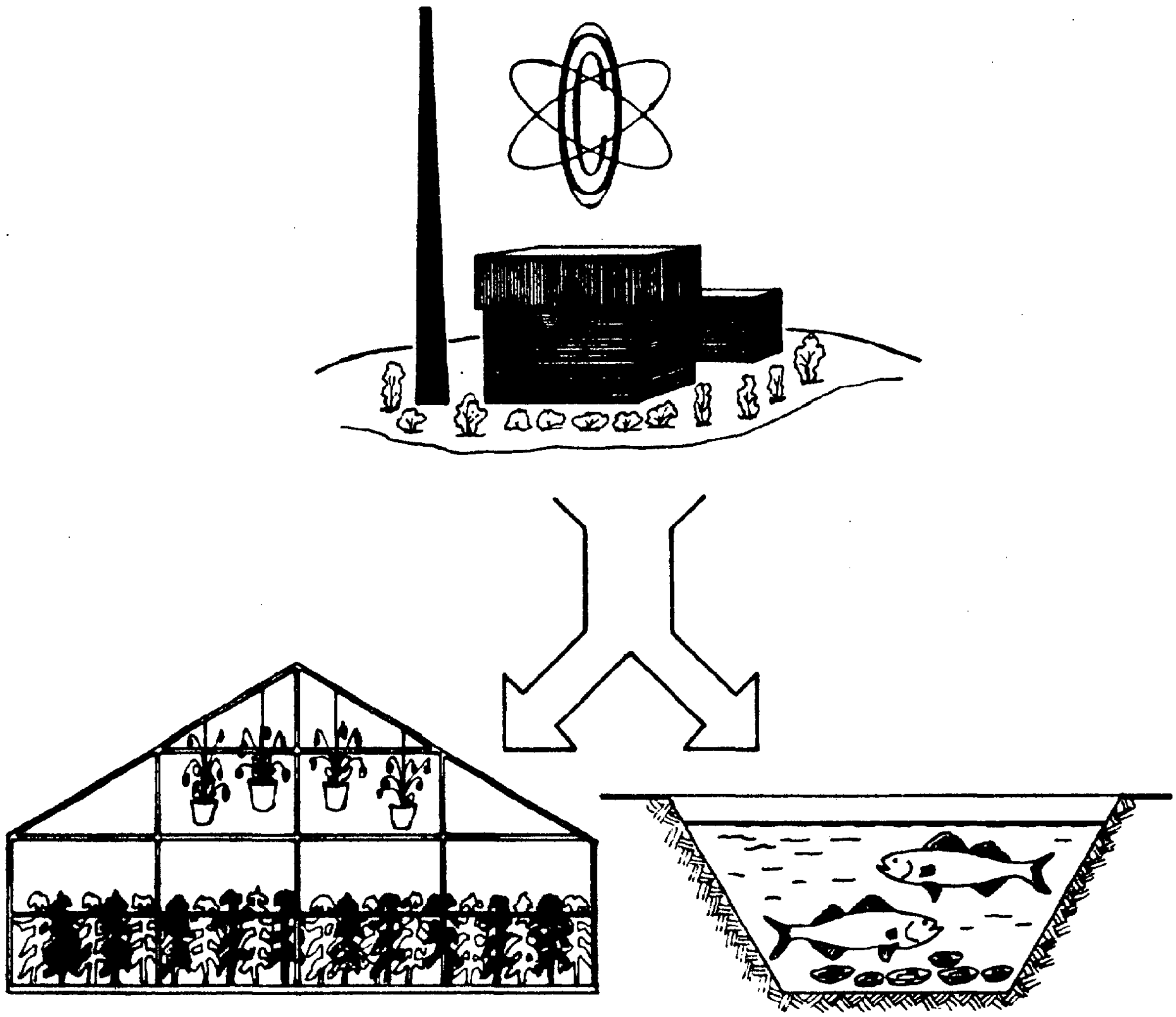
LACEY INDUSTRIAL PARK



WASTE HEAT UTILIZATION STUDY

FINAL REPORT

FINANCIAL ASSISTANCE PROVIDED BY:

THE OFFICE OF COASTAL ZONE MANAGEMENT, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION; NEW JERSEY DEPARTMENT OF ENERGY; LACEY TOWNSHIP

New Jersey. Department of Energy.

A REPORT ON POTENTIAL FOR THERMAL POLLUTION MITIGATION BY WASTE HEAT UTILIZATION FROM POWER PLANT CONDENSER COOLING WATER FOR INDUSTRIAL AND COMMERCIAL OPERATIONS LOCATED ADJACENT TO NUCLEAR OR FOSSIL FUEL FIRED GENERATING PLANTS

SHORT TITLE: LACEY TOWNSHIP, NEW JERSEY WASTE HEAT DISPERSION BY UTILIZATION STUDY

Prepared By:

NORTHWEST ENGINEERING, INC.

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EXECUTIVE SUMMARY

The following report has been prepared to present the results of a Waste Heat Utilization Study conducted by Consultants, Northwest Engineering, Inc., for the governing body of Lacey Township, Ocean County, New Jersey. The study has been funded 35% by Lacey Township, and 65% by funds provided by the National Oceanic and Atmospheric Administration through the New Jersey Department of Energy.

The principal objective on the study was to ascertain if mitigation of thermal pollution to Barnegat Bay from power generating plant condenser cooling water from Oyster Creek Nuclear Generating Station (OCNGS) is possible. The potential means of this mitigation is the utilization of the heat energy content of the cooling water in some commercial process prior to discharge of the cooling water to Barnegat Bay or other public waters.

This study was primarily a general investigation intended to be applicable to situations where relatively large amounts of energy are released through cooling processes accomplished by small temperature increases in massive amounts of water. A further incentive prompting this investigation was the availability of industrially zoned land immediately adjacent to the Lacey Township installation and the desire and intent of the Lacey Township governing body and its Industrial Commission to establish an Industrial Park at that location.

The general steps undertaken in this study were as follows:

1. A bibliography of available existing research applicable to Waste Heat Utilization was prepared and the pertinent documents were acquired and reviewed.

2. Certain processes, it became apparent, have utilized waste heat from energy for years with varying degrees of success and were further investigated. Typical uses of waste heat or other low level heat transfers similar to those occurring in power plant effluent are:

   a. High Intensity Aquaculture
   b. High Intensity Mariculture
   c. Commercial Agriculture

Other processes were identified and investigated as to their applicability in relation to the temperatures available from OCNGS and the proposed Forked River Unit #1 (FR#1) plants. Material and market considerations were explored to determine which of the identified possible processes might be most applicable to the specific Lacey Township site. Criteria were developed in this process which are useful in determining similar specifics at other geographical locations.

After identifying possible processes it was necessary to determine what constraints exist that would influence the cost-effectiveness of implementing the interfacing with the power generating facility to supply the waste heat to energize the selected processes. Several problems and needs were identified as follows:

1. All processes identified require a constant supply of energy. For this reason Waste Heat Utilization operations will probably only be successful where complexes of two (2) or more generating stations adjacently located but operating independently exist, and some alternate heat sources or large storage capability exist for periods of generating station outages, or ambient climate limitations.

2. The uses investigated in this report, and other reports dealing with Waste Heat Utilization, have been selected primarily because they fit the available temperature criteria with little or no augmentation required. This leads to a dilemma in our climate; i.e., processes which operate at relatively low temperatures may utilize the available low grade heat during winter conditions, however, many of these processes, since their operational range is on the low side, may require cooling during the summer months and are, therefore, rendered ineffective in mitigating thermal pollution. It would, therefore, appear that temperature augmentation to the range of 140° - 200° F and the keying of processes utilizing temperatures in that range, could be effective in Waste Heat Utilization on a year-round basis.

3. An examination of regulatory agencies and their permitting procedures shows that Local, State and Federal approvals are necessary and a unified and well coordinated effort will be required to make a project of this magnitude feasible.

4. Certain psychological and financial factors exist in the concept of an industrial operation located immediately adjacent to a nuclear generating facility. These considerations are largely in the area of the preception of risks in the following areas:

   a. The work force
   b. Financial Institutions
   C. Insurance Companies

   An examination of these risks and the mechanisms available for minimizing them, and an objective attempt at assessing the actual risks involved is also presented.

Summary of Conclusions

A summary of conclusions to be found in the report is as follows:

1. It would appear that there are certain commercial applications which may be useful in both mitigating thermal discharges and usefully utilizing waste heat from power generating stations.

2. The successful utilization of waste heat from cooling water would appear to have a much better chance in applications planned in conjunction with the design of the plant and its operational plan rather than in retrofitting existing facilities.

3. There would appear to be advantages to be gained in the siting of plants and in the public acceptability of proposed plants if industrial usages could be presented concurrently with the presentation of proposed new plants.

4. Proposed uses should be limited to non-labor intensive applications in view of the psychological limitations of the general public in accepting high labor intensive operations in areas where evacuation considerations are deemed necessary. A further caveat is that some insurance limitations will probably exist in these areas, however, no statistical evidence exists, at this time, to justify any such activities as they would apply to personal health or safety.

5. Aztec Energy Associates (See Appendix F) reviewed the possibilities of obtaining temperature augmentation of process water and chilling of effluent by utilization of ground water storage and transfer with conventional heat pump (chiller) technology now available. Substantial promise for this concept may exist if the site to be utilized contains the necessary ground water quantities and temperatures required for compatibility with the process being considered. It is quite likely that this caveat would pose no problems in instances where the Waste Heat Utilization facility were being planned in conjunction with new power plant sites as a criterion for siting. In instances were the reuse facility is being retrofitted to an existing plant the ground water concept will not be viable if the minimum requirements do not exist.

TITLE OF REPORT: A REPORT ON POTENTIAL FOR THERMAL POLLUTION MITIGATION BY WASTE HEAT UTILIZATION FROM POWER PLANT CONDENSER COOLING WATER FOR INDUSTRIAL AND COMMERCIAL OPERATIONS LOCATED ADJACENT TO NUCLEAR OR FOSSIL FIRED GENERATING PLANTS

EXHIBITS

EXHIBITS

I. WATER QUALITY

I. WATER QUALITY

The subject of water quality will address the Barnegat Bay, the intake canal, the effluent after passage through the condenser and the ground water in the area. (EXHIBIT I)
Ground water analysis, although not specified in the scope of services, has been included as indications are that, for some of the processes of heat transfer included in this report, the use of fresh water or natural Bay Water is preferable to the direct use of the nuclear plant effluent. The specific processes referred to are in the production of food products for human consumption. The hesitancy to utilize the effluent directly is related to the Delaney Amendment to the Pure Food, Drug and Cosmetic Act, which reads in part;

> . . "fail to establish that the proposed use of the food and the additive, under the conditions of use to be specified in the regulation, will be safe; provided, that no additives shall be deemed to be safe if it is found to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of the safety of food additived, to induce cancer in man or animal, except this proviso shall not apply with respect to the use of a substance as an ingredient of feed for animals which are raised for food production, if the Secretary finds (i) that, under the conditions of use in feeding specified in proposed labeling and reasonably certain to be followed in practice. Such additive will not adversely affect the animals for which such feed is intended, and (ii) that no residue of the additive will be found (by methods of examination prescribed or approved by the Secretary by regulations, which regulations shall not be subject to subsections (f) and (g) in any edible portion of such animal after slaughter or in any food yielded by or derived from the living animal; . . ."

Research, to date, has established a link between radiation exposure and cancer incidence, without satisfactorily establishing a risk relationship quantitatively, the net result being that the Delaney Amendment:

> . ."is currently acting as an effective check to the use of nuclear plant effluents for aquaculture". (Ref. I p. 31)

The same restrictions would hold true for uses other than aquaculture where the food chain is involved. The direct use of effluent from facilities, other than nuclear, are presently being utilized, as described in later sections of this report.

These restrictions, on the use of nuclear power plant cooling water, lead to the concept of a dual loop process. The loops separate the direct usages from the food production processes which require an intermediate exchange. The examples below demonstrate the processes applicable to each loop.

A. Direct use of the effluent for:

1. Soil Warming
2. Greenhouse Warming Applications
3. Some drying operations utilizing water to air heat pumps
4. Direct Radiant Transfers

B. Power plant effluent to pass through a heat pump (chiller) surrounded by 53°F fresh well water, the fresh water is to then be utilized in food production such as:

1. Greenhouses - Warm water irrigation and/or hydroponics
2. Fresh Water Aquaculture
3. Food Processing
4. Mariculture - utilizing the fresh water supply in conjuction with heat exchangers to modify the temperature of the Bay Water collected before or at the power plant intake.

Limited samples of the undiluted effluent are presented on page 8 of this Final Report, but extensive data could not be obtained for inclusion in Volumns II and III, due to the extended shut down of the OCNGS. Temperature, however, is an important parameter for which data was available. It is shown graphically in Exhibit II. The temperature curves shown represent the following:

1. The average temperature of the intack canal over a three (3) year period; the temperature was recorded daily.

2. The temperature of the effluent from the OCNGS. The temperature was taken daily. Only those periods when the plant was in operation were used in averages. Periods of operation at less than 100% power generation capability were included in the averages to insure a more realistic estimate of the available Delta T.

3. The curve designated as OCNGS Delta T +5 is included because indications from Jersey Central Power and Light Company (JCP&L) are that the effluent temperature could possibly be raised by 5°F without causing undue back pressure on the turbine. By increasing effluent more than 5°F a back pressure is developed which can result in the loss of 1 megawatt of generation capability for each 1°F rise in effluent temperature. The cost of the lost power would have to be absorbed by the energy park and could seriously affect the economic viability of the park.

4. The curve shown for the proposed FR#1 Station is theoretical and assumes the plant running at 100% capability at the design Delta T of 28°F.

An examination of Exhibit I shows the chemical properties of the Barnegat Bay, the intake canal, the effluent, and the ground water. Various sources were contacted, for information, to present as complete a report as possible within budgetary limits, these sources included:

1. State of New Jersey Division of Water Quality
2. Jersey Central Power & Light Company
3. Environmental Testing Laboratories, Incorporated

Exhibit I is a composite of information supplied generated by these sources.

Temperature data is shown on Exhibit II and ph data is shown on Exhibit III.

This investigation of water quality and quantity leads to the following conclusions:

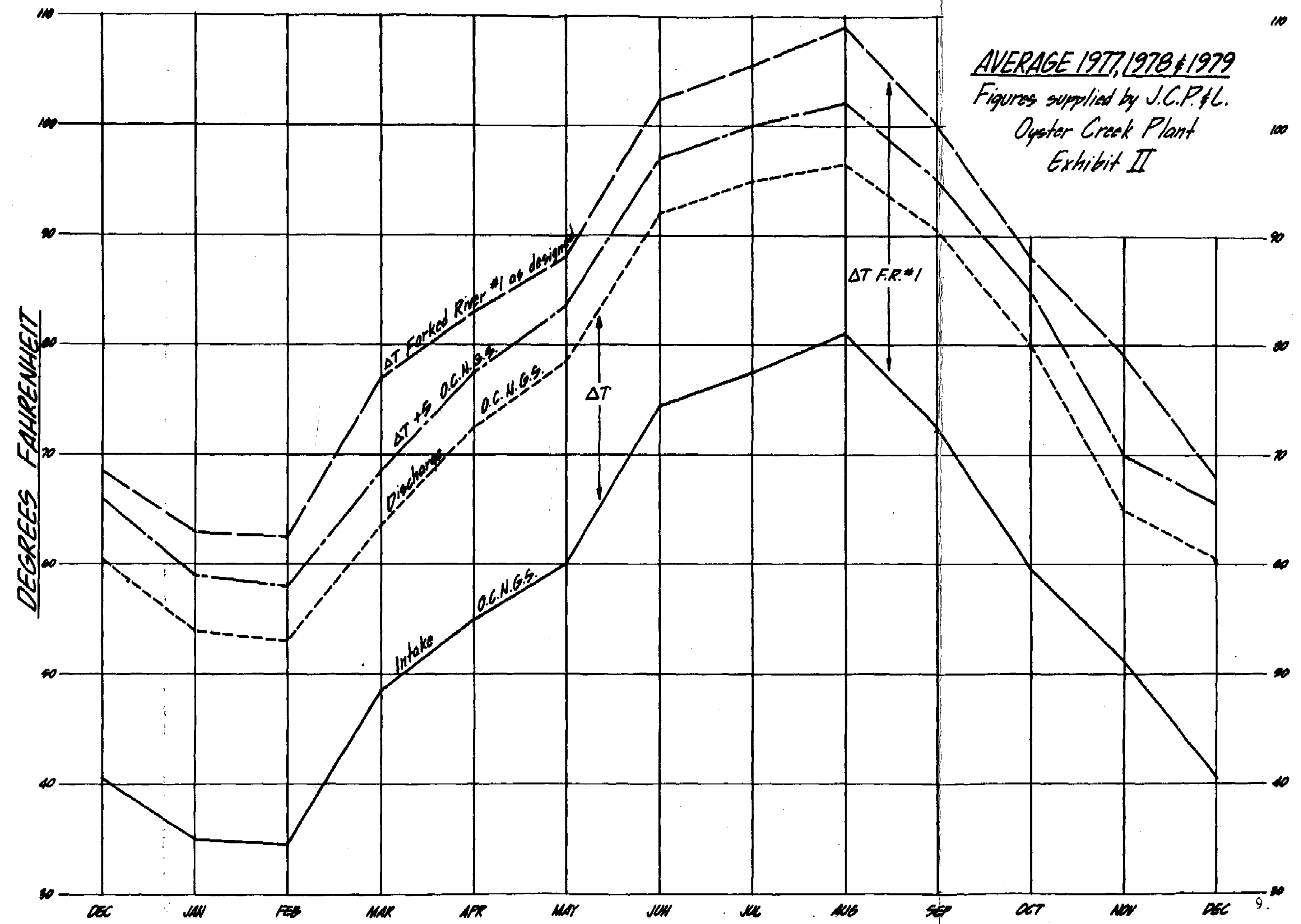
1. Sufficient effluent can be supplied to meet the volumetric needs of the proposed energy park. See "Proposed Lacey Energy Park Flow Diagrams". (Exhibits IV & V)

EXHIBIT I

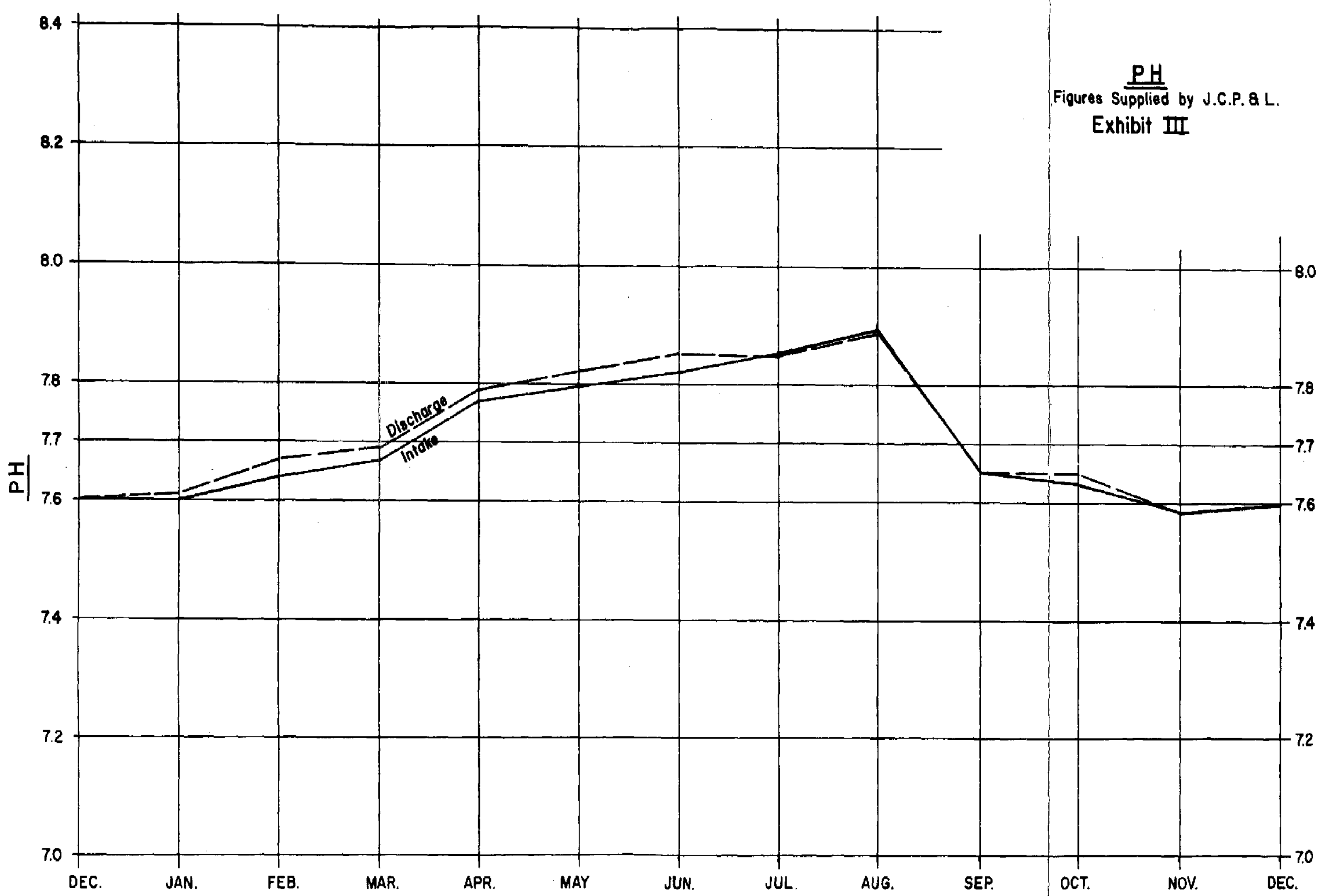
GROUND WATER ANALYSIS

PARAMETER	N.J. DEP* MONITORING BARNEGAT BAY	OCNGS MONITORING INTAKE CANAL	OCNGS MONITORING EFFLUENT	ENVIRONMENTAL TESTING LABS. MONITORING GROUND WATER
BOD_5 mg/l	1.75	1.3 ppm	0.6 ppm	0
COD	841	48 ppm	24 ppm	-
ALKALINITY AS PPM $CaCO_3$	82	92 ppm	90 ppm	(Phenol (Phthalein 0.0 (Methyl (Prange 18.0
BICARBONATE PPM	100	101	100	0.0
CHLORIDE PPM	13,200	12,680		19.0
PHOSPHATE PPM	0.08	0.05	0.02	1.95
SALINITY PPM	24,000	17,500	17,500	
SILICA PPM	2.2	0.4	0.2	10.80
SULFATE PPM	1,843	2150	2100	7.50
TOTAL RESIDUE				96.0
SUSP. MATTER				0.0
VOLATILE RES.				36.0
HARDNESS AS $CaCO_3$		5200 ppm	5500 ppm	26.6 (Ca, Mg) (+Fe)
pH	7.7	7.60	7.56	6.35
TEMPERATURE	34°F - 81°F	34°F - 81°F	53°F - 96°F	53°F

*N.J. Division of Environmental Protection


AVERAGE 1977, 1978 & 1979
Figures supplied by J.C.P.&L.
Oyster Creek Plant
Exhibit II
DEGREES FAHRENHEIT
ΔT Forked River #1 as designed
ΔT +5 O.C.N.G.S.
Discharge O.C.N.G.S.
Intake O.C.N.G.S.
ΔT
ΔT F.R.#1
110
100
90
80
70
60
50
40
30
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

<u>P H</u>
Figures Supplied by J.C.P. & L.
Exhibit III



2. Sufficient deep well fresh water is available to meet the need for make up water; i.e., water that, due to process contamination, cannot be recycled in the system. (See Appendix E)

3. Temperature augmentation sufficient to supply constant temperature fresh water as a source of commercially usable heat is possible through the use of heat pumps (chillers), solar, methane and extraction of process heat where applicable.

4. This configuration of the central heat source effectively isolates the effluent from potential for introduction into the food chain in aquaculture or mariculture applications.

5. The quality of the various water sources in some instances will require treatment. The treatment will not be of such a level of sophistication as to preclude its use.

6. The loss of heat during transmission has been determined to be virtually negligible. Review of the Bruce Nuclear Power Development project in Ontario, Canada, illustrates this point. The Bruce project transports effluent 9.94 miles in 52" uninsulated steel pipe at a rate of 29,587 gpm with a loss of 1.6% of the heat, and experiences a temperature drop of 0.72°F. The proposed Forked River complex would improve upon the figures sited above. The improvement would include the use of insulated fiberglass pipe and the reduction of pumping distances to the neighborhood of 1000 feet. The expected loss in heat under these conditions would be about 0.75% or a temperature drop of 0.15°F. The minimal heat loss in the transmission of the effluent demonstrated in the Bruce Park project and calculated for the Forked River complex indicate that a careful economic analysis, at the design stage, will be required to justify any insulating or other measures to reduce heat loss.

Due to the complexity and specialized nature of water quality evaluation and testing a special consultant, Environmental Testing Laboratories, Inc., of Lanoka Harbor, New Jersey, was secured. The consultants report is attached in its entirety along with a curriculum vitae for Environmental Testing Laboratories, Inc., as Appendix E to this report.

Environmental Testing Laboratories, Inc., has been utilized previously by Northwest Engineering, Inc., and were selected based on past performance and demonstrated ability.

II. WASTE HEAT TRANSFER SYSTEMS

II. WASTE HEAT TRANSFER SYSTEM OPTIONS

A. CENTRAL HEAT SOURCE

The central heat source shown on the "Proposed Lacey Energy Park Flow Diagrams" (Exhibits IV & V), will accomplish the amelioration of some factors which are identified concerning water quality, specifically:

1. Only relatively low temperature applications can be considered if additional heat sources or methods of augmentation are not incorporated.

2. No single plant application is practical if auxiliary heat sources and/or storage facilities are not available for periods of suspended plant operation.

3. Probable energy source costs for alternative systems would destroy any economic advantages of Waste Heat Utilization unless the alternative source could be generated largely as an integral function of the utilization process without the requirement for external fuel purchases per se.

4. Food production activities are presently precluded from direct contact between any product for human consumption or any product to be fed to or incorporated in a product for human consumption, from direct contact with cooling water due to possible presence of radio nuclides.

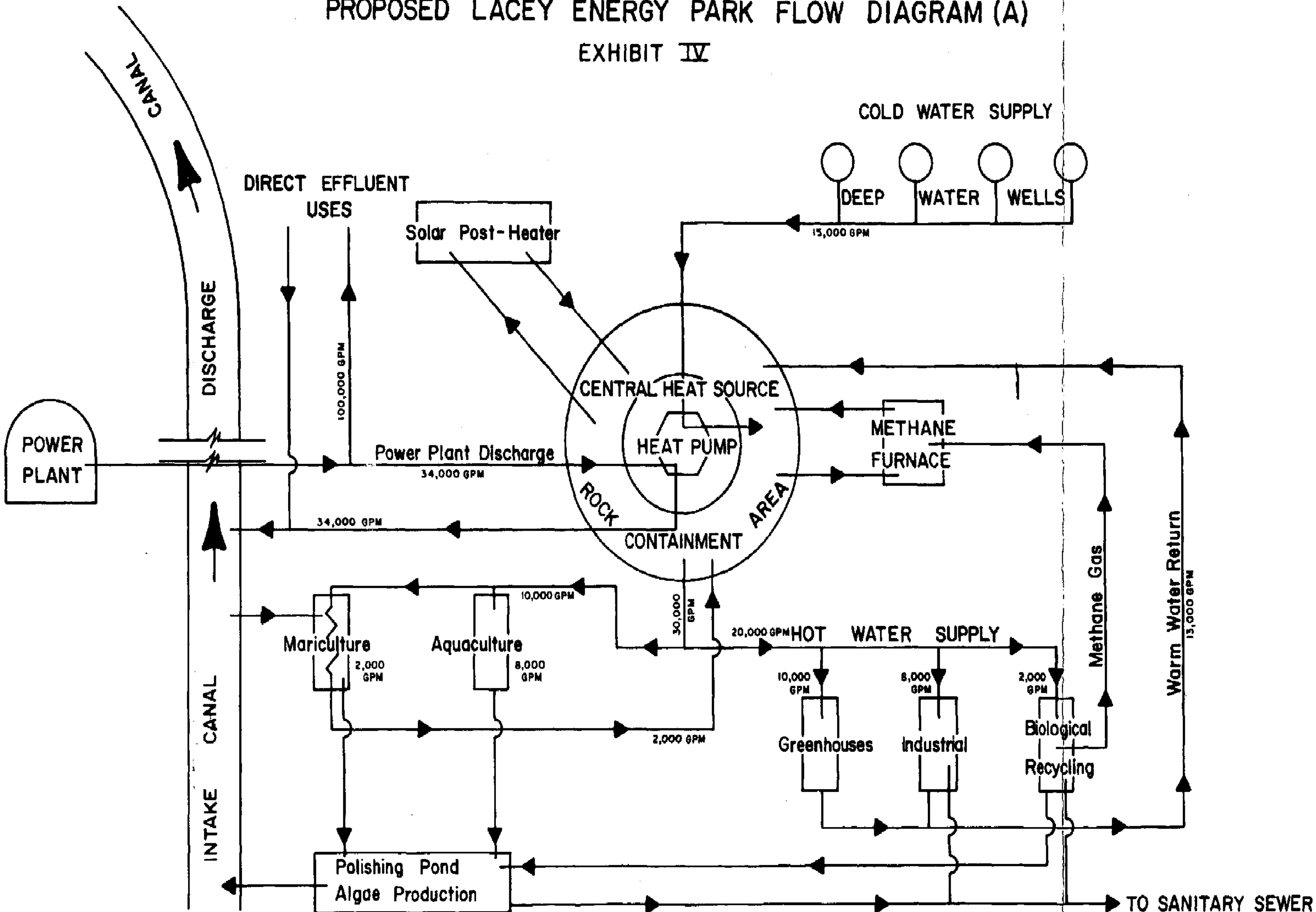
The proposed central heat source consists of a central water to water heat pump (chiller) which will accomplish a transfer of heat from the power plant effluent to the deep well fresh water. The cooled effluent will be returned to one of two areas depending on its temperature at discharge:

1. Directly to the Intake Canal for recycling.
2. Directly to the dilution pumps or proposed cooling tower for further cooling and subsequently to the discharge canal.

The heated fresh well water will be pumped into a rock containment. Without specific design parameters it is not possible to state with any certainty the amount of temperature augmentation and corresponding reduction in thermal pollutant that will occur in the heat pump (chiller), however, temperature augmentation in the range of 30 to 50°F appear reasonable. Total thermal pollution reduction

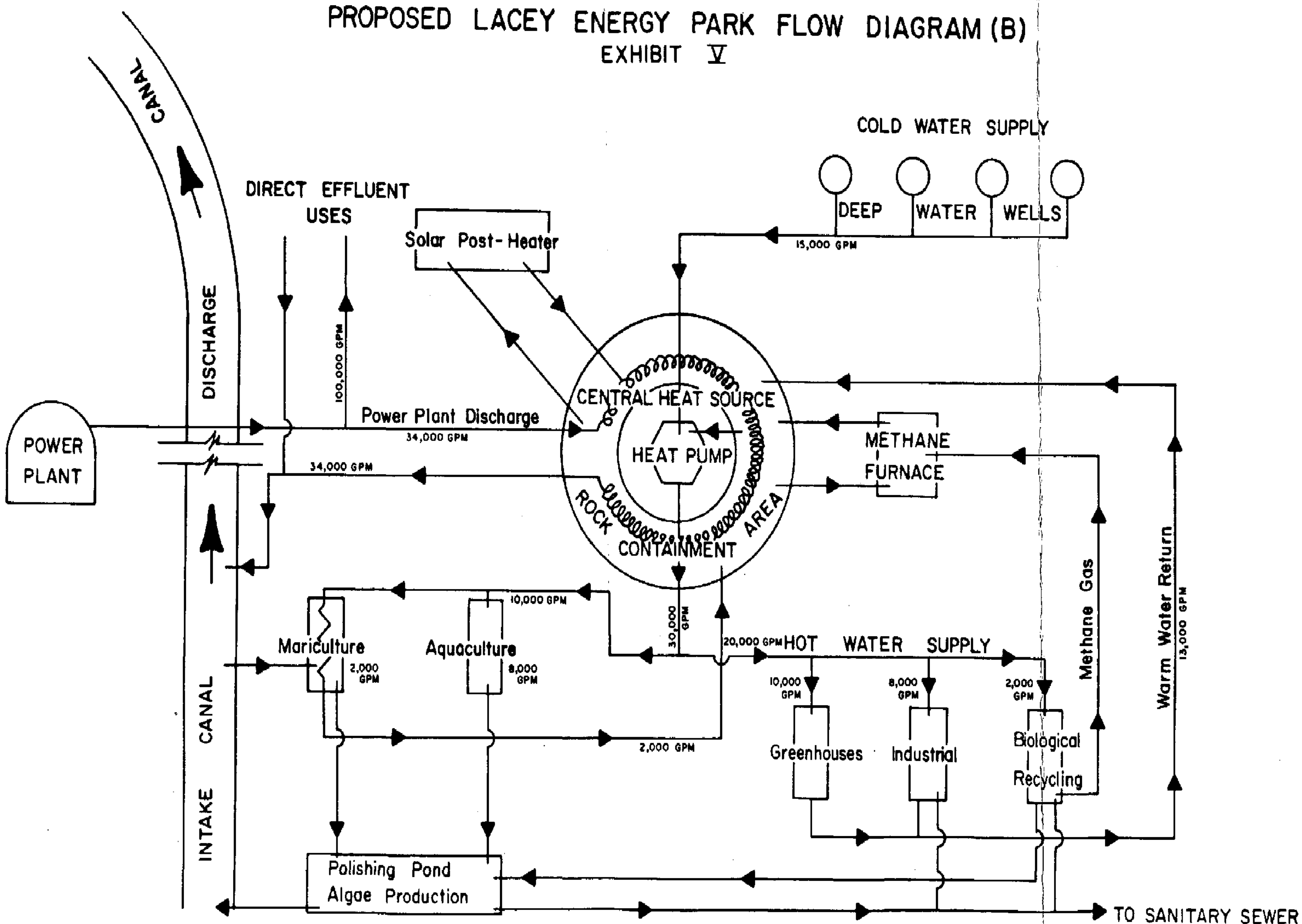
PROPOSED LACEY ENERGY PARK FLOW DIAGRAM (A)

EXHIBIT IV



PROPOSED LACEY ENERGY PARK FLOW DIAGRAM (B)

EXHIBIT V



will be a function of both the hydraulic capacities of the delivery system and the process system and the transfer capacities of the central heat pump (chiller).

A central heat pump (chiller) operating with coefficient of performance (COP) in the range of 3.0 to 5.0 will supply the temperature augmentation necessary to supply the various processes.

> "Heating units are rated by their coefficient of performance (COP). This is based on electrical-resistance heating in which one kilowatt provides 3412 Btu in an hour, for a COP of one. A heat pump not only produces heat, but moves it from one place to another, so the COP of an air-source system can be much higher than one--even three, when the outside temperature is around 50°F. In other words, for each watt of electricity consumed by the unit, three watts of heat energy are available for warming; . . ." (Ref. 12, p. 78)

Initially, a great deal of the heat will be transferred to the rocks, however, when the system stabilizes the rocks will become a heat storage mechanism. Based on the following calculations, one ton of rock will store 8,800 Btu's.

Design Parameters:

1. Specific Heat of Stone = 0.2 cal/gm C° or 0.22 Btu/lb.F°.
2. Delta T = assumed 20°F over ambient.
3. One Ton (2,000 lbs.) of well sorted rock.

Heat Storage Capacity

$$H_s = S \times \text{Delta T} \times \text{vol}$$
$$= 0.22 \times 20°F \times 2000$$
$$= 8,800 \text{ Btu/Ton}$$

Assuming, a 100 ft. diameter x 20 ft. deep heat sink with a 50 ft. diameter center section for heat pump (chiller) installation, the resultant torus would accomodate 7,050 Tons of rock assuming 20% voids.

The heat storage capacity would then be 62,140,000 Btu's. Rock was chosen as the storage medium, due to low cost and availability, the use of higher specific heat materials, of course, would increase the storage capacity significantly. This type of determination would require an economic analysis beyond the scope of this project.*

Should the cost of a heat pump (chiller), large enough to handle the established volume of effluent delivered from the power plant, be prohibitive, the effluent could be circulated through the rock containment area in protected heat exchangers. The fresh water in the rock containment area would be heated by the effluent and only that portion of the fresh water to be delivered to the processes would be passed through the ground water stabilized heat pump (chiller) for the purpose of augmentation. See "Proposed Lacey Energy Park Flow Diagram"(B) (Exhibit V). This would effect the design parameters of the heat pump (chiller) as follows:

1. Since the transfer would involve only fresh water, conventional, stock materials could be used in its construction.

2. The size of the unit could be reduced significantly.

As the temperature of the stored fresh water increases the temperature differential between it and the effluent would narrow and less heat would be transferred from the effluent. The final recommended configuration of the central heat source will be addressed in the final segment of this report.

The energy park diagram also shows the possible inclusion of a methane heat augmentation capability. If the energy consuming processes have as waste products animal or vegatable wastes that are appropriate for methane generation or if a crop such as Water Hyacinth is cultivated, to polish certain effluents, and can be harvested periodically to supply

*However, see Appendix F for a discussion of other storage material.

the raw materials for methane generation, the initiation of these processes using the effluent would effectively supply heat for process water temperature augmentation.

Solar augmentation is a viable option which varies in effectiveness with the season of the year. The coordination of scheduled power plant shut downs for periodic maintenance to coincide with the months of highest solar effectiveness would be necessary to fully realize the benefit of Solar augmentation. Cooperation and coordination between the Utility and the Energy Park management is critical and cannot be stressed enough. Without this relationship, the chances of success are negligible.

The water quality in each instance presents some problems which impact on its use or the design of the various components of the energy park.

The Intake Water, which is common to the OCNGS and the proposed FR#l plant, is salt water. This fact is most important for design consideration. The condensers at the OCNGS use titanium tubes because of the corrosive nature of the salt water. This will add considerable expense to any heat pump (chiller) which may be designed for use in the central heat source. The effluent is also routinely treated with chlorine to prevent biofouling. The fact that the effluent is chlorinated will not be a consideration since the effluent would not come in direct contact with food products or food production processes. The chlorination would be beneficial as it would serve the same function in the heat pump (chiller) or other direct uses as it does in the power plant cooling system.

The deep well water characteristically has a high percentage of iron, an acidic pH and in some cases a percentage of Hydrogen Sulphide which emits a foul odor. The most serious problem is the excessive iron content, which could build up in the heat pump (chiller) therby increasing the total dynamic pumping head, which would necessitate design of the heat pump (chiller) in such a way that excessive scaling, causing total dynamic head buildup, could be removed without undue interruption of service. It is probable that a duplicate heat pump (chiller) for standby service would be a requirement under any circumstances and this would further mitigate this contingency. A second alternative would be the capability to substitute heat sink water during periods of heat pump (chiller) shutdown, however, this option would not address the possible need for constant cooling of the effluent. The adjustment of pH is readily accomplished with the injection of Lime Soda into the water. This is a reasonable treatment process and would not increase costs appreciably. The deep well water has a temperature of 53°F which remains stable; i.e., does not fluctuate seasonally.

III. POTENTIAL COMMERCIAL USES OF EFFLUENT

A. AQUACULTURE AND MARICULTURE - DIRECT AND INDIRECT USAGES

Aquaculture and Mariculture are considered applicable to the Forked River site and are included on the proposed flow diagrams A and B. It is necessary to point out that these processes are high intensity in nature and require expertise in areas such as disease control, feeding procedures and water quality such as oxygenation, to keep mortality rates within acceptable limits. The choice of species raised will impact on the economic viability. New Jersey has many streams and lakes which are stocked with trout, for recreationa purposes, and the State could have an interest in this area, as a State hatchery, in the future. Recent developments in the rearing of lobsters in containment, could provide a product which is highly desirable and could possibly show a profit potential in relation to existing commercial lobstering techniques. Oyster farming has already shown economic viability at the Lilco Long Island facility and could be considered for the Lacey Township Park, along with seed clam production.

"The application of heated waters to aquaculture in temperate regions could result in several benefits:

1. A lengthened or year-around growing season.
2. Optimization of the aquaculture facility with resultant reduction in production costs.
3. Production of Commercial Species near marketing sites.
4. Production of tropical organism in temperate climates.
5. Enhanced rates of maturation and metamorphasis so that increased survival is experienced in early life stages.

Optimum temperatures differ substantially among cultured species.

For example:

Species	Optimum Temperature
Rainbow Trout	59°F
Yellow Perch	72°F
Channel Catfish	84°F
Freshwater Prawns	84°F

> Changes of a few degrees above or below optimum can have signigicant effects on food consumption, food conversion and growth rate. For example, a 9°F reduction from optimum of 84°F reduces by almost one-half the growth rate of channel catfish and reduces the food conversion efficiency by on-fifth". (Ref. 11, p. 9-1)

The accompanying table reprinted from Factors Affecting Power Plant Waste Heat Utilization shows the vast interest in Aquaculture in the United States. (Ref. I, pp. 20-25)

Table 1

Waste Heat Aquaculture Projects in the United States

Organization	Location	Culture System	Organisms
Long Island Oyster Farms[a,b]	Long Island Lighting Co., Northport, NY	Seed hatchery	Oysters, clams, scallops
International Shellfish Enterprises[a,b]	Pacific Gas and Electric Co., Moss Landing, CA	Seed hatchery	Oysters, clams
University of Maine	Maine Yankee Nuclear Power Co., Wiscasset, ME	Rafts	Oysters, mussels
University of California	Pacific Gas and Electric Co., Hombolt Bay, CA	Rafts	Oysters
Northeast Utilities[a]	Northeast Utilities New London, CT	Rafts, seed hatchery	Oysters, scallops
Texas A&M University, Department of Wildlife and Fisheries Science[a]	Houston Light and Power Co., Baytown, TX	Ponds, tanks, cages, hatchery	Oysters, shrimp, marine finfishes
University of Connecticut	Connecticut Light and Power Co., Norwalk, CT	Cages	Oysters

[a]Currently in operation.
[b]Commercial scale.

Table 1 (Continued)

Waste Heat Aquaculture Projects in the United States

Organization	Location	Culture System	Organisms
Marine Department of Marine Resources	Central Maine Power Co., Wiscasset, ME	Rafts	Oysters, mussels
San Diego State University[a]	San Diego Gas and Electric Co., Encina, CA; Southern California Edison Co., Redono Beach and Ormond Beach, CA; Scripps Institute of Oceanography	Tanks, hatchery, and rearing	Lobsters, striped bass
Ralston Purina Company[a]	Florida Power Corporation, Crystal River, FL	Ponds	Shrimp
Texas A&M University Agririculture Extension Service[a]	Central Power and Light Co., Corpus Christi, TX	Ponds	Shrimp
University of Miami	Florida Power and Light Co., Miami, FL	Ponds, tanks	Shrimp, pompano
Maine Salmon Farm[b]	Central Maine Power Co., Wiscasset, ME	Pens	Salmon, trout

[a]Currently in operation.
[b]Commercial scale.

(Ref. 1, pp. 20-25)

Table 1 (Continued)

Waste Heat Aquaculture Projects in the United States

Organization	Location	Culture System	Organisms
Weyerhaeuser Company[a,b]	Weyerhaeuser Co., Springfield, OR	Hatchery	Salmon
Alaska Department of Fish and Game[a]	Fort Richardson and Elmondorf Air Force Base, AK	Hatchery	Salmon
University of New Hampshire	New Hampshire Public Service Co., Newington, NH	Tanks	Flounder
Public Service Electric and Gas Co., Trenton State College, Rutgers University[a]	Public Service Electric and Gas Co., Trenton, NJ	Tanks, raceways, ponds	Freshwater prawns, trout, eels, striped bass, catfish
Tampa Electric Company	Tampa Electric Co., FL	Tanks	Marine finfishes
Farm Fresh Shrimp Company[a]	Florida Power and Light Co., Miami, FL	Tanks	Freshwater prawns
Texas Electric Company[a]	Texas Electric Co., Monahans, TX	Tanks	Freshwater prawns, tilapia, catfish

[a]Currently in operation.
[b]Commercial scale.

Table 1 (Continued)

Waste Heat Aquaculture Projects in the United States

Organization	Location	Culture System	Organisms
University of Nevada - Reno[a]	Sierra Pacific Power Co., Xerington, NV	Ponds	Freshwater prawns, shrimp
Tennessee Valley Authority, Cal-Maine, Inc.	Tennessee Valley Authority, Gallatin, TN	Raceways	Catfish
Kansas Gas and Electric Company	Kansas Gas and Electric Co., Colwich, KS	Ponds	Catfish
Kansas Power and Light Company, Kansas State University	Kansas Power and Light Co., Hutchinson, KS	Ponds	Catfish
Aquarium Farms Incorporated	Fremont, NE	Raceways	Catfish, tilapia
Kraft Incorporated, Franklin Institute Laboratories[a]	Pennsylvania Power and Light Co., Harrisburg, PA	Raceways	
Cultured Catfish Incorporated[a,b]	Texas Electric Service Co., Colorado City, TX	Cages, raceways	Catfish

[a]Currently in operation.
[b]Commercial scale.
(Ref. 1, pp. 20-25)

Table 1 (Continued)

Waste Heat Aquaculture Projects in the United States

Organization	Location	Culture System	Organisms
Texas A&M University, Department of Wildlife and Fisheries Science	Texas Power and Light Co., Trinidad, TX	Cages	Catfish
Mississippi Power and Light Company	Mississippi Power and Light Co., Jackson, MS	Cages	Catfish
Clemson University	Oconee Nuclear Station, SC	Cages	Catfish

(Ref. I, pp. 20-25)

"One of the oldest users of Power Plant Waste Heat in the United States is the Long Island Oyster Farm. Since the mid 1960's, the firm has produced American Seed Oysters Utilizing effluent from Long Island Lighting Company's (Lilcos) Northport Plant. Seed Oysters are produced to stock the company's 100,000 acres of Oyster Beds in Long Island Sound; and the use of heated water in the hatchery enhances growth, reducing the period to market size from 4 to 6 years to 2 to 5 years. Hatchery facilities are located adjacent to the discharge canal of a 3-unit 1,125 MW fossil-fuel power plant. The 4.5 acre discharge lagoon has a flow of 470,000 gpm during normal operation with a Delta T of 25° to 28°F. An additional pumping capacity of 459,000 gpm for diluting plant discharge with ambient temperature water to keep discharge temperatures below 90°F. No chlorine or other biocides are used by the power plant. The utility considered the needs of the aquaculture facility in designing and constructing the discharge lagoon". (Ref. 11, pp. 9-8, 9-9)

The cooperation of the utility at the design stage of a project is critical to establishing a successful operation.

The four key factors in the Lilcos operation are:

1. The fact that they have a three unit facility to insure a constant supply of heated water. (See Appendix D)
2. They are fossil fueled plants which precludes complications with the Pure Food, Drug and Cosmetic Act, specifically the Delaney Amendment.
3. No Chlorine or biocides are used in the plants.
4. The cooperation of the utility was secured in the design stage.

The many studies underway at the present time indicate that the biological benefits and the technical feasibility of waste heat utilization for aquaculture and mariculture are viable. The Forked River site which has an abundance of both salt; i.e., Bay Water and Fresh Water from deep wells would seem to be an ideal location for aquaculture and mariculture processes. Water treatment such as pH adjustment, ion exchange and temperature regulation would all appear to be well within the capabilities of existing techniques.

The four key factors aforementioned have relevance to the proposed FR#1 if a decision is made to proceed with construction of a fossil fuel plant, and the cooperation of the utility is secured in the design stage. The OCNGS interfacing will be a retrofit and these factors, as such, cannot be addressed.

Barnegat Bay is a natural protected habitat for the maturation of oysters and clams, and other mollusks, and the local area has the work force and expertise to harvest these products. The raising of seed clams could greatly benefit the Ocean County area. The secondary economic effects, providing more claming in the Bay for tourists, could be substantial. The techniques involved are analogous to oyster production and are applicable to the site. Markets for commercial applications are well established and the necessary transportation networks are defined.

The present studies indicate that indirect use of waste heat; i.e., transfer of heat through heat exchangers, is too expensive for commercial aquaculture and mariculture ventures. The economic viability of projects using direct effluent flows, such as the Gallatin Catfish Project conducted by the Tennessee Valley Authority, have not been able to demonstrate a profit potential to date, even though the interfacing techniques are relatively simple. The inclusion of heat exchangers in the interfacing could add considerable cost and seriously reduce the benefit to cost ratio. However, by integrating aquaculture and mariculture facilities in the concept of an energy park, the interfacing costs are shared by all the users of the heated waters and this may bring the economic feasibility into the realm of practicality.

An area which will require further study is the possible use of the end product of alcohol production, (See Gasohol-Alcohol) a grain slurry, as a feedstock for trout and carp. Presently the pellets, as supplied to fish hatcheries, such as the one in Hackettstown, New Jersey, use a formula which incorporates vitamins, grain and various admixtures as a total diet for the trout. It is possible that much of the protein, as contained in the grain after fermentation, could be supplied either as a direct feedstock or marketed to commercial suppliers of these pellets.

At present, with the proposed system for the Forked River site, aquaculture and mariculture merit further investigation with particular emphasis on the following:

1. Interfacing Techniques
   a. Temperature control
   b. Piping
   c. Mixing
   d. Controls and monitoring devices

2. Water Treatment
   a. pH adjustment
   b. Metallic ion removal
   c. Filtering
   d. Waste water treatment or disposal

3. Utility-Commercial Venture Relationships
   a. Economic
   b. Legal implications
   c. Role of Regulatory Agencies

It would be advantageous to continue to monitor the studies that are in commercial or pilot stages that are considered applicable to the Forked River site. As more data is generated, future studies could further evaluate the viability of aquaculture and mariculture to this proposed project.

B. GREENHOUSE PRODUCTION

The use of waste heat in greenhouses appears to have much potential for several reasons.

> "Greenhouse production is very energy-intensive. Fuel costs may comprise 30 to 50 percent of total production costs in colder climates. High costs and limited availability of fossil fuels for heating are having a serious adverse impact on the greenhouse industry; therefore, a low-cost alternate energy source is needed. Temperature requirements for greenhouse production, normally 10° to 18°C minimum, are in the range that can theoretically be maintained with thermal condenser effluent. In addition, since greenhouses normally use or are easily adapted to use evaporative cooling systems, large complexes have potential for cooling condenser effluents during summer months to supplement, reduce, or even replace cooling tower requirements, or to improve cooling efficiency of existing cooling towers at specific power plants". (Ref. 1,p.3)

Several utility companies, in both the United States and Canada, are currently investigating the creation of a warm water utility to make commercial warm water available to greenhouse growers. To date, many greenhouse prototypes have been constructed to operate on waste heat, or other forms of residual heat, and some commercial greenhouse growers are under long term contracts with electrical generators to purchase residual heat at a substantial savings over other fuel supplies

> "For instance, two growers are currently under ten year contract with Northern States Power for supply of residual heat at $6,000 to $8,000 per acre for a full heating year. The total energy costs to these growers is approximately $18,000 to $19,000 per acre per year including extra electrical costs and back-up heating. Both growers are currently considering expansion of their existing residual heat acres". (Ref. 2, p.11)

Major ongoing efforts in the United States utilizing power plant reject heat for agricultural purposes have been investigated. Each type of heating system employed will be described in the following.

POROUS CONCRETE FLOOR SYSTEM (RUTGERS DESIGN)

> "Public Service Electric and Gas Company and Rutgers University have constructed a 7.3 x 12.2 m (24 x 40 ft.) double-layer plastic greenhouse at the Mercer Generating Station near Trenton, New Jersey. The heat exchanger

design is based on previous studies concerning greenhouse heat transfer performed at Rutgers University. The heat exchanger system includes a porous concrete floor, with the warm condenser effluent flowing through and underneath the floor. Thus, the plant growing medium is essentially surrounded by a warm water bath. In addition to providing heat for the greenhouse air, this system maintains the crop root zone at an elevated temperature. In addition to providing heat for the greenhouse air, this system maintains the crop root zone at an elevated temperature.

In addition to the porous floor, a vertical plastic curtain heat exchanger will be used for additional heat input to the greenhouse. This heat exchanger uses polyethylene film draped over a PVC pipe. Warm condenser effluent water supplied to the pipe is allowed to flow onto the interior of the plastic "tent" by means of holes in the PVC header. Air in contact with the exterior of the "tent" is heated by means of natural convection. The PVC header can be raised or lowered to provide the appropriate heat transfer area.

This pilot project will also utilize CELdek evaporative pads to cool the heated discharge water to determine if the greenhouse complex can function as a horizontal cooling tower". (Ref. 3, pp. 4-5)

A third and important component of this heating system, especially in colder climates, is a movable curtain insulation system to reduce heat loss at night.

In addition to this project, Rutgers is expanding their research in a larger scale project in Allentown, New Jersey. This will simulate power plant waste heat with larger solar collectors.

The Vermont Yankee Nuclear Power Corporation has constructed a facility of this design, also, in their energy park in Rutland, Vermont. This prototype is being tested and evaluated with three other greenhouse heating systems.

FIN-TUBE HEAT COIL SYSTEM

The Northern States Power Company (NSP) and the University of Minnesota began investigating ways to use power plant waste heat in 1970. First studies concluded that the water temperatures from "once-through cooling plants" were too low in Minnesota for potential beneficial uses; while water from closed-cycle plants at temperatures of 29.4°C (85°F) or above, did have potential for development.

(Ref. 3, pp. 4-5)

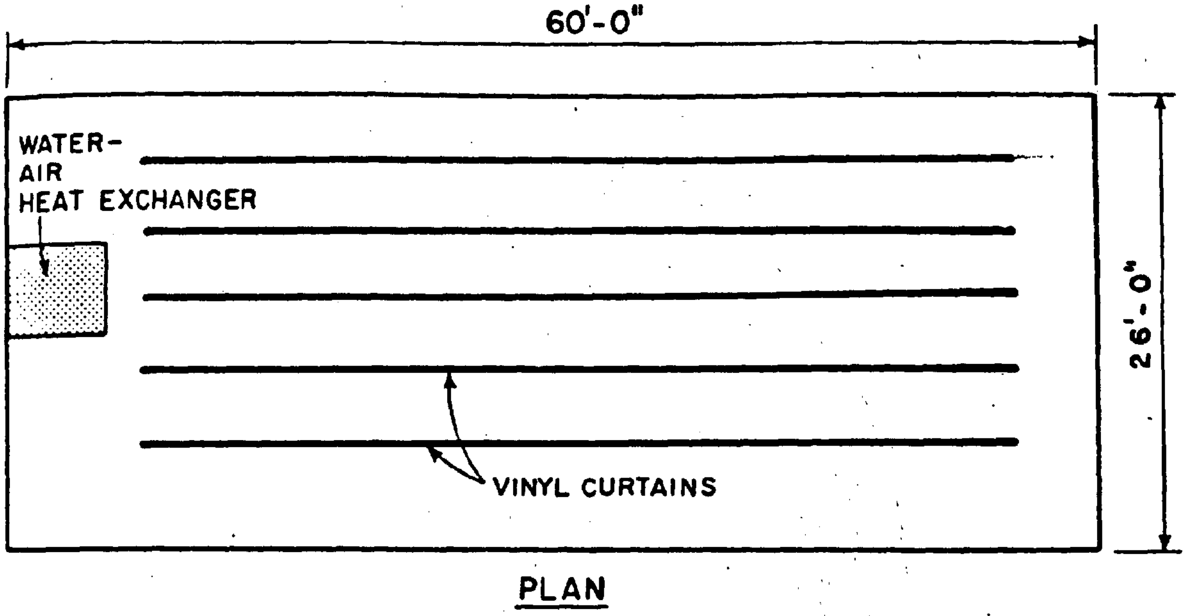
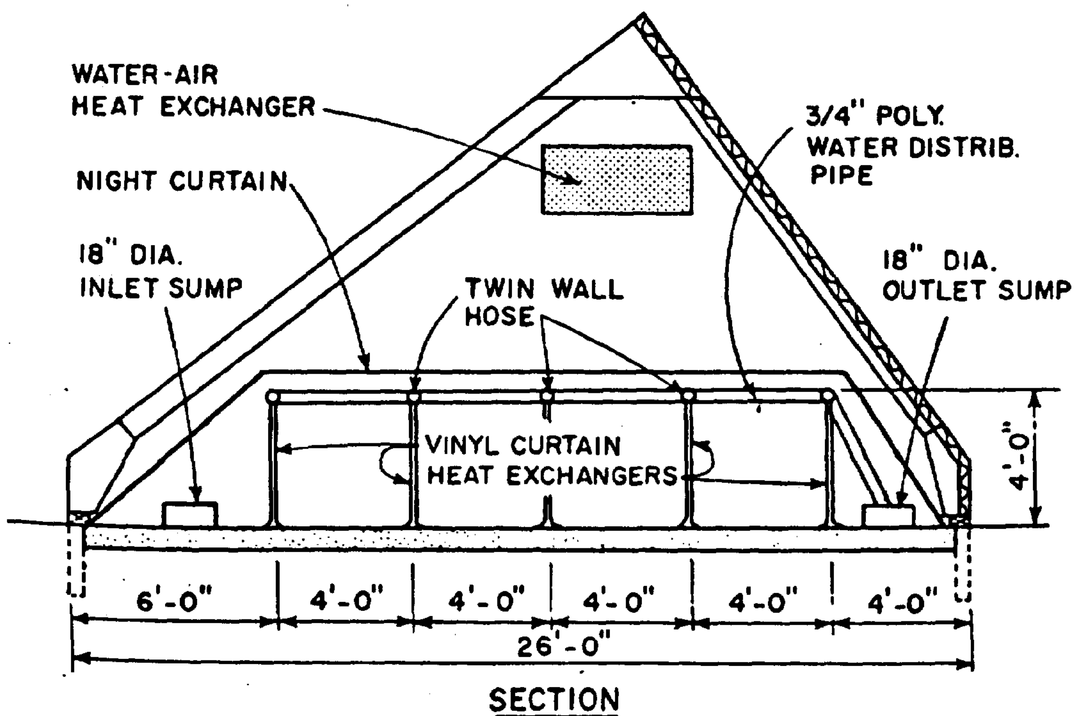


FIG. 9. PLAN OF RUTGERS' GREENHOUSE



RUTGER'S GREENHOUSE FLOOR AND VINYL CURTAIN HEAT EXCHANGER SYSTEM

END CROSSECTION OF RUTGERS' GREENHOUSE

Since then, "Northern States Power Company (NSP) has demonstrated the technical and economic feasibility of using power plant reject heat in a fin-tube heat coil system with successful operation of the Sherco Greenhouse. The three-year demonstration project has led the way for commercial adaptation of the concept. Presently, three commercial greenhouse operators have put 0.7 ha (1.7 acres) of greenhouses into production using waste heat from the Sherburne County Power Plant.

The Sherco Greenhouse is an arch roof, gutter-connected house covered with a double layer of polyethylene. The greenhouse consists of 14 bays each 5 m (17 ft.) wide by 29 m (96 ft.) long for a total enclosed area of about 2056 m^2 (22,848 $ft.^2$).

The heating system consists of an air heating system and a soil heating grid. The air heating system was designed to carry 100% of the greenhouse heat load, while the soil heating system was designed primarily for crop root zone temperature control; though it does contribute somewhat to the heat requirements of the greenhouse. The air heating system consists of commercially available packaged fan-coil air handling units. Warm water is circulated through fin-tube heat exchangers located in the fan-coil units. One fan-coil unit is located in each of the 14 bays of the greenhouse and heated air is distributed down the length of each bay in a 762 mm (30 in.) diameter perforated plastic duct. The heating system is controlled by thermostats in each bay of the greenhouse that start and stop in heating fans.

Experience during the demonstration project proved that condenser waste heat available at approximately 29°C (85°F) was suitable to maintain a greenhouse growing environment of 13 to 16°C (55 to 60°F) when outside air temperatures fell as low as -42°C (-43°F).

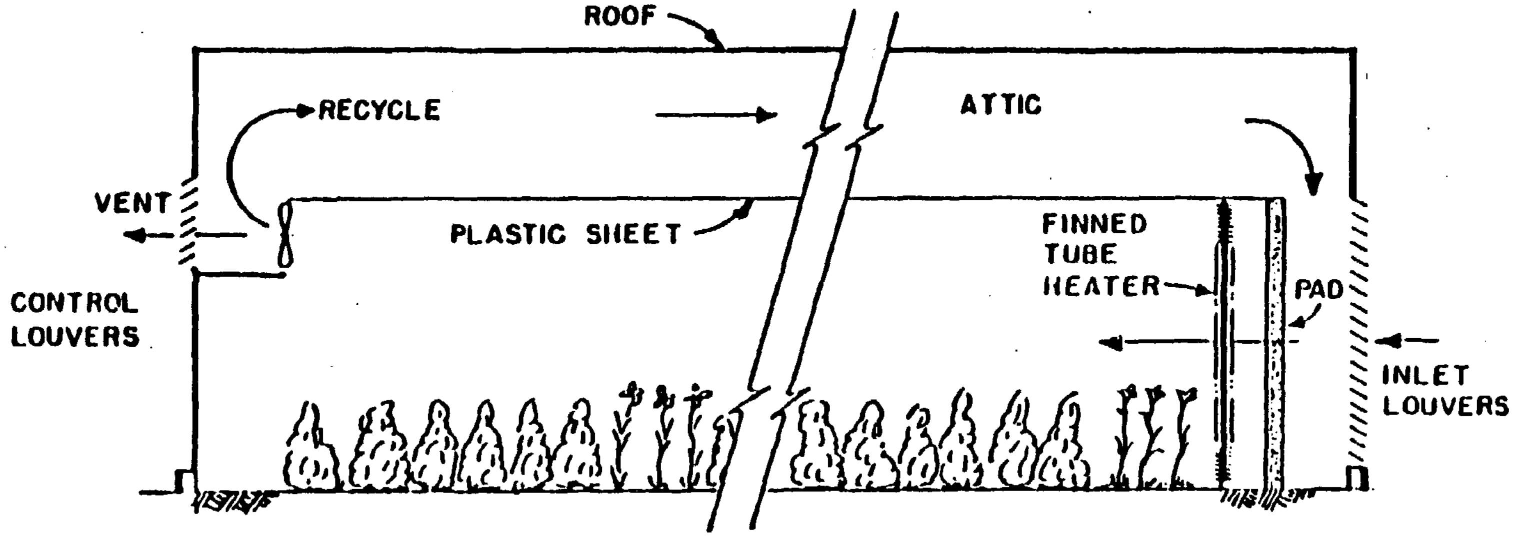
During the first year of operation of the pipeline system serving waste heat to commercial greenhouse customers, an overall availability of service of 97% was achieved. Backup heating capacity is supplied by propane fired heaters.

The first crop, planted in January, 1976, included rose bushes, tomatoes and green peppers. During subsequent plantings, the vegetables were replaced by floral crops so that the entire greenhouse was in floral production in the 1977-1978 growing season.

As a result of the successful experience of the Sherco Greenhouse Project, NSP was approached by commercial operators in the spring of 1977, and asked to provide a site and warm water service to a 0.4-ha (1-acre) commercial floral operation and to a 0.08-ha (0.2-acre) commercial vegetable operation. Both commercial facilities began construction in 1977 and warm water was first sold commercially to the 0.4-ha (1-acre) floral operation in November, 1977. The smaller, 0.08-ha (0.2-acre), vegetable operation did not require warm water service until February, 1978.

The annual savings in heating costs to commercial operators using waste heat have amounted to nearly $12,500/hr. ($5000/acre) compared to conventionally heated greenhouses.

(Ref. 3, pp. 1-2)



Schematic of Greenhouse Heating System

The experiences of commercial operators have been sufficiently satisfactory that future expansion of waste heat service at the Sherburne County Plant site is expected". (Ref. 3, pp. 1-2)

EVAPORATIVE-PAD SYSTEM

"The use of low-grade power plant reject heat has been investigated at the Oak Ridge National Laboratory (ORNL) for a number of years. As part of this program greenhouse uses of this heat have been studied. These investigations have focused on evaporative-pad concepts that are capable of providing both summer cooling and winter heating.
The greenhouse, shown in Figure 1, is heated by pumping warm water to the top of the evaporative pad and allowing it to drip through the packing. As the water flows through the packing, it interacts with the air flow being drawn through the pad by the fans located at the rear of the house.
In summer operation, the inlet and exhaust shutters are opened and ambient air is drawn into the pad where it is cooled and humidified. It is then cycled through the growing section and exhausted to the atmosphere.
In winter operation, the inlet and exhause shutters are partially or completely closed (depending upon ambient conditions) to conserve heat. In this mode of operation, some or all of the greenhouse air exiting from the growing section is recycled through the attic back to the pad where it is heated. Because the air is continually recycled, the humidity and the growing section hovers near 100% unless significant solar flux or dry heat is added to the air.
To accomplish the latter objective a fin-tube heating coil can be added downstream of the pad". (Ref. 4, p. 2)

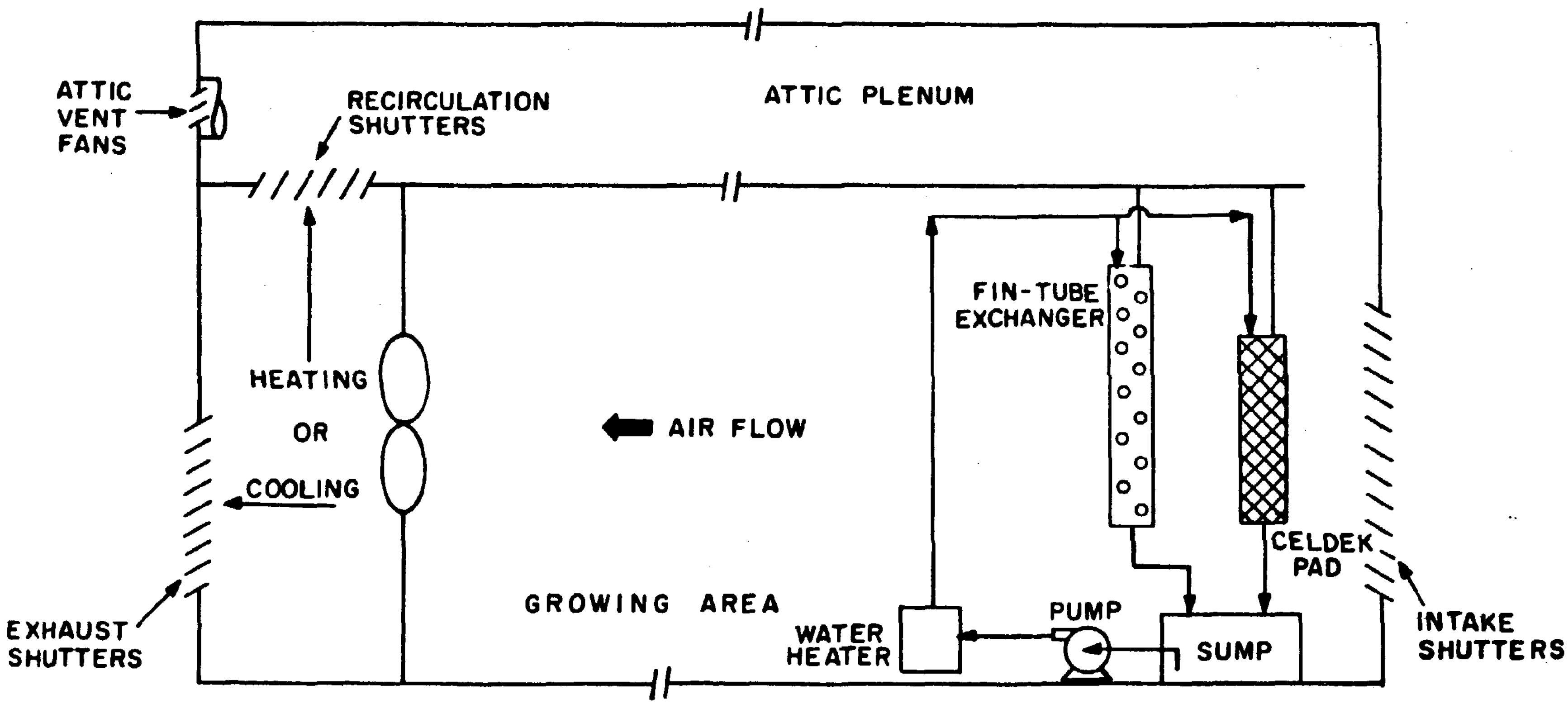
Heating and cooling of the greenhouse was initially accomplished using an aspen fiber pad. However, subsequent experimental work at ORNL indicated that CELdek*, a cooling tower packing, was a superior pad material. In 1975, CELdek replaced the aspen pads.

THERMAL ENVELOPE SYSTEM

"The University of Illinois has been conducting an experimental program aimed at determing the feasibility of reducing greenhouse heat losses by spraying warm condenser water over the roof of a greenhouse.[7] They operated a 3.7 x 7.3 m (12 x 24 ft.) plastic film covered greenhouse using condenser effluent from the Vermillion Power Station, which is located near the university. The condenser water was applied to the greenhouse roof at the flow rate of 2.5×10^{-3} m^3/s (40 gpm). At this flow rate it was possible to maintain the greenhouse at 15°C (50°F) using 30°C (86°F) water when the ambient temperature fell to 0°C (32°F). Results from this program were promising and let to a

*A trademark of Munters Corporation, Ft. Myers, Florida.

(Ref. 4, p. 2)



Schematic Diagram of the Waste Heat Research Greenhouse,
Muscle Shoals, Alabama

EVAPORATIVE-PAD SYSTEM

laboratory effort using a smaller greenhouse. This study examined a number of parameters including roof slope, water flow rate, and surface type to determine the operating characteristics of the system.
Current efforts are directed at examining the applicability of this system to conventional greenhouse structures. A conventional type greenhouse is being constructed at the Baldwin Power Station near St. Louis, Missouri. The greenhouse will have two bays, each 5.3 m wide by 14.6 m long (17.5 ft. wide by 48 ft. long) and will use condenser effluent from the power station".
(Ref. 3, p. 5)

"Data collected were used to develop the following equation relating greenhouse temperature (G), heated water temperature (W), and outside ambient temperature (A):

$$(G = -2.07 + 0.642 W + 0.358A)$$

This equation can be used to predict greenhouse temperature when ambient and warm water temperatures are known. For example, the minimum greenhouse temperature would be 15° C (59°F) at an ambient of -6° C (21°F) using 30° C (86°F) water. For these same conditions, the waste heat input is about 5.9 kW/m^2 (1.87 Btu/hr. $ft.^2$) of growing area, compared with about 0.24 kW/m^2 (0.076 Btu/hr. $ft.^2$) with a conventional system. Although the heating system is very inefficient from a thermal standpoint, the system may still be economically desirable. Greater efficiencies would also be expected with larger greenhouses since the ratio of heated surface area to growing area would be less".
(Ref. 5, pp. 3-34 to 3-35)

UNDER SOIL HEATING SYSTEM

"The Pennsylvania State University has had an active program in undersoil heating research since 1972 (8). Their program has included analytical modeling and experimental efforts. The experimental program included development of a 15 x 60 m (50 x 200 ft.) prototype soil warming field to test functions for prediction of heat transfer from buried hot-water parallel pipe networks used in their computer model. A unique feature of the prototype is the spray application of treated municipal waste water on the warmed soil to maintain efficient heat transfer and supply crop nutrients.
The pipe network consists of 26 parallel 50 mm (2 in.) diameter polyethylene plastic pipes buried at a 300 mm (12 in.) depth with a 600 mm (24 in.) spacing. Warm water is supplied continuously at 38 to 40°C (100 to 104°F) from oil-fired hot-water furnace.
The spray irrigation system is constructed of aluminum surface irrigation pipe. Laterals running perpendicular to the long axis of the plot are spaced every 13.3 m (44 ft.) with offset 450 mm (18 in.) high risers (for sprinklers) at 13.3 m (0.5 in.) intervals. Waste water is applied at the rate of 10 mm (0.4 in.) per week in

biweekly applications to both the heated plot and an adjacent 15 x 30 m (50 x 100 ft.) control plot. Current research is concentrating on year-round heat dissipation capability; crop growth and development, and municipal waste water renovation questions". (Ref 3, p. 5)

METHANE SYSTEM

Indirectly related to the concept of an energy park is the use of methane gas as an alternate energy source. Methane gas is a by-product of the fermentation of solid waste (animal waste, sewage sludge, landfill waste) and is readily adapted to greenhouse heating.

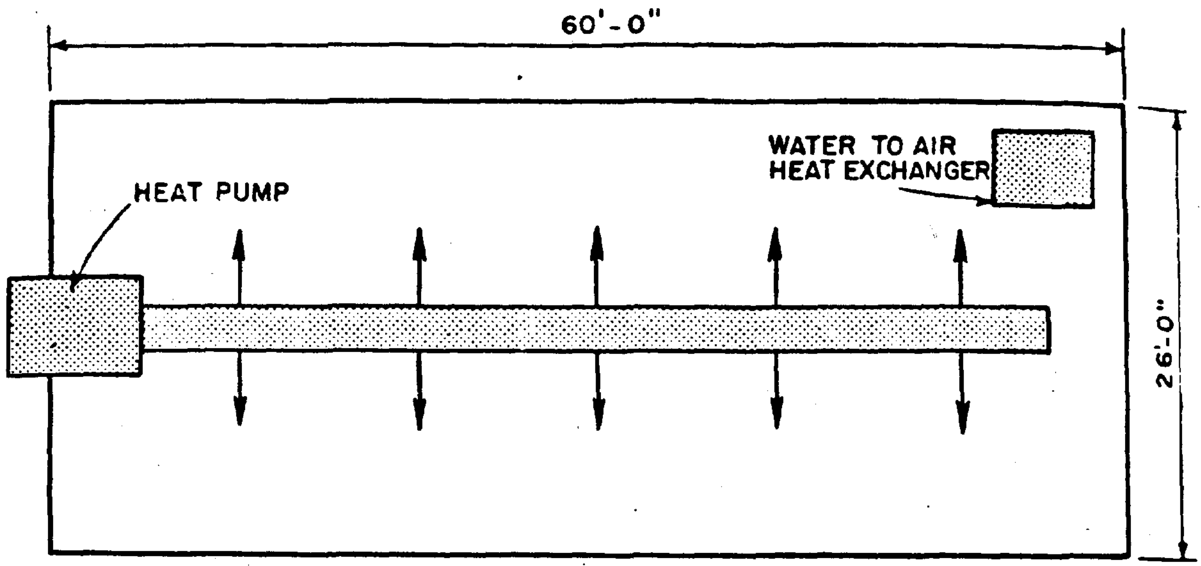
The energy park of the Vermont Yankee Nuclear Power Corporation has constructed and is evaluating a greenhouse 26 feet wide by 60 feet long.

"In this house, heating is provided by methane gas. Manure from about 200 dairy cows is converted to methane gas in an anaerobic digester located on the site. The gas is piped to the greenhouse by underground pipeline. Two gas unit heaters are utilized to provide the total heating of this structure. Sufficient gas will be produced to maintain maximum temperatures of 65°F to 70°F on a continuous basis. Because of the capability of maintaining the higher temperatures, either roses or cucumbers are suggested as ideal crops for this house". (Ref. 6, p. 3.4)

In addition, a project undertaken by the Candian Government in 1978, in Saint Thomas, Ontario, has proven that recovering and utilizing landfill gas in an unprocessed state is feasible both physically and economically. This experiment involved a 21 feet by 24 feet fiberglass panelled greenhouse, heated by a conventional domestic forced air furnace

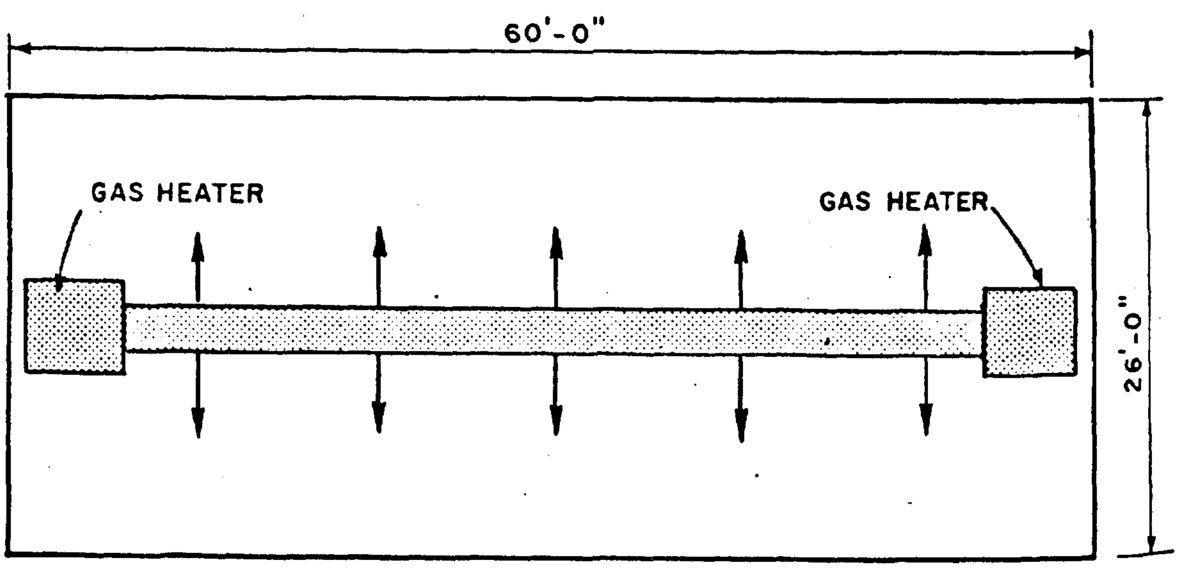
"The heat requirements for the greenhouse were calculated to be 110,000 BTU per hour (116 kilojouies per hour) for the St. Thomas area. The gas furnace which was installed in the greenhouse was designed to operate on natural gas, providing an output of 160,000 BTU/hour (169 kilojoules/hour). Because of the lower quality of landfill gas, the orifice size of the furnace was enlarged. The original orifice size was No. 40 or .098 inches in diameter (.249 centimeters) which was reamed out to a drill size No. 28 or 0.1405 inches in diameter (.357 centimeters). After the orifice size was changed, a gas flow rate of 4.4 cfm (.123 cubic meters/minute) into the furnace resulted. This converts into a heating valve of approximately 132,000 BTU/hour (139 kilojoules/hour)". (Ref. 7, pp. 66-68)

(Ref. 6, p. 3.4)



WATER TO AIR HEAT PUMP SYSTEM

FIG. 7. HEAT PUMP PLAN VIEW



METHANE GAS HEATING SYSTEM

PLAN VIEW OF METHANE UNIT

Methane gas recovery projects are also ongoing in Ednomton, Alberta, and St. Cecile de Milton, Quebec, in Torrance, Mountaingate, Industry, Palos Verdes, and Mountain View, California.

The significance of methane gas to the project will be explained in further detail in the "Biological Recycling" section.

SOLAR SYSTEM

The Vermont Yankee project is also evaluating a solar heated greenhouse.

> "This greenhouse is equipped to store excess solar energy in gravel storage benches located inside the structure. The heat is recovered from the gravel storage, a commercial water-to-air heat exchanger is utilized. A backup 9.5 kw electric resistance heater is included in the design". (Ref. 6, p. 3.2)

HEAT PUMP SYSTEM

The fourth type of greenhouse being evaluated at Vermont Yankee is one which utilizes a heat pump.

> "The same basic greenhouse design is utilized without the solar storage units. In this house, a water-to-air heat pump is utilized with a constant source of 70°F water supplied by the power plant. The operating coefficient of performance (COP) for the water-to-air heat pump is higher than for the air-to-air units now commonly used.
> In addition to the heat pump, one water-to-air heat exchanger (commercial unit) is utilized for base load heating. The heat pump will be utilized as an assist during the coldest operating periods. There is no other backup heating provided for this house, as the heat pump is designed to meet the greenhouse design temperature requirements for the outdoor design temperature of -15°F". (Ref. 6, p. 3.3)

GREENHOUSE PRODUCTION OUTSIDE THE UNITED STATES

In Canada, the Saskatchewan Power Corporation and Tri-Ted Growth Systems, Inc., have developed three systems for utilizing exhaust gases for heating greenhouses. One system used exhaust gas from a natural gas-fired turbine while the other two use coal-fired boiler exhaust.

(Ref. 6, p. 3.2)

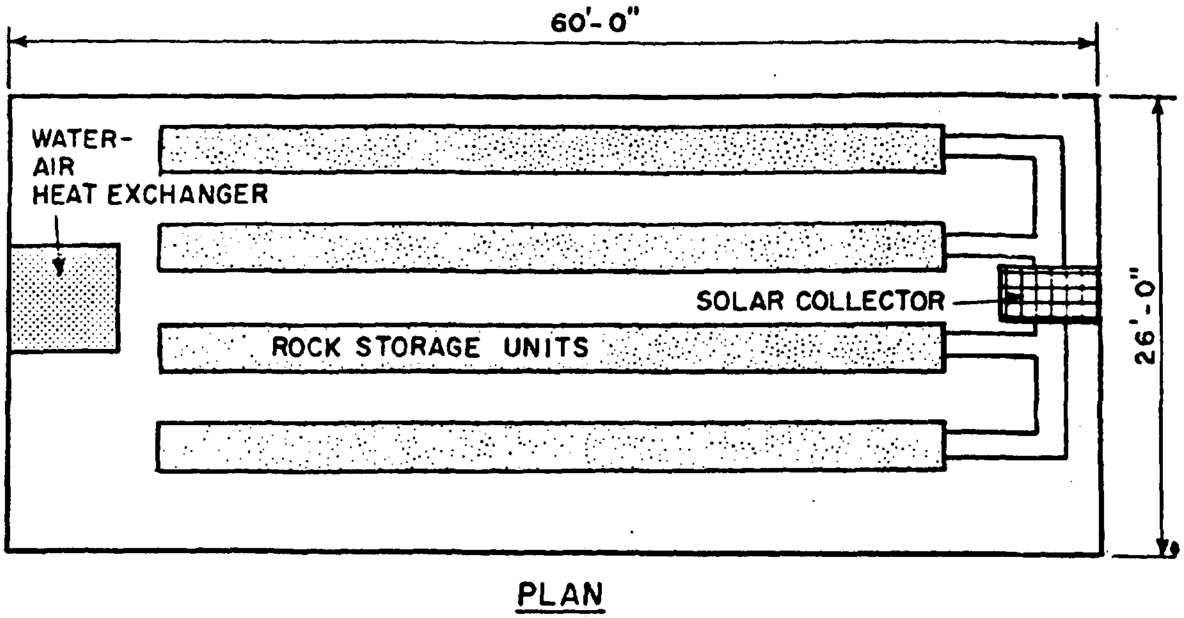
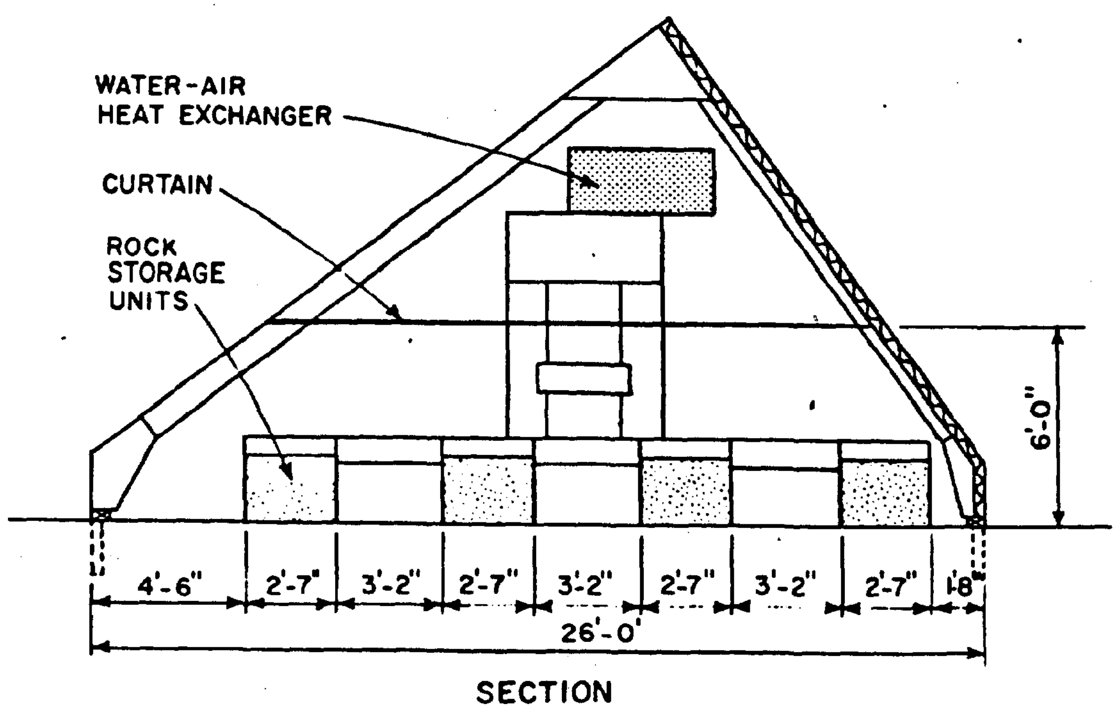


FIG. 4. PLAN VIEW OF SOLAR HOUSE



SOLAR ASSISTED WITH WATER TO AIR
HEAT EXCHANGER SYSTEM

END CROSSECTION VIEW OF SOLAR HOUSE

"Agricultural uses of nuclear power plant reject heat have been studied in France since 1972. These investigations have included studies of a double-wall plastic mulching technique, utilization of heat pumps, and outdoor soil heating.

An experimental greenhouse at the Grenoble Nuclear Center has been used to determine the technical feasibility of the double-wall plastic mulch technique. This greenhouse is 250 m^2 (2700 $ft.^2$) and is covered with a polyethylene film. The greenhouse is heated by allowing the condenser effluent to flow at a very low speed inside double-wall polyethylene mulching placed directly on the soil.

During the first year of operation, this provided a heat exchanger surface of 52% of the greenhouse floor area. In these conditions, a temperature of 9°C (48°F) was maintained in the greenhouse with an outside temperature of -11°C (12°F) and water at 33°C (91°F).

After the initial experiments a new perforated mulching led to an increase in the ratio of heat exchange area to floor area to over 80% without affecting crop density. Using this new mulch the following crops were feasible:

1. Lettuce with water at 18-20°C
2. Tomatoes with water at 25-31°C
3. Cucumbers with water at 33-35°C

The use of heat pumps to boost condenser effluent temperatures was studied on a semi-industrial scale near the Saint Laurent dex Eaux Power Plant. A 3000 m^2 (32,300 $ft.^2$) greenhouse was constructed in 1973-1974 and rented to a commercial grower. Results from this study indicate that normal crop production rates can be maintained but the heat pumps must be carefully designed and controlled to be economically viable.

A 10-ha (25-acre) agricultural-forestry site at the Cadacache Nuclear Research Center has been used to study open-circuit irrigation and undersoil heating using power plant reject heat. Open-circuit irrigation is used in the forestry section utilizing a system of sprinklers and gutters. Warm water is applied to the ground throughout the year. For conifer and poplar trees the increase in production is approximately 25% by weight per year. Results from the undersoil heating experiments have shown yields three to four times normal for strawberry plants. Adaptation of priority industrial crops (soya and late varieties of corn) has also proven successful". (Ref. 3, pp. 6-7)

In West Germany, undersoil heating experiments in greenhouses and open fields have been performed since 1961. Since 1974, experimental systems have been constructed using power plant reject heat. Results from these studies indicate yield increases for corn of up to 57%, winter wheat up to 40%, and spring potatoes up to 60%.

"Two types of systems are being developed in the Soviet Union. The first technique distributes a layer of water 30-40 mm (1.2-1.6 in.) over the greenhouse roof while the second uses dry heat exchangers located in a room adjacent to the greenhouse. The major difference between these designs and those used in the United States is that they have been developed not only to supply heat to the greenhouse in winter but also to provide adequate heat rejection capability for the power station in the summer.

The water-filled roof greenhouse concept is being investigated using a 0.6 ha (1.5 acre) greenhouse located near a 300 MW power station. Condenser outlet water is distributed over the roof by special water lines. The insulating layer of water at 18 to 20°C (65 to 68°F) reduces the heat demand from 6 to 8 MW/ha (8.2 to 10.9 x 10^6 Btu/hr-acre) to 0.7 to 0.9 MW/ha (1.0 to 1.2 x 10^6 Btu/hr-acre).

During summer operation the condenser effluent is supplied to the central zone of the greenhouse roof where it is sprayed using special nozzles. Water cooling occurs both in the spray and in the layer of water running along the roof. Thus, in addition to providing adequate cooling for the condenser, the water acts as a solar filter. Short wave radiation, necessary for photosynthesis, is transmitted to the greenhouse while a significant portion of the long-wave thermal spectrum is absorbed by the water.

The air-heated greenhouse uses a finned-tube heat exchanger located in an annex structure. The condenser cooling water is supplied to the heat exchanger where it heats air supplied from the outside, the greenhouse, or a mixture of the two. The air flow is regulated by the greenhouse fans and a series of special louvers. During summer operation, ventilating air taken from the ambient passes through the greenhouse and then to the heat exchanger. During winter operation, greenhouse air is circulated between the heat exchanger annex and the greenhouse to maintain proper growing temperatures. The warmed air is distributed in the greenhouse by means of performated poylethylene tubes". (Ref. 3, pp. 7-8)

C. GASOHOL- (ALCOHOL)

The production of Alcohol is an area which we feel has great potential. The financial viability of Alcohol production depends, to a large extent, on the ability to process and sell the end product of the grain fermentation process. The energy balance for Alcohol production is shown on the following chart. (Exhibit VI) For a more detailed discussion of the four (4) steps outlined below refer to Appendix C.

Step I - Grain preparation is a very low energy user representing only 20% of heat requirements. Cooking is accomplished in either a Batch System or a continous system. In either case, the Slurry must be exposed to temperatures in the range of 250° - 300°F, this is accomplished with steam. The exposure to these temperatures is for a very short time; i.e., 5 minutes and this step is considered a low energy step.

Step II - The fermentation cycle is basically a refrigeration process. The normal heat of Fermentation would result in a temperature in the range of 140°F, whereas the optimum temperature which must be maintained is 85° to 90°F. A portion of deep well water may be passed through this process and act to keep fermentation processes at their optimum temperature and pick up heat to be transferred to the main heat source for the park.

Step III - The concentration, rectifying process operates at a temperature range of 170°F to 270°F as shown in the accompanying chart, this process requires approximately 42% of the energy requirements.

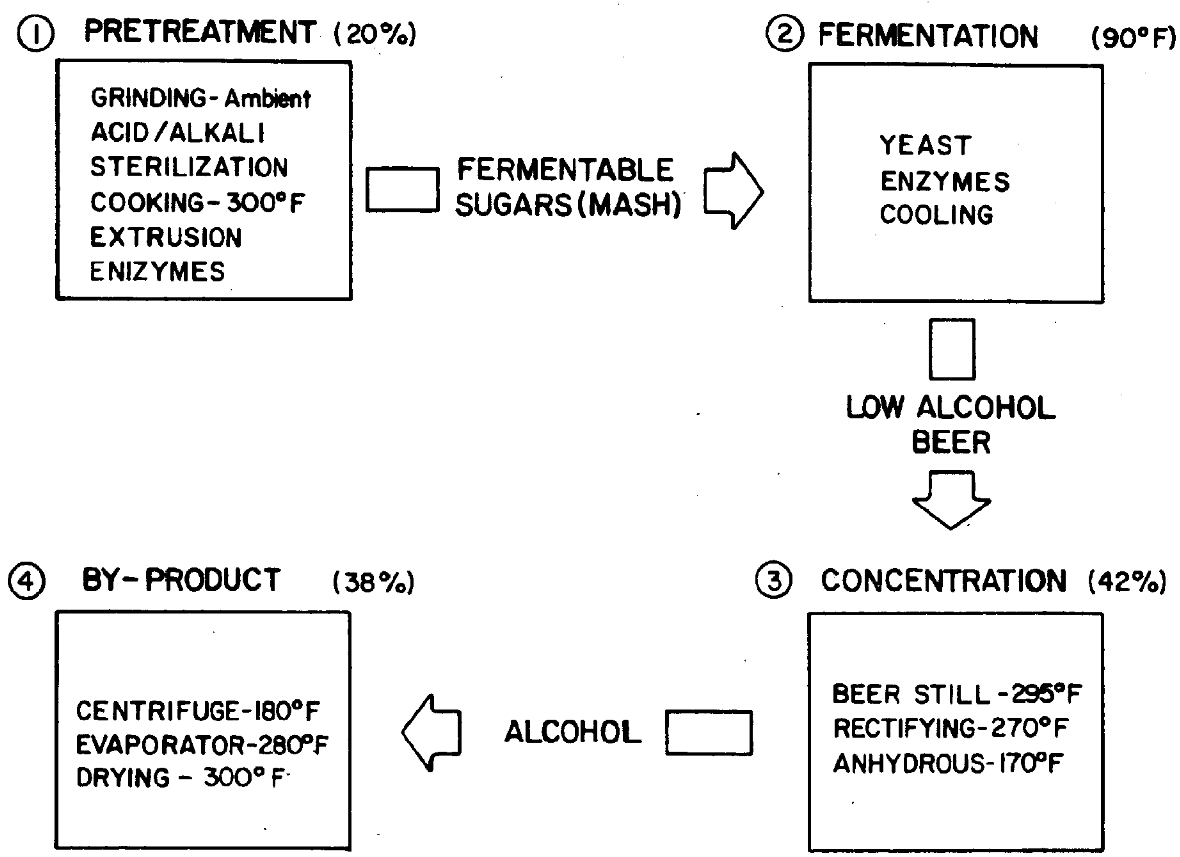
Step IV - The final process is the most applicable to the utilization of waste heat. The drying cycle requires 38% of the total heat requirement and a large capital investment for specialized equipment, at the present time. The Slurry consists of 10% solids, 90% water, the final configuration for the end product should be 90% Solids, 10% Liquid. The use of power plant effluent may make the use of centrifuges and other capital intensive water extraction methods unnecessary, by supplying hot dry air for evaporation via a water to air heat pump and/or fin coil heater immersed in the slurry using the power plant effluent to accelerate evaporation of the unwanted water component.

One of the possible heat sources being investigated for inclusion in a later report, is the use of a water to air heat pump with water supplied by the central heat source. The water source heat pump utilizing constant temperature fresh water will supply hot dry air suitable for drying operations. The efficiency of the water source heat pumps, depending on the characteristics of the water supplied can be in the range of 3.0 - 5.0 COP. The energy balance for the various processes, if known, can be converted to design parameters by computer programs such as the "SEE" System by Singer. The use of water source heat pumps will be further investigated as applicable to the individual and overall processes as more specific data are developed.

Mention was made to the use of grain as feedstock for aquaculture. The liquid vehicle or Slurry water as extracted by mechanical means may be useful as a nutrient solution to support the growth of algae which is the main feedstock for clams and oysters in the mariculture process. It is hoped that the algae would act to "polish" the Slurry water to facilitate its disposal at the same time as it provides a necessary food source for the mariculture operations.

ENERGY BALANCE FOR ALCOHOL PRODUCTION

EXHIBIT VI



Step	Energy Usage (% of total)
①	20%
②	Neglegable
③	42%
④	38%
Total	100%

D. BIOLOGICAL RECYCLING

There have been numerous schemes to recover and recycle agricultural residues for its energy potential. This section will consider the pertinent projects on waste recovery which have a potential for waste heat application in a related energy park.

Projects which use livestock manures as a source of fertilizer or nutrients for aquatic growth are the most common types.

> "The increasing costs of commercial fertilizers, increasing public awareness of environmental pollution, and other restrictions on farming are expected to complicate manure disposal problems and place more emphasis on nutrient recovery in the future. Land application, direct refeeding of wastes, and aquacultural fertilization are three methods of nutrient recovery being intensively studied. Land application, the traditional route of disposal, may still be the best alternative if sufficient land is available and longer decomposition times are required. Various pretreatment and storage applications may be practiced prior to land application: aerobic lagoons, anaerobic lagoons, faculative lagoons, oxidation ditches, composting and methane production". (Ref. 8, pp. 4-2)

Having examined many such projects it must be concluded that those which concern the production of biogas have the most energy potential.

Currently, the U.S. ERDA is involved in several large scale efforts to demonstrate the feasibility of adapting the anaerobic fermentation of sewage solids and animal wastes to the full scale production of methane gas. A three million dollar demonstration plant is now under consideration for a 10,000 head beef feedlot operation and Cornell University has been given authority to demonstrate methane production technology for dairies at its research facility in Hartford, New York.

A most successful project, to date, has been the Vermont Yankee Nuclear Power Corporation's methane generator. The process begins with the daily delivery of the manure from 200 dairy cows to the methane-generating holding tank at the nuclear plant site.

> "This solid waste is then deposited into a premix tank where 60°F water from the heat exchangers is mixed with it to create a sludge. Many variables, such as temperature, organic residence time, and solids retention period, affect the volatility of the bacterial anaerobic fermentation process. In the cold weather of the Vermont climate, the temperature of the manure exposed to the winter climate may be as low as 35°F. The temperature of the sludge must be increased to produce methane. If no external heat is utilized, the majority of the energy of the decomposing manure would be used to maintain the natural reaction temperature of 95°F, thereby greatly reducing the methane gas production. However, by utilizing the nuclear plant's discharge water to preheat the residue, efficiency of the bacterial fermentation process is increased.
> The external heat source will maintain a sludge temperature of $\pm$ 65°F in the premix tank. The sludge is then pumped through a heat exchanger which uses methane gas to increase the sludge temperature an additional 30°F. This supplemental heating is done to increase the rate of the digestive process. At 95°F the sludge enters the digester where natural fermentation processes change the liquid to methane gas. The gas will not only serve to heat one of the expermental greenhouses, but will also supply supplemental heat to the sludge water. Any excess gas would be utilized to heat other facilities. The remaining sludge effluent is held in a storage holding pond for a specified length of time before being distributed to farm fields as fertilizer". (Ref. 6, pp. 3.4 - 3.5)

This system utilized mesophilic bacteria in the anaerobic digestion process. By providing supplemental heat, the generation time for the methane gas was cut nearly in half. The optimum temperature for mesophilic bacteria is approaching 113°F.

If temperatures of 113°F to 145°F could be attained, thermophilic bacteria could be employed, and thereby increase the process efficiency by two to three times.

A number of other methane-related projects have been referred to in the "Greenhouse Production" section. The capturing of methane gas from decomposing sanitary landfills with the purpose of greenhouse heating, soil warming or space heating has proven successful in those previously noted passive projects.

The availability of raw materials in quantity, is critical to methane production feasibility. In the Ocean County area, which does not have large concentrations of farming, the cooperation of county agencies, such as the Ocean County Sewerage Authority or the County Solid Waste Administration, is necessary to provide the raw materials for methane generation, in conjunction with the fish waste generated on site.

The end result of the digestion of sewerage could be a supply of usable fertilizer for either commercialization or enrichment of the soils in the Pine Barrens, and the reduction of solid wastes could result in a supply of compost which could be used for the same applications as the treated sludge.

Further research on the controlling of the evironment with supplemental waste heat from sources such as power plant waste water will prove significant in future methane production projects.

E. POULTRY INDUSTRY

In the investigation of the Poultry Industry, Perdue Farms in Accomac, Virginia, were contacted. Selection of this industry was prompted by the fact that the SIC Industrial listing revealed that 100% of the Poultry Dressing Industry utilized water under 212°F. The most used process water, by Perdue, is presently heated to approximately 136° - 140°F and is used in the scalding operation. Although this water is within the temperature range which this study assumes would be delivered to potential customers, the logistics of the business would preclude locating outside an area such as the Delmarva Peninsula. The proximity of the food source; i.e., soybean and corn and the volume of poultry processed precludes on-site growing. At present, Chickens are grown by private contractors, picked up and processed by Perdue Farms at their Accomac, Virginia Facility.

In summation, the poultry business, on a viably economic scale, would not be able to locate on the site, Lacey Township, due to the symbiotic relationship of the poultry production with available feed and the processing facility. Two general areas of possible interest were the rendering operation and grain, specifically soybean, processing. It is not possible to address these areas, in specific, within the restrictions of this report.

F. CHEMICAL AND PETROCHEMICAL INDUSTRY

Research into the possible use of low grade heat in the chemical and/or petrochemical industry proved somewhat discouraging because of their need for much higher temperatures in their processes. As a matter of fact, many industries are faced with the problem of dissipating large quantities of their own process heat, which in most cases is of a higher temperature than our source.

A specific example of this is the styropor plant of BASF Wyandott Company in Jamesburg, New Jersey, which discharges 50 gpm of process waste water at temperatures of 230°F in 13 minute bursts at various intervals in their process. They are making attempts to modulate these cooling waters so that some type of recycling may be incorporated. There has been no success, to date.

Along the same lines, a large effort has been made towards power recovery in the petroleum industry. Specifically, many fluid catalytic cracker units in oil refineries presently under construction will utilize power recovery systems which recover high-temperature regenerator flue gases.

One of the largest operating expenses in a cracker is the cost of the horsepower to drive the regenerator air blower. Such power recovery systems preserve and reuse the energy otherwise lost in the flue gasses by putting it back into the refinery operation, thus significantly reducing power requirements from outside utility sources.

An example of one of the more recent power recovery units now in operation is a 17,500 hp unit at Amoco's Whiting, Indiana Refinery, which is saving the owners approximately 140 million Btu per hour. This is equivalent to heating 7,000 homes in the Chicago area in the winter.

A 15,000 hp power recovery system has also been retrofitted to an existing fluid catalytic cracker unit at the Pasadena Texas Refinery, of Crown Central Petroleum, which has an estimated savings of approximately 80 million Btu's per hour.

Although these power recovery units may not be directly applicable to this study, it is a subject worth investigating, in the future, with relation to possible recovery of waste heat from flue gases in the power plants.

G. CO-GENERATION THROUGH CLOSED CYCLE GAS VAPORIZATION

The possibility of utilizing waste heat to co-generate electricity by the use of closed cycle gas vaporization has also been researched. The present bulk of research, on this process, is being conducted in the field of Geothermal recovery. The two (2) systems reviewed are, direct-flash and Binary Cycle technology.

The Binary Cycle technology is being investigated primarly at the Herber Project in Valles Caldera, New Mexico by D.O.E., Public Service Company of New Mexico and Union Oil Company, of California.

> "At Herber, brine is pumped from 12 production wells at the center of the reservior and delivered to heat exchangers at approximately 360°F and will be returned to the reservoir periphery at about 160°F. Because 80% of the reservoir heat is actually contained in solid material, the re-injected brine will continuously sweep the reservoir or heat as it flows toward the drawn-down center to be pumped again for another heat extraction cycle. The possibility of declining temperature is very real. However, by altering the properties of the working fluid this possibility can be hedged. With temperatures too low for direct-flash approach the second fluid vaporizes at a much lower temperature than water.
> A surface heat exchanger transfers the heat from the geothermal water to the working fluid which vaporizes and is piped to a turbine. At Herber, the working fluid initial design is a mixture of isobutene 90% and isopentane 10% delivered to the turbine at 300°F and 575 psi. Even though by changing the proportions of the two hydrocarbons, the molecular weight of the fluid can be increased, enhancing its kinetics so that reduced heat input has the least adverse effect on turbine performance and power output". (Ref. 9, p. 10)

The temperatures involved are significantly above those with which we are dealing. In the case of direct flash technology, the temperature must be above 410°F and were not considered.

It appears that, given the present State-of-the-Art, the utilization of power plant waste heat is not applicable to this process.

Based on the availability and quantity of the heated waste water at the present Oyster Creek site, the indeterminate status of the Forked River Unit #1 Power Plant, and the over-abundance of technical information available, on this broad subject of Waste Heat Utilization, it is necessary to make certain assumptions which will help unify and focus the direction which this study will pursue:

1. Public reaction and industry reluctance discovered in preliminary investigations is proving to be a serious limitation to using power plant discharge water directly unless overwhelming precautionary measures can be demonstrated. The prohibition of this type use by the Delaney Amendment renders this consideration moot.
2. The economics of systems utilizing waste water, in the past, have proven marginally profitable without the use of heat exchangers and break-even or below profitability with the use of heat exchangers. Escalating fuel costs are changing this to a potentially profitable situation.
3. <u>Determining the size of the smallest commercially viable project in relation to interfacing costs is critical and will be addressed in further reports.</u>
4. The projects having attained the most success to date, and containing the most potential, are those which maximize cascading; i.e., energy parks with several varied components, that extract heat in a direct ratio to the heat available.

5. The reliability of the OCNGS (downtime and seasonal temperature variations) proves to be the most limiting factor. Without multiple units and/or higher temperatures with heat storage capability, the available waste heat from the power plant will require its users to provide independent sources of supplementary heat, thereby lowering its desirability.

Having accepted these findings we must examine alternate uses of this reject heat which will fit with the areas acceptable land uses so as to maximize the long range potential of this otherwise neglected energy source. The following table reflecting those processes previously examined will summarize findings to date. (Exhibit VII)

An examination of the heat requirements listed will help define the cascading temperature design. The designs shown on the "Proposed Lacey Energy Park Flow Diagrams", could prove to be an economical, environmentally sound and energy efficient approach to the utilization of power plant waste heat. The key note of the approach is to take advantage of present technology and the available resources of Forked River, and to transform that into a concept with a universal application. All proposed systems to be incorporated will utilize documented and proven technology.

The concept is outlined in the flow chart on the following page. The "heart" of the proposed system is the construction of a central heat source which will use the power plant discharge water as the heat exchanger input into either one large or a series of staged heat pumps (chillers). (Exhibits IV and V)

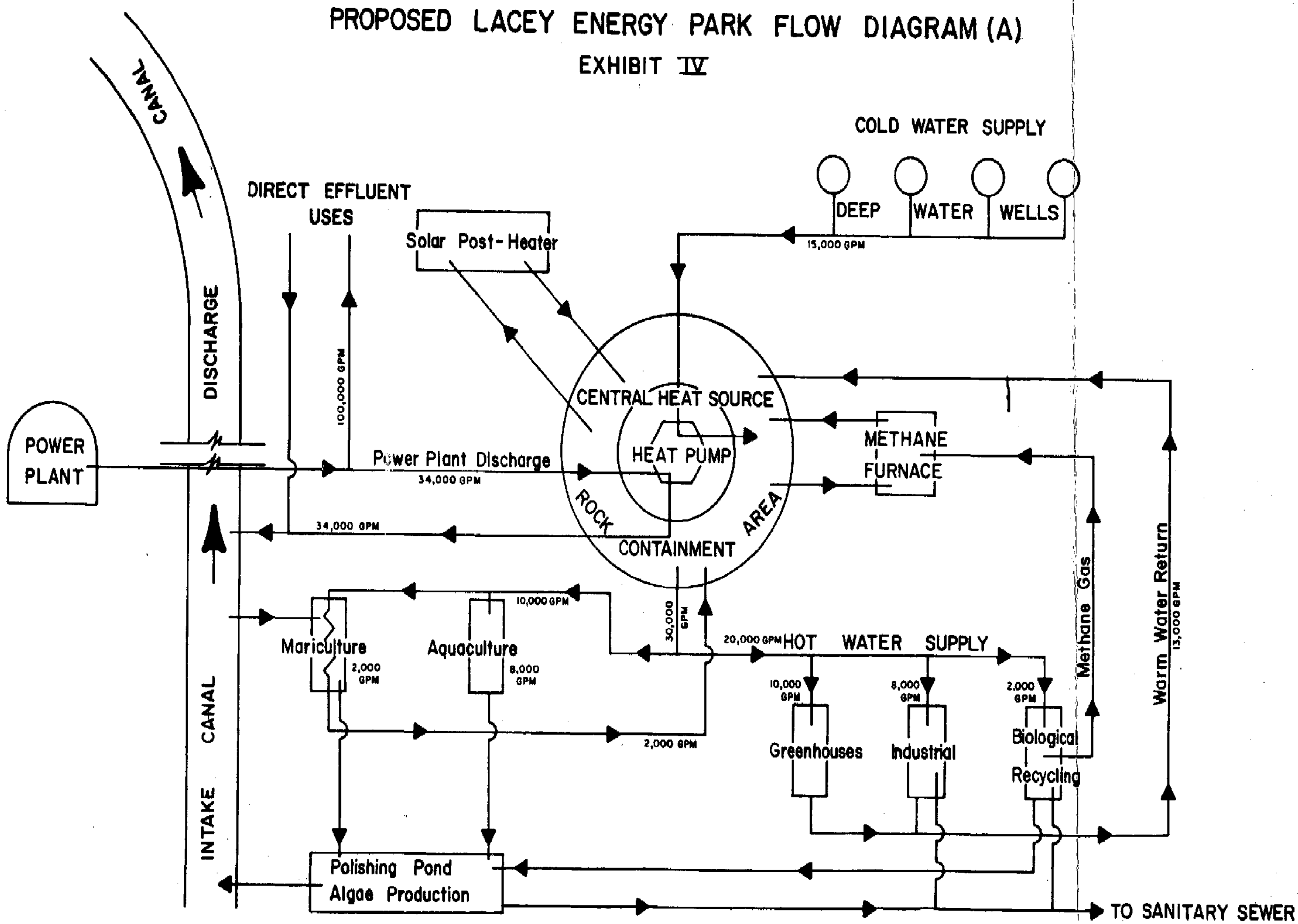
This central heat source via the heat pumps will provide large quantities of hot water in the range of 80°F to 140°F to the heat storage; i.e., rock containment area. The process water to be heated

EXHIBIT VII

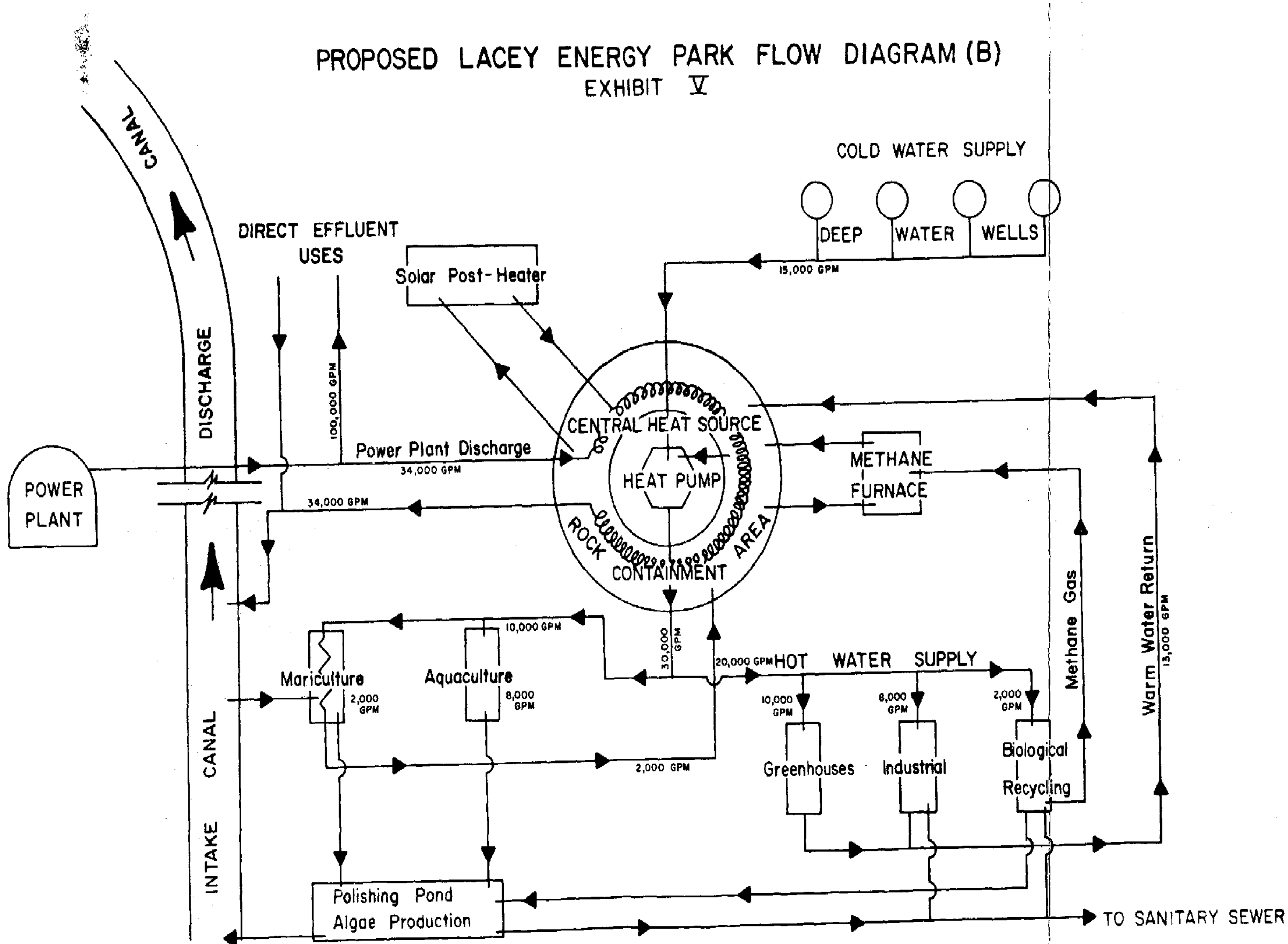
	TEMPERATURE RANGE REQUIRED	ESTIMATED WATER QUANTITY	WATER SOURCE	WATER TREATMENT REQUIRED	IS PROCESS DEEMED APPLICABLE TO FORKED RIVER SITE?	SPECIAL CONSIDERATIONS
AQUACULTURE	58°F - 80°F	8,000 gpm	Fresh well from central heat source.	pH adjustment de-ionization oxygenation	yes	Type of fish raised relating to economic viability and market considerations; e.g. trout for stream stocking.
MARICULTURE	50°F - 72°F	10,000 gpm	2,000 gpm from heat source and/or deep wells for temperature modification. 8,000 gpm saline from Intake Canal.	Screening of Bay Water oxygenation	yes	Type of fish raised for reasons above; e.g. lobsters.
GREENHOUSE A. DIRECT USES	85°F - 105°F	10,000 gpm	Fresh well from central heat source for warm water irrigation or hydroponics.	pH adjustment de-ionization	yes	Type of crops - vegatables for commercial high yield production.
B. INDIRECT USES	70° Minimum	10,000 gpm	Effluent for direct radiant transfer and as a source for heat pumps.	None	yes	Type of crops - ornamental plants and bushes have high economic viability.
GASOHOL/ALCOHOL	53°F - 120°F	4,000 gpm	Central heat source fresh water as heat source for water to air heat pump.	None	yes	Drying stillage for resale or feedstock.
BIOLOGICAL RECYCLING	90°F - 95°F	2,000 gpm	Effluent for indirect pre-heating central heat source fresh water for slurry.	None	yes	Availability of raw materials and a "market" for end products.
POULTRY PROCESSING	136°F - 140°F	-	-	-	no	-
CHEMICAL	-	-	-	-	no	-
CLOSED CYCLE GAS CO-GENERATION	310°F	-	-	-	no	-

PROPOSED LACEY ENERGY PARK FLOW DIAGRAM (A)

EXHIBIT IV



PROPOSED LACEY ENERGY PARK FLOW DIAGRAM (B)
EXHIBIT V



will be provided from deep water wells that tap the Cohansee Sands or Krikwood Strata.

The efficiency of these heat pumps can be improved dramatically with the controlled water temperature input. The proposed system will attempt to attain a continuous coefficient of performance in the range of 3.0 to 5.0.

The flow diagrams, which outline the proposed configuration of the energy park, show additional temperature augmentation capability through the use of solar collectors and methane gas fired heaters. These features will be addressed at a later date when sufficient design parameters have been developed.

IV. EVALUATION OF DESIGN OPTIONS

A. Open vs. Closed Loop Characteristics

The previous sections of this report have served to define the applicable processes that could lend themselves to the Forked River site, keeping in mind the most efficient use of the water involved, both from the standpoint of heat utilization and quantity available. For purposes of clarity the definitions of a closed loop and open loop, in this report, are as follows:

Closed Loop

The subject water experiences no chemical or biological pollution that could render it unacceptable for reuse in the central heat source or in other processes. The water may be subject to energy transfer; i.e., temperature modification and based on the resultant temperature may be:

1. Retained and reused for progressively lower temperature processes within the park.
2. The fresh water component could be reinjected into the aquafer for subsequent reuse.
3. The water may be returned to the central heat source for augmentation and subsequent recycling through the Energy Park system.
4. Any closed cycle water may be returned to the intake canal for recycling as condenser cooling water provided its temperature is at or below the ambient intake canal temperature

The quality of the water returned to the ecosystem must be equal to, or better than, the natural water within limits as established by the New Jersey Department of Environmental Protection, Division of Water Resources. The effluent from the power plant will be received at the central heat source with chemical characteristics that meet the discharge criteria established. Since no further chemical treatment is contemplated on this effluent and only the extraction of heat will be accomplished, the return of this portion of effluent for recycling in the system may be possible.

The 34,000 gpm fraction of the effluent, the source for the central heat pump (chiller), could be returned, to the intake canal, for recycling as a closed loop. The same rationale applies to the proposed 100,000 gpm fraction labeled as "effluent direct uses" on the Proposed Lacey Energy Park Flow Diagrams. (Exhibits IV & V)

This fraction of the effluent could be used for direct radiant transfer applications such as:

1. Soil Heating
2. Roadway and Walkway heating.
3. Supplying an On Site Fire Pond; i.e., Suction Point.
4. Some district heating depending on the temperature of the effluent and the heat demand.

During summer months when little or no temperature differential exists, or when in fact heat may be transferred from the hot roadway surface to the effluent the cost of circulating this system could be counter-productive and may not extract enough heat to be economically viable.

Open Loop

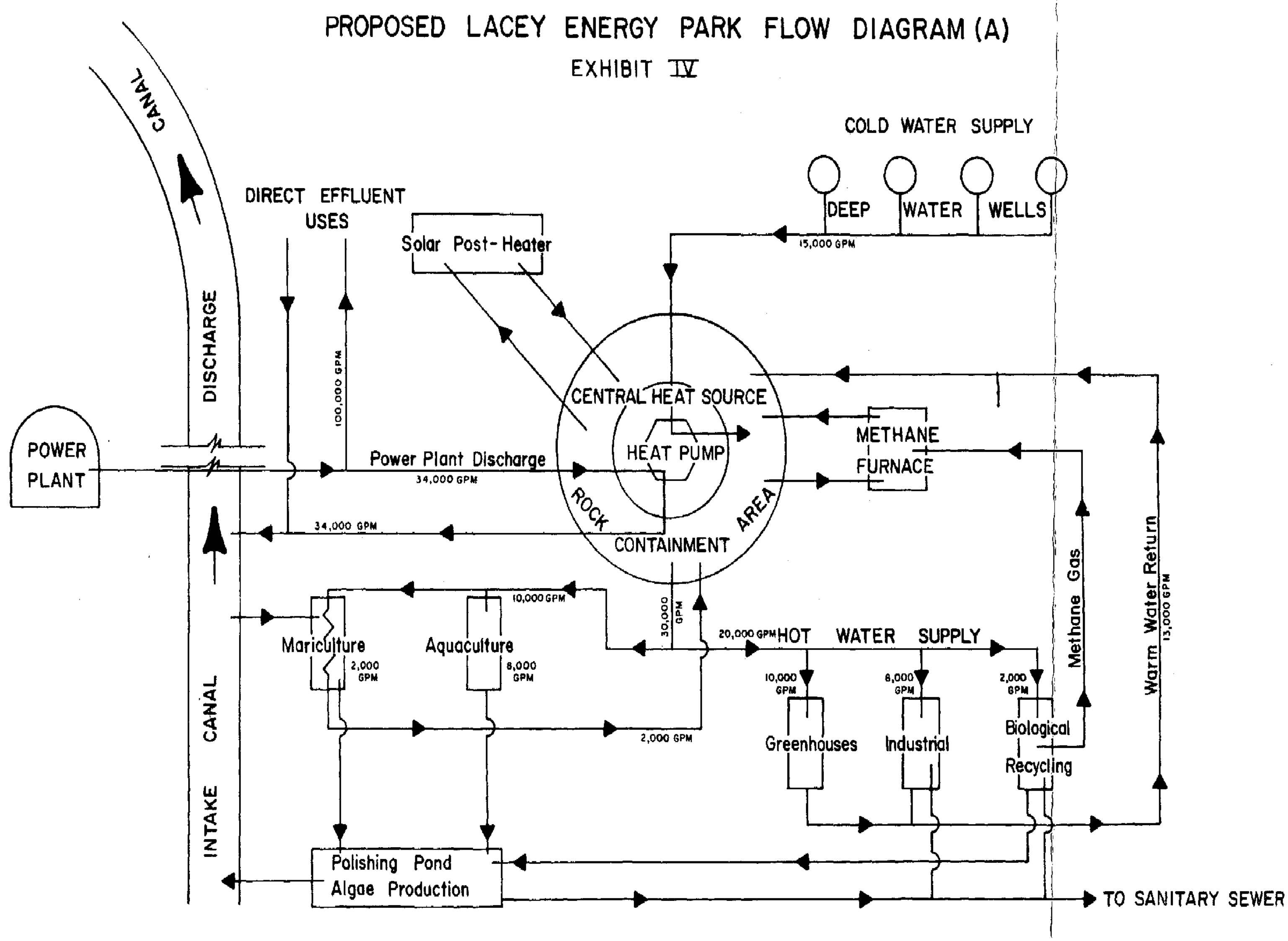
The subject water is exposed to chemical or biological contamination and regardless of temperature must be treated either on site or by the Ocean County Central Sewer System or both.

The only interest in open loop processes in this report is the volume of water that will have to be disposed of and the make up water that will have to be supplied. The Proposed Lacey Energy Park Diagrams, (Exhibit IV & V) and the Flow Chart (Exhibit VII) show a net loss of 10,000 gpm of fresh water from the aquaculture and biological re-cycling processes. The make up water will be provided by the deep water wells as shown. The mariculture facility shows a loss of 8,000 gpm of saline water with make up water pumped directly from the intake canal and a portion of the mariculture effluent supplying the polishing pond for algae production and harvesting.

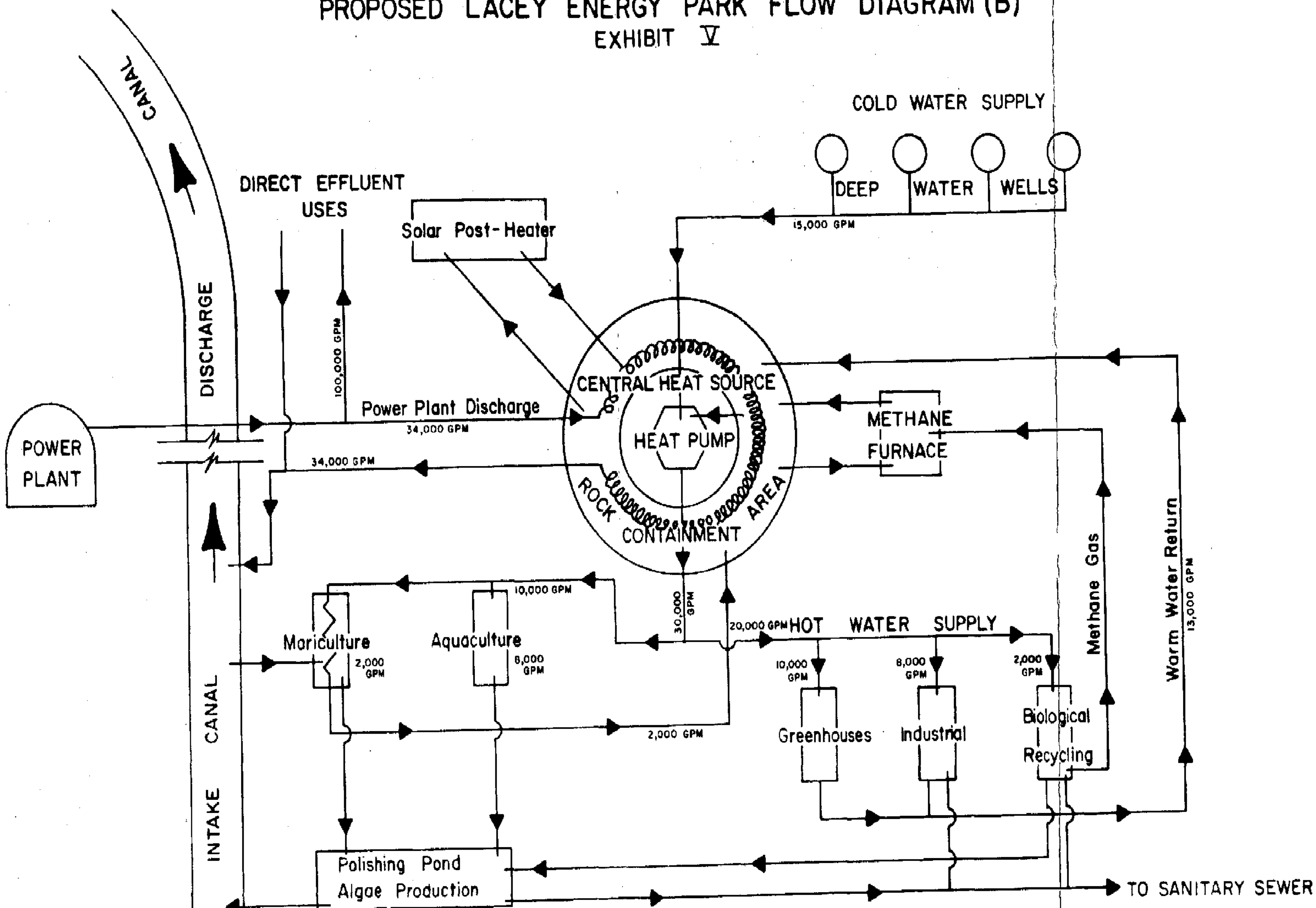
The processes previously discussed are shown on the following table with a determination as to their open or closed loop characteristics.

PROPOSED LACEY ENERGY PARK FLOW DIAGRAM (A)

EXHIBIT IV



PROPOSED LACEY ENERGY PARK FLOW DIAGRAM (B)
EXHIBIT V



B. Replacement of Cooling Tower

The elimination of the proposed cooling tower would require the utilization of an estimated 7.6 x 10^9 Btu/hr. generated by the proposed FR#I power plant, as designed. The OCNGS, in this scenario, would continue to function as it does now and would not be subject to retrofit except as a backup heat source.

TABLE II

ASSUMPTION CONCERNING TYPES OF USES

Uses	Delta T	Assumed Flow	Estimated Percentages of Time in use
Soil Heat	5°F	15,000 gpm	40
Greenhouse Type I	10°F	20,000 gpm	40
Greenhouse Type II	10°F	4,000 gpm	40
	38°F	15,000 gpm	60
Aquaculture	3°F	15,000 gpm	93
Industrial	5°F	20,000 gpm	90
Biological Recycling	38°F	9,000 gpm	93
Fingerlings	5°F	2,000 gpm	93

The figures, as shown were converted to Btu/hr. as a means of comparison to the available Btu/hr. from the proposed FR#I power plant, as follows; using the general formula:

gpm x 8.345 lb/gal. x °F utilized x 60 = Btu/hr.

Soil Heating	3.8 x 10^7 Btu/hr.
Greenhouse I	1.0 x 10^8 Btu/hr.
Greenhouse II	2.0 x 10^7 Btu/hr.
	2.9 x 10^8 Btu/hr.
Aquaculture	2.3 x 10^7 Btu/hr.
Industrial	5.0 x 10^7 Btu/hr.
Biological	1.7 x 10^8 Btu/hr.
Fingerlings	5.0 x 10^6 Btu/hr.

The results of these calculations show that for maximum utilization; i.e., winter conditions, the energy consumption could be 6.9 x 10^8 Btu/hr. When these figures are extrapolated to a yearly energy demand, based on the estimated percentage of the time the processes can utilize the waste heat available, the Btu consumption, of the park, could be 4.07 x 10^{12} Btu/yr.. The waste heat available is 6.65 x 10^{13} Btu/yr. this indicated that, at peak load time; i.e., winter, the heat available will be sufficient to supply an energy park of the configuation shown above and excess heat will exist.

The storage capacity designed into the central heat source, at the Lacey Park, is capable of 6.2 x 10^{7} Btu of stored heat. It may not be feasible to store the differential of 3.3 X 10^{13} Btu, therefore, it can be concluded that in both winter and summer a surplus of heat which cannot be utilized must be returned, at a unacceptable Delta T that may require cooling before return to the ecosystem. The previous assumption; i.e., those as reported in the Watts Bar Study, are not valid for the proposed Forked River site. The usable land area* of the proposed Lacey Energy Park, is estimated at 250 acres available for subdivision and subsequent industrial development, this as opposed to 400 acres available at Watts Bar. The Lacey Energy Park will have to carefully evaluate the energy requirements of those processes previously enumerated and put special emphasis on the processes considered high energy users that require energy input for the highest percentage of the time. A possible energy balance for the Proposed Lacey Energy Park, using flows as shown on the Proposed Lacey Energy Park Diagrams, with the following assumptions kept in mind, could be: (Exhibits IV & V)

* See comments economic section Reference: Increased land area.

1. Winter conditions; i.e., full process utilization will occur for approximately 146 days/year.

2. The remaining 219 days will show process utilization at the percentages of time as previously shown, in Table II.

WINTER CONDITIONS (146 days)

	Use	GPM	Delta T	Heat Utilized
1.	Aquaculture Mariculture	10,000 gpm	3°F	BTU=5.3×10^{10}
2.	Greenhouse	10,000 gpm	38°F	BTU=6.7×10^{11}
3.	Industrial	8,000 gpm	5°F	BTU=7.0×10^{10}
4.	Biological	2,000 gpm	38°F	BTU=1.3×10^{11}
5.	Polishing pond	4.5 Acres	-200BTU/hr/ft^2	BTU=1.4×10^{11}
6.	Clam depuration	2.0 Acres	-200Btu/hr/ft^2	BTU=6.1×10^{10}
	+	2,000 gpm	3°F	BTU=1.0×10^{10}
	Total proposed heat utilization			BTU=1.1×10^{12}
	Storage capacity			BTU=$+6.2 \times 10^{7}$
	Total Heat capacity of system			BTU=1.1×10^{12}
	Total heat available @34,000 gpm			BTU=1.7×10^{12}
	Estimated reject heat/146 days			BTU=6.0×10^{11}
	Reject heat BTU/hr			BTU=1.7×10^{8}

REMAINDER OF YEAR (219 days)

	Use	GPM	Delta T	Heat Utilized
1.	Aquaculture Mariculture	10,000 gpm	3°F	BTU=0
2.	Greenhouse	10,000 gpm	38°F	BTU=3.3×10^{11}
3.	Industrial	8,000 gpm	5°F	BTU=8.8×10^{10}
4.	Biological	2,000 gpm	38°F	BTU=1.8×10^{11}
5.	Polishing pond	4.5 Acres		BTU=2.1×10^{11}
6.	Clam depuration	2.0 Acres		BTU=9.2×10^{10}
	Total proposed heat utilization			BTU=9.0×10^{11}
	Total heat available			BTU=-2.5×10^{12}
	Estimated reject heat/219 days			BTU=1.6×10^{12}
	Estimated reject heat BTU/hr.			BTU=4.6×10^{8}

The figures above deal with processes utilizing heat supplied by the central heat source which utilizes 34,000 gpm of effluent to energize the system. The closed loop direct effluent uses, shown on the flow diagrams, will utilize a portion of the effluent for soil heating, direct radiant uses and to supply a fire pond on site. Soil heating will utilize approximately, 15,000 gpm with a heat loss of 5°F or 1.3×10^{11} BTU for winter conditions only. The fire pond; i.e., suction point, estimated at 5 acres will average a utilization of 200 BTU/ft^2/hr or 1.5×10^{11} BTU for 146 days and 2.3×10^{11} BTU for 219 days.

The preceeding calculations lead to the following conclusions:

1. Waste heat available during winter conditions: (146 days)

   FR#I as designed, 34,000 gpm = 1.67×10^{12} BTU
   OCNGS operational, 50,000 gpm = 1.67×10^{12} BTU

2. Waste Heat Utilization of proposed energy park processes; i.e., not including 10,000 gpm direct use fraction, could be 1.46×10^{12} BTU. Sufficient heat is available from either power generating facility to energize the energy park during winter conditions utilizing approximatel 2% of the total available heat.

3. Waste heat available during summer conditions: (219 days)

   FR#I as designed, 34,000 gpm = 2.51×10^{12} BTU
   OCNGS operational, 50,000 gpm = 2.50×10^{12} BTU

4. Waste Heat Utilization of proposed energy park processes; i.e., not including 100,000 gpm direct use fraction, could be 9.0×10^{11} BTU sufficient heat is available from either power generating facility to energize the energy park during summer conditions utilizing approximately 1/2% of the total available heat.

5. Excess heat will be generated during winter and summer conditions. The cooling tower must be designed to handle the excess heat generated during the summer conditions. The heat utilization of the proposed energy park at Lacey could represent 2.1% of the total heat available, therefore, it does not appear feasible to reduce the capacity of the proposed cooling tower by any significant amount, without more area available for industrial development and/or the identification of processes which utilize more of the heat energy available.

6. As further investigations define the capabilities of the central heat source, both from the stand-point of augmentation and storage, higher temperatures may be possible to achieve, which could open up a whole new range of possible processes for consideration.

C. Alternate Heat Sources

It has been determined in the previous reports that given the reliability of nuclear power generating facilities and the need for periodic maintenance shut downs it is highly desirable to have two (2) heat sources; i.e., power generating facilities, as the energy sources for an energy park. It is also desirable that scheduled shut downs be coordinated with the park management to take place during periods of low energy usage and high effectiveness of the proposed augmentation systems, specifically solar. The summer months are the most desirable from the standpoint of these criteria but may not be from the standpoint of power generation.

In any case, auxiliary heating systems are indicated for each individual process adequate to maintain minimum conditions if a shut down occurs during the worst climatological period. If sufficient methane can be generated and stored on site it could be utilized for this purpose. The heat storage, as shown, is not significant in terms of supplying heat during a period of shut down but can act as a leveling area to insure a constant water temperature and to mitigate diurnal variations.

V. RADIOLOGICAL MONITORING

V. RADIOLOGICAL MONITORING

A prime concern of any proposed energy usage connected with nuclear power generation must be the safety of both the workers and the products produced. To insure the safety of all involved and to ascertain the level of additional radiological monitoring required, an investigation has been conducted of the existing monitoring systems in place.

GASEOUS EMISSIONS

The chance of unscheduled or unexpected occurrences are significantly higher for smaller particulate and gas emissions, than a liquid spillage. Additionally, the spread of radioactive material, after an on site incident, which could cause evacuation or other protective measures, would be through gaseous emissions.

The prime monitoring system consists of sampling probe mounted at the top of the stack. Samples are run through particulate filters which are removed and counted twice weekly in accordance with NRC regulations. The samples are then run through two consecutive gas chambers to detect and record any noble gas emissions. The levels of contaminants are very small and the detectors noted are highly sensitive to record the low levels of contaminant normally present. The final stage of stack monitoring is a high level recorder to monitor the possible high level emissions which may be associated with an accident. Additional air monitoring stations are positioned at varying distances up to 30 miles. These are automatic stations with the records retrieved weekly. These results are compiled and the result published semiannually by JCP&L. Several improvements are currently planned and proposed to improve and update the gas monitoring system. A system of continous computer monitoring of the existing system is now in final design stages, and is projected to be on line within the next three (3) years. The computer will tie the stack monitoring to concurrent meteorological data from an on site weather station. This data can then be used to project possible radioactive drift in case of a major accident on site. The next improvements projected for site monitoring is a system of twenty perimeter monitoring stations. Each station will be tied to a central computer and will be monitored in real time. The primary function of this system will be to monitor any increase in off-site deposition or drift in a post accident phase.

LIQUID EMMISION

COOLING WATER: The design of OCNGS excludes the mixing of the cooling water with the primary cooling loop except for catastrophic event. Between the primary cooling loop and the condensor cooling loop there is a 28 inch of mercury vacuum. If a leak should develop in any of the condensor tubes cooling water would be sucked into the primary cooling loop. No primary coolant would flow to the condensor cooling water.

RAD WASTE BUILDING

The EPA and NRC permit certain radiological contaminents to be discharged in small quantities. This discharge is totally separate from the condensor cooling water. The discharge from the rad waste building is located approximately 100 feet downstream from the discharge structure for the condenser cooling. The discharge is constantly monitored with automatic shut down valves set at small percentages of the allowed discharge levels. During normal operation mode there is no discharge through this system. Releases of liquid radioactive wastes are scheduled and metered during outages and is associated with cleaning and refueling operations.

NEED FOR ADDITIONAL MONITORING

Based on the information provided above the need for any additional monitoring would be related to factors other than worker health and safety.

A small monitoring system, as a psychological asset, may add to employees mental perception of safety but would add no real measure of safety.

Two (2) areas would possibly benefit from additional monitoring or an extension of the plant site monitoring. The first area would be related to long term effect of a very low level radiation. All exposure of radiation is now well below excepted standards for both workers and local population. However, on going research is being conducted on the effect of long term, low dose radiation. This type of monitoring would be of value, if at some time in the future, possible negative effects of this exposure were discovered. Records would be available on employee exposure to determine the individual exposure data.

The second area of interest of additional monitoring would be in a post accident phase. Records from the controlled environment of Lacey Energy Park would aid in prediction of drift patterns and deposition rates. Additionally in a post accident stage Lacey Energy Park site monitoring may aid in clean up and restarting any processes in Lacey Energy Park.

To summarize what the proposed Lacey Energy Park may need as supplemental monitoring:

1. Effluent Probe: Psychological in effect.
2. Individual Dose Meter: monitor long term low level dosage.
3. Gas Destination: post accident monitoring of drift and deposition.

It is further recommended that any on site monitoring be tied to the computerized monitors on the OCNGS site.

ACKNOWLEDGEMENT

The data on the existing and proposed monitoring systems and radiation release procedures for Oyster Creek Nuclear Generating Station was obtained from Mr. Richard Pelrine, Chemical Supervisor. Mr. Pelrines' help and guidance is gratefully acknowledged.

VI. SITE SPECIFIC REPORT

VI. SITE INVENTORY

The various physical and environmental features which act upon and influence the design and function of the proposed industrial park have been catalogued and limiting features for future design and feasibility studies identified.

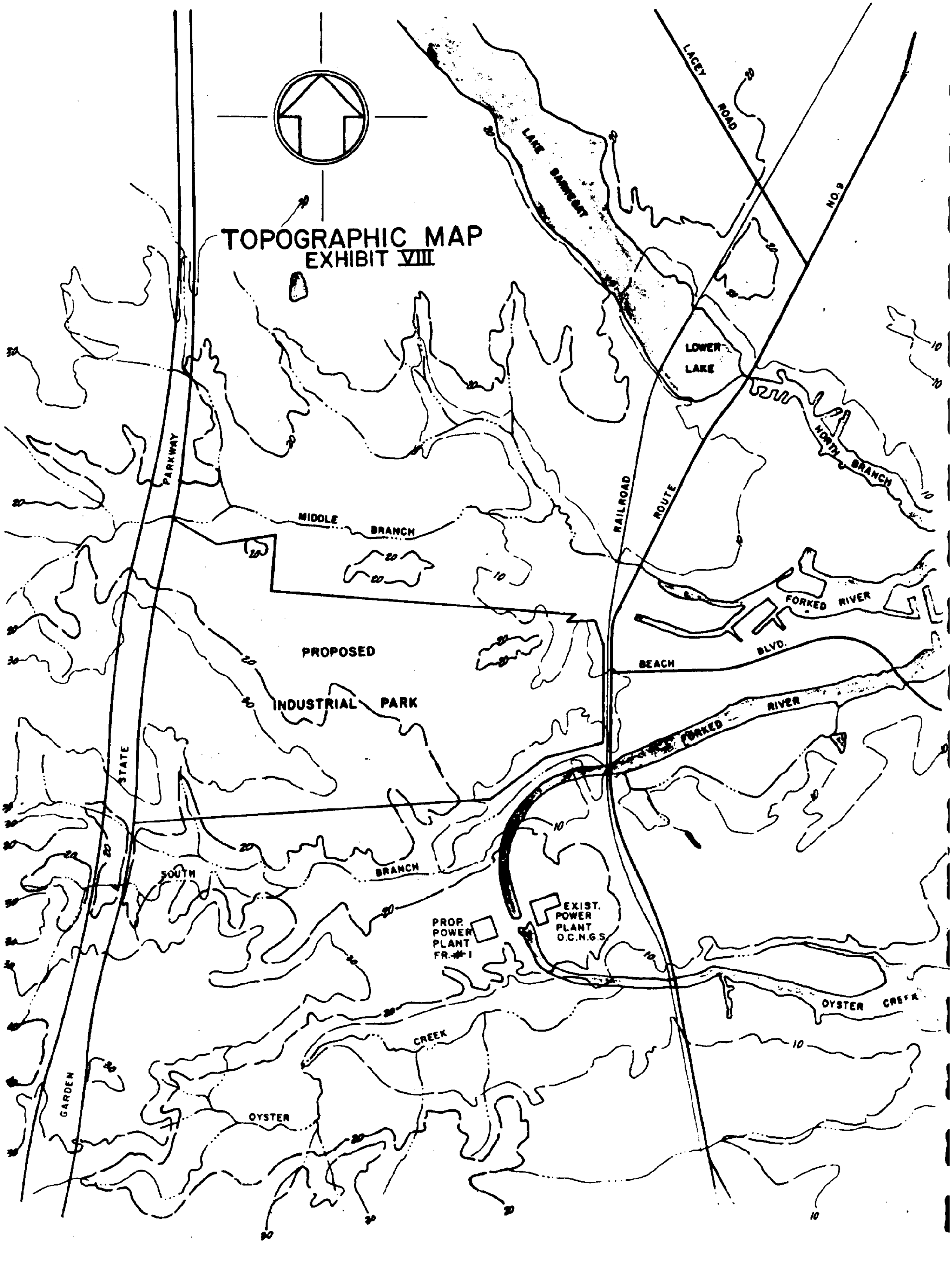
A. TOPOGRAPHY

The proposed site lies within the coastal plains region of South Central New Jersey. The site topography is typical of the coastal plains consisting of flat to mildly sloping sandy soil.

The site straddles the drainage basins of the South and Middle branches of the Forked River. The following topographic map shows the site gently sloping from west to east and from the drainage basin ridge between the Middle and South branches of the Forked River north and south. The site contains no areas of steep slopes which would impact construction. The existing topography lends itself to the proposed industrial complex and will present only minimal engineering problems to any development. (Exhibit VIII)

B. SOIL TYPE

The Ocean County Soil Survey has identified the following soil types within the proposed industrial complex:

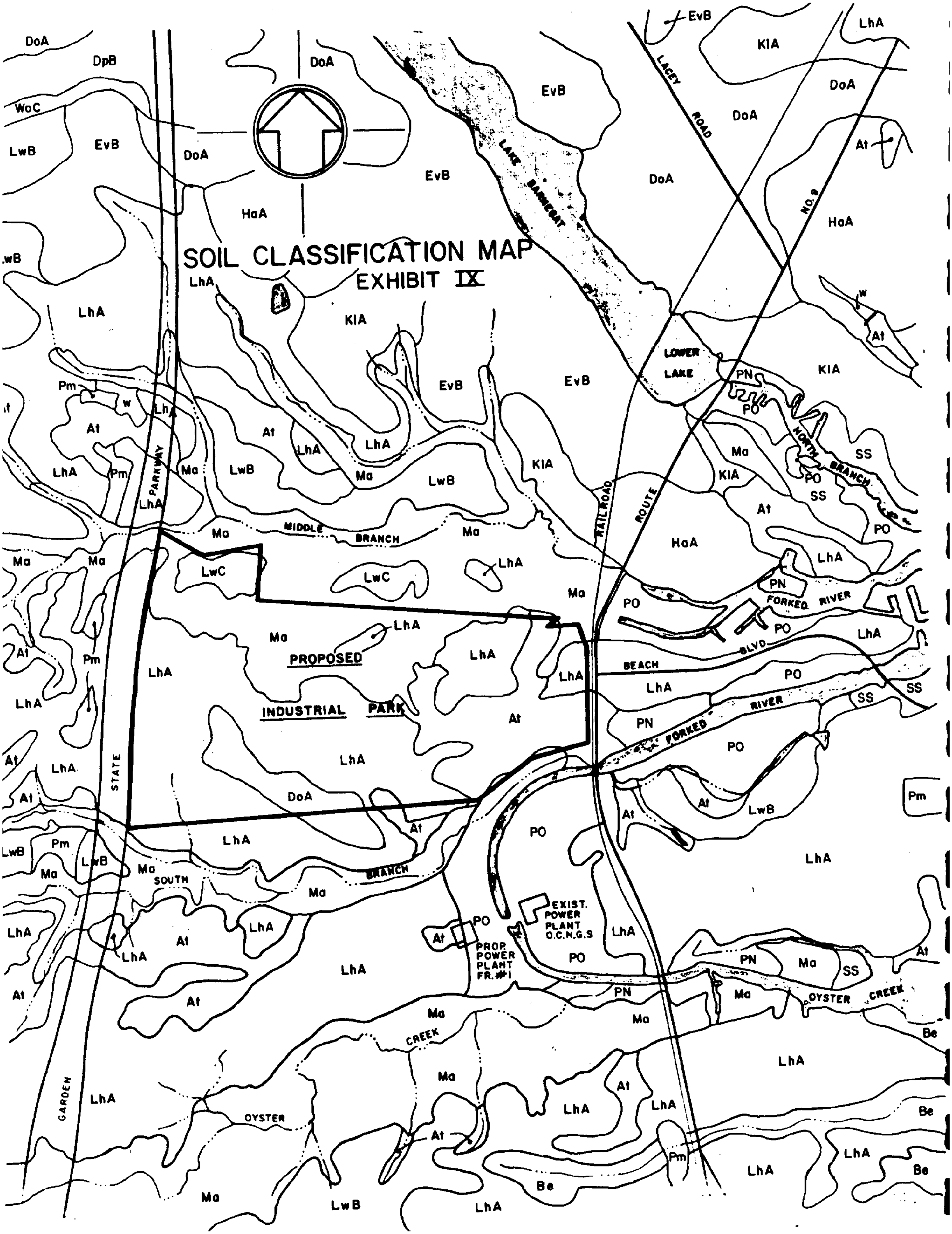

TOPOGRAPHIC MAP
EXHIBIT VIII
LAKE BARNEGAT
LACEY ROAD
NO. 9
LOWER LAKE
NORTH BRANCH
PARKWAY
MIDDLE BRANCH
RAILROAD
ROUTE
FORKED RIVER
BEACH BLVD.
PROPOSED INDUSTRIAL PARK
STATE
FORKED RIVER
SOUTH BRANCH
PROP. POWER PLANT FR. # 1
EXIST. POWER PLANT O.C.N.G.S.
OYSTER CREEK
CREEK
OYSTER
GARDEN

NAME	SYMBOL	SOIL TYPE
1. Atsion	At	Sand
2. Downer	DOA	Loamy sand
3. Lakehurst	LHA	Sand
4. Lakewood	LWC	Sand
5. Manahawkin	Ma	Organic Matter

The following composite shows the soil distribution through the site. Each of the individual soils will have certain impacts on the design and construction of the proposed park. (Exhibit IX)

The two soil types which will present the major challenge during design stage are the Atsion and Manahawkin soils. The Atsion sands have an extremely high seasonal water table with the high water table being at the surface in some cases. Construction of road and other permanent features must be undertaken with extreme care in these soils, to prevent structure damage due to the high water table.

The Manahawkin organic soil is basically unsuitable for construction activity. The soil is composed of decayed organic matter. It is highly plastic with low bearing capacity. During dry periods, when the water table falls, the soil is subject to extreme shrinkage. Additionally, the soil falls under the N.J. Department of Environmental Protections (DEP) classification of natural water's edge. The DEP discourages any development unless it meets all the following conditions:


SOIL CLASSIFICATION MAP
EXHIBIT IX
PROPOSED
INDUSTRIAL PARK
GARDEN STATE PARKWAY
LACEY ROAD
ROUTE NO. 9
RAILROAD
LAKE BARNEGAT
LOWER LAKE
NORTH BRANCH
MIDDLE BRANCH
SOUTH BRANCH
FORKED RIVER
BEACH BLVD.
OYSTER CREEK
EXIST. POWER PLANT O.C.N.G.S
PROP. POWER PLANT FR. #1
DoA
DpB
WoC
LwB
EvB
HaA
LhA
KlA
At
Pm
Ma
LwC
PN
PO
SS
Be
W

1. Requires water access or is water-oriented as a central purpose of the basic function of the activity (this condition applies only to development proposed on or adjacent to waterways).

2. Has no prudent or feasible alternative on a non natural water's edge site.

3. Is immediately adjacent to existing water's edge development.

4. Would result in minimal feasible alteration of on-site vegetation. (Ref. 13, p. 85)

C. VEGETATION AND WILDLIFE

The site has, within recent time, been cut clear for either pulp wood, cedar or firewood. This has reduced the vegetation to rapid growth weeds and bushes common to the coastal plains. The State records show no significant or record trees located in the immediate area. The following table was prepared by Rutgers University for JCP&L and groups the common vegetation by cluster type. (Ref. 14, pp. 3-67, 3-68)

HARDWOODS:

Overstory

Quercus velutina	Black Oak
Quercus coccinea	Scarlet Oak
Quercus alba	White Oak

Understory

Quercus ilicifolia	Scrub Oak
Kalmia latifolia	Mountain Laurel
Vaccinium stamineum	Deerberry
Sassafras albidum	Sassafras
Pteris aquilina	Bracken

CEDARS:

Overstory

Chamaecyparis thyoides	White Cedar

Understory

Ilex glabra	Inkberry
Acer rubrum	Red Maple
Myrica pennsylvanica	Bayberry
Vaccinium corymbosum	Highbush Blueberry
Parthenocissus quinquefolia	Virginia Creeper
Rhus vernix	Poison Sumac
Clathra alnifolia	Sweet Pepperbush
Magnolia virginiana	Sweetbay Magnolia
Ilex decidua	Deciduous Holly
Rhododendron viscosum	White Swamp Azalea
Chamaedaphne calyculata	Leatherleaf

PINE:

Overstory

Pinus rigida	Pitch Pine

Understory

Acer rubrum	Red Maple
Quercus phellos	Willow Oak
Quercus alba	White Oak
Quercus velutina	Black Oak
Sassafras albidum	Sassafras
Nyssa sylvatica	Black Gum
Diospyros virginiana	Persimmon
Prunus serotina	Black Cherry

Shrub Layer

Quercus ilicifolia	Scrub Oak
Quercus prinoides	Scrub Chestnut Oak
Myrica pennsylvanica	Bayberry
Kalmia angustifolia	Sheep Laurel

MARSH:

Hibiscus palustris	Rose Mallow
Kosteletzkya virginica	Seashore Mallow
Sabatia stellaris	Marsh Pink
Asclebias incarnata	Swamp Milkweed
Ipomoea lacunosa	Morning Glory
Verbena stricta	Blue Vervain
Solidago sempervirens	Seaside Goldenrod
Phragmites communis	Common reed
Rosa palustris	Swamp Rose
Rhus copallina	Dwarf Sumac
Viburnum recognitum	Smooth arrowood
Baccharis halimifolia	Groundsel Bush
Vaccinium corymbosum	Highbush Blueberry
Myrica pennsylvania	Bayberry
Sassafras albidum	Sassafras
Osmunda regalis	Royal Fern
Dicksonia pilousinscula	Hayscented Fern
Carex spp.	Sedges

MIXED:

Overstory

Pinus rigida	Pitch Pine
Quercus alba	White Oak
Quercus coccinea	Scarlet Oak
Quercus velutina	Black Oak
Nyssa sylvatica	Black Gum

Understory

Sassafras albidum	Sassafras
Kalmia latifolia	Mountain Laurel
Kalmia angustifolia	Sheep Laurel
Simlax rotundifolia	Greenbrier
Quercus ilicifolia	Scrub Oak
Vaccinium corymbosum	Highbush Blueberry
Gaultheria procumbins	Teaberry
Amelanchier canadensis	Shadbush
Rhus copallina	Winged Sumac (Dwarf Sumac)
Comptonia peregrina	Sweetfern
Pteris aquilina	Bracken

The New Jersey Division of Fish, Game and Shellfish summarizes the wildlife population at and near the site as:

"1. A large population of whitetail deer is in the Pine Barren and white cedar forests nearby.

2. Large populations of quail are in the heavily wooded sections of the area.

3. Heavy and cyclic grouse populations can be found near the site.

4. Marsh and river-bottom dwellers, such as the raccoon, reside in large quantities near the site." (Ref. 14, p.3-60)

A herpetologist, under contract to the Endangered and Non-game Species Project for DEP, has investigated the proposed industrial site, the power plant, and the surrounding area. The following map, furnished by NJDEP, Division of Fish, Game and Shellfish, recaps his sightings of the Pine Barrens Tree Frog, an endangered species. He also noted, in his report on this area, sightings of both the Northern Pine Snake and the Corn Snake, which are threatened species. (Exhibit X)
JCP&L, as part of the environmental report for Forked River Unit #1 (FR#1), contracted with consultants from Rutgers to physically inventory the land vertebrates in the Forked River area. The following is a summary of the Rutgers findings: (Ref. 14, p.3-62)

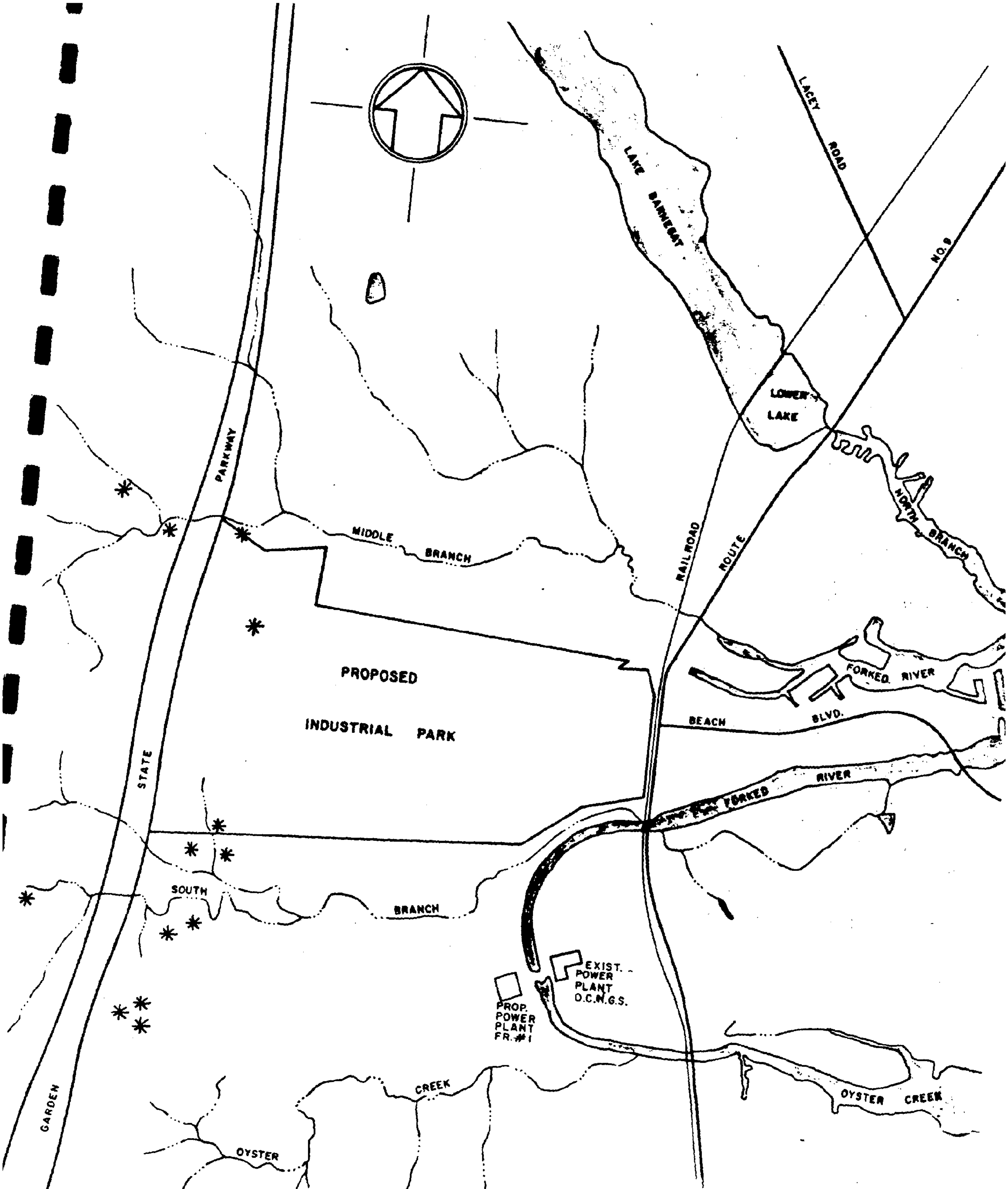


EXHIBIT X

* = PINE BARRENS TREEFROGS

FIELD SURVEY OF LAND VERTEBRATES

FORKED RIVER AREA

FROGS AND TOADS

Green Frog
Southern Leopard Frog
Pine Barrens Treefrog
Carpenter Frog
Fowler's Toad

TURTLES

Eastern Painted Turtle
Spotted Turtle
Wood Turtle
Eastern Box Turtle

LIZARDS

Northern Fence Lizard

SNAKES

Northern Black Racer
Northern Water Snake

MAMMALS

Opossum
Eastern Cottontail
Red Squirrel
Gray Squirrel
White-footed Mouse
Red-backed Vole
Meadow Vole
Pine Vole
Muskrat
Eastern Mole
Raccoon
White-tailed Deer

BIRDS (Species judged to be nesting within the 5-mile radius area from field observations.)

Green Heron
Mallard
Black Duck
Wood Duck
Turkey Vulture
Red-shouldered Hawk
Sparrow Hawk
Ruffed Grouse
Bobwhite
Killdeer
Mourning Dove
Yellow-billed Cuckoo
Whip-poor-will
Common Nighthawk
Belted Kingfisher
Yellow-shafted Flicker
Hairy Woodpecker
Downy Woodpecker
Eastern Kingbird
Great Crested Flycatcher
Eastern Phoebe
Eastern Wood Pewee
Tree Swallow
Barn Swallow
Purple Martin
Blue Jay
Common Crow
Fish Crow
Carolina Chickadee
Tufted Titmouse
White-breasted Nuthatch
House Wren
Mockingbird
Catbird
Brown Thrasher
Robin
Starling
Red-eyed Vireo
Black and White Warbler
Blue-winged Warbler
Pine Warbler
Ovenbird
Yellowthroat
House Sparrow
Red-winged Blackbird
Baltimore Oriole
Common Grackle
Brown-headed Cowbird
Scarlet Tananger
Cardinal
American Goldfinch
Rufous-sided Towhee
Seaside Sparrow
Chipping Sparrow
Field Sparrow
Swamp Sparrow
Song Sparrow

(Ref. 14, p.3-62)

The proposed industrial park will have little impact on the existing vegetation, as the only remaining vegetation of any ecological value is located in the Manahawkin soil which is excluded from development.

The endangered and threatened species likewise will be minimally impacted by the proposed construction, as the vast majority of which is upstream of the proposed development and would remain unaffected by it.

D. ADJACENT LAND USE

The proposed site lies in the M-6 zone of the current Lacey Township Zoning Ordinance. This zone allows all forms of general industrial and manufacturing uses with certain provisions regarding any industry which produces a toxic or hazardous material or waste.

The site is bounded along its entire southern border by the JCP&L power plant site. Ocean Township, to the south of the power plant site, has zoned that section abutting the power plant for industrial use.

On the west, the site is bounded by the Garden State Parkway. West of the Parkway the land is totally undeveloped. The existing zoning, on this land, is M-6, the same zoning as the proposed site.

To the north, the site is bounded by the flood plain of the Middle Branch of the Forked River. The area to the north of the river is zoned residential. The nearest existing dwellings are approximately 2,000 feet to the north along Route #9.

The easterly side of the proposed site is bounded by an inactive railroad right-of-way and U.S. Route #9. The area immediately to the east of the highway is zoned for commercial development.

The adjacent land uses will not conflict with the proposed industrial development. The presence of the nuclear power plant, which may have posed a deterent to development, is an integral part of the proposed industrial complex.

E. TRANSPORTATION

The availability of a transportation network to distribute products and provide raw materials is a major concern whenever industrial development is considered. While all of Ocean County and Eastern Central New Jersey suffers from a lack of modern transportation facilities, the proposed site makes a maximum usage of the transportation available.

Truck and car access to the site will be via U.S. Route #9. U.S. Route #9 highway is the main north/south commercial route through eastern Ocean County. While the highway is near its peak capacity during rush hours and summer weekends, adequate capacity is available during normal work hours and off hours. Additionally, the site has both north and south access to the Garden State Parkway via Exit 69, to the south in Ocean Township and Exit 74, to the north.

Direct access to either rail or barge facilities will become a possibility if the proposed FR#I should be converted from the currently proposed nuclear fired plant to fossil fuel, specifically coal. The Central Railroad of New Jersey owns a right-of-way which bounds both the proposed industrial complex and the power plant site. If rail transportation of coal, as fuel, was to be initiated, the establishment of a rail siding at the proposed site would be a simple matter. If the coal were to be barged into FR#I, the dual usage of the dockage and ship channels would offer access to the most inexpensive bulk transportation system to any proposed industrial users.

Limited mass transportation along the Route #9 corridor is currently available through common carrier. Lacey Township, in conjunction with the Ocean County Planning Board, is working on establishing a rural transportation system to service the local transportation needs and to feed the established mass transit routes.

F. MUNICIPAL SERVICES

As is common in many rural and suburban communities, standard municipal services are provided by a combination of private enterprise, governmental agencies and volunteer service groups.

1. Solid Waste Removal

The Township provides residential curbside garbage removal. All commercial and industrial sites are serviced by private haulers. The County is currently investigating the acquisition of several private commercial sanitary landfills for the establishment of regional solid waste management. It appears that the existing private carters will be able to satisfy the needs of the proposed industrial park.

2. Police Service

The municipal police force is geared to the expanded summer population of the Township which grows from a permanent population of 13,000 to seasonal level of 30,000. The time demands of periodic patrols and additional services will not place any strain on the existing police capacity. Additionally, if the industrial park or central heat system falls within the jurisdiction of J.C.P.&L., the power company maintains a private security force for its Oyster Creek Installation which could possibly include a limited role in the industrial complex.

3. Fire and Ambulance Service

Fire and First Aid services are provided by volunteer organizations. The proposed industrial usages are inherently non labor intensive. The local First Aid Squad will be capable of handling any proposed development. The local Fire Company, while primairly geared to the residential unit and forest fire threats, is well equipped. The Township has cooperated in providing suction stations throughout the eastern sections of the Township. The proximity of the intake canal will allow the industrial park to be designed to include a suction point fire station. Additional emergency water may be supplied through the well field proposed under other sections of this report. Local ordinances pertaining to industrial/commercial development include height limitations in keeping with the existing fire fighting equipment.

4. Sewer Service:

A regional collection and treatment system has been constructed and placed into operation. The system has been designed to handle a 20 MGD load with an ultimate capacity of 33 MGD. Due to revisions in land use control and population trends, current projection of sewer loads leaves 8 to 10 MGD excess capacity. The proposed industrial complex will not have a negative impact on the regional system. The local collection system does not extend to the proposed site, however, the regional collection main passes the northeast corner of the site. Tapping the collection system for the complex to the regional system will not require any special consideration as the regional system is in gravity flow at this point.

G. AIR AND WATER QUALITY

1. Water Quality

The impact of the quality of the bay water, power plant effluent, and groundwater on the proposed operation have received considerable attention in other segments of this report. Comments in this section will be limited to impacts resulting from construction and industrial park operation.

The Ocean County 208 Water Quality program has tested and cataloged all the fresh water streams in the county. The original testing station included both the South Branch and Middle Branch of the Forked River. The South Branch was deleted from the program when it was discovered that the existing intake canal had altered the stream to a tidal and salt water stream.

The following table excerpts were compiled over a three (3) year period from 1976 to 1978, by the County 208 program on the Middle Branch from a testing station at the Route #9 bridge. (Exhibit XI)

EXHIBIT XI

STORET DATE 78/12/29

OCEAN COUNTY DATA INVENTORY

OCNO-8 OCHD-048
39 49 39.0 074 12 05.0 2
MID BR FORKED RIVER ROUTE 9
34029 NEW JERSEY
NORTHEAST 013409
NEW JERSEY COASTAL
REG11208 771110
0000 CLASS 00

/TYPA/AMBNT/STREAM

INDEX 0134085
MILES 0000.00
PARAMETER

PARAMETER			NUMBER	MEAN	VARIANCE	STAN DEV.	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00070	TURB JKSN	JTU	62	2.43548	1.88922	1.37449	.564360	.174560	8.00000	1.00000	76/10/05	78/10/10
00299	DO PEOBE	MG/L	8	8.35000	1.66288	1.28953	.154434	.455916	10.2000	6.00000	78/03/30	78/10/10
00300	DO	MG/L	49	8.51014	3.72650	1.93041	.226837	.275773	12.0000	4.60000	76/10/05	78/04/10
00310	BOD 5 DAY	MC/L	11	1.83636	1.13855	1.06703	.581055	.321721	3.70000	.000000	76/10/20	78/09/13
00335	COD LOWLEVEL	MG/L	16	16.4687	92.3185	9.60825	.583424	2.40206	38.8000	6.40000	76/12/08	78/09/13
00340	COD HI LEVEL	MG/L	3	8.00000	16.0000	4.00000	.500000	2.30940	12.0000	4.00000	76/10/20	76/12/08
00400	PH	SU	64	4.13483	.088015	.296672	.071749	.037084	5.30000	3.50000	76/10/05	78/10/10
00436	ACIDITY MINERAL	MG/L	16	12.8667	38.6953	6.22055	.483463	1.60614	28.0000	3.00000	78/02/28	78/10/10
00500	RESIDUE TOTAL	MG/L	13	85.4000	11068.5	105.207	1.23193	29.1791	414.000	31.7000	76/10/05	78/10/10
00530	RESIDUE TOT NFLT	MG/L	45	2.02222	3.74950	1.93636	.957542	.288656	9.00000	1.00000	76/10/05	78/01/11
00940	CHLORIDE CL	MG/L	19	10.000	206.222	14.3604	1.43604	3.29451	69.00000	4.00000	76/10/20	78/10/10
01045	IRON FE,TOT	UG/L	6	651.666	81537.0	285.547	.438179	116.574	1090.00	320.000	78/07/05	78/10/10
31613	FEC COLI M-FCAGAR	/100ML	58	17.7069	2135.37	46.2100	2.60972	6.06768	30.000	.000000	76/10/27	78/10/10

Reference taken from Ocean County 208 Program

The proposed development may have an impact on the water quality through the construction phase. Following the "Standards for Soil Erosion and Sediment Control in New Jersey" published by the New Jersey Department of Agriculture should control runoff and sediment to minimize any stream degradation. (Exhibit XII)

As all the proposed processes are in a controlled environment no impacts on water quality are anticipated as a function of their operation. The long term effects on existing water quality would be related to the storm water collection and discharge system. With careful design and employing retention and detention basins to limit runoff, any negative impacts on the existing water quality can be controlled.

2. Air Quality

In general the air quality in Ocean County is very good when compared to New Jersey Department of Environmental Protection standards for air quality. Attached is data obtained from New Jersey Department of Environmental Protection from their nearest continuous monitoring station which is located in Toms River, New Jersey, approximately 10 miles north of the proposed site, and data from the Department of Environmental Protection Intermediate stations in Toms River, Waretown,(immediately to the south of the site), and Island Beach State Park. Without specific industry and process information full analysis of air quality is not possible. The limits of low labor intensive industries and the process water

EXHIBIT XII

TOMS RIVER
AIR QUALITY IN NEW JERSEY COMPARED WITH STANDARDS

SULFUR DIOXIDE
PARTS PER MILLION

Standards: 3-Hour Secondary 0.5 ppm; 24-Hour Primary 0.14 ppm; 24-Hour Secondary 0.10 ppm; 12-Month Primary .03 ppm; 12-Month Secondary .02 ppm

1977	% Valid Data	Hourly Avg. Max.	Hourly Avg. 2nd	3-Hr. Average Max.	3-Hr. Average 2nd	Times > 0.5	24-Hr. Average Max.	24-Hr. Average 2nd	Times > 0.14	Times > 0.10	Monthly Avg.	12-Month Moving Avg.
JAN	77.4	0.074	0.066	0.064	0.064	0	0.041	0.038	0	0	0.023	.008
FEB	97.8	0.058	0.054	0.050	0.047	0	0.027	0.026	0	0	0.016	.009
MAR	98.1	0.042	0.036	0.037	0.034	0	0.020	0.016	0	0	0.008	.009
APR	98.2	0.081	0.066	0.057	0.054	0	0.011	0.009	0	0	0.004	.009
MAY	94.6	0.035	0.032	0.028	0.027	0	0.012	0.012	0	0	0.006	.009
JUNE	94.6	0.043	0.042	0.040	0.039	0	0.016	0.009	0	0	0.005	.009
JULY	81.3	0.026	0.023	0.022	0.020	0	0.010	0.010	0	0	0.006	.009
AUG	90.6	0.024	0.022	0.019	0.018	0	0.008	0.007	0	0	0.004	.009
SEPT	99.0	0.025	0.020	0.022	0.020	0	0.009	0.008	0	0	0.004	.009
OCT	94.1	0.039	0.039	0.038	0.036	0	0.027	0.018	0	0	0.007	.009
NOV	97.5	0.033	0.028	0.027	0.026	0	0.017	0.017	0	0	0.007	.009
DEC	78.4	0.064	0.044	0.047	0.037	0	0.023	0.019	0	0	0.012	.009
YEAR		0.081	0.074	0.064	0.064	0	0.041	0.038	0	0		

1978	% Valid Data	Hourly Avg. Max.	Hourly Avg. 2nd	3-Hr. Average Max.	3-Hr. Average 2nd	Times > 0.5	24-Hr. Average Max.	24-Hr. Average 2nd	Times > 0.14	Times > 0.10	Monthly Avg.	12-Month Moving Avg.
JAN	67.9	0.056	0.052	0.052	0.047	0	0.028	0.025	0	0	0.014	.009
FEB	98.5	0.085	0.083	0.083	0.077	0	0.050	0.038	0	0	0.023	.009
MAR	74.7	0.124	0.089	0.098	0.095	0	0.042	0.026	0	0	0.018	.009
APR	97.6	0.057	0.053	0.044	0.043	0	0.025	0.020	0	0	0.011	.010
MAY	90.5	0.052	0.052	0.043	0.041	0	0.015	0.014	0	0	0.007	.010
JUNE	76.8	0.035	0.034	0.029	0.029	0	0.010	0.009	0	0	0.005	.010
JULY	87.1	0.020	0.020	0.017	0.017	0	0.008	0.007	0	0	0.005	.010
AUG	98.8	0.036	0.029	0.025	0.024	0	0.012	0.011	0	0	0.005	.010
SEPT	70.7	0.019	0.017	0.018	0.016	0	0.009	0.009	0	0	0.005	.010
OCT	84.9	0.039	0.039	0.035	0.030	0	0.015	0.013	0	0	0.004	.010
NOV	86.0	0.047	0.045	0.043	0.041	0	0.025	0.024	0	0	0.013	.010
DEC	69.1	0.039	0.036	0.035	0.032	0	0.018	0.017	0	0	0.010	.010
YEAR		0.124	0.089	0.098	0.095	0	0.050	0.042	0	0		

EXHIBIT XII

Toms River

AIR QUALITY IN NEW JERSEY COMPARED WITH STANDARDS

CARBON MONOXIDE
PARTS PER MILLION

STANDARDS: 1-Hour Primary and Secondary 35 ppm
8-Hour Primary and Secondary 9 ppm

a) Indicates Non-Overlapping 8-Hour Time Periods Were Considered

1977	% Valid Data	Hourly Avg. Max.	Hourly Avg. 2nd	Times ≥ 35	8-Hour Moving Avg. Max.	8-Hour Moving Avg. 2nd	8-Hour Moving Avg. 2nd[a]	Times ≥ 9	Times[a] ≥ 9	Daily Avg.	Monthly Avg.	12-Month Avg.
JAN	77.3	30.2	21.6	0	13.9	11.3	11.3	16	3	6.4	3.3	–
FEB	96.6	16.0	16.0	0	10.9	10.9	10.9	23	5	6.6	3.6	4.32
MAR	97.2	14.5	13.1	0	9.9	9.9	9.5	9	3	6.2	3.7	4.37
APR	98.1	13.2	12.7	0	10.9	10.6	8.3	6	1	5.4	3.2	4.27
MAY	96.8	12.8	10.9	0	9.4	9.4	7.5	2	1	5.4	3.1	4.02
JUNE	99.0	13.8	13.4	0	12.2	11.9	8.9	8	1	6.5	3.6	3.84
JULY	69.4	13.0	12.8	0	10.9	10.9	8.9	8	1	6.8	3.6	3.80
AUG	95.8	13.9	12.8	0	11.3	11.3	9.3	10	2	6.4	4.0	3.78
SEPT	99.0	17.0	16.6	0	12.2	12.1	11.0	24	4	7.3	4.3	3.78
OCT	94.1	16.6	16.4	0	12.9	12.8	12.7	41	8	8.3	3.9	3.73
NOV	95.8	16.2	16.0	0	13.1	13.1	9.8	12	2	6.9	3.5	3.67
DEC	79.0	19.2	16.9	0	15.2	15.2	12.2	17	3	9.2	3.7	3.63
YEAR		30.2	21.6	0	15.2	15.2	13.9	177	34	9.2		3.6

1978	% Valid Data	Hourly Avg. Max.	Hourly Avg. 2nd	Times ≥ 35	8-Hour Moving Avg. Max.	8-Hour Moving Avg. 2nd	8-Hour Moving Avg. 2nd[a]	Times ≥ 9	Times[a] ≥ 9	MAX Daily Avg.	Monthly Avg.	12-Month Avg.
JAN	70.2	13.6	13.4	0	9.1	9.1	8.9	2	1	6.4	3.4	3.63
FEB	99.1	15.8	15.7	0	11.7	11.3	10.3	29	5	8.0	4.0	3.67
MAR	74.3	15.7	14.3	0	9.8	9.7	9.5	9	4	6.4	2.8	3.59
APR	97.6	9.1	9.1	0	7.3	7.2	6.1	0	0	3.6	1.7	3.47
MAY	90.3	16.5	15.7	0	12.1	12.1	11.8	19	3	8.3	3.8	3.53
JUNE	81.9	12.3	12.0	0	9.8	9.4	9.1	4	2	6.5	3.9	3.55
JULY	95.8	11.0	10.6	0	9.4	9.2	7.3	2	1	6.3	3.0	3.50
AUG	98.7	18.7	13.0	0	10.7	10.5	9.8	8	2	5.6	3.1	3.43
SEPT	90.7	17.3	12.6	0	9.4	9.2	8.8	2	1	6.0	3.5	3.36
OCT	85.3	17.5	17.0	0	14.6	14.0	10.0	25	5	9.9	4.2	3.38
NOV	89.0	31.1	24.7	0	17.5	18.4	13.7	20	5	9.9	4.2	3.44
DEC	78.5	12.1	11.6	0	7.9	7.9	7.9	0	0	5.8	3.2	3.40
YEAR		31.1	24.7	0	18.5	18.4	14.6	120	29	9.9		

EXHIBIT XII

TOMS RIVER
AIR QUALITY IN NEW JERSEY COMPARED WITH STANDARDS

SMOKE SHADE
COEFFICIENT OF HAZE(COHS)

STANDARDS: NO AIR QUALITY STANDARDS HAVE BEEN ESTABLISHED

1977	% Valid Data	Hourly Avg. Max.	Hourly Avg. 2nd	24-Hour Avg. Max.	24-Hour Avg. 2nd	Monthly Avg.	12-Month Moving Avg.
JAN	75.4	3.18	2.82	1.46	1.29	0.94	0.55
FEB	87.4	3.68	2.71	1.21	1.21	0.76	0.58
MAR	98.0	3.04	2.43	0.93	0.83	0.47	0.59
APR	96.1	2.05	1.87	0.81	0.77	0.42	0.60
MAY	88.6	2.07	1.54	0.69	0.64	0.43	0.60
JUNE	99.0	1.25	1.22	0.64	0.59	0.40	0.61
JULY	46.4	2.45	2.18	0.92	0.80	0.58	0.61
AUG	71.2	1.85	1.78	0.82	0.71	0.54	0.60
SEPT	99.0	1.63	1.60	0.92	0.73	0.46	0.60
OCT	82.5	1.87	1.86	0.88	0.80	0.45	0.59
NOV	96.0	3.59	2.90	1.90	1.55	0.75	0.59
DEC	(47.8)	4.23	3.47	2.09	1.69	(1.08)	0.61
YEAR		4.23	3.68	2.09	1.90		

1978	% Valid Data	Hourly Avg. Max.	Hourly Avg. 2nd	24-Hour Avg. Max.	24-Hour Avg. 2nd	Monthly Avg.	12-Month Moving Avg.
JAN	67.2	3.45	2.87	1.23	1.12	0.64	0.58
FEB	68.5	3.92	3.38	1.97	1.83	1.18	0.62
MAR	74.3	4.52	3.84	1.65	1.63	0.92	0.65
APR	88.6	2.69	2.61	1.72	0.82	0.57	0.67
MAY	82.9	2.68	2.56	2.00	1.02	0.70	0.69
JUNE	63.8	2.75	2.72	1.33	1.22	0.58	0.70
JULY	94.4	2.58	2.54	1.31	1.09	0.38	0.69
AUG	98.7	1.79	1.67	1.04	0.96	0.57	0.69
SEPT	77.5	3.22	2.59	1.48	1.46	0.92	0.73
OCT	77.0	2.17	2.12	1.49	1.34	1.02	0.78
NOV	54.3	2.22	2.17	1.71	1.34	0.48	0.75
DEC	(32.7)	1.88	1.87	1.44	1.16	0.63	0.72
YEAR		4.52	3.92	2.00	1.97		

EXHIBIT XII

NEW JERSEY STATE BUREAU OF AIR POLLUTION CONTROL
SUSPENDED PARTICULATE CONCENTRATIONS FROM HIGH-VOLUME AIR SAMPLERS

Sampler No. 040 Municipality TOMS RIVER (DOVER TOWNSHIP) Year 1978

Address MUNICIPAL BLDG., 33 WASHINGTON STREET

DAILY CONCENTRATIONS

No.	Date	Day	Conc	No.	Date	Day	Conc
1	Jan 2	Mon	–	31	Jul 1	Sat	37
2	8	Sun	41	32	7	Fri	62
3	14	Sat	33	33	13	Thu	62
4	20	Fri	–	34	19	Wed	68
5	26	Thu	39	35	25	Tue	20
				36	31	Mon	50
6	Feb 1	Wed	–				
7	7	Tue	–	37	Aug 6	Sun	–
8	13	Mon	43	38	12	Sat	33
9	19	Sun	70	39	18	Fri	56
10	25	Sat	45	40	24	Thu	28
				41	30	Wed	67
11	Mar 3	Fri	40				
12	9	Thu	47	42	Sep 5	Tue	–
13	15	Wed	65	43	11	Mon	–
14	21	Tue	51	44	17	Sun	–
15	27	Mon	43	45	23	Sat	30
				46	29	Fri	33
16	Apr 2	Sun	97				
17	8	Sat	42	47	Oct 5	Thu	33
18	14	Fri	68	48	11	Wed	54
19	20	Thu	28	49	17	Tue	41
20	26	Wed	–	50	23	Mon	68
				51	29	Sun	37
21	May 2	Tue	26				
22	8	Mon	36	52	Nov 4	Sat	59
23	14	Sun	83	53	10	Fri	97
24	20	Sat	34	54	16	Thu	24
25	26	Fri	50	55	22	Wed	89
				56	28	Tue	50
26	Jun 1	Thu	78				
27	7	Wed	67	57	Dec 4	Mon	–
28	13	Tue	37	58	10	Sun	17
29	19	Mon	–	59	16	Sat	34
30	25	Sun	46	60	22	Fri	75
				61	28	Thu	32

CLASS INTERVAL DATA

No.	Conc Range	Number in Interval	Cumulative Percent
1	0-10		
2	11-20	2	4.0
3	21-30	5	14.0
4	31-40	13	40.0
5	41-50	11	62.0
6	51-60	4	70.0
7	61-65	3	76.0
8	66-70	6	88.0
9	71-75	1	90.0
10	76-80	1	92.0
11	81-90	2	96.0
12	91-100	2	100.0
13	101-125		
14	126-150		
15	151-175		
16	176-195		
17	196-260		
18	261-300		
19	301+		

Conc = Concentration of suspended particulates in micrograms per cubic meter of air, $\mu g/m^3$.

Arithmetic and geometric means, minimum, maximum, and standard deviation all in $\mu g/m^3$. Standard geometric deviation is dimensionless.

SUMMARY OF STATISTICS

Number of Samples	Min	Max	Arithmetic Mean	Standard Deviation	Geometric Mean	Standard Geometric Deviation	Samples Above 260 $\mu g/m^3$	Samples Above 150 $\mu g/m^3$
50	17	97	49.3	19.6	45.6	1.496	0	0

EXHIBIT XII

NEW JERSEY STATE BUREAU OF AIR POLLUTION CONTROL
SUSPENDED PARTICULATE CONCENTRATIONS FROM HIGH-VOLUME AIR SAMPLERS

Sampler No. 040 Municipality Toms River (Dover Twp.) Year 197

Address Municipal Bldg., 33 Washington Street

DAILY CONCENTRATIONS

No.	Date	Day	Conc	No.	Date	Day	Conc
1	Jan 1	Wed	39	32	Jul 6	Sun	53
2	7	Tue	49	33	12	Sat	35
3	13	Mon	-	34	18	Fri	72
4	19	Sun	42	35	24	Thu	63
5	25	Sat	42	36	30	Wed	30
6	31	Fri	56				
				37	Aug 5	Tue	73
7	Feb 6	Thu	33	38	11	Mon	61
8	12	Wed	69	39	17	Sun	42
9	18	Tue	55	40	23	Sat	59
10	24	Mon	36	41	29	Fri	-
11	Mar 2	Sun	43	42	Sep 4	Thu	-
12	8	Sat	48	43	10	Wed	42
13	14	Fri	35	44	16	Tue	45
14	20	Thu	29	45	22	Mon	31
15	26	Wed	22	46	28	Sun	39
16	Apr 1	Tue	43	47	Oct 4	Sat	31
17	7	Mon	34	48	10	Fri	32
18	13	Sun	91	49	16	Thu	44
19	19	Sat	71	50	22	Wed	65
20	25	Fri	49	51	28	Tue	62
21	May 1	Thu	47	52	Nov 3	Mon	49
22	7	Wed	46	53	9	Sun	-
23	13	Tue	76	54	15	Sat	55
24	19	Mon	58	55	21	Fri	-
25	25	Sun	40	56	27	Thu	28
26	31	Sat	31				
				57	Dec 3	Wed	35
27	Jun 6	Fri	33	58	9	Tue	52
28	12	Thu	41	59	15	Mon	31
29	18	Wed	50	60	21	Sun	20
30	24	Tue	44	61	27	Sat	57
31	30	Mon	62				

CLASS INTERVAL DATA

No.	Conc Range	Number in Interval	Cumulati Percent
1	0-10	0	0.0
2	11-20	1	1.8
3	21-30	4	8.9
4	31-40	15	35.7
5	41-50	17	66.1
6	51-60	8	80.4
7	61-65	5	89.3
8	66-70	1	91.1
9	71-75	3	96.4
10	76-80	1	98.2
11	81-90	0	98.2
12	91-100	1	100.0
13	101-125		
14	126-150		
15	151-175		
16	176-195		
17	196-260		
18	261-300		
19	301+		

Conc = Concentration of suspen particulates in microgr per cubic meter of air, $\mu g/m^3$.

Arithmetic and geometric means minimum, maximum, and standard deviation all in $\mu g/m^3$. Standard geometric deviation i dimensionless.

SUMMARY OF STATISTICS

Number of Samples	Min	Max	Arith-metic Mean	Standard Deviation	Geo-metric Mean	Standard Geometric Deviation	Samples Above 260 $\mu g/m^3$	Samples Above 150 $\mu g/m^3$
56	20	91	46.8	14.8	44.5	1.375	0	0

EXHIBIT XII

NEW JERSEY STATE BUREAU OF AIR POLLUTION CONTROL
SUSPENDED PARTICULATE CONCENTRATIONS FROM HIGH-VOLUME AIR SAMPLERS

Sampler No. S23 Municipality Waretown (Ocean Township) Year 1978

Address Elementary School, Railroad Avenue

DAILY CONCENTRATIONS

No.	Date	Day	Conc	No.	Date	Day	Conc
1	Jan 2	Mon	21	31	Jul 1	Sat	28
2	8	Sun	26	32	7	Fri	44
3	14	Sat	15	33	13	Thu	41
4	20	Fri	25	34	19	Wed	47
5	26	Thu	39	35	25	Tue	23
				36	31	Mon	40
6	Feb 1	Wed	53				
7	7	Tue	25	37	Aug 6	Sun	18
8	13	Mon	27	38	12	Sat	24
9	19	Sun	24	39	18	Fri	62
10	25	Sat	45	40	24	Thu	79
				41	30	Wed	54
11	Mar 3	Fri	29				
12	9	Thu	--	42	Sep 5	Tue	32
13	15	Wed	33	43	11	Mon	26
14	21	Tue	43	44	17	Sun	--
15	27	Mon	19	45	23	Sat	20
				46	29	Fri	28
16	Apr 2	Sun	16				
17	8	Sat	21	47	Oct 5	Thu	--
18	14	Fri	32	48	11	Wed	58
19	20	Thu	31	49	17	Tue	28
20	26	Wed	--	50	23	Mon	28
				51	29	Sun	25
21	May 2	Tue	48				
22	8	Mon	35	52	Nov 4	Sat	47
23	14	Sun	28	53	10	Fri	75
24	20	Sat	68	54	16	Thu	19
25	26	Fri	43	55	22	Wed	61
				56	28	Tue	30
26	Jun 1	Thu	73				
27	7	Wed	61	57	Dec 4	Mon	25
28	13	Tue	21	58	10	Sun	--
29	19	Mon	48	59	16	Sat	34
30	25	Sun	45	60	22	Fri	26
				61	28	Thu	12

CLASS INTERVAL DATA

No.	Conc Range	Number in Interval	Cumulative Percent
1	0-10		
2	11-20	7	12.5
3	21-30	21	50.0
4	31-40	8	64.3
5	41-50	10	82.1
6	51-60	3	87.5
7	61-65	3	92.9
8	66-70	1	94.6
9	71-75	2	98.2
10	76-80	1	100.0
11	81-90		
12	91-100		
13	101-125		
14	126-150		
15	151-175		
16	176-195		
17	196-260		
18	261-300		
19	301+		

Conc = Concentration of suspended particulates in micrograms per cubic meter of air, µg/m^3.

Arithmetic and geometric means, minimum, maximum, and standard deviation all in µg/m^3. Standard geometric deviation is dimensionless.

SUMMARY OF STATISTICS

Number of Samples	Min	Max	Arithmetic Mean	Standard Deviation	Geometric Mean	Standard Geometric Deviation	Samples Above 260 µg/m^3	Samples Above 150 µg/m^3
56	12	79	36.2	16.4	32.9	1.552	0	0

EXHIBIT XII

NEW JERSEY STATE BUREAU OF AIR POLLUTION CONTROL
SUSPENDED PARTICULATE CONCENTRATIONS FROM HIGH-VOLUME AIR SAMPLERS

Sampler No. S23 Municipality Waretown (Ocean Twp.) Year 19

Address Waretown Elementary School, Railroad Ave.

DAILY CONCENTRATIONS

No.	Date	Day	Conc	No.	Date	Day	Conc
1	Jan 1	Wed	22	32	Jul 6	Sun	48
2	7	Tue	28	33	12	Sat	30
3	13	Mon	31	34	18	Fri	73
4	19	Sun	35	35	24	Thu	53
5	25	Sat	34	36	30	Wed	53
6	31	Fri	25				
				37	Aug 5	Tue	58
7	Feb 6	Thu	21	38	11	Mon	57
8	12	Wed	--	39	17	Sun	31
9	18	Tue	--	40	23	Sat	64
10	24	Mon	17	41	29	Fri	43
11	Mar 2	Sun	19	42	Sep 4	Thu	--
12	8	Sat	32	43	10	Wed	37
13	14	Fri	18	44	16	Tue	59
14	20	Thu	16	45	22	Mon	36
15	26	Wed	11	46	28	Sun	29
16	Apr 1	Tue	27	47	Oct 4	Sat	22
17	7	Mon	22	48	10	Fri	23
18	13	Sun	61	49	16	Thu	38
19	19	Sat	56	50	22	Wed	55
20	25	Fri	32	51	28	Tue	57
21	May 1	Thu	38	52	Nov 3	Mon	25
22	7	Wed	39	53	9	Sun	50
23	13	Tue	63	54	15	Sat	42
24	19	Mon	42	55	21	Fri	18
25	25	Sun	29	56	27	Thu	22
26	31	Sat	26				
				57	Dec 3	Wed	25
27	Jun 6	Fri	21	58	9	Tue	22
28	12	Thu	--	59	15	Mon	17
29	18	Wed	--	60	21	Sun	18
30	24	Tue	32	61	27	Sat	32
31	30	Mon	51				

CLASS INTERVAL DATA

No.	Conc Range	Number in Interval	Cumulati Percent
1	0-10	0	0.0
2	11-20	8	14.3
3	21-30	17	44.6
4	31-40	13	67.9
5	41-50	5	76.8
6	51-60	9	92.9
7	61-65	3	98.2
8	66-70	0	98.2
9	71-75	1	100.0
10	76-80		
11	81-90		
12	91-100		
13	101-125		
14	126-150		
15	151-175		
16	176-195		
17	196-260		
18	261-300		
19	301+		

Conc = Concentration of suspen particulates in microgr per cubic meter of air, $\mu g/m^3$.

Arithmetic and geometric means minimum, maximum, and standard deviation all in $\mu g/m^3$. Standard geometric deviation i dimensionless.

SUMMARY OF STATISTICS

Number of Samples	Min	Max	Arithmetic Mean	Standard Deviation	Geometric Mean	Standard Geometric Deviation	Samples Above 260 $\mu g/m^3$	Samples Above 150 $\mu g/m^3$
56	11	73	35.4	15.3	32.3	1.553	0	0

EXHIBIT XII

NEW JERSEY STATE BUREAU OF AIR POLLUTION CONTROL
SUSPENDED PARTICULATE CONCENTRATIONS FROM HIGH-VOLUME AIR SAMPLERS

Sampler No. S16 Municipality Island Beach State Park Year 1978

Address Number 2 Bath House

DAILY CONCENTRATIONS

No.	Date	Day	Conc	No.	Date	Day	Conc
1	Jan 2	Mon	26	31	Jul 1	Sat	27
2	8	Sun	66	32	7	Fri	49
3	14	Sat	141	33	13	Thu	34
4	20	Fri	--	34	19	Wed	39
5	26	Thu	59	35	25	Tue	52
				36	31	Mon	64
6	Feb 1	Wed	--				
7	7	Tue	--	37	Aug 6	Sun	62
8	13	Mon	40	38	12	Sat	48
9	19	Sun	57	39	18	Fri	67
10	25	Sat	32	40	24	Thu	71
				41	30	Wed	69
11	Mar 3	Fri	39				
12	9	Thu	--	42	Sep 5	Tue	38
13	15	Wed	49	43	11	Mon	27
14	21	Tue	33	44	17	Sun	56
15	27	Mon	40	45	23	Sat	41
				46	29	Fri	23
16	Apr 2	Sun	13				
17	8	Sat	20	47	Oct 5	Thu	92
18	14	Fri	26	48	11	Wed	63
19	20	Thu	30	49	17	Tue	43
20	26	Wed	27	50	23	Mon	49
				51	29	Sun	33
21	May 2	Tue	27				
22	8	Mon	83	52	Nov 4	Sat	55
23	14	Sun	52	53	10	Fri	85
24	20	Sat	80	54	16	Thu	38
25	26	Fri	48	55	22	Wed	60
				56	28	Tue	27
26	Jun 1	Thu	65				
27	7	Wed	36	57	Dec 4	Mon	54
28	13	Tue	19	58	10	Sun	13
29	19	Mon	51	59	16	Sat	16
30	25	Sun	52	60	22	Fri	36
				61	28	Thu	17

CLASS INTERVAL DATA

No.	Conc Range	Number in Interval	Cumulative Percent
1	0-10		
2	11-20	6	10.5
3	21-30	9	26.3
4	31-40	12	47.4
5	41-50	7	59.6
6	51-60	10	77.2
7	61-65	4	84.2
8	66-70	3	89.5
9	71-75	1	91.2
10	76-80	1	93.0
11	81-90	2	96.5
12	91-100	1	98.2
13	101-125	-	
14	126-150	1	100.0
15	151-175		
16	176-195		
17	196-260		
18	261-300		
19	301+		

Conc = Concentration of suspended particulates in micrograms per cubic meter of air, µg/m³.

Arithmetic and geometric means, minimum, maximum, and standard deviation all in µg/m³. Standard geometric deviation is dimensionless.

SUMMARY OF STATISTICS

Number of Samples	Min	Max	Arithmetic Mean	Standard Deviation	Geometric Mean	Standard Geometric Deviation	Samples Above 260 µg/m³	Samples Above 150 µg/m³
57	13	141	46.6	22.8	41.6	1.644	0	0

EXHIBIT XII

NEW JERSEY STATE BUREAU OF AIR POLLUTION CONTROL
SUSPENDED PARTICULATE CONCENTRATIONS FROM HIGH-VOLUME AIR SAMPLERS

Sampler No. S16 Municipality Island Beach St. Park Year 1977

Address Number 2 Bath House

DAILY CONCENTRATIONS

No.	Date	Day	Conc	No.	Date	Day	Conc
1	Jan 1	Wed	19	32	Jul 6	Sun	52
2	7	Tue	49	33	12	Sat	41
3	13	Mon	29	34	18	Fri	70
4	19	Sun	32	35	24	Thu	40
5	25	Sat	32	36	30	Wed	43
6	31	Fri	21				
				37	Aug 5	Tue	52
7	Feb 6	Thu	15	38	11	Mon	54
8	12	Wed	60	39	17	Sun	40
9	18	Tue	33	40	23	Sat	70
10	24	Mon	32	41	29	Fri	32
11	Mar 2	Sun	21	42	Sep 4	Thu	-
12	8	Sat	35	43	10	Wed	25
13	14	Fri	22	44	16	Tue	21
14	20	Thu	28	45	22	Mon	32
15	26	Wed	22	46	28	Sun	-
16	Apr 1	Tue	34	47	Oct 4	Sat	11
17	7	Mon	21	48	10	Fri	24
18	13	Sun	78	49	16	Thu	-
19	19	Sat	70	50	22	Wed	58
20	25	Fri	67	51	28	Tue	-
21	May 1	Thu	42	52	Nov 3	Mon	61
22	7	Wed	62	53	9	Sun	-
23	13	Tue	73	54	15	Sat	35
24	19	Mon	70	55	21	Fri	18
25	25	Sun	33	56	27	Thu	33
26	31	Sat	34				
				57	Dec 3	Wed	-
27	Jun 6	Fri	33	58	9	Tue	57
28	12	Thu	51	59	15	Mon	119
29	18	Wed	43	60	21	Sun	38
30	24	Tue	25	61	27	Sat	42
31	30	Mon	51				

CLASS INTERVAL DATA

No.	Conc Range	Number in Interval	Cumulative Percent
1	0-10	0	0.0
2	11-20	4	7.3
3	21-30	11	27.3
4	31-40	16	56.4
5	41-50	6	67.3
6	51-60	8	81.8
7	61-65	2	85.5
8	66-70	5	94.5
9	71-75	1	96.4
10	76-80	1	98.2
11	81-90	0	98.2
12	91-100	0	98.2
13	101-125	1	100.0
14	126-150		
15	151-175		
16	176-195		
17	196-260		
18	261-300		
19	301+		

Conc = Concentration of suspende particulates in microgram per cubic meter of air, $\mu g/m^3$.

Arithmetic and geometric means, minimum, maximum, and standard deviation all in $\mu g/m^3$. Standard geometric deviation is dimensionless.

SUMMARY OF STATISTICS

Number of Samples	Min	Max	Arithmetic Mean	Standard Deviation	Geometric Mean	Standard Geometric Deviation	Samples Above 260 $\mu g/m^3$	Samples Above 150 $\mu g/m^3$
55	11	119	41.9	20.1	37.6	1.606	0	0

temperatures available seem to indicate that any industry locating in the industrial park will have minimal impacts on air quality.

H. INFRASTRUCTURE

Lacey Township is basically a rural area which has experienced rapid growth over the last fifteen years. The rapid growth has caused several problems in local government maintaining infrastructure growth equivalent to population expansion. Ocean County has been the fastest growing county in the State for many years and Lacey Township has been a leader in individual community growth. The absence of a local property tax for municipal purposes has contributed greatly to the rapid growth. The Township has taken the following steps to handle the expanding growth.

1. Sewerage: The local sewer system is nearing completion and is being phased in as each section is inspected and accepted. In previous sections the availability of excess treatment capacity was discussed.
2. School: The rapid growth has caused an overcrowding and split sessions in the regional school system. Lacey Township is currently building a Middle School and High School to handle the Township's school population. The Middle School opened in September, 1980, and the High School is expected to be opened in September, 1981.

3. Storm Sewers: The collection and management of storm runoff is the responsibility of the individual developer. The Township has a master drainage plan covering the developed sections of the Township which is being constructed as funds are available. The industrial complex and its developer will be responsible to collect and dispose of the runoff generated by the development.

4. Tax Base: As stated earlier the municipal general purpose tax is zero.

I. AVAILABLE ACREAGE

Several sites for the industrial park were considered and the site immediately north of the power plant site was selected as the best available site.

The selection process included the following considerations:

1. Zoning: Only those areas zoned under the exisiting Township Zoning Ordinance for industrial use were considered.

2. Regional Land Use Control: All areas west of the Garden State Parkway were elimated. During the selection process, a moratorium was placed on all development in the "core" area of the Pinelands until the State's Master Plan for the Pinelands could be completed. The Master Plan for the "core" area has just been adopted which limits development to those uses traditionally associated with the Pinelands.

3. Central Services: The availability of central sewer service was a prime concern for any industrial development.

4. Relationship to Power Plant: The close proximity to the power plant was a prime factor in selection process. The relationship aids in reducing initial capital costs for piping and pumping.

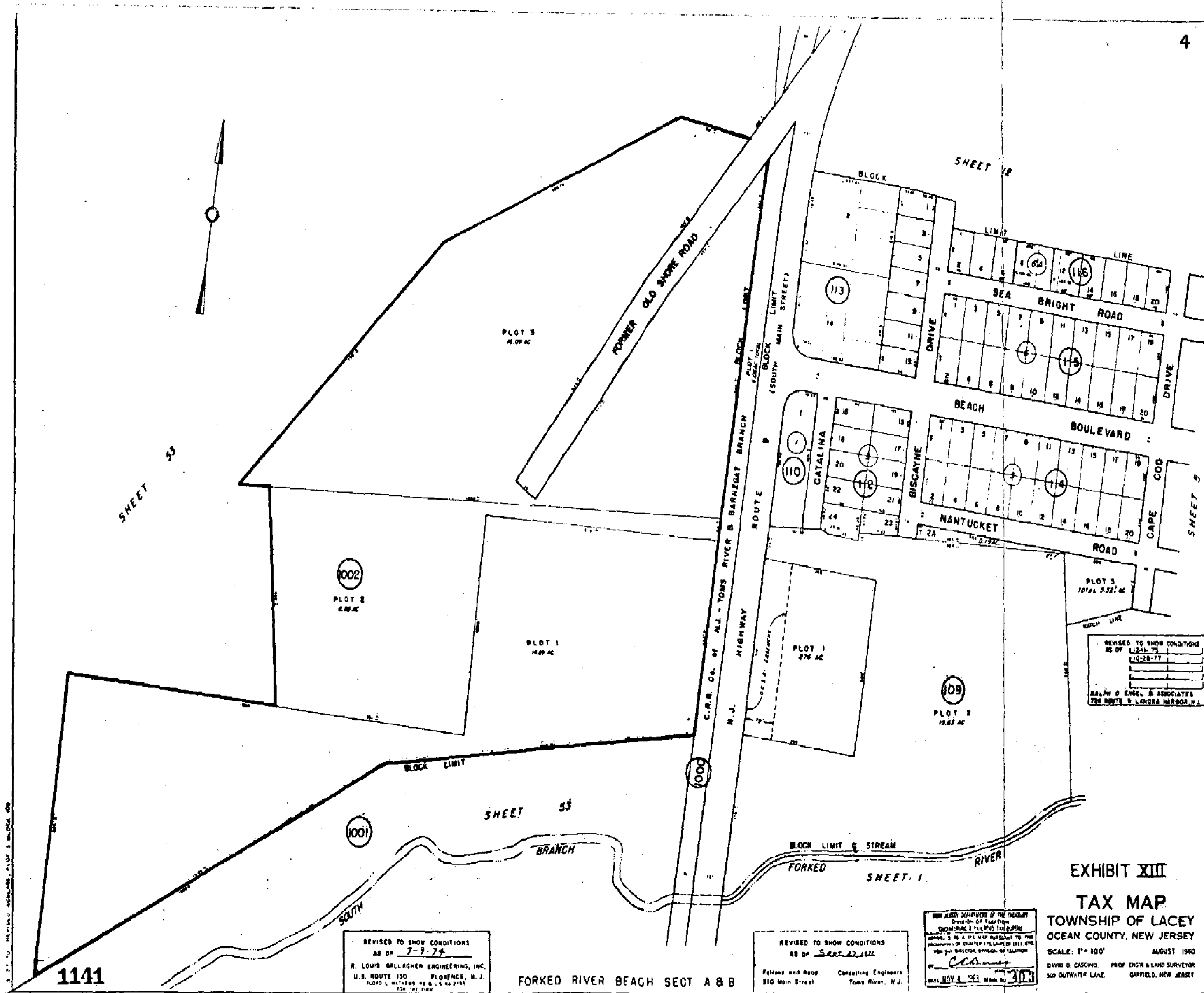
The attached copies of Lacey Township Tax Map Sheets 4 and 53, shows the area under consideration. The originally selected area included Plot 6 along the northern boundary, however, due to the soils none of that parcel of land would be developable and, as such, was eliminated from further consideration.

The availability of land for development and the amount of land actually developed is contingent on several factors. The economic considerations of initial investments for land, development costs, and interfacing will limit the local authority to a staged process. The demand for space by potential industrial users will influence the number of site developed at any one time. Additional land owned by JCP&L is available directly east of the power plant and possibly would be available should the demand for space warrant expansion of the complex. The land identified as the proposed site is currently owned by:

OWNER	LOT	BLOCK	ACRE
Hannan, R. % DCA*	1	1002	14.89±
DCA of N.J.	2	1002	6.83±
Hannan, R. % DCA	3	1002	16.08±
Lawrence Beach Co.	4	1002	34.34±
Finninger, Norman C. & Elsie	5	1002	338±
" " "	6	1002	68.22±
" " "	15	1024	35.49±

The Lacey Township Industrial Commission has had the property appraised for possible purchase. The owners have given the Industrial Commission options to purchase the property which are currently expired but considered renewable.

*Development Corporation of America (New Jersey Branch)


4
SHEET 12
BLOCK
LIMIT
LINE
SEA BRIGHT ROAD
DRIVE
BEACH BOULEVARD
CATALINA
BISCAYNE
NANTUCKET ROAD
CAPE COD DRIVE
SHEET 5
113
115
116
110
112
114
109
1000
1001
1002
PLOT 3
PLOT 2
PLOT 1
FORMER OLD SHORE ROAD
C.R.R. Co. of N.J. - TOMS RIVER & BARNEGAT BRANCH
N.J. HIGHWAY ROUTE 9
(SOUTH MAIN STREET)
BLOCK LIMIT
SHEET 53
BRANCH
SOUTH
BLOCK LIMIT & STREAM
FORKED RIVER
SHEET 1
1141
REVISED TO SHOW CONDITIONS AS OF 7-9-74
R. LOUIS GALLAGHER ENGINEERING, INC.
U.S. ROUTE 130 FLORENCE, N.J.
FORKED RIVER BEACH SECT A & B
REVISED TO SHOW CONDITIONS AS OF Sept 27 1972
Fellows and Read Consulting Engineers
310 Main Street Toms River, N.J.
REVISED TO SHOW CONDITIONS AS OF
RALPH O. ENGEL & ASSOCIATES
EXHIBIT XIII
TAX MAP
TOWNSHIP OF LACEY
OCEAN COUNTY, NEW JERSEY
SCALE: 1" = 100'
AUGUST 1960
DAVID O. CASCINO PROF. ENGR & LAND SURVEYOR
300 OUTWATER LANE GARFIELD, NEW JERSEY

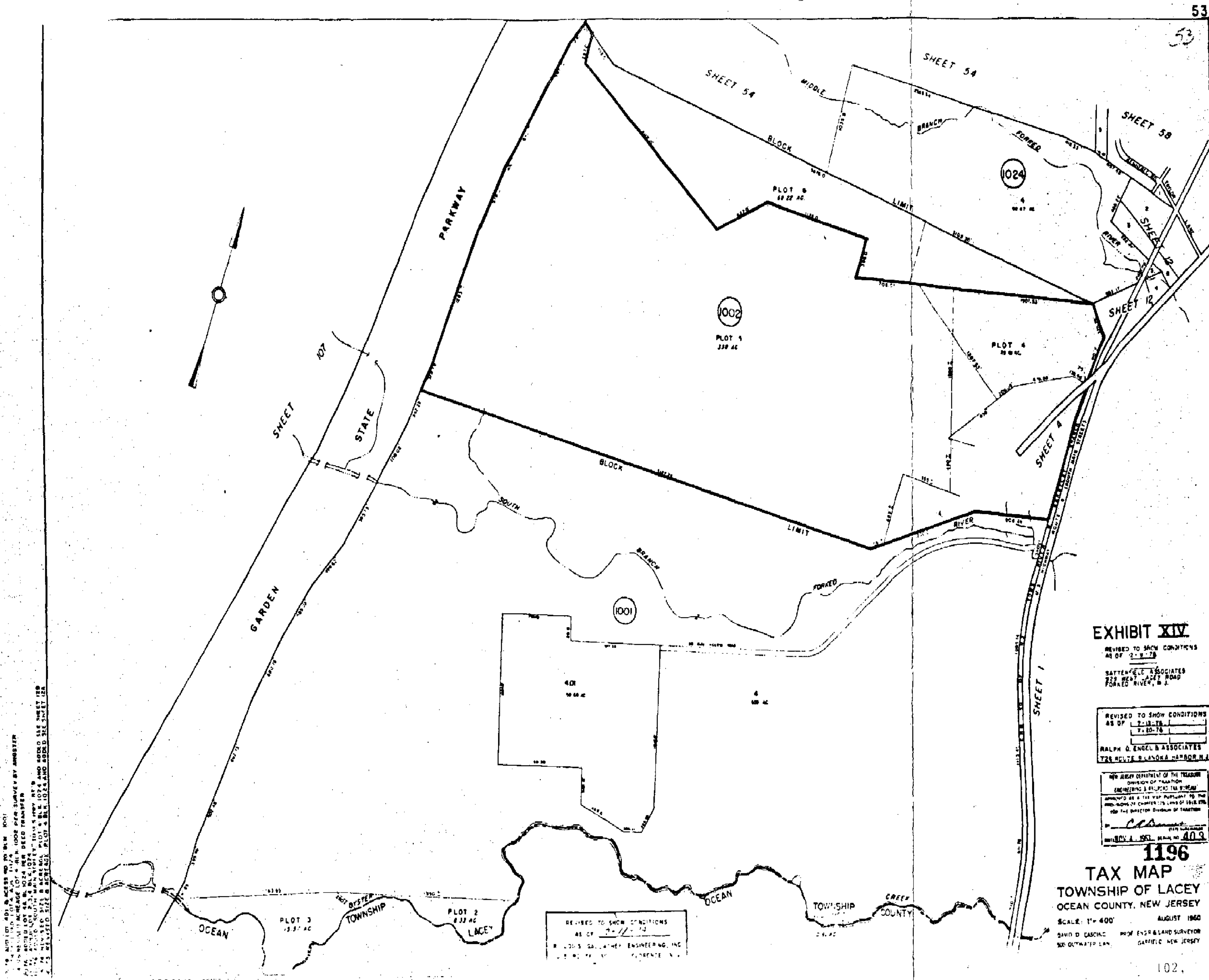


EXHIBIT XIV
REVISED TO SHOW CONDITIONS AS OF 2-9-78
SATTERFIELD ASSOCIATES
FORKED RIVER, N.J.
REVISED TO SHOW CONDITIONS AS OF 7-13-76 / 9-20-76
RALPH O. ENGEL & ASSOCIATES
1196
TAX MAP
TOWNSHIP OF LACEY
OCEAN COUNTY, NEW JERSEY
SCALE: 1"=400'
AUGUST 1960
SHEET 54
SHEET 58
SHEET 12
SHEET 4
SHEET 1
SHEET 107
1024
1002
1001
PLOT 1
PLOT 4
PLOT 9
PLOT 2
PLOT 3
BLOCK LIMIT
MIDDLE BRANCH FORKED RIVER
SOUTH BRANCH FORKED RIVER
GARDEN STATE PARKWAY
OCEAN TOWNSHIP
LACEY TOWNSHIP
OCEAN COUNTY
REVISED TO SHOW CONDITIONS

VII. ENVIRONMENTAL IMPACTS

VII. ENVIRONMENTAL IMPACTS

A. Construction Phase

1. Runoff & Sedimentation

Any major construction effort which involves the stripping of existing vegetation and the movement of fresh soil presents a potential for erosion and stream sedimentation. To control soil erosion and sedimentation the State enacted Chapter 251, of the Public Laws of 1975, known as the "Soil Erosion and Sediment Control Act". The act requires that all construction activities conform to the guidelines of the New Jersey Department of Agriculture. These guidelines are presented in "Standards for Soil Erosion and Sediment Control in New Jersey" available through the Department of Agriculture or the local Soil Conservation Districts. The implementation of of these guidelines through the local districts and the accompanying permit process requires that all development plans be reviewed and erosion control delineated. The review process and construction phase inspection effectively serve to mitigate the erosion and sedimentation impacts from construction activities.

The design of the proposed industrial park must take into account the large areas of Manahawkin Soils along the northern boundary of the site. This undevelopable area will serve as a sediment trap during the operation phase but is extremely fragile and quickly cut up and muddied by construction activity.

Care must be exercised in the design and construction of any industrial complex component which by necessity must cross these areas.

The erodibility of soil can be judged by the "K" factor used to calculate sediment losses. Soils can generally be classed as follows:

"K"	Erodibility Class
0.17 - 0.24	Low
0.28 - 0.37	Medium
0.43 - 0.49	High

(Ref. 15, p. A1.6)

The "K" factor for the soil found on the site other than the Manahawkin soils are:

Soil	"K" Factor	Class
Atsion	0.17	Low
Downer	0.24	Low
Lakehurst	0.17	Low
Lakewood	0.17	Low

(Ref. 16, pp. 72&73)

Full erosion control will be required during the design phase. The plan will include diversion berms to slow runoff, sediment traps to serve until vegetation cover can be established and construction entrance aprons to prevent sedimentation due to construction equipment traffic.

2. Air and Water Quality

The impacts on water quality are directly related to to the previous section as runoff and sedimentation will be the only water quality impact.

Construction phase air quality can be affected by two factors, both of a temporary nature.

The exhausts of the construction equipment could have an adverse effect on air quality by increasing both the carbon monoxide and nitrogen oxides concentrations, however, the proximity of both Route #9 and the Garden State Parkway will mask any increases caused by the construction activity.

The suspended solids may also be affected by dust generated by the construction activity. The standards on sediment and erosion control contain several recommendations for dust control. The type of control employed will be determined by the construction activity, equipment and time of year. The Ocean County Soil Conservation Service has classified only two (2) of the soils encountered on the site, the Lakehurst and Lakewood soils, both of which fall in the lowest class of soil susceptible to wind erosion.

3. Salt Deposition

Impacts of salt deposition, if any, on the construction phase will depend on the status of Forked River Unit #1 (FR#1) at the time of construction.

If the plant is not operative due to construction activities or economic reasons there will be no effects. Other sections of this report have indicated that maximum benefits will be realized by concurrent construction of FR#1 and the Lacey Energy Park.

If the Lacey Energy Park is constructed after the completion of FR#I and the activation of the cooling tower, the impacts of salt deposition will be no worse than is experienced in ocean front construction. Typical measures utilized to reduce the effects of the salty environment include the use of rust inhibitors, more frequent lubrication of moving parts, and washing of equipment to remove accumulated salt.

B. OPERATION PHASE

I. Water Quality

The effects of the proposed Lacey Energy Park on the existing water quality are dependent on several design functions. These factors include:

a. National Pollution Discharge Elimination System Permit: As it appears that large quantities of water will be returned to the bay at some point, a discharge permit will be required which will set maximum levels of contaminates which can be returned to the Bay water.

b. Industries: Within the framework of the discharge permit, the actual industries and industrial process will have an effect on the quality of the discharge. The aquaculture and mariculture usages will most likely require polishing ponds to reduce BOD and organic pollutant prior to discharging. Greenhouse applications may require some treatment if the water comes in direct contact with fertilizers or other nutrients. The biological recycling will have to discharge to the central sewerage system or an on site treatment system. As these examples indicate the type and size of each industrial usage will determine what, if any, pre-treatment will be required to meet National Pollution Discharge Elimination System Permit requirements.

c. Central Heat Sink: The power plant effluent will receive no further treatment with the exception of temperature reduction and will be discharged as is current practice or will be returned in a closed loop to the plant for further cooling and possible reuse.

d. Process Water: To reduce ground water extractions and for energy conservation reasons process water will be recycled through the heat sink whenever possible. For water not recycled see section (b) above.

e. Storm Water: Storm water collection and ultimate disposal is a detailed design function and will not be addressed in this report except to mention that sound design of collection and possible detention basin techniques can keep the runoff quality equal to, or better than, the runoff occurring naturally.

2. Air Quality

A review of previous sections, of this report, indicate that the industries proposed for this site, have little or no airborne emissions and the overall effect on air quality will be negligible.

3. Salt Deposition

The effects of salt deposition during the operating phase is closely tied to the size and operation of the Lacey Energy Park. The quantity of heat recoverable and quantity of effluent run through the Lacey Energy Park will have a direct reduction in the amount of salt discharged into the atmosphere.

Section IV of the report has shown that given the assumptions established for the proposed Lacey Energy Park without consideration for an expanded facility the reduction in terms of total volume are probably not significant.

The accomplished reduction in terms of ecological benefits cannot be addressed within the scope of this report, however, they may be of an order that is significant.

a. Construction Materials: Any material susceptible to corrosion from salt attack; i.e., steel, should be used only with great care.

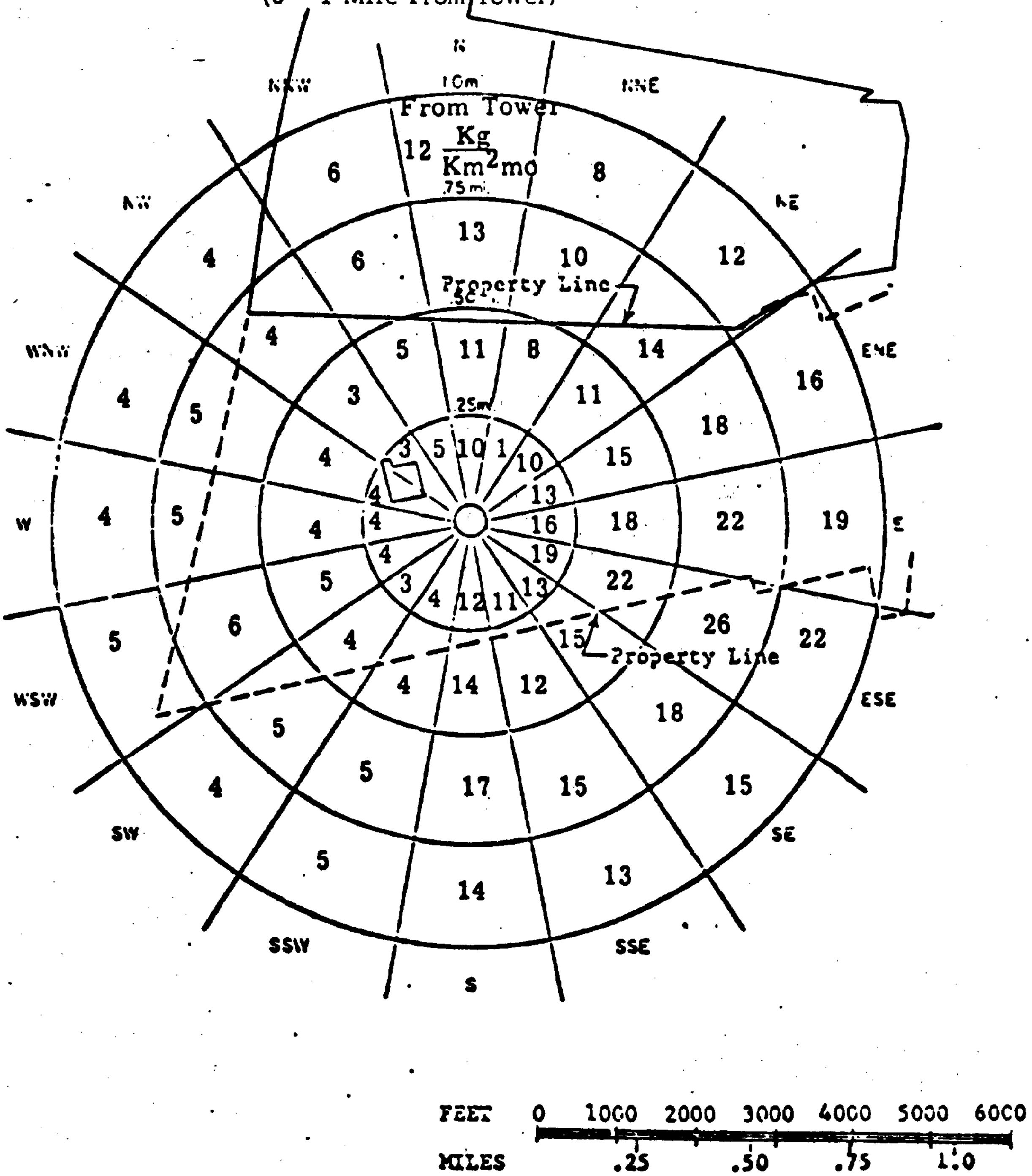
b. Salt Buildup: Any open air process, such as field grown crops or open air aquaculture, will have to be selected with the knowledge that a certain level of salt deposition is possible. The following chart, (Fig. 7) from the JCP&L study on the effects of the cooling tower, shows the rate of deposition expected under full load conditions. (Ref. 14, p.4-135)

   Additionally, the deposition of salt and salt buildup may require that greenhouse glass exteriors be washed down from time to time. Similarly the use of solar collectors as a supplimental heat source will require periodic cleaning to remove salt on the collection surfaces.

EXHIBIT XV.

FIGURE 7

PREDICTED AVERAGE ANNUAL GROUND DEPOSITION RATES (Kg/Km^2 mo)
OF SALT FROM FORKED RIVER COOLING TOWER
(0 - 1 Mile From Tower)



C. PHYSICAL IMPACTS

1. Sewer Service:

Due to high estimates of county growth potential and new land use controls, the regional sewer system has vast quantity of excess capacity. The treatment plant is designed for a 20 MGD loading with expansion to 33 MGD. Current estimates of existing flows are less than 6 MGD and the growth expected is now 10 to 12 MGD. The proposed Lacey Energy Park, with industrial pretreatment as required by the Ocean County Utilities Authorities will cause no negative effects on the sewer collection or treatment system.

2. Water Supply

The proposed system control heat service will require deep wells for water. The eventual developers can extend these wells to the individual tenants as a park service or require each user to obtain his water by private well.

The central wells and individual wells will require well permits and the central wells will require ground water diversion permits issued by the State.

There is no existing central water supply system in Lacey Township.

3. Road And Transportation

Route 9, the eastern boundary of the proposed site, is the major North/South commercial corridor in Ocean County. The road is concrete with a bituminous concrete overlay with one lane in each direction. During the morning and afternoon rush hours, the road is very close to capacity, with minor tie ups at the traffic lights north and south of the site.

The western boundary of the site is the Garden State Parkway, which provides express service north and south. Trucks are currently permitted north to Exit 105, the Interchange with Routes 36 and 18 for connection to the New York metropolitan area. There are no truck restrictions on the Parkway south. Lacey Road, to the north of the site, has a northbound entrance and southbound exit to the Parkway, travel distance from the site is approximately 4.4 miles. County Route 532, to the south of the site, has a southbound entrance and northbound exit to the Parkway, approximate travel distance of 4.6 miles.

The workers at the site during the operation phase for the most part will be local workers and the net change in commuter traffic may be negligible.

VIII. ECONOMIC EFFECTS

VIII. ECONOMIC EFFECTS

A. Taxes

The existing site is presently zoned as industrial and is undeveloped. The site is comprised of a 500 acre tract that has previously been described, in detail, in this portion of the report. The present tax revenue generated for Ocean County and the Lacey School District is calculated as; $23,667.12 per year based on an assessed valuation of $1,507,406.00 and a tax rate of $1.57/hundred. The property is not usable for agriculture due to the relatively poor soil conditions, and is not considered for residential dwellings, e.g.; high density uses, due to its proximity to the OCNGS. The highest and best usage for this tract is considered to be industrial utilizing a non-labor intensive configuration, as evidenced in the Lacey Township Master Plan which established this zoning, and this use is well within the spirit of the plan as quoted below:

> "GOAL: The Township will actively encourage expansion and improvement of existing business and industry as well as attempt to attract new industrial and business uses into planned areas, expecially adjacent to compatible use areas, e.g.; the county airport, the railroad, and Rt. 9.
>
> OBJECTIVES: The expansion of exisitng industry and the attraction of new industry should be encouraged to provide local opportunities for an expanding resident population. Planned and properly protected industrial development should be encouraged to help create and maintain an attractive and harmonious, as well as economically vigorous community.

Industry which relies upon the extraction of natural resources from the Township will be required to indicate how and at what stage disturbances to the environment will be corrected. No such industry will be permitted to permanently disfigure areas of the Township. Plans for environmental rehabilitation will be required for each petition.

Areas suitable for business and industrial use should be initially determined and periodically reviewed within the context of the Comprehensive Plan and the zoning ordinance Areas suitable for future development of a residential or non-residential nature will not be prematurely zoned for such use, even though such use may be indicated in the twenty year Comprehensive Plan." (Ref. 17, pp. 41 &42)

B. Employment Opportunities

Utilizing projections of employment opportunities expected from similar projects and adjusting them to the space available at the Lacey Township Site, it would appear that the number of employees at the park per se could be in the range of 148 to 278 with an expected gross annual payroll of from $1,776,000 to $3,336,000. The secondary multiplier effects could be in the range of 44 to 83 employees with the secondary economic impact in the range of $1,073,000 to $2,035,000. The overall regional impact is not possible to access without more specific information, in particular the industrial configuration of the park, however, a regional income multiplier of 1.5 X gross revenue generated is possible.

C. Impacts on Boundary Municipalities

Section IV of this report has demonstrated the enormous amount of heat available from OCNGS and/or FR #1 as designed, far more than enough to energize the proposed Lacey Industrial Park.

Ocean Township has zoned the property to the south of the power plant property industrial. This approximately 280 acre tract is similar in physical characteristics to the proposed Lacey Energy Park property and is in fact, closer to the power plant than the Lacey property. Ocean Township receives very little of the tax base revenue benefits enjoyed by Lacey Township, the host municipality, and may be amendable to investigating the utilization of a portion of the waste heat generated along with Lacey to attract industry which would contribute substantially to their tax base revenue. This approach would also serve to utilize approximately twice the amount of waste heat as may be utilized by the Lacey installation alone, thereby further mitigating the adverse effects of waste heat on the environment.

IX. REGULATORY CONSIDERATIONS

IX. REGULATORY CONSIDERATIONS

A. Federal

1. Food & Drug Administration

The Food & Drug Administration (FDA) is responsible for administration of the Federal Food, Drug and Cosmetic Act (FFD&C). This Act prohibits the introduction of adulterated food into interstate commerce. Food is generally considered "adulterated if it contains any poisonous or deleterious substances or filth, is a product of a diseased animal, or has intentionally been subjected to radiation in a manner not specifically permited by regulation". (Ref. 18, pp. 152-155)

The presence of anticorrosive agents, biocides to prevent condensor biofouling and any other additives injected into the cooling water to ease plant operation would become a food additive under the FDA regulation, and would be subject to strict monitoring to meet FDA limits. The Delaney Clause of the FFD&C Act, which has been discussed in a previous section, flatly prohibits FDA approval of any carcinogen as a food additive in any amount. As radiation is a recognized carcinogen it would appear that all direct contact with the cooling water and the food chain would be prohibited by FDA.

The Vermont Yankee Nuclear Power Corporation Study, indicates that a cooling system operated in a manner similar to the Oyster Creek system, in fact would not subject the cooling water to exposure to radiation and direct usage of cooling water would not violate the Delaney Clause of the FFD&C Act. Pending final outcome of FDA review of the Vermont Yankee claims, and due to the need for temperature boosting from the Oyster Creek site, the Lacey Energy Park has been conceptually planned with heat exchangers which satisfy the Delaney Clause restriction on direct usage.

2. Nuclear Regulatory Commission

The location of the proposed Lacey Energy Park, off the power plant site and out of the exclusion zone, would remove the Lacey Energy Park from direct review and jurisdiction of NRC. The proposed project would be subject to a secondary review by the NRC in two (2) areas.

a. The interfacing system connected to the condenser cooling loop will be subject to NRC review. The utility must receive a license modification if any technical changes are proposed in the circulating water system. The review by the NRC would be to ascertain if the proposed interface would:

    i. Present an unreviewed safety question.
    ii. Increase the probability of the occurrence or the consequences of an accident.
    iii. Create the possibility of an accident or a malfunction of a different type than any previously evaluated.

The request for license modifications would have to be submitted and supported by the utility company.

b. The other area of concern by the NRC with regard to the Lacey Energy Park would be the impact on the local and regional evacuation contingencies as will be discussed later.

3. Environmental Protection Agency

National Pollutant Discharge Elimination System (NPDES) permits will be required by any operation discharging a pollutant into navigable waterways. The type of permit and whether each usage will require a separate permit or one master permit can be obtained for the entire operation, will be dependent on the parameters established during the design phase of the Lacey Energy Park.

B. STATE REGULATORY AGENCIES

1. The following is taken from the Directory of State Programs for Regulating Construction. Revised March, 1979:

SOIL EROSION AND SEDIMENT CONTROL PLAN CERTIFICATION

Department: Agriculture

Project Type: Land Distrubance Control

Statute Title: Soil Erosion and Sediment Control Act.

Statute Number: N.J.S.A. 4:24-1 et seq.

Purpose: Requires municipalities to condition development project approvals upon local soil conservation district certification of a plan for soil erosion and sediment control. Certification is required for projects that disturb more than 5,000 square feet of surface area of land for which the State uniform construction code would require a building permit. Excludes single-family dwelling unit unless such unit is part of a proposed subdivision, site plan, condition use, zoning variance, planned development or construction permit application involving two or more single family dwelling units. Since municipalities may have adopted upon State approval soil erosion and sediment control ordinances, applicant should determine whether municipality in which construction activity is to occur has such an ordinance.

Submit:
- Application for soil erosion and sediment control plan certification (standard form)
- Project or development plan
- Soil maps or other resource data used
- Narrative soil erosion and sediment control plan
- Fees to be determined by local soil conservation district.

Contact: Local Soil Conservation District Office

COASTAL AREA FACILITY REVIEW ACT (CAFRA) PERMIT

Department: Environmental Protection

Project Type: Coastal and Waterfront Development

Statute Title: Coastal Area Facility Review Act.

Statute Number: N.J.S.A. 13:19-1 et seq.

Purpose: Requires permit to construct major residential (25 or more dwelling units), industrial, transportation, utility and energy-related facilities in the coastal area. CAFRA area extends from the Atlantic Coast three-mile limit at sea and includes that portion of the State lying inland to a line drawn in an irregular pattern beginning from the confluence of Cheesequake Creek with Raritan Bay, Middlesex County, south to Cape May, and then north and west along the Delaware River to Pennsylvania, Salem County. Included are all riparian, tideland, and wetland acreage in a 1,376 square mile land area. CAFRA area ranges in width from a few thousand feet to 24 miles.

Permit covered by 90-day Review Law (P.L. 1975 c, 232)

Submit: CP-1 application form for permit (standard form)
Environmental Impact Statement
Application fee
Affidavit stating applicant submitted application to require local agencies

Contract: CAFRA Permit Section
Office of Coastal Zone Management
Division of Marine Services
Department of Environmental Protection
Labor and Industry Building
Box 1889
Trenton, New Jersey 08625
609-292-0060

STREAM ENCROACHMENT PERMIT

Department: Environmental Protection

Project Type: Flood Control

Statute Title: Stream Encroachment Act

Statute Number: N.J.S.A. 58:1-26
N.J.A.C. 7:8-3.15

Purpose: Requires permit for the construction, installation or alteration of any structure or permanent fill along, in, or across the channel or floodway of any stream. Permit also required for any alteration of the stream itself (dredging or filling) within the high-water mark of 100-year flood as determined by the State. The Flood Plain Act, N.J.S.A. 58:16A 50 et seq., empowers the State to control use and development on floodway portions of flood hazard areas and flood fringe areas. Until rules and regulations under the Act are administered, the review of DEP of permit applications for development within this area is being administered under the provision of the Stream Encroachment Statute.

Permit covered by 90-Day Review Law (P.L. 1975, c 232)

Submit: CP-1 application form for permit (standard form)
Engineering data sheet
Location Key map
Drawings showing property lines, contours, profiles, etc.
Photographs upstream and downstream from proposed project.
Channel relocation and major fill projects require EIS
Hydrologic computation based on 100-year flood
Erosion and sediment control practices
Application fee
Evidence that notification of application made to required local agencies

Contact: Stream Encroachment Section
Bureau of Flood Plain Management
Division of Water Resources
Department of Environmental Protection
Box CN 029
Trenton, New Jersey 08625
609-292-4869

CERTIFICATION OF 50 OR MORE REALTY IMPROVEMENTS

Department: Environmental Protection

Project type: Sewerage Facilities

Statute Title: Realty Improvement Sewerage and Facilities Act.

Statute Number: N.J.S.A. 58:11-25.1 et seq.

Purpose: Requires that no subdivision approval shall be granted by any municipal or other authority in the State to cover 50 or more realty improvements, until DEP has certified that the proposed water supply and sewerage facilities for realty improvements comply with applicable State standards. Realty improvement is a dwelling unit not served by an approved sewerage facility or water supply. DEP will review an application only after the local board of health or planning board has indicated that it will grant subdivision approval.

Submit: Plan of proposed realty improvement.
Results of subsoil and ground water tests.
Description of proposed water supply system.
Expected rate of construction
Estimated date of availability of public water and sewers.

Contact: Local board of health or planning board.

CERTIFICATION OF SEWERAGE FACILITY FOR REALTY IMPROVEMENTS IN CRITICAL AREA

Department: Environmental Protection

Project Type: Sewerage Facilities

Statute Title: Realty Improvement Sewerage and Facilities Act

Statute Number: N.J.S.A. 58:11-44, 58:11-45
N.J.A.C. 7:8-3,22

Purpose: Requires that no building permit be issued until DEP has certified the sewerage facilities for the proposed unit. Sewerage facilities include on-site facilities, such as septic tanks. Realty improvement is a dwelling unit not served by an approved sewerage facility or water supply. Critical area has been defined by regulation (N.J.A.C. 7:9-10.1 as amended January 23, 1978) as those areas in Monmouth, Ocean, Atlantic and Cape May Counties, and along the Mullica River basin in Burlington County, lying between any tidal waterway and 10 feet above the mean sea level datum of 1929 and the Central Pine Barrens region. DEP will review application only after local board of health has indicated that it will grant building permit approval.

Submit: Plan of proposed realty improvements
Results of subsoil and groundwater tests
Description of proposed sewerage facility.
Description of proposed water supply system
Expected rate of construction

Contact: Local board of Health

TREATMENT WORKS APPROVAL

Department: Environmental Protection

Project Type: Sewerage Facilities

Statute Title: New Jersey Water Pollution Control Act of 1977

Statute Number: N.J.S.A. 38:10A-1 et al.
N.J.A.C. 7:8-3,17
N.J.A.C. 7:14-1 et seq.

Purpose: Requires approval to construct and operate any components of a sewer system, including interceptors, collectors, force mains and pumping stations or any plant that will treat domestic or liquid industrial wastes and discharge to surface waters. In reviewing plans for sewerage facilities, DEP must consider development of a comprehensive regional sewerage system.

Submit:
- Application for approval of plans and specifications for construction of sewerage (standard form)
- Map of project with key map showing municipal boundaries
- Map showing probable future tributary areas for sewer system
- Plan and profiles of all proposed sewers
- Details of construction of sewer appurtenances
- General and detailed plans for treatment plants and specifications for all proposed construction (2 sets)
- Engineer's report
- Appropriate endorsements
- Operation and Maintenance Manual

Contact: Public Wastewater Facilities Element (for municipal facilities)
Division of Water Resources
Department of Environmental Protection
Box CN 029
Trenton, New Jersey 08625
609-292-0959

Contact: Monitoring, Surveillance and Enforcement Element (for industrial facilities)
Division of Water Resources
Department of Environmental Protection
Box CN 029
Trenton, New Jersey 08625
609-292-0580

PERMIT TO DIVERT SUBSURFACE OR PERCOLATING WATERS

Department: Environmental Protection

Project Type: Water Diversion

Statute Title: Diversion of Subsurface and Percolating Waters Act.

Statute Number: N.J.A.C. 7:8-3,9
N.J.S.A. 58:4A-2

Purpose: Requires permit to divert water from subsurface or percolating sources, which include all wells and ponds not supplied by surface runoff, in excess of 70 gallons per minute (appoximately 100 thousand gallons per day). Maximum withdrawal rate is specified by the State. All abondoned wells must be sealed.

Submit: Application for permit to divert subsurface or percolating waters (standard form)
Map showing location of diversion point
Certified engineer's report
Approval by DEP on water disposal method

Contact: Bureau of Water Supply, Planning & Management
Division of Water Resources
Department of Environmental Protection
Box CN029
Trenton, New Jersey 08625
609-292-2956

HIGHWAY OCCUPANCY PERMIT

Department: Transportation

Project Type: Road Impact

Statute Type: State Highway Laws

Statute Number: N.J.S.A. 27:1-1 et seq.

Purpose: Requires permit from regional DOT office for any of the following uses of a State highway right-of-way, unless use is a condition of another permit: street intersection construction, curb construction, sidewalk construction, over-dimensioned and overweight movement, temporary use of right-of-way, telephone booth installation, crossover and/or U-turn slots in median, left turn slot, parade, detour decorations on highway, tree trimming, fill removal, bus shelter erection, test holes, guard rail removal, grading, landscaping bench erection, pedestrain overpass or underpass or other uses not specified but covered under the statute. Permit required for overdimensioned and overweight movement only if such movement is to be upon an apparatus not required to be licensed by Division of Motor Vehicles. If upon a licensed vehicle, permit must be obtained from Division of Motor Vehicles. Highway occupancy permit valid for up to one year or for period stipulated. Applicant must verify municipal approval, when required, has been obtained. (the details of the above are found under N.J.A.C. 16:41.1 et seq.).

Submit: Application for highway occupancy (standard form)
Application and permit fees
Plan showing proposed installation

Contact: Regional DOT offices

Of particular concern to any major development project within the coastal zone of New Jersey, is the Coastal Area Facility Review Act (CAFRA) permit. Due to the wide latitude given to the CAFRA review process, and the need to provide a complete Environmental Impact Statement as part of the review application, the CAFRA permit is often considered a State umbrella permit. The Lacey Industrial Commission has submitted to the CAFRA review process a preapplication request which outlines the area in question, and the conceptual idea behind the Lacey Energy Park. The following is a reprint of the CAFRA staff analysis of the proposal. (Ref. 13)

(REFERENCE 13)

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
TRENTON

~~DIVISION OF MARINE SERVICES~~

PLEASE ADDRESS REPLY TO:
P. O. BOX 1889
TRENTON, N. J. 08625

December 10, 1979

Mr. William R. Layton, Jr.
Satterfield Associates
P. O. Box 162
Forked River, New Jersey 08731

RE: CAFRA Inquiry, P# 810
Lacey Industrial Park
Lacey Township, Ocean County

Dear Mr. Layton:

Based on staff review of the information presented and discussed at the pre-application conference held 16 November your project has the following status in terms of the Rules on Coastal Resource and Development Policies as stated in Part II, Chapter 4, <u>New Jersey Coastal Management Program - Bay and Ocean Shore Segment</u> - August 1978 (N.J.A.C. 7:7E-1 et seq.). This staff review refers to specific policies by section number. Please understand that this informal guidance is not a binding commitment by the Department to approve or deny any forthcoming permit application for this project or site.

<u>Project Description</u>

The proposed project would entail the construction of an industrial park on approximately 500 acres (Block 1002, plots 1-6 and Block 1024, Lot 15). The site fronts on U.S. Route 9, immediately north of the Oyster Creek Nuclear Generating Station. The project would be built in phases; phase one would utilize plots 1-3 (about 34 acres). A study is presently on-going to determine the feasibility of utilizing the heated wastewater from the nuclear power plant by tennants of the industrial park.

<u>Location Policies</u> (3.0)

These policies classify all land and water features of the coastal zone into at least one category and assign a policy on the use of each type of location in each category.

Special Areas (3.2)

Certain specific areas merit focused attention and special management policies and their policies supplement the more general Location Policies and take precedence.

Bogs and Freshwater Wetlands (3.2.23)

Development that would adversely affect the natural functioning of these Special Areas is prohibited. All on-site bog and freshwater wetlands areas are to be mapped on a site plan.

Natural Water's Edge (3.4.2)

This area is the natural, undisturbed land area that is contiguous with a Water Area and stretches from a Water Area to the landward limit of soils with a seasonal high water table at the surface, including Atsion soils. In general, development is discouraged in this Water's Edge Area unless the project satisfies all of the conditions listed under 3.4.2 (page 85).

The applicant is to map the site's Natural Water's Edge Area on a site plan.

Coastal Region (3.5.3)

The site lies in the Barnegat Corridor Region and is designated a Moderate Growth Region.

Environmental Sensitivity (3.5.4)

Those sections of the site with Lakehurst and Atsion soils, which are high percolation wet soils, and a forest vegetation receive a High Environmental Sensitivity. The remainder of the site, exclusive of the Special Area, recieves a Moderate rating. The latter appears to apply only to small segments of the site with a Downer soil type.

Development Potential (3.5.5.3)

The site has direct access to a road and wastewater treatment system and meets the infill requirements as it is adjacent to the Oyster Creek Nuclear Generating Station. However, it is not within two miles of an existing intersection with a limited access highway or within one-half mile of a freight rail line. Therefore, it receives a Medium Development Potential.

Acceptable Development Intensity (3.5.6)

Use of the appropriate Land Acceptability Table (3.5.7) shows that the site receives a Low Acceptable Development Intensity.

Based on the policies for Land Areas, the proposed project is discouraged due to a Low Acceptable Development Intensity. However, due to the uniqueness of the industrial park (i.e., the proposed use of the waste heat from the electrical generating station), it must be sited adjacent to a generating station. This subject is discussed under the following Use Policy.

Energy Use Policies (4.4)

The acceptability of proposed coastal energy facilities shall be determined by a review process that includes both DEP and N.J. D.O.E. according to the procedures defined in the Memorandum of Understanding between DEP and DOE coordination of permit review.

One of the policy guidelines used in siting a General Energy Facility is "that no better locational alternative to the proposed site exists." Because the proposed project is to utilize the waste heat from an electrical generating station, it must be built in close proximity to the facility. Therefore, provided that the other policy guidelines of this Use Policy can be met, the site is acceptable for the proposed use.

The applicant has been in contact with D.O.E. regarding a grant to conduct a feasibility study.

Resource Policies (5.0)

Here a project is reviewed in terms of its effects on various resources of the built and natural environment of the coastal region, both at the proposed site and in the surrounding region. These policies serve as standards to which proposed development must adhere. Appropriate policies which the applicant must adequately address are: Water Quality (5.3), Groundwater Use (5.5), Runoff (5.6), Vegetation (5.8), Air (5.10), Secondary Impacts (5.14), Solid Waste (5.16), and Energy Conservation (5.17).

Conclusion

If the policies for the Special Areas discussed are met, as well as all appropriate Resource Policies, then the proposed site is conditionally acceptable. This conclusion is based on the fact that a project utilizing waste heat from an electrical generating station must be sited in close proximity to such a facility.

It is a recommendation, at this time, that the tenants of the park be limited to non-labor intensive industries which utilize the waste heat. The goal here is to keep to a minimum the number of persons in the area immediately adjacent to a nuclear generating station.

The application shall also contain a section in which it is demonstrated how the proposed use complies with the applicable Coastal Resource and Development Policies.

I trust this guidance helps you to proceed along the design and development process. If you have any questions about the CAFRA permit application process, please do not hesitate to contact this Office at the above address or at (609) 292-0060.

Sincerely yours,

Phil Sandine

Phillip H. Sandine, Supervisor
North Shore Region

PHS/dy
cc: Lacey Township Planning Board
Ocean County Planning Board
Mr. Thomas F. Hampton, Chief, Coastal Enforcement
Mr. George Tyler, Director, Environmental Quality

2. BOARD OF PUBLIC UTILITIES

The major regulatory agency with which a public utility must deal with is the Board of Public Utilities (BPU). This agency has the right to review, approve, or disapprove all utility tariffs and tarrif increases within the State. Based on this fact, it would appear that the BPU would play an integral part in the establishment of a facility which uses heat from a electrical generating station as its energy source. However, research indicates that the involvement of the BPU in the establishment and operation of such a facility is contingent on several other factors.

The role of the BPU in its simpliest terms is to insure that a utility's customers receive service at the lowest possible rate while insuring the economic viability of the utility. Under this mandate, the BPU requires that any capital expenditure by a utility be presented to the BPU along with the proposed method of financing or recovering the funds expended. If the capital expended is self supporting without effecting the utility customer the BPU's only interest is that any profits are reported and included in the rate determination formula. If the capital expended is to be recovered by rate tariff increase, the BPU requires that the utility prove that the increase in service benefits to the consumer is equal to or greater than the proposed rate increase.

The above recapitulation of rate determination philosophy is presented as background for the following discussion of possible BPU involvement in a Waste Heat Utilization project. To date, little or no attention has been paid to Waste Heat Utilization and cascading heat use, as it has been of little consequence in the total rate structure of any New Jersey Utility. However, with the growing national concern for conservation and rising energy costs the BPU will soon be faced with formulating a policy to cover such a situation.

The following guidelines were developed based on the rate setting philosophy above and discussion with the legal department of BPU.

a. Effects on Power Generating Capacity:

If the proposed facility in any manner reduces the total generating capacity of the power plant the BPU would require that the user or facility owner reimburse the utility for the loss of generating capacity. This fact would be a determination in the involvement of BPU in the proposed Lacey Energy Park, if the industrial developers were to ask for a higher discharge temperature during the winter months. This higher discharge temperature would increase the back pressure on the turbine and reduce generation capacity. A 1° F increase in discharge temperature corresponds to a 1 MWT reduction in generating capacity, as a rule of thumb.

b. Capital Investment:

If the utility company expends any capital in the construction of the interfacing system to supply the heated water to the industrial facility the BPU will request a full disclosure of the utility involvement.

The BPU will require that the utility receive a pay back from the industrial facility rather than the utility consumer. The exception being if the cost of the interfacing system produces a reduction in environmental degradation equal to, or greater than, the cost of the system. This may be a consideration when a Waste Heat Utilization project is designed as part of a power generation facility from the inception. The case of the Lacey Energy Park appears that the percentage of heat utilized will not significantly affect the amount of heat rejected.

If the proposed industrial developer bears the entire cost of the interfacing system without capital investment on the utilities part, the BPU may not be involved as the power company does not have an investment cost to be recovered. In this instance the BPU would require only a disclosure of any funds paid to the utility for the waste heat and the basis of the payment; i.e., cost per thousand gallons or MBTU's.

This payment must than be included in any future rate determination formula.

c. Lacey Energy Park as a Public Utility:

Under certain circumstances the industrial developer may come under the jurisdiction of the BPU as a utility. Assuming that the industrial developer will charge a fee for the heat energy delivered to each tenant of the industrial park, he could be considered a public utility. If, as currently proposed, the industrial facility remains totally within a single municipality, the distribution system is exempted from BFU review. However, if the industrial facility expands to an adjoining municipality, the fee charged to each tenant would than be subject to BPU review and approval.

C. LOCAL REGULATIONS

1. Ocean County Utilities Authority

The Regional Sewerage Authority will have to review functions with regard to this proposed project. The local collection system and tie-in to the regional interceptor must be submitted to the Authority prior to construction for review and approval. Their review will be made to insure compliance with the Authority's design standards, and that the proposed flows can be handled by the regional collection and treatment system.

The individual industrial tenant will be required to submit applications to the regional Authority prior to hook-up. The individual applicant will be required to submit a projected analysis of his discharge, including flow, BOD loading and suspended solids. These figures will be used to calculate any user surcharge required for sewage above normal strength. Additional industrial cost recovery may be leveled by the Authority if applicable to the individual discharge.

D. TOWNSHIP REGULATIONS

As the proposed developers, the Lacey Industrial Commission is a body of the Township and any work proposed by this body would be subject to local Planning Board approval as a matter of courtesy. The developers responsibility would include the subdivision, road layout and grading, storm drainage and sewage collection.

As sites are developed the individual developers will be required to submit site plans detailing the planned operation, building location, parking, utilities, and grading. Each plan would have to meet minimum Township standards and any additional criteria established by the Industrial Commission and/or the Planning Board.

X. SPECIAL CONSIDERATIONS
NUCLEAR HEALTH

X. SPECIAL CONSIDERATIONS NUCLEAR HEALTH

A. EVACUATION PLANS

1. On Site:

Several configurations for possible eventual park layout were discussed and prepared for the Lacey Township Industrial Commission. The original plans were prepared without regard to unuseable location due to topographic features.

The proposed plan resulted in the following conclusions for park safety:

a. All internal roads should be through roads to the maximum extent possible.

b. The main entrance is to be double width. In time of emergency evacuation, this allows four (4) lanes of exit traffic.

c. The exit has been located directly opposite Beach Boulevard. A traffic study currently under way may justify a traffic light at the existing Route 9/ Beach Boulevard intersection.

d. The plan should provide for possible rear exit, if any further expanded development should approach the site from the northwest.

The following preliminary plans show the proposed subdivision. The plan would require modification to conform with site conditions previously identified. (Exhibit XVI)

2. Regional

In light of the recent incident at Three Mile Island, the Nuclear Regulatory Commission (NRC) and the Federal Emergency Management Agency (FEMA) are requiring that all regional plans be revised. In January, 1980, the new interim

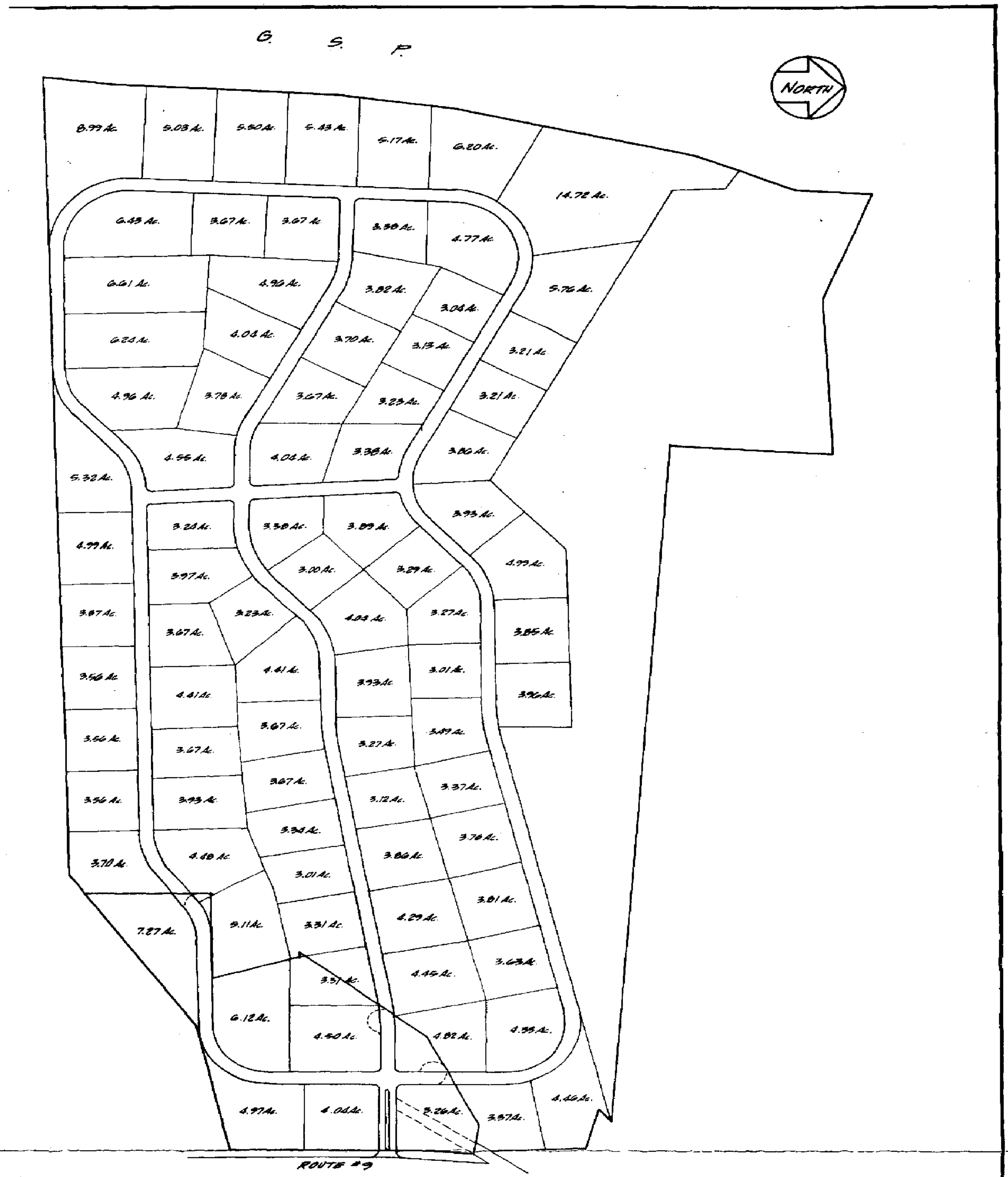


EXHIBIT XVI

GEORGE ATKIN, JR. N J PE LICENSE NO 13602	PRELIMINARY SUBDIVISION SKETCH
MARION M. SATTERFIELD NJ PE & LS LICENSE NO [illegible]	LACEY INDUSTRIAL PARK
WILLIAM R. LAYTON, JR. N J PE LICENSE NO 23268	LACEY TOWNSHIP, OCEAN COUNTY, N.J.
	— SATTERFIELD ASSOCIATES — ENGINEERS · PLANNERS SURVEYORS A DIVISION OF NORTHWEST ENGINEERING, INC 540 W. LACEY ROAD, FORKED RIVER, NEW JERSEY 08731 (609) 693-8127
SIGNATURE	DRN BY W.D.T. · SCALE Shown · DATE 11-8-79 CHK'D BY · PROJ NO 79-109 · SHT NO 1 of 1

regulations were issued as NUREG-0655/FEMA-REP-1 "Criteria for Preparation and Evaluation of Radiological Emergency Plans and Preparedness in Support Nuclear Power Plants." The County Civil Defense unit is currently revising its regional plan in accordance with these interim regulations. Since this plan is still being prepared, no exact impacts can be identified, but several areas of possible impacts are:

a. The site is close enough that immediate notification is possible through a siren alerting system at the plant.

b. The Lacey Energy Park will contribute a unit of vehicles at the inner most core area of the evacuation region. The current estimate of vehicles involved is 2 people/acre x 250 developable acres ÷ 1.25 people/vehicle = 400 vehicles.

c. The majority of the workers to be evacuated from the Lacey Energy Park would have to be evacuated from another sector of the plan as most of the workers will be local residents.

The effects on evacuation plans will be similar during the construction phase with two (2) modifications.

i. Number of workers on site will vary with the type of construction activity.

ii. Workers may be from regions not included in evacuation plans and there will be additional vehicular movement not previously accounted for.

B. HEALTH RELATED DANGERS POSED BY PROXIMITY OF NUCLEAR PLANT

1. Section IV of the report has described the monitoring procedures utilized by JCP&L for detection of radiation and proposed additions to the system, which will result in Oyster Creek facility being monitored by the most complete and sophisticated system in the country at this time. The simultaneous construction of the proposed Lacey Energy Park

and Forked River Unit #1 could integrate the two (2) systems into one unified system which could alleviate the need for any additional on site monitoring.

The effluent, as previously noted in Section IV, is isolated from the closed turbine loop by a vacuum of 28 inches of mercury and infiltration of turbine working fluid into the condenser cooling water is not possible except under catastophic conditions.

The work force at the Energy Park location may expect no more exposure to radiation than the general population surrounding the power plant site and any further monitoring, such as individual dosage badges will be more psychological in nature than necessary for worker protection.

2. ACCIDENTAL RELEASE AT POWER PLANT

The remaining health risks arise from an accidental release of gases or fluids of contaminated material within the power plant complexes. The risk to anyone, not just the workers in the Lacey Energy Park is related to distance from the source, wind direction and quantity and strength of radioactive material.

The NRC list four (4) classes of incident with procedures for each. The classes are:

a. Notification of Unusual Event

b. Alert

c. Site Emergency

d. General Emergencies

The following charts are from NUREG-0654 and review each class and the required response of the power plant operator and government agencies.

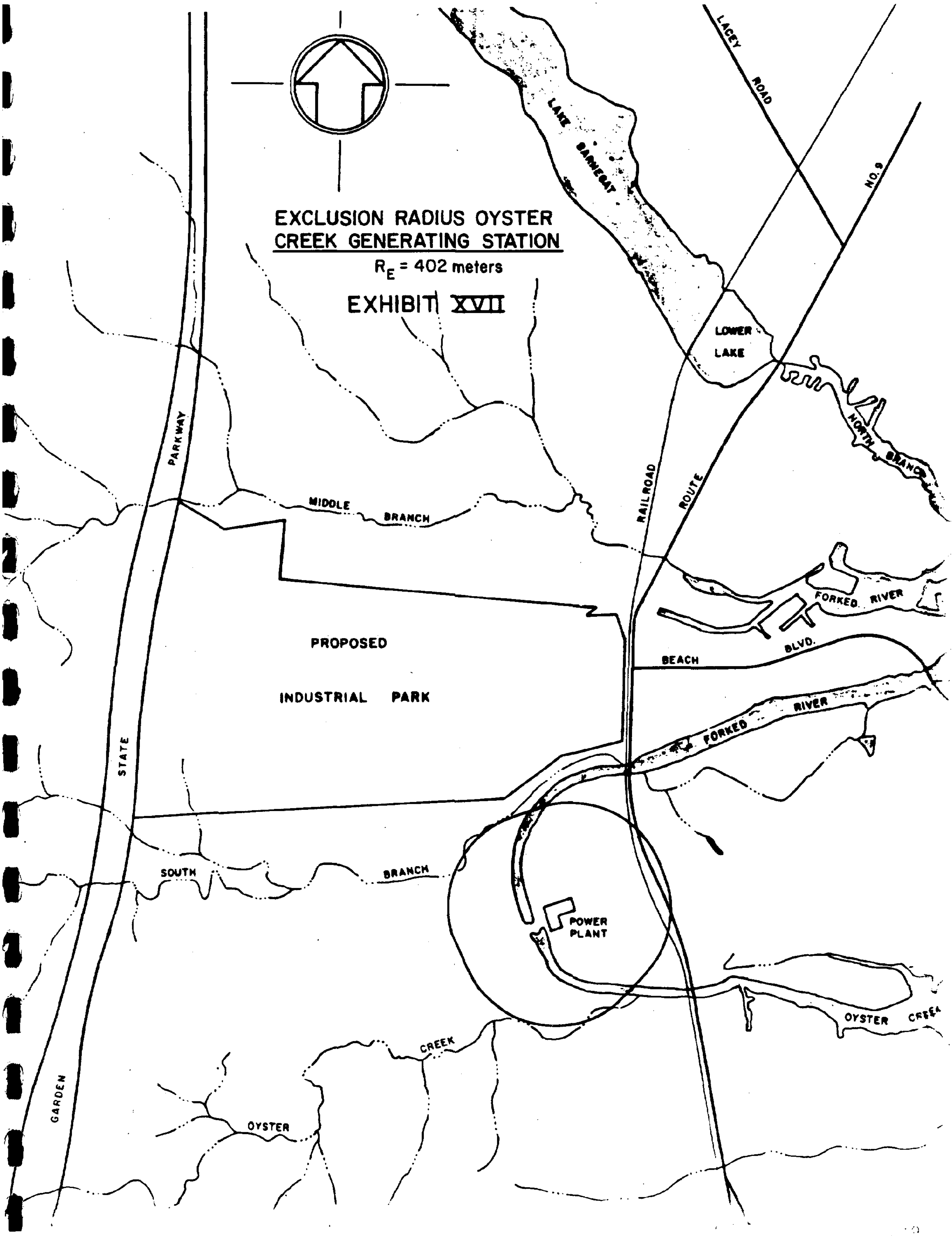
The four (4) classes of incidents noted address the strength of any release. The local plan for evacuation is based on various distance determinations.

The innermost zone, known as the "exclusion area", is shown on the following map. The exclusion area is a specified distance around the plant in which all activities must remain under the control of the licensee. The proposed Lacey Energy Park is located beyond the perimeter of the exclusion zone determined for OCNGS.

The areas surrounding the exclusion zone are further divided into two (2) Emergency Planning Zones (EPZ). The inner zone has a radius of approximately 10 miles. The outer zone extends to a 50 mile radius.

The interior zone is the area of immediate evacuation and is known as the "Plume Exposure Pathway".

"The principal exposure sources from this pathway are: (a) whole body external exposure to gamma radiation from the plume and from deposited material; and (b) inhalation exposure from the passing radioactive plume. The duration of the release leading to potential exposure could range from one-half hour to days. For the plume exposure pathway, shelter and/or evacuation would likely be the principal immediate protective actions to be recommended for the general public. The possible administration of the thyroid blocking agent, potassium iodide, should also be considered. The ability to best reduce exposure under specific conditions during the course of an accident should determine the appropriate response." (Ref. 19, p. 7)


EXCLUSION RADIUS OYSTER CREEK GENERATING STATION
R_E = 402 meters
EXHIBIT XVII
LACEY ROAD
LAKE BARNEGAT
NO. 9
LOWER LAKE
NORTH BRANCH
PARKWAY
MIDDLE BRANCH
RAILROAD
ROUTE
FORKED RIVER
PROPOSED
INDUSTRIAL PARK
BEACH BLVD.
FORKED RIVER
STATE
SOUTH BRANCH
POWER PLANT
OYSTER CREEK
CREEK
OYSTER
GARDEN

REPRINTED FROM: 1980, NUREG-0655/FEMA-REP-1 - "CRITERIA FOR PREPARATION AND EVALUATION OF RADIOLOGICAL EMERGENCY PLANS AND PREPAREDNESS IN SUPPORT NUCLEAR POWER PLANTS." INTERIM REPORT (Ref. 19, p.7)

Class	Licensee Actions	State and/or Local Offsite Authority Actions
Notification of unusual event **Class Description** Unusual events are in process or have occurred which indicate a potential degradation of the level of safety of the plant. **Purpose** Purpose of offsite notification is to (1) assure that the first step in any response later found to be necessary has been carried out, (2) provide current information on unusual events, and (3) provide a periodic unscheduled test of the offsite communication link. **Release Potential** No releases of radioactive material requiring offsite response or monitoring are expected unless further degradation of safety systems occurs. **Expected Frequency** Once or twice per year per unit.	1. Promptly inform State and/or local offsite authorities of nature of unusual condition as soon as discovered 2. Augment on-shift resources 3. Assess and respond 4. Close out with verbal summary to offsite authorities; followed by written summary within 24 hours or 5. Escalate to a more severe class	1. Provide fire or security assistance if requested 2. Standby until verbal closeout or 3. Escalate to a more severe class

Class

Alert

Class Description

Events are in process or have occurred which involve an actual or potential substantial degradation of the level of safety of the plant.

Purpose

Purpose of offsite alert is to (1) assure that emergency personnel are readily available to respond if situation becomes more serious or to perform confirmatory radiation monitoring if required, (2) provide offsite authorities current status information, and (3) provide possible unscheduled tests of response center activation.

Release Potential

Limited releases of up to 10 curies of I-131 equivalent or up to 10^4 curies of Xe-133 equivalent.

Expected Frequency

Once in 10 to 100 years per unit.

Licensee Actions

1. Promptly inform State and/or local authorities of alert status and reason for alert as soon as discovered
2. Augment resources by activating on-site technical support center, on-site operations center and near-site emergency operations center (EOC)
3. Assess and respond
4. Dispatch on-site monitoring teams and associated communications
5. Provide periodic plant status updates to offsite authorities (at least every 15 minutes)
6. Provide periodic meteorological assessments to offsite authorities and, if any releases are occurring, dose estimates for actual releases
7. Close out by verbal summary to offsite authorities followed by written summary within 8 hours

or

8. Escalate to a more severe class

State and/or Local Offsite Authority Actions

1. Provide fire or security assistance if requested
2. Augment resources by activating near-site EOC and any other primary response centers
3. Alert to standby status key emergency personnel including monitoring teams and associated communications
4. Provide confirmatory offsite radiation monitoring and ingestion pathway dose projections if actual releases substantially exceed technical specification limits
5. Maintain alert status until verbal closeout

or

6. Escalate to a more severe class

Class

Site Emergency

Class Description

Events are in process or have occurred which involve actual or likely major failures of plant functions needed for protection of the public.

Purpose

Purpose of the site emergency warning is to (1) assure that response centers are manned, (2) assure that monitoring teams are dispatched, (3) assure that personnel required for evacuation of near-site areas are at duty stations if situation becomes more serious, (4) provide current information for and consultation with offsite authorities and public, and (5) provide possible unscheduled test of response capabilities in U. S.

Release Potential

Releases of up to 1000 ci of I-131 equivalent or up to 10^6 ci of Xe-133 equivalent.

Expected Frequency

Once in one hundred to once in 5000 years per unit.

Licensee Actions

1. Promptly inform State and/or local offsite authorities of site emergency status and reason for emergency as soon as discovered.
2. Augment resources by activating on-site technical support center, on-site emergency operations center and near-site emergency operations center (EOC)
3. Assess and respond
4. Dispatch on-site and offsite monitoring teams and associated communications
5. Provide a dedicated individual for plant status updates to offsite authorities and periodic press briefings (perhaps joint with offsite authorities)
6. Make senior technical and management staff onsite available for consultation with NRC and State on a periodic basis
7. Provide meteorological and dose estimates to offsite authorities for actual releases via a dedicated individual or automated data transmission
8. Provide release and dose projections based on available plant condition information and foreseeable contingencies
9. Close out or recommend reduction in emergency class by briefing of offsite authorities at EOC and by phone followed by written summary within 8 hours

<u>or</u>

10. Escalate to <u>general</u> <u>emergency</u> class

State and/or Local Offsite Authority Actions

1. Provide any assistance requested
2. Activate immediate public notification of emergency status and provide public periodic updates
3. Augment resources by activating near-site EOC and any other primary response centers
4. Dispatch key emergency personnel including monitoring teams and associated communications
5. Alert to standby status other emergency personnel (e.g., those needed for evacuation) and dispatch personnel to near-site duty stations
6. Provide offsite monitoring results to licensee and others and jointly assess them
7. Continuously assess information from licensee and offsite monitoring with regard to changes to protective actions already initiated for public and mobilizing evacuation resources
8. Recommend placing milk animals within 2 miles on stored feed and assess need to extend distance
9. Provide press briefings, perhaps with licensee
10. Maintain site emergency status until closeout or reduction of emergency class

<u>or</u>

11. Escalate to <u>general</u> <u>emergency</u> class

Class	Licensee Actions	State and/or Local Offsite Authority Actions
General Emergency **Class Description** Events are in process or have occurred which involve actual or imminent substantial core degradation or melting with potential for loss of containment integrity. **Purpose** Purpose of the general emergency warning is to (1) initiate predetermined protective actions for public, (2) provide continuous assessment of information from licensee and offsite measurements, (3) initiate additional measures as indicated by event releases or potential releases, and (4) provide current information for and consultation with offsite authorities and public. **Release Potential** Releases of more than 1000 ci of I-131 equivalent or more than 10^6 ci of Xe-133 equivalent. **Expected Frequency** Less than once in about 5000 years per unit. Life threatening doses offsite (within 10 miles) once in about 100,000 years per unit.	1. Promptly inform State and local offsite authorities of general emergency status and reason for emergency as soon as discovered (Parallel notification of State/local) 2. Augment resources by activating on-site technical support center, on-site emergency operations center and near-site emergency operations center (EOC) 3. Assess and respond 4. Dispatch on-site and offsite monitoring teams and associated communications 5. Provide a dedicated individual for plant status updates to offsite authorities and periodic press briefings (perhaps joint with offsite authorities) 6. Make senior technical and management staff onsite available for consultation with NRC and State on a periodic basis. 7. Provide meteorological and dose estimates to offsite authorities for actual releases via a dedicated individual or automated data transmission 8. Provide release and dose projections based on available plant condition information and foreseeable contingencies 9. Close out or recommend reduction of emergency class by briefing of offsite authorities at EOC and by phone followed by written summary within 8 hours	1. Provide any assistance requested 2. Activate immediate public notification of emergency status and provide public periodic updates 3. Recommend sheltering for 2 mile radius and 5 miles downwind and assess need to extend distances 4. Augment resources by activating near-site EOC and any other primary response centers 5. Dispatch key emergency personnel including monitoring teams and associated communications 6. Dispatch other emergency personnel to duty stations within 5 mile radius and alert all others to standby status 7. Provide offsite monitoring results to licensee and others and jointly assess these 8. Continuously assess information from licensee and offsite monitoring with regard to changes to protective actions already initiated for public and mobilizing evacuation resources 9. Recommend placing milk animals within 10 miles on stored feed and assess need to extend distance 10. Provide press briefings, perhaps with licensee 11. Consider relocation to alternate EOC if actual dose accumulation in near-site EOC exceeds lower bound of EPA PAGs 12. Maintain general emergency status until closeout or reduction of emergency class

This is the area within which the Lacey Energy Park is situated. The exposure potential in this area is weather dependent as the spread of the plume is related to the wind direction and speed. The accompanying chart of the wind rose from the Oyster Creek and Forked River Unit #1 shows the proposed site is upwind of the plant during the predominate weather conditions. This fact will add to the time from inception of the emergency to exposure at the Lacey Energy Park site. Time estimates by the Nuclear Regulatory Commission for exposure within the downwind sectors are 0.5 to 2.0 hours from the time the utility is aware of the accident.

The outer zone is known as the "Ingestion Exposure Pathway" and is concerned with longer term exposure problems. (Exhibit XVIII)

"The principal exposure from this pathway would be from ingestion of contaminated water or food such as milk or fresh vegetables. The duration of potential exposure could range in length from hours to months. For the ingestion exposure pathway, the planning effort involves the identification of major exposure pathways from contaminated food and water and the associated control points and mechanisms. The ingestion pathway exposures in general would represent a longer term problem, although some early protective actions to minimize subsequent contamination of milk or other supplies should be initiated (e.g., put cows on stored feed)." (Ref. 19, pp.7-8)

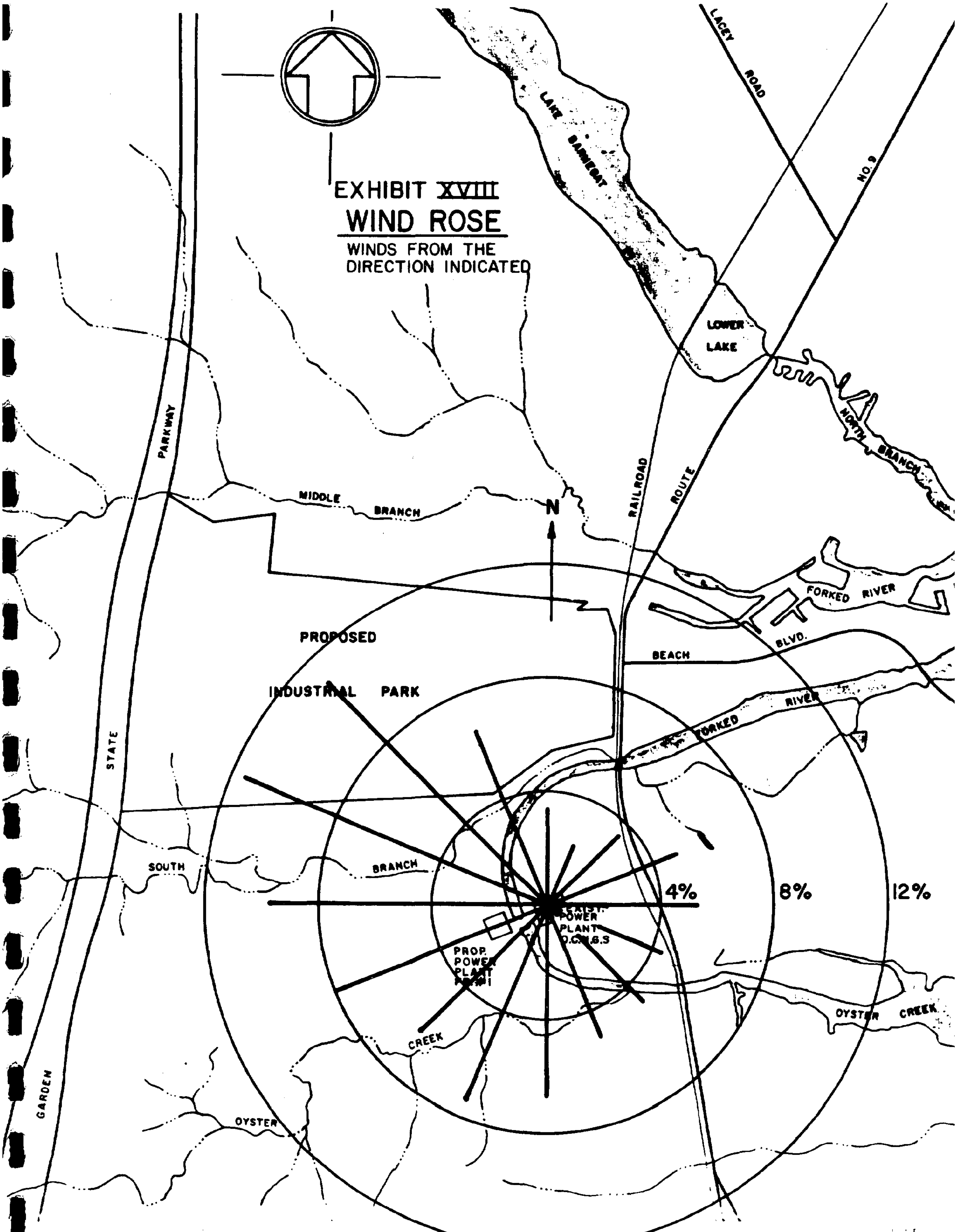


EXHIBIT XVIII
WIND ROSE
WINDS FROM THE DIRECTION INDICATED
LAKE BARNEGAT
LACEY ROAD
NO. 9
LOWER LAKE
NORTH BRANCH
PARKWAY
MIDDLE BRANCH
N
RAILROAD
ROUTE
FORKED RIVER
BLVD.
BEACH
PROPOSED INDUSTRIAL PARK
FORKED RIVER
STATE
SOUTH BRANCH
4%
8%
12%
EXIST. POWER PLANT O.C.N.G.S
PROP. POWER PLANT
OYSTER CREEK
CREEK
OYSTER
GARDEN

In general, the exposure potential of workers in Lacey Energy Park is minimally higher than that of the general populace in the inner plume exposure zone. The existing monitoring system on the plant site and the proposed backup system for Lacey Energy Park will give maximum warning time to the site employ-ees for both evacuation and/or sheltering.

C. SPECIAL CONSIDERATION FOR BUILDING MATERIALS

1. RADIOACTIVE EMISSIONS

The probability of emissions of a strength that would effect normal building materials at the distance involved are so small, and the cataclysmic nature of the associated accident, that no general change in construction techniques and material will be required.

It may be advisable, especially for the employees dealing directly with the power plant effluent, to have a shelter accessible. If the County evacuation system would be unable to handle the projected traffic in a reasonable time, the construction of shelters for the percent of the employees unable to be evacuated in the allowable time frame would be advisable. The type of emission would be gaseous and light particulate matter. Standard fall-out shelters with air filtration would serve as holding areas until the effected employees could be safely evaucated.

The number of employees to be considered for shelter designing and stocking will be developed when final design configuration is completed, and the County evacuation plan is completed.

2. SALT EMISSIONS

The following charts (Figs. 10 & 11) show projections by JCP&L of the amounts of salt deposition that could be expected under full load conditions. These figures may be modified by the Lacey Energy Park usage of effluent, and the corresponding reduction of cooling tower load. The calculations of the effects of the Lacey Energy Park upon the cooling tower load with regard to salt emissions, is beyond the scope of this report. The following discussions will be based on JCP&L figures which can be assumed to be a worst case situation. Figure #11 shows the predicted air concentration of salt from the Forked River cooling tower compared to the naturally occurring salt due to the proximity of the Bay and Ocean. The chart reveals that the increase in salt concentration is on the order of 4% or less. The threshold of salt concentration which will begin to have effect on vegetation is 10 ug/m^3. The expected combined salt concentration over the site is less than 2 ug/m^3, which is well below the figure which would cause vegetative damage. (Ref. 14, pp. 4-132 & 4-135)

The expected natural deposition of salt is 300 Kg/Km^2 per month ten (10) miles inland from the ocean. Figure #10 gives the expected concentration of salt deposition due to cooling water tower operations. The maximum deposition on the Lacey Energy Park is 14 Kg/Km^2 per month or an increase of 4.3%.

While in general the increase in air concentration and ground deposition are below the generally expected levels to effect vegetation or structures, a separate evaluation of the future tenants of Lacey Energy Park will have to be made. The slight increases noted may have a decided effect on some of the more delicate vegetation or processes interested in locating within Lacey Energy Park.

EXHIBIT XIX

FIGURE 10

PREDICTED AVERAGE ANNUAL GROUND DEPOSITION RATES (Kg/Km^{2}mo) OF SALT FROM FORKED RIVER COOLING TOWER (0 - 1 Mile From Tower)

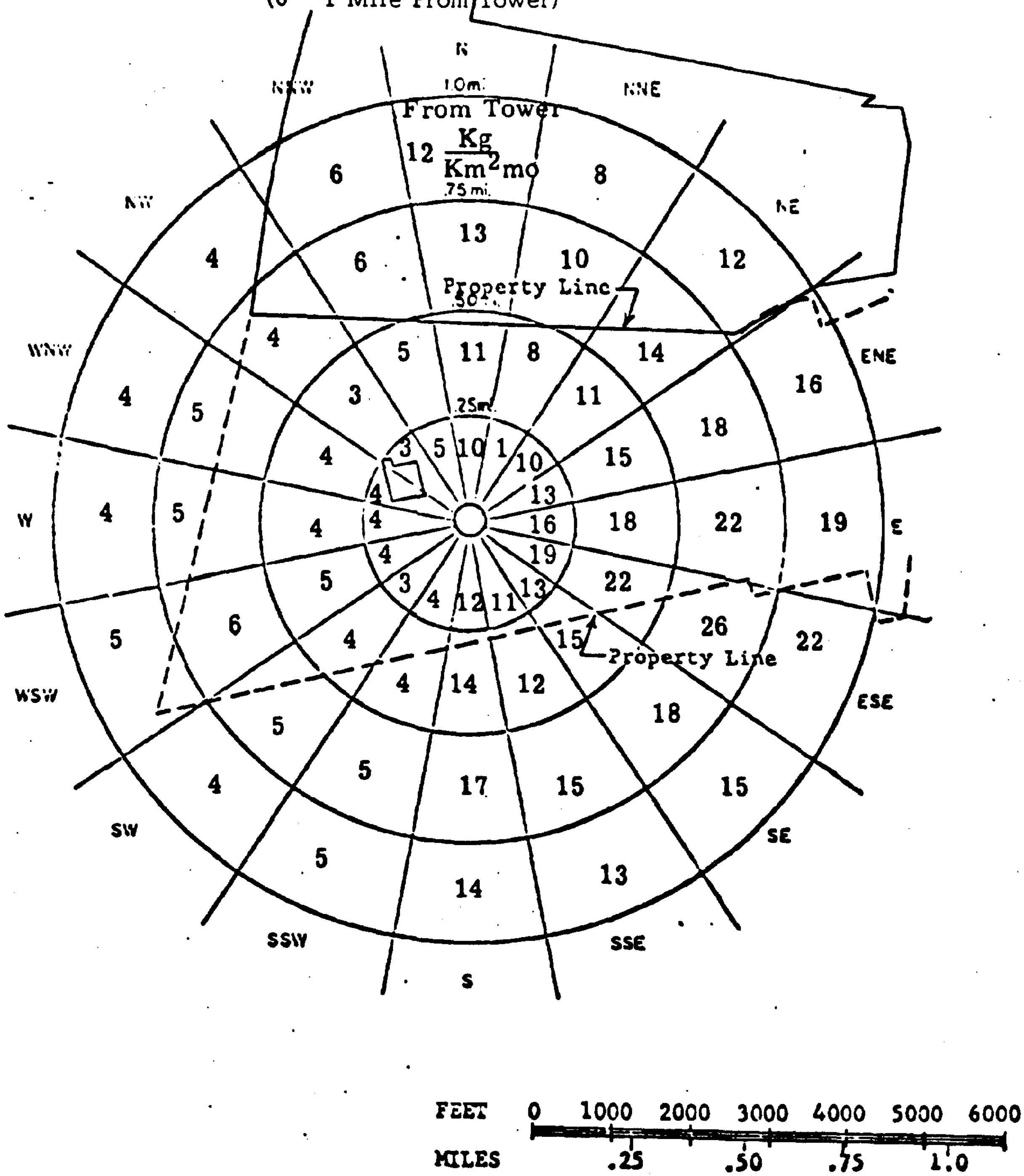
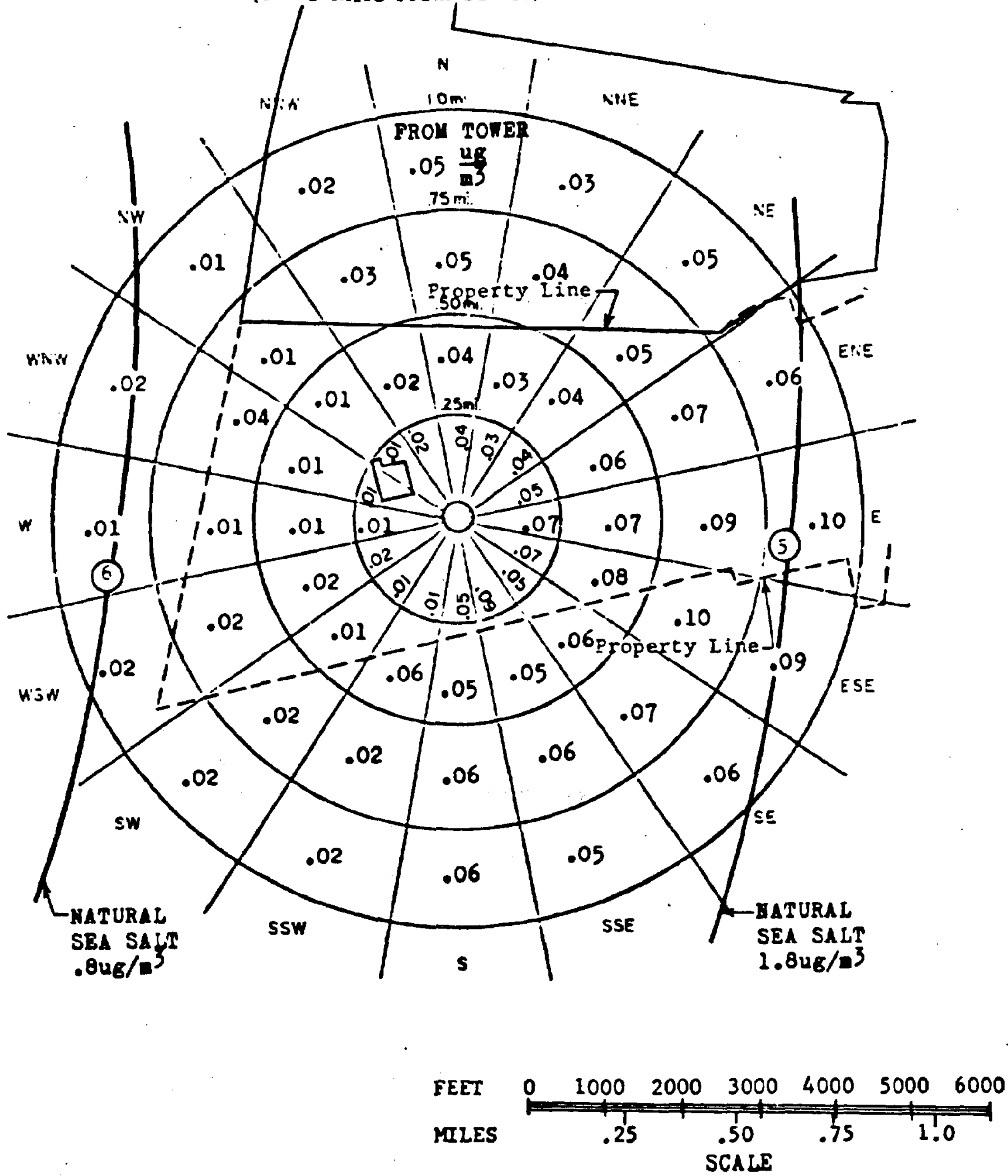


EXHIBIT XX

FIGURE 11

PREDICTED AVERAGE ANNUAL NEAR GROUND AIR CONCENTRATIONS (ug/m^3) OF SALT FROM FORKED RIVER COOLING TOWER AND FROM THE SEA (0 - 1 Mile From Tower)



XI. INSURANCE CONSIDERATIONS

XI. INSURANCE CONSIDERATIONS

Local insurance carriers were contacted to determine the insurability of an Industrial Site located adjacent to the Oyster Creek Nuclear Generating Station. The buildings and appurtenances would be insured at the prevailing area rates with only the usual considerations, such as the availability of a water distribution system used in the rate determination. In the event of a nuclear disaster an exclusion clause would be invoked that would negate all coverage and responsibility to pay on the part of the insurance company. This situation would prevail not only with the Proposed Industrial Park properties but is a general insuring exception in all such insurances wherever located.

No health insurance limitations currently exist for workers who would be employed in the Proposed Lacey Industrial Site other than general limitations regarding nuclear war or accident contingencies and consequent radiation exposure which may be contained as exclusions for general insurance practice regardless of location.

Special attention should be given to Federal Statutes limiting nuclear accident liability in some instances.

If insuring limitations were to become an obstruction to the location of industrial parks adjacent to nuclear generating stations some special governmental insurance programs might become necessary as is currently the case with such programs for limiting loss from foreign political actions by United States based corporations operating in foreign countries.

XII. CRITERIA FOR SITING

XII. CRITERIA FOR SITING

The following checklist may serve as a guide to assist in the siting of an industrial complex adjacent to a power generating facility:

A. Regulatory Considerations

1. Local: Does the zoning of the proposed site comply with local zoning and planning criteria?
2. State: Have State agencies established a criteria for land usage around a generating facility compatable with proposed development?
3. Federal: Will the project comply with Federal requirements?

B. Physical Characteristics

1. Is the proposed site comprised of sufficient area to support an economically viable project? Minimum area dependent on proposed industries and density.
2. Is the topography of the proposed site conducive to industrial development?
3. Does the site contain any environmentally sensitive areas that might preclude development or reduce developable acreage to an uneconomical level?
4. Is sufficient water of good quality available for proposed industrial processes?

C. Infrastructure:

1. Does a sufficient transportation network exist for the movement of goods to and from the proposed facility?
2. Does the local work force have the necessary skills for the proposed industries?
3. Can the local economy support any proposed growth resulting from the industrial development?
4. Does the proposed project have the support of the local governing body?

D. Technical:

1. Will condenser cooling water be discharged at a sufficiently high temperature for use with little or no augmentation?
2. Are two (2) generating facilities available as heat sources to insure a reliable supply of heat?
3. Will the utility cooperate in allowing interfacing with condensor cooling discharge lines?
4. If heat augmentation and/or storage are required, what type are contemplated in relationship to local climatological conditions?

XIII. ESTIMATED COST ELEMENTS

XIII. ESTIMATED COST ELEMENTS

Estimates of the costs of implementing the various elements, of this study, are extremely difficult due to the continuously emerging inovations in materials, technology, and the fact that none of the items have really entered the mass production stage as yet.

To give some idea of the magnitude of the costs that could be encountered in the total application, as discussed in the Aztec Energy Associates Report (See Appendix F), the "139 Edwards Engineering" heat pump units projected currently, carry a capital cost of $400,000.00 per unit, require 322 KVA's to operate and are classified as 240 ton units.

The type of solar collectors that would be utilized for augmentation purposes probably would run in the neighborhood of $1,000,000.00 per acre of collectors completely installed with storage and the necessary auxiliary equipment.

The greenhouse construction could probably be estimated at from $3.50 to $5.00 per square foot of floor space completely erected with all necessary coils, heat transfer fins, and other devices.

Ponds, such as would be utilized for aquaculture areas, could probably be constructed at an estimated cost of $400,000.00 per acre foot of capacity.

Obviously, any detailed costs based on a report of this nature would not be very accurate when final design of such a facility were completed. If a conceptual study involving exact elements and sizing were to be performed much more accurate costing could be accomplished.

It would appear though that one of the conclusions that can be drawn from this information is that large capital costs would be involved, substantial operating costs would be involved, substantial energy usage during power plant outages would be involved, and it would almost be necessary that the operator of the power plants be an interested party in the industrial venture or that extremely tight and enforceable agreements be drawn. It should further be noted that the cost-effectiveness of these concepts is on an increasing curve of feasibility in view of the fact that heat pump and solar equipment will undoubtably become more efficient and less expensive in terms of performance as greater demand occurs and manufacturing techniques are developed to meet those demands. In the same context purchased energy for the purposes involved will also increase greatly in price in the future, therefore, if the past five (5) years is a guide to the future the feasibility of these concepts will increase with time and further depletion of other energy sources.

CONCLUSIONS

CONCLUSIONS

Certain conclusions have been reached by virtue of the studies conducted to prepare this report. There are two (2) types of conclusions. Listed first are General Conclusions that would apply to Waste Heat Utilization as a general concept for consideration by electrical generating plants. These will be listed under General Conclusions.

The other grouping of conclusions are more Site Specific and would deal with the Oyster Creek Nuclear Generation Station (OCNGS) and the proposed Forked River Unit #1 (FR#1) installations and may or may not be applicable to other installations in other locales. We have included under the Site Specific Conclusions those derived from the Aztec Energy Associates Report inasmuch as that report was based largely on observations of conditions at the OCNGS and FR#1 locations, however, some of its applicability may be readily transferred to other locations.

A. GENERAL CONCLUSIONS

1. Several commercial processes investigated would appear to have potential for Waste Heat Utilization from power generating plants as follows:

   a. Agriculture (Greenhouse Maintanenence)
   b. Aquaculture
   c. Mariculture
   d. Gasohol Production
   e. Composting
   f. Methane Production
   g. Large scale biological or pharmaceutical culture production

   These operations have been listed as top priority operations inasmuch as they would require the minimum of temperature augmentation, alternative heat sources, and other additional energy sources or facilities. In addition, another group suggests itself where major heat augmentation either by on site production or otherwise, and major alternative heat sources are to be considered. These are in the category of higher temperature applications such as:

h. Chicken Processing
i. Seafood Processing
j. Vegetable or fruit processing

2. A fine balance exists between the most efficient generating process and the temperature of its cooling water discharge versus the threshold of commercial application of the cooling water. The ideal situation is consideration of reject heat utilization in the design of the original generating facility. Retrofit operations will, of necessity, probably be somewhat less efficient and more costly.

3. Generally speaking, the problems of Waste Heat Utilization of generating plant effluents will be lesser in cooler climates.

4. Any successful cost-effective evaluation will probably have to attribute the value of the thermal pollution reduction as well as the value of the commercial operations to show a significant fiscal advantage at current fuel rates. This advantage will obviously widen as fuel prices increase.

5. No commercial processes can be contemplated without an alternate heat source. The number of generating units, independently operating, available in one (1) location will determine the magnitude of the alternate heat source requirement. In addition to alternate heat sources, temperature augmentation of either the basic source water (coolant) or transfer medium would be desirable, if obtainable on a cost-effective basis. This may be necessary under certain operating conditions for some of the processes investigated, particularly during periods of marginal climatic temperatures.

6. Probable fuel costs for standby systems would destroy any economic advantages of Waste Heat Utilization unless the alternative source could be generated largely as an integral function of the utilization process without the requirement for external fuel purchases per se. Alternate heat source possibilities are:

   a. Utilization of a portion of the available energy to create an alternate fuel, such as; Alcohol or Methane.

   b. Solar augmentation of a fraction of the effluent during periods of solar availability, combined with ground storage and heat pump recovery.

c. Ground water storage and heat pump application for recovery.

7. It appears that the entire concept of the Central Heat Source with heat storage and temperature augmentation of process water, as well as chilling of discharge water may be accomplished in State-of-the-Art technology as presented in the Aztec Energy Associates Report appended hereafter.

8. Radiation monitoring, as practiced at operating nuclear facilities, appears to be adequate for warning and protection from a purely objective point of view, but probably more stringent applications would be necessary at an adjacent industrial plant for psychological work force and health insurance program acceptance.

9. Current government regulations may limit the options available in utilization of waste heat from nuclear facilities in preparation of products involved in the food chain.

10. Where possible, certain necessary local or area functions may be feasibly integrated into a Waste Heat Utilization system to the partial advantage of the system in such a way that they could minimize, or offset perceived disadvantages of the site as a location for the primary plant. These would be particularly in the fields of sewage and solid waste treatment and reduction.

B. SITE SPECIFIC CONCLUSIONS

1. There appears to be a potential for the utilization of a portion, or all, of the waste heat available from the condenser cooling water discharge from the OCNGS and the FR#1 generating facilities.

2. A direct economic benefit to the proposed FR#1, would be the possible reduction of cooling load and reduction in sizing of cooling towers or other cooling methods. A previously un-evaluated benefit to the environment could be establishing, at little or no cost, either a closed circuit for OCNGS or a return of cooling water to the Bay with little or no Delta T, thereby eliminating certain ecological degradation factors which may be undesirable. The caveat regarding this possibility is whether or not in the space available sufficient different activities can be intergrated to obtain the necessary thermal reduction. It would appear that this potential exists by utilization of the chiller concept as proposed in the Aztec Energy Associates Report.

3. In the specific situation of Lacey Township, it would appear that the traditional commercial occupations of the area, the make up of the work force available and other factors lend substantial support to the concept of Agriculture, Mariculture and Aquaculture operations. These activities also appear to have a potential for the utilization of both highly trained and low level skills available in the work force. They also appear to have the advantage of being non-labor intensive, a necessity for any commercial activity immediately adjacent to nuclear facilities where the considerations of area evacuation is a factor.

4. Water-to-water heat pumps do exist which, on a reduced unit scale, perform the necessary temperature augmentation for the utilization of the waste heat from the OCNGS.

5. It appears impractical to utilize heat exchangers to preheat incoming winter well water because of the low difference in temperature between the two water streams. Even if heat exchangers were utilized the resulting "heated" well water would require heat pump temperature augmentation because it would be below 60°F.

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BIBLIOGRAPHY

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APPENDICIES

APPENDIX A

TECHNICAL REPORT DATA

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	April 1979	Greenhouse Waste Heat Utilization

TITLE AND SUBTITLE
Greenhouse Heating with Condenser Waste Heat

AUTHOR(S) / EDITOR(S)
G.C. Ashley, J.S. Hietala, and R.V. Stansfield

PERFORMING ORGANIZATION
Northern States Power Company

SPONSORING AGENCY
Northern States Power, the University of Minnesota, and U.S. Environmental Protection Agency

SUPPLEMENTARY NOTES

ABSTRACT

"Northern States Power Company's Sherburne County Plant produces both electricity and waste heat for commercial sale. After several years of research, development and demonstration, it is now feasible to utilize condenser reject heat for commercial greenhouse heating in Minnesota. A three-year demonstration project jointly funded and sponsored by Northern States Power Company, the University of Minnesota, and the U.S. Environmental Protection Agency has lead to commercial adoption of the concept. Commercial greenhouse operators now have 1.7 acres in production using waste heat from the Sherburne County Power Plant."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
		Greenhouses Power Plant Waste Heat

TITLE AND SUBTITLE
The Sherco Greenhouse Project: From Demonstration to Commercial Use of Condenser Waste Heat

AUTHOR(S) / EDITOR(S)
G.C. Ashley, et al.

PERFORMING ORGANIZATION
Northern States Power Company
Minneapolis, Minnesota

SPONSORING AGENCY
Northern States Power Company
Minneapolis, Minnesota

SUPPLEMENTARY NOTES
Abstracted from Proceedings of the Second Conference on Waste Heat Management and Utilization, December 4-6, 1978, Miami Beach, Florida

ABSTRACT

"Northern States Power Company's Sherburne County Plant produces both electricity and waste heat for commercial sale. As a result of nearly ten years of research, development and demonstration, it is now technically and economically feasible to utilize condenser reject heat for commercial greenhouse heating in Minnesota. A three-year demonstration project jointly funded and sponsored by Northern States Power Company, the University of Minnesota, and the U.S. Environmental Protection Agency has lead the way for commercial adoption of the concept. Experience during the demonstration project proved that condenser waste heat available at approximately 85°F was suitable to maintain a greenhouse growing environment of 55 to 60°F when outside air temperatures fell as low as -43°F. During the first year of operation of the pipeline system serving waste heat to commercial greenhouse customers, an overall availability of service of 97% was achieved. The savings in heating costs to commercial operators using waste heat have amounted to nearly $5,000 an acre year compared to conventionally heated

ABSTRACT (CONTINUED)

greenhouses. While there are presently three commercial operators with 1.7 acres in production, the experiences of these operators have been sufficiently satisfactory that future expansion of waste heat service at the Sherburne County Plant site is expected."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	October 1979	Waste Heat Utilization Greenhouses Aquaculture Low grade Heat
TITLE AND SUBTITLE Energy From Cooling Water, Industrial Water Engineering		
AUTHOR(S) / EDITOR(S) S.E. Beall et al.		
PERFORMING ORGANIZATION Oak Ridge National Laboratory		
SPONSORING AGENCY U.S. Department of Energy		

SUPPLEMENTARY NOTES

ABSTRACT

"There is increasing potential for handling industrial cooling water in ways that reuse its heat content. This potential extends to lowgrade waste heat streams once thought suitable only for dispersal to the environment. Considerable research and analysis has been done by ORNL in this area, with projects including co-generation, heating and cooling of greenhouses and animal shelters, sea water distillation and aquaculture. Some waste heat utilization systems are already operating in the U.S. and abroad, but increased implementation requires interest and action by industrial water engineers and managers at their own myriad locations. The judgement of feasibility must be made locally, using local conditions of reject heat, potential uses, economic factors and alternative fuel costs."

TECHNICAL REPORT DATA

REPORT No.	
REPORT DATE	May 1978
KEY WORDS	Waste Heat Utilization Expense
TITLE AND SUBTITLE	Waste Heat: A Neglected Resource?
AUTHOR(S) / EDITOR(S)	Sam E. Beall, Jr.
PERFORMING ORGANIZATION	Oak Ridge National Laboratory
SPONSORING AGENCY	U.S. Department of Energy
SUPPLEMENTARY NOTES	Paper also published in <u>Workshop Proceedings: Dual Energy Use Workshop</u>

ABSTRACT

"Opportunities for the utilization of warm waters discharged from power plants have not been realized in the past. Several reasons are low wintertime water temperatures, the inconvenience of relocating the "using" facilities at power station sites, excessive utilization costs (pipelines, etc.), small perceived benefits to the utility, and a lack of convincing demonstrations.

Presently it appears that waste heat utilization could be attractive for heating enclosed animal and plant growing areas and for aquaculture operations. If individual utilities assumed an entrepreneurial role and EPRI and DOE assisted in pilot plants and demonstrations, large-scale warm-water utilization could become a reality."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE January 1979	KEY WORDS Greenhouses Soil Heating
TITLE AND SUBTITLE "How Waste Heat from Electricity Generation Can Heat Greenhouses", Agricultural Engineering		
AUTHOR(S) / EDITOR(S) L.L. Boyd et al.		
PERFORMING ORGANIZATION		
SPONSORING AGENCY Northern States Power Company Minneapolis, Minnesota		
SUPPLEMENTARY NOTES		

ABSTRACT

A description of the Sherburne County (Sherco) Greenhouse Project designed and operated by Northern States Power, Minnesota. This 14 acre greenhouse facility utilizes a closed loop of cooling water from the Sherco Power Plant to provide heat to the facility.

This article describes the mechanics of the operation as well as a detailed economic analysis of providing a commercial service.

TECHNICAL REPORT DATA

REPORT No. TVA/Z-71	REPORT DATE December 1976
TITLE AND SUBTITLE Using Power Plant Discharge Water in Controlled Environment Greenhouses - Program Report II	KEY WORDS Greenhouse, Horticulture, Low Grade Energy, Waste Heat
AUTHOR(S) / EDITOR(S) E.R. Burns et al.	
PERFORMING ORGANIZATION Tennessee Valley Authority	
SPONSORING AGENCY Tennessee Valley Authority	
SUPPLEMENTARY NOTES	

ABSTRACT

"Primary objectives of TVA's waste heat utilization program are to identify potential uses of the low-grade energy contained in the condenser cooling water discharged from power plants and to develop and demonstrate technology to utilize this energy in efficient agricultural and aquacultural systems. This report focuses on progress made in developing a system to utilize waste heat energy in an environmental control system for greenhouse production. This is one of several projects TVA has underway to develop technologies to utilize waste heat. The program is part of the agency's effort to ensure efficient use of resources to accelerate economic development without degrading the environment.

Thus far, waste heat greenhouse developmental work has been conducted in a pilot-scale greenhouse at Muscle Shoals, Alabama. It uses an electric boiler to simulate condenser cooling water temperatures and is a preliminary step to a broader program. The facility

ABSTRACT (CONTINUED)

is a conventional 7.3- by 30.5-meter glass-glazed structure that has been equipped with a waste heat environmental control system. A direct-contact evaporative pad is used in both heating and cooling. Heating is achieved by recirculating saturated air through the evaporative pad over which warm water is flowing. During cooling, the greenhouse air is vented to the atmosphere, and ambient air is drawn through the pad system to provide evaporative cooling. This amount of heating or cooling is controlled by louvers allowing either recirculation or venting of the greenhouse air. A fin-tube heat exchanger is available for use in reducing greenhouse relative humidity."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE January 1978	KEY WORDS Aquaculture Thermal Effluent Lobsters

TITLE AND SUBTITLE
A Comparison of Larval and Juvenile Stages of the Lobsters, Homarus americanus, Homarus gammarus, and their Hybrid

AUTHOR(S) / EDITOR(S)
J.M. Carlberg, J.C. Van Olst and R.F. Ford

PERFORMING ORGANIZATION
San Diego State University,
Department of Biology

SPONSORING AGENCY
NOAA Office of Sea Grant and
Southern California Edison Company

SUPPLEMENTARY NOTES
Reprint from: Proceedings of the Ninth Annual Meeting, World Mariculture Society, Atlanta, Georgia, January 3-6, 1978

ABSTRACT

"Previous studies have shown that H. gammarus progeny are generally larger than those of H. americanus at all stages(Gruffydd et al., 1975; Van Olst et al., 1976). In addition, the 2 nephropid lobsters are known to be similar genetically (Gedgecock et al., 1977)

Recently these 2 closely related species have been successfully hybridized. A comparison of the growth rates of the progeny from these crosses with the parental types was conducted. The larvae of the 3 varieties reached the post-larval stage in approximately the same time, with no significant differences in survival. The H. gammarus and hybrid larvae were larger than the H. americanus larvae. A comparison of growth and survival for one year of culture showed no significant differences in the size attained by juveniles of the 2 lobster species or by their hybrids.

Variation in morphological characters, pigmentation patterns, and behavior are discussed. Biochemical analyses of pereiopod tissue were performed to verify the pedigree of the hybrid progeny."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE 1978
TITLE AND SUBTITLE Pilot - Scale Systems for the Culture of Lobsters in Thermal Effluent	KEY WORDS Aquaculture Lobsters
AUTHOR(S)/EDITOR(S) J.M. Carlberg, J.C. Van Olst and R.F. Ford	
PERFORMING ORGANIZATION San Diego State University Department of Biology	
SPONSORING AGENCY Southern California Edison Company and NOAA Office of Sea Grant	

SUPPLEMENTARY NOTES
Reprint from: Power Plant Waste Heat Utilization in Aquaculture-Workshop II, New Brunswick, New Jersey, March 29-31, 1978

ABSTRACT

"This paper reviews the recent progress made in the aquaculture program at San Diego State University to develop commercially viable lobster culture in the United States. It summarizes work on the evaluation of the use of thermal effluent in the culture of the American lobster, Homarus americanus, and on the development of techniques for the culture of this species.

Studies show that there appear to be no detrimental effects of potentially toxic chemicals, such as heavy metals or chlorinated hydrocarbons, when using thermal effluent directly in lobster culture. The levels of excretion and acute toxicity for the metabolites secreted by the culture organism have been determined and can now be controlled. The influence of constant elevated and fluctuating temperatures on growth and survival also have been measured.

The development of prototype production modules for the intensive individual rearing of lobsters is discussed. Related problems

ABSTRACT (CONTINUED)

on broodstock development, communal rearing of juvenile stages, formulation of artificial pelletized diets and estimates of production costs are presented."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE

KEY WORDS

Aquaculture
Lobsters

TITLE AND SUBTITLE

Potential for Communal Rearing of the Nephropid Lobsters

AUTHOR(S) / EDITOR(S)

J.M. Carlberg, J.C. Van Olst and R.F. Ford

PERFORMING ORGANIZATION

San Diego State University, Center for Marine Studies

SPONSORING AGENCY

NOAA Office of Sea Grant and Southern California Edison Company

SUPPLEMENTARY NOTES

ABSTRACT

"A series of experiments was conducted with American Lobsters (Homarus americanus) and European lobsters (Homarus gammarus) to develop methods to reduce cannibalism among communally-reared juveniles. The primary factors studied were substrate type, stocking density and photoperiod. Other conditions investigated were the effects of different water temperatures, food type, segregating large individuals and claw immobilization. Preliminary studies also were conducted on the effects of shelter density, feeding level and tank area. These studies showed that by the use of vertical substrates, segregating techniques and immobilization of claws, carrying capacity can be increased considerably."

TECHNICAL REPORT DATA

REPORT No. 978-547	REPORT DATE September, 1979
TITLE AND SUBTITLE Preliminary Investigation Reject Heat Utilization	
AUTHOR(S) / EDITOR(S)	
PERFORMING ORGANIZATION Conestoga - Rovers and Associates and Ashley Engineering	
SPONSORING AGENCY Greenwood Energy Center Detroit Edison	

KEY WORDS
Waste Heat
Greenhouses

SUPPLEMENTARY NOTES

ABSTRACT

" The Greenwood Energy Center, located on 3,600 acres of land in northern St. Clair County, Michigan, is now the site of an 800 MW residual oil fired peaking generating station. Future plans call for the addition of two nuclear base load units by 1990 and 1992 respectively. With the expected operation of large generating units at the site both now and in the future, vast quantities of condenser reject heat may become available at temperatures sufficiently high to be of interest to commercial industrial heat users. Experience elsewhere in North America has indicated that relatively low temperature heat can be applied to certain agricultural and aquacultural applications in a commercially cost effective manner. The present study was conducted to ascertain if the characteristics of the Greenwood site, its present and expected future residual heat sources, and the local agri-business interest would be sufficiently compatible to allow further serious consideration of a commercially viable reject heat use project.

ABSTRACT (CONTINUED)

The focus of the study was on employing presently available reject heat as a substitute for fuel oil and natural gas now used by the greenhouse industry in Michigan. The greenhouse heating application was chosen as the focal point, because it has been shown to be a commercially feasible use of reject heat in other places, because heating costs now represent 20% of the cost of doing business for commercial greenhouse operators, and because of a firm business inquiry to Detroit Edison by a greenhouse operator in mid-1978.

The primary objectives of the study were to:

1) Identify feasible options for reject heat use at Greenwood;
2) Characterize the reject heat supply capability of the single unit peaking plant;
3) Determine the smallest commercially viable project;
4) Determine the local industry interest in reject heat use at Greenwood; and
5) Identify the long range potential of the site for large scale reject heat use for greenhouses or other activities.

TECHNICAL REPORT DATA

REPORT No. DSS #01SS KE204-8-0890	REPORT DATE July, 1979
TITLE AND SUBTITLE Gas Recovery and Utilization from Municipal Waste Disposal Site (Final Report)	KEY WORDS Greenhouse, Methane, Gas recovery
AUTHOR(S) / EDITOR(S) Anthony J. Crutcher, Frank A. Rovers	
PERFORMING ORGANIZATION Conestoga - Rovers and Associates, Waterloo, Ontario	
SPONSORING AGENCY Environment Canada, Department of Supply and Services	
SUPPLEMENTARY NOTES	

ABSTRACT

" The St. Thomas Gas Recovery and Utilization Project commenced in August, 1978 after receiving funding from Environment Canada, and the Department of Supply and Services. The purpose of this project was to evaluate and demonstrate gas recovery and utilization technology and to project the economics of such an energy recovery system.

The St. Thomas Gas Recovery and Utilization System consisted primarily of pumping landfill gas from a well installed within the landfill and utilizing that gas to heat an on-site greenhouse. Numerous gas and pressure monitoring probes were placed radially from the gas well, to measure the pressure distribution and methane concentrations within the landfill and to determine the effects of the pumping on the landfill. A conventional forced air gas furnace was utilized with minor modifications to heat the greenhouse over the winter of 1979. Both tomato plants and bedding plants were grown in the greenhouse, commencing in February, 1979.

ABSTRACT (CONTINUED)

The results of this project indicate that recovering and utilizing landfill gas in an unprocessed state is feasible both physically and economically. The recovery of landfill generated gas in the Canadian climate is greatly enhanced during the winter months when the demand for gas is highest."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	December, 1977	Waste Heat Greenhouses Aquaculture

TITLE AND SUBTITLE
Feasibility Analysis of the Utilization Moderator Heat for Agriculture & Aquaculture Purposes (Final Report)

AUTHOR(S) / EDITOR(S)
Conestoga - Rovers and Associates

PERFORMING ORGANIZATION
Bruce Nuclear Power Development

SPONSORING AGENCY
Ontario Ministry of Energy
56 Wellesley Street West
Toronto, Ontario M7A 2B7

SUPPLEMENTARY NOTES

ABSTRACT

" The report investigates the engineering and economic parameters involved in the delivery of moderator heat to a potential agricultural and aquacultural consumer. Ontario Hydro has determined the amount, reliability and suggested pricing structure for heat delivered to the Bruce Nuclear Power Development boundary. This information has been incorporated into the various analysis and sensitivity determinations which form part of the report.

The report investigates a commercially viable greenhouse operation with regard to the phasing of construction, the possible commodities, the market situation, the capital and operating costs, economic effects on a variety of parameters, possible construction and operation employment and the acceptability of a variety of site locations.

The aquacultural section of the report investigates two major areas. The feasibility of a hatchery facility utilizing warm water to aid in the rate of production of release fish to be used in

ABSTRACT (CONTINUED)

the rehabilitation of Lake Huron and some inland waters is the first area. This area of the report has investigated the economic benefits of both the potential commercial fishing operation and the potential sport fishing which would be dramatically affected by the rehabilitation programs planned by the Ontario Ministry of Natural Resources. The second area of aquaculture to be investigated is the commercial growing of fish for table consumption. This area of the study discusses a first stage operational unit and investigates the market and types of product available for such an undertaking."

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE
June 1974

KEY WORDS
Waste Heat
Soil Warming
Cooling Towers

TITLE AND SUBTITLE

An Agro-Power-Waste Water Complex for Land Disposal of Waste Heat and Waste Water

AUTHOR(S) / EDITOR(S)

Dr. David R. DeWalle

PERFORMING ORGANIZATION

Pennsylvania State University

SPONSORING AGENCY

National Science Foundation, Program of Research Applied to National Needs

SUPPLEMENTARY NOTES

ABSTRACT

"An Agro-Power-Waste Water Complex was evaluated as a system in which waste heat from power generation was dissipated by recycling hot water through a pipe network buried in agricultural land. Concurrently, municipal waste water was renovated by sprinkler irrigation on the land and served to maintain a high soil moisture content and soil thermal conductivity. A 0.23 acre field prototype of the Agro-Power-Waste Water Complex was constructed and measurements were obtained of soil temperature, soil thermal conductivity, heat dissipation, degree of waste water renovation, soil surface temperature, and climatic variables. These data were used to test equations for prediction of heat dissipation and surface temperature used in a system analysis. The systems analysis indicated 4,500 acres of land with 2-in diameter pipe buried at 1-ft depth and 2-ft spacing in sandy soil would be required for a 1,500 MWe nuclear electric plant. A nuclear fuel penalty concept was used in comparing this system with conventional heat dissipation systems. The preliminary results of a system design

ABSTRACT (CONTINUED)

and cost analysis indicated the concept was less expensive than dry-cooling towers but more expensive than wet-cooling towers."

TECHNICAL REPORT DATA

REPORT No.
ORNL/TM-7099

REPORT DATE
November 1979

KEY WORDS
Energy-Agro-Waste
Waste Heat Utilization
Animal Production
Aquaculture
Greenhouse

TITLE AND SUBTITLE

Input-Output Analysis of Various Elements of an Energy-Agro-Waste Complex

AUTHOR(S)/EDITOR(S)
Dr. Luis F. Diaz, Dr. Clarence G. Golueke and Dr. John C. Glaub

PERFORMING ORGANIZATION
Cal Recovery Systems, Inc.
Richmond, California 94804

SPONSORING AGENCY
U.S. Department of Energy
Oak Ridge National Laboratory

SUPPLEMENTARY NOTES

D.O.E. Project Officer: Dr. Mitchell Olszewski

ABSTRACT

The mass input and output streams of various agricultural and waste treatment processes were quantified and models developed to serve in the engineering analysis of potential waste heat utilization schemes. The unit process models can be integrated into energy-agro-waste complexes, in which waste heat from power plants is used by certain processes and the wastes of some processes are used as inputs to others. The models provide a means of determining the sizing of subsystems, the compatibility of subsystems, and the overall feasibility of an integrated complex. Ten potential complexes were qualitatively discussed and the considerations involved in forming such complexes explained. A mass balance analysis was performed on four integrated complexes demonstrating the engineering value of the analytical models developed.

TECHNICAL REPORT DATA

REPORT No. EPRI/EM-718-W	REPORT DATE May 1978
TITLE AND SUBTITLE Workshop Proceedings: Dual Energy Use Systems	
AUTHOR(S) / EDITOR(S) Deborah A. Dougherty (Editor)	
PERFORMING ORGANIZATION Electric Power Research Institute Fossil Fuel and Advanced Systems Division	
SPONSORING AGENCY Electric Power Research Institute Fossil Fuel and Advanced Systems Division	

KEY WORDS
Cogeneration
District Heating
Total Energy Systems
Aquaculture

SUPPLEMENTARY NOTES

ABSTRACT

"The proceedings of the EPRI-sponsored workshop on Dual Energy Use Systems (DEUS), held September 19-23, 1977, in Yarmouth, Maine, are reported in this volume. Participants from the electric utility industry, industrial and other consumer experts, government representatives, academicians, and equipment manufacturers met to discuss and evaluate the various options for using thermal and electric energy produced from a common source. The 39 presentations which served as a basis for this discussion form the body of this report. An overview report of this meeting (EPRI EM-718-SR) contains summaries of workshop sessions, general conclusions, and lists of research items identified as being of interest to utilities.

The following application areas were reviewed:

* District heating
* Cogeneration
* Use of power plant reject heat
* Total energy applications
* Emerging technologies with potential for

ABSTRACT (CONTINUED)

simultaneous production of heat and power

Each type of application was covered in some detail in presentations, group discussions, and core group meetings where daily discussions were reviewed by utility industry personnel. This report focuses on the technical, economic, and institutional aspects of each application covered, contains papers describing the DEUS experiences of 11 domestic and foreign utilities and provides additional background material in three appendixes."

TECHNICAL REPORT DATA

REPORT No.
EPRI/EM-718-SR

REPORT DATE
March 1978

KEY WORDS
Cogeneration
District Heating
Total Energy Systems
Aquaculture

TITLE AND SUBTITLE
Dual Energy Use Systems
Workshop Summary

AUTHOR(S) / EDITOR(S)
Deborah A. Dougherty and Quentin Looney
(EPRI Workshop Chairmen)

PERFORMING ORGANIZATION
Electric Power Research Institute
Fossil Fuel and Advanced Systems Division

SPONSORING AGENCY
Electric Power Research Institute
Fossil Fuel and Advanced Systems Division

SUPPLEMENTARY NOTES
Workshop proceedings published under separate cover. (EPRI/EM-718-W)

ABSTRACT

Results of EPRI's Dual Energy Use Systems (DEUS) Workshop held September 19-23, 1977, in Yarmouth, Maine, are presented in this report. Participants from the electric utility industry, industrial and other consumer experts, government representatives, academicians, and equipment manufacturers met to discuss and evaluate the various options for using thermal and electric energy produced from a common source. Work sessions based on formal presentations and group discussion resulted in a list of 32 research, development, and demonstration (RD&D) projects of potential interest to state and federal program managers as well as to utility personnel. A resource document, which should be useful to utilities in the process of developing programs related to DEUS, has been compiled from the workshop presentations.

The application areas reviewed were:

* District heating
* Cogeneration
* Use of power plant reject heat
* Total energy applications

ABSTRACT (CONTINUED)

* Emerging technologies with potential for simultaneous production of heat and power.

Each type of application was covered in some detail. This report presents an overview of the workshop sessions, lists the research projects identified, and contains abstracts of the papers presented."

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE
November 1977

TITLE AND SUBTITLE
Jersey Central Power and Light Company
Oyster Creek Nuclear Generating Station
Alternate Cooling Water System Study

AUTHOR(S) / EDITOR(S)

PERFORMING ORGANIZATION
Ebasco Services Incorporated

SPONSORING AGENCY
Jersey Central Power and Light Company

KEY WORDS
Oyster Creek Nuclear Generating Station
Open-cycle cooling
Closed-cycle cooling
Natural Draft Cooling Tower
Mechanical Draft Cooling Tower

SUPPLEMENTARY NOTES
Three Volume Set

ABSTRACT

"Ebasco Services Incorporated evaluated sixteen alternative open-cycle and closed-cycle cooling systems for Oyster Creek Nuclear Generating Station. The evaluation considered engineering, licensing, and environmental factors. Twelve alternatives were eliminated either because: 1) they exhibited overriding evnironmental impacts; 2) they did not exhibit compensating advantages for important disadvantages in one or more disciplinary areas; or 3) they involved significant commercial risk. The four remaining alternatives (natural draft cooling tower, round mechanical draft cooling tower, fan-assisted natural draft cooling and discharge canal to Barnegat Bay systems) were designated "preferred" alternative systems and evaluated in greater detail.

The round mechanical draft tower system was eliminated from consideration because no practical method could be identified to achieve compliance with nighttime New Jersey noise limits. The discharge canal-to-bay alternative was considered less desirable than the

ABSTRACT (CONTINUED)

remaining preferred alternatives because it would provide, at best, a marginal improvement on existing environmental conditions compared to the remaining preferred alternatives. The fan-assisted natural draft tower system was judged to be less desirable than the natural draft tower system on the basis of noise mitigation and operating experience considerations. Other differences between these latter two alternatives are comparatively minor.

Based on its study of engineering, licensing, and environmental factors, Ebasco concluded that the natural draft cooling tower system is the optimum of the sixteen alternatives considered."

TECHNICAL REPORT DATA

REPORT No. EPRI/3(3):38	REPORT DATE April 1978	KEY WORDS Greenhouse Power Plant Waste Heat
TITLE AND SUBTITLE Waste Heat May Help Greenhouse Operators, <u>EPRI Journal</u>		
AUTHOR(S) / EDITOR(S)		
PERFORMING ORGANIZATION Electric Power Research Institute		
SPONSORING AGENCY		
SUPPLEMENTARY NOTES		

ABSTRACT

Article which examines the alternate source of heat to greenhouses in vicinity of power plants.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
		Peat District Heating Underground Oil Storage Hydro Power Generation

TITLE AND SUBTITLE

Finn Energy '79 Symposium

AUTHOR(S) / EDITOR(S)

PERFORMING ORGANIZATION

SPONSORING AGENCY

Finnish Ministry of Trade and Industry

SUPPLEMENTARY NOTES

Copy referenced found at PSE&G Co. Newark, NJ

ABSTRACT

Finnish know-how, equipment and energy technology have been presented to the U.S. and Canadian energy experts in the Finn Energy '79 symposium series. District heating technology, small hydro power generation plants, the utilization of peat as a fuel and underground storage of fuel are the main categories of examination which have been presented and published in this volume.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
		Aquaculture Thermal Effluent Lobster
TITLE AND SUBTITLE Effects of Fluctuating and Constant Temperatures and Chemicals in Thermal Effluent on Growth and Survival of the American Lobster		
AUTHOR(S) / EDITOR(S) Richard F. Ford et al.		
PERFORMING ORGANIZATION San Diego State University, Department of Biology		
SPONSORING AGENCY NOAA Office of Sea Grant and San Diego Gas and Electric Company		

SUPPLEMENTARY NOTES

ABSTRACT

"The effects of long-term exposure to a fluctuating temperature regime typical of that produced by coastal generating stations were investigated for juvenile Homarus americanus held in individual rearing containers. Juveniles reared in a 15-22°C daily temperature fluctuation for 126 days had significantly slower growth ($p<0.05$) than those reared at a constant 22 ± 0.5°C. They also had significantly higher mortality and less resistance to a high stress temperature (31°C) than those reared at the constant temperature. These effects appeared to be the result of physiological stress produced by the fluctuating temperature regime. Exposure to fluctuating temperatures for 1-2 weeks had no evident effect on growth and survival, suggesting that such short-term exposures would not be harmful in commercial culture. Related experiments were conducted to assess effects of thermal effluent water chemistry and constant temperatures on growth and survival of larvae and juveniles (Stages I-XI). Experiments at the Encina Power Plant employed thermal effluent and non-effluent water at

ABSTRACT (CONTINUED)

four constant temperatures (16.9±1.0°C, 20.3±0.7°C, 24.2±0.6°C, and 26.3±0.6°C). Comparative experiments at the Redondo Generating Station employed a single temperature (23.8±0.9°C). The experiments were conducted in individual rearing containers supplied with a continuous, open flow of effluent or non-effluent water. There were no significant differences in growth and survival among lobsters held in either thermal effluent or non-effluent water at a give temperature, indicating that effluent water chemistry had no apparent effects. There were significant differences in growth of both larvae and juveniles held at the four constant temperatures. Survival of juvenile lobsters was not affected significantly by temperature, while that of larvae was. Juvenile lobsters molted more frequently at successively higher temperatures. More frequent molting at 24.2°C and 26.3°C, however, did not result in larger individuals than those produced by slower molting at 20.3 C. This was attributed to absence of a corresponding increase in feeding rate and the relatively high oxygen consumption rates observed at the two highest temperatures."

TECHNICAL REPORT DATA

REPORT No. ERDA/C002869-1	REPORT DATE September 1977
TITLE AND SUBTITLE Nuclear Power Plant Waste Heat Utilization	KEY WORDS Waste Heat Utilization, Aquaculture, Horticulture, Greenhouses, Methane Generator
AUTHOR(S) / EDITOR(S) Edmund P. Gaines Jr. (Editor)	
PERFORMING ORGANIZATION Kramer, Chin & Mayo, Inc., Vermont Yankee Nuclear Power Corporation	
SPONSORING AGENCY United States Energy Research and Development Agency, Environmental Protection Agency	
SUPPLEMENTARY NOTES	

ABSTRACT

"The possibility of using Vermont Yankee condenser effluent for commercial food growth enhancement was examined. It was concluded that for the Vermont Yankee Nuclear Station, commercial success, both for horticulture and aquaculture endeavors, could not be assured without additional research in both areas. This is due primarily to two problems. First, the particularly low heat quality of our condenser discharge, being nominally 72± 2°F; and second , to the capital intensive support systems. The capital needed for the support systems include costs of pumps, piping and controls to move the heated water to growing facilities and the costs of large, efficient heat exchangers that may be necessary to avoid regulatory difficulties due to the 1958 Delaney Amendment to the U.S. Food, Drug and Cosmetics Act.

Recommendations for further work include construction of a permanent aquaculture research laboratory and a test greenhouse complex based on a unique greenhouse, designed by Cornell University staff, wherein a variety of heating configurations would be installed

ABSTRACT (CONTINUED)

and tested. One greenhouse would be heated with biogas from an adjacent anaerobic digester thermally boosted during winter months by Vermont Yankee condenser effluent.

The aqualculture laboratory would initially be dedicated to the Atlantic salmon restoration program. It appears possible to raise fingerling salmon to smolt size within 7 months using water warmed to about 60°F. The growth rate by this technique is increased by a factor of 2 to 3.

A system concept has been developed which includes an aqua-laboratory, producing 25,000 salmon smolt annually, a 4-unit greenhouse test horticulture complex and an 18,000 square foot commercial fish-rearing facility producing 100,000 pounds of wet fish (brook trout) per year. The aqualab and horticulture test complex would form the initial phase of construction. The trout-rearing facility would be delayed pending results of laboratory studies confirming its commercial viability."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	1979	Aquaculture Waste Heat Power Plants Thermal Pollution

TITLE AND SUBTITLE
Power Plant Waste Heat Utilization in Aquaculture, Workshop II

AUTHOR(S)/EDITOR(S)
Bruce L. Godfriaux et al.

PERFORMING ORGANIZATION
Public Service Electric and Gas Company
Rutgers - The State University
Trenton State College

SPONSORING AGENCY
Public Service Electric and Gas Company
Rutgers - The State University, Trenton State College, Electric Power Research Institute, National Science Foundation

SUPPLEMENTARY NOTES

ABSTRACT

The result of a workshop held March 21-31, 1979, at Rutgers - The State University, New Brunswick, New Jersey, is this publication of 21 technical papers dealing specifically with utilization of power plant waste heat in aquaculture. Low-grade industrial waste heat and cooling water available from industry, especially electric generating stations, was examined with relation to present research applied to aquaculture technology.

Workshop contributors included representatives from private industry, utility companies, academic institutions, research groups and government agencies.

Engineering, economics, marketing and regulatory aspects of several research and commercial projects is also examined, as well as a world-wide review of waste heat aquaculture.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE: May 1978
TITLE AND SUBTITLE: Use of Low-Temperature Waste Heat in Aquaculture and Agriculture	
AUTHOR(S) / EDITOR(S): Bruce L. Godfriaux	
PERFORMING ORGANIZATION: Public Service Electric and Gas Company	
SPONSORING AGENCY: Public Service Electric and Gas Company	

KEY WORDS
Waste Heat
Aquaculture
Agriculture

SUPPLEMENTARY NOTES
Paper also published in Workshop Proceedings: Dual Energy Use Systems

ABSTRACT

"This paper presents a brief assessment of the current state of technical development of low-temperature uses of waste heat in aquaculture and agriculture, primarily within the United States. Nontechnical facets related to the use of waste heat are also considered These include institutional barriers, technical and economic considerations, utility impacts, and benefits of low-grade waste heat utilization."

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE

KEY WORDS
Waste Heat
Aquaculture

TITLE AND SUBTITLE
Experience with the New Mercer Proof-of-Concept Waste Heat Aquaculture Facility

AUTHOR(S) / EDITOR(S)

Bruce L. Godfriaux et al.

PERFORMING ORGANIZATION
Public Service Electric and Gas Company,
Buchart - Horn Consulting Engineers, and
Trenton State College

SPONSORING AGENCY

Public Service Electric and Gas Company

SUPPLEMENTARY NOTES

ABSTRACT

"At the First Waste Heat Management and Utilization Conference, a paper was given that summarized the results of our pilot waste heat aquaculture research program and explained the concept of sequential (diseasonal) aquaculture. The design of a proposed proof-of-concept aquaculture facility was also discussed. This design was subsequently modified.

In April, 1978, construction of the modified Mercer Proof-of-Concept Aquaculture Facility was completed. Facility process water can be derived wholly or in part from five sources: generating station discharge water, ambient river water, well water, tempering pond (reservoir) water, and recirculated facility process water. The operation of the overall system is discussed.

Results through the use of this system for the rearing of rainbow trout, Salmo gairdneri, (Richardson), completed on June 6, 1978, in addition to the results to date (August, 1978) for the other species presently being cultured at the facility are discussed. These species include the American eel, Anguilla rostrata (Lesueur) and

ABSTRACT (CONTINUED)

channel catfish, Ictalurus punctatus (Rafinesque). Projected harvest densities for the latter two species are briefly outlined."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
TITLE AND SUBTITLE Waste Heat User Criteria for Power Plant Interface		Waste Heat Soil Warming Greenhouse
AUTHOR(S) / EDITOR(S) Bruce L. Godfriaux		
PERFORMING ORGANIZATION Public Service Electric and Gas Company		
SPONSORING AGENCY Public Service Electric and Gas Company		
SUPPLEMENTARY NOTES		

ABSTRACT

"Potential needs of waste heat users for utilizing waste heat for aquacultural and agricultural uses will be discussed for both existing and new generating stations. Different factors which must be considered by potential waste heat users when contemplating the establishment of a new aquaculture/agriculture facility will be examined.

Some of the more important factors to be discussed in this paper include quantity and quality of water available, reliability of waste heat source, space available for facility location, lead time required to put user interconnections in a new generating station, discharge permits required from regulatory agencies by waste heat user for process/cleaning effluent and waste heat user/utility agreements."

TECHNICAL REPORT DATA

REPORT No.	
REPORT DATE	
TITLE AND SUBTITLE	Factors Affecting Power Plant Waste Heat Utilization
AUTHOR(S) / EDITOR(S)	L. Barry Goss (Chairman)
PERFORMING ORGANIZATION	Tennessee Valley Authority Electric Power Research Institute
SPONSORING AGENCY	Tennessee Valley Authority Electric Power Research Institute
KEY WORDS	Waste Heat Environmental Effects Public Health Aspects Institutional Aspects

SUPPLEMENTARY NOTES

Proceedings of this workshop to be available in March 1980.

ABSTRACT

A workshop was held on November 29-December 1, 1978 in Atlanta, Georgia, sponsored by a joint effort from TVA/EPRI. This workshop focussed "on factors affecting power plant waste heat utilization (WS77-27). Participants will include representatives of the electric power industry, the waste heat user community, and various federal agencies, such as the Environmental Protection Agency, the Food and Drug Administration, Nuclear Regulatory Commission, Department of Energy, and Department of Commerce. The overall objective of the workshop was to describe and analyze problems that have to be resolved both by the utilities that supply waste heat and by the users of waste heat. Waste heat utilization technology was discussed briefly, but the primary emphasis was on such topics as legislation affecting waste heat utilization at nuclear power plants, and utility charter constraints on waste heat utilization."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE October 9, 1979	KEY WORDS District Heating/Cooling Cogeneration
TITLE AND SUBTITLE District Heating and Cooling Through Retrofit of Public Utility		
AUTHOR(S) / EDITOR(S) C.R. Guerra, M.L. Zwillenberg, G.W. Bowdren, R.H. Tourin, V. Saleta, M.G. Kurz		
PERFORMING ORGANIZATION Public Service Electric and Gas Research Corporation		
SPONSORING AGENCY U.S. Department of Energy, Division of Conservation and Solar Applications		
SUPPLEMENTARY NOTES		

ABSTRACT

"The technical-economic feasibility and environmental acceptability of a district heating and cooling system serving communities by retrofit of existing intermediate and base-load electric generating stations has been studied. The study area was a densely populated area of New Jersey not being served by district heating.

A range of power plant retrofit concepts were examined. These included steam extraction (reheat or crossover) from a condensing turbine cycle, to supply a heat exchanger or back-pressure turbine and modification of condensing turbines to back-pressure operation. Conceptual designs for retrofitting power plants for cogenerative operation (electricity and district heating/cooling) were developed. Innovative adaptations of existing technology were investigated that could make delivery of thermal services from central stations a reasonable investment for private capital.

A market analysis was conducted to establish the extent and nature of the potential heating and cooling loads which are

ABSTRACT (CONTINUED)

technically available within the proposed project areas. Both survey and simulation techniques were used. Potential for growth in thermal energy requirements was projected for each type of end-use consumer for periods ranging from 5 to 20 years beyond the study period.

Results of the study and possibilities for a demonstration project are presented."

TECHNICAL REPORT DATA

REPORT No. PSE & G/RO-443

REPORT DATE June, 1978

KEY WORDS
Aquaculture
Waste Heat
Thermal Pollution

TITLE AND SUBTITLE
Power Plant Waste Heat Utilization in Aquaculture (Second Semi-Annual Report)

AUTHOR(S) / EDITOR(S)
C.R. Guerra and B.L. Godfriaux (PSE&G)

PERFORMING ORGANIZATION
Public Service Electric and Gas Company
Research and Development Department
Newark, New Jersey

SPONSORING AGENCY
The National Science Foundation's
Division of Problem Focused Research Applications

SUPPLEMENTARY NOTES

ABSTRACT

Construction of the Mercer Proof - of - Concept Aquaculture Facility was completed in April 1978. This project evaluates the potential of intensive aquaculture operations using power plant thermal discharges to enhance productivity. The field experiments involve rearing rainbow trout, American eel, channel cat fish, striped bass and freshwater shrimp.

The program research comprises of four main areas of study: 1. biology 2. engineering 3. economics 4. product quality. This report is the results of the research which are reported on a six-month basis.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	1976	Aquaculture Waste Heat Utilization Thermal Effluent

TITLE AND SUBTITLE
Power Plant Waste Heat Utilization in Aquaculture - Workshop I

AUTHOR(S) / EDITOR(S)
C.R. Guerra and B.L. Godfriaux (PSE & G)
A.F. Eble (Trenton State College)

PERFORMING ORGANIZATION
Public Service Electric and Gas Company
Trenton State College

SPONSORING AGENCY
Public Service Electric and Gas Company

SUPPLEMENTARY NOTES

ABSTRACT

"The first workshop specifically devoted to the subject of Power Plant Waste Heat Utilization in Aquaculture was held November 6-7, 1975, at Trenton State College in Trenton, New Jersey.

The purpose of the Workshop was to bring together experts and representatives from industry, government and universities who could either relate their field experiences in this area of research or present considerate views on the status of aquaculture in thermal effluents from power plants, future research needs, funding and regulatory policies."

The eighteen (18) technical papers presented at this workshop have been reprinted and comprise this publication.

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE
1975

KEY WORDS
Aquaculture
Thermal Effluents
Mariculture

TITLE AND SUBTITLE
Aquaculture in Thermal Effluents from Power Plants

AUTHOR(S) / EDITOR(S)
C.R. Guerra et al.

PERFORMING ORGANIZATION
Public Service Electric and Gas Company
Trenton State College

SPONSORING AGENCY

SUPPLEMENTARY NOTES
Reprinted from the Proceedings of the 10th European Symposium on Marine Biology, Ostend, Belgium, September 17-23, 1975

ABSTRACT

"Research on the culture of the giant freshwater shrimp, Macrobrachium rosenbergii, and rainbow trout, Salmo gairdneri, is being conducted using the thermal effluents of a power station sited adjacent the Delaware River (New Jersey). The pilot scale experiments are being funded by a grant from the National Science Foundation. Research Applied to National Needs.

The paper outlines fundamental factors which influence the potential and limitations of stimulating growth of aquatic organisms by the addition of low-grade thermal energy from power plants and other sources. Some of the significant experiments and results from the tests carried out at the Aquaculture Facility of the Public Service Electric and Gas Company (PSE and G) Mercer Generating Station are described.

About 2,200 shrimp were stocked as the summer crop and successfully maintained at low density levels (10/m) in an experimental pond using condenser cooling water effluent from the power station (28° C average temperature). Various types of submerged substrates were tested

ABSTRACT (CONTINUED)

for suitability in providing protection and habitat niches to the shrimp. In less than 4 months, the shrimp grew from an average of 22 to 70 mm with some animals reaching 108 mm. Mortalities were low (9.7%).

The winter trout culture was also successful. Five thousand 17.5 cm rainbow trout fingerlings (65 grams average) were stocked and grown in the power plant effluent (10°C average temperature) for 3-5 months reaching an average length of 25 cm and weighing 190 g. Dual crop aquaculture operations appear viable in temperature zones. High intensity pond stocking of shrimp and trout are planned for 1975 and 1976.

Future projections of thermal aquaculture and conceptual designs of aquaculture systems which could be adapted to open- or closed-loop cooling water systems of power stations sited on land or floating offshore in the ocean are presented."

TECHNICAL REPORT DATA

REPORT No. TVA/Y-132 EPRI/EA922	REPORT DATE August, 1978
TITLE AND SUBTITLE State of the Art-Waste Heat Utilization for Agriculture and Aquaculture	KEY WORDS Waste Heat, Greenhouse Heating, Agriculture, Aquaculture, Soil Heating, Biological Waste Recycling
AUTHOR(S)/EDITOR(S) Wayne A. Hubert and Carl E. Madewell (TVA Project Manager) Robert Kawaratani (EPRI Project Man.)	
PERFORMING ORGANIZATION Tennessee Valley Authority Electric Power Research Institute	
SPONSORING AGENCY Tennessee Valley Authority Electric Power Research Institute	

SUPPLEMENTARY NOTES

Published in two versions, one by EPRI, and one by TVA

ABSTRACT

"A state-of-the-art assessment of research, demonstration, and commercial projects that involve the use of power plant condenser cooling water for agricultural and aquacultural purposes was conducted. Information was obtained from published literature, site visits, and communications with knowledgeable individuals. Thermal effluent uses were discussed for controlled environment greenhouses, biological recycling of nutrients from livestock manures, soil heating and irrigation, environmental control for livestock housing, grain drying, food processing, as well as the culture of numerous aquatic organisms. A large number of research and feasibility studies have been conducted, but few commercial enterprises are utilizing thermal effluent. Interfacing problems, environmental and legal restrictions, along with insufficient technology, have not allowed widespread commercial application. Specific research needs were discussed."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
NOAA/DEL-SG-22-76	October 1976	Finfish Crustaceans Molluscs Marine Plants

TITLE AND SUBTITLE

Aquaculture 1976
A Digest of Sea Grant Research

AUTHOR(S) / EDITOR(S)

Kathi Jensen (Editor)

PERFORMING ORGANIZATION

University of Delaware

SPONSORING AGENCY

National Sea Grant Program
National Oceanic and Atmospheric Administration

SUPPLEMENTARY NOTES

ABSTRACT

A brief update of current aquaculture projects being sponsored by the Office of Sea Grant, N.O.A.A.

Several of the described projects utilize waste heat to provide the environmental controls needed for the research.

TECHNICAL REPORT DATA

REPORT No.	
REPORT DATE	January 1972
TITLE AND SUBTITLE	Forked River Nuclear Station Unit 1-Environmental Report - Construction Permit Stage
AUTHOR(S) / EDITOR(S)	
PERFORMING ORGANIZATION	Jersey Central Power and Light Company
SPONSORING AGENCY	
KEY WORDS	Forked River Nuclear Station Environmental Impact Statement
SUPPLEMENTARY NOTES	

ABSTRACT

"This Environmental Report includes descriptions of the plant and its surrounding environment, an assessment of the environmental impact of the plant, a description of the preoperational and post-operational environmental surveillance studies conducted by Jersey Central Power and Light Company, an evaluation of possible alternatives to the project, and cost-benefit analysis of the project in terms of environmental, economic, technical, social and other relevant considerations."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS Oyster Creek Nuclear Generating Station Forked River Nuclear Generating Station Environmental Effects
TITLE AND SUBTITLE Oyster Creek and Forked River Nuclear Generating Stations, 316(a) & (b) Demonstration Text		
AUTHOR(S) / EDITOR(S)		
PERFORMING ORGANIZATION		
SPONSORING AGENCY Jersey Central Power and Light Company		
SUPPLEMENTARY NOTES		

ABSTRACT

Jersey Central Power and Light Company submitted this demonstration regarding its Oyster Creek Nuclear Generating Station and Forked River Nuclear Generating Station to the New Jersey Department of Environmental Protection and the U.S. Environmental Protection Agency, Region II, pursuant to Sections 401, 316(a) and 316(b) of the Federal Water Pollution Control Act Amendments of 1972.

"The purpose of the demonstration is to support the establishment of effluent limitations and other operating conditions for the two stations which are consistent with current plant operating conditions and designs."

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE

TITLE AND SUBTITLE
Proceedings of the Conference on Waste Heat Management and Utilization

AUTHOR(S) / EDITOR(S)
Samuel S. Lee and Subrata Sengupta

PERFORMING ORGANIZATION
University of Miami

SPONSORING AGENCY
NASA, U.S. N.R.C., U.S. E.P.A., Duke Power Company, Florida Power and Light Company, University of Miami

KEY WORDS
Waste Heat
Agriculture
Aquaculture
Thermal Discharges

SUPPLEMENTARY NOTES

ABSTRACT

On May 9-11, 1976, a conference was held in Miami Beach, Florida with the intention of providing a forum for inter-disciplinary exchange. "The widely scattered biological, economic and engineering state-of-the-art knowledge of waste heat and energy could then be compiled into a single source, namely the conference proceedings.

The conference gave equal emphasis to pollution abatement and utilization." This three volume set includes 128 published technical papers dealing with the management, institutional barriers, environmental and ecological effects, computer models, economic aspects and mechanical design of waste heat utilization systems.

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE
September 1978

KEY WORDS
Waste Heat
Agriculture
Greenhouses
Aquatic Agriculture

TITLE AND SUBTITLE
TVA's Projects on Agricultural Uses of Waste Heat

AUTHOR(S) / EDITOR(S)

C.E. Madewell, et al.

PERFORMING ORGANIZATION
Tennessee Valley Authority
Division of Agricultural Development

SPONSORING AGENCY
Tennessee Valley Authority
Division of Agricultural Development

SUPPLEMENTARY NOTES

ABSTRACT

"A major concern of the Tennessee Valley Authority (TVA) is to ensure efficient use of resources, especially energy, in the Tennessee Valley region in achieving optimum economic development without degrading the environment. As part of this effort, TVA is exploring many uses for the low-grade heat energy (waste heat) contained in the large quantities of power plant condenser cooling effluent. This paper describes only the agricultural activities of TVA to develop ways to use waste heat, and they have been underway since the early 1970's. The agricultural waste heat pilot-scale research and development projects facilities are located at the National Fertilizer Development Center, Muscle Shoals, Alabama. The primary objectives of the agricultural effort are to: (1) identify potential agricultural uses of waste heat, (2) develop and test technologies and management criteria for more productive uses, (3) demonstrate technologies in commercial-scale production facilities, and (4) provide technical assistance for commercial application."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
TVA/Z-56	January 1975	Greenhouse Brown's Ferry Nuclear Plant Horticulture

TITLE AND SUBTITLE

Progress Report - Using Power Plant Discharge Water in Greenhouse Vegetable Production

AUTHOR(S) / EDITOR(S)

C.E. Madewell et al

PERFORMING ORGANIZATION

Tennessee Valley Authority and
Oak Ridge National Laboratory

SPONSORING AGENCY

Tennessee Valley Authority and
U.S. Atomic Energy Commission

SUPPLEMENTARY NOTES

ABSTRACT

This paper focuses on one potential method of using waste heat in agriculture-heating and cooling greenhouses.

"The three major overall objectives of the research project are to test the capabilities of the environmental control system, to determine the effect of the resulting environment on production of horticultural crops, and to evaluate the overall economics of the system. Results of engineering and horticultural tests and economic analyses will be used to refine the production system and to provide the basis for designing and building a demonstration facility. About 1 acre will be used for this purpose at the Browns Ferry Nuclear Plant site in north Alabama where TVA has reserved 180 acres for possible waste heat research and development."

TECHNICAL REPORT DATA

REPORT No.	
REPORT DATE	June 1977
TITLE AND SUBTITLE	New Types of Hot Water Distribution Systems for Low Density Heat Areas
AUTHOR(S) / EDITOR(S)	Peter Margen
PERFORMING ORGANIZATION	A.B. Atomenergi, Nykoping, Sweden
SPONSORING AGENCY	
KEY WORDS	District Heating Distribution Pipes
SUPPLEMENTARY NOTES	

ABSTRACT

"District heating is used widely in Sweden and in many other European countries, with combined heat/electric stations supplying the base heat load in most of the larger schemes. The fuel crisis, the reluctance to have major increases in electric power commitments, and the increasing concern about the environment have increased the national incentives to introduce such district heating systems which use, to a large extent, heat otherwise rejected.

So far the economics of district heating have been debatable in the districts with low heat densities, particularly those with individual one-family houses. To extend the economic use of district heating even to such districts in the face of competition from electric space heating and individual boilers, cheaper distribution pipe systems are being developed and have already been introduced in a few demonstration districts. In particular, flexible pipes of relativel temperature-resistant plastic can be layed with very little labour effor and can distribute space heating water and hot tap water in the same pip

ABSTRACT (CONTINUED)
Also, special components which do not corrode in oxygenated water have been developed or adapted to such systems; e.g., a plastic tube radiator.

This paper starts by outlining the evolution of district heating schemes in Sweden, examing the economic background, and describing the technology currently in use, particularly for the smaller distribution pipe networks. It then proceeds to outline the newer technology under development, and the experimental and demonstrated work which backs it up.

To complete the picture of the district heating development issues, a brief account is given also of development in the progress on larger pipes, such as those required for large bulk heat transport from future nuclear heat/electric stations to cities able to use such large heat quantities."

TECHNICAL REPORT DATA

REPORT No.
ASAE/NA77-401

REPORT DATE
July 1977

KEY WORDS
Greenhouse
Solar Heating

TITLE AND SUBTITLE

The Rutgers Solar Heating System for Greenhouses

AUTHOR(S) / EDITOR(S)

David R. Mears et al.

PERFORMING ORGANIZATION

Cook College - Rutgers University

SPONSORING AGENCY

SUPPLEMENTARY NOTES
Paper presented at 1977 Annual Meeting of the North Atlantic Region, American Society of Agricultural Engineers, July 31-August 3, 1977

ABSTRACT

"Research on solar heating of greenhouses at Rutgers has been geared to applications with commerical, double-covered polyethylene structures. Emphasis has been placed on the development of relatively low-cost systems in order to have an economically feasible alternative to fossil fuel for greenhouse heating as soon as possible. The materials and construction techniques being utilized are currently available in the greenhouse industry. The performance of the system from September 1, 1976 through May 3, 1977 is presented. Based upon experience to date some estimates are made regarding the economic potential of the entire system based on current prices.

The Rutgers integrated solar assisted greenhouse heating system was first presented by Roberts et al. in 1976. This system consists of four major elements, all of which are necessary for maximum conservation of fossil fuel: a low-cost external plastic solar collector a movable curtain insulation system, a porous concrete-capped storage/heat exchanger composite floor and vertical curtain heat exchangers.

ABSTRACT (CONTINUED)

A fossil-fuel-fired backup unit provides heat to the greenhouse when the solar energy in storage has been depleted."

Although the system described in this report utilizes heated water from solar collectors, the design is virtually identical to a system which would utilize heated power plant discharge water.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
ASAE/78-4512		Greenhouse Solar Heating Heat Exchanger

TITLE AND SUBTITLE

Development of a Greenhouse Solar Heating Demonstration

AUTHOR(S) / EDITOR(S)

David R. Mears, W.J. Roberts and Paul W. Kendall

PERFORMING ORGANIZATION

Cook College - Rutgers University

SPONSORING AGENCY

SUPPLEMENTARY NOTES

Presented at 1978 Annual Meeting of the American Society of Agriculture Engineers, December 18-20, 1978

ABSTRACT

"A 0.54-hectare greenhouse, heated by solar energy, has been constructed at the Kube Pak Corporation, Allentown, New Jersey. The floor serves as the primary heat exchange surface and provides thermal storage. Movable plastic curtains provide insulation at night. Water is heated by 1,000 m^2 of air-inflated plastic film solar collectors.

Although the system described in this report utilizes heated water from solar collectors, the design is virtually identical to a system which would utilize heated power plant discharge water.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
PU/CES 76	December 1978	Oyster Green Nuclear Generating Facility Housing Growth Nuclear Regulatory Commission

TITLE AND SUBTITLE

Housing Growth in the Vicinity of Nuclear Power Plants: A Case Study of Oyster Creek, New Jersey

AUTHOR(S) / EDITOR(S)

David Morell, G. Dyche Kinder and Todd Cronan

PERFORMING ORGANIZATION

Princeton University, Center for Environmental Studies

SPONSORING AGENCY

Energy Policy Analysis Group of the Brookhaven National Laboratory

SUPPLEMENTARY NOTES

Draft Report

ABSTRACT

"The principal objective of this investigation was to document the growth of housing around the Oyster Creek nuclear generating facility between 1965, when construction of the power plant began, and 1976, when the state land use controls were announced. Two main methods were used to accomplish this objective: examination of aerial photographs to count structures, and study of township records. In addition, selected interviews were held with officials and real estate developers in the area, local zoning laws and planning documents were studied, and data on taxes were analyzed."

TECHNICAL REPORT DATA

REPORT No. PU/CES 48	REPORT DATE July 1977
TITLE AND SUBTITLE Who's In Charge? - Governmental Capabilities to Make Energy Facility Siting Decisions in New Jersey	
AUTHOR(S)/EDITOR(S) David Morell	
PERFORMING ORGANIZATION Princeton University, Center for Environmental Studies	
SPONSORING AGENCY New Jersey Department of Environmental Protection and U.S. Federal Energy Administration	

KEY WORDS
Energy Facilities
Facility Sitings
Department of
Environmental Protection
CAFRA
Oyster Creek Facility

SUPPLEMENTARY NOTES

ABSTRACT

"The basic purpose of the research on which this report is based has been to carry out a critical assessment of the capabilities of governmental institutions in New Jersey, at state and local levels, to cope with the need anticipated at some point in the relatively near future to make decisions on siting onshore facilities associated with oil and gas activities in the mid-Atlantic Ocean Outer Continental Shelf (OCS) area."

The approach taken in this report was "to evaluate the relevance and adequacy of these various state statutes to an overall state program of guiding the facility siting process, and to evaluate the respective roles and apparent readiness of the state and its constituent municipalities--which under New Jersey law retain the vast majority of land use decision-making authority -- to implement such an effort."

TECHNICAL REPORT DATA

REPORT No. ASAE/78-3572	REPORT DATE December 1979
TITLE AND SUBTITLE Waste Heat Utilization From Electric Generating Plants	
AUTHOR(S) / EDITOR(S) M. Olszewski	
PERFORMING ORGANIZATION Oak Ridge National Laboratory	
SPONSORING AGENCY Advanced Systems and Materials Production Division, U.S. Department of Energy	

KEY WORDS
Waste Heat Utilization
Greenhouses
Agriculture
Evaporative Pad System
Porous Concrete
Thermal Envelope
Soil Heating

SUPPLEMENTARY NOTES
Paper presented at 1978 Winter Meeting of American Society of Agricultural Engineers, December 18-20, 1978

ABSTRACT

"Power plants reject about(11 x 10^{15} Btu) of low-grade heat to the atmosphere annually. Typically, this heat is found in the large quantities of cooling water necessary to condense the steam in the power generating cycle. Such cooling water is generally discharged in the range of 15 to 43°C (60 to 110°F) depending on the temperature of the available inlet water, quantity circulated, plant load, and heat rejection system used.

A number of possible uses have been suggested for this low-grade heat. Because of the low available temperatures, these uses have concentrated on agricultural and aquaculture applications.

It is the purpose of this paper to describe several innovative agricultural techniques that utilize power plant reject heat. The vast majority of these projects involve greenhouse applications although undersoil heating applications are also being investigated. Schematic descriptions will be given for these techniques and a brief review of the project status will be provided."

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE
August 1979

KEY WORDS
Greenhouse
Waste Heat Utilization
CELdek

TITLE AND SUBTITLE
Evaporative-Pad Heat Transfer Performance in a Sumulate Waste-Heat Greenhouse Environment

AUTHOR(S) / EDITOR(S)
M. Olszewski

PERFORMING ORGANIZATION
Oak Ridge National Laboratory

SPONSORING AGENCY
Advanced Nuclear Systems and Projects Division, U.S. Department of Energy

SUPPLEMENTARY NOTES
Presented at the 18th National Heat Transfer Conference, August 6-8, 1979, San Diego, California

ABSTRACT

"Greenhouse uses of low-grade waste heat have been investigated at the Oak Ridge National Laboratory (ORNL) for a number of years. These investigations have focused on evaporative-pad concepts that are capable of providing both summer cooling and winter heating. As part of this program, performance testing of potential evaporative-pad materials has been performed at ORNL.

This paper details results of an experimental investigation of the performance of CELdek** packing under simulated waste heat greenhouse conditions. The objective of this study was to characterize the air heating capability of the material as well as its air cooling ability.

A cooling efficiency of 85 to 95% was achieved for adiabatic saturation operation. For nonadiabatic saturation conditions air cooling in excess of 11°C can be achieved if the inlet air wet bulb depression is 15°C. When the wet bulb depression is decreased to 7.8°C air cooling in excess of 5.6°C is achievable.

ABSTRACT (CONTINUED)

The results also indicate that CELdek is effective in the heating mode. Energy transport was found to be strongly dependant on water flow rate.

Air side pressure drop was found to vary linearly with face velocity and varied from 10.2 to 28.1 Pa over a face velocity range of 1.3 to 2.6 m/sec. The pressure drop was also found to be independent of water flow rate up to the limit (8.4 x 10^{-4} m^3/s/m of pad length) tested.

A large nonlinear vertical air temperature variation over the down-stream face of the CELdek existed for some operating conditions. A modified water distribution system was designed which introduced the water at several horizontal planes. This reduced the vertical air temperature variation by a factor of two.

CELdek was found to be satisfactory for evaporative-pad greenhouse applications and appears to be superior to other pad materials previously examined."

**Trademark of the Munter Corporation, Fort Myers, Florida.

TECHNICAL REPORT DATA

REPORT No.	
REPORT DATE	April 1979
TITLE AND SUBTITLE	Overview of Waste Heat Utilization Techniques
AUTHOR(S) / EDITOR(S)	Mitchell Olszewski
PERFORMING ORGANIZATION	Oak Ridge National Laboratory
SPONSORING AGENCY	Nuclear Energy Programs, U.S. Department of Energy
KEY WORDS	Waste Heat Utilization Greenhouses Agriculture Evaporative Pad System Porous Concrete Thermal Envelope Soil Heating Aquaculture
SUPPLEMENTARY NOTES	Paper presented at the 41st Annual American Power Conference, Chicago, Illinois, April 23-25, 1979

ABSTRACT

"Power plants annually reject about 11 x 10^9 GJ (11 x 10^{15} Btu) of low-grade heat to the atmosphere. Typically, this heat is found in the large quantities of cooling water necessary to condense the steam in the power generating cycle. Such cooling water is generally discharged in the range of 15 to 43°C (60 to 110°F) depending on the temperature of the available inlet water, quantity circulated, plant load, and heat rejection system used.

A number of possible uses have been suggested for this low-grade heat. These uses include: greenhouse horticulture, soil heating (both open-field and in greenhouses, spray irrigation for frost protection, organic waste treatment (particularly for algae or biomass production), and aquaculture/mariculture.

To date, greenhouse and aquaculture/mariculture systems have received the most attention and have, therefore, progressed furthest. It is the purpose of this paper, therefore, to describe several innovative techniques that utilize power plant reject heat for these application

ABSTRACT (CONTINUED)

Schematic descriptions will be given for these techniques and a brief review of the project status will be provided."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
ORNL/TM-6547	February 1979	Waste Heat Utilization Aquaculture Polyculture

TITLE AND SUBTITLE

An Economic Feasibility Assessment of the Oak Ridge National Laboratory Waste-Heat Polyculture Concept

AUTHOR(S) / EDITOR(S)

M. Olszewski

PERFORMING ORGANIZATION

Oak Ridge National Laboratory

SPONSORING AGENCY

U.S. Department of Energy

SUPPLEMENTARY NOTES

ABSTRACT

" An economic feasibiltiy analysis was performed for a proposed waste-heat aquaculture system that uses a tilapia polyculture concept. The system is designed to use waste water nutrients to grow plankton which is fed to the fish.

The system was judged to be economically viable if fish production costs of \$1.32/kg (60¢/lb) or lower were achieved for production rates that have been experimentally verified. The results of the analysis indicate that the system is economically viable if capital costs are annualized using a 15% fixed charge rate (FCR). Feasibility of the system at a 25% FCR depends upon aeration turnover time and system food conversion efficiency.

Eliminating cages from the system design decreases the capital costs and improves the economic potential of the system. Additional capital cost reductions are possible if the aerators are removed from the system. However, expected fish production rates are also decreased and the system does not appear economically viable for a 25% FCI

ABSTRACT (CONTINUED)

System design modifications due to biological considerations included lining the algal pond with a plastic liner and using commercial fertilizers in place of organic waste streams. Lining the algal ponds did not affect the feasibility of the system at a 15% FCR, but did result in the system becoming economically unattractive at a 25% FCR. The use of commercial fertilizers added 15¢/kg (7¢/lb) to the production but did not have serious adverse affects on the feasibility of the system.

The system appears to have economic promise and should be examined further. Operation of a small experimental system to verify the estimated performance parameters is needed."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	January 1979	Greenhouse Porous Concrete

TITLE AND SUBTITLE

Floor Heating of Greenhouses

AUTHOR(S) / EDITOR(S)

William J. Roberts and David R. Mears

PERFORMING ORGANIZATION

Cook College - Rutgers University

SPONSORING AGENCY

Cook College - Rutgers University

SUPPLEMENTARY NOTES

ABSTRACT

Design report describing construction of heating system for greenhouses to be heated with solar collectors or power plant waste heat.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE December 1978
TITLE AND SUBTITLE Waste Heat Management and Utilization	
AUTHOR(S) / EDITOR(S) Dr. Subrata Sengupta et al.	
PERFORMING ORGANIZATION University of Miami, U.S. D.O.E., N.R.C., U.S. E.P.A., E.P.R.I., Florida Power & Light Company	
SPONSORING AGENCY University of Miami	

KEY WORDS
Waste Heat
Ecological Effects
Environmental Regulations
Thermal Pollution
Cogeneration

SUPPLEMENTARY NOTES
Proceedings of second conference on Waste Heat Management and Utilization held in Miami Beach, Florida on December 4-6, 1978

ABSTRACT

"The first WHMU conference was held in Miami Beach, during May, 9-11, 1977. The participants represented a diverse cross-section of disciplines. A comprehensive proceedings was published. Since the interest in this area has grown rapidly, especially in the utilization area, a second conference was appropriate. However, the emphasis was to be in presenting current information through original papers and providing working sessions for direct interaction between investigators.

The general objectives of the conference were:

1. To provide a forum for representatives of industry, regulatory agencies, research establishments and universities to exchange ideas.
2. To provide interactive working sessions.
3. To identify research and development directions.
4. To identify areas of basic research, necessary for practical engineering applications.
5. To develop documents in the form of conference proceedings, and workshop recommendations which will help in the assessment of the state-of-art in waste heat research."

TECHNICAL REPORT DATA

REPORT No. ASAE/77-4532	REPORT DATE December 1977
TITLE AND SUBTITLE Computer Simulation of Warm Floor Greenhouse Heating	
AUTHOR(S) / EDITOR(S) Hwan Shen and David R. Mears	
PERFORMING ORGANIZATION Cook College - Rutgers University	
SPONSORING AGENCY	
KEY WORDS Greenhouse; Simulation Study; Heat Exchanger	

SUPPLEMENTARY NOTES

Paper presented at 1977 Winter Meeting of American Society of Agricultural Engineers, December 13-16, 1977

ABSTRACT

"A dynamic simulation has been used to investigate the feasibility of heating a greenhouse with warm water. Several greenhouse systems have been simulated utilizing insulated and uninsulated polyethylene greenhouses. Results indicate recently developed warm floor and movable curtain heat exchangers will be capable of heating the greenhouse."

TECHNICAL REPORT DATA

REPORT No. EPA-600/7-79-091	REPORT DATE March, 1979
TITLE AND SUBTITLE Nuclear Power Plant Waste Heat Horticulture (Final Report)	
AUTHOR(S) / EDITOR(S) Thomas Sproston (Plant Biologist Inc.), E.P. Gaines, Jr. & D.J. Marx (Editors)	
PERFORMING ORGANIZATION Vermont Yankee Nuclear Power Corporation, 77 Grove Street, Rutland, Vermont 05701	
SPONSORING AGENCY EPA, Office of Research and Development, Industrial Environmental Research Laboratory, Research Triangle Park, NC 27711	
KEY WORDS Nuclear Power Plants; Heat Recovery; Horticulture; Greenhouses; Heating; Methane; Dairies	

SUPPLEMENTARY NOTES

EPA Project Officer: Theodore G. Brna

ABSTRACT

The report gives results of a study of the feasibility of using low grade(70°F) waste heat from the condenser cooling water of the Vermont Yankee Nuclear Plant at Vernon for commercial food enhancement. The study addressed: the possible impact of laws on the use of waste heat from a nuclear plant for food production, alternative greenhouse designs suitable for the site, and an economic and marketing model for greenhouse crops. Using surface heat exchangers for greenhouse heating appeared to permit compliance with the Delaney Amendment of the Food, Drug, and Cosmetic Act when condenser cooling water is the heating medium at a nuclear plant. The low temperature of the waste heat source suggested that supplemental greenhouse heating will be required (a biogas facility using wastes from a dairy herd near the plant was proposed as being economically attractive). A greenhouse design employing heaters using methane from the proposed biogas facility and a cropping schedule for the greenhouses was recommended. The report includes the computer program used to determine the costs of greenhouse production in the Northeast.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
TITLE AND SUBTITLE Analysis of Economic and Biological Factor of Waste Heat Aquaculture		Waste Heat Utilization Aquaculture Freshwater Clam Polyculture
AUTHOR(S) / EDITOR(S) J.S. Suffern and M. Olszewski		
PERFORMING ORGANIZATION Oak Ridge National Laboratory		
SPONSORING AGENCY U.S. Department of Energy		
SUPPLEMENTARY NOTES		

ABSTRACT

"A waste heat aquaculture system using extensive culture techniques is currently under investigation at the Oak Ridge National Laboratory. The system uses nutrients in waste water streams to grow algae and zooplankton which provide feed for fish and clams. A tilapia polyculture association and the freshwater clam Corbicula are the animals cultured in the system.

The investigations detailed in this study have been performed to determine the economic and biological feasibility of the system and examine energy utilization. A net energy analysis identified the energy saving potential for the system. This analysis included all energy costs (both direct and indirect) associated with building and operating the system.

The economic study indicated that fish production costs of $0.55/kg ($0.24/lb) were possible. This cost, however, depends upon the fish production rate and food conversion efficiency and could rise to as much as $1.65/kg)$0.75/lb).

ABSTRACT (CONTINUED)

The biological studies have examined growth relationships and production potential of the cultured organisms. In the laboratory, growth-temperature optima have been defined (32 C, with good growth rates between 26 and 34°C) for tilapia hybrids. In addition, growth rate acceleration experiments have been carried out, developing techniques which yield 40% higher growth rates in experimental fish as compared with controls. Using cage culture techniques in sewage oxidation ponds, we have obtained production estimates in excess of 50,000 kg/ha/yr (50,000 lb/acre/yr).

The energy utilization study indicated that, when all energy costs are included , fish from the aquaculture system may require only 35% of the net energy now required for fish products from the ocean. However, the energy requirements also depend on system parameters and could be as large as the energy required for ocean caught products.

The analyses indicate that the system is economically feasible. They also indicate that significant energy savings are possible if waste heat aquaculture products replace ocean caught products.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE 1978	KEY WORDS
TITLE AND SUBTITLE District Heating		District Heat Cogeneration Nuclear Heat Reactors Heat Exchangers Heat Distribution Systems
AUTHOR(S) / EDITOR(S) Swedish Trade Office (Editors)		
PERFORMING ORGANIZATION		
SPONSORING AGENCY Swedish Trade Office Swedish Embassy Swedish Export Council		

SUPPLEMENTARY NOTES

ABSTRACT

This publication is a comprehensive examination of district heating with respect to the Swedish state-of-the-art. The district heating systems are examined with and without cogeneration, as well as all components comprising the system, such as nuclear heat reactors, piping, steam generators, heat exchangers, control equipment, etc.

The pros and cons of district heating in Sweden are discussed with emphasis on the environmental and economic aspects.

Design data and available product literature are incorporated in this complete volume.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE January, 1979	KEY WORDS Waste Heat Greenhouses Space Heating Waste Heat Park
TITLE AND SUBTITLE Watts Bar Waste Heat Park Feasibility Analysis (Final Draft)		
AUTHOR(S)/EDITOR(S)		
PERFORMING ORGANIZATION Energy Research - Office of Power Tennessee Valley Authority		
SPONSORING AGENCY Energy Research - Office of Power Tennessee Valley Authority		
SUPPLEMENTARY NOTES		

ABSTRACT

" Watts Bar Nuclear Plant is TVA's most suitable power plant for near-term commercial waste heat development. In late June 1978, authorization was received to proceed with a first phase of the Watts Bar Waste Heat Park development which was to take approximately six months and consist mainly of (1) preparing an engineering design and cost estimate for a full-scale waste heat tie-in and distribution system, (2) identifying and describing factors affecting park development (legal, regulatory, socioeconomic, etc.), (3) assessing waste heat augmentation technologies, and (4) identifying potential classes of waste heat users. The results of Phase I are reported herein and are the product of inputs from virtually every division and/or office within TVA.

The Phase I feasibility analysis, conducted on a 100,000 gpm waste heat distribution system for a 400-acre site at Watts Bar, uncovered no insurmountable barriers (engineering, regulatory, economic, institutional, etc.) to prevent entering another developmental

ABSTRACT (CONTINUED)

phase for the park. An analysis of multiple uses showed greenhouse heating and cooling has the greatest near-term potential for commercial application in a portion of the park, while several other applications showed definite development potential for locating in the park over time. Ultimate park employment could conceivably range from 400 to 750 with a $3.2 million to $6.0 million annual payroll, and secondary employment in surrounding communities could result in an additional 120 to 225 employees with an additional total secondary economic impact of $2.9 million to $5.5 million. The park also has potential to serve as a demonstration site for a number of the latest energy technology developments."

TECHNICAL REPORT DATA

REPORT No.	
REPORT DATE	1974
TITLE AND SUBTITLE	Utilization of Waste Heat from Power Plants for Aquaculture, Gallatin Catfish Project, 1974 Annual Report
AUTHOR(S)/EDITOR(S)	
PERFORMING ORGANIZATION	Tennessee Valley Authority and Cal-Maine Foods, Inc.
SPONSORING AGENCY	Tennessee Valley Authority
KEY WORDS	Aquaculture Waste Heat Catfish
SUPPLEMENTARY NOTES	

ABSTRACT

"For the past three years, the Tennessee Valley Authority has been conducting with private industry a cooperative interdisciplinary research program to determine the feasibility of high-density raceway production of catfish utilizing steam-electric generating plant heated water discharges. A pilot-scale raceway facility located on the bank of TVA's Gallatin Steam Plant condenser discharge canal has been used for the research. Condenser circulating water averaging 12°F above ambient plant intake water temperature is pumped from the discharge canal through the facility and returned to the canal. Results have proven the benefits of heated water in extending the catfish growing season, enhancing growth rates, and increasing production poundage.

The following report presents the results of 1974's research for the Gallatin Catfish Project."

TECHNICAL REPORT DATA

REPORT No.	5(5): 12-18, 47-49
REPORT DATE	July 1979
KEY WORDS	Aquaculture Thermal Effluent Lobsters
TITLE AND SUBTITLE	"Recent Developments in Lobster Research", <u>The Commercial Fish Farmer & Aquaculture News</u>
AUTHOR(S) / EDITOR(S)	Jon C. Van Olst and James M. Carlberg
PERFORMING ORGANIZATION	San Diego State University, Center for Marine Studies
SPONSORING AGENCY	
SUPPLEMENTARY NOTES	

ABSTRACT

This article gives an overview of the present state of lobster farming and its potential for commercial application.

"The use of waste heat in thermal effluent from electric generating stations to accelerate growth of aquatic organisms and thereby reduce production time and costs shows considerable promise as one means of attaining economic viability in aquaculture."

TECHNICAL REPORT DATA

REPORT No.

REPORT DATE
January 1978

TITLE AND SUBTITLE
The Effects of Container Size and Transparency on Growth and Survival of Lobsters Cultured Individually

AUTHOR(S) / EDITOR(S)
J.C. Van Olst and J.M. Carlberg

PERFORMING ORGANIZATION
San Diego State University,
Department of Biology

SPONSORING AGENCY
Southern California Edison Company and
NOAA Office of Sea Grant

KEY WORDS
Aquaculture
Thermal Effluent
Lobster

SUPPLEMENTARY NOTES
Reprint from: Proceedings of the Ninth Annual Meeting, World Mariculture Society, Atlanta, Georgia, January 3-6, 1978

ABSTRACT

"The high rates of cannibalism observed in American lobsters (Homarus americanus) held in communal rearing systems dictate that for a majority of the culture period the animals must be held individually in order to prevent these losses. An experiment was conducted to assess the dependence of growth rate, molting frequency and survival on the amount of horizontal surface area provided for each lobster. Eight sizes of individual containers ranging from 6 to 750 cm^2 were provided. Parallel experiments were conducted in containers made of both transparent and translucent materials so that the effects of visual communication also could be determined.

The experiments have been in progress for 24 months. Growth and survival have been severely reduced in the smaller rearing containers. Molting frequency was not as severely affected. No significant differences in growth were found between lobsters in visual contact and visual isolation. Equations describing the relationship between space and growth are presented and estimates are made of the effects of

ABSTRACT (CONTINUED)

space requirements on the design of a commercial lobster culture facility.

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS
	1978	Aquaculture Thermal Effluent American Lobster

TITLE AND SUBTITLE

Aquaculture Systems Utilizing Thermal Effluent

AUTHOR(S) / EDITOR(S)

Jon C. Van Olst, J.M. Carlberg and R.F. Ford

PERFORMING ORGANIZATION

San Diego State University
Department of Biology

SPONSORING AGENCY

NOAA Office of Sea Grant
and Southern California Edison

SUPPLEMENTARY NOTES

ABSTRACT

"The effect of elevated temperatures in accelerating the growth rates of many aquatic organisms is well documented. In aquaculture this can help reduce total production costs within temperature ranges that produce normal survival and food conversion efficiency. Low-cost sources of warm seawater for use in mariculture include the naturally occurring warm areas of the tropics, geothermal brine wells, solar energy devices to heat seawater indirectly, and thermal effluent from coastal power plants. Research at San Diego State University has focused on the use of this latter heat source in the culture of the American lobster, *Homarus americanus*.

The major objectives of this continuing program have been to develop a commercially feasible production system for the American lobster and to assess the benefits and problems involved in using thermal effluent as an economical source of heated water.

The research is being conducted in laboratories at two electrical generating stations--the Encina Power Plant of the San Diego

ABSTRACT (CONTINUED)
Gas and Electric Company, and the Ormond Beach Generating Station of the Southern California Edison Company. Other related experiments are conducted in the San Diego State University aquaculture laboratory at the Scripps Institution of Oceanography.

The work is part of an integrated and carefully planned program to develop commercially viable lobster culture in the United States. Major areas of investigation include: 1) the use of thermal effluent to accelerate growth rates; 2) the effects of various temperature and photoperiod regimes on growth; 3) the physiological effects of potentially toxic substances from industrial pollution or culture system materials on lobsters cultured in thermal effluent; 4) the development of suitable artificial foods in cooperation with scientists at the Bodega Marine Laboratory and the Foremost Research Center; 5) energetics and food conversion studies; 6) development of more efficient techniques for communal rearing of lobsters; 7) evaluation of an *H. americanus* X *H. gammarus* hybrid for use in commercial culture; 8) development of methods and systems for the individual rearing of lobsters to market size; and 9) economic studies of the commercial feasibility of lobster culture.

This paper describes several of the techniques and systems developed for use of thermal effluent in aquaculture. Novel methods are used in interfacing with the electrical generating station so that interference with plant operations is minimal. Automated mixing valve systems also are employed to blend intake and discharge water to intermediate temperatures. Solutions for gas supersaturation problems are described."

TECHNICAL REPORT DATA

REPORT No.	REPORT DATE	KEY WORDS Aquaculture Thermal Effluent Lobster
TITLE AND SUBTITLE Use of Thermal Effluent in Culturing the American Lobster		
AUTHOR(S) / EDITOR(S) J.C. Van Olst et al		
PERFORMING ORGANIZATION San Diego State University Department of Biology		
SPONSORING AGENCY NOAA Office of Sea Grant and San Diego Gas & Electric Company		

SUPPLEMENTARY NOTES

Reprint from: Power Plant Waste Heat Utilization-Workshop I. Trenton, New Jersey, November 6-7, 1975

ABSTRACT

"Comparative water quality analyses, tissue analyses, toxicity studies and rearing experiments are being conducted to assess the benefits and problems in using thermal effluent from typical coastal generating stations to culture the American lobster, Homarus americanus, from the egg to market size. Part of this research is underway in a special laboratory developed in cooperation with the Research and Development Program of the Southern California Edison Company at their Redondo Beach Generating Station. Separate studies supported by the NOAA Office of Sea Grant and the State of California are underway in a similar laboratory at the Encina Power Plant of the San Diego Gas & Electric Company. These laboratories are supplied with both thermal effluent and ambient temperature seawater. Pneumatic mixing valves are employed to obtain experimental temperatures. Parallel experiments are conducted using electrically heated and ambient ocean temperature water in the University's aquaculture laboratory at the Scripps Institution of Oceanography.

ABSTRACT (CONTINUED)

The effects of chemicals in thermal effluent on lobsters maintained in aquaculture systems were evaluated. Atomic absorption analysis of intake and effluent water samples from three fossil fuel generating stations in southern California indicated that their chemical additions did not affect concentrations of Cu, Zn, Cd, Cr, Pb, and As in the thermal effluent. Concentrations of these metals in the intake effluent water at the Encina Power Plant were not significantly different than their concentrations in seawater from Scripps, and were well within the reported ranges for levels of those metals in normal seawater.

All of these studies indicate that the thermal effluent from typical fossil fuel generating stations in southern California provides a suitable heated water source for the culture of Homarus americanus. The optimal temperature for culturing H. americanus is approximately 22 C. During late summer and early fall, ambient ocean temperatures approach this level in southern California. Therefore, thermal effluent would be utilized to a lesser extent during that part of the year. In other areas with lower ambient water temperatures, thermal effluent would provide a major, year-round source of waste heat for lobster production."

TECHNICAL REPORT DATA

REPORT No.
14(5):566, 675

REPORT DATE
October 1979

KEY WORDS
Greenhouse
Waste Heat

TITLE AND SUBTITLE
"Commercial Greenhouse Heating with Reject Heat from Electric Generating Plants," Hort Science

AUTHOR(S)/EDITOR(S)

R.E. Widmer

PERFORMING ORGANIZATION
University of Minnesota
Department of Horticultural Science and
Landscape Architecture

SPONSORING AGENCY

SUPPLEMENTARY NOTES

ABSTRACT

" Warm waste water is currently available in large quantities. It is a practical and economically desirable source of heat for commercial greenhouses. Since it has been proven practical for greenhouses glazed with 2 air-separated layers of polyethylene film, inclusion of addition energy saving techniques can make warm water heat even more desirable. Possible development of more efficient heat exchangers also could make the process even more attractive.

The time may come when fuel for heating greenhouses on a year-round basis may be unavailable as well as too expensive. Recycling of waste heat appears to be the best approach for greenhouse operators at present and in the uncertain future."

APPENDIX B

INTERVIEW DATA

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Gary Ashley Ashley Engineering St. Paul, Minnesota (612) 482-1183	P. Kavka
	DATE 10/22/79
	LOCATION Telephone

DISCUSSION

1. Mr. Ashley is one of the most well-known authorities on low grade waste heat utilization. In his eight years with Northern States Power Company, he designed and carried through the successful operation of the Sherco Greenhouse Project (sponsored partially by EPA). The project proved that low temperature waste heat was suitable for heating greenhouses in northern latitudes.

2. Mr. Ashley has since formed his own consulting engineering firm to provide services to those interested in waste heat utilization.

3. Other projects which he has been involved:

    a. Bruce Agra Park - Toronto, Ontario

    b. Detroit Edison Waste Heat Study - Greenwood, Michigan

4. Other projects to reference which he was not involved:

    a. Browns Ferry - TVA

    b. Dow Midland Cogeneration Project - Midland, Michigan

5. Other Contacts:

    a. Don Haycock - Conestoga Rovers

    b. Mitchell Olscewski - U.S. D.O.E., gaseous diffusion

INTERVIEW DATA

PERSON INTERVIEWED

Dr. Edmund P. Gaines
Vermont Yankee Nuclear Power Corporation
Rutland, Vermont
(802) 773-2711

INTERVIEWER

P. Kavka

DATE

11/13/79

LOCATION

Telephone

DISCUSSION

1. Dr. Gaines has been the project director of the Vermont Yankee waste heat project since its beginning in the summer of 1975. The project includes an aquaculture laboratory that produces 25,000 salmon smolt annually, a 4 unit greenhouse complex and a demonstration methane generator.
2. This project is dedicated to the Atlantic Restoration Program which is trying to bring the native salmon back to the Connecticut River.
3. Question of downtime - tested brown trout with a drop of 10 F in temperature in 15 minutes and had no problems.
4. His project uses cooling discharge water directly, without any heat exchangers.
5. Suggested reference project - Domsea, subsidiary of Union Carbide, raising salmon in Puget Sound in power plant discharge water.
6. Suggested people to contact:
   a. Ted Brna - EPA
   b. John Ryther - Woods Hole Oceanographic Institute

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Dr. Bruce Godfriaux Senior Marine Biologist - Research Public Service Electric and Gas Company Newark, New Jersey (201) 430-6638	P. Kavka **DATE** 3/5/79, 10/15/79 **LOCATION** PSE&G Newark, NJ

DISCUSSION

1. Dr. Godfriaux is the project director for the Mercer Aquaculture Facility, near Trenton, New Jersey. This project is being sponsored by Public Service Electric and Gas Company and Rutgers University. Facilities include a commercial stage diseasonal aquaculture facility which rears rainbow trout, freshwater shrimp, striped bass, yellow perch and the American eel. Also in this facility are several pilot stage greenhouses heated with power plant waste heat. Model heat exchangers being tested in greenhouses include a porous concrete floor system and vertical plastic curtains.

2. Suggested contacts:

   Gary Ashley - Northern States Power (Sherco Greenhouses)

   Mike Roche - Jersey Central Power & Light Co.
   (Oyster Creek clam project)

   Randy Snipes - Tennessee Valley Authority

3. Other areas of discussion

   a. Question of who will be entrepreneur in waste heat park development.

   b. Problems related to establishing market value for waste heat.

   c. Specific marketing problems associated with industrial park with adjacent nuclear power plant.

   d. Institutional barriers not a serious problem.

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Donald Haycock Conestoga Rovers & Associates Waterloo, Ontario (519) 884-0510	P. Kavka
	DATE 10/22/79
	LOCATION Telephone

DISCUSSION

1. Mr. Haycock is a senior partner in Conestoga Rovers and Associates, specializing in reject heat utilization and energy conservation.
2. Discussed their "Feasibility Analysis of the Utilization of Moderator Heat for Agricultural and Aquacultural Purposes" at the Bruce Nuclear Power Development (Ontario, Canada)
3. Discussed their report prepared as a joint venture with Ashley Engineering on "Reject Heat Utilization" at the Greenwood Energy Center, Michigan.
4. Dow-Midland Cogeneration Project - dual responsibility between Dow and Consumers Power, complex financial return to Consumers Power over an extended period of time.
5. Other reject heat and energy conservation projects Conestoga Rovers are involved:
   a. Sherco Greenhouse Project - Minnesota
   b. St. Thomas, Ontario Landfill gas recovery

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Bernie Heiler Environmental Protection Agency Washington D.C. (202) 755-0646	P. Kavka DATE 11/5/79 11/8/79 LOCATION Telephone

DISCUSSION

1. Bernie Heiler, an environmental engineer for EPA, called in response to a letter sent to Mr. Stephen Gage, EPA's Administrator for Research Development.
2. EPA's role in the development of this park will be secondary. They will only become involved if asked to review by another agency (DOE). EPA is in the "conservation business" and may only be asked to review the environmental impact statement.
3. EPA has turned the solid waste studies, that they were previously involved in, over to D.O.E.
4. He was checking for reference information with "Conservation and Solar Applications Division" and the "Energy Extension Service".
5. Other people to contact:
    a. Dr. Michael Karnitz - Oak Ridge National Laboratory
    b. Herb Feinroth or Charles Baxter - D.O.E. regional office.

INTERVIEW DATA

PERSON INTERVIEWED

Ira Helms
U.S. Department of Energy
Washington D.C.
(301) 353-2927

INTERVIEWER

P. Kavka

DATE

11/8/79

LOCATION

Telephone

DISCUSSION

1. Mr. Helms has conducted economic studies of many waste heat projects and is somewhat less optimistic than most others interviewed.

2. Projects discussed which he had some knowledge of:

   a. Sherco Greenhouse Project - Northern States Power

   b. Vermont Yankee Project - similar to Oyster Creek Plant, break even without heat exchangers, operate at loss with heat exchangers in waste heat facilities.

   c. Long Island Oyster farms - in trouble with EPA, not a heat use, but rather a thermal condition.

3. Other people to contact:

   a. Sherman Reed or Mitch Olscewski - ORNL

   b. Maddox or Pyle - TVA

4. Suggested reading D.O.E. reports on gaseous diffusion

5. The approach he recommends:

   a. Use waste heat for preheating, because any heat saved is better than none.

   b. Investigate idea of "cascading".

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER / DATE / LOCATION
Carl E. Madewell Agricultural Economist Tennessee Valley Authority Agricultural Energy Applications Section Muscle Shoals, Alabama (205) 386-2866	INTERVIEWER: P. Kavka DATE: 10/10/79 LOCATION: Telephone

DISCUSSION

1. Mr. Madewell has been involved in most of TVA's reject heat projects since it was identified as a potential energy source.

2. Major reject heat project now at TVA is the Watts Bar Waste Heat Park. A $30 million industrial park is being planned with a nuclear power plant supplying reject heat to the following industries:

greenhouses	100 acres
soil heating	25 acres
biological recycling	50 acres
aquaculture	160 acres
fingerling production	5 acres
industrial	60 acres

3. Other TVA projects he was involved in were the Gallatin Catfish Project and the Browns Ferry Nuclear Plant Greenhouse Project.

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Thomas Manning Rutgers University, Research Assistant Department of Biological and Agricultural Engineering New Brunswich, New Jersey	P. Kavka
	DATE 10/17/79
	LOCATION Rutgers University New Brunswick, NJ

DISCUSSION

1. Mr. Manning is working with Dr. David Mears on the demonstration agriculture facilities at Rutgers, under the sponsorship of PSE&G.

2. Demonstration greenhouses visited on Cook College campus were testing porous concrete floor heat exchanger and movable vertical curtains. Heat supply comes from 85°F water from solar collectors, which concept is the same as power plant cooling water.

3. Another larger scale project that Rutgers is managing is in Allentown, where 1¼ acres of solar heated greenhouses are being successfully demonstrated. Preliminary estimates indicate that the supplemental heating and environmental control can increase crop yield up to eight (8) times.

4. Other suggested projects to investigate

   a. Bruce Agra Park - Toronto, Ontario

   b. Becker Project - Minnesota Power Company

   c. Watts Bar - TVA

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER / DATE / LOCATION
Dr. David Mears Rutgers University, Professor Department of Biological and Agricultural Engineering New Brunswick, NJ (201) 932-9753	INTERVIEWER: P. Kavka DATE: 10/10/79 LOCATION: Telephone

DISCUSSION

1. Dr. Mears is in charge of the Rutgers University research group operating the pilot waste heat and solar greenhouses, sponsored by PSE&G. This research group has designed the porous concrete floor heat exchanger being utilized in the Mercer Aquaculture Facility. He has worked with Dr. Bruce Godfriaux, PSE&G.

2. Suggested contacts:

   Carl Madewell - Tennessee Valley Authority

   Peter Zeago - Project Coordinator for Bruce Agra Park, Toronto, Canada.

   Conestoga Rovers - Designers of several power plant waste heat systems.

3. Opinion - Need to get new greenhouses and new growers to get the waste heat concept in agriculture "off the ground".

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Mitchell Olscewski U.S. Department of Energy Oak Ridge National Laboratory Oak Ridge, Tennessee (615) 624-0369	P. Kavka DATE 11/26/79 LOCATION Telephone

DISCUSSION

1. Mr. Olscewski is a development staff member at the ORNL, a division of the U.S. D.O.E. supported by the Union Carbide Nuclear Division. Mr. Olscewski is the author of many reports on the topic of waste heat utilization in aquaculture and agriculture.

2. Suggested reference projects:

   a. Savannah River Project - gaseous diffusion

   b. Watts Bar Waste Heat Park - TVA

   c. Sherco Greenhouse Project - Northern States Power

   d. Long Island Oyster Farm

3. Suggested people to contact:

   a. Marvin Gunn - Savannah River Project

   b. Barry Goss - TVA

   c. Robert Brockson - EPRI

   d. Phil Campbell - Long Island Oyster Farm

   e. Wayne Hubert - TVA, aquaculture

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
James J. Vouglitois Environmental Scientist Jersey Central Power & Light Company Morristown, NJ (201) 455-8768	P. Kavka
	DATE 3/5/78 10/11/79 (telephone)
	LOCATION JCP&L Madison, NJ

DISCUSSION

1. Mr. Vouglitois is the project manager for JCP&L's clam culture project in the discharge canal of Oyster Creek Nuclear Generating Station, Forked River, New Jersey. This project is being sponsored by JCP&L and operated by Rutgers University to demonstrate the effects of raising seed clams in power plant condenser cooling water

2. Set up clam project tour for October 29, 1979.

3. Provided information on several pilot and commercial aquaculture programs.

4. Provided information which JCP&L has concerning restrictions on using waste heat from power plant.

   a. The Delaney Amendment to FDCA

   b. JCP&L legal counsel's opinion on the impact of Delaney Clause on clam culture project at Oyster Creek

   c. U.S. EPA's regulations on Aquaculture projects

5. Other topics of discussion

   a. possible tie-in locations

   b. quantity and quality of waste heat at both Oyster Creek and Forked River Unit #1

   c. Deep water wells for cooling

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
David Yosh Jersey Central Power and Light Company Morristown, New Jersey (201) 455-8740	Paul Kavka
	DATE 10/31/79
	LOCATION Telephone

DISCUSSION

1. Mr. Yosh is a senior engineer at JCP&L who has offered to his company's cooperation in this project.

2. Discussion of quality of Oyster Creek cooling water:

   a. temperature can be increased by shutting down one or more of the dilution pumps.

   b. can also change back pressure to increase waste heat discharge, but sacrifice electricity generation.

3. Forked River Unit #1 to be "on-line" by 1985-1986, but probably will not be nuclear.

4. Must address downtime - 4-5 weeks per year, minimum, but up to 7-8 weeks possible for scheduled maintenance.

5. Shut downs are scheduled around availability of other large sources of electricity. They try to schedule down-time in June, July and August.

6. Sent bibliography on cogeneration, which is his field of expertise.

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Peter Zeago Bruce Agra-Park, Project Coordinator Ontario Energy Corporation Toronto Ontario (416) 965-6276	P. Kavka DATE 10/19/79 LOCATION Telephone

DISCUSSION

1. As project coordinator for the Bruce Agra Park, Mr. Zeago discussed the one acre simulation greenhouse presently in operation which will be the model for a proposed 100 acre industrial park development, in 4-acre units. The source of heat is 100°F discharge water from a "once-through" cooling system at a nuclear power plant 10 miles from the site.

2. Scale of operation is the key to economic success.

3. Cost of waste heat supply - waste heat projects are only feasible if utility company will work out an incremental profit scheme. If utility company wants an immediate profit, project will not work.

4. Bruce Agra Park is a condominium firm which is owned and operated by a private concern. The Ontario Energy Corporation is a 10% partner in this firm.

5. Suggested contacts

   Gary Ashley - Northern States Power

   Conestoga - Rovers

INTERVIEW DATA

PERSON INTERVIEWED	INTERVIEWER
Dr. Melvin Zwillenberg Public Service Electric & Gas Company Newark, New Jersey	P. Kavka
	DATE 10/15/79
	LOCATION PSE&G Newark, NJ

DISCUSSION

1. Dr. Zwillenberg is one of PSE&G's experts on district heating who is presently working on a U.S. D.O.E. sponsored grant to study the retrofiting of several power plants for the possibility of supplying district heat.
2. Phase I study conclusion was that only fossil fuel plants can be retrofitted for district heat application; it is too expensive to retrofit nuclear plant.
3. General observation is that district heating will not be commercially available until 1985. Aquaculture and Agriculture are ready for commercial application now.
4. Heat pumps are necessary for district heat.
5. The most efficient heat source for district heating was found to be steam at approximately 290 F, which would have to be extracted from the boiler's main steam.
6. The Dow-Midland Cogeneration project was discussed.

APPENDIX C

OVER VIEW OF ALCOHOL PRODUCTION

APPENDIX C

AN OVER VIEW OF ALCOHOL PRODUCTION

Before embarking on detailed discussions on alcohol production, it is necessary and interesting to first consider the overall process. Regardless of the raw materials being used to produce alcohol, there are invariably four major steps involved:

1. Raw materials rich in carbohydrates must in some way be converted into fermentable sugars.

2. The fermentable sugars must be utilized by yeast to produce alcohol.

3. The alcohol produced during dermentation must be concentrated by distillation.

4. The spent mash left after the alcohol has been removed must be processed into a by-product.

PRETREATMENT STEPS

The object of the pretreatment step is to make available a fermentable sugar for the yeast. To do this, it may be necessary to reduce the size of the raw material to make it accessable to either acid or enzyme treatment.

The raw material, having been ground, will need to be cooked in order to bring about a liquefaction of the carbohydrates.

If the raw material is coated by an obstructing material, it may need to be extracted with the use of acid or alkali. For example, in the case of straw, lignin has to be extracted using alkali.

Where the raw material is already in a fermentable form, for example sugarcane, sugar beets, or molasses, it may need to be sterilized to enable the yeast to successfully ferment without undue competition from contaminating bacteria.

The pretreatment stage very often depends upon nature's catalyst, namely the enzymes, for its success.

FERMENTATION

Having produced the fermentable sugars, the next stage is to convert these by means of yeast in an aerobic fermentation into alcohol. Yeast is a living organism which we will later refer to as Saccharomyces cerevisiae, or literally, "sugar fermenting". The yeast selected will be such that it can tolerate high alcohol content and work under the widest possible conditions. The fermentation step may involve strict control over the acidity and the temperature of the mash and will probably utilize commercial enzymes. These enzymes will continue the breakdown of the carbohydrates to fermentable sugars.

Fermentation takes place over a period of 1-3 days and at the end of fermentation we have a low alcohol beer. The alcohol content may vary between 5 and 15%.

CONCENTRATION STEP

Concentration is either carried out in a pot still or in a continuous still based on the original copy still design. The object of the concentration is to remove selectively the volatile alcohol leaving behind the nonvolatile components.

Continuous fermentation will occur in a number of stills commencing with the beer still, which brings the strength of the alcohol from 10-11% present in the beer to 50-60%. The rectifying column will then further concentrate the alcohol up to 95% alcohol. In order to bring about the final concentrations to 100%, it is necessary to use a further column, the so-called anhydrous column.

In the operation of the anydrous column, it will be necessary to use an entrainer such as Benzene, Heptone, Hexane, Ether, or Gasoline to remove the final 5% water. Having removed the alcohol from the mash, we are left with a resultant called stillage.

This stillage presents both an effluent disposal problem and also an opportunity, in that it is very high in protein and represents an excellent animal feed supplement. Normally, the insoluble solids are centrifuged off whereas the solubles are evaporated in a multi-stage evaporator and then mixed with the insoluble solids.

APPENDIX D

RELIABILITY OF THE INTERFACING SYSTEM

APPENDIX D

RELIABILITY OF THE INTERFACING SYSTEM

> "The availability of waste heat to the users is dependent upon the availability of substantial waste heat from at least one unit and the proper functioning of the waste heat interfacing system. Several features which enhance the reliability of the interfacing system are included in the conceptual design. The single most important feature is that there is a tie-in to both generating units regardless of the operating status of the other unit. Each of the two pumping stations in the interfacing system has three 50-percent capacity pumps, so that outage of a single pump in each station does not reduce the waste heat availability. Other than the pumping stations and the tie-ins to the plant, there are no moving parts in the interfacing system. The simplicity of the interfacing system enhances its reliability.
> Also, the fiberglass-reinforced plastic (FRP) piping is not susceptible to corrosion, which should reduce the potential for leakage problems.
> The overriding factor in the delivery of heated water is the availability of the Watts Bar Nuclear Plant units. Availability of heated water has been analyzed on two different bases. In the first method the three Browns Ferry units were used to prepare an estimated outage rate for two units. When the average of the three possible combinations is used, we obtain a total outage rate of about 8 percent for two nuclear units. Our current records indicate that during the commercial operation, since the fire occurred at Browns Ferry Nuclear Plant, the three units have had 132 outages with an average length of about 35 hours. The longest forced outage was about 1,308 hours. The data for the Browns Ferry units only covers about 6.4 unit years of commercial operation excluding the outage for the fire, and this short period of commercial operation could lead to false assumptions in using the data.
> The second method used to estimate the probability of outage time on an annual basis was based upon the cumulative availability factors of the 38 PWR nuclear units as reported in the Operating Units Status Report (NRC Gray Book). The September, 1978, data indicates these units have an average cumulative availability factor of about 74 percent. The probability of only one unit being on line is about 38 percent. The probability of both units being out of service is about 7 percent or about 613 hours per year".
> (Ref. 10, C. IV., p.11)

Appendix D has been included only to demonstrate the advisability of having two or more power plants serving as heat sources for industria park applications, as is the case for the Watts Bar Study.

APPENDIX E

ENVIRONMENTAL TESTING REPORT

I. Introduction

The Lacey Township Industrial Commission has undertaken this study to evaluate the concept of using waste heat supplied by the Oyster Creek Nuclear Generating Station (OCNGS) as a source of supplemental energy. It is the hope of the Commission that this system may help support an industrial park adjacent to the power plant.

It is the objective of this study to review and assess any priorities and problems which may occur in the employment of a heat distribution system. The proposed design calls for the use of the heated effluent water from OCNGS in a condenser system which will transfer the waste heat to piped-in groundwater from a well situated on OCNGS property. The condenser will be encased in a rock containment through which the heated saltwater effluent will flow. (See Figs. 1, 2.)

This report will investigate the quality of both the intake and effluent waters of OCNGS and their relationship to direct use in the condenser system. Also point out will be the factors involved in the use of the groundwater system.

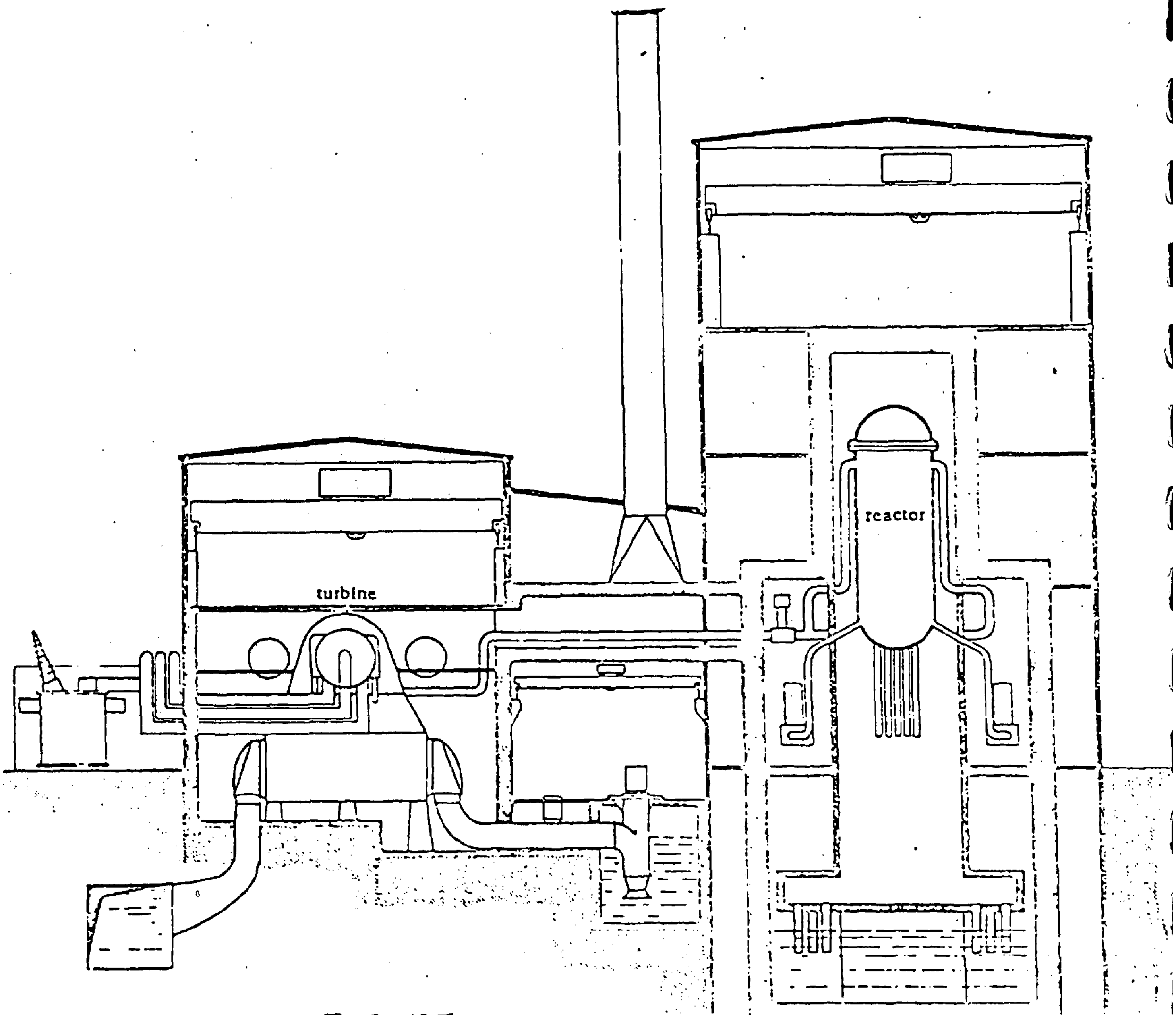


FIGURE 1
OYSTER CREEK NUCLEAR GENERATING STATION

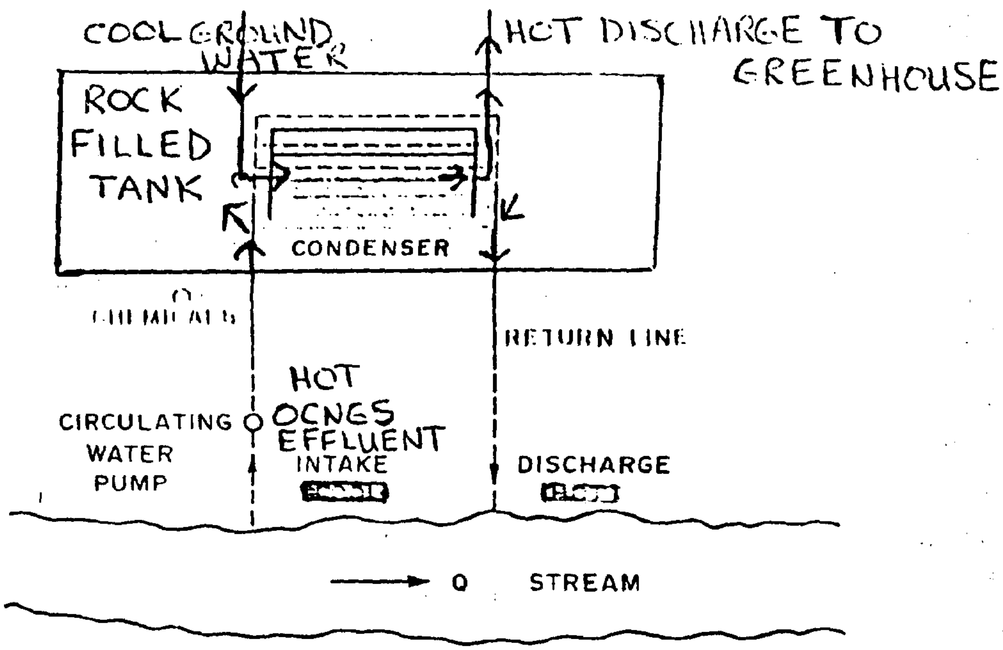


Fig. 2 -

Diagram of Proposed Heat Recapture System, with Rock Containment and Condenser

II. Intake Water of the Power Plant

1. Quality

The intake water at OCNGS is drawn from Barnegat Bay through a dredged circulating canal. This cooling water is then sent into the power plant condenser at a dam constructed across the circulating canal.

The quality of this intake water lists as follows:

TABLE 1

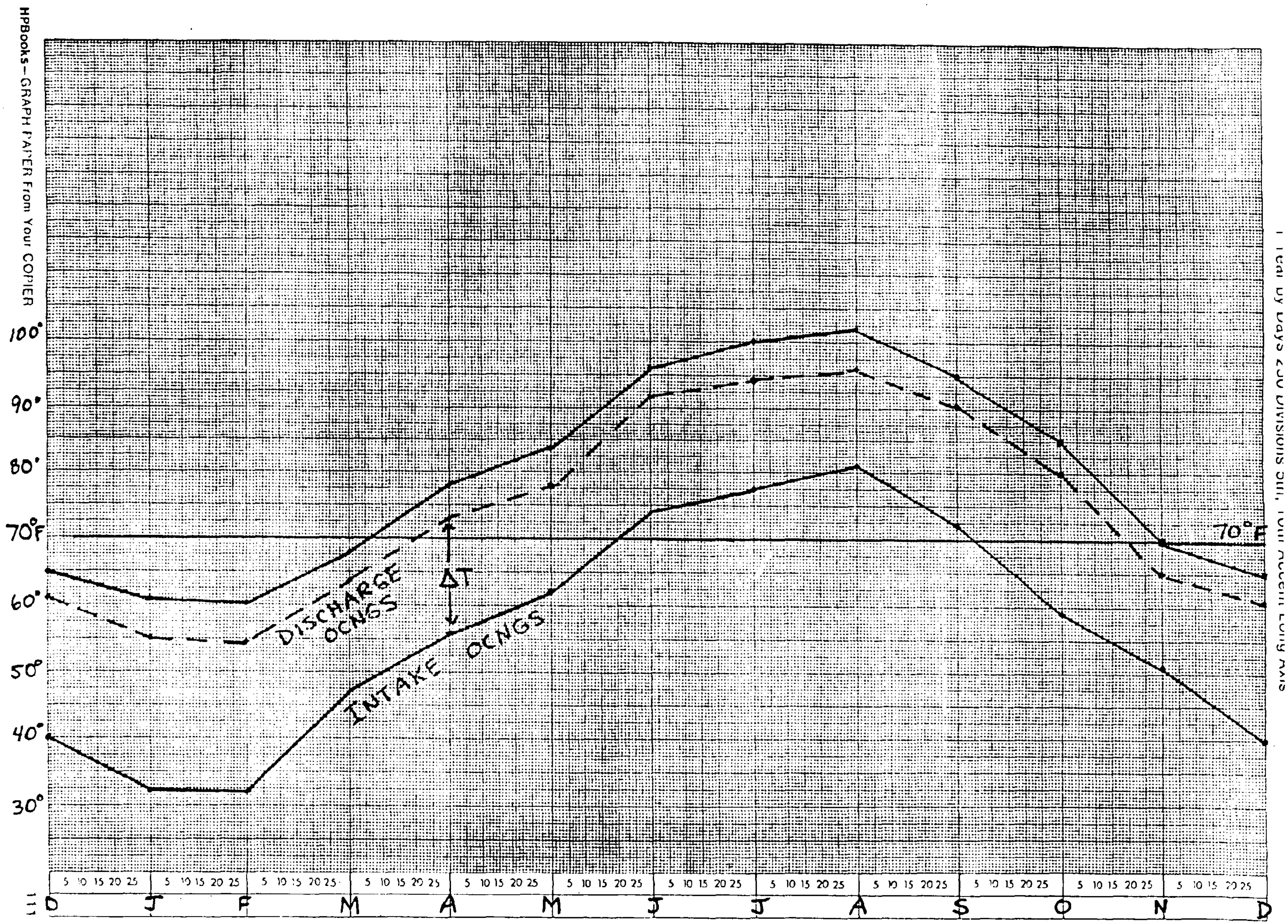
PARAMETER	OCNGS INTAKE
Calcium	289
Magnesium	881
Sodium	7,134
Chloride	12,680
Sulfate	1,816
Phosphate	0.7
Bicarbonate	100
Silica	18.0
Iron	0.6
Manganese	0.01
Salinity	23,000
Alkalinity $CaCO_3$	82
pH	6.95

III. Effluent Water of the Power Plant in relation to direct use in the Heat Distribution System

1. Quality

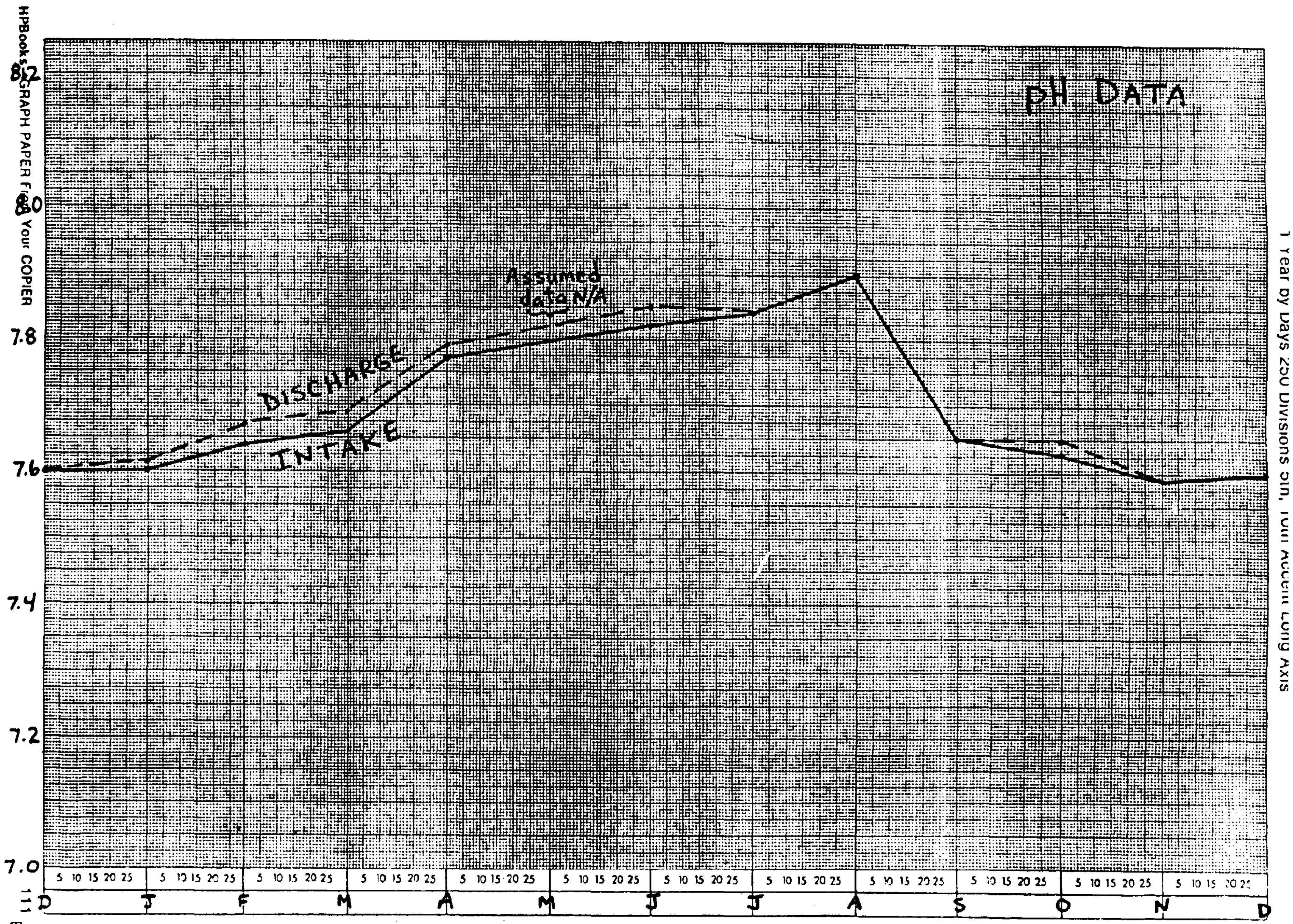
It is assumed that the effluent from the OCNGS condenser owns the same parameters as the intake water from Barnegat Bay (see Table 1) except for the temperature increase and the effects of the chlorination that is employed to clean the condenser system at the power plant. (See Graphs 1, 2) This cooling water effluent is released back into the discharge canal and drains further into the Barnegat Bay system, thereby havings its waste heat assimilated by the receiving water. In the desire to make the most effective use of this waste heat, the cooling water effluent will be pumped into the condenser and will transfer it's heat there before being released back into the bay system.

As stated earlier, the condenser will be surrounded by a containment filled with rocks through which the heated waste water will circulate (see Fig. 2). It is suggested that these rocks be large cobble size, rounded and uniform, and also be well sorted. According to the principles of geology, the movement of any subsurface water is largely controlled by the porosity and permeability of various rocks. The porosity of a rock deposit (i.e., condenser rock containment) is equal to the ratio of the volume of pore space to the total volume of the material, including it's pores. The velocity, or rate of flow, of the heated effluent water through the condenser system tank would equal the hydraulic gradient (loss of energy due to friction per unit of distance traveled) multiplied by the co-efficient of permeability (degree to which material can transmit flow of fluid). Large cobbles such as those encountered in the Delaware River system may be the type of material needed to surround the condenser system. Through the action of the river transportation system, these cobbles have been well sorted and weathered to a smooth round size. The use of these rocks would lower infiltration velocity around the condenser core with a net savings in pumping costs and a lower horsepower. Let it also be noted that the temperature effects from the heated cooling water should be negligible in relation to further physical weather of these cobbles (Allison, et. al.



(TEMPERATURE VERSUS TIME)

GRAPH 1



(pH VERSUS TIME)

GRAPH 2

1. Quality (continued)

Geology: The Science of a Changing Earth, 1974, p. 115).

2. Heating and Chlorination

The major problem that must be addressed in this section is the possible buildup of bacteria and algae within the condenser rock containment. First, the choice of rounded cobbles is supported here in that there will be less "hidden" areas where bacterial and algal growths may proliferate undisturbed by the circulating water velocity.

There do occur certain thermophilic bacteria and algae in nature that are able to carry on active cell metabolism and multiply at approximate temperatures of 50°-60° C. (encyclopedia reference). Some thermophiles are active also at lower temperature ranges which are within the boundaries of the low grade heat that occurs in power plant effluents. Heat added to water has been known to result in growths of filamentous algae, other types of aquatic plants and increased incubation of bacteria due to increased rates of photosynthesis and productivity. (Krenkel, P.A., and Parker, F. L., Biological Aspects of Thermal Pollution, 1969, p. 147) Nevertheless, for all bacteria and algae, there exist specific critical points of temperature, which above or below, there occurs decreased growth and eventual death. Natural systems are characterized by a high diversity of species and it has been found that raising temperatures beyond the optimum for these species reduces diversity (Krenkel, Parker, p. 183).

As with temperature variations in seawater, bacteria and algae are known to become adapted to changes in pH values and maintain normal physiological functions. (encyclopedia reference)

The destruction rate of bacteria and algae is dependent on temperature, pH and chlorine concentration; however, since temperature and pH ranges that are encountered in practice are normally in the acceptable range for growth, the chlorination of power plant cooling water is essential to prevent condenser fouling. The condenser rock containment will depend on the chlorination process in the power plant to prevent bacteria and algae buildup on the rocks if the ef-

2. Heating and Chlorination (continued)

fluent water is to be piped directly from the plant to the rock containment. Further chlorination may be needed if the effluent water is first mixed with the water in the discharge canal and then diverted to the rock containment. Research indicates that the effect of chlorination of the heated water at the point of discharge seemed to reduce the sizes of certain algal populations (number of individuals), but not the number of species in discharge canals. (Krenkel, Parker, p. 173 T.P.)

One final parameter on the quality of the OCNGS effluent concerns the effects of stratified flow. "If the discharge from a power plant is in the form of an overflow, mixing between the upper and lower layers is inhibited, thus minimizing oxygen replacement and self-purification in the lower layer." The heated effluent water will remain on the top layer. "Due to lack of mixing, organic wastes discharged into the lower layer do not have access to the oxygen in that portion of the stream flowing in the upper layer. Thus, there is less dissolved oxygen, less dilution water and a more concentrated organic load in the lower layer leading to an acceleration of the dissolved oxygen depletion. The result may be a considerable reduction in the waste-assimilative capacity of the receiving water.

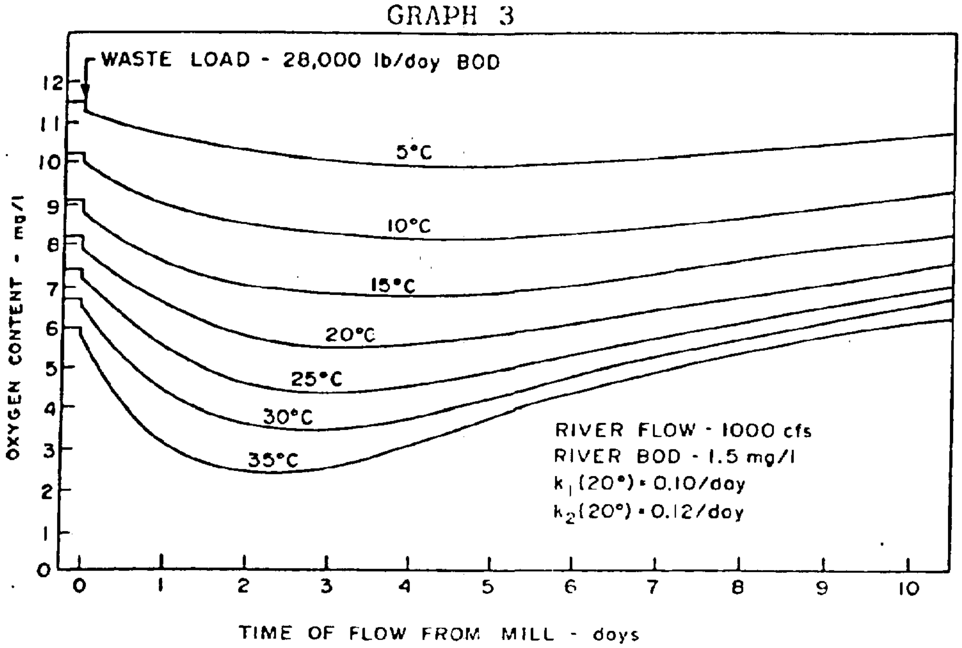
If the Heated discharge is completely mixed with the receiving water, some of the above-mentioned effects are eliminated; however, the rise in temperature still causes a decrease in the ability of the water to hold dissolved oxygen, an increase in the metabolic activity of organisms, an increased rate of BOD exertion, and a possible reduction in waste-assimilative capacity." (Krenkel, Parker, pp. 22-23)

It has also been observed that heated effluents may "hug" shoreline areas. This separation of flow has the same effects as vertical separation.

Thus, temperature has a marked effect on the waste assimilative capacity of the receiving water causing them to no longer satisfactorily assimilate BOD loads, as under preveious lower temperature conditions. (see graphs 3, 4, 5)

All of these factors will effect the usefulness of the condenser unit if the heated effluent from OCNGS is first released into the

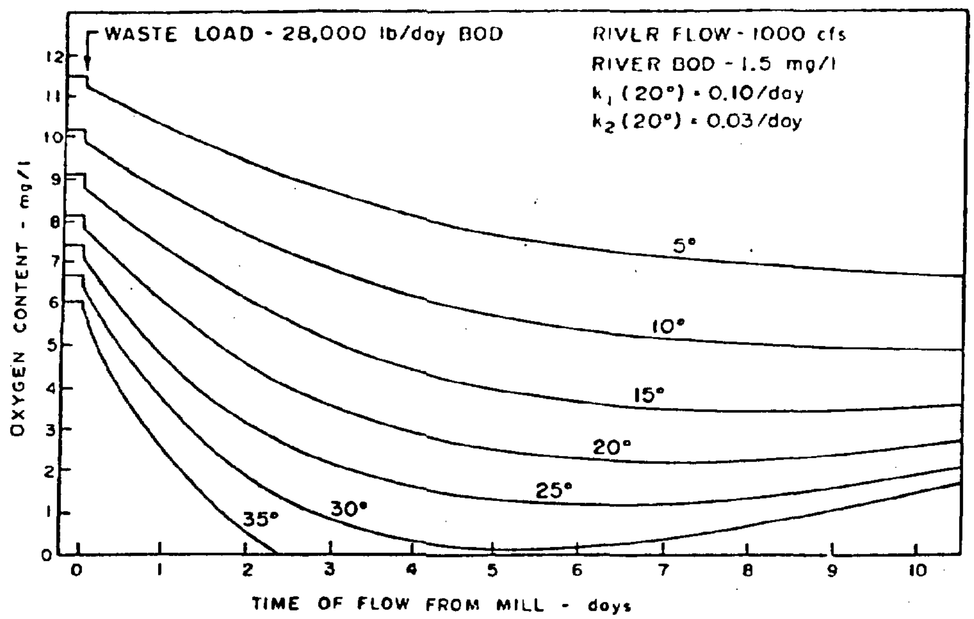
GRAPH 3



OXYGEN SAG CURVE - FREE FLOWING CONDITION

Oxygen-sag curves for Coosa River, free-flow condition

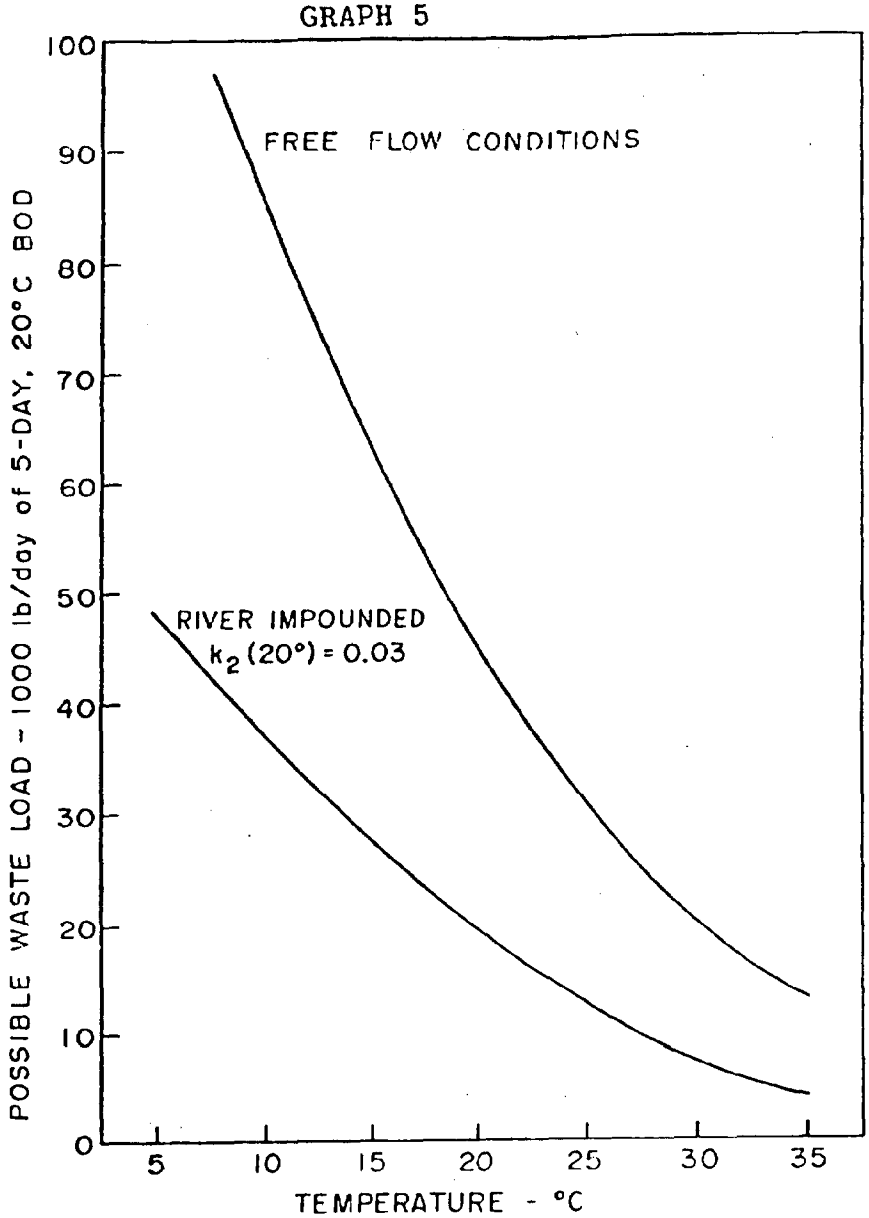
GRAPH 4



OXYGEN SAG CURVES - RIVER IMPOUNDED

Oxygen-sag curves for Coosa River, impounded conditions

GRAPH 5



.Waste-assimilative capacity of Coosa River at Georgia Kraft Mill, river flow of 940 CFS

2. Heating and Chlorination (continued)

receiving water of the discharge canal and then pumped into the rock containment.

3. Mechanical Pumping

Mechanical pumping can be accomplished by using horizontal/centrifugal booster pumps. The effects of the nuclear effluent water would be several in nature. Short-term effects are thermal expansion and contraction of the metals that the pump is made of, resulting in early mechanical seal leaks around the shaft that drives the impeller. The change of algae buildup, or bacteria, would be very limited due to the chlorination and the high volute velocities. Mechanical embrittlement is possible after a significant number of years in service. Embrittlement is a function of thermal transience and the inter-relationship between active radioisotopes in the water and the metals that make up the centrifugal pump fluid end.

Downstream effects in the distribution system are possible algae buildup and bacteria development. It is the belief that the distance of pumping the effluent to this heat distribution system is important due to the velocities and frictional forces that would make it easier for bacteria and algae buildup to survive. Thus, we would have a changing total dynamic pumping head on the centrifugal pump. As a result, this would greatly affect the flow into the area surrounding the condenser, i.e., rock containment.

Special epoxy lined pumps can be designed in hopes of reducing probabilities of pump failure due to the above criteria at a nominal cost.

Environmental Testing Laboratories, Inc.

IV. Groundwater

1. Quality

The quality of the water well at Oyster Creek is as stated in Table 3-8 of the Oyster Creek Well Water analysis. Groundwater in the Kirkwood Formation aquifer is commonly acidic, may contain excess iron and have a hydrogen sulfide odor. (see figs. 3, 4) (Temperature log supplied by Holm Well Drilling, Inc.)

2. Quantity

A deep well lineshaft vertical turbine could be installed in the Oyster Creek water well to supply the necessary needs of water flow through the condenser to heat same. Pump tests have been conducted by Holm Well Drilling, Inc. which show a yield exceeding 400 GPM. Greater yields can be obtained from the Oyster Creek well, if needed. The size and horsepower of the deep well water-lubricated vertical turbine could be designed to meet the pumping characteristics for the condenser. The estimated top end yield on the Oyster Creek well would be 2000 GPM. (Information obtained from Holm Well Drilling, Inc. See included log.)

3. Mechanical Handling Properties

As outlined in the brief above, mechanical pumping would be handled by a deep well lineshaft vertical turbine. The pumping characteristic, i.e., total dynamic head of the system, could be met without any difficulty. Oxidation/reduction action and constituent parameters listed in Table 3-8 would have a long term effect on the pump: bowls, lineshaft and column, and also in the distribution system after the discharge from the head of the pump.

4. Possible Treatment Required

Treatment of this water could be accomplished by filtering through rapid sand filtration and softening could be accomplished by an ion-exchange column, assuming that the flows are below 250 GPM to make it equitable for the condenser. Ion-exchange columns to handle flows greater than that mentioned get involved in prohibitive costs and other methods, such as aeration and sedimentation, would be more effective in removing the iron, which is the largest problem on the list. Lime soda injection could adjust the pH at a reasonable expense, independent of flow.

If the water was not treated prior to entering the condenser,

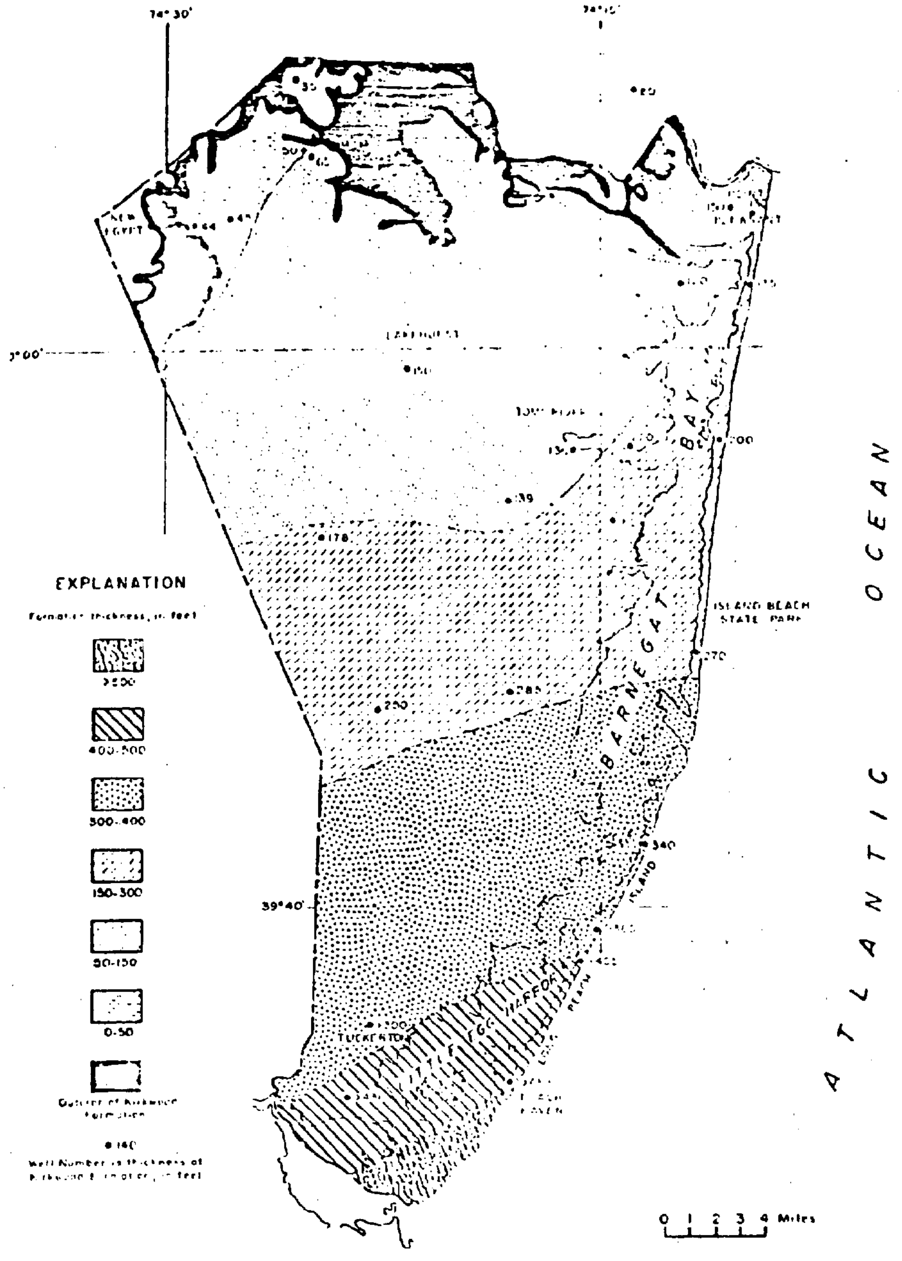


Fig. 3
Thickness map of Kirkwood Formation

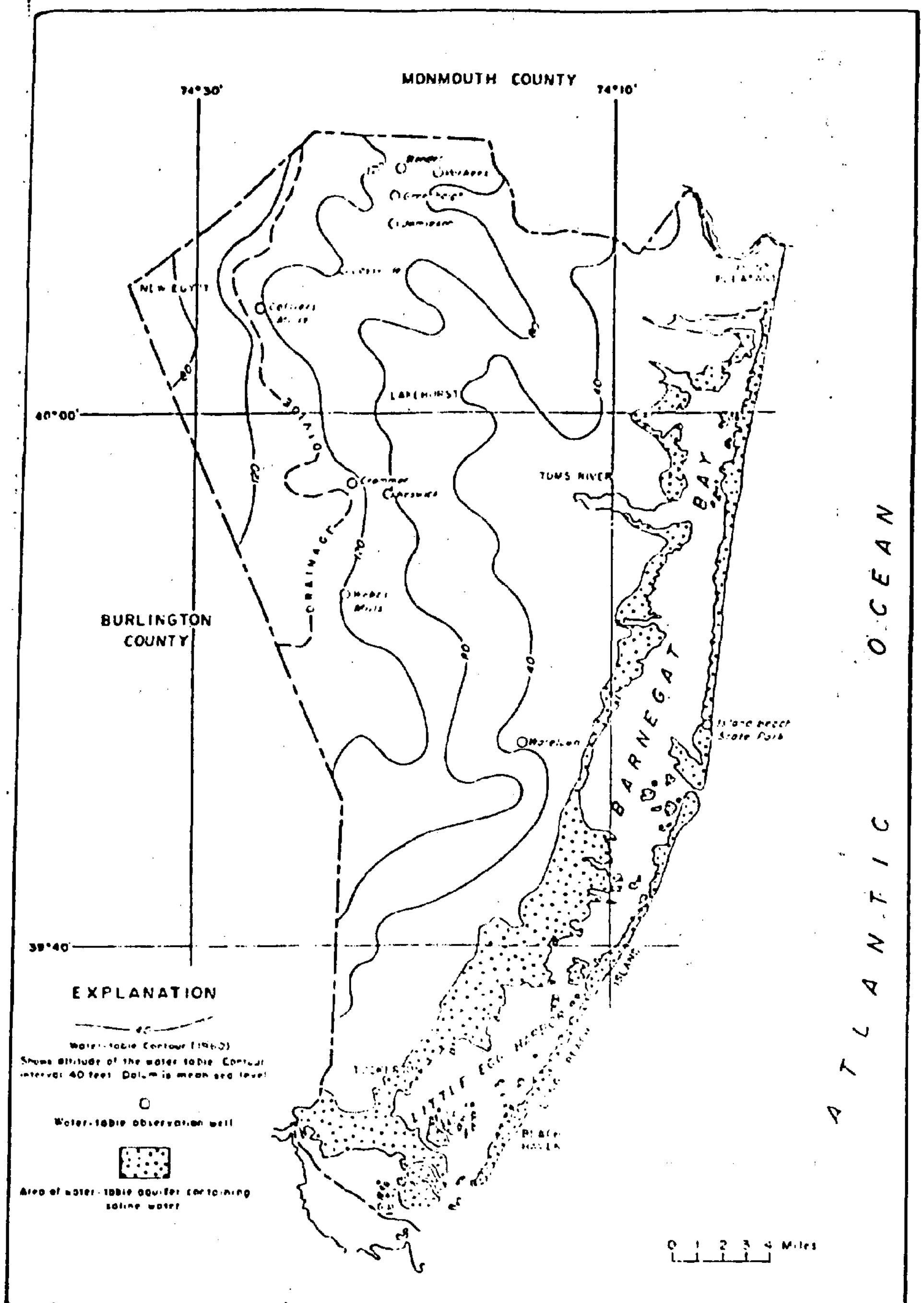


Fig. 4
Water Table Contour Map of Ocean County

HOLM

PRINCIPALS OF THE FIRM ARE MEMBERS OF:
International Association of Drilling Contractors
New Jersey Water Well Contractors Association
National Water Well Association
American Water Well Association
Penn Oil & Gas Association
IN REPLY PLEASE REFER TO:

COUNTY OCEAN
FIELD or LOCATION OYSTER CREEK
WELL NUCLEAR GEN STA
COMPANY WALTER HOLM

COMPANY WALTER HOLM WELL DRILLING

WELL OYSTER CREEK NUCLEAR GENERATING STA.

FIELD

COUNTY OCEAN STATE NEW JERSEY

LOCATION

Sec. Twp. Rge.

Other Services: NONE

Permanent Datum: G.L., Elev. 20
Log Measured From G.L., 0 Ft. Above Perm. Datum
Drilling Measured From G.L.

Elev.: K.B. 24
D.F.
G.L. 20

Date	9-4-64			
Run No.	ONE			
Depth—Driller	302			
Depth—Logger	302			
Btm. Log Interval	296			
Top Log Interval	20			
Casing—Driller	@ 20	@	@	@
Casing—Logger	8"			
Bit Size	MUD, FRESH			
Type Fluid in Hole	BAROID, SUPERIOR GEL			
Dens. / Visc.				
pH / Fluid Loss	ml	ml	ml	ml
Source of Sample				
R_m @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	@ °F	@ °F	@ °F	@ °F
Source: R_{mf} R_{mc}				
R_m @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.				
Max. Rec. Temp.	53 °F	°F	°F	°F
Equip. / Location	3833 / FAIRMONT			
Recorded By	D. BICKNELL			
Witnessed By	W. HOLMES			

FOLD HERE

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WELLS

All water supplies in the area surrounding the site are derived from wells, whether individual or multiple residence water systems. Such wells generally are at least 60 feet deep to preclude contamination from saltwater intrusion or septic tanks. A 300-foot well supplies potable and other water demands to Oyster Creek Nuclear Generating Station, with the analysis given in Table 3-8.

During test boring for Oyster Creek Station, ground water levels were encountered less than 10 feet below grade. The ground water surface slopes from the west downward toward the bay. Thus, surface drainage at the Forked River Station site is toward the canals to the east, the South Branch of Forked River to the north, and Oyster Creek to the south. The Oyster Creek Nuclear Generating Station circulating water canals have been in existence for three years without known salt water intrusion into the local aquifers.

TABLE 3-8

OYSTER CREEK WELL WATER ANALYSIS

Constituent	Parts per Million
Calcium	5.82
Magnesium	1.30
Sodium and Potassium (by difference)	16.56
Chloride	19.00
Sulfate	7.50
Nitrate	0.25
Phosphate	1.95
Bicarbonate	0.00
Silica	10.80
Iron (Total)	3.75
Manganese	.01
Total Residue	96.0
Suspended Matter	.0
Volatile Residue	36.0
Hardness as Calcium Carbonate ($CaCO_3$)	26.6 (Ca, Mg & Fe)
Phenol Phthalein Alkalinity ($CaCO_3$)	0.0
Methyl Orange Alkalinity ($CaCO_3$)	18.0
pH	6.35
Biochemical Oxygen Demand	0
Temperature	53°

4. Possible Treatment Required (continued)

and with the addition of the thermal transient in conjunction with the geo-chemical parameters in Table 3-8, problems could arise with the buildup of calcium, magnesium, and iron at an accelerated rate in the condenser, increasing the total dynamic pumping head of the deep well lineshaft vertical turbine, as a result of the increased surface friction on the walls of the condenser from buildup of the same parameters. Filtration would be highly recommended in the condenser design concept.

V. Summary

It has been the purpose of this study to outline the priorities and problems in the use of OCNGS waste heat as a supplemental energy source for condenser heat.

The use of Barnegat Bay water in the power plant alters the temperature, the chloride content and the pH slightly. These factors all have an effect on the receiving water in the discharge canal. By itself, the increased temperature will not destroy growths of algae and bacteria, which could build up within the condenser rock containment. The chlorination of the cooling water to clean the power plant condensers should effectively aid in keeping the rock containment free from fouling, if the effluent is piped directly to the condenser system. High BOD loads, due to stratified flow in the receiving canal, may cause problems by decreasing the waste-assimilative capacity of this water.

Pre-filtering of the groundwater should prevent any problems associated with the buildup of geo-chemical parameters.

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APPENDIX F
AZTEC SOLAR HEAT PUMP REPORT

AZTEC ENERGY ASSOCIATES

1044 LACEY ROAD
FORKED RIVER, NEW JERSEY 08731

Abstract

A review of current heat pump technology indicates it is feasible in terms of existing equipment to augment the temperature of the waste heat from the Oyster Creek Nuclear Generating Station. It is also possible to store a given quantity of heat for use during plant shutdown periods. Two designs are outlined which offer promise in terms of heat storage capacity and suitable temperature delivery.

One design utilizes phase change materials to store heat. The technology and materials for this type of storage presently exists in the marketplace. The second design proposal involves heat storage as chemical potential energy. As the technology of the chemical heat pump remains to be developed, it is more likely the first design proposal has more merit.

In conclusion it appears that the entire concept of the Central Heat Source with heat storage is feasible.

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INTRODUCTION

The Lacey Township Industrial Commission has proposed the concept of a municipally-supported industrial park adjacent to the Oyster Creek Nuclear Generating Station (OCNGS). In conjunction with this proposal Lacey Township has undertaken a study to evaluate the concept of utilizing waste heat from the power plant as a supplemental energy source for the industrial park. The commissioned study, prepared by Northwest Engineering, Inc., proposes a central heat source to interface the power plant with the industrial park. It is the purpose of this report to evaluate this concept in light of current technology and, if appropriate, to suggest the most efficient combination of technologies to accomplish the desired goal of the Central Heat Source facility.

The objectives of this report are to:

1. Review current heat pump technology as it applies to the proposed Central Heat Source.
2. Evaluate the feasibility of utilizing a heat pump system to augment the temperature of the waste heat from the Oyster Creek Nuclear Generating Station (OCNGS).
3. Identify storage systems appropriate to the Central Heat Source facility.

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REVIEW OF CURRENT HEAT PUMP TECHNOLOGY

The concept of the heat pump is quite old having its origins in the sixteenth and seventeenth century theories of mechanical engines. The earliest analogies of heat pumps to water pumps are still used in the modern literature to describe the theoretical operation of the equipment. Just as a water pump requires the addition of outside energy to increase the potential energy of the water, so does a heat pump require outside energy to move heat against its natural potential gradient, i.e., from a lower temperature to a higher temperature. The apparent contradiction of the conservation of energy principle (the First Law of Thermodynamics) arises from a failure to consider the entire system involved. In general only the electrical energy input and the heat output of the engine are discussed because to the engineer these are the relevant design parameters. As defined previously this ratio of heat output to electrical input is the coefficient of performance (COP) of the equipment. If the entire system involved in the energy transfer were considered the operating efficiency would agree with the conservation of energy principle and in fact for a real engine this efficiency would be well below 100%, as predicted by the Second Law of Thermodynamics.

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The specific application of heat pump technology which is the subject of this report involves the input of large volumes of salt water at low temperatures and subsequent heat transfer to large volumes of fresh water from deep wells. Of significant importance is the fact that the salt water input to the heat pump is the effluent from the Oyster Creek Nuclear Generating Station. Therefore, not only must the heat pump be capable of handling input water of pH8.0 but also of isolating this water in a nuclear sense. The use of titanium steel for the coil of the heat pump would solve both the salt water and the isolation problems.

The quality of the incoming fresh water also impacts on the design of the equipment. The incoming fresh water contains relatively high concentrations of iron which would eventually cause fouling of the exchanger in the heat pump. Provision must be made for periodic cleaning of the fresh water exchange coil if the problem of fouling is to be eliminated. Fortunately all large-scale industrial heat pumps provide for the capability to perform regular cleaning and maintenance on exchanger coils.

The heat pump specified in the Proposed Lacey Energy Park Flow Diagram (A) is the water-to-water type, commonly referred to as a "water chiller". As indicated by the name the most frequent

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use of this equipment is for commercial refrigeration. However, a water-cooled water chiller also serves well the designated purpose of temperature augmentation. Heat is removed from the entering effluent by means of the expansion cycle of a refrigerant, and this heat is added to the entering fresh water by way of a compression cycle with the same refrigerant. The technology necessary to accomplish this task is well-developed and reliable as any mechanical engineer can attest. However, in order to evaluate the feasibility of the application of this technology to the Central Heat Source the specific design parameters must be matched to existing equipment.

Heat Pump Design Parameters - Central Heat Source

As proposed the heat pump in the Central Heat Source is most necessary during the winter months. Because the OCNGS is a single-pass open-cycle plant the average effluent temperature during the 146 day winter period is 59 degrees F. Based on the suggested Energy Park industry mix a minimum temperature augmentation of 42 degrees F is necessary to sustain winter production. Therefore, the design parameters for the Central Heat Source heat pump are as follows:

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	OCNGS Effluent	Deep Well Fresh Water
Entering Temperature	53 degrees F minimum	53 degrees F
Exiting Temperature	34 degrees F minimum	95 degrees F
Flow	34000gpm	15000gpm

Because OCNGS operates at a maximum delta T of +19 degrees F environmental benefit is maximized by returning effluent water at a delta T of -19 degrees F, i.e., the intake water to the plant and the outlet water from the Central Heat Source are at the same temperature. An additional environmental benefit can result if it is possible to recirculate the cooled effluent back to the power plant in a closed loop. To gain these advantages it is necessary to operate the Central Heat Source heat pump at a delta T equal to that of the cooling cycle of the power plant.

Heat pumps do exist with characteristics within the given parameters though on a much smaller scale. For example, Application Engineering of Elkgrove Village, Illinois manufactures a 217 ton unit (1 ton of refrigeration = 12,000 BTU/hour) that uses 261 gpm of entering water at 53 degrees F to raise 118 gpm of fresh water from 53 degrees F to 95 degrees F. The temperature augmentation of this unit is correct for the Central Heat Source

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design though the capacity of the unit is well below optimum. The COP of this unit under design condition is 5.0, i.e., 192 kilowatts input and 953 kilowatts output. Because of its capacity approximately 130 units would be required to handle the projected flow of 34,000 gpm inlet water. Unfortunately this unit is typical of present large-scale heat pump technology. Economics of scale apparently preclude the manufacture of units above the 300 to 400 ton range. Based on this fact a minimum number of heat pump units can be calculated to provide the desired temperature augmentation:

Mass. Specific Heat . Change in Temperature = Heat to be Augmented

(34000gpm)(60 min/hr)(8.34 lb/gal)(1 BTU/lb-degree F)(19 degrees F)=

$$3.23 \times 10^8 \text{ BTU/hr.}$$

$$\frac{(3.23 \times 10^8 \text{ BTU/hr.})}{(1.2 \times 10^4 \text{ BTU/hr/ton capacity })} = 2.69 \times 10^4 \text{ tons capacity}$$

Assuming 217 tons capacity/ unit

$$\frac{2.69 \times 10^4 \text{ tons capacity}}{2.17 \times 10^2 \text{ tons capacity / unit}} = 1.24 \times 10^2 \text{ units} = 124 \text{ units}$$

The minimum number of heat pump units necessary to carry out the proposed design conditions is 124. Assuming a regular maintenance

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program and 10% additional capacity for emergency backup the most probable minimum number of heat pump units in the proposed Central Heat Source is 136.

Summary Of Central Heat Source Review

Technology presently exists to varify the feasibility of the proposed Central Heat Source as shown in the Proposed Lacey Energy Park Flow Diagram (A). Water-to-water heat pumps do not exist which, on a reduced unit scale, perform the proposed design temperature augmentation. The material construction of these units appears to successfully answer problems of corrosion, maintenance and flow isolation. The relatively high COP's of these unity indicates an efficient use of external energy in the augmentation process.

As to the Proposed Lacey Energy Park Flow Diagram (B) only a brief observation is appropriate. The proposed use of heat exchangers to transfer heat from the effluent to the deep well fresh water is only feasible when a significant delta T exists between the two fluid streams. As the average winter temperature of the effluent is 60 degrees F and the well water is a constant 53 degrees F, the necessary thermal gradient for significant heat transfer is lacking. Since heat pumps are still required to augment fresh water temperatures for practically the same delta T, it would appear impractical to utilize heat exchangers to preheat incoming winter well water.

Central Heat Source Storage

The proposed Central Heat Source contains a rock containment area designed to store 6.2×10^7 BTU of heat. The points are made that rock storage is low-cost and readily available. It is also true that rocks store sensible heat, i.e., heat as a function of temperature change. In an industrial park where the temperature of the delivered heat may be critical, sensible heat storage is a potential problem. Assuming heat removal from storage becomes necessary during a winter shutdown of the power plant, it would be expected that the initial temperature of the delivered heat would equal that of the temperature augmented fresh water circulating within the rock containment area. However, as heat continues to be removed from rock storage, the temperature would drop in proportion to the heat removal rate. Very quickly the stored heat would require its own augmentation to be of value to park industries.

The problems associated with sensible heat storage can be overcome through the use of phase change at a suitable temperature. In the phase change process, large quantities of latent heat are involved. This latent heat is associated with the change of state of material and in no way is it related to sensible heat. Latent heat transfer occurrs at a constant temperature while sensible heat transfer requires a temperature gradient. Therefore, by proper selection of the phase change material the output of the heat storage area can be delivered at a constant, useful temperature.

Most of the research involving latent heat storage materials has been applied by the solar energy industry. Early problems such as the corrosive nature of the materials and the limited number of phase changes of some materials have been overcome. Two commercially available materials, calcium chloride ($CaCI_2.6H_2O$) and sodium sulfate ($Na_2SO_4.10H_2O$), are commonly used in the solar industry and have suitable phase change temperatures. Of the two, sodium sulfate decahydrate (Glauber's salt) has the higher phase change temperature, 90 degrees F (32.2 degrees C) but the lower latent heat, 60 BTU/lb. Calcium chloride hexahydrate's phase change occurrs at 81 degrees F (27.2 degrees C) but it can store 82 BTU/lb. The following summarizes the application of each material to the heat storage facility:

	$Na_2SO_4.10H_2O$	$CaCl_2.6H_2O$
Phase Change Temperature	90 degrees F	81 degrees F
Latent Heat	60 BTU/lb.	82 BTU/lb.
Storage Capacity	120,000 BTU/ton	164,000 BTU/ton

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When compared to rock (8,800 BTU/ton) either of the above materials can provide an equal heat storage capacity in a much reduced volume. Assuming a need to store 6.2 x 10^7 BTU's as in the proposed design, the weight and space requirements are as follows:

	$Na_2SO_4.10H_2O$	$CaCl_2.6H_2O$	Rocks
Weight Required For Design Heat Storage	517 tons	378 tons	7050 tons
Storage Volume Relative to Rock (20% voids)	.096	.061	1.0

Storage of heat in phase change materials presents advantages in weight, volume, and delivery temperature. Even the durability of phase change materials is equal to or better than that of rocks because the materials are encapsulated in an ultra-high molecular weight, high density polyethelene. The only limitation imposed by this material is a high temperature limit of 190 degrees F. Under design operating conditions this limit poses no problem.

Even with the advantages inherent in the use of phase change materials the delivery temperature of heat is somewhat below optimum. A second possibility exists for the storage of heat and subsequent delivery at high temperatures. The chemical heat storage associated with a chemical heat pump has the desired operational characteristics. A chemical heat pump operates in the following way:

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"Two chambers, designated A and B, are connected with each other by vacuum-tubes. The chamber A contains a substance absorbing vapour, for instance Na_2S, while an evaporating substance or liquid, water for instance, is found in chamber B. All gases other than water vapour are assumed to be removed by means of a simple vacuum pump which, having completed its task, is in principle disconnected."

"Owing to its hydroscopic properties the salt readily absorbs the water, with the result that the water vapour evaporating from the water in chamber B is absorbed by the salt in chamber A. The absorbed water is integrated in the crystal structure of the salt, as water of crystallization, forming a hydrate. During the process, thermal energy is required in B to evaporate the water (vaporization heat). In chamber A thermal energy is released when the water vapor is absorbed by the salt (condensation heat). At the same time a certain quantity of chemical binding energy (hydration heat) is released when the water molecules are integrated in the crystal structure of the salt. Thus chamber B is cooled in the process and at the same time heat is evolved in chamber A." (Ref.2, p.10)

Assuming chamber B is kept at 53 degrees F by circulating ground water, the output temperature would be between 120 degrees F and 140 degrees F, depending on the rate of heat removal.

The concept of interest is the storage of heat in the form of chemical potential energy. The heat is stored during the charging cycle of chamber A which for the above materials takes place at 158 degrees F. Obviously in the Central Heat Source facility as proposed the temperature augmented fresh water is well below this temperature.

One possible method of supplying high temperature heat for chemical storage is through the use of solar collectors. The tem-

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peratures required are beyond the practical operating range of typical flat plate solar collectors but a simple non-tracking concentrator-type collector would be suitable. An example of such a product is the Solartron Vacuum Tube Collector, TC100, by General Electric Co. This collector has a concentration ratio of 1.1 and an operating efficiency of 50% under typical winter conditions in New Jersey. It has the capability of delivering the high temperature heat necessary to charge the chemical storage material.

The number of solar collectors necessary to charge the chemical storage is a function of heat requirements and charging time. For example, the heat output of chamber A as described is 1550 BTU/lb. of dry Na_2S/lb of water vapor, thus requiring 40,000 lb of material to store the design heat storage of 6.2×10^7 BTU's. The ability of solar collectors to produce this amount of heat is a function of location and season. For the purpose of this analysis it is assumed the collectors are mounted at 50 degrees up from the horizontal and face true solar south. On an average day in January, each square foot of collector can absorb and transfer to storage 900 BTU's. If the assumed time period for collection and charging of storage is one month, then the required amount of solar collector area is calculated as follows:

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(900 BTU/day/sq. ft.) (30 day) (Area of Collectors) = 6.2×10^7 BTU

Area of Collectors = 2,300 square feet

For the General Electric collector specified, the net operture area is 14.7 sq. ft./collector thereby requiring 156 collector units to accomplish the required charging of storage.

The concept of chemical heat storage appears feasible when coupled to a high-temperature heat source for charging. Some problems associated with this form of storage are material handling and corrosion. As technology advances in this area, solutions will have to be divised to minimize these concerns. At present, only relatively small protypes of the chemical heat pump have been built and tested.

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Interview Data

Person Interviewed: Tom Bension
Applications Engineering
850 Pratt Avenue
Elkgrove Village, Ill. 60007

Interviewer: W. A. Post

Date: 11/25/80 (telephone)

Location: Elkgrove, Illinois

Discussion:

1. Applications Engineering manufacturers some of the largest water-cooled water chillers in the United States.

2. Corrosion and nuclear isolation of incoming water is not a problem when titanium steel coils are used.

3. All commercial heat pump units have coils accessible for maintenance.

4. Applications Engineering's largest water-cooled water chiller is a 217 ton unit with the following characteristics.

Intake Water (coolant)		Conditioned Water delta T 42 Deg.F.	
Discharge Water (coolant)			
flow	261 gpm	Electrical Input	192 kw
COP	5.0	Energy Output	953 kw

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Interview Data

Person Interviewed: Lloyd Ludkey
Heat Exchangers Inc.
8100 N. Monticello Avenue
Skokie, Ill. 60076
(312) 267-8282

Interviewer: W. A. Post

Date: 11/25/80 (telephone)

Location: Skokie, Illinois

Discussion:

1. Characteristics of commercial heat exchangers - necessary temperature gradients at various flow conditions to allow for heat exchange.

2. Regular maintenance of large units is necessary to guarantee performance.

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Interview Data

Person Interviewed: Robert A. Pennabere
Edwards Engineering Corp.
101 Alexander Avenue
Pompton Plains, N. J. 07444

Interviewer: W. A. Post

Date: 11/24/80 (telephone)

Location: Pompton Plains, N. J.

Discussion:

1. Largest water - cooled water chiller manufactured by Edwards Engineering is 240 tons.

2. Expressed concern about maintenance of units operating on continuous demand.

3. Felt a 10% increase in equipment was necessary for emergency backup because of above maintenance concern.

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Interview Data

Person Interviewed: Torbjorn Lindahl
Swedish Trade Office
333 North Michigan Avenue
Chicago, Ill. 60601
(312) 372-1680

Interviewer: W. A. Post

Date: 12/2/80

Location: Chicago, Ill.

Discussion:

1. Technology of chemical heat pumps still not fully developed.

2. Sweden is a world leader in chemical heat pump development.

3. Swedish research group headed by Professor Ernst Ake Brunberg of Stockholm is working on construction of an 8 ton prototype unit. This is the largest prototype to date.