr (39,600 gpm) from the hot strip mill. The hot strip mill flow includes all waters from the roughing and finishing stands plus flume flushing water. The combined flow from the scale pit is pumped to a filter plant consisting of 42 - 4.9m 16 feet) high by 4.9m (16 feet) diameter pressure filters. Polymer is added to aid in filtration. Two filters are backwashed at a time and the backwash water is supplied from the effluent water of the operating filters. The backwash water is sent back to the scale pits and the balance of the effluent water is sent to the north lagoon. The average flow from backwashing is approximately 318 m^3/hr (1400 gpm). The total flow to the filters is approximately 9590 m^3/hr (42,200 gpm) and the filtrate discharged is 9210 m^3/hr (40,550 gpm). Other flows that combine with the filtered water are non-contact cooling water flows of 1140 m^3/hr (5000 gpm) from Cold Strip Mill No. 3 and 12,300 m^3/hr (54,000 gpm) from Hot Strip No. 3. The entire flow of 22,680 m^3/hr (99,800 gpm) is then discharged to the North Lagoon and, from the North Lagoon, to Intake No. 3.

At Hot Strip Mill No. 3 a tank beneath the runout table collects the runout table spray water and directly recirculates approximately 7950 m^3/hr (35,000 gpm).

1.2.4 Water Discharges and Qualities

The Indiana Harbor Works has performed extensive sampling at their outfalls for NPDES permit compliance. The quality of these discharges are tabulated in Table E-1.

Data for the treated wastes discharged to Intakes 2 and 3 is not available but some assumptions can be made.

- Discharges to Intake No. 2 from the seamless pipe mill should be high in suspended solids and oils. However, due to the treatment provided at both the scale pit and the lagoon and also the dilution of the process water with non-contact cooling water it is assumed that the quality will not be too significantly different from that of the lake water.

- The discharges to Intake No. 3 should be of fairly good quality with respect to suspended solids and oils. However, because of the addition of pickle rinse water, chemical additions of acid and caustic at the chemical treatment plant together with the apparent lack of blowdown from the completely self contained system the total dissolved solids, especially iron, the water should be too high for reuse.

No blowdown is reported from this recycle system but, in the opinion of Hydrotechnic one must be present. This is based on two factors: first if there is a continuous buildup of dissolved solids in the system scaling would occur in the pipes and second, the loss of 1136 m^3/hr (5000 gpm) is too high an evaporative loss to be encountered in this type of a facility.

Solids and Sludge Production

A summary of the quantities of solids and sludges produced at the various production and waste treatment facilities is shown on Table E-2.

1.2.5 Air Pollution Control Facilities

The plant has committed itself to provide control of pushing emission by the use of scrubber cars but the manufacturer or type has not been selected as yet. No emission controls are presently installed on the coke plant stacks.

An electrostatic precipitator has been installed at the sinter plant. The sinter plant has been shut down due to fire but it will be rebuilt and a high energy scrubber provided immediately following the existing precipitator. The discharge end of the sinter machine has a scrubber and the water from the discharge end scrubber and the new scrubber following the precipitator will be sent to the blast furnace thickener system.

Each of the blast furnaces gas cleaning systems are equipped with variable throat scrubbers. Furnaces 1,2 and 3 are equipped with single stage scrubbers and Furnace 4 is equipped with a two stage scrubber.

TABLE E-2

PRESENT SOLIDS & SLUDGE PRODUCTION AND DISPOSAL

SOURCE	QUANTITIES PRODUCED	ULTIMATE DISPOSAL
Coke Plant	4820 kkg/mo (5313 tons/mo)	Sinter Plant
Blast Furnaces		
Flue Dust	548 kkg/mo (604 tons/mo)	Sinter Plant
Slag	68000 kkg/mo (75000 tons/mo)	Vulcan Slag Co.
BOF - Slag	1996 kkg/mo (2200 tons/mo)	Heckett Slag
Scale Pits	3900 kkg/mo (4300 tons/mo)	70% to Sinter Plant 30% to Slag Pile
Terminal Lagoon	4.54 kkg/mo (5 tons/day)*	Land Fill and Slag Pile
Central Treatment Plant	75.3 kkg/day (83 tons/day)	Hauled Off Site by Contractor
6 Stand Rolling Oil Recovery	182 m^3/mo (48000 gal/mo)**	Land Fill
84-Inch Mill Treatment	Negligible	-

* Dry Basis

** Oily Sludge

BOF gases are quenched with service water. The open hearth shop when operating utilizes a scrubber for gas cleaning. The slabbing mill is equipped with a venturi scrubber which is reported to be operating satisfactorily.

Emissions are not controlled at the pickling lines, the tinning line, the hot dip galvanizing line or at the cold mills. In addition, there is no dust suppression practiced at material storage stock piles or at material transfer points.

SECTION 2.0 PROPOSED PROGRAM

2.1 GENERAL

The Indiana Harbor Works of Youngstown Sheet & Tube Company is presently practicing some degree of recirculation and is also providing treatment of wastes prior to discharge. Presently all water is disposed of or consumed by one of four methods: evaporation from cooling towers and various processes, evaporation during quenching of coke and blast furnace slag, discharge to the City of East Chicago sewage treatment plant and discharge to Lake Michigan and the Indiana Harbor Ship Canal.

If total recycle is shown to be impractical, the plant may still be required to provide treatment to meet the requirements mandated for BAT. The plant is presently treating all contaminated flows prior to discharge and an additional treatment facility is presently under construction at Outfall 011. At some outfall systems large quantities of non-contact cooling water are mixed with contaminated waste flows either prior to or subsequent to treatment. This procedure of mixing non-contact wastes with contaminated wastes is an extremely non- cost effective method of water handling.

The plant is installing new facilities with the goal of attaining a complete recycle system per their agreement with the Metropolitan Sanitary District of Greater Chicago. However, complete recycle is impossible without some degree of blowdown. For BAT, some discharges are permitted which would be in the form of flows containing no more than the permitted quantities of regulated substances. In the case of total discharge, no water could be discharged, thus eliminating blowdown. Before the water can be indefinitely recycled, constituents present in the blowdown must be removed regardless of whether they appear on the BAT limitation. Total recycle is interpreted to be no discharge to any body of water be it surface, ground or to any treatment facility outside of the plant limits. Exceptions to this are sanitary sewage which may be discharged after treatment and storm water runoff from areas other than material storage.

In view of the above interpretation, three present plant discharges would have to be discontinued: Coke Plant wastes presently being sent to the City of East Chicago for biological treatment, water supplied to Sinclair and waste pickle liquor to the shallow wells. The water being pumped to Sinclair is presently a mixture of wastes from the Seamless Pipe Mill and lake water. Any commitment that the Indiana Harbor Works has with Sinclair could be fulfilled by diverting the wastes from the lagoon directly to the Pump Station No. 2 intake and allowing only lake water to flow through the tunnel to the low head pumping station.

Waste pickle liquor deposited in the shallow well cannot be evaporating and may be entering the ground water at some points even though plant personnel have stated that it has not been detected in the areas around the shallow well.

To achieve BAT in the steel making, rolling and plating areas all existing facilities under construction can be used and water recycled. However, in the Blast Furance area, additional facilities may be required for treatment of the recycle system wastes that are presently used to quench blast furnace slag. This treatment may be required due to anticipated air pollution limitations with respect to the quenching of slag with water containing high levels of dissolved solids.

2.2 WATER RELATED MODIFICATIONS TO AIR QUALITY CONTROL

There are various areas within the Indiana Harbor Works that require additional air pollution control facilities that will impact on water use and quality. Specifically these are at the Coke Plant and the Continuous Picklers.

At the Coke Plant, fugitive emissions that arise as the result of pushing of coke are assumed to be controlled by the future use of scrubber cars. The water application rate using scrubber cars, for Batteries 3, 4 and 9 would be approximately 0.84 m^3per kkg of coke produced (202 gallons per ton) and on the basis of 3630 kkg of coke produced per day (4000 TPD) the average water flow would be 127 m^3/hr (560 gpm). A recirculation system would be used and the blowdown requiring treatment would be approximately 42 m^3/hr (185 gpm).

At the present time acid mists are not controlled at the three strip picklers although exhaust fans are installed. Low energy scrubbers are assumed to be installed at each of the exhaust outlets, based on air flow rates of 142, 142 and 307 m^3/sec (30,000, 30,000 and 65,000 cfm) from No. 1 Tin Mill and the No. 2 and No. 3 Sheet Mills, respectively. The water requirements will be 55, 55 and 115 m^3/hr (240, 240 and 500 gpm).

The water uses described above have been assumed present and are included in the discussions following on the treatment of liquid wastes.

2.3 REQUIREMENTS FOR PLANT TO MEET BAT

To develop a plan for the Indiana Harbor Works to meet BAT certain assumptions were made. These are:

1. Guidelines for plating operations, are in development document guidelines established for the metal finishing segment of the Electroplating Point Source Category (EPA-440/1-75/040a) and are specified to be applicable to steel plant plating operations. For electroplating operations the requirement of zero discharge of pollutants was used in the preparation of the proposed water system.

2. In the absence of guidelines covering iron and steel making with respect to boiler houses and power houses, the guidelines established by the EPA for Steam Electric Power Generating Point Source Category as published in the Federal Register October 8, 1974 (Vol. 39, No. 196, Part III) were used. The limitations of contaminants with respect to low volume waste sources are: suspended solids - 30 mg/l and oil and grease - 10 mg/l.

3. All non-contact cooling waters could be discharged since there is no product contact and, therefore, as long as there is no mixing with product contact water, no limitations are set.

4. Modifications would be required at the Coke Plant to reduce pushing emissions using scrubber cars.

5. The use of blowdown from the Blast Furnace Recycle Treatment Plant for slag quenching would be discontinued and the quench water would be replaced by lake water or some other water that has a dissolved solids concentration of less than 1000 mg/l.

6. The dissolved solids content of makeup water at all intakes is assumed to be 175 mg/l. This assumption is based on TDS analyses of Lake Michigan water being utilized at Inland Steel and U.S. Steel's Gary Works.

A summary of discharges allowable under BAT requirements is shown on Table E-3.

TABLE E-3

ALLOWABLE DISCHARGES AS PERMITTED UNDER BATEA LIMITATIONS

Production Facility	Average Daily Production kkg/T	DAILY ALLOWABLE DISCHARGES kg/day / lbs/day: Susp. Solids	Oil & Grease	Cyanide	Ammonia	Phenol	BOD_5	Fluoride	Sulfide	Nitrate	Dissolved Iron	Dissolved Chromium	Nickel	Zinc
Coke Plant	3625/4000	13.7	13.7	0.33	13.7	0.69	27.1		0.39					
		30.2	30.2	0.73	30.2	1.52	59.8		0.86					
BOF	9525/10500	0	0											
		0	0											
Open Hearth	6895/7600	35.8						29.0		64.8				69.0
		78.9						63.9		14.3				15.2
Blast Furnaces	9525/10500	49.5		1.24	49.5	2.48		99.1	1.52					
		109.2		2.73	109.2	5.46		218.4	3.36					
Sinter Plant	3625/4000	19.2	7.6					15.2	0.22					
		42.3	16.8					33.5	0.49					
No. 2 Slabbing	8165/9000	9.0	9.0											
Mill		19.9	19.9											
No. 1 Blooming	3810/4200	4.2	4.2											
Mill		9.2	9.2											
No. 3 Hot Strip	10200/11250	0	0											
Mill		0	0											
No.3 Seamless	635/700	0	0											
Tube Mill		0	0											
Continuous	757/834	0	0											
Buttweld Tube Mill		0	0											
No. 2 Sheet	2180/2400	11.3	4.6								0.46			
Mill Pickling		24.9	10.1								1.0			
No.3 Cold Strip	3400/3750	17.7	7.2								0.71			
Mill Pickling		38.9	15.8								1.52			

TABLE E-3

ALLOWABLE DISCHARGES AS PERMITTED UNDER BATEA LIMITATIONS
(continued)

Production Facility	Average Daily Production kkg/T	DAILY ALLOWABLE DISCHARGES kg/day lbs/day: Susp. Solids	Oil & Grease	Cyanide	Ammonia	Phenol	BOD_5	Fluoride	Sulfide	Nitrate	Dissolved Iron	Dissolved Chromium	Nickel	Zinc
No. 1 Tin Mill Pickling	2820/3110	14.7 32.3	5.9 13.0								0.59 1.30			
No. 2 Sheet Mill Cold Red.	1525/1680	4.0 8.7	1.6 3.5								0.16 0.35			
No. 3 Cold Strip Mill Cold Red.	1770/1950	63.5 140.1	29.5 65.1								2.95 6.51			
No. 1 Tin Mill Cold Red.	770/850	32.1 70.9	12.9 28.4								1.29 2.84			
No. 2 Tin Mill Cold Red.	1525/1680	25.7 56.7	10.3 22.7								1.03 2.27			
No. 2 Sheet Mill Galvanizing	895/984	13.9 30.6	5.6 12.4					1.12 2.47				0.1 0.24		
Boiler House* & Power House	--	30 mg/l	10 mg/l											
Electrolytic** Plating		0	0	0							0	0	0	

* Estimated by Hydrotechnic based on Guidelines for Steam Power Plants
** Estimated by Hydrotechnic based on Guidelines for Electroplating Industry

2.3.1 Outfall 011

The largest flow presently is being discharged through Outfall 011 which, based on computer records for a seven-month period, supplied by Y S & T, averaged 11,100 m^3/hr (40,000 gpm), with a high of 17,800 m^3/hr (78,200 gpm). For the purposes of this report and in the interest of conservatism, the flows used to establish BAT for all outfalls are those shown on Figure E-1. Outfall 011 presently receives water from Blast Furnaces 3 and 4 (all reported to be non-contact cooling water), the Open Hearth Shops, the BOF Shop, Slabbing Mill No. 2, Blooming Mill No. 1, backwash from the Continuous Butt Weld Mill No. 2 filters and the Boiler House and Water Treatment Plant.

Based on the production of these facilities and the limitations established in the guidelines, Indiana Harbor Works would be permitted to discharge a total of 212 kg (467 pounds) of suspended solids per day through Outfall 011. With an average intake concentration of 8 mg/l suspended solids and an average discharge concentration of 15 mg/l as presently exists, the plant could discharge a flow of 1264 m^3/hr (5560 gpm). The balance would have to be recirculated. Filters presently under construction to treat the flow to Outfall 011 are specified to discharge 10 mg/l suspended solids. On the basis of 9.5 mg/l the plant could discharge 6300 m^3/hr (27,700 gpm). The closest point to recirculate the water would be the No. 1 intake which is located approximately 150 m (500 feet) east of the terminal lagoon.

Since a portion of the flow from the Pumping Station No. 1 supplies non-contact cooling water to the Tin Mills, that water would have to be segregated and recirculated to eliminate discharges of suspended solids that would be transferred from Outfall 011 to Outfalls 001 and 002.

If the water is recirculated, there is no apparent need for filters to produce a suspended solids level low enough for discharge. However, Indiana Harbor Works has indicated that high costs are entailed in the cleaning of the Terminal Lagoon and analyses supplied by the plant indicate substantial variations in the quality of water discharged from the Terminal Lagoon. Therefore, on the basis of reduced operating costs and consistency of effluent quality achievable by filters, to achieve BAT the discharges through Outfall 011 should be limited to 6300 m^3/hr (27,700 gpm). The balance would be discharged to Pump Station No. 1 Intake.

Pump Station No. 1 presently pumps an average of 8160 m^3/hr (35,900 gpm) and the quantity returned to it from Outfall 011 would be approximately 10,300 m^3/hr (43,400 gpm).

There is sufficient installed capacity at Pump Station No. 1 to pump the additional quantity. However, a hydraulic analysis should be made of the existing piping system before this modification is made. A flow and quality diagram of the modified terminal treatment plant is shown on Figs. E-3 and E-4 and shows facilities required to meet BAT and total recycle.

Additionally, due to the recommended recirculation of the non-contact cooling water at the Tin Mills, the water requirements at that facility will be reduced to 16 m^3/hr (70 gpm) instead of the present 568 m^3/hr (2500 gpm).

2.3.2 Outfall 010

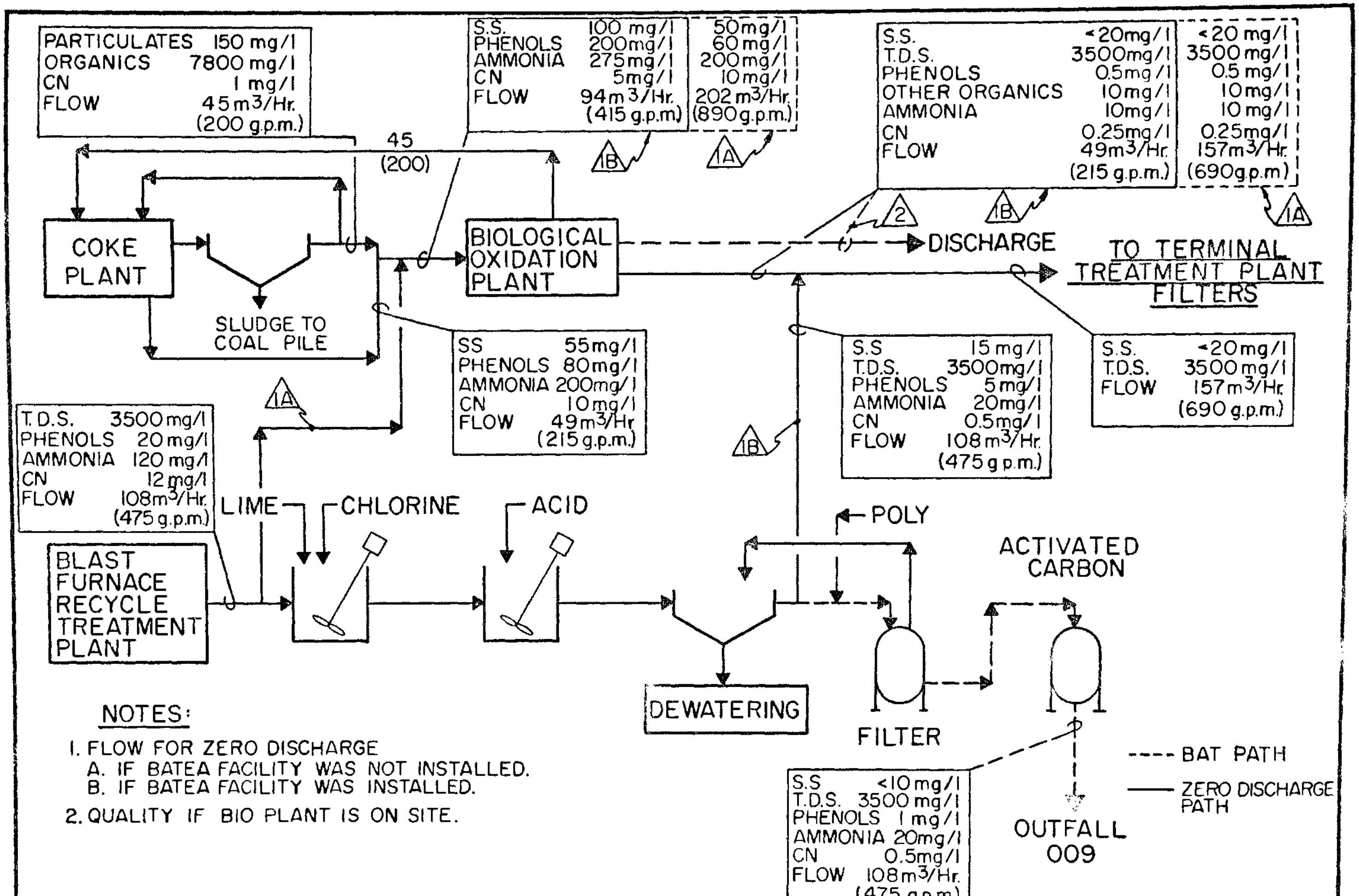
Current discharges to Outfall 010 consist of filtrate from Continuous Butt Weld Mill No. 2 filter plant and non-contact cooling water from the Power House and Blast Furnaces 1 and 2. BAT mandates zero discharge from pipe mills; therefore, the filtrate should be pumped back to the mill for reuse. Once this is done, the non-contact cooling water from other sources can be discharged.

2.3.3 Seamless Pipe Mill

The Seamless Pipe Mill is apparently on an almost total recirculation system. One modification could be made to eliminate all discharges. Presently the discharges from the pipe mill pond are mixed with lake water and a portion of the mixed water is used at the Coke Plant which ultimately discharges to the City of East Chicago Sewage Treatment Plant and a portion is pumped directly to Sinclair Oil. To achieve the BAT requirements of zero discharge, the pond discharge should be diverted to discharge directly into Pump Station No. 2 and thus have the Low Head Pumping Station pump only lake water.

2.3.4 Outfall 001

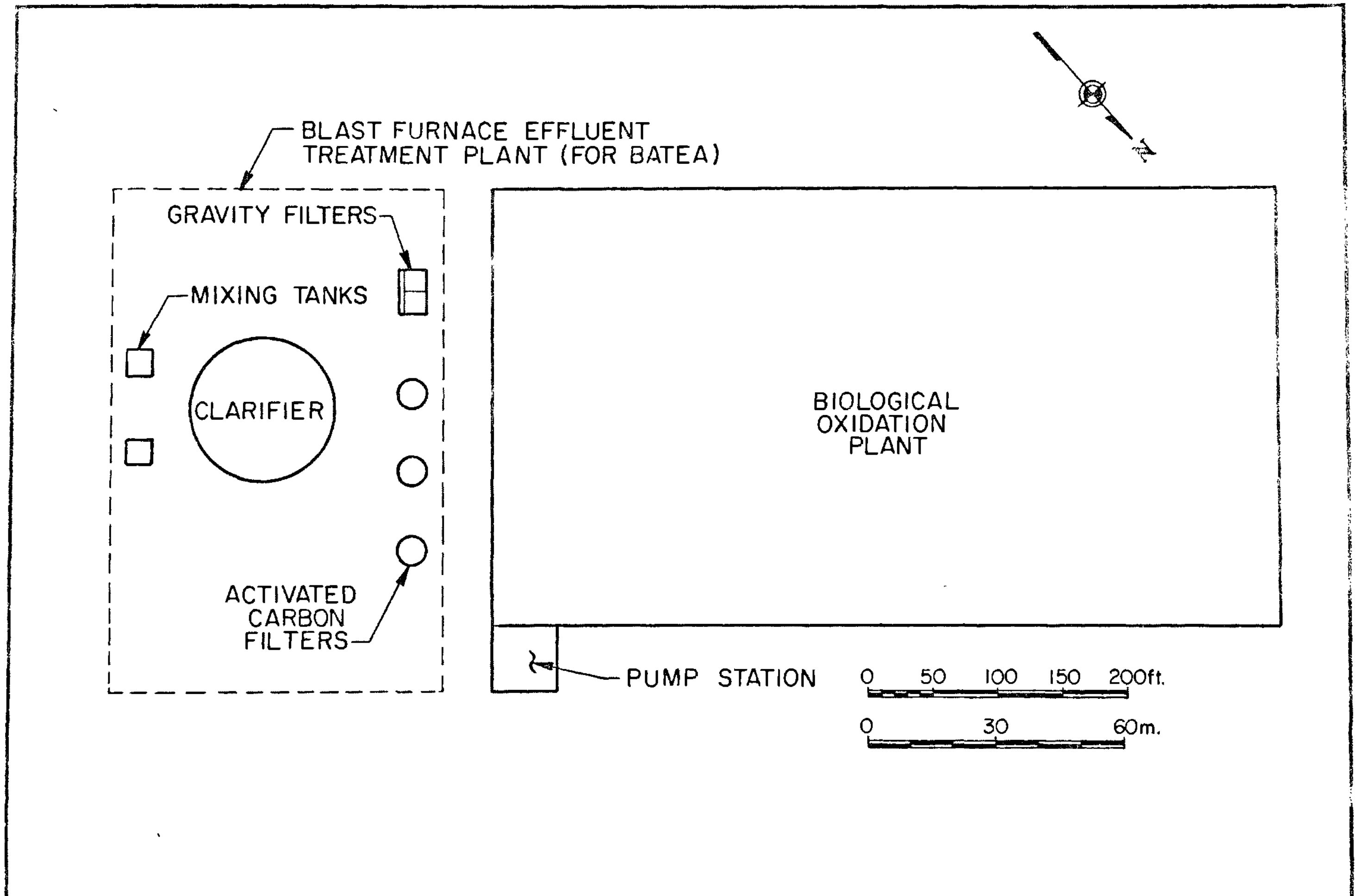
Current treated discharges from the Central Treatment Plant which treats all discharges from the Tin Mills and Galvanizing Lines are presently in compliance with the BAT limitations established for Galvanizing Lines. However, for Electrolytic Plating Lines, the guidelines stipulate zero discharge. Since all wastes from this area are combined at the Central Treatment Plant, the Central Treatment Plant wastes are shown as passing through treatment facilities to enable total recycle of waters at the area. It is possible that with in-plant repiping and segregation of electrolytic plating wastes that the facility to achieve total recycle could be materially reduced in size and the Central Treatment Plant could continue to be used for the Galvanizing Lines water only.



HYDROTECHNIC CORPORATION
NEW YORK, N. Y.

ORGANIC TREATMENT PLANT - FLOW & QUALITY DIAGRAM

FIGURE E-3



HYDROTECHNIC CORPORATION
NEW YORK, N. Y.

ORGANIC TREATMENT PLANT-GENERAL ARRANGEMENT

FIGURE E-4

2.3.5 Blast Furnace Area

The EPA has indicated that the quenching of slag with recycle blowdown may not be permissible in the future; therefore, the Blast Furnace Treatment Plant blowdown will require treatment for control of regulated parameters prior to discharge.

To meet BAT the non-contact cooling waters would be discharged as at present. The wastes presently being used to quench slag would require treatment in a system consisting of successive additions of lime and chlorine to oxidize cyanide and ammonia and also to precipitate fluorides and sulfides. The alkaline chlorination would be followed by acid addition for pH adjustment and then settling. The settled wastes would be filtered and passed through an activated carbon bed for additional cyanide and phenol removal. A carbon regeneration system would be required. Due to the expected high dissolved solids in the treated wastes after this treatment, they could not be used for slag quenching and would have to be discharged.

2.3.6 Coke Plant

Wastes from the Coke Plant are presently discharged to the City of East Chicago Sewage Treatment Plant to be treated with municipal and other industrial wastes. This biological treatment is assumed to be meeting BAT requirements. However, an additional waste would be added due to the minimizing of the air discharges from the coke pushing operations. The blowdown from the coke pushing scrubber system will require treatment with the Coke Plant discharges and the flow is estimated at 45 m^3/hr (200 gpm).

To meet BAT requirements, negotiations with the City of East Chicago should be undertaken to allow this additional volume of wastes to be treated in their plant. If this cannot be negotiated, a treatment plant would have to be installed on the steel plant site. In that event, it would be advantageous to install the treatment plant to treat not only this additional volume but all wastes; i.e., the pusher scrubber wastes, the present Coke Plant discharges, plus Blast Furnace wastes. Under this plan there will be no need for the Blast Furnace Waste Treatment System described above, with the exception of fluoride precipitation, and the wastes would be treated biologically.

Treatment with activated carbon was considered and eliminated because experience has shown that both capital and operating costs are very high for a raw waste stream.

Chemical treatment with ozone was also considered and eliminated because of the ineffectiveness of ozone in the removal of ammonia. Chemical treatment with chlorine was eliminated because of the high volumes of chlorine that would be required and also the odor problems that might occur by the creation of residual chlorinated phenols.

The only viable treatment was, therefore, by biological means. Of the various activated sludge treatment processes presently in use, the one most acceptable is the extended aeration system since minimum operator attention is required and the second step, that of handling sludge produced as a result of biological metabolism, is eliminated. Virtually no sludge is produced.

A biological oxidation system consisting of an extended aeration plant to be located near the terminal lagoon is shown on Figs. E-3 and E-4. These figures show requirements for both BAT and total recycle.

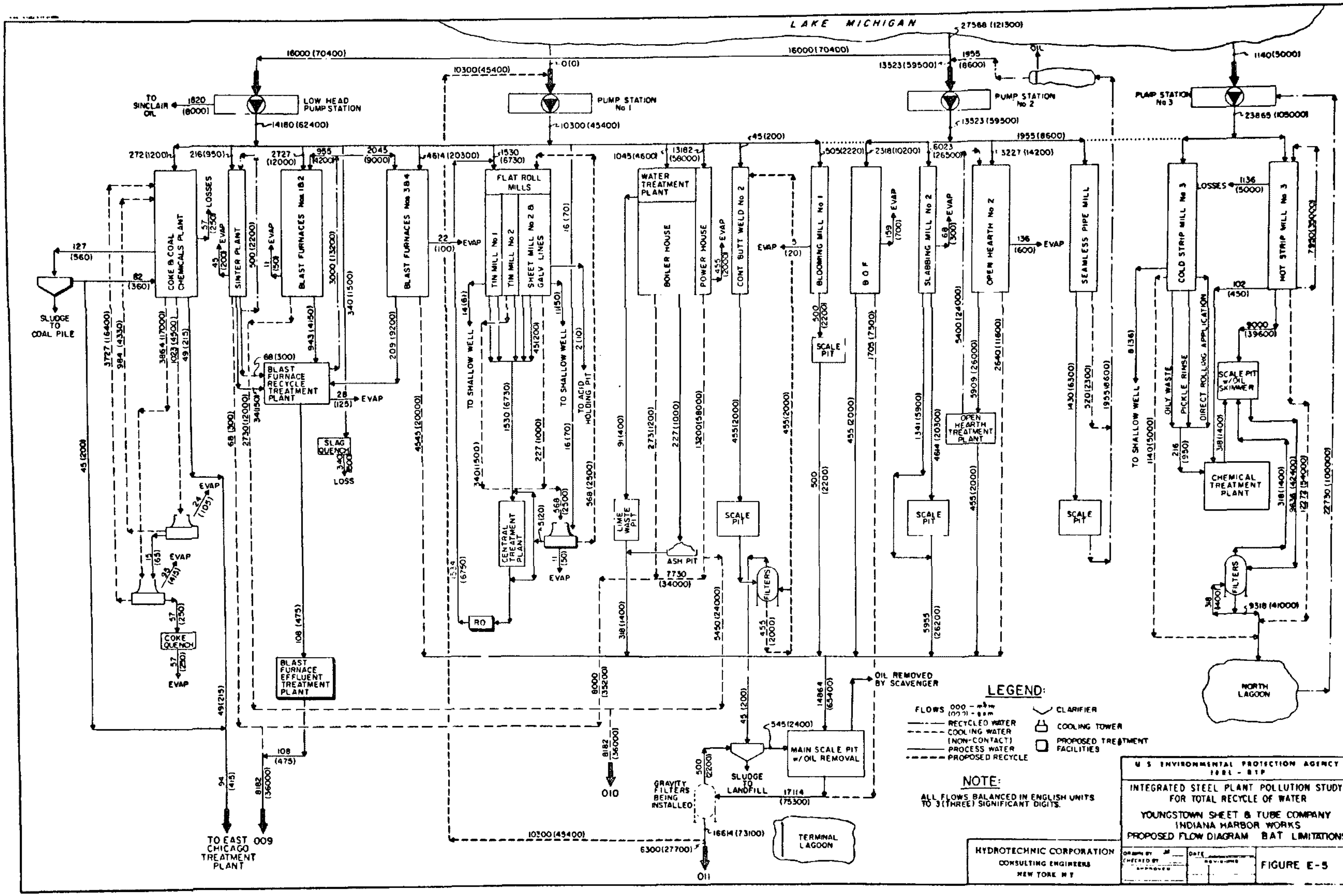
A modified plant flow diagram which incorporates all of the above modifications to meet BAT requirements is shown as Fig. E-5.

2.4 REQUIREMENTS FOR PLANT TO MEET TOTAL RECYCLE

For the Indiana Harbor Works to meet total recycle the plant would have to cease its discharges to the City of East Chicago Sewage Treatment Plant and the discharges of waste pickle liquor to the "shallow well" would have to be discontinued. Provisions for treatment of material storage pile storm water runoff would not be required since the plant has indicated that all such piles are in lined, self-contained areas and there is no runoff.

The following provisions would be required to achieve total recycle.

1. Install cooling towers at four locations; one to cool and recirculate 4980 m^3/hr (21,900 gpm) of water from Open Hearth No. 2, Slabbing Mill No. 2 and the BOF Shop. The blowdown would be to Outfall 011. One cooling tower installation would cool and recirculate 13,500 m^3/hr (59,200 gpm) from the Boiler House and Power House. Blowdown would be to Blast Furnace slag quenching. One cooling tower installation would cool and recirculate 7340 m^3/hr (32,300 gpm) of Blast Furnace and Sinter Plant non-contact water. Blowdown would be to Blast Furnace slag quenching. The fourth installation would be at the Flat Rolling Mills to cool and recirculate 568 m^3/hr (2500 gpm) of non-contact cooling water. Blowdown would be to the


LAKE MICHIGAN
LOW HEAD PUMP STATION
PUMP STATION No 1
PUMP STATION No 2
PUMP STATION No 3
TO SINCLAIR OIL
COKE & COAL CHEMICALS PLANT
SINTER PLANT
BLAST FURNACES Nos 1&2
BLAST FURNACES Nos 3&4
FLAT ROLL MILLS
TIN MILL No 1
TIN MILL No 2
SHEET MILL No 2 & GALV LINES
WATER TREATMENT PLANT
BOILER HOUSE
POWER HOUSE
CONT BUTT WELD No 2
BLOOMING MILL No 1
B O F
SLABBING MILL No 2
OPEN HEARTH No 2
SEAMLESS PIPE MILL
COLD STRIP MILL No 3
HOT STRIP MILL No 3
SLUDGE TO COAL PILE
BLAST FURNACE RECYCLE TREATMENT PLANT
SLAG QUENCH
COKE QUENCH
BLAST FURNACE EFFLUENT TREATMENT PLANT
CENTRAL TREATMENT PLANT
RO
TO SHALLOW WELL
TO ACID HOLDING PIT
LIME WASTE PIT
ASH PIT
SCALE PIT
FILTERS
OPEN HEARTH TREATMENT PLANT
SCALE PIT w/OIL SKIMMER
CHEMICAL TREATMENT PLANT
OILY WASTE
PICKLE RINSE
DIRECT ROLLING APPLICATION
NORTH LAGOON
TERMINAL LAGOON
MAIN SCALE PIT w/OIL REMOVAL
OIL REMOVED BY SCAVENGER
SLUDGE TO LANDFILL
GRAVITY FILTERS BEING INSTALLED
TO EAST CHICAGO TREATMENT PLANT
009
010
011
LEGEND:
FLOWS 000 – m³/hr (000) – gpm
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO 3 (THREE) SIGNIFICANT DIGITS.
U S ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
YOUNGSTOWN SHEET & TUBE COMPANY
INDIANA HARBOR WORKS
PROPOSED FLOW DIAGRAM BAT LIMITATIONS
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N Y
FIGURE E-5

Central Treatment Plant.

Makeup to the cooling towers would be lake water quality. Makeup to the Blast Furnaces Cooling Tower and a portion of the makeup to the Power House and Boiler House Cooling Tower would be the filtered effluent from the Continuous Butt Weld Mill. The balance of the makeup water to the Power House and Boiler House Cooling Tower and the total makeup to the Open Hearth, BOF and Slabbing Mill Cooling Tower would be lake water quality from Pumping Station No. 1.

2. Install a biological treatment plant to treat the wastes from the Coke Plant and the Blast Furnace recycle system blowdown. This is an alternative if the plant is to go from present operations to total recycle directly. However, if total recycle is to be considered as an additional step after achieving BAT, then the biological treatment plant would be required to treat only the wastes from the Coke Plant and the Blast Furnace wastes would continue to use the treatment system installed for BAT.

3. Recycle all treated wastes at the Flat Roll Mills after treatment at the Central Treatment Plant. Before recycling, it would be necessary to reduce the dissolved solids level so that product quality is not affected. Plant data supplied indicates that there are dissolved solids increases in the water of approximately 475 mg/l. A dissolved solids removal facility capable of producing water with a quality of 175 mg/l TDS, similar to lake water, would be required to treat 920 m^3/hr (4050 gpm) and 654 m^3/hr (2880 gpm) could be by-passed and blended to achieve a water quality of 500 mg/l TDS which would be usable at the mills. In addition, it is estimated that each mill requires 45.4 m^3/hr (200 gpm) of makeup water with a quality of 175 mg/l TDS or better. A reject stream of approximately 230 m^3/hr (1010 gpm) from the dissolved solids removal facility would have to be evaporated, condensed and returned to the system or used at points in the processes where very high purity water may be required. On the basis of reducing the TDS concentration of 920 m^3/hr (4050 gpm) from 950 mg/l to 175 mg/l, approximately 17 kkg (18.8 tons) per day of dried solids would be produced. Assuming a density of 962 kg per m^3 (60 pounds per cubic foot), 17.7 m^3 (23.1 cubic yards) per day would require disposal. See Figure E-6.

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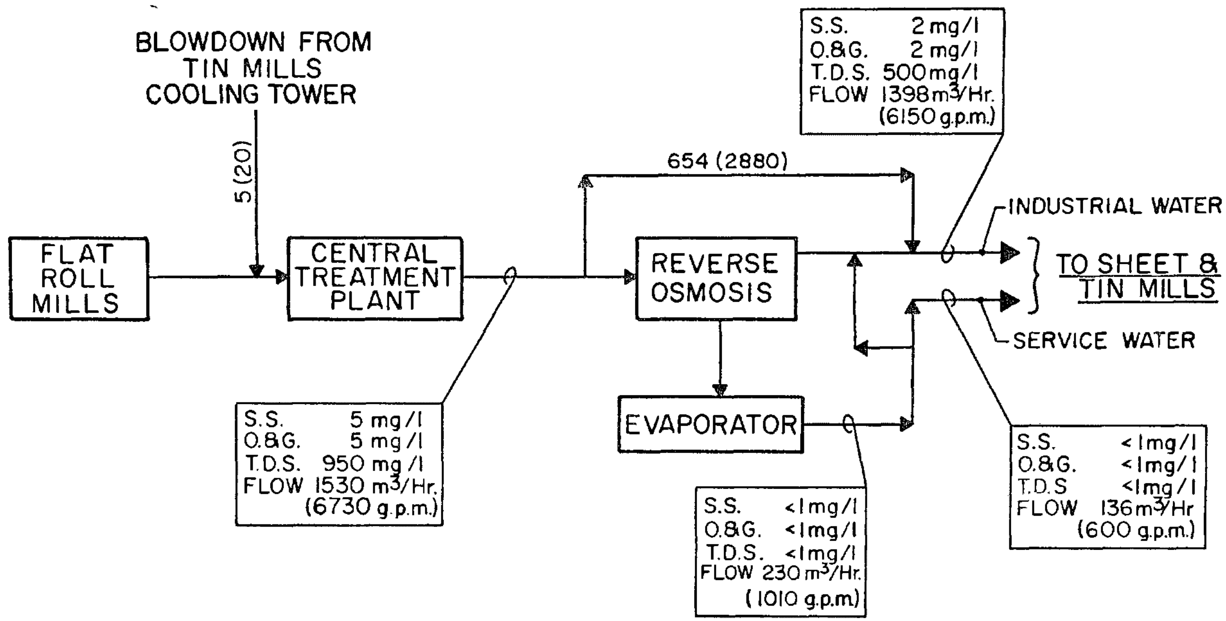
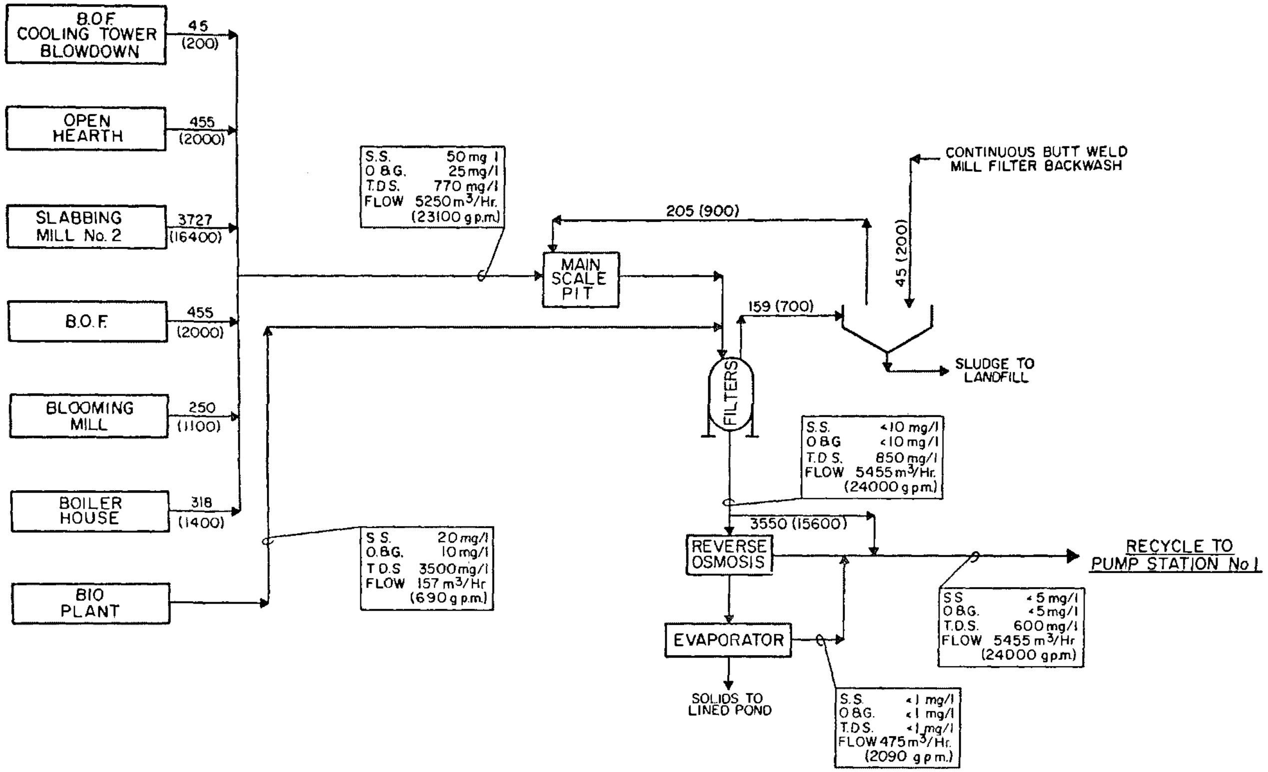


MODIFIED CENTRAL TREATMENT PLANT — FLOW & QUALITY DIAGRAM FIGURE E-6

4. At Outfall 011 the volume of wastes requiring filtration from the mills would be reduced from the design level of 15,900 m^3/hr (70,000 gpm) to approximately 5360 m^3/hr (23,600 gpm). The wastes from the proposed biological treatment plant would be pumped to the Outfall 011 filters, together with the wastes from the Blast Furnace BAT installation after settling. The filters and activated carbon units installed for BAT would be abandoned or salvaged. The loading at the Outfall 011 filters would be approximately 5455 m^3/hr (24,000 gpm). Assuming an increase in TDS of mill wastes of approximately 170 mg/l and the TDS of both, the biological plant and the Blast Furnace BAT installation of 3500 mg/l and, also, assuming a quality of 600 mg/l being used at all mills other than the Flat Roll Mills, the quality with respect to TDS leaving the filters will be approximately 850 mg/l. Installing a dissolved solids removal facility capable of reducing the concentration to 175 mg/l approximately 1090 m^3/hr (8350 gpm) would have to be demineralized to a level of 175 mg/l and the balance 3550 m^3/hr (15,600 gpm) could bypass the facility and be blended with the demineralized water and then discharged to Intake No. 1. Approximately 475 m^3/hr (2090 gpm) of reject brine would have to be evaporated and condensed and returned to the blended water, or if desired, pumped to the boiler house to be used for steam. On the basis of reducing 1090 m^3/hr (8350 gpm) from 850 mg/l TDS to 175 mg/l TDS approximately 33 kkg (33.8 tons) per day of dried solids would be produced with a volume of 31.9 m^3 (41.7 cubic yards). See Figures E-7 and E-8.

5. The method of rinsing at the Pickle Lines should be modified to be a counter current, cascade rinse system. This will reduce rinse water discharge flows to 19.4 m^3/hr (85 gpm). A pickle liquor regeneration plant should be installed to recover the 33.4 m^3/hr (147 gpm) of waste pickle liquor presently disposed of in the shallow well or hauled away from the acid holding pit and also the cascade rinse water. The alternative to regenerating the acid would be to neutralize it which would produce large sludge volumes and an increased volume of water containing high dissolved solids which would require further treatment.

Based on the above discussion, it can be seen that, to achieve total recycle of water, it would be necessary to have two separate water supply systems providing water to the plant. One system, here called industrial water, would be used at processes where dissolved solids content is not critical but



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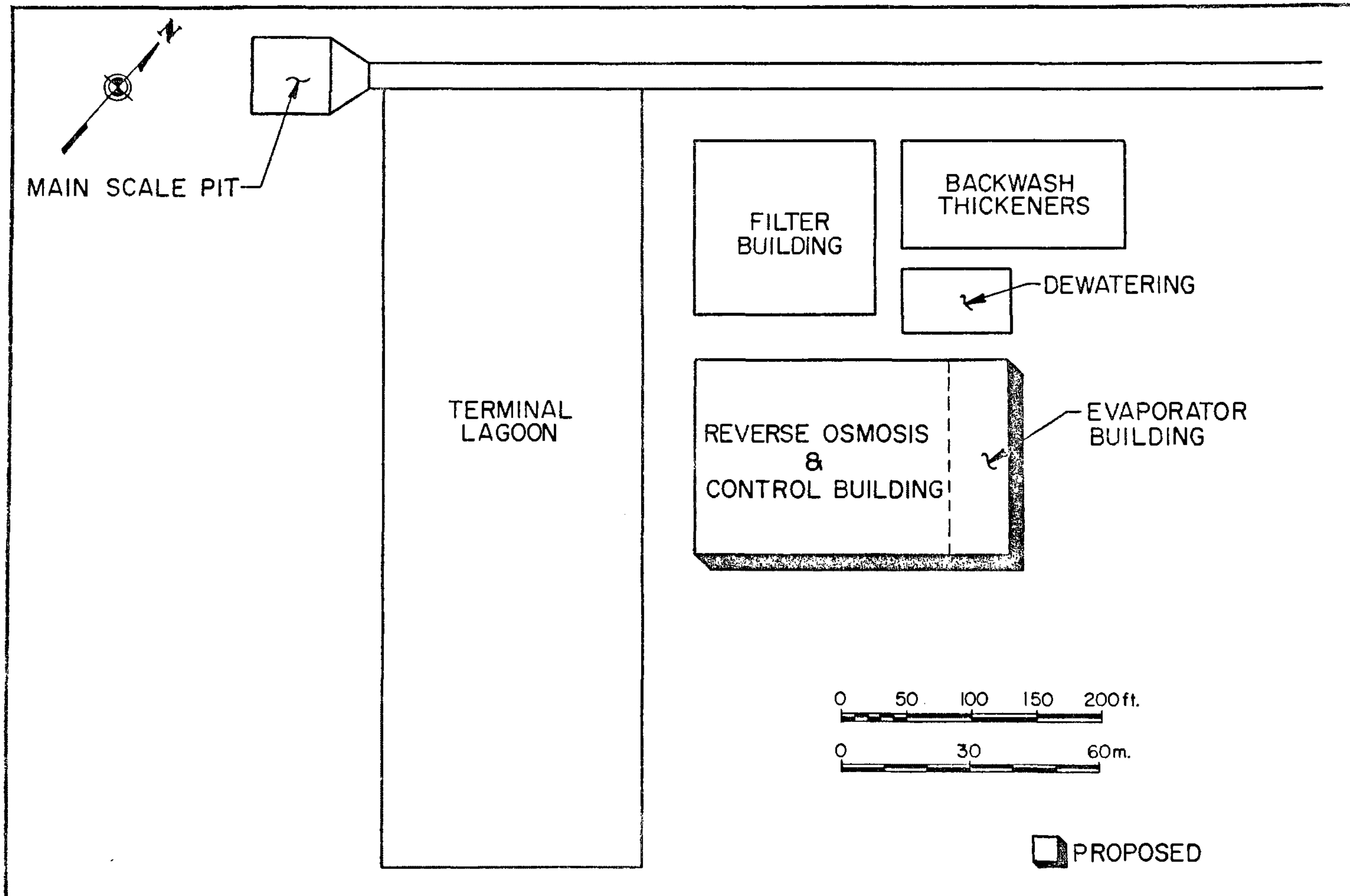
MODIFIED TERMINAL TREATMENT PLANT - FLOW & QUALITY DIAGRAM

FIGURE E-7



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MODIFIED TERMINAL TREATMENT PLANT - GENERAL ARRANGEMENT FIGURE E-8 yet must be maintained at a reasonable level. The second system called service water would be required at areas where lake water quality is necessary, such as at the boiler house or steam production and at the cooling towers for makeup in non-contact cooling water circuits.

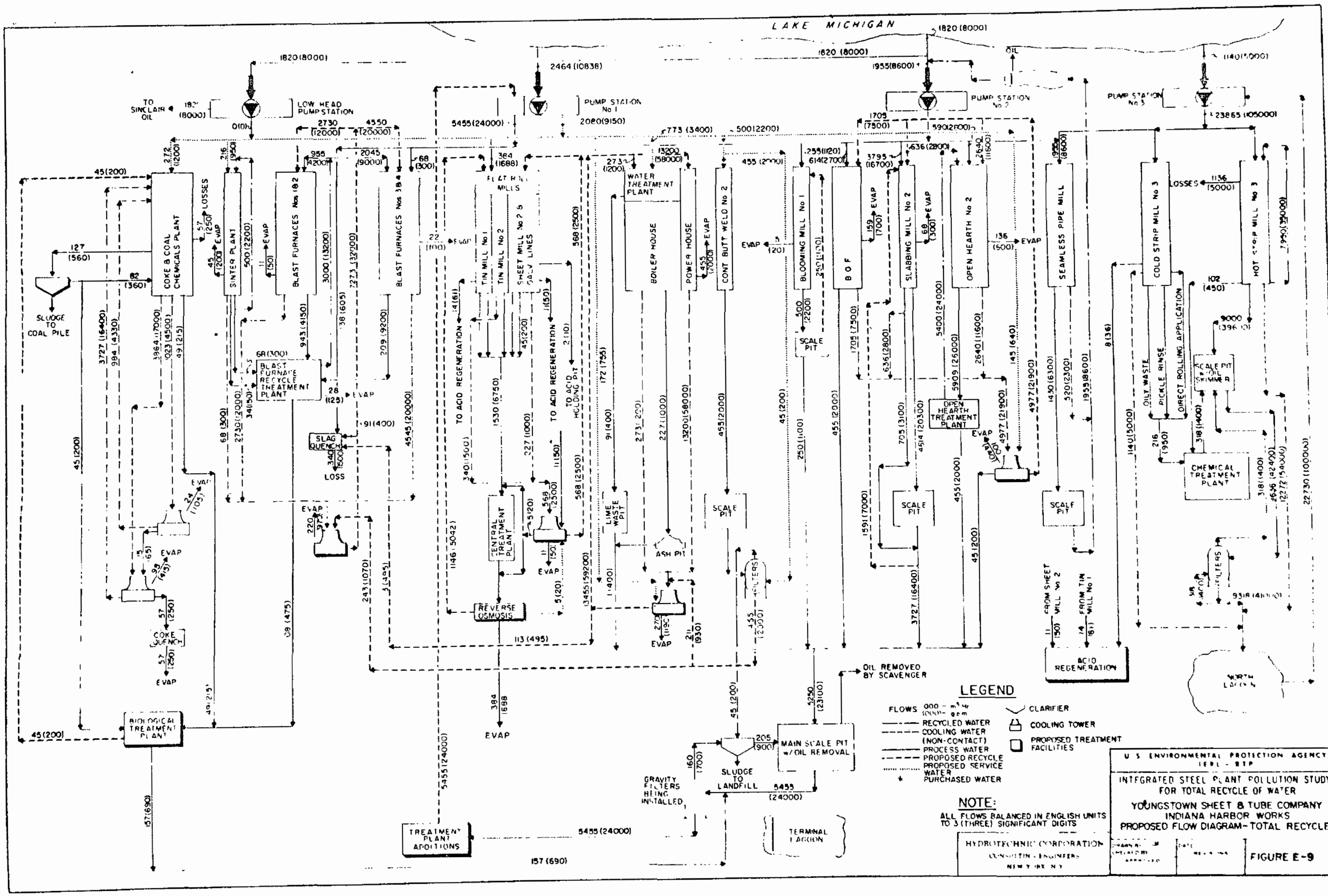
To permit circulation of these two qualities of water, it is recommended that Pumping Station No. 1 be segregated to pump both water qualities. One section would be self-contained and isolated to recirculate water with a quality of 600 mg/l TDS. The second section would pump Lake Michigan water for make up due to evaporation losses in cooling, quenching and various other processes.

The Flat Roll Mills would require a lake water quality makeup of approximately 11.4 m^3/hr (50 gpm). However, since this production area is so distant from Pumping Station No. 1, and the flow is so small, this makeup water should be purchased from nearby local sources.

A flow diagram incorporating all of the above recommendations to achieve zero discharge is shown as Figure E-9.

Quantities of solid wastes would be produced as a result of the extensive waste treatment that would be practiced. Solid wastes produced at the recommended Coke Plant pushing facilities would be disposed of on coal piles. Sludges produced at the Outfall 011 scale pit and filters would be high in oil and metallics. Additional studies should be carried out to determine ways to clean the solids of oils and recover both the oil and metallic portions. There are presently proprietory systems in use to do this and they should be investigated. Solids produced at the Blast Furnace BAT treatment would be inorganic in nature and should be disposed of at acceptable landfill sites. If sites are not available, an impervious site should be prepared on the steel plant property. The solids produced at the dissolved solids removal facilities should be contained in an on-site lined area to prevent percolation into the ground during periods of precipitation.

Due to the nature of the facilities recommended, i.e., recirculation, cooling, demineralization, physical-chemical treatment and biological oxidation, it is suggested that all assumptions be confirmed, a hydraulic analysis of the plant water distribution system using the modified flows shown for both BAT and total recycle be made and pilot plant testing on actual plant wastes be performed to establish the design parameters.



LAKE MICHIGAN
LOW HEAD PUMP STATION
PUMP STATION No 1
PUMP STATION No 2
PUMP STATION No 3
TO SINCLAIR OIL
COKE & COAL CHEMICALS PLANT
SINTER PLANT
BLAST FURNACES Nos 1&2
BLAST FURNACES Nos 3&4
FLAT ROLL MILLS
TIN MILL No 1
TIN MILL No 2
SHEET MILL No 2 & GALV LINES
WATER TREATMENT PLANT
BOILER HOUSE
POWER HOUSE
CONT BUTT WELD No 2
BLOOMING MILL No 1
B O F
SLABBING MILL No 2
OPEN HEARTH No 2
SEAMLESS PIPE MILL
COLD STRIP MILL No 3
HOT STRIP MILL No 3
SLUDGE TO COAL PILE
BLAST FURNACE RECYCLE TREATMENT PLANT
SLAG QUENCH
COKE QUENCH
BIOLOGICAL TREATMENT PLANT
TO ACID REGENERATION
TO ACID HOLDING PIT
CENTRAL TREATMENT PLANT
REVERSE OSMOSIS
LIME WASTE PIT
ASH PIT
SCALE PIT
FILTERS
OPEN HEARTH TREATMENT PLANT
CHEMICAL TREATMENT PLANT
SCALE PIT w/OIL SKIMMER
OILY WASTE
PICKLE RINSE
DIRECT ROLLING APPLICATION
FROM SHEET MILL No 2
FROM TIN MILL No 1
ACID REGENERATION
NORTH LAGOON
OIL REMOVED BY SCAVENGER
MAIN SCALE PIT w/OIL REMOVAL
SLUDGE TO LANDFILL
GRAVITY FILTERS BEING INSTALLED
TERMINAL LAGOON
TREATMENT PLANT ADDITIONS
EVAP
LOSSES
LEGEND
FLOWS 000 – m³/hr (000) – gpm
RECYCLED WATER
COOLING WATER (NON-CONTACT)
PROCESS WATER
PROPOSED RECYCLE
PROPOSED SERVICE WATER
PURCHASED WATER
CLARIFIER
COOLING TOWER
PROPOSED TREATMENT FACILITIES
NOTE:
ALL FLOWS BALANCED IN ENGLISH UNITS TO 3 (THREE) SIGNIFICANT DIGITS
HYDROTECHNIC CORPORATION
CONSULTING ENGINEERS
NEW YORK N.Y.
U S ENVIRONMENTAL PROTECTION AGENCY
IERL - RTP
INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER
YOUNGSTOWN SHEET & TUBE COMPANY
INDIANA HARBOR WORKS
PROPOSED FLOW DIAGRAM-TOTAL RECYCLE
FIGURE E-9

APPENDIX F

COST ESTIMATE SUMMARIES

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U.S.E.P.A.

INTEGRATED STEEL PLANT

TOTAL RECYCLE STUDY

COST ESTIMATE - PRICING ASSUMPTIONS

AMORTIZATION - An interest rate of 10% and an expected useful life of 15 years was used. The resultant factor is 0.13147.

O & M - OPERATING PERSONNEL - An hourly rate of $12.50 was used for operating personnel. This includes fringe benefits and overhead. For supervisors an hourly rate of $20.00 was used.

O & M - EQUIPMENT REPAIR AND MAINTENANCE - 8% of installed equipment module exclusive of contingency and contractors fee.

O & M - MATERIALS - The following are representative on-site material costs, expressed in 1979 dollars.

Polymer	$2.5/Pound
Lime	$35.0/Ton
Sulfuric Acid	$1.0/Gallon
Metabisulfite	$5.0/Pound

O & M - SOLIDS DISPOSAL - The cost for disposing of solid wastes which may be generated by some treatment processes is included only to the point of ultimate disposal. A transport cost of $2.00 per metric ton has been applied to represent this cost.

O & M - TAXES AND INSURANCE - Annual taxes and insurance costs are estimated to be 2% of the capital cost.

ENERGY electricity cost is based on motor horsepower ratings and a cost of $.025 per kilowatt hour. Same unit price has been considered for lighting.
Fuel (gas) cost is based on $1.5 per 1,000 cubic feet.

COST OF MECHANICAL EQUIPMENT - Unit prices for pumps and motors, piping, sludge mechanism, dewatering units and R. O. system have been established based on quotations from manufacturers.

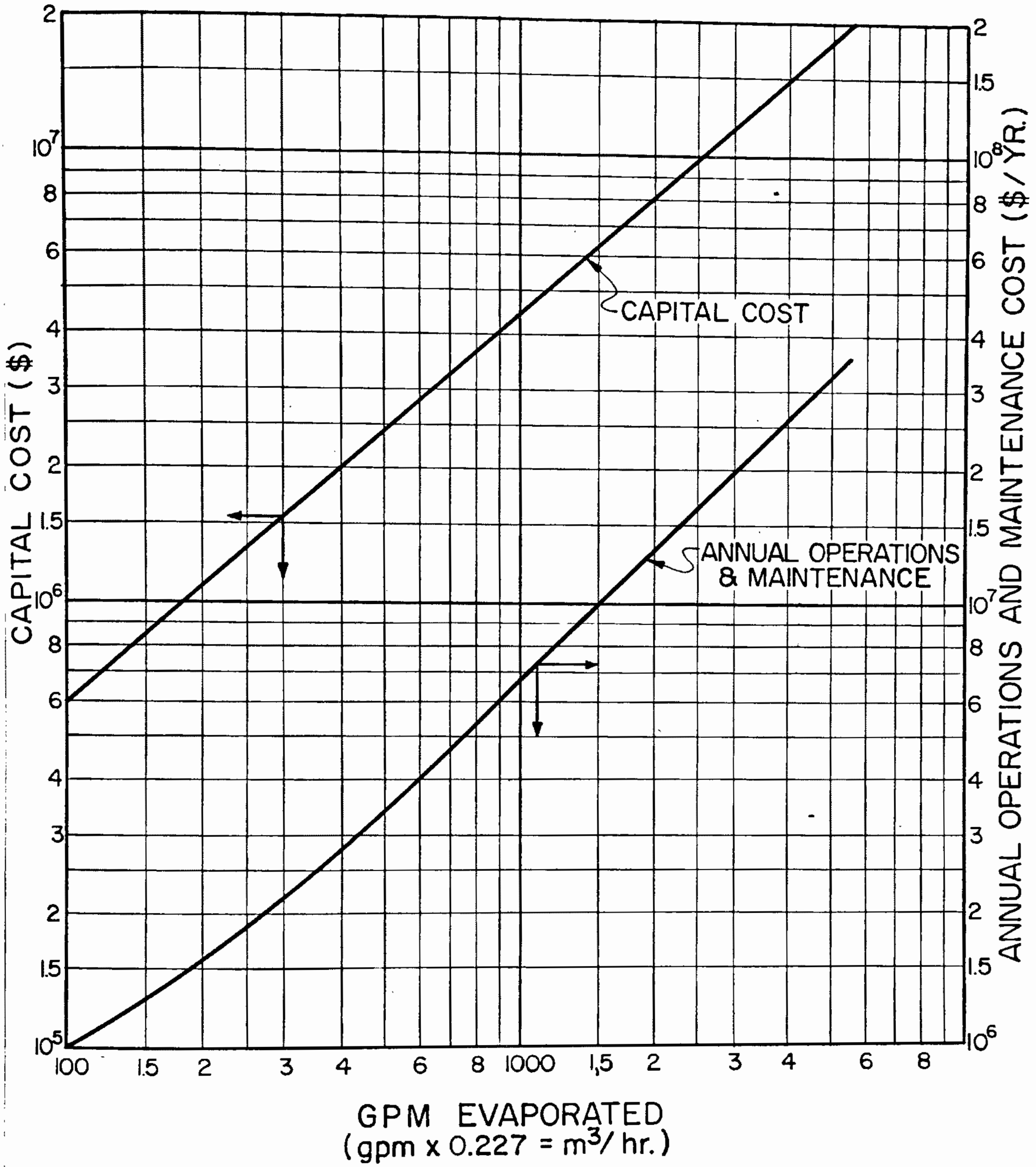
COST OF ELECTRICAL EQUIPMENT AND INSTRUMENTATION - Based on our experience the cost for electrical equipment and instrumentation has been considered at 30% of the cost of the purchased mechanical equipment.

DEVELOPMENT OF COAL USE COSTS - In the capital cost estimates developed figures are shown for the additional costs that would be incurred if coal were to be used as the source of evaporation energy. These costs were developed by treating the facility as a coal fired steam electric generating station. Evaporating 1 gallon per minute of water is approximately equivalent to the steam required to generate 55 KWe. Using proprietory in-house data the cost for installation of coal and ash handling facilities for a 640 MWe steam electric generating station was $6.13 per KWe (1976 prices). Using escalation of 10 percent per year the cost for 1978 would be $7.42 per KWe. This cost was factored for economy or penalty of size.

Assuming flue gas desulfurization would be necessary to meet sulfur dioxide emission standards the cost of installing a system shown in the "National Public Hearings on Power Plant Compliance With Sulfur Dioxide Air Pollution Regulations" of $60. per KWe was used, with no factoring for size.

In developing the annual costs the cost of handling the coal bottom ash and fly ash to an off site location was considered to be $2. per kkg and a cost of $.0032 per KW-hr was used for flue gas desulfurization. Power, labor, amortization, and maintenance were estimated based on capital costs and manning estimates and energy requirements.

The capital and operating costs for the evaporation of 100, 500, 1000, 2000, and 4000 gpm were estimated and plotted as shown on Figure F-1. From these plots the costs shown in this section were estimated.



ADDITIONAL COST FOR USE OF COAL FOR EVAPORATION

FIG. F-1

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	17,717,000
2.	Total Operating Cost	$/Yr	7,432,000
3.	Total Annual Cost	$/Yr	9,762,000

For Coal Add: $ 2,400,000 Capital Cost

$ 3,620,000 Annual Cost

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE - INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF FACILITIES COSTS

	Capital	Annual
Terminal Treatment Plant	$ 6,727,000	$ 5,380,000
Organic Waste Treatment	10,405,000	4,266,000
Material Storage Pile Runoff	585,000	116,000
	17,717,000	9,762,000

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

TERMINAL TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
	$	$	$	$
Tin Mill - Alkaline/Acid Pump Sta.	18,350	38,000	4,000	60,350
Cold Reduction - Alk. Waste/Pump Sta.	9,000	19,000	2,000	30,000
HSM, Storage Pile & BOP/Pump Stas.	26,250	56,500	6,000	88,750
Scalping Tanks	64,750	143,000	25,000	232,750
Chrome Waste Pump Sta. & Reduct. System	17,750	53,500	10,000	81,250
Mixing Tanks & Flocculators	40,000	88,000	12,000	140,000
Clarifier Modifications	10,000	10,000	-	20,000
Filters & B.W. Basins	169,400	154,000	35,000	358,400
Control Bldg, R.O. & Evap. System & Pond	307,500	3,585,000	180,000	4,072,500
Return Pump Station	24,000	57,000	10,000	91,000
	Subtotal:			$5,175,000
Contingency:				$1,552,000
	Total Capital Cost:			$6,727,000

For use of coal add $1,590,000

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

TERMINAL TREATMENT PLANT

ANNUAL COST	TOTAL
Amortization	$ 885,000
O & M - Operating Personnel	190,000
- Equipment Repair & Maintenance	352,000
- Material (Chemicals)	144,000
- Taxes & Insurance	135,000
- Solids Disposal (Hauling)	164,000
Energy	3,510,000
Total Annual Cost	$ 5,380,000

For use of coal add $2,320,000

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

ORGANIC WASTE TREATMENT

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Lift Station	$ 24,500	$ 11,500	$ 3,000	$ 39,000
Rotating Biological Contactors	1,000,000	3,520,000	520,000	5,040,000
Final Clarifier	68,500	52,000	10,000	130,500
Filters & B.W. Basins	113,000	140,000	20,000	273,000
Return Pump Sta.	13,500	42,000	8,000	63,500
Control Bldg w/R.O. & Evap. System	157,000	1,948,000	100,000	2,205,000
Scrubber Clarifiers & Pump Sta.	68,800	156,000	28,000	252,800
		Subtotal:		$8,003,800
Contingency:				2,401,200
		Total Capital Cost:		$10,405,000

For use of coal add $810,000

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

ORGANIC WASTE TREATMENT

ANNUAL COST

Amortization	$ 1,368,000
O & M - Operating Personnel	190,000
- Equipment Repair & Maintenance	481,000
- Material (Chemicals)	47,000
- Taxes & Insurance	208,000
- Solids Disposal (Hauling)	140,000
Energy	1,832,000
Total Annual Cost	$ 4,266,000

For use of coal add $1,300,000

COST ESTIMATE

TOTAL RECYCLE STUDY

KAISER STEEL - FONTANA

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

MATERIAL STORAGE PILE RUNOFF

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Storm Water Lagoon & Pump Sta.	$396,500	$50,500	$3,000	$450,000
Contingency:				135,000
	Total Capital Investment			$585,000

ANNUAL COST	
Amortization	$ 77,000
O & M - Operating Personnel	8,000
- Equipment Repair & Maintenance	17,000
- Taxes & Insurance	12,000
Energy	2,000
Total Annual Cost	$116,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY

INDIANA HARBOR WORKS

BAT

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	36,300,000
2.	Total Operating Cost	$/Yr	14,049,000
3.	Total Annual Cost	$/Yr	18,823,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY

INDIANA HARBOR WORKS

BAT

SUMMARY OF FACILITIES COST

	CAPITAL	ANNUAL
Outfall 002	$ 2,690,000	$ 784,000
Outfall 003 & 005	2,080,000	713,000
Outfall 013 & 014	15,125,000	8,873,000
Outfall 017 & 24N	14,210,000	7,503,000
Material Storage Pile Runoff	2,195,000	350,000
	$36,300,000	$18,823,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY

INDIANA HARBOR WORKS

BAT

OUTFALL 002

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Lift Station	$ 17,000	$ 29,000	$ 4,000	$ 50,000
Mixing Tanks	22,000	23,000	2,000	47,000
Flocculator-Clarifier	82,000	73,000	15,000	170,000
Filters & B.W. Basins	142,000	153,000	30,000	325,000
Activated Carbon	100,000	800,000	100,000	1,000,000
Control Building	167,000	270,000	40,000	477,000
			Sub-Total	2,069,000
Contingency:				621,000
		Total Capital Cost		$2,690,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 002

ANNUAL COST	TOTAL
Amortization	$ 354,000
O & M - Operating Personnel	115,000
- Equipment Repair & Maintenance	120,000
- Material (Chemicals)	82,000
- Taxes & Insurance	54,000
- Solids Disposal	40,000
Energy	19,000
Total Annual Cost:	$ 784,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 003 & 005

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Lift Station	$24,500	$211,000	$30,000	$265,500
Filters & B.W. Basins	72,000	154,000	30,000	256,000
Return Pump Sta.	16,000	36,000	6,000	58,000
Chemical & Control Bldg.	116,000	155,000	30,000	301,000
Piping				720,000
	Subtotal:			$1,600,500
Contingency:				479,500
	Total Capital Cost:			$2,080,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 003 & 005

ANNUAL COST	TOTAL
Amortization	$ 273,000
O & M - Operating Personnel	115,000
- Equipment Repair	110,000
- Material (Chemicals)	15,000
- Taxes & Insurance	42,000
- Solids Disposal	35,000
Energy	123,000
Total Annual Cost:	$ 713,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 013 & 014

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Pump Station	$ 142,000	$ 721,000	$ 100,000	$ 963,000
Filtration Plant	981,000	3,813,000	400,000	5,194,000
Cooling Towers & Pump Sta.	172,500	2,235,000	250,000	2,657,500
Control Building	176,000	120,000	50,000	346,000
Piping (Non Contact-Sewers)				1,625,000
Piping (Contact)				850,000
	Subtotal:			$ 11,635,500
Contingency:				3,489,500
	Total Capital Cost			$ 15,125,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 013 & 014

ANNUAL COST	TOTAL
Amortization	$ 1,990,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	824,000
- Material (Chemicals)	1,523,000
- Taxes & Insurance	303,000
- Solids Disposal	2,710,000
Energy	1,358,000
Total Annual Cost:	$ 8,873,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 017 & 24N

CAPITAL COSTS	CIVIL	MECH.	ELECT	TOTAL
Scale Pit #2 Pump Sta.	$ 63,500	$ 190,000	$ 30,000	$ 283,500
Scale Pit #4A&4B - Pump Sta.	52,500	145,000	25,000	222,500
Lagoon Pump Station	42,000	100,000	16,000	158,000
Treatment Plant Pump Sta.	123,000	620,000	80,000	823,000
Filters	623,000	2,521,000	250,000	3,394,000
Cooling Towers & Pump Stas.	125,000	1,570,000	100,000	1,795,000
Non Contact Cooling Tower	78,000	1,017,000	60,000	1,155,000
Piping				3,100,000
	Subtotal:			$10,931,000
Contingency:				3,279,000
	Total Capital Cost:			$14,210,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
OUTFALL 017 & 24N

ANNUAL COST	TOTAL
Amortization	$ 1,868,000
O & M - Operating Personnel	190,000
- Equipment Repair & Maintenance	774,000
- Material (Chemicals)	1,427,000
- Taxes & Insurance	284,000
- Solids Disposal	1,700,000
Energy	1,260,000
Total Annual Cost:	$ 7,503,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
MATERIAL STORAGE PILE RUNOFF

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Plant #2 - Ore Storage Area	$ 719,000	$ 13,000	$ 4,000	$ 736,000
Plant #3 - Ore Storage Area	439,000	13,000	4,000	456,000
Plant #3 - Coal Storage Area	439,000	13,000	4,000	456,000
Piping				40,000
	Subtotal:			1,688,000
Contingency:				507,000
	Total Capital Cost:			$ 2,195,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

BAT
MATERIAL STORAGE PILE RUNOFF

ANNUAL COST	TOTAL
Amortization	$ 289,000
O & M - Operating Personnel	8,000
- Equipment Repair & Maintenance	7,000
- Taxes & Insurance	44,000
Energy	2,000
Total Annual Cost	$ 350,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	96,924,000
2.	Total Operating Cost	$/Yr	93,309,000
3.	Total Annual Cost	$/Yr	106,051,000

For use of coal add: 26,190,000 Capital Cost

48,275,000 Annual Cost

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF FACILITIES COSTS

	CAPITAL	ANNUAL
Outfall 001 & 002	$ 3,532,000	$ 4,134,000
Outfall 011	1,084,000	242,000
Outfall 012	6,670,000	6,001,000
Outfall 013 & 014	28,796,000	34,462,000
Outfall 018	5,160,000	5,088,000
Sludge Lagoon	7,020,000	1,213,000
Northward Expansion	5,610,000	5,272,000
	$57,872,000	$56,412,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 001 & 002

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Pump Station 001	$ 15,500	$ 19,000	$ 3,000	$ 37,500
Bio Plant Lift Station	15,500	19,000	3,000	37,500
Aeration Basins	177,500	147,000	25,000	349,500
Clarifiers	55,500	44,000	10,000	109,500
Filters & B.W. Basins	76,800	143,000	25,000	244,800
Power House Pump Station	6,000	6,000	2,000	14,000
Control Building W/R.O., Evap. and Pump Station	52,000	1,472,000	100,000	1,624,000
Piping				300,000
		Sub-Total		2,716,800
Contingency:				815,200
		Total Capital Cost		3,532,000

For use of coal add: $620,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 001 & 002

ANNUAL COST	TOTAL
Amortization	$ 464,000
O & M - Operating Personnal	165,000
- Equipment Repair & Maintenance	110,000
- Material (Chemicals)	38,000
- Taxes & Insurance	70,000
- Solids Disposal	185,000
Energy	3,102,000
Total Annual Cost:	$4,134,000

For use of coal add: $1,225,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 011

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Sintering Pump Station	$14,000	$17,000	$3,000	34,000
Piping				800,000
		Sub-Total		834,000
Contingency:				250,000
		Total Capital Cost		$1,084,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 011

ANNUAL COST		TOTAL
Amortization		$143,000
O & M - Operating Personnel		8,000
- Equipment Repair & Maintenance		66,000
- Taxes & Insurance		22,000
Energy		3,000
	Total Annual Cost	$242,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 012

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Lift Station	$ 46,000	$ 35,000	$ 5,000	$ 86,000
Aeration Basins	438,000	65,000	18,000	521,000
Clarifiers	94,000	110,000	20,000	224,000
Filters & B.W. Basins	108,200	71,000	25,000	204,200
Control Building W/R.O., Evap. and Return Pump Station	191,500	3,327,000	176,000	3,694,500
Piping				400,000
		Sub-Total		5,129,700
Contingency:				1,540,300
		Total Capital Cost		$6,670,000

For use of coal add: $1,850,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 012

ANNUAL COST	TOTAL
Amortization	$ 898,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	236,000
- Material (Chemicals)	136,000
- Taxes & Insurance	137,000
- Solids Disposal	300,000
Energy	4,594,000
Total Annual Cost	6,001,000

For use of coal add: $2,650,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 013 & 014

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cold Mill #1 & 2 LIFT STATION	$ 22,000	27,000	4,000	53,000
Oil Flotation Tank	128,000	73,000	18,000	219,000
Filters & B.W. Basins	159,000	150,000	50,000	359,000
Control Building W/R.O. and Evap.	136,000	5,125,000	150,000	5,411,000
Control Building W/R.O. and Evap.	204,000	14,480,000	250,000	14,934,000
Piping				1,175,000
	Sub-Total			22,151,000
Contingency:				6,645,000
	Total Capital Cost			$28,796,000

For use of coal add: $9,900,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 013 & 014

ANNUAL COST	TOTAL
Amortization	$ 3,785,000
O & M - Operating Personnel	330,000
- Equipment Repair & Maintenance	2,240,000
- Material (Chemicals)	765,000
- Taxes & Insurance	576,000
- Solids Disposal	550,000
Energy	26,216,000
Total Annual Cost	$34,462,000

For use of coal add: $15,800,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 018

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Control Building W/R.O., Evap. and Return Pump Station	$167,000	$3,294,000	$108,000	$3,569,000
Piping				400,000
		Sub-Total		3,969,000
Contingency:				1,191,000
		Total Capital Cost		5,160,000

For use of coal add: $1,820,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

OUTFALL 018

ANNUAL COST	TOTAL
Amortization	$ 678,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	273,000
- Material (Chemicals)	110,000
- Taxes & Insurance	103,000
- Solids Disposal	25,000
Energy	3,899,000
Total Annual Cost	$5,088,000

For use of coal add: $2,550,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

SLUDGE LAGOON

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Excavation, Backfill and Lining	$5,400,000	-	-	$5,400,000
Contingency:				1,620,000
		Total Capital Cost		$7,020,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

SLUDGE LAGOON

ANNUAL COST		TOTAL
Amortization		$ 923,000
O & M - Operating Personnel		150,000
- Taxes & Insurance		140,000
	Total Annual Cost	$1,213,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

NORTHWARD EXPANSION

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Additional Aeration	$190,000	$ 45,000	$ 10,000	$ 245,000
Clarifiers	78,000	95,000	20,000	193,000
Filters & B.W. Basins	86,500	63,000	20,000	169,500
Control Building W/R.O., Evap. and Return Pump Station	147,500	3,288,000	108,000	3,543,500
Piping				165,000
		Sub-Total		4,316,000
Contingency:				1,294,000
		Total Capital Cost		$5,610,000

For use of coal add: $1,650,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

NORTHWARD EXPANSION

ANNUAL COST	TOTAL
Amortization	$ 738,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	306,000
- Material (Chemicals)	113,000
- Taxes & Insurance	112,000
- Solids Disposal	350,000
Energy	3,488,000
Total Annual Cost	$5,272,000

For use of coal add: $2,300,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1. Total Capital Cost	$	125,779,000
2. Total Operating Cost	$/Yr	104,514,000
3. Total Annual Cost	$/Yr	121,052,000

For use of coal add:	$ 27,350,000	Capital Cost
	$ 49,575,000	Annual Cost

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF FACILITIES COSTS

	CAPITAL	ANNUAL
Outfall 001 & 002	$ 8,200,000	$ 5,633,000
Outfall 003 & 004	686,000	341,000
Outfall 007	4,580,000	1,897,000
Outfall 008	6,146,000	3,615,000
Outfall 011	1,084,000	242,000
Outfall 012	13,195,000	10,875,000
Outfall 013 & 014	28,796,000	34,462,000
Outfall 015	2,122,000	892,000
Outfall 017	38,652,000	48,468,000
Outfall 018	9,688,000	8,142,000
Sludge Lagoon	7,020,000	1,213,000
Northward Expension	5,610,000	5,272,000
	$ 125,779,000	$ 121,052,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 001 & 002

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Pump Station 001	$ 15,500	$ 19,000	$ 3,000	$ 37,500
Pump Station 002	135,000	795,000	100,000	1,030,000
Cooling Tower & Pump Station	151,000	2,160,000	200,000	2,511,000
Bio Plant Lift Station	15,500	19,000	3,000	37,500
Aeration Basins	177,500	147,000	25,000	349,500
Clarifiers	55,500	44,000	10,000	109,500
Filters & B.W. Basins	76,800	143,000	25,000	244,800
Power House Pump Station	6,000	6,000	2,000	14,000
Control Building W/R.O.,Evap. and Pump Station	52,000	1,472,000	100,000	1,624,000
Piping				350,000
			Sub-Total	6,307,800
Contingency:				1,892,200
		Total Capital Cost		$8,200,000

For use of coal add: $ 620,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 001 & 002

ANNUAL COST	TOTAL
Amortization	$ 1,078,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	347,000
- Material (Chemicals)	373,000
- Taxes & Insurance	164,000
- Solids Disposal	185,000
Energy	3,321,000
Total Annual Cost:	$ 5,633,000

For use of coal add: $ 1,225,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 003 & 005

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Towers & Pump Station	$50,500	$317,000	$50,000	$417,500
Piping				110,000
			Sub-Total	527,500
Contingency:				158,500
		Total Capital Cost		$686,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 003 & 005

ANNUAL COST		TOTAL
Amortization		$ 90,000
O & M	- Operating Personnel	25,000
	- Equipment Repair & Maintenance	29,000
	- Material (Chemicals)	104,000
	- Taxes & Insurance	14,000
Energy		79,000
	Total Annual Cost	$341,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 007

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
007 Pump Station	$ 61,000	$ 249,000	$ 40,000	$ 350,000
Cooling Tower & Pump Station	172,000	1,862,000	250,000	2,284,000
Piping				890,000
			Sub-Total	3,524,000
Contingency:				1,056,000
	Total Capital Cost			$4,580,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 007

ANNUAL COST		TOTAL
Amortization		$ 602,000
O & M	- Operating Personnel	75,000
	- Equipment Repair & Maintenance	263,000
	- Material (Chemicals)	219,000
	- Taxes & Insurance	92,000
Energy		646,000
	Total Annual Cost	$1,897,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 008

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Tower & Pump Station	$209,000	$3,224,000	$300,000	$3,733,000
Piping				995,000
			Sub-Total	4,728,000
Contingency:				1,418,000
	Total Capital Cost			$6,146,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 008

ANNUAL COST		TOTAL
Amortization		$ 808,000
O & M	- Operating Personnel	25,000
	- Equipment Repair & Maintenance	362,000
	- Material (Chemicals)	851,000
	- Taxes & Insurance	123,000
Energy		1,446,000
	Total Annual Cost	$3,615,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 011

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Sintering Pump Station	$14,000	$17,000	$3,000	$ 34,000
Piping				800,000
			Sub-Total	834,000
Contingency:				250,000
	Total Capital Cost			$1,084,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 011

ANNUAL COST		TOTAL
Amortization		$143,000
O & M	- Operating Personnel	8,000
	- Equipment Repair & Maintenance	66,000
	- Taxes & Insurance	22,000
Energy		3,000
	Total Annual Cost	$242,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 012

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Tower	$101,000	$ 788,000	$130,000	$ 1,019,000
Cooling Tower	75,000	544,000	90,000	709,000
Cooling Tower	75,000	558,000	90,000	723,000
Lift Station	46,000	35,000	5,000	86,000
Aeration Basins	438,000	65,000	18,000	521,000
Clarifiers	94,000	110,000	20,000	224,000
Filters & B.W. Basins	108,200	71,000	25,000	204,200
Control Building W/R.O., Evap. and Return Pump Station	191,500	5,344,000	178,000	5,713,500
Piping				950,000
			Sub-Total	10,149,700
Contingency:				3,045,300
		Total Capital Cost		$13,195,000

For use of coal add: $2,750,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 012

ANNUAL COST		TOTAL
Amortization		$ 1,735,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	546,000
	- Material (Chemicals)	485,000
	- Taxes & Insurance	264,000
	- Solids Disposal	300,000
Energy		7,380,000
	Total Annual Cost	$10,875,000

For use of coal add: $4,000,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 013 & 014

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cold Mill #1 & 2 LIFT STATION	$ 22,000	$ 27,000	$ 4,000	$ 53,000
Oil Flotation Tank	128,000	73,000	18,000	219,000
Filters & B.W. Basins	159,000	150,000	50,000	359,000
Control Building W/R.O. and Evap.	136,000	5,125,000	150,000	5,411,000
Control Building W/R.O., and Evap.	204,000	14,480,000	250,000	14,934,000
Piping				1,175,000
			Sub-Total	22,151,000
Contingency:				6,645,000
		Total Capital Cost		$28,796,000

For use of coal add: $9,900,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 013 & 014

ANNUAL COST		TOTAL
Amortization		$ 3,785,000
O & M	- Operating Personnel	330,000
	- Equipment Repair & Maintenance	2,240,000
	- Material (Chemicals)	765,000
	- Taxes & Insurance	576,000
	- Solids Disposal	550,000
Energy		26,216,000
	Total Annual Cost	$34,462,000

For use of coal add: $15,800,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 015

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Towers & Pump Station	$99,000	$1,118,000	$100,000	$1,317,000
Piping				315,000
			Sub-Total	1,632,000
Contingency:				490,000
	Total Capital Cost			$2,122,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 015

ANNUAL COST		TOTAL
Amortization		$280,000
O & M	- Operating Personnel	25,000
	- Equipment Repair & Maintenance	97,000
	- Material (Chemicals)	148,000
	- Taxes & Insurance	42,000
Energy		300,000
	Total Annual Cost	$892,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 017

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Control Building W/R.O., Evap. and Return Station	$277,000	$27,343,000	$490,000	$28,110,000
Cooling Towers & Pump Station	139,500	1,033,000	100,000	1,272,500
Piping				350,000
			Sub-Total	29,732,500
Contingency:				8,919,500
		Total Capital Cost		$38,652,000

For use of coal add: $10,330,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 017

ANNUAL COST		TOTAL
Amortization		$ 5,082,000
O & M	- Operating Personnel	190,000
	- Equipment Repair & Maintenance	2,310,000
	- Material (Chemicals)	963,000
	- Taxes & Insurance	773,000
	- Solids Disposal	430,000
Energy		38,720,000
	Total Annual Cost	$48,468,000

For use of coal add: $23,300,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 018

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Towers & Pump Station	$1,036,000	$1,270,000	$ 85,000	$2,391,000
Control Building W/R.O.,Evap. and Return Pump Station	167,000	4,024,000	158,000	4,349,000
Piping				712,000
			Sub-Total	7,452,000
Contingency:				2,236,000
	Total Capital Cost			$9,688,000

For use of coal add: $2,100,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

OUTFALL 018

ANNUAL COST		TOTAL
Amortization		$1,274,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	572,000
	- Material (Chemicals)	319,000
	- Taxes & Insurance	194,000
	- Solids Disposal	29,000
Energy		5,589,000
	Total Annual Cost	$8,142,000

For use of coal add: $2,950,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SLUDGE LAGOON

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Excavation, Backfill and Lining	$5,400,000	-	-	$5,400,000
Contingency				1,620,000
	Total Capital Cost			$7,020,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SLUDGE LAGOON

ANNUAL COST		TOTAL
Amortization		$ 923,000
O & M - Operating Personnel		150,000
- Taxes & Insurance		140,000
	Total Annual Cost	$1,213,000

COST ESTIMATE
TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS
TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

NORTHWARD EXPANSION

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Additional Aeration	$190,000	$ 45,000	$ 10,000	$ 245,000
Clarifiers	78,000	95,000	20,000	193,000
Filters & B.W. Basins	86,500	63,000	20,000	169,500
Control Building W/R.O., Evap. and Return Pump Station	147,500	3,288,000	108,000	3,543,500
Piping				165,000
			Sub-Total	4,316,000
Contingency:				1,294,000
	Total Capital Cost			$5,610,000

For use of coal add: $1,650,000

COST ESTIMATE

TOTAL RECYCLE STUDY

INLAND STEEL COMPANY - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

NORTHWARD EXPANSION

ANNUAL COST		TOTAL
Amortization		$ 738,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	306,000
	- Material (Chemicals)	113,000
	- Taxes & Insurance	112,000
	- Solids Disposal	350,000
Energy		3,488,000
	Total Annual Cost	$5,272,000

For use of coal add: $2,300,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	24,051,000
2.	Total Operating Cost	$/Yr	7,136,000
3.	Total Annual Cost	$/Yr	10,298,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

SUMMARY OF FACILITY COSTS

	CAPITAL	ANNUAL
Blast Furnaces	$ 598,000	$ 150,000
Coke Plant	1,300,000	389,000
Sinter Plant	64,000	29,000
Power House & Boiler House	1,257,000	501,000
Blooming Mill & Scarfer	1,626,000	709,000
"B" Sewer Treatment Plant	3,420,000	1,175,000
"C" & "E" Sewers Treatment Plant	2,786,000	836,000
Hot Strip Mill	13,000,000	6,509,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

BLAST FURNACES

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Blowdown Treatment	$ 36,000	$93,000	$15,000	$144,000
Piping				120,000
Chemical & Control Building	116,000	55,000	25,000	196,000
		Sub-Total		460,000
Contingency:				138,000
		Total Capital Cost		$598,000

ANNUAL COST	
Amortization	$ 79,000
O & M - Operating Personnel	8,000
- Equipment Repair & Maintenance	25,000
- Material (Chemicals)	18,000
- Taxes & Insurance	12,000
Energy	8,000
Total Annual Cost	$150,000

COST ESTIMATE
TOTAL RECYCLE STUDY
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
BAT
COKE PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Biological Treatment Plant	$380,000	$570,000	$50,000	$1,000,000
Contingency:				300,000
Total Capital Cost				$1,300,000

ANNUAL COST	
Amortization	$ 171,000
O & M - Operating Personnel	115,000
- Equipment Repair & Maintenance	50,000
- Taxes & Insurance	26,000
Energy	27,000
Total Annual Cost	$ 389,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

SINTER PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Pump Station	$13,000	$31,000	$5,000	$49,000
Contingency:				15,000
Total Capital Cost				$64,000

ANNUAL COST		
Amortization		$ 8,000
O & M	- Operating Personnel	8,000
	- Equipment Repair & Maintenance	5,000
	- Taxes & Insurance	1,000
	- Material (Chemicals)	5,000
Energy		2,000
Total Annual Cost		$29,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

POWER HOUSE AND BOILER HOUSE

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Filters & B.W. Basins	$243,000	$191,000	$50,000	$ 484,000
Chemical & Control Building	193,000	220,000	50,000	463,000
Piping				20,000
			Sub-Total	967,000
Continency:				290,000
	Total Capital Cost			$1,257,000

ANNUAL COST		
Amortization		$ 165,000
O & M	- Operating Personeel	165,000
	- Equipment Repair & Maintenance	43,000
	- Material (Chemicals)	41,000
	- Taxes & Insurance	25,000
	- Solids Disposal (Hauling)	45,000
Energy		17,000
	Total Annual Cost	$ 501,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

BLOOMING MILL AND SCARFER

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Blooming Mill Pump Station	$ 30,000	$ 46,000	$10,000	$ 86,000
Scarfer Pump Station	23,000	25,000	5,000	53,000
Settling Basins, B.W. Basins & Pump Station	103,000	211,000	30,000	344,000
Pressure Filters	31,000	182,000	25,000	238,000
Cooling Towers & Pump Station	36,000	158,000	30,000	224,000
Chemical & Control Building	81,000	50,000	25,000	156,000
Piping				150,000
			Sub-Total	1,251,000
Contingency:				375,000
		Total Capital Cost		$1,626,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

BLOOMING MILL AND SCARFER

ANNUAL COST		TOTAL
Amortization		$214,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	77,000
	- Material (Chemicals)	53,000
	- Taxes & Insurance	33,000
	- Solids Disposal (Hauling)	112,000
Energy		55,000
	Total Annual Cost	$709,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

"B" SEWER TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Tin Mill Cleaning Lines - Conveyance	$ 16,000	$	$	$ 16,000
Demineralizer - Conveyance	10,500	40,000	4,500	55,000
Tin Plating Conveyance	14,000	81,000	15,000	110,000
Continuous Annealing Conveyance	14,500	40,000	8,000	62,500
Lift Station	43,000	83,000	15,000	141,000
Equalization Basins - Alkaline	415,000	145,000	30,000	590,000
Equalization Basins - Acid	234,000	92,000	20,000	346,000
Mixing Tanks	86,000	64,000	10,000	160,000
Flocculator - Clarifiers	130,000	133,000	25,000	288,000
Chemical and Control Building	202,000	360,000	50,000	612,000
Chrome Recovery Unit		125,000		125,000
Piping				125,000
			Sub-Total	$2,630,500
Contingency:				789,500
		Total Capital Cost		$3,420,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

"B" SEWER TREATMENT PLANT

ANNUAL COST		TOTAL
Amortization		$ 450,000
O & M	- Operating Personnel	115,000
	- Equipment Repair & Maintenance	109,000
	- Material (Chemicals)	252,000
	- Taxes and Insurance	68,000
	- Solids Disposal (Hauling)	100,000
Energy		81,000
	Total Annual Cost	$1,175,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

"C" & "E" SEWERS TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Pump Stations & Conveyances	$ 82,000	$135,000	$ 22,000	$ 239,000
Equalization Basins	48,000	57,000	12,000	117,000
Mixing Tanks	29,500	32,000	5,000	66,500
Flocculator - Clarifiers	142,000	128,000	25,000	295,000
Filters & B.W. Basins	145,200	128,000	40,000	313,200
R.O. & Chemical Building	192,500	420,000	100,000	712,500
Piping				400,000
			Sub-Total	2,143,200
Contingency:				642,800
	Total Capital Cost			$2,786,000

Quantity to be evaporated too small to consider coal

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

"C" & "E" SEWERS TREATMENT PLANT

ANNUAL COST		TOTAL
Amortization		$366,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	120,000
	- Material (Chemicals)	45,500
	- Taxes & Insurance	56,000
	- Solids Disposal	55,000
Energy		28,500
	Total Annual Cost	$836,000

Quantity to be evaporated too small to consider coal

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

HOT STRIP MILL

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Modification to Existing Facilities	$60,000	$ 391,000	$ 50,000	$ 501,000
Pump Stations	655,000	1,635,000	185,000	2,475,000
Settling Basins	461,000	648,000	70,000	1,179,000
Filters, B.W. Basins & Pump Stations	1,021,000	571,000	265,000	1,857,000
Cooling Towers	130,000	1,728,000	200,000	2,058,000
Chemical & Control Building	348,000	435,000	87,000	870,000
Pipe Bridge				340,000
Piping				720,000
			Sub-Total	10,000,000
Contingency:				3,000,000
		Total Capital Cost		$13,000,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

BAT

HOT STRIP MILL

ANNUAL COST		TOTAL
Amortization		$1,709,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	544,000
	- Material (Chemicals)	665,000
	- Taxes & Insurance	260,000
	- Solids Disposal	932,000
Energy		2,234,000
	Total Annual Cost	$6,509,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE NOT INCLUDING NON CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	96,582,000
2.	Total Operating Cost	$/Yr	102,600,000
3.	Total Annual Cost	$/Yr.	115,297,000

For use of coal add	$ 29,550,000	Capital
	$ 55,700,000	Annual

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE NOT INCLUDING NON CONTACT COOLING WATER

SUMMARY OF FACILITIES COST

	CAPITAL	ANNUAL
Coke Plant & Blast Furnaces	$ 16,507,000	$ 10,912,000
"B" Sewer Treatment Plant	32,015,000	42,171,000
"C" & "E" Sewers Treatment Plant	48,060,000	62,214,000
	$ 96,582,000	$115,297,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE NOT INCLUDING NON CONTACT COOLING WATER

COKE PLANT & BLAST FURNACES

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Coke Plant (Contact)	85,000	3,215,000	150,000	3,450,000
Blast Furnace (Contact)	872,250	8,025,000	350,000	9,247,250
		Sub-Total		12,697,250
Contingency:				3,809,750
		Total Capital Cost		16,507,000

For use of coal add: $3,550,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE NOT INCLUDING NON CONTACT COOLING WATER

COKE PLANT & BLAST FURNACES

ANNUAL COST	TOTAL
Amortization	$ 2,170,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	977,000
- Material (Chemicals)	227,000
- Taxes & Insurance	330,000
- Solids Disposal	68,000
Energy	6,975,000
Total Annual Cost	$10,912,000

For use of coal add: $ 5,200,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE NOT INCLUDING NON CONTACT COOLING WATER

"B" SEWER TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Treatment Plant W/R.O., Evap., & Control Building	$157,000	$23,970,000	$500,000	$24,627,000
Contingency:				7,388,000
For Use of Coal Add: $11,500,000				
		Total Capital Costs		$32,015,000

ANNUAL COST		
Amortization		$ 4,209,000
O & M	- Operating Personnel	125,000
	- Equipment Repair & Maintenance	1,959,000
	- Material (Chemicals)	640,000
	- Taxes & Insurance	640,000
	- Solids Disposal	370,000
Energy		34,228,000
	Total Annual Cost	$42,171,000

For Use of Coal Add: $20,000,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE NOT INCLUDING NON CONTACT COOLING WATER

"C" & "E" SEWERS TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
R.O., Evaporating & Control Building	$157,000	$36,130,000	$500,000	$36,787,000
Piping				180,000
			Sub-Total	36,967,000
Contingency:				11,093,000
For Use of Coal Add: $ 14,500,000		Total Capital Cost		$48,060,000

ANNUAL COST	
Amortization	$ 6,318,000
O & M - Operating Personnel	125,000
- Equipment Repair & Maintenance	2,946,000
- Material (Chemicals)	894,000
- Taxes & Insurance	961,000
- Solids Disposal	500,000
Energy	50,470,000
For Use of Coal Add: $ 30,500,000 — Total Annual Cost	$62,214,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTRACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	105,763,000
2.	Total Operating Cost	$/Yr	105,727,000
3.	Total Annual Cost	$/Yr	119,635,000

For Coal Add: $ 29,550,000 Capital

$ 55,700,000 Annual Cost

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

SUMMARY OF FACILITIES COST

	CAPITAL	ANNUAL
Coke Plant & Blast Furnaces	$ 19,882,000	$ 12, 593,000
Blooming Mill & Scarfer	1,124,000	486,000
"B" Sewer Treatment Plant	32,015,000	42,171,000
"C" & "E" Sewers Treatment Plant	48,060,000	62,214,000
Tandem Mill	836,000	372,000
Hot Strip Mill	1,841,000	747,000
Brown Island Coke & By-Product Plant	210,000	107,000
Temper Mill	360,000	153,000
Power House	1,435,000	792,000
	$105,763,000	$119,635,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

COKE PLANT & BLAST FURNACES

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Coke Plant (Non Contact)	$223,000	$ 772,000	$120,000	$ 1,115,000
Coke Plant (Contact)	85,000	3,215,000	150,000	3,450,000
Blast Furnace (Non Contact)	299,000	1,027,000	155,000	1,481,000
Blast Furnace (Contact)	872,250	8,025,000	350,000	9,247,250
			Sub-Total	15,293,250
Contingency:				4,588,750
		Total Capital Cost		$19,882,000

For Use of Coal Add: $ 3,550,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

COKE PLANT & BLAST FURNACES

ANNUAL COST		TOTAL
Amortization		$ 2,614,000
O & M	- Operating Personnel	165,000
	- Equipment Repair & Maintenance	1,121,000
	- Material (Chemicals)	880,000
	- Taxes & Insurance	398,000
	- Solids Disposal	68,000
Energy		7,347,000
	Total Annual Cost	$12,593,000

For Use of Coal Add: $ 5,200,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

BLOOMER MILL & SCARFER

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Towers & Pump Stations	$52,500	$467,000	$65,000	$ 584,500
Piping				280,000
			Sub-Total	867,500
Contingency:				259,500
		Total Capital Cost		$1,124,000

ANNUAL COST		
Amortization		$ 148,000
O & M	- Operating Personnel	25,000
	- Equipment Repair & Maintenance	65,000
	- Material (Chemicals)	145,000
	- Taxes & Insurance	22,000
Energy		81,000
	Total Annual Cost	$ 486,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

"B" SEWER TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Treatment Plant W/R.O., Evap., & Control Building	$157,000	$23,970,000	$500,000	$24,627,000
Contingency:				7,388,000
For Use of Coal Add: $11,500,000				
Total Capital Costs				$32,015,000

ANNUAL COST	
Amortization	$ 4,209,000
O & M - Operating Personnel	125,000
- Equipment Repair & Maintenance	1,959,000
- Material (Chemicals)	640,000
- Taxes & Insurance	640,000
- Solids Disposal	370,000
Energy	34,228,000
Total Annual Cost	$42,171,000

For Use of Coal Add: $20,000,000

COST ESTIMATE
TOTAL RECYCLE STUDY
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER
"C" & "E" SEWERS TREATMENT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
R.O., Evaporating & Control Building	$157,000	$36,130,000	$500,000	$36,787,000
Piping				180,000
			Sub-Total	36,967,000
Contingency:				11,093,000
For Use of Coal Add: $ 14,500,000	Total Capital Cost			$48,060,000

ANNUAL COST		
Amortization		$ 6,318,000
O & M	- Operating Personnel	125,000
	- Equipment Repair & Maintenance	2,946,000
	- Material (Chemicals)	894,000
	- Taxes & Insurance	961,000
	- Solids Disposal	500,000
Energy		50,470,000
For Use of Coal Add: $ 30,500,000	Total Annual Cost	$62,214,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

TANDEM MILL

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Towers and Pump Stations	$45,000	$398,000	$50,000	$493,000
Piping				150,000
			Sub-Total	643,000
Contingency:				193,000
	Total Capital Cost			$836,000

ANNUAL COST		
Amortization		$113,000
O & M	- Operating Personnel	25,000
	- Equipment Repair & Maintenance	36,000
	- Material (Chemicals)	111,000
	- Taxes & Insurance	17,000
Energy		70,000
	Total Annual Cost	$372,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

HOT STRIP MILL

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Towers & Pump Stations	$83,000	$753,000	$120,000	$ 956,000
Piping				460,000
			Sub-Total	1,416,000
Contingency:				425,000
		Total Capital Cost		$1,841,000

ANNUAL COST		
Amortization		$ 242,000
O & M	- Operating Personnel	25,000
	- Equipment Repair & Maintenance	70,000
	- Material (Chemicals)	258,000
	- Taxes & Insurance	37,000
Energy		115,000
	Total Annual Cost	$ 747,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

BROWN ISLAND COKE & BY-PRODUCT PLANT

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Tower & Pump Stations	$19,000	$101,000	$12,000	$132,000
Piping				30,000
			Sub-Total	162,000
Contingency:				78,000
		Total Capital Cost		$210,000
ANNUAL COST				
Amortization				
O & M - Operating Personnel				8,000
- Equipment Repair & Maintenance				8,000
- Material (Chemicals)				38,600
- Taxes & Insurance				4,000
Energy				20,400
		Total Annual Cost		$107,000

COST ESTIMATE
TOTAL RECYCLE STUDY
NATIONAL STEEL CORPORATION
WEIRTON STEEL DIVISION
TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER
TEMPER MILL

CAPITAL COSTS		CIVIL	MECH.	ELEC.	TOTAL
Facilities:					
Cooling Tower & Pump Stations		$27,000	$149,000	$20,000	$196,000
Piping					80,000
				Sub-Total	276,000
Contingency:					84,000
		Total Capital Cost			$360,000
ANNUAL COST					
Amortization					$ 47,000
O & M	- Operating Personnel				8,000
	- Equipment Repair & Maintenance				11,000
	- Material (Chemicals)				55,000
	- Taxes & Insurance				7,000
Energy					25,000
		Total Annual Cost			$153,000

COST ESTIMATE

TOTAL RECYCLE STUDY

NATIONAL STEEL CORPORATION

WEIRTON STEEL DIVISION

TOTAL RECYCLE INCLUDING NON CONTACT COOLING WATER

POWER HOUSE

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Cooling Tower & Pump Stations	$89,500	$743,000	$120,000	$ 952,500
Piping				150,000
			Sub-Total	1,102,500
Contingency:				332,500
	Total Capital Cost			$1,435,000

ANNUAL COST	
Amortization	$ 189,000
O & M - Operating Personnel	8,000
- Equipment Repair & Maintenance	60,000
- Material (Chemicals)	304,000
- Taxes & Insurance	29,000
Energy	202,000
Total Annual Cost	$ 792,000

COST ESTIMATE

TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

BAT

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	7,760,000
2.	Total Operating Cost	$/Yr	4,539,000
3.	Total Annual Cost	$/Yr	5,559,000

For coal add:	$ 1,530,000	Capital Cost
	$ 2,100,000	Annual Cost

COST ESTIMATE

TOTAL RECYCLE STUDY

U.S.S.C. - FAIRFIELD WORKS

BAT

SUMMARY OF FACILITIES COSTS

	CAPITAL	ANNUAL
Finishing Facilities	$ 5,478,000	$ 4,977,000
Q - BOP	140,000	35,000
Blast Furnaces	720,000	242,000
Coke Plant	570,000	148,000
Material Storage Pile Runoff	852,000	157,000
	$ 7,760,000	$ 5,559,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

BAT
FINISHING FACILITIES

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Lift Station, Filters & B.W. Basins	$150,600	$ 151,000	$ 33,000	$ 334,600
R.O. Evaporator, Control Bldg & Return P. Sta.	130,000	3,377,000	155,000	3,662,000
Piping				217,000
	Sub-total:			$4,213,600
Contingency:				1,264,400
For coal add: $1,530,000	Total Capital Cost:			$5,478,000

ANNUAL COST		
Amortization		$ 720,000
O & M - Operating Personnel		165,000
- Equipment Repair & Maintenance		298,000
- Material (Chemicals)		115,000
- Taxes & Insurance		110,000
- Solids Disposal		120,000
Energy		3,449,000
For coal add: $2,100,000	Total Annual Cost:	$4,977,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

BAT
Q - B.O.P.

CAPITAL COSTS		CIVIL	MECH.	ELECT.	TOTAL
Facilities:					
Pump Station		$ 15,500	$ 19,000	$ 3,000	$ 37,500
Piping					69,500
	Sub-total				117,000
Contingency:					33,000
	Total Capital Cost:				$ 140,000

ANNUAL COST		
Amortization		$ 18,000
O & M - Operating Personnel		8,000
- Equipment Repair & Maintenance		2,000
- Taxes & Insurance		3,000
Energy		4,000
	Total Annual Cost:	$ 35,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

BAT
BLAST FURNACES

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Fluoride Precipitation System	$44,000	$104,500	$15,000	$ 163,500
Piping				391,000
Sub-total:				554,500
Contingency:				165,500
Total Capital Cost:				$ 720,000

ANNUAL COST	
Amortization	$ 95,000
O & M - Operating personnel	115,000
- Equipment Repair & Maintenance	10,000
- Material (Chemicals)	4,000
- Taxes & Insurance	14,000
Energy	4,000
Total Annual Cost:	$ 242,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

BAT
COKE PLANT

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Additional Aeration	$172,500	$95,000	$20,000	$ 287,500
Clarifiers	74,250	66,000	10,000	150,250
Sub-total:				$ 437,750
Contingency:				132,250
Total Capital Cost:				$ 570,000

ANNUAL COST	
Amortization	$ 75,000
O & M - Operating Personnel	25,000
- Equipment Repair & Maintenance	15,000
- Taxes & Insurance	11,000
Energy	22,000
Total Annual Cost:	$ 148,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

BAT
MATERIAL STORAGE PILE RUNOFF

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Storage Pond & Pump Sta.	$114,000	$13,500	$3,000	$130,500
Piping				525,000
	Sub-total:			655,500
Contingency:				196,500
	Total Capital Cost:			$852,000

ANNUAL COST		
Amortization		$112,000
O & M - Operating Personnel		25,000
- Equipment Repair & Maintenance		1,000
- Taxes & Insurance		17,000
Energy		2,000
	Total Annual Cost:	$157,000

COST ESTIMATE

TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	51,432,000
2.	Total Operating Cost	$/Yr	57,024,000
3.	Total Annual Cost	$/Yr	63,785,000

For coal add:	$ 10,100,000	Capital Cost
	$ 18,500,000	Annual Cost

COST ESTIMATE

TOTAL RECYCLE STUDY

USSC - FAIRFIELD WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF FACILITIES COSTS

	CAPITAL	ANNUAL
Final Effluent Control Pond	$51,045,000	$63,701,000
Q - BOP	387,000	84,000
	$51,432,000	$63,785,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER
FINAL EFFLUENT CONTROL POND

CAPITAL COSTS

Facilities:				
Pump Sta, Filters & B.W. Basins	$373,850	$ 249,000	$ 80,000	$ 702,850
R.O., Evap, Control Bldg, Return Pump Sta.	378,500	36,368,000	515,000	37,261,500
Flocculator-Clarifiers	280,000	218,000	40,000	538,000
Piping				762,000
	Sub-total:			$39,264,350
Contingency:				11,780,650
For coal add: $10,500,000	Total Capital Cost:			$51,045,000

ANNUAL COST

Amortization	$ 6,710,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	3,000,000
- Material (Chemicals)	1,187,000
- Taxes & Insurance	1,020,000
- Solids Disposal	250,000
Energy	51,369,000
Total Annual Cost:	$63,701,000

For use of coal add: $18,000,000

COST ESTIMATE
TOTAL RECYCLE STUDY

UNITED STATES STEEL CORPORATION - FAIRFIELD WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

Q - B.O.P.

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Pump Sta. Modif. & Surge Tank	$18,000	$12,000	$3,000	$ 33,000
Piping				265,000
Sub-total:				298,000
Contingency:				89,000
Total Capital Cost:				$387,000

ANNUAL COST	
Amortization	$ 51,000
O & M - Operating Personnel	13,000
- Equipment Repair & Maintenance	11,000
- Taxes & Insurance	8,000
Energy	1,000
Total Annual Cost:	$ 84,000

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

BAT

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	19,580,000
2.	Total Operating Cost	$/Yr	21,074,000
3.	Total Annual Cost	$/Yr	23,648,000

For coal add:	$ 7,000,000	Capital Cost
	$ 11,250,000	Annual Cost

COST ESTIMATE
TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

BAT
FACILITIES ESTIMATES

CAPITAL COSTS	CIVIL	MECH.	ELECT.	TOTAL
Facilities:				
Coke Breeze Clarifier & Pump Sta.	$ 87,500	$ 82,500	$ 15,000	$ 185,000
Blast Furnace Treatment Plant:				
Sinter Plant Pump Sta.	13,500	15,000	5,000	33,500
Mixers	31,700	30,500	5,000	67,200
Clarifier	49,500	64,500	10,000	124,000
Filters, B.W. Basins & Act. Carbon & Chemical Bldg.	278,000	604,000	55,000	937,000
Central Treatment Plant W/R.O., Evap.	15,000	13,111,000	300,000	13,426,000
Continuous Butt Weld-Pump Sta.	37,000	72,000	5,000	114,000
Piping				175,000
	Subtotal:			15,061,700
Contingency:				4,518,300
	Total Capital Cost:			$19,580,000

For use of coal add: $7,000,000

COST ESTIMATE
TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

BAT
FACILITIES ESTIMATES

ANNUAL COST	TOTAL
Amortization	$ 2,574,000
O & M - Operating Personnel	290,000
- Equipment Repair & Maintenance	1,164,000
- Material (Chemicals)	556,000
- Taxes & Insurance	392,000
- Solids Disposal	275,000
Energy	18,397,000
Total Annual Cost:	$23,648,000

For use of coal add: $ 11,250,000

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	46,300,000
2.	Total Operating Cost	$/Yr	29,437,000
3.	Total Annual Cost	$/Yr	35,524,000

For use of coal add: $ 8,950,000 Capital

$ 14,700,000 Annual

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

FACILITIES ESTIMATES

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Biological Treat. Plant & Return Pump Station	$236,500	$ 742,000	$103,000	$ 1,081,500
Terminal Treatment Plant W/R.O., Evap. & Return Pump Station	152,000	17,580,000	300,000	18,032,000
Acid Regeneration (L.S.)				16,380,000
Return Piping from Filter to P. Sta #1				110,000
	Sub-Total			35,603,500
Contingency:				10,696,500
	Total Capital Cost			$46,300,000

For use of coal add: $9,960,000

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

TOTAL RECYCLE NOT INCLUDING NON-CONTACT COOLING WATER

FACILITIES ESTIMATES

ANNUAL COST

Amortization	$ 6,087,000
O & M - Operating Personnel	165,000
- Equipment Repair & Maintenance	1,498,000
- Material (Chemicals)	850,000
- Taxes & Insurance	926,000
- Solids Disposal	500,000
Energy	25,498,000
Total Annual Cost:	$35,524,000

For use of coal add: $11,775,000

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

SUMMARY OF TOTAL COSTS

1.	Total Capital Cost	$	54,770,000
2.	Total Operating Cost	$/Yr	33,723,000
3.	Total Annual Cost	$/Yr	40,923,000

For coal add:	$ 8,950,000	Capital Cost
	$ 14,700,000	Annual Cost

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

FACILITIES ESTIMATES

CAPITAL COSTS	CIVIL	MECH.	ELEC.	TOTAL
Facilities:				
Open Hearth, BOF & SM	$102,000	$ 1,153,000	$170,000	$ 1,425,000
Boiler & Power House	173,000	2,537,000	250,000	2,960,000
Blast Furnace & Sinter Plant	112,000	1,618,000	180,000	1,910,000
Flat Rolling Mills	39,000	274,000	30,000	343,000
Biological Treat. Plant & Return Pump Station	236,500	742,000	103,000	1,081,500
Terminal Treatment W/R.O., Evap. & Return Pump Station	152,000	17,580,000	300,000	18,032,000
Acid Regeneration (L.S.)				16,380,000
		Sub-Total		$42,131,500
Contingency:				12,638,500
		Total Capital Cost		$54,770,000

For use of coal add: $8,950,000

COST ESTIMATE

TOTAL RECYCLE STUDY

YOUNGSTOWN SHEET & TUBE CO. - INDIANA HARBOR WORKS

TOTAL RECYCLE INCLUDING NON-CONTACT COOLING WATER

FACILITIES ESTIMATES

ANNUAL COST

Amortization	$ 7,200,000
O & M - Operating Personnel	330,000
- Equipment Repair & Maintenance	3,595,000
- Material (Chemicals)	1,391,000
- Taxes & Insurance	1,095,000
- Solids Disposal	500,000
Energy	24,866,000
Total Annual Cost:	$38,977,000

For use of coal add: $14,700,000

APPENDIX G

THE INTEGRATED IRON AND STEEL PLANT

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1.0 THE INTEGRATED IRON AND STEEL PLANT

In this study, an integrated steel plant is defined as having the following production processes:

1. Production of coke for use in blast furnaces and production of by-product chemicals from the coke oven gas.

2. Production of sinter from raw ore and process wastes for use in the blast furnace.

3. Production of iron in blast furnaces.

4. Production of steel in basic oxygen furnaces and, if applicable, open hearth furnaces and/or electric arc furnaces.

5. Hot forming of steel shapes from ingots and intermediate products. This category includes continuous casting.

6. Cold finishing of hot rolled products. These processes include continuous pickling and cold rolling.

Figure G-1 shows the process flow of materials and products as defined above and the following sections describe individual processes and manufacturing facilities.

1.1 INTEGRATED IRON AND STEEL PLANT PRODUCTION PROCESSES

1.1.1 Coke Making and By-Product Plant Operation

1.1.1.1 Coke Plant

Coal is distilled in the coke plant of an integrated steel mill to supply elemental carbon or coke, for the production of iron in blast furnaces. There are two accepted methods for manufacturing coke: the beehive or non-recovery process and the by-product or chemical recovery process. Today the by-product process accounts for about 99 percent of all metallurgical coke produced in the U.S., and therefore the beehive process will not be discussed further in this report.

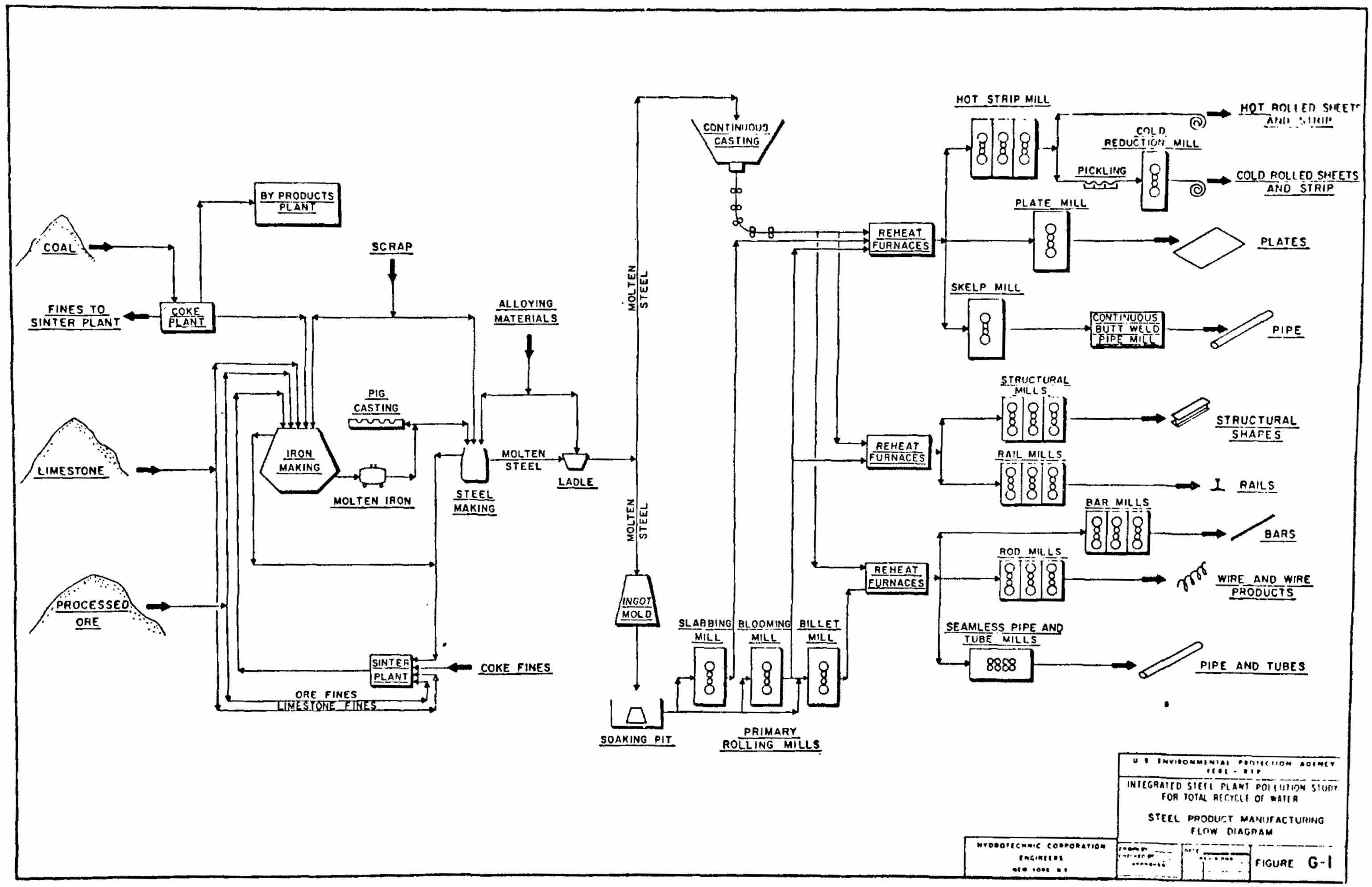
By-product coke is produced by heating bituminous coal in closed ovens, in the absence of air to remove volatile components. The necessary heat for this distillation is supplied from the external combustion of coke oven or blast furnace gas in flues located within walls between ovens. The residue remaining in the ovens is coke and the volatile components driven off with the gas are processed in the by-product plant. Modern ovens are approximately 12 meters (40 feet) long, 3 to 6 meters (10 to 20 feet) high and 35 to 46 centimeters (14 to 18 inches) wide with a capacity of 10 to 30 tons of coal each. The ovens are constructed in groups of thirty or more, each group being referred to as a battery.

Coal is charged into the top of each oven either from hopper bottom rail cars called larrycars or via a pipeline aspirated by steam. During the coking period, which is from 12 to 24 hours, the distilled gases and volatiles are collected in ascension pipes at the oven tops and pass into a collection main running the length of the battery. At the end of the coking period, doors are removed from the ends of an oven and a pushing machine forces the hot coke into a quenching car. The car moves immediately to the quenching tower where the incandescent coke is cooled by water sprays, and the quenched coke is delivered to handling and holding equipment for subsequent use.

1.1.1.2 By-Product Plant

The gases and volatiles collected from the coke ovens are processed in a by-products plant where coke oven gas, tars, ammonia and organic chemicals are recovered.

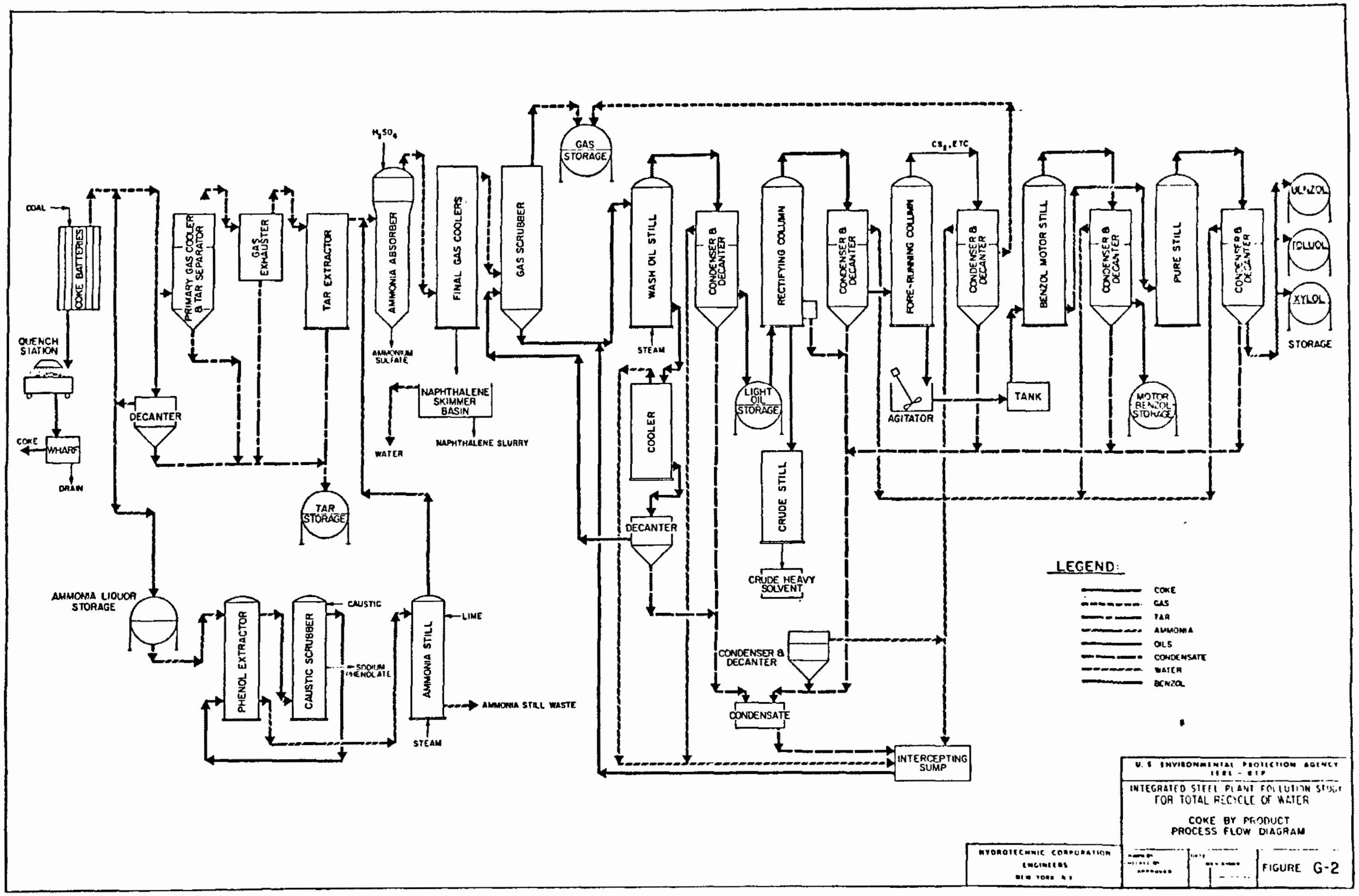
A general representation of a complete by-product operation is shown on Figures G-2. The raw coke oven gases are first cooled by sprays of flushing liquor and then by indirect contact in a primary cooler. Water and tar are condensed and the flushing liquor is decanted from the tar. Most of the flushing liquor is recycled for spray cooling and a blowdown of excess waste liquor is directed to storage facilities. The stored waste ammonia liquor passes through treatment facilities to remove ammonia, phenol, cyanide, sulfide and suspended solids prior to discharge. The ammonia is returned to the cooled gas stream which has undergone complete tar removal. The combined gases pass through an ammonia absorber (ammonia recovery), then through a final cooler (naphthalene removal), a wash oil scrubber and a desulfurizer before use as fuel. The wash oil from the gas scrubber is stripped of absorbed light aromatic oils, which are processed to recover crude naphtha, crude heavy solvents, benzol, toluol and xylol. The crude coal tar is sold or processed on site to recover a variety of organic chemicals. By-product plants vary in specific processes and extent of chemical recovery.



INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

STEEL PRODUCT MANUFACTURING FLOW DIAGRAM

FIGURE G-1



U.S. ENVIRONMENTAL PROTECTION AGENCY

INTEGRATED STEEL PLANT POLLUTION STUDY FOR TOTAL RECYCLE OF WATER

COKE BY PRODUCT PROCESS FLOW DIAGRAM

FIGURE G-2

1.1.2 SINTERING

The primary function of a sintering plant, as part of an integrated steel plant, is to agglomerate iron-bearing fines for use in the blast furnaces. The fines consist mostly of iron ore and wastes such as dust from the steelmaking and blast furnace processes: in some plants rolling mill scale is also used. These waste fines are blended with fine coal or coke and limestone in a sinter mix to make an agglomerate for charging into the blast furnace.

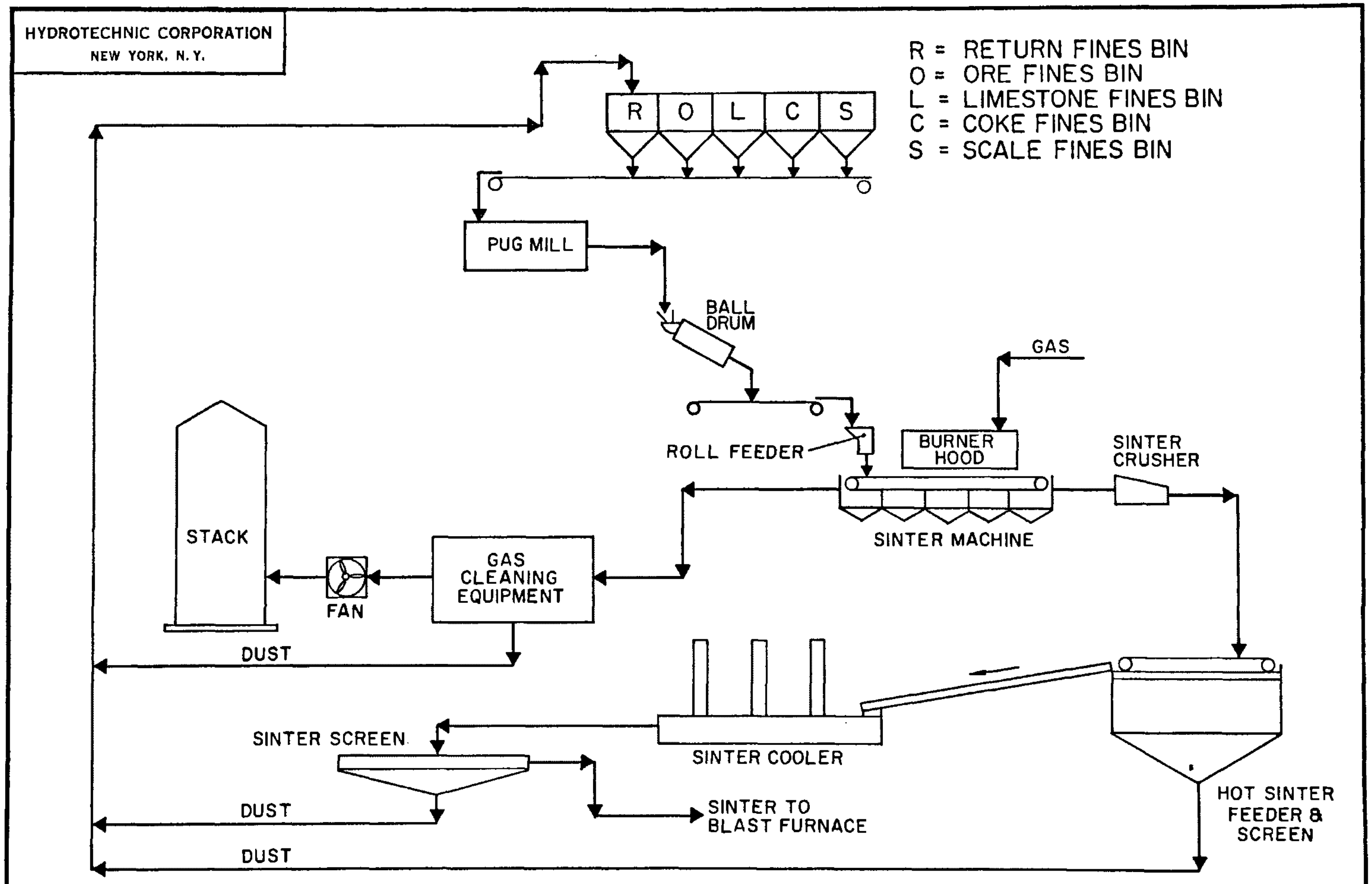
The sintering is achieved, as shown on Figure G-3, by blending and grinding the various iron-bearing components, limestone and fuel in the form of coal or coke fines. The mixture from the pug mill is then bedded (i.e., spread evenly) on a moving downdraft grate and heated by a gas fired ignition furnace over the sintering bed with combustion air induced through the bed. After ignition, the downdraft of air keeps the coal or coke burning, to achieve a temperature in the bed sufficient to fuse or sinter the mixture. As the bed burns, carbon dioxide is driven from the limestone, and a large part of the sulfur, chloride and fluoride contaminants are combusted or volatized into the waste gasses. If mill scale is included in the sinter mix, oils are also combusted or volatilized.

The hot sinter is crushed as it is discharged from the sinter machine, and the crushed sinter is screened before it is air cooled on a sinter cooler. After cooling, the sinter is further screened into several size fractions. Fines from the screening that are too small for use in the blast furnace are recycled without being cooled to the head end of the sintering process along with captured dust.

1.1.3 IRON MAKING

Iron is produced in a blast furnace, as shown on Figure G-4, by the chemical reduction of iron oxides to elemental iron from a charge of iron ore and miscellaneous iron bearing materials including sinter, enriched ore pellets, ferromanganese ores and iron or steel wastes in various combinations. Other materials required in the iron making process are coke and flux materials. These various raw materials, referred to as the burden, are usually stored in stock piles and charged through atmosphere isolation gates (called bells) into the top of the furnace via either skip cars (batch charging) or continuous belt feed.

The coke provides the main source of heat, carbon monoxide and carbon, with the carbon and carbon monoxide acting as the reductants for the iron oxide according to the general reduction reaction: $FeO + CO = Fe + CO_2$. $C + CO_2 = 2CO$.



SINTER PLANT PROCESS FLOW DIAGRAM

FIGURE G-3

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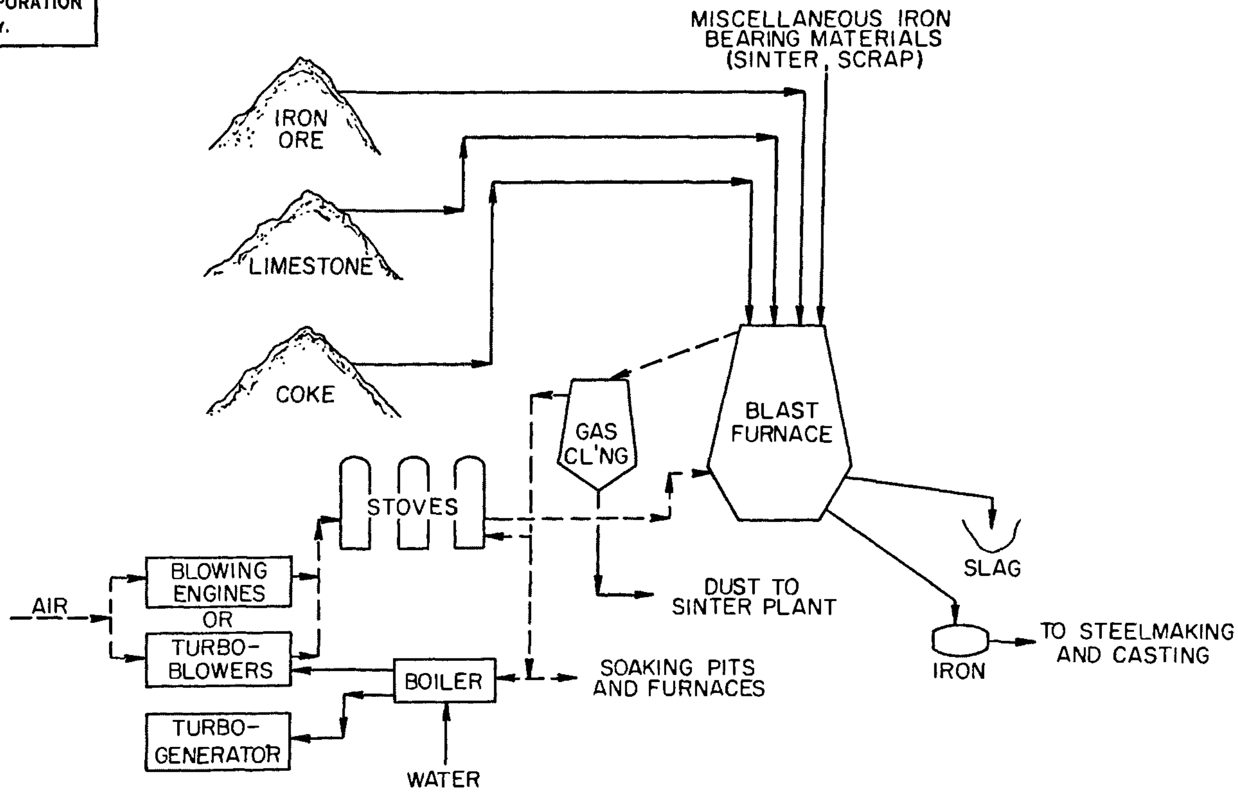


IRON MAKING PROCESS FLOW DIAGRAM

FIGURE G-4

The alkaline flux materials, usually limestone or dolomite, after giving off their CO_2 via in situ calcination form a molten slag with the non-volatile impurities (e.g., the ash in the coke or the gangue in the ore) produced during the reduction in such a manner that the chemical composition and fluidity of the iron can be controlled. The slag is largely calcium and magnesium silicates, aluminates and sulfides.

The production of iron in the blast furnace is performed at high temperature and pressure under reducing conditions. Air, that has been compressed and preheated (hot blast), is injected into the blast furnace through tuyeres just below the bosh, a section low in the furnace where melting begins. The air is required to support the combustion of the coke (and other injected fuel, e.g., oil or coal fines). As the iron oxides are reduced in the furnace, the molten iron collects on a bottom hearth and the molten slag, due to its lower density, floats on the surface of the iron. Periodically, the slag is skimmed off into ladle cars and the molten iron is tapped into hot metal cars for transport to steel making or casting facilities. Surplus molten iron is cast into solid shapes or pigs in a pig machine.

In addition to slag and iron, a mixture of blast furnace gases (containing some carbon monoxide) is produced and cleaned and cooled to remove entrained fine particles of iron oxide and other impurities prior to further use in fueling the hot blast stoves, boilers for steam and electrical generation and in reheating furnaces.

1.1.4 STEELMAKING

The modern steelmaking processes refine iron in combination with scrap metal, alloying material and flux, to produce various grades of steel with specified compositions. The old Bessemer process has been replaced by modern processes using the open-hearth furnace, the basic oxygen furnace (BOF) and the electric furnace.

The basic open-hearth and basic oxygen processes produce carbon and alloy steel of the same general grades. Basic oxidation processes are required to remove phosphorous and sulfur impurities and are more common than acidic oxidative processes. Electric furnaces are used to produce both common grades of steel and also stainless and alloy steel grades which are generally not produced by the other two processes. Most of the steel currently produced in the United States is made by the basic oxygen process, with the remainder divided between open-hearth and electric furnaces. A relatively new process, the Q-BOP, is a variation of the basic oxygen furnace which is bottom blown similar to the Bessemer converters.

1.1.4.1 Open-Hearth Furnace

The open-hearth process is composed of several stages, i.e, charging, meltdown, hot metal addition, fettling (startup), ore and lime boil, working (refining), tapping and delay. As shown on Figure G-5, the raw materials charged to the open-hearth furnace consist of flux material, with various combinations of pig iron, iron ore, steel scrap, molten iron and steel. During hot metal addition, molten pig iron is introduced and in the final stages there are additions of fluorspar and alloying substances to produce steel of a specified quality. Oxygen may be lanced over the molten charge to speed the refining stage. A slag, forming a continuous layer on the metal surface contains the impurities removed.

The open-hearth furnace is essentially a shallow rectangular basin or hearth enclosed by walls and a roof, all constructed of refractory brick and provided with access doors along one wall adjacent to the operating floor. A tap hole at the base of the opposite wall is provided to drain the finished molten steel into ladles. Fuel is burned at one end, the flame traveling the length of the furnace above the charge resting upon the hearth. The hot gases are conducted downward in a flue into a brick regenerator chamber or checkerwork, which provides a large number of passage ways for absorbing the heat from the gases. The combustion system burners, checkers and flues are duplicated at each end of the furnace to allow frequent and systematic reversal of heat flow.

Heat is stored in the checkers and is subsequently given up to a reverse direction stream of air flowing to the reverse burner.

Open-hearth furnace capacities range from 100 to 300 tons per cycle or heat. Each heat requires between 8 and 12 hours. Oxygen lancing may shorten heat time to a minimum of 5 hours.

1.1.4.2 Basic Oxygen Furnace

The basic oxygen process is a modified pneumatic steelmaking process in which pure, high pressure oxygen is blown through a water-cooled lance into the charge of molten pig iron, scrap and flux material. There is no external fuel requirement since oxidation of the impurities provides the heat necessary for the process. During the various stages of a heat, especially oxygen-blowing, iron oxide and carbon particles are carried out of the furnace along with flue gas and other dust in a dense reddish-brown discharge.

As shown in Figure G-6, the BOF is generally a vertical cylinder surmounted by a truncated cone. The material charge and oxygen is introduced through the open top; the vessel pivots on a horizontal axis for charging, slag dumping and steel tapping. A BOF has a tap to tap cycle of approximately 45 minutes and can produce 200 to 300 or more tons of steel per hour, with very close control of quality. Another important advantage of this process over the open-hearth is the ability to handle a wider range of raw materials, though most of the charge is molten metal.

The Q-BOP (Quick Basic Oxygen Process) also utilizes pure oxygen, but oxygen is injected into the molten metal through the bottom of the furnace. Burnt lime flux is also injected through the bottom of the vessel.

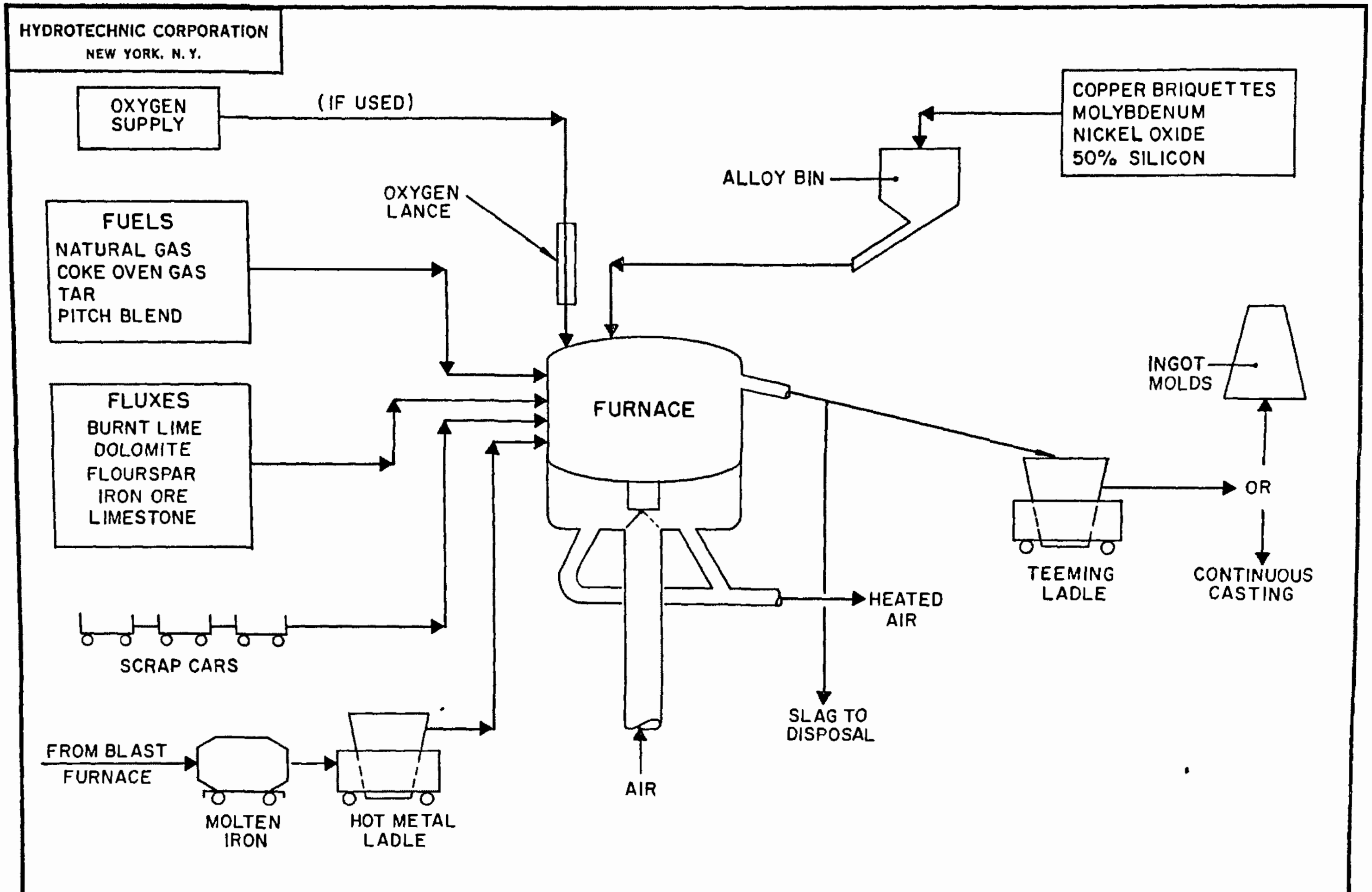
1.1.4.3 Electric Arc Furnaces

Electric furnace steelmaking utilizes a charge of cold steel scrap with fluxes and the process cycle consists of the meltdown, molten metal period, boil, refining, and pouring. The required heat is generated by an electric arc passing from carbon electrodes through the charge in the furnace. This non-oxidizing heat source allows more flexibility in charge control. The refining process is similar to that of the open-hearth furnace. Electric arc furnaces range in size from 2.1 to 9.1 meters (7 to 30 feet) in diameter and produce from 2 to 200 tons of steel cycle within a time ranging from 1.5 to 4 hours.

Electric arc furnaces offer maximum flexibility due to the variety of types of steel that can be produced, ability to operate on an intermittent basis, and the short heat time. They are used in large integrated plants especially to supplement other steelmaking processes in meeting peak demands. Also, this type of facility is uniquely adaptable to specialty steel producers.

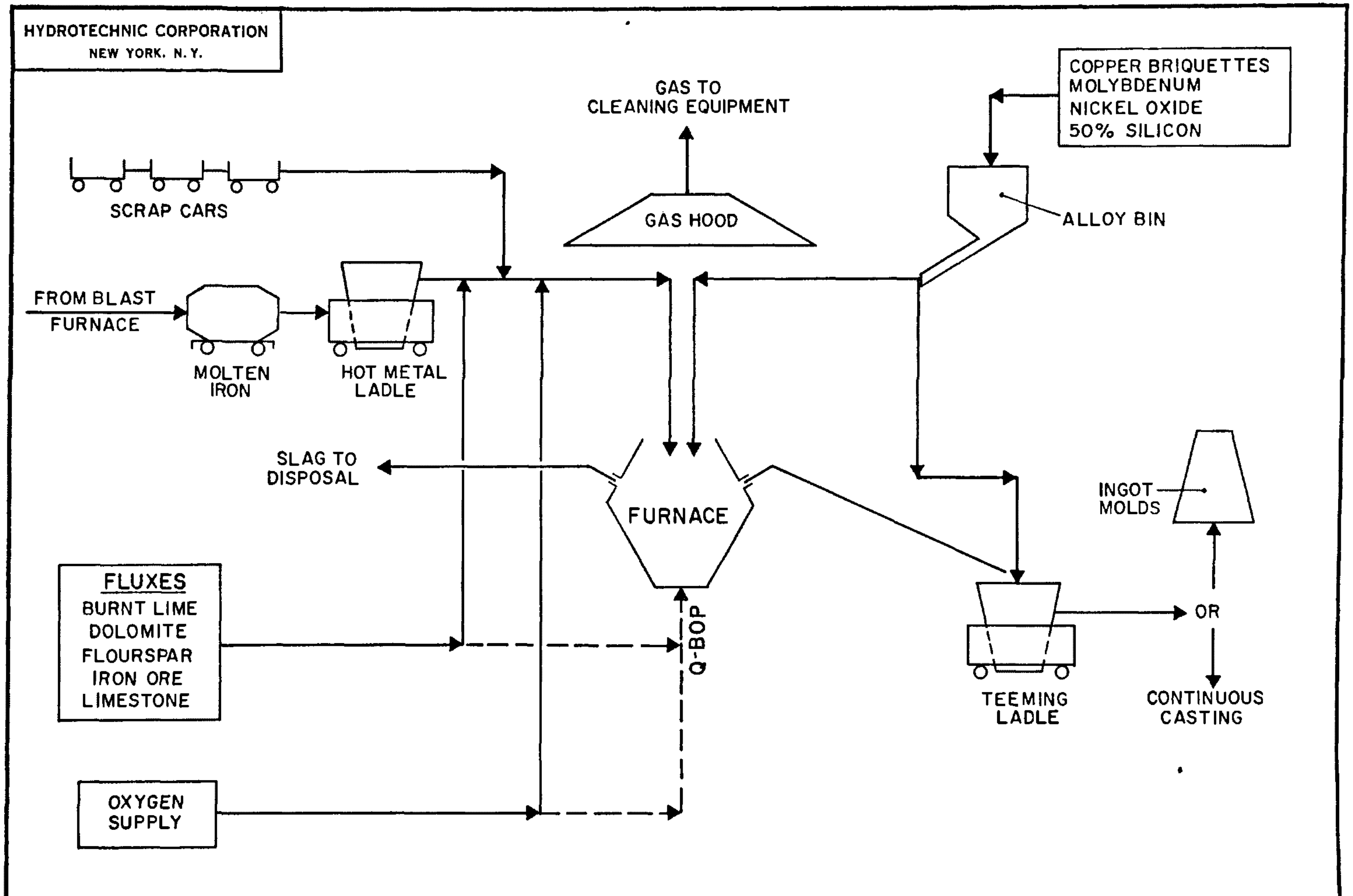
1.1.4.4 Vacuum Degassing

The molten steel is often treated under very low pressures (40-140 Pa) to reduce hydrogen, oxygen and carbon content to produce a cleaner steel with improved physical properties. Alloying materials may also be added. Less than 10 percent of current U.S. steel production is vacuum degassed, and mostly in conjunction with continuous casting or large piece steel casting operations. General process types are stream degassing and recirculation degassing. High temperature must be maintained in the molten steel and the vacuum is usually created by a multistage steam ejector and barometric condenser. The process time is about 30 minutes. There are also vacuum melting processes (e.g., vacuum arc remelting or VAR) which are used to refine certain high strength and alloy steels.



OPEN HEARTH - PROCESS FLOW DIAGRAM

FIGURE G-5



BASIC OXYGEN PROCESS FLOW DIAGRAM

FIGURE G-6

1.1.4.5 Ingot Casting

The molten metal from the steelmaking furnace is tapped into a teeming ladle for transfer to vacuum degassing or directly to ingot molds or continuous casting machines. If ingots are made, the steel is transferred to a series of molds which have been prepared by coating the cast iron mold with a compound to facilitate ingot removal (stripping) and also to reduce splashing of molten steel during ladle pouring or teeming. Alloying material may be added during teeming. The continuous casting process is described in Section 1.1.5.2.

1.1.5 HOT FORMING

The production of specified shapes by rolling hot solid steel in mills or by the casting of molten steel is defined as hot forming. The forming is divided into three broad categories, primary rolling, continuous casting and secondary rolling.

1.1.5.1 Primary Rolling

Steel that has been cast into ingots is shaped at primary rolling units, as shown on Figure G-7, into basic forms (slab, bloom or billet) that are then sold or shaped in other hot mills for the production of products that require special finishing or products for direct sale.

Ingots that have been stripped and sufficiently cooled are placed in soaking pit furnaces to be uniformly reheated to a temperature suitable for plastic working (deformation) with a minimum of power consumption. The soaking pits also act as storage to hold the ingots at the selected temperature until they can be rolled on a mill.

Scale that has formed on the ingot surface is scoured off by top and bottom high pressure water sprays (descaled) and the ingot is shaped by successive passes through the rolls of the mill stands. After each pass, the ingot is turned or the position of the rolls is changed for shaping during the reverse pass. The final elongated shapes are slabs, which have a rectangular cross section, blooms which have essentially a square cross section and billets which have either a round or square cross section. In some plants billets are produced from blooms as an intermediate rolling step. After the steel has assumed its final shape it advances down the table to a shear where the irregular ends are cropped off. If the product of a single ingot is larger than desired, as might occur in a billet mill, it is cut to length by a crop shear, a flying shear or hot saw. The product is then cooled and stored in a slab yard until it is needed for subsequent processing or sale.

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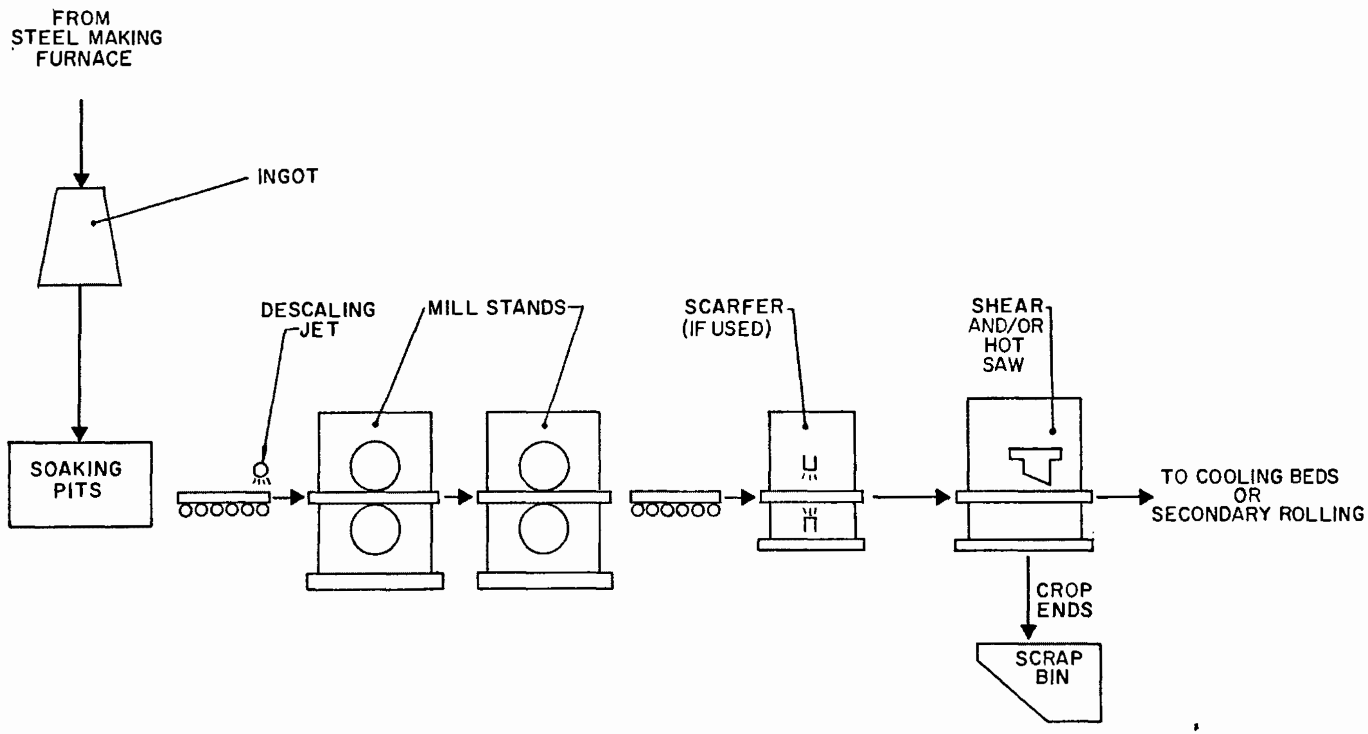

HOT FORMING PRIMARY PROCESS FLOW DIAGRAM

FIGURE G-7

In many mills, mechanical or acetylene scarfers are installed between the mill stand and the shear. Scarfing is the process of removing surface irregularities mechanically or by burning off a thin surface layer around the entire perimeter of the product. Slag and scale is produced from all scarfing operations and, in addition, a large quantity of fumes are produced from acetylene scarfing.

1.1.5.2 Continuous Casting

Slabs, blooms and billets can be formed directly from the molten steel without the intermediate process of ingot casting (See Figure G-8).

The molten steel is transported directly from the steelmaking or vacuum degassing facility to continuous casting machines which form the primary shapes directly, thereby, eliminating the ingot casting, cooling, soaking pit reheating and primary rolling steps. The molten steel is poured into a heated, refractory tundish which regulates the metal flow to water cooled molds of the desired shape. As the semi-solid steel exits from the mold it enters a spray chamber where it is cooled until the entire shape is solidified. Generally, each tundish serves from 2 to 6 parallel casting units or stands which are oriented vertically. The cast product is then bent to the horizontal, straightened and often scarfed before being cut by shears or torch. The product is stored in a slab yard until it is needed for subsequent processing.

1.1.5.3 Secondary Rolling

The slabs, blooms and billets formed in the primary hot rolling or continuous casting operations are shaped in secondary rolling mills to produce specific shapes to be shipped as a final product or to be further processed at plant finishing facilities.

As shown on Figure G-1, slabs are hot rolled in different mills for producing strip, skelp and plates; blooms are rolled to structural shapes and rails; and billets are shaped to bars, rods and seamless pipe. In all processes the raw shapes must be heated in reheat furnaces to a temperature where rolling or piercing can be accomplished with a minimum use of power and still maintain the required characteristics of the steel.

1.1.5.3.1 Hot Strip Mills

In a hot strip mill, a slab is reduced by successive rolls to a flat strip of steel of 1.0 to 32 mm (0.04 to 1.25 inches) thick, from 600 to 2,440 millimeters (24 to 96 inches) wide, and up to 660 m (2,000 feet) long. A modern mill can

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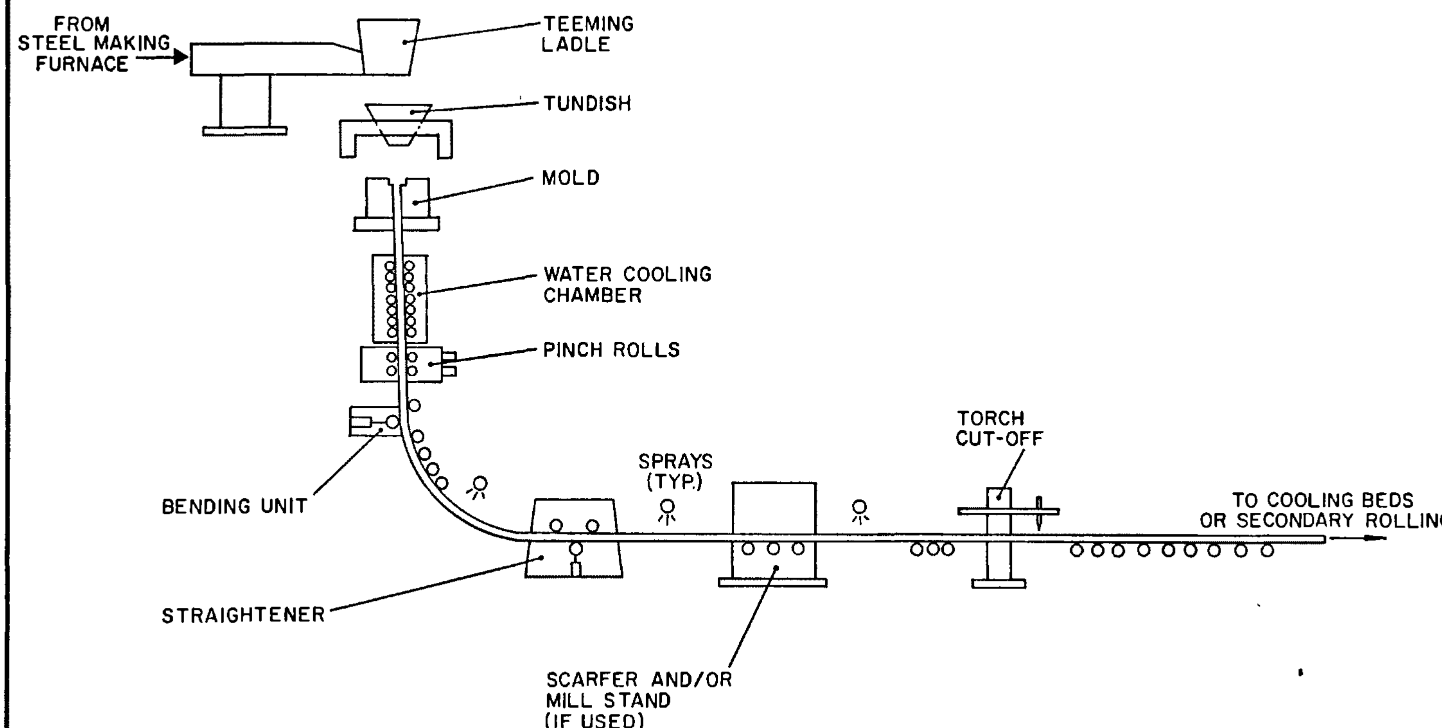

HOT FORMING CONTINUOUS CASTING PROCESS FLOW DIAGRAM

FIGURE G-8

reduce a steel slab to thin strip in three minutes, as shown on Figure G-9. The heated slab is discharged from reheat furnace and passes through a roughing scale breaker and high pressure water spray to remove the loosened iron oxide. The slab then passes through either a series of roughing stands or a single reversing stand where the initial reductions in thickness and final width of the product is achieved. The steel is cut and squared prior to entering the finishing stand. The slab then rolls through a finishing scale breaker and water jets before passing through series of finishing stands where the final thickness and length is achieved by a successive series of high speed reductions. The finished strip then proceeds over a runout table where it is cooled by water sprays. The strip is then coiled and either shipped or stored for further finishing.

1.1.5.3.2 Skelp Mills

Skelp is hot rolled strip shaped to make butt weld pipe. The skelp width corresponds to the circumference of the pipe and is produced from slabs or blooms in the same manner as strip with variations in the functions of the mill stands.

1.1.5.3.3 Plate Mills

Plates are classified, according to certain size limitations to distinguish them from sheet, strip and flat bars; i.e., more than 200 mm (8 inches) wide and 6 mm (0.23 inches) thick, or over 1,200 mm (48 inches) wide and 4.6 mm (0.18 inches) thick.

Plates are shaped from slabs and the sequence of operations, as shown on Figure G-10, is heating in reheat furnaces, descaling, rolling, leveling, cooling and shearing. The slab may be rolled in one of several types of mills; single stand, tandem, semi-continuous or continuous. In a single stand mill the final size of the plate is obtained by passing the slab through a single reversing stand. In a tandem mill, a second stand is added as a finishing stand. Semi-continuous and continuous plate mills utilize one roughing stand and a series of finishing stands. The plate is then leveled or flattened in a leveling bed, cooled uniformly by a series of cooling sprays and finally sheared to the final size for shipping.

1.1.5.3.4 Seamless Pipe Mills

Seamless pipe is produced by heating round billets in a reheat furnace to a plastic state after which a hole is pierced through the billet by a mandrel. The rough pipe is then reheated for further processing to bring the diameter and wall thickness to the required specifications. Larger diameters of pipe require several piercing and reheating operations.

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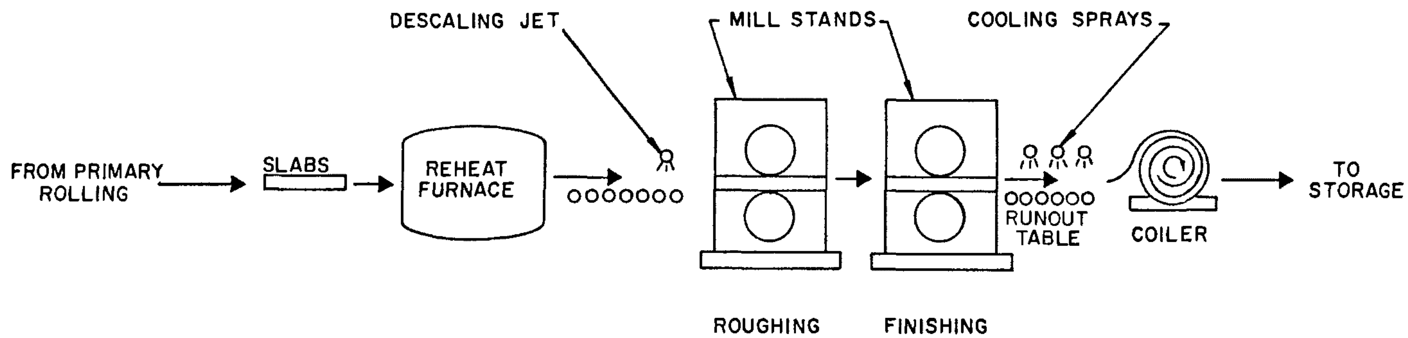

SECONDARY ROLLING – STRIP PROCESS FLOW DIAGRAM

FIGURE G-9

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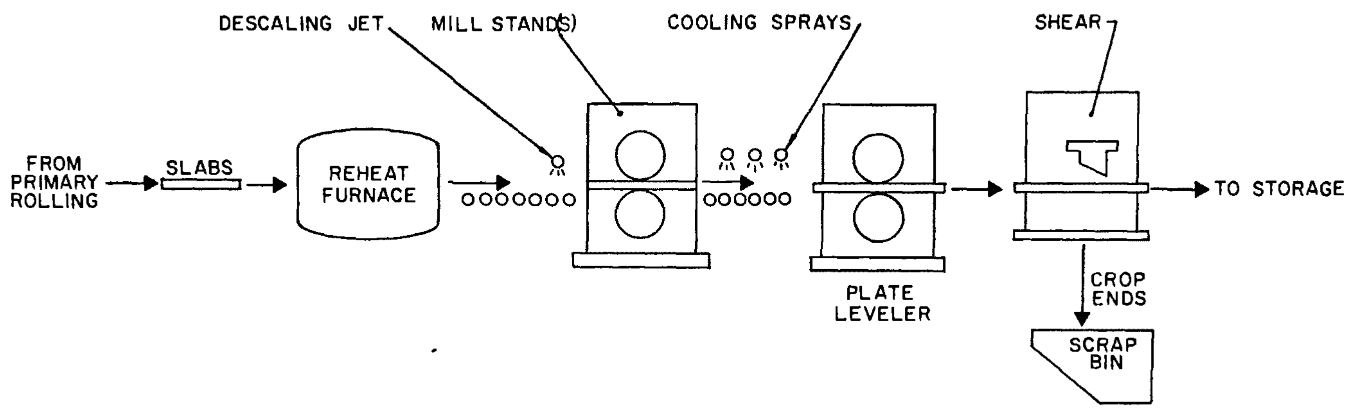

SECONDARY ROLLING - PLATE PROCESS FLOW DIAGRAM

FIGURE G-10

1.1.5.3.5 Other Secondary Hot Mills

Other hot formed products such as structural shapes, rails, rods and flat bars are produced from blooms and billets in essentially the same manner as strip is formed; i.e., by changing the shape of the hot feed stock by successive passes through various stands, each of which makes small changes on the shape until the final shape is reached. The butt-welded pipe mill takes skelp for welding into a continuous strip which is then heated, longitudinally shaped and welded into pipe. Other welded pipe mills use similar processes.

1.1.6 Cold Finishing

1.1.6.1 Pickling

An essential step in the finishing of steel is the cleaning of the surface of the metal between processing steps via the pickling process. This process consists of immersing formed steel shapes, sheets or strip in a heated bath of acid to chemically remove scale (i.e., metallic oxides) from the metal surface. Sulfuric or hydrochloric acids are generally used for pickling carbon steels, whereas phosphoric, nitric and hydrofluoric acids in combinations with sulfuric acid are used for stainless steels. Depending on the product being pickled, the process may be accomplished in continuous or batch operations. In this study emphasis will be placed on continuous sulfuric and hydrochloric acid pickling which accounts for the great majority of product tonnages.

1.1.6.1.1 Continuous Pickling

The most common surface preparation operation is the continuous pickling of hot rolled carbon steel strip. A typical continuous pickling line, as shown in Figure G-11, consists of an uncoiler processor, a shear, a welder, a wet looping pit, pickling tanks, rinse tanks, a dryer, a dry looping pit, a shear and a recoiler. Their respective functions are:

a. Uncoiler Processor: The coil is unwound, alternately flexed and straightened to break any surface scale to allow acid attack at the sub-oxide layer.

b. Shear and Welder: The ends of the coil are sheared square to permit smooth, even welding of successive coils.

c. Wet Looping Pit: Extra lengths of strip are stored to allow the continuous pickling to proceed while the uncoiler is stopped to permit shearing and welding. The pit is kept full of water to prevent scratching of the strip, to increase the wetting

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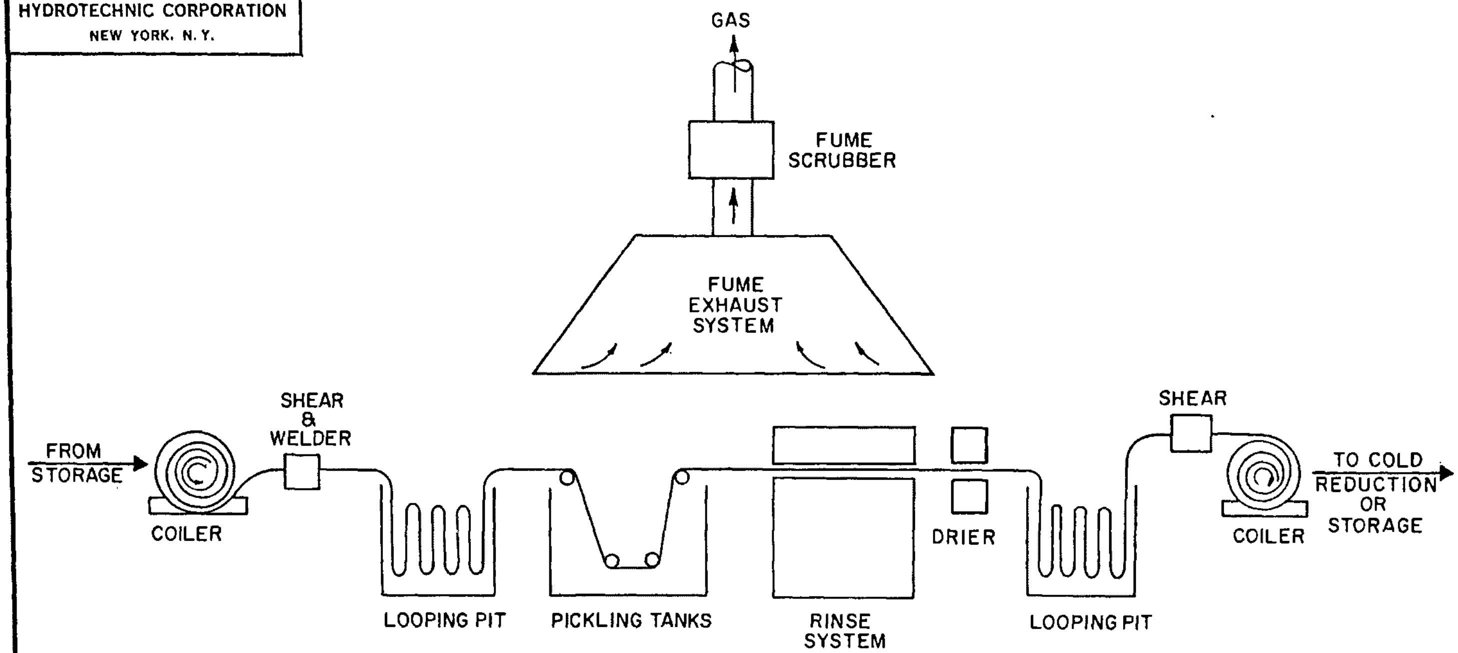

PICKLING PROCESS FLOW DIAGRAM

FIGURE G-11

action in the first pickling tank and to remove dirt and other foreign matter.

d. Pickling Tanks: A series of heated tanks contain the pickling acid and fresh acid is added to the last tank and cascaded towards the head tank so that the flow of acid is counter to the direction of travel of the strip. The acid concentration drops from about 12% H_2SO4 or 10% HCI at the final tank, down to about 8% H_2SO4 or 1% HCl at the head tank. In these tanks the iron oxide on the surface of the strip is converted to a soluble iron salt according to one of the following reactions:

HCl Pickling:	$FeO + 2\,HCl$	=	$FeCl_2 + H_2O$
H_2SO_4 Pickling:	$FeO + H_2SO_4$	=	$FeSO_4 + H_2O$

e. Rinse Tanks: After the steel is pickled the residual acid is removed by one of two methods, staged rinsing or countercurrent, cascade rinsing. In the staged rinse, the steel first passes through a cold water spray rinse and then through a hot water bath. The spray rinse tank and dip rinse tank act independently. In the cascade rinse, fresh water is added to the last of a series of tanks and then overflows or is pumped into the preceding tanks countercurrent to the direction of strip travel.

f. Dryer: After the strip emerges from the rinse section it is dried in a bank of low pressure hot air dryers.

g. Looping Pit, Shear and Recoiler: The strip is sheared at the weld and is then recoiled to maintain integrity of each coil. To provide for stopping of the strip as it is sheared, a dry looping pit is provided for storage. Before the strip is recoiled, a small amount of oil is applied to both sides of the strip to lubricate it and protect it from rusting during storage.

1.1.6.1.2 Batch Pickling

Steel sheets, billets, bars, wire, and pipe are pickled by immersion of product batches in tanks of acid. Two or more tanks are used in the complete process depending on whether the product is to be further treated. Steel plate is usually dipped in a tank of concentrated acid, is agitated, then dipped into a dilute acid tank or a cold rinse tank and finally into a hot rinse tank. In a two tank system the cold rinse and dilute acid tank dips are omitted. If the product is to be further treated, such as cold drawing in a wire or pipe facility, a lubricant tank is provided to coat the product before further processing. The final step is drying of the product either by air or in a drying oven.

1.1.6.2 Cold Reduction

Cold reduction is a process, as shown on Figure G-12, in which unheated metal is passed through one or a series of mill stands containing reduction rolls for the purpose of reducing metal thickness and producing a smooth dense sheet with controlled mechanical properties. Hot rolled and pickled coils are most commonly used in the cold reduction process. There are several types of cold rolling mills varying from mills with a single reversing stand to continuous mills with up to six stands in tandem. These mills have the same basic process: uncoiling, oiling and gradual reduction to the desired thickness prior to recoiling. Oil and water application practice vary from mill to mill with either water or water-oil emulsions used at the various stands. The rolling solutions can either be recycled after filtration or discharged directly after one use. Combinations of these methods are also employed.

Cold rolled steel is not ductile and must be cleaned and annealed. A large percentage of cold rolled products are finished by a metal coating process such as galvanizing, aluminum coating, terne coating or tin plating.

1.1.6.3 Heat Treating Steel

Steel is heat treated to change properties, relieve stresses and make the steel suitable for further working. Low amounts of water are used for this process.

1.1.6.4 Coating

After the steel is cold rolled various coating processes are used on some of the cold rolled coils to produce specialty products. The processes include galvanizing, tin plating, organic coating etc. The cold rolled strip is cleaned, prepared for coating and the coated prior to recoiling. Rinse, solution baths, washes, etc. are used in those processes which can contain various chemicals in widely varying amounts.

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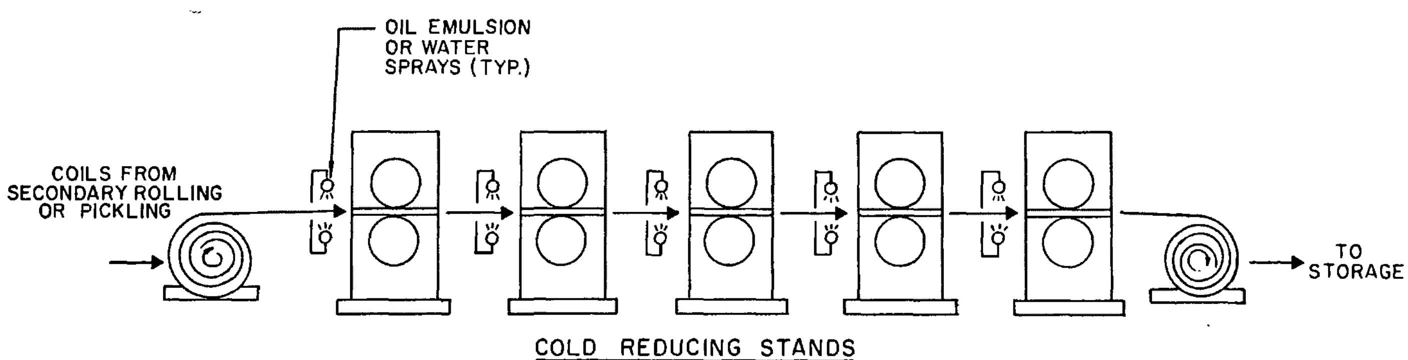

COLD REDUCTION PROCESS FLOW DIAGRAM

FIGURE G-12

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Harold Hofstein and Harold J. Kohlmann		8. PERFORMING ORGANIZATION REPORT NO.
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12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development, Industrial Environmental Research Laboratory, Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Final; 1/77 - 5/79
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16. ABSTRACT The report gives results of an engineering study of five integrated U.S. steel plants to determine how each might ultimately achieve total recycle of water. The plants represent a broad cross section of plant-specific factors (e.g., size, age, location, and available space) that are present in U.S. steel plants. Conceptual engineering designs were prepared for each plant to advance from its present water discharge situation to achievement of the Clean Water Act's 1984 Best Available Technology limitations and finally to achieve total water recycle. Potential treatment technologies for meeting these goals were evaluated: the most promising were incorporated into the plant designs. Capital and operating costs and energy requirements were estimated, and problems associated with implementation of the designs were addressed. Problems include: the lack of steel plant experience with the technologies required, the high cost and energy requirements, the additional solid waste disposal problems, and the more difficult management requirements for sophisticated water systems. The report is intended as a reference for planning and implementing programs to meet the more stringent water quality requirements that steel plants may face in the future.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution; Waste Disposal	Pollution Control	13B
Steel Plants	Stationary Sources	13I
Water Reclamation	Water Recycle	
Capital Costs	Energy Requirements	05A
Operating Costs		14A
Energy		14B

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