

ENVIRONMENTALLY BALANCED INDUSTRIAL COMPLEXES

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ABSTRACT

There is still time to save our biosphere from the ravages of pollution of all types. Human beings as well as industrial production will continue to increase with time. We are at such a high level of each that any increase no matter how small demands too much of our dwindling fixed environmental resources. By changing our concept of manufacturing we can slow down the buildup in resource entropy of the world.

Environmentally balanced industrial complexes (EBIC) are simply a selective collection of compatible industrial plants located together in a complex so as to minimize environmental impact as well as industrial production costs. These objectives are accomplished by utilizing the waste materials of one plant as the raw material for another with a minimum of transportation, storage, and raw material preparation costs. When the same industry neither treats its wastes, imports, stores, or pre-treats its raw materials, its overall production costs must be reduced significantly.

Large, water-consuming, and waste-producing industrial plants are ideally suited for location in these industrial complexes. Not only are their wastes hazardous to our fragile environment, but they are also amenable to reuse by close association with satellite industrial plants using wastes and producing raw materials for others within the complex.

In this paper preliminary concepts of five typical complexes centered about the following major industries--(1) fertilizer; (2) steel mill; (3) pulp and paper ; (4) sugar cane; and (5) tannery are proposed. Detailed description of only the tannery complex is presented in this paper.

1. INTRODUCTION

Although the real measurable cost of industrial environmental pollution control remains relatively small when compared to total production or value added costs, it can be considered a significant amount when considered by itself. In fact, it may be enough to influence management of an industry to produce or discontinue the manufacture of specific consumer goods. While environmental engineers are usually not involved in that decision, our goal should be to reduce waste treatment costs to a minimum while protecting the environment to a maximum.

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In conventional industrial solutions to waste problems, industry uses separate treatment plant units such as physical, chemical, and biological systems. These add production costs onto already highly competitive manufacturing problems. These costs are also easily identified and, even if relatively small when compared to other production costs, are strenuously opposed or objected to by industry. On the other hand, reuse costs, if any, in an environmentally balanced industrial complex, will be difficult to identify and more easily absorbed into reasonable production costs.

Large, water-consuming, and waste-producing industrial plants are ideally suited for location in such industrial complexes. Not only are their wastes hazardous to our fragile environment, but they are also amenable to reuse by close association with satellite industrial plants using wastes and producing raw materials for others within the complex. Examples of such major industries are steel mills, sugar refineries, fertilizer plants, pulp and paper mills, and tanneries.

These complexes are not without their own problems, or at least some unknowns which may determine their acceptability. For example, will it be politically and socially feasible, and practical to encourage several specific industries of predetermined definite production capacity to locate in one complex at a certain site? Will contaminants build up in recirculated and reused wastewaters to a degree which will interfere with production of industrial goods? Or will these contaminants be removed in the manufactured products and cause product quality rejections? How will fluctuations in product demand in the external market affect production in the complex? Will special temporary raw material(waste) storage facilities be necessary? Will malfunctioning of equipment in the production of one product affect the other industrial components within the complex? These and other answers need verification before continuing promotion of the complexes.

In this paper we will consider only one of the possible complexes. This will be referred to as the Tannery Complex, since the tannery can be considered the "heart" of this complex concept. Other industrial plants will be located in this complex since they are deemed essential ancillary manufacturing entities.

2. ENVIRONMENTALLY BALANCED TANNERY COMPLEX

Tannery wastes from upper sole, chrome tanning mills contribute to a significant pollution problem in the United States. The wastes are hot, highly alkaline, odourous, highly colored, and contain elevated quantities of dissolved organic matter, B.O.D., total suspended solids, lime, sulfides and chromium. The treatment of such wastes has been difficult because of the non compatible pollutional parameters of high

pH, organic matter, and potential toxic compounds. Most successful treatment plants utilize some form of biological treatment to reduce the oxygen demand on receiving wastes. This necessitates the use of well-designed and operated preliminary treatments to ensure safe and efficient biodegradation. High sludge quantities result from these treatments. Therefore, properly designed and operated tannery waste treatment systems are considered costly to build and operate; while the lack of these facilities will cause excessive stream, land, and air pollution. Building and operating the tannery in an environmentally optimized industrial complex eliminates both of these negatives. A detailed study of this type of tannery complex is given in the remainder of the paper which follows.

3. THE SLAUGHTERHOUSE-TANNERY -RENDERING COMPLEX

The author has presented two formal papers at technical meetings on the EBIC subject (1, 1977 and 3,1980) and a Report (4,1980) representing a first attempt at providing a complete mass balance of reference-validated inputs and outputs of plants within an industrial complex. The fulcrum industrial plant of this complex is a tannery. Supporting industries include slaughterhouse and rendering plants. The three-industry complex is also expanded to consist of an animal grazing and feedlot facility as well as a residential area for homes of all personnel working in the complex. As the complex is expanded to include the feedlot, residences, biogas and power plant services the complex becomes more self sustaining. Outside service requirements are minimized by the expansion. All power is generated within the complex in the expanded third stage version. Excess products of leather, meat, meal, soap, and even electricity are sold to consumers outside the complex. Chemicals, water, cattle, and animal feed are imported to the complex. Wastewater, blood and bone meal, hide and leather trimmings, cattle dung, and residential solid wastes are recovered and reused within (internally) the expanded complex. The complex can be constructed as shown in the first stage , second stage, or fully expanded to the third stage. Criteria for decision will be based upon area requirements and individual, local objectives.

STAGE 1

This is the first of the three stage industrial complex which is balanced internally so that little or no adverse environmental impact results from any of the industrial plant's productive activities. Each stage represents a totally balanced and individual industrial complex.

The first stage consists of a three industry plant complex comprising 1) a slaughterhouse 2) a tannery and 3) a rendering plant. A schematical drawing of the complex is given in the following Figure 1 which includes inputs and outputs from each industrial plant. External raw materials and manufactured products for external sale are given in Table 1.

STAGE 2

The second of the three stage industrial complex is also balanced internally so that little or no adverse environmental impact results from any of the industrial plant's productive activities. It differs from the first stage in that it provides a more complete and self sufficient complex. It also provides more reuse potential for the three industrial effluents than the first stage. In addition, it provides living space in the complex for employees of the industrial plants and feedlot and grazing area for raising the animals to the required weight. Whenever feasible the second stage complex is recommended in preference to the

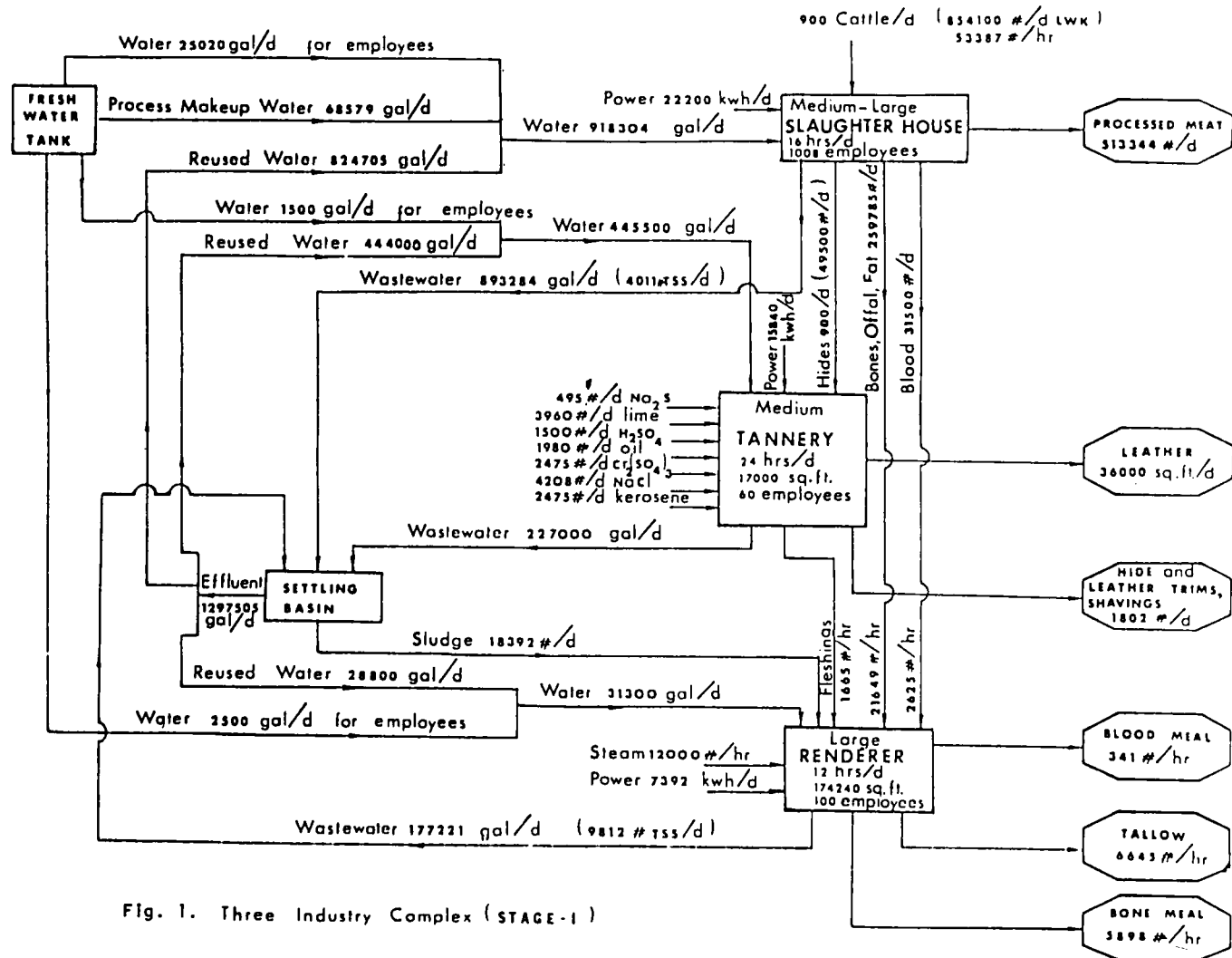


Fig. 1. Three Industry Complex (STAGE-1)

RAW MATERIAL REQUIRED FROM
OUTSIDE THE COMPLEX

MANUFACTURED PRODUCTS FOR
OUTSIDE SALE

Material	Amount	Material	Amount
1. Fresh Makeup water	97,599 gal/d	1. Meat products	513,341 #/d
2. Elect. Power	45,432 KWH/d	2. Tanned leather	36,000 sq.ft./d
3. Cattle	900/d 854,100 #LWK/d	3. Blood meal	4092 #/d
4. Chemicals	495 #/d Na ₂ S 3960 #/d Ca(OH) ₂ 1500 #/d H ₂ SO ₄ 2475 gal/d kerosene 1980 #/d oil or wax 2475 #/d Cr ₂ (SO ₄) ₃ 4208 #/d NaCl	4. Tallow	79,740 #/d
		5. Bone meal	70,776 #/d
		6. Tanned hide trimmings, shavings etc.	1802 #/d

TABLE - 1 External Raw Materials and Manufactured Products in Three Industry Complex (STAGE - 1)

first stage. Mass balance of the second complex is given in Figure 2. External raw materials and manufactured products for external sale are given in Table 2.

STAGE 3

This is the third of three stage industrial complex. It enlarges the smaller complex and is more balanced internally so that little or no adverse environmental impact results from any of the industrial plant's productive activities. Agriculture and municipal residence services are provided in this complex. Residential solid wastes from both industrial and municipal facilities are fermented to methane gas which is used subsequently to produce electrical energy for use in the complex. Waste sludge from the fermenter is incinerated to produce additional electrical energy for use in the complex. The schematic arrangement of the third phase of the complex is shown along with the mass balances of each unit in Figure 3. External raw materials and manufactured products for external sale are given in Table 3.

4. GENERAL DISCUSSION

As we proceed from the first stage to the three industry complex (Figures 1, 2, and 3) by adding stages, some apparent potential problems arise. For example, when we add stage 2 to the complex, we compute that a cattle grazing and feedlot area of 620 acres is required for the 135,000 cattle. This vast acreage may be difficult to obtain in the same location as the three industries. In addition, a large quantity, 1350 tons per day, of feed must be supplied from internal and external sources.

In the third stage of the complex I propose to produce methane gas from all solid waste residues. This gas will subsequently be used for power production. An excess of power within the complex results from this sequence of operations. An alternative to exporting power for sale outside the complex would be the production of other valuable intermediate products such as alcohol from the fermenters. This choice can be determined from market conditions at the time of establishment of the complex.

The tannery three-stage complex analysis is the deepest study of the new concept. As shown in Table 3 the managers of the three stage complex still must import four basic materials: water, calves, chemicals, and cattlefeed. About three million gallons of water, 2.6 million pounds of feed, 900 calves, and about 6 tons of chemicals are needed each and every production day. This complex also will produce for external sale about 250 tons of meat, 36,000 square feet of leather, 40 tons of tallow, and almost 700,000 kilowatts of energy each production day. Although a complete economic analysis of such a system is still necessary, it appears at least self-sustaining and probably will show a considerable net profit. The implications of such complexes are obvious. However, if we are able to produce a profit and protect the environment from any degradation, our major goals will have been achieved.

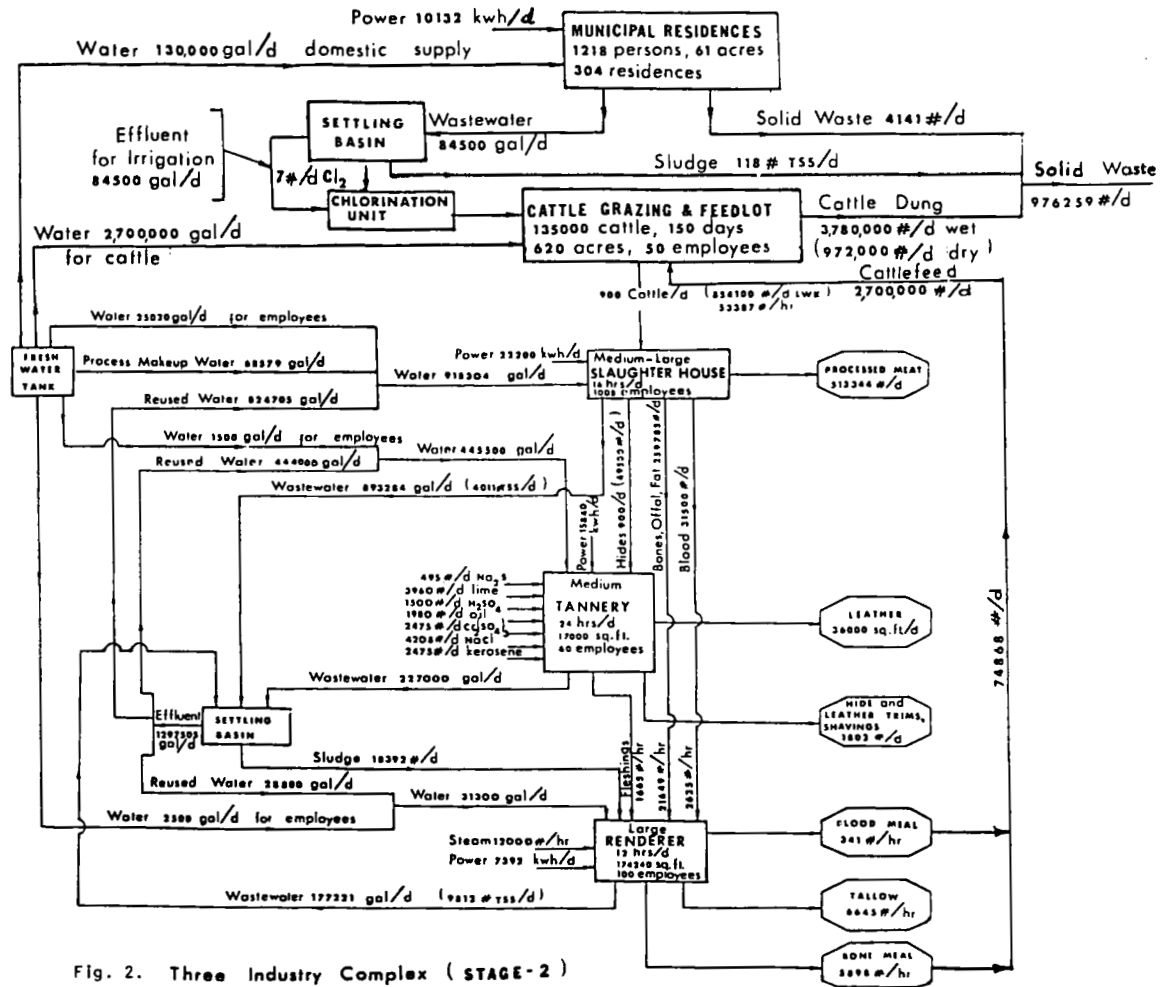


Fig. 2. Three Industry Complex (STAGE-2)

RAW MATERIAL REQUIRED FROM
 OUTSIDE THE COMPLEX

 MANUFACTURED PRODUCTS FOR
 OUTSIDE SALE

Material	Amount	Material	Amount
1. Fresh Makeup water	2,927,599 gal/d	1. Meat products	513,341 #/d
2. Elect. Power	55,564 KWH/d	2. Tanned leather	36,000 sq.ft./d
3. Calves	900/d (150 days prior to production) 540,000 #/d	3. Tanned hide trimmings, shavings etc.	1802 #/d
4. Chemicals	495 #/d Na ₂ S 3960 #/d Ca(OH) ₂ 1500 #/d H ₂ SO ₄ 2475 gal/d kerosene 1980 #/d oil or wax 2475 #/d Cr ₂ (SO ₄) ₃ 4208 #/d NaCl 7 #/d Cl ₂	4. Tallow	79,740 #/d
5. Cattlefeed	2,625,000 #/d	5. Solid Waste (Municipal refuse and sludge)	4,259 #/d dry wt.
		6. Animal Dung	3,760,000 #/d (wet) or 972,000 #/d (dry)

TABLE - 2 External Raw Materials and Manufactured Products in Three Industry Complex (STAGE - 2)

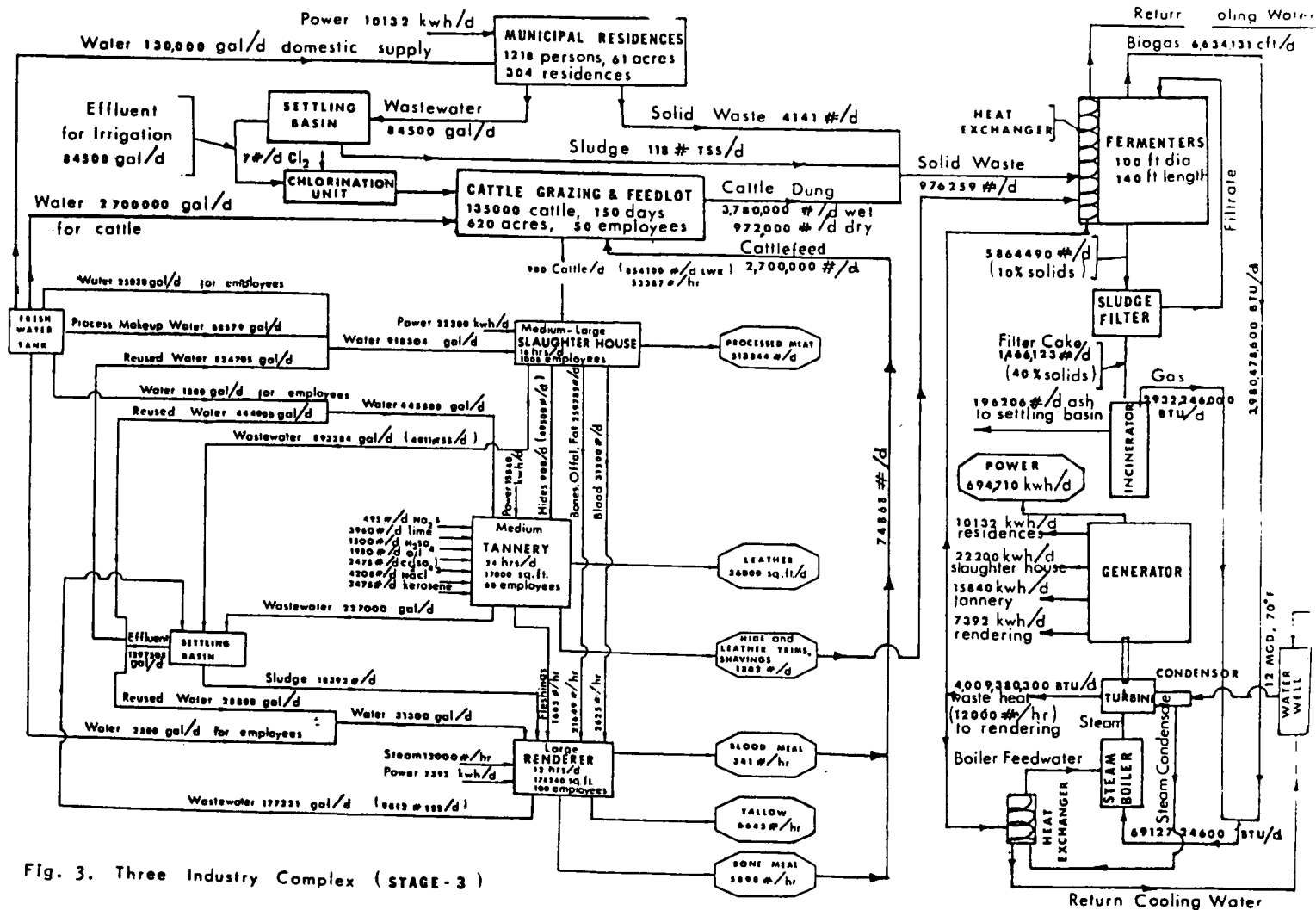


Fig. 3. Three Industry Complex (STAGE-3)

TABLE 3

RAW MATERIAL REQUIRED FROM OUTSIDE THE COMPLEX		MANUFACTURED PRODUCTS FOR OUTSIDE SALE	
Material	Amount	Material	Amount
1. Fresh Makeup Water	2,927,599 gals/day	1. Meat Products	513,341#/day
1A. Well water (one time only)	12MGD	2. Tanned Leather	36,000ft ² /day
2. Calves	900/day-150 days 540,000 #/day	3. Tallow	79,740#/day
3. Chemicals	495#/day Na ₂ S 3960#/day Ca(OH) ₂ 750#/day H ₂ SO ₄ 1980#/day Oil or wax 2475#/day Cr ₂ (SO) ₄ ₃ 2475#/day kefosene 7#/day Chlorine	4. Energy	694,710KWH/day
4. Cattlefeed	2,625,000 #/day		

5. CONCLUSIONS

A three stage environmentally balanced complex has been designed. Mass balances of all plant inputs and outputs have been computed based upon the most recent published industrial data. From an analytical standpoint an industrial complex consisting of a slaughterhouse, tannery, and rendering plant is technically feasible. This complex is also technically feasible when expanded to include animal grazing and feedlots as well as municipal residences (second stage). The expanded version (third stage) of the complex is more self-sustaining as far as reused products and electrical energy generation are concerned.

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