ZERO WATER DISCHARGE SYSTEM FOR THE BABYLON RESOURCE RECOVERY FACILITY

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ABSTRACT

This paper describes the design and planned operation of the zero water discharge system for a mass-burn type waste-to-energy facility in the Northeast. The Babylon Resource Recovery Facility is presently under construction in Long Island, New York. The facility design is particularly unique in that it will receive process make-up water from the underground leachate plume of the adjacent existing landfill. In addition, all wastewater will be treated on-site and recycled. The facility water balance and the water and wastewater treatment systems design are discussed.

INTRODUCTION

The Babylon Resource Recovery Facility is designed to incinerate municipal solid waste to produce steam and electricity. Major design data for the facility are listed in Table 1 and the overall layout of the facility is shown schematically in Fig. 1. It is located at the site of an existing landfill, in the Town of Babylon, Long Island, New York. It is designed to receive and combust 750 tons/day (680 t/d) of solid waste, serving the Town's 386,000 residents.

The resource recovery plant design is based on mass-burn technology for the combustion of the waste. A simplified facility process diagram is presented in Fig. 2. In the mass-burn process, there is little or no sorting of municipal refuse before incineration. The unprocessed municipal waste will be delivered to the facility primarily in standard packer vehicles, each containing approximately 5–8 tons (4.5–7.3 t) of refuse. The waste will be deposited directly into the storage pit

TABLE 1 FACILITY MAJOR DESIGN DATA

Facility Nominal Capacity at 4450 Btu/lb (10,340 kJ/kg)	750 tons/day (680 t/d)
Facility Nominal Capacity	228,000 tons/year (207,000 t/year)
Number of Combustion Trains	2
Combustion Train Nominal Capacity	375 tons/day (340 t/d)
Steam Produced (total)	172,000 lb/h (78,000 kg/h)
Steam Pressure	655 psig (4,520 kPa (ga))
Steam Temperature	700°F (371°C)
Number of Turbine-Generators	1
Type of Turbine-Generator	Condensing with uncontrolled extractions and provision for future controlled extraction
Turbine-Generator Nominal Capacity	17 MW
Condenser Cooling Method	Wet Cooling Tower
Air Pollution Control Equipment	Dry scrubber and baghouse

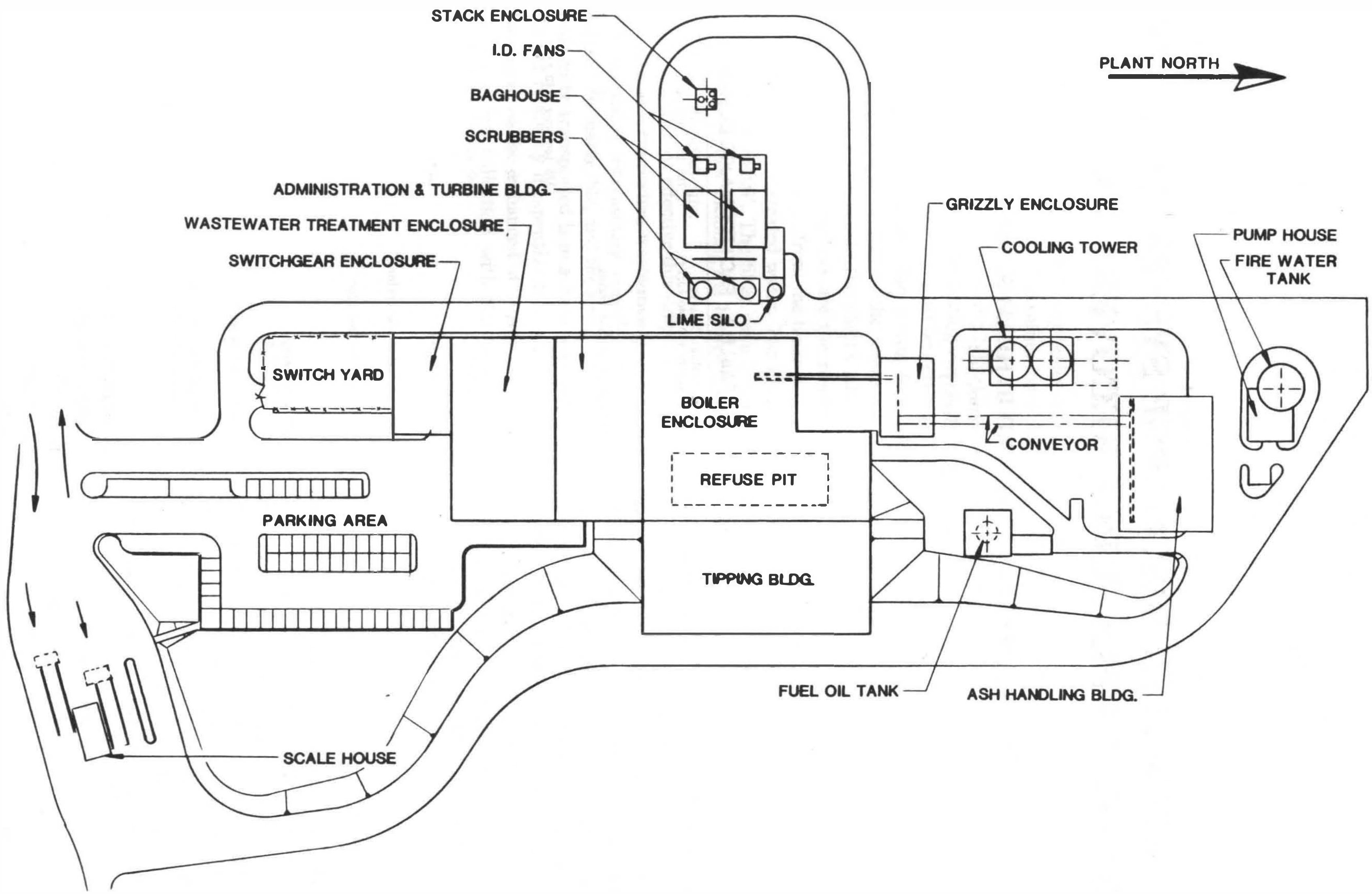

FIG. 1 FACILITY LAYOUT

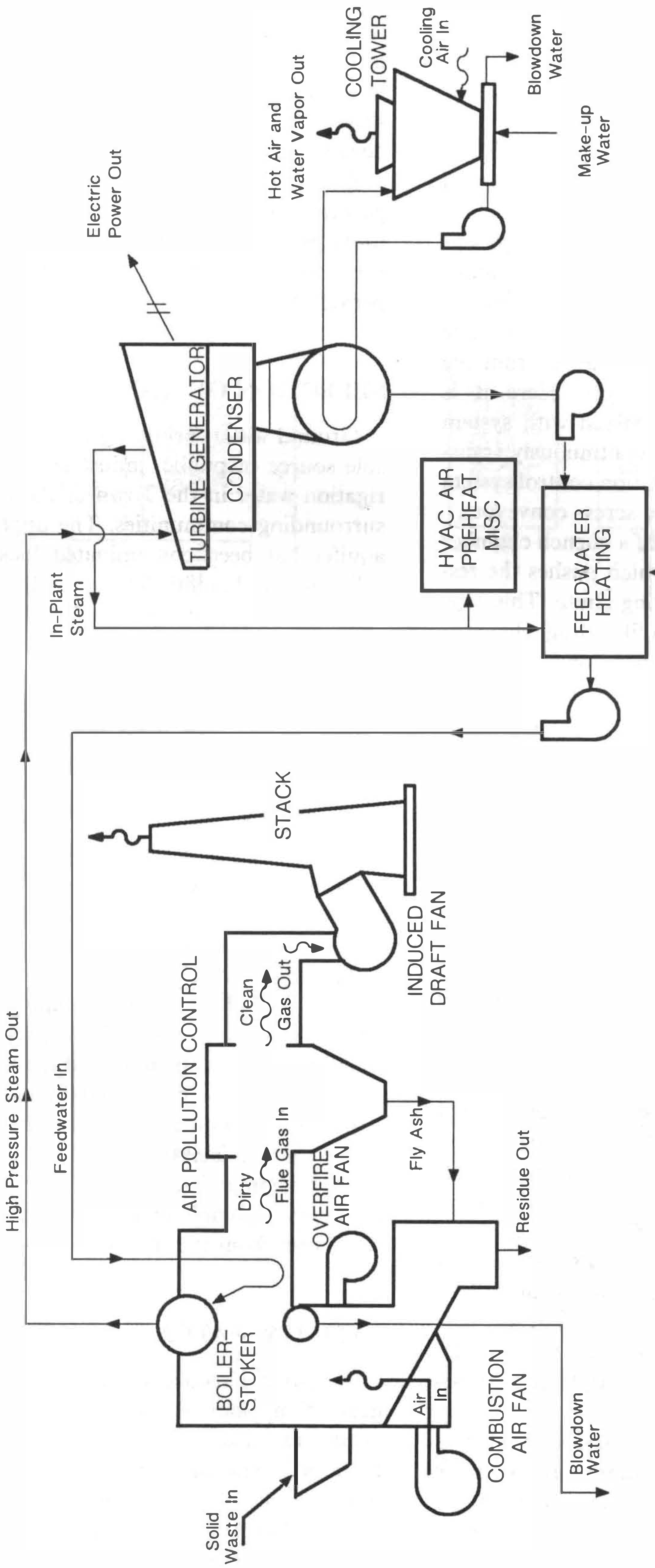

FIG. 2 SIMPLIFIED PROCESS FLOW DIAGRAM

from the delivery trucks. From the storage pit, the refuse will be fed into the combustion unit feed chute hoppers by one of two overhead cranes. These cranes will also be used to mix and restack the refuse in the pit.

After being charged into the feed chute hoppers, the refuse will be metered out from the bottom of the feed chutes by hydraulic feed rams onto the stoker grates. The reverse-reciprocating action of the grate agitates the fuel bed continuously in a manner which causes refuse burning from the bottom of the refuse bed, resulting in a burnout of better than 98% of combustible matter. The burned-out material is directed from the grate surface to a residue discharger. Here it is quenched, cooled, moistened and mixed with system fly ash and reacted lime which is continuously transported from the boiler and air pollution control system hoppers via a series of heavy duty screw conveyors.

The residue discharger consists of a quench chamber and a hydraulically driven ram which pushes the residue up an inclined draining/drying chute. This type of residue removal approach, unlike drag chain or other type systems, requires no blowdown of water. Excess water from the residue will drain back into the quench bath. The quenched residue is moved via a system of vibrating and belt conveyors to an enclosed residue storage area prior to final disposal in a landfill.

The energy derived from the heat of combustion of the incinerated refuse is transformed into 86,000 lb/hr (39,000 kg/h) of 655 psig (4520 kPa), 700°F (371°C) steam in each of the facility's two integral waterwall boilers. This high pressure superheated steam is transported via steam piping to a single condensing type steam turbine. Suitable steam purity is maintained by continuously blowing down a small portion of the boiler drum water and making up with onsite treated demineralized water.

In the turbine, the energy of the steam is transformed into 17 MW of electric power. A small part of this power will be utilized for normal in-plant requirements; the remainder to be sold to the local utility, Long Island Lighting Co. (LILCO). Exhaust steam from the turbine will pass to the facility's watercooled surface condenser where the cycle waste heat will be transferred to circulating cooling water. The temperature rise of the cooling water will be 20°F (11°C). The heated water will be cooled in a multiple cell evaporative (wet) cooling tower.

The heat remaining in the flue gasses as they leave the economizer sections of the boilers is released for absorption into the atmosphere through the facility's chimney. Prior to discharge, the hot flue gasses pass through dry type flue gas scrubbers for removal of hydrochloric, sulfuric and other acid gasses and through high efficiency fabric filter baghouses for removal of particulates. The scrubbing process involves lowering the flue gas temperature by slurry (water and slaked lime) injection. The dry scrubber technology does not generate wastewater.

During the initial startup of the facility, wastewater generated will be treated and reused within the system to the greatest extent possible. Excess wastewater, however, will be disposed of offsite during this limited period of time.

SELECTION OF WATER SOURCES

Ground water, primarily from a deep aquifer, is the sole source of public, industrial, commercial, and irrigation water in the Town of Babylon as well as the surrounding communities. The upper, shallow glacial aquifer has been contaminated locally, primarily by solid waste landfill leachate. The leachate plume spreads south from the landfill site. The deep aquifer is generally protected from downward migration of leachate from the upper aquifer by a 10–15 ft (3–4.5 m) thick impermeable clay layer. In an effort to further protect the ground water supply from contamination, and to reduce demand on the potable water supply system, the Town of Babylon elected to have the majority of the process makeup water fed from the contaminated upper aquifer. By pumping almost a half million gallons per day of water from the leachate plume area, the Babylon Resource Recovery Facility is anticipated to have a positive impact on the limitation of upper contaminant migration into the deep aquifer. In addition, the pumping of contaminated groundwater from the shallow upper aquifer will tend to aid in plume mitigation and may reduce the further lateral migration of the contamination.

Consistent with the need for high quality potable water for the facility workers and visitors, and high quality demineralized water for boiler system makeup, a supply of potable quality water will be provided for these uses from the municipal water supply.

FACILITY WATER BALANCE

A resource recovery plant, like any electric power generation plant, involves a complex series of water users and wastewater producers. The water quality of each usage and discharge presents different treatment requirements. The water and wastewater systems for the Babylon Resource Facility are further complicated by the use of a makeup water source which needs

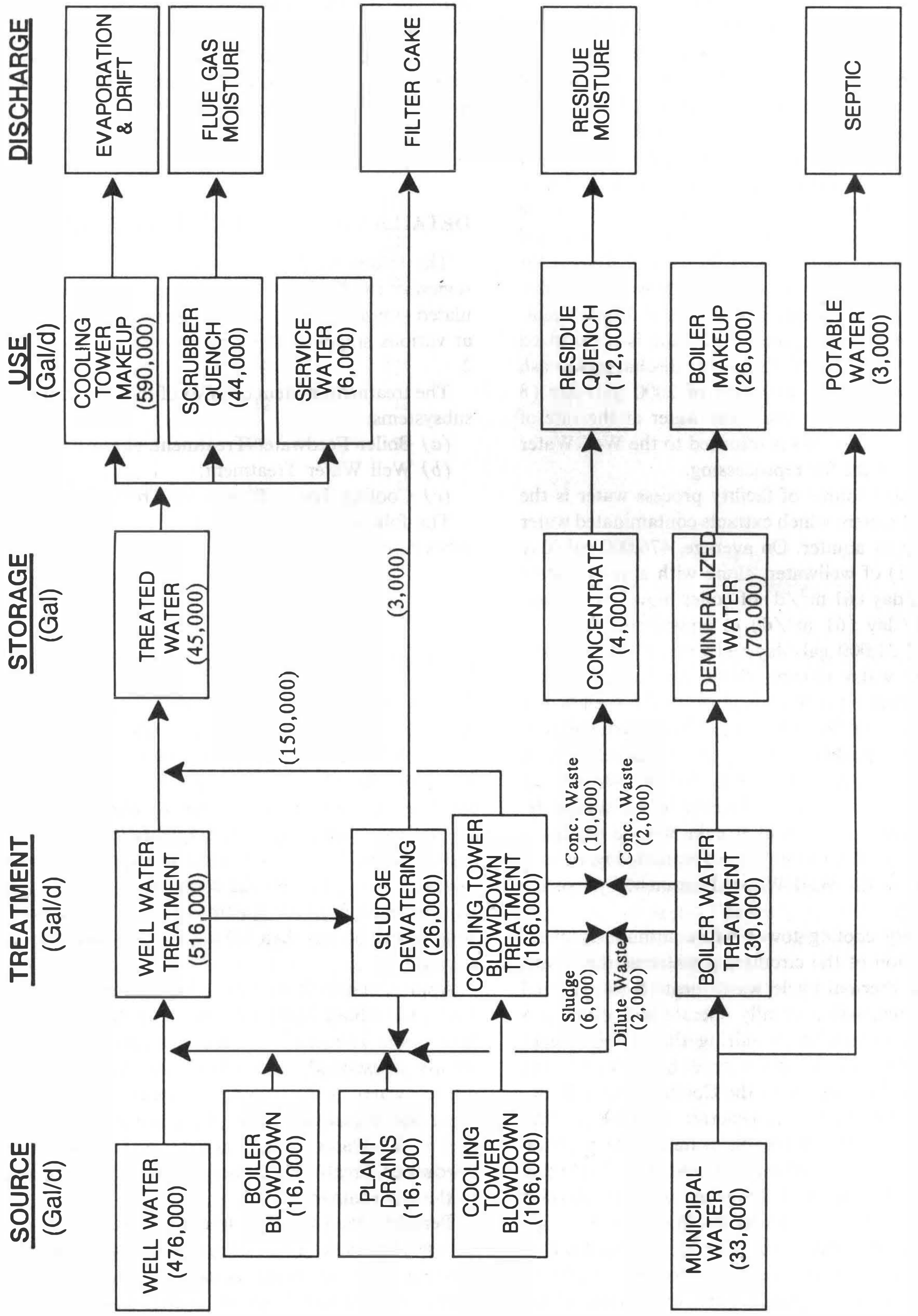

FIG. 3 SIMPLIFIED WATER SYSTEM FLOW CHART

substantial treatment prior to use and a requirement for zero wastewater discharge from the facility. Proper design of these systems, therefore, is extremely significant to the overall success of the project.

A simplified water system flow chart for normal facility operation is presented in Fig. 3. A limited supply of makeup water will be available from the municipal water supply system for potable and boiler makeup water use. On average, 3000 gal/day (11 m^3/d) of municipal water is expected to be used directly as potable water and 30,000 gal/day (114 m^3/d) will be treated in the Boiler Water Treatment System for use as thermal cycle makeup. Sanitary wastes are discharged to an on-site septic system. Boiler Water Treatment System strong regeneration waste is neutralized and directed to the facility's residue dischargers as ash quench water at a normal rate of 2000 gal/day (8 m^3/d). The backwash and rinse water at the rate of 2000 gal/day (8 m^3/d) is returned to the Well Water Treatment System for reprocessing.

The primary source of facility process water is the shallow well system which extracts contaminated water from the upper aquifer. On average, 476,000 gal/day (1800 m^3/d) of wellwater, along with approximately 16,000 gal/day (61 m^3/d) of boiler blowdown water, 16,000 gal/day (61 m^3/d) of equipment and floor drains, and 31,000 gal/day (117 m^3/d) of intermediate waste water streams from the facility's other water treatment equipment is piped to the Well Water Treatment System for processing. This system will produce 490,000 gal/day (1855 m^3/d) of treated makeup water and 26,000 gal/day (98 m^3/d) of system reject water. Reject water will be directed to the sludge dewatering system where a filter cake will be produced and 23,000 gal/day (87 m^3/d) of extracted water will be returned to the Well Water Treatment System for reprocessing.

The facility cooling tower will continuously evaporate a portion of the circulating water as the means of rejecting thermal cycle waste heat. It is expected that the system will normally operate at about 3.5–4 cycles of concentration, requiring that 166,000 gal/day (628 m^3/d) of blowdown water be extracted. The blowdown will be treated in the Cooling Tower Blowdown Treatment System to generate 150,000 gal/day (570 m^3/d) of treated recycle water, 6000 gal/day (23 m^3/d) of clarifier underflow, and 10,000 gal/day (38 m^3/d) of concentrated wastewater. The clarifier underflow will be returned to the Well Water Treatment System for reprocessing. The concentrated wastewater will supplement the Boiler Water Treatment System wastewater as quench water to the residue dischargers. The treated recycle water will be directed to the treated water storage tank where it will be mixed with the treated well water. These streams together will provide approximately 590,000 gal/day (2233 m^3/d) of cooling tower makeup, 44,000 gal/day (163 m^3/d) of flue gas quench water and 6000 gal/day (23 m^3/d) of plant service water.

DETAILS OF THE TREATMENT SYSTEM

The following discussions provide a more detailed review of the Facility's water treatment system. A tabulated summary of the chemical composition of water at various stages of the system is presented in Table 2.

The treatment system consists of the following major subsystems:

(a) Boiler Feedwater Treatment.
(b) Well Water Treatment.
(c) Cooling Tower Blowdown Treatment.

The following is a brief description of each of the subsystems:

BOILER FEEDWATER TREATMENT

High purity boiler makeup water is produced from municipal water in this system with the use of activated carbon filters and strong acid cation and strong base anion demineralizers. The municipal water is demineralized to meet the high water quality demands of the boilers and the high steam quality demands of the turbine. Two trains, each sized to support full plant operation, are provided for complete availability. The effluent water from the system is stripped of impurities; sodium will be less than 1.0 mg/L and silica less than 0.1 mg/L.

Approximately 50 lb/day (23 kg/d) each of sulfuric acid and sodium hydroxide will be utilized in the regeneration. The small amount of salt laden liquid that results is isolated, neutralized and disposed of as quench water in the residue discharger system. Clean rinse and backwash wastes are collected and treated in the Well Water Treatment System. Thus, the Boiler Feedwater Treatment System produces no net waste to the environment.

Demineralized water is stored in a 70,000 gal (265 m^3) storage tank. This volume provides for intermittent operation and maintenance downtime of the Boiler Feedwater Treatment System as well as sufficient freeboard to accept the complete draining of one boiler.

TABLE 2 CHEMICAL COMPOSITION OF WATER STREAMS (mg/L as $CaCO_3$)

Constituents	Incoming Well Water	Treated* Water	Cooling Tower Blowdown	Electrodialysis Treated Water	Electrodialysis Concentrate
Calcium	483	27	112	17	481
Magnesium	184	58	243	27	770
Sodium	490	490	2,027	676	19,498
Potassium	158	158	653	218	6,287
Ammonia-Nitrogen	235	235	972	324	9,287
Bicarbonate	1,100	30	124	<1	<1
Sulfate	32	515	2,130	727	20,974
Chloride	346	346	1,431	477	13,768
Silica	12	12	50	20	20
Carbon Dioxide	408	50	<1	28	28
Suspended Solids	122	<1	<1	<1	<1
Nitrate	72	72	298	99	2,865
pH	6.8	7.8	7.8	7.0	7.0

* Combined well water treatment system effluent and ED treated water.

WELL WATER TREATMENT

The predominant constituents in the contaminated well water include salts, carbon dioxide, bicarbonate alkalinity, suspended solids, iron, and decomposed organic by-products (ammonia–nitrogen). Before this water can be used in the cooling tower and for general plant requirements, much of the contaminants must be removed. The Well Water Treatment System flow diagram is shown in Fig. 4.

The first stage of treatment strips out volatile gasses (mostly carbon dioxide) using a packed tower, forced draft degassifier. This stage also assists in oxidizing the iron to promote its precipitation. Following the degassifier, the well water is mixed with miscellaneous plant equipment drains, floor drains, demineralizer backwash and rinse water and boiler blowdown water.

The second stage of treatment employs lime softening and clarification. An unique feature of this clarifier is that it also acts as a sludge thickener and sludge holding tank. The influent water will be mixed with lime and polymer. Iron, excess calcium, magnesium, silica, suspended solids, trace heavy metals, alkalinity, and absorbable organics will be induced to settle at the bottom of the clarifier.

Sludges produced in the lime clarifier are stored and thickened in the bottom section of the unit to await scheduled dewatering operations. The clarifier also receives the sludges from the Cooling Tower Blowdown Treatment System. The sludge holding capacity of the clarifier has been sized for three (3) days to optimize operational flexibility.

The third stage of the treatment system filters the clarifier effluent through dual media (anthracite and sand) gravity filters for the further removal of suspended particles. Following filtration, the water is adjusted to a neutral pH by controlled injection of sulfuric acid. The gravity filters are intermittently backwashed to the well water clarifier inlet. The filtered water is stored in a 45,000 gal (170 m^3) storage tank and is available for use as cooling tower makeup, scrubber quench water, and other general plant requirements. This storage volume represents an approximate two (2) hr supply; sufficient to ensure the availability of fully processed water during system surges and routine maintenance downtime. During long term waste treat-

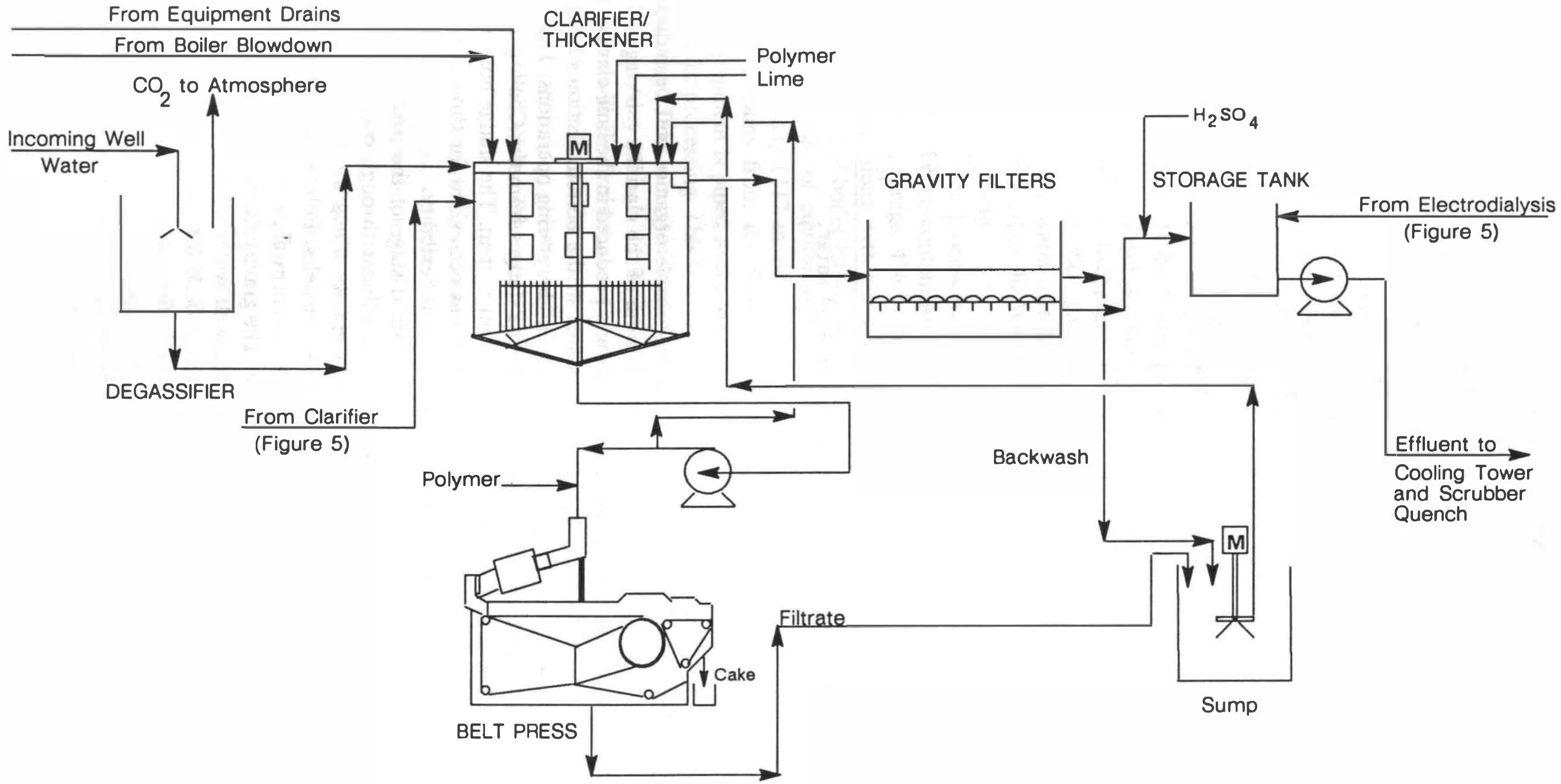

FIG. 4 WELL WATER TREATMENT SYSTEM FLOW DIAGRAM

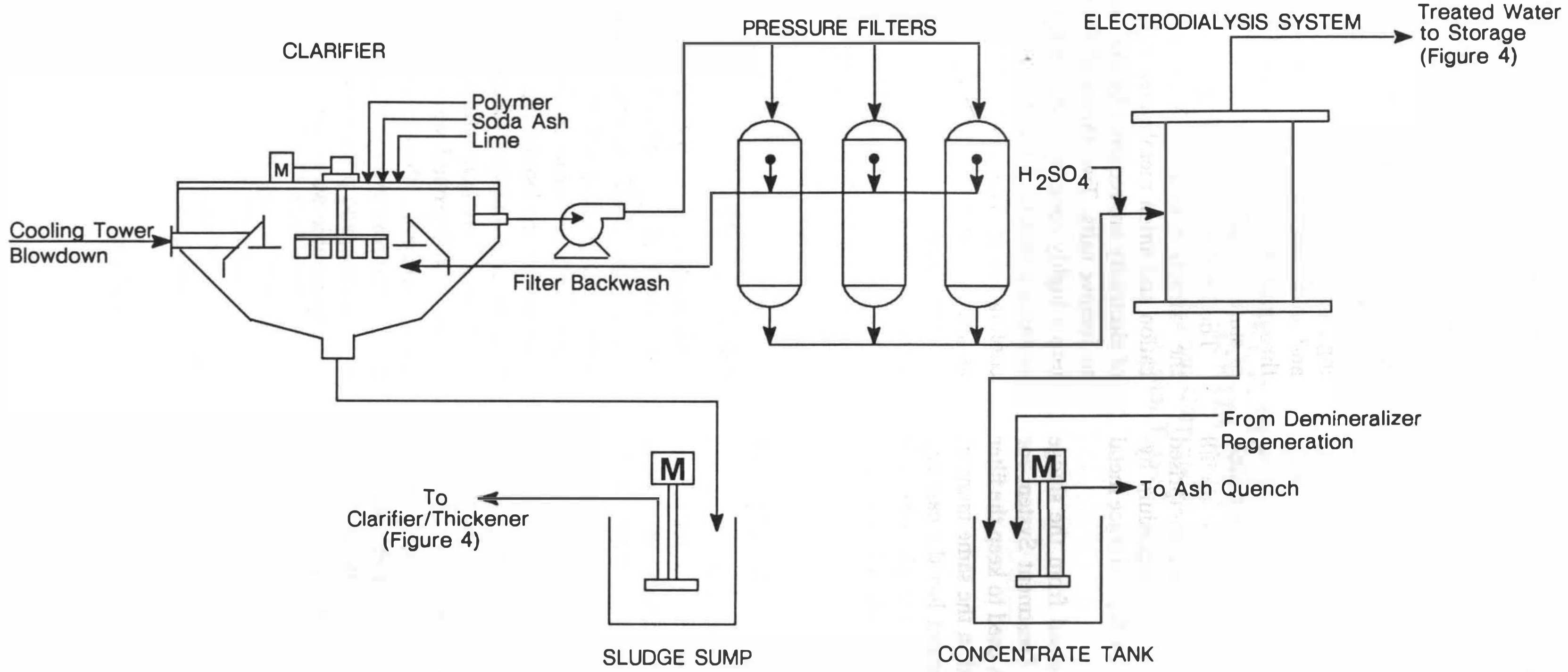

FIG. 5 COOLING TOWER BLOWDOWN TREATMENT SYSTEM FLOW DIAGRAM

ment system outages, facility makeup water may be provided from the municipal water supply system.

Sludge dewatering is the final phase of the water treatment system. All sludges generated from the water treatment operations are collected, thickened, and stored in the well water treatment lime clarifier/thickener. As the sludge quantity builds up, the operator will schedule dewatering.

The dewatering process involves pumping the sludge to a belt press filter unit. Polymers are mixed with the sludge to bind the particles. Then, free water is pressed from the mass. The filter will produce approximately 6 tons/day (5.4 t/d) truckable quality cake for landfill disposal with the facility residue. The cake is comprised mainly of calcium carbonate (66%), magnesium hydroxide (13%), ferric hydroxide (4%) and trace metal hydroxides (0.2%).

The filtrate that has been pressed from the sludge is returned to the Well Water Treatment System for reprocessing. Spray water that is used to keep the filter press belt clean is also recovered in the same manner.

The sludge dewatering equipment has the capacity to dewater three days inventory in a single 8-hr shift operation. This enables orderly operation and flexibility.

COOLING TOWER BLOWDOWN TREATMENT

Evaporation of water in the main facility cooling tower causes the salts in the circulating water to concentrate. Uncontrolled, these salts can form scale in the condenser, circulating water pipes, pumps and the cooling tower. These scale forming salts are controlled by continuously discharging, or blowing down a portion of water from the circulating water loop and replacing it with fresh treated makeup water. The total makeup water quantity required is equal to the sum of the evaporation, drift and blowdown.

The blowdown flow, due to its high concentration of dissolved salts, is not suitable for direct usage as scrubber quench water. Since it cannot be discharged from the facility, it must be treated and reused within the system. The Cooling Tower Blowdown Treatment System functions as a kidney to the cooling tower. The system removes scaling contaminants and excess salts as they build up in the cooling water system. Two processes are employed to accomplish this removal. The Cooling Tower Blowdown Treatment System flow diagram is shown in Fig. 5.

The process uses lime clarification to precipitate scaling components such as calcium, magnesium, and silica and settle suspended solids. The water is then filtered through pressure filters and pH adjusted by addition of sulfuric acid.

The next stage of the system is electrodialysis for the extraction of salts. This system employs special cation and anion membranes. Approximately 100 kW of electricity are required by the electrodialysis system to remove salts. Two-thirds of the salts are extracted into a highly concentrated, small volume stream. The remaining water, reduced in salts, is returned to the cooling tower. The concentrate stream is disposed of as quench water in the residue discharger system.

Lime sludge and other processing wastes from the Cooling Tower Blowdown Treatment System are directed to the Well Water Treatment System clarifier/thickener for further processing and recovery.

CONCLUSION

Since all plant equipment drains, floor drains, cooling tower and boiler blowdown water is treated in the system and reused, the system meets the objective of zero water discharge. The construction and operation of the Resource Recovery Facility will reduce the volume needed for landfilling, allow the existing landfill to be capped, and thus reduce the potential for related groundwater contamination. Since the existing leachate contaminated ground water is to be used for the facility's processes, the operation of the facility should help to improve ground water quality, contain the existing plume, and preserve the precious source of community potable water supply.