DOE/ET/27041-1
Distribution Category UC-66g

KELLEY HOT SPRING GEOTHERMAL PROJECT

Kelley Hot Spring Agricultural Center

Preliminary Design

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August 1980

Prepared for the Department of Energy
Under Contract DE-AC-03-79ET27041

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ABSTRACT

A Phase I Preliminary Design, Construction Planning and Economic Analysis has been conducted for the Kelley Hot Spring Agricultural Center in Modoc County, California. The core activity is a 1,360 breeding sow, swine raising complex that utilizes direct heat energy from the Kelley Hot Spring geothermal resource. The swine raising is to be a totally confined operation for producing premium pork in controlled-environment facilities. The complex contains a feed mill, swine raising buildings and a complete waste management facility that produces methane gas to be delivered to a utility company for the production of electricity.

The complex produces 6.7 million pounds of live pork (29,353 animals) shipped to slaughter per year; 105,000 cu. ft. of scrubbed methane per day; and fertilizer. Total effluent is less than 200 gpm of agricultural quality water with full odor control.

The methane production rate made possible with geothermal direct heat is equivalent to at least 400 kw continuous. Sale of the methane on a "co-generation" basis is being discussed with the utility company.

Assuming a construction start in the Fall of 1980, a nominal $8.6 million in facilities and working capital (with escalation) will be spent to achieve full production at the beginning of 1983. Shipments to market will begin in 1982. Positive earnings will be achieved in the first full year of production (1983). Owner's equity (25%) will be returned over the first 3.4 years or less depending upon the investment structure. Depending upon the business structure, the internal rate of return on owners cash is calculated to be 28.4% or greater.

The use of geothermal direct heat energy in the complex displaces nearly 350,000 gallons of fuel oil per year. Generation of the biogas displaces an additional 300,000 gallons of fuel oil per year.

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INTRODUCTION

This report documents the Preliminary Design of the Kelley Hot Spring Agricultural Center. The effort encompasses the Criteria Development, Trade Studies and Conceptual and Preliminary Designs, Construction Plan and the Economic Analysis. For completeness, the Reservoir Assessment and Environmental Considerations are summarized. The Preliminary Design in this report is documented in accordance with the configuration presented at the Final Review on July 2, 1980, at the Department of Energy, San Francisco Operations Office.

The Kelley Hot Spring Agricultural Center was conceived in 1977 as a direct use application of the geothermal resources under lease to Geothermal Power Corporation in southern Modoc County, California. Between that time and the time of contracting in September, 1979, the concept evolved and the results of the Mountain Home Geothermal Project[65] were incorporated. It should be noted that the Project is a phased program and that the Phase I effort encompasses only the preliminary design and analysis activities.

The proposed core activity in the KHSAC is a nominal 1,360 sow swine raising complex. It should be noted that the Project was initially defined as a 1200 sow facility in order to fully utilize the output of a minimum commercial sized feed mill. After conceptual design was completed, it was found that the production could be increased by at least 13% if the farrowing building was rearranged but not increased in size. This permits the same sized facility to operate with a 1,360 sow "pregnant and farrowing" herd. The Preliminary Design was conducted on this 1,360 sow basis.

The swine raising is to be a totally confined operation for producing premium pork in controlled environment facilities that utilize geothermal energy. The complex will include a feed mill for producing the various feed formulae required for the animals from breeding through gestation, farrowing, nursery, growing and finishing. A sprout raising facility has been incorporated to produce a green grass constituent for use in the breeding, gestation and lactation feed formulae. The market animals are to be shipped live by truck to slaughter in Modesto, California. A complete waste management facility will include manure collection from all animal raising areas, transport via an enclosed water flush system to a methane (biogas) generator, solids separation, settling ponds and disposition of the surplus agricultural quality water. The design is based upon a distillation of the findings as collected and analyzed by the Team Members in the performance of the project. In the Team Members' opinion it has been based upon the best known commercial practices in confined swine raising available in the U.S. today. The most unique feature of the facility is the utilization of geothermal hot water heat for space heating and process energy throughout the complex. For the Preliminary Design effort, Site 6 (Figure 1-1) was selected as the site for the swine raising complex. An environmental evaluation was conducted on six sites in and around the Kelley Hot Spring area in southern Modoc County.

This report has been compiled from contributions as prepared and submitted by the Team Members. The Geothermal Power Corporation's Kelley Hot Spring Project Team Members are:

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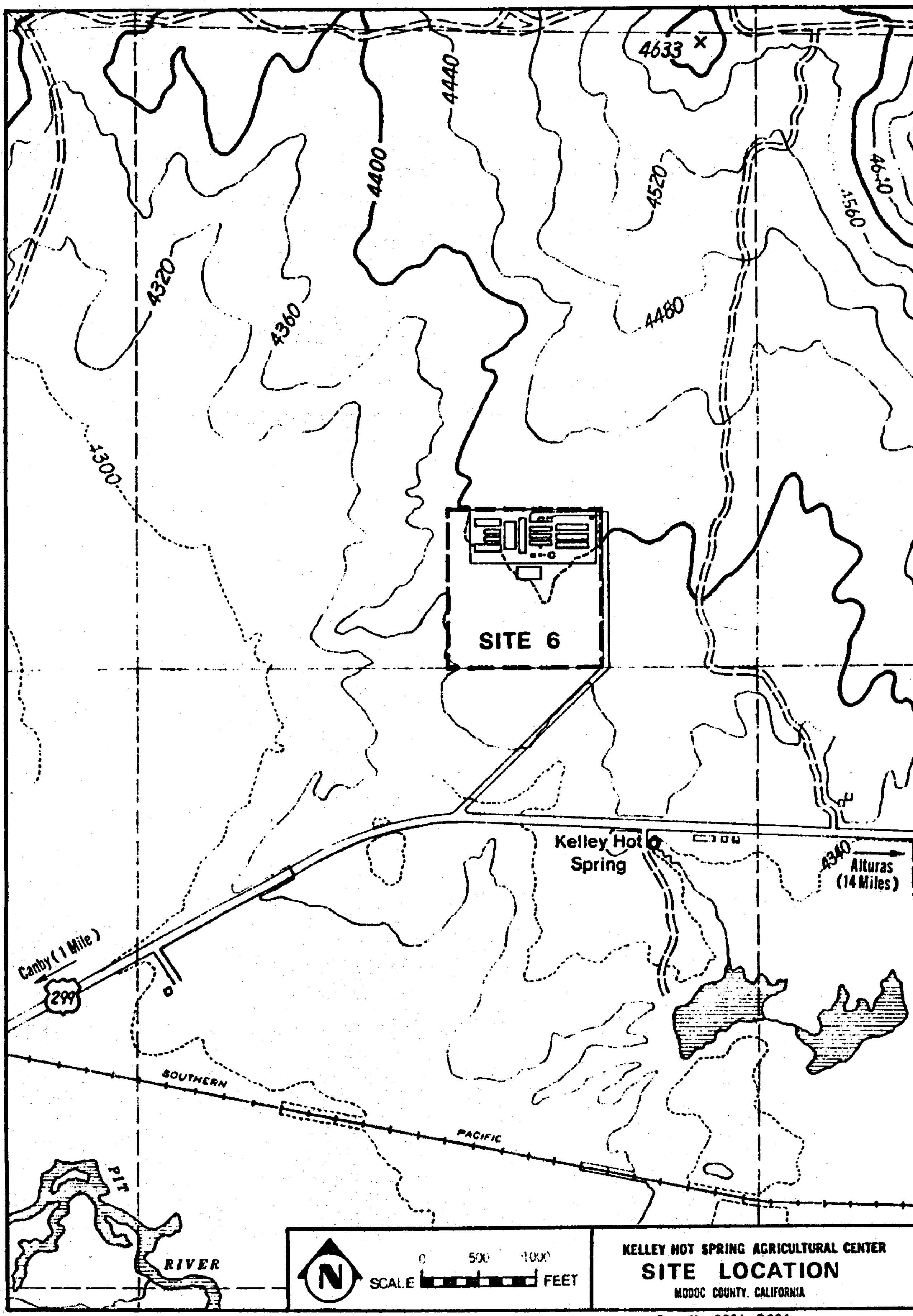

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Figure 1-1 - SITE LOCATION

International Engineering Co.

Sam F. Fogleman, IECo Program Manager

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CHAPTER 1 -- PROJECT OVERVIEW

Summary

The technical effort in Phase I effectively commenced on the first of December, 1979. Early work in December indicated that an Environmental Survey would be required in order to complete a proper Environmental Assessment.

Environmental Considerations --

An environmental assessment of the general area of Kelley Hot Spring for the location and operation of an agricultural complex based upon confined raising of hogs was undertaken during the winter of 1979-1980. An initial site reconnaissance established six areas to be considered for development. These sites were carefully examined by Mr. Frank Metcalfe for possible purchase. One most promising site (Site #3) was appraised by a professional real estate appraiser. Negotiations were begun with the land owner. In addition, negotiations have begun with the land owner on Site #6. Careful examination of the terrain, access, water availability and land acquisitions have established a potential project site in which Site #6 would support the geothermal well (most favorable from the standpoint of heat probe tests) along with the swine operation.

Water quality control and production of offensive odors arising from a large concentration of swine were the most critical environmental areas of concern. These potential problems have been effectively mitigated by the inclusion of three important features in the design of the complex:

1) A closed waste collection transport system;
2) Methane generation; and
3) Water reclamation.

All animal pens are cleaned several times each day by flushing water through gutters and into a closed sewer pipe system leading directly into the methane generation plant. This geothermally heated, anaerobic digestion, slug flow system is dependent on thermophilic bacteria that effectively reduce all organic wastes to methane, carbon dioxide, water and minor amounts of other odorless and nontoxic compounds plus some H_2S. Inert solids are reclaimed from the ponding system into which digestive materials flow. The H_2S and CO_2 are scrubbed from the methane before it is utilized as fuel for an electric generation system. A system of ponds purifies the water so it can be recycled through a portion of the waste removal system.

Methane generated is piped to the boundary of the property and delivered to the local utility for its use in a generator to produce electricity that would be put into the electrical distribution system. This distribution system would furnish the power to the facility. Discussions of co-generation have been initiated and are continuing with the Surprise Valley Rural Electrical Cooperative.

Geothermal fluids, after heat extraction, will be used in the make-up water for the methane generation system and for flushing of the farrowing and nursery buildings. During the hot part of the year fresh and/or recycled (cool) water will be utilized if humidity levels must be reduced. The purity of the water after methanation and ponding permits release of any surplus effluence into the existing overland water drainage systems. Alternatively, excess water collected in the waste management system will be spray-irrigated onto lands controlled by the operators. Surplus fluids will be disposed of in accordance with local regulations.

A separate system for potable water will provide clean pure water for domestic purposes as well as drinking water for the hogs and a fresh water flush for the farrowing and nursery buildings. Geothermal water in this area is sufficiently low in dissolved solids and environmentally sensitive substances that it can be used as the water source for waste management. Elements such as boron and fluorine may be removed, if necessary, in the sediments of the ponds or the methane generator. The methane digestor completely removes objectionable odors of hogs waste in the anaerobic process which is conducted in an entirely closed system. Discharged waters are free of odors. The methane process is so effective that initial ponds have no odors such as those characteristic of the common aerated tertiary treatment systems of similar non-geothermal operations.

Another area of environmental concern, while minor in impact in the 1,360 sow complex, is the potential influx of new people and their demands on the school system. If, as is proposed, the majority of persons required to operate the complex (17) are from the indigenous population or live mostly outside the Canby area, little impact will be felt. It is the intent of this project to hire as many personnel as possible, including the training of such personnel, from the immediate area in southern Modoc County. But if additional personnel must be employed from outside the area and they are housed in the plant vacinity, some crowding will occur in the Kindergarten-through-Ninth Grade school which are at capacity now.

Other areas investigated in this assessment were geology and seismicity, hydrology, soils, flora and fauna, air quality, esthetics, health and safety, land-use conflicts, socio-economics and spill prevention. No adverse impact or impact of cumulative proportion leading to an adverse impact were detected. Very positive socio-economic impact can be expected through increased job opportunities, local cash flow and increased tax revenues at little or moderate cost to the county.

Factors effecting design operations and economics from an environmental standpoint are principally associated with the waste management system. It was found that conventional anaerobic ponds could be extensive in land coverage. Aerobic ponds would require less area but still more than that required by the methane system. These conventional pond systems would not sterilize the effluent and could spread disease if the water were recycled through the buildings. Hence, additional fresh water would be required. The cognizant regional water quality control board expressed doubt that a conventional ponding system of the proposed size could be permitted. In any case, there are instances in Europe and the U.S. where conventional ponding systems have been shut down. These factors caused the consideration of the methane system. Though the methane system tends to be slightly more costly, ($100,000 increase over conventional ponds); it can be permitted, is more healthy, reduces odors to a minimum, reduces fresh water requirements and may recover the capital difference in one year if the methane is sold at current natural gas prices. Also, there is a possibility that it could offer co-generation tax advantages.

Geothermal Reservoir Assessment --

The following information has been excerpted from the Drill Site Selection and Justification Report[58]. The Warm Springs Valley of the Pit River, a part of the Modoc plateau province, is highlighted by Kelley Hot Spring, flowing at 96°C (205°F) at 320 gallons per minute from a single orifice. The flow is at boiling for the elevation (4,360 feet).

Extensive exploration data include: reconnaissance level geologic mapping and gravity surveys, an aeromagnetic survey, at least 30 square miles of electrical resistivity surveys, a reconnaissance-type telluric survey, a ground noise and microearthquake survey, geochemical analyses, and extensive temperature gradient surveys over a 15 square mile area with 2.5 - 3.0 HFU across the area and a high of over 20.0 HFU in certain holes.

Two exploration wells have been drilled. In 1969, Geothermal Resources International drilled a GRI-1 well to 3200 feet, ¼mile south of the springs, with a maximum temperature of 110°C (230°F) at the bottom. In 1974 Geothermal Power Corporation drilled a Kelley Hot Spring #1 well to 3,396 feet approximately 1½ miles due east of the GRI-1 well. Maximum bottom hole temperature of 115°C (239°F) was measured in 1977 in KHS-1. The lithology of the two wells is similar.

In November, 1979, Geothermal Power Corporation began rework operations on the GRI-1 well. The operations performed are summarized in the

California Division of Oil and Gas Well History and Summary Report contained in the Appendix of Reference 58. After rework operations were complete, a flow test was attempted. The resultant flow rate proved to be less than expected. It is believed that the main reason for not obtaining the expected flow rate is due to the sealing-off of the producing zones during the initial drilling of the well. From a lithologic log of the initial well, zones of lost circulation were encountered below 1600 feet. Lost circulation material was added to the drilling lfuids in an attempt to seal off these zones. It is believed that this material together with the mud cake formed on the well bore wall during drilling has effectively blocked the producing zones of the reservoir. Rather than incur the additional expense of further rework involving a well stimulation program which may not yield the expected flow rates after completion, it was decided to use the proposed standby well as the primary supply well. Funding for this well has been allocated in the original proposal and is planned to be drilled in Phase II of the program.

The Kelley Hot Spring geothermal field is described as a body of hot water at over 240^{o}F in a porous reservoir between 1600 to 3400 feet depth covering an area of several square miles. A conservative estimate of the resource assuming an aerial extent of four square miles, thickness of 2,000 feet, a reservoir temperature of 240^{o}F, a final disposition temperature (of waste fluid) of 80^{o}F, and volumetric specific heat of 0.6 calories/cm^{3}/^{o}C is 3.37 X 10^{17} calories of gross heat reserve in the reservoir. Log analysis data from KHS-1 well indicate an average porousity on the order of 20% in the reservoir. This gives a minimum estimate of the heat in the fluid only of 6.73 X 10^{16} calories. However, more heat will be available by conduction from the rock matrix and recharge from a deeper heat source by peripheral recharge into the reservoir.

The expected utilization rate of the hot water at 208^{o}F is less than 325 gallons per minute. Assuming a disposition temperature of 95^{o}F, the gross energy production rate will be 8.1 X 10^{10} BTU's per year. Over a thirty year plant life, the total resource required is 6.12 X 10^{14} calories, which is less than 1% of the heat reserved in the fluid alone, as described before. Thus, the reservoir within the drilled depth has sufficient reserve to supply a plant many times the size of the proposed demonstration plant.

Chemically the fluid is believed to be mildly saline. From chemical analysis of the Kelley Hot Spring no severe scaling or corrosion problems are anticipated and no problems of toxicity are expected.

It is proposed that the supply well for Kelley Hot Spring agricultural center be located in the northeast corner of Site #6. The criteria for the design of the supply well included the geological information used to formulate the interpretation of the geothermal regime together with the engineering design requirements for the agricultural center. The expected well characteristics include drilling to 3,400 feet where a flow of 325 gallons per minute is expected at a temperature of 115°C (240°F). The casing program calls for the diameters ranging from 13 3/8 inches near the surface to 9 5/8 inches from 500 feet to 1800 feet depth.

A seven day flow test is programmed to determine the sustaining yielding temperature of the fluids from the supply well. To test the properties of the natural system including mean hydraulic conductivity, storativity, and boundaries, a 10,000 minute constant-rate pumping test with observation wells is proposed. To test the characteristics of the wells, a short (2½ hour) five increment step test is proposed. The step test will be made first to determine the optimum rate of the constant rate test.

Engineering Considerations --

The engineering effort was divided into three overlapping and interconnecting activities: criteria development, trade studies, and conceptional and preliminary design efforts. An extensive field survey was made to review commercial swine raising enterprises, research facilities and equipment manufacturers in the United States. From this survey and a review of published literature, fundamental design criteria were established, evaluated and applications criteria derived. Final selection of criteria was made in conjunction with selected Trade Studies, (Appendix A). Engineering options were evaluated through these Trade Studies, with final selections decided on the basis of the economic criteria for the project. The design effort was conducted utilizing the aforementioned criteria and the results of the Trade Studies. The design effort was iterated through a conceptional phase and a subsequent preliminary design.

It should be noted that the Project was directed to determine the economic optimum utilization of geo-direct heat. Although all practical areas of application were evaluated, total application of geo-heat was limited by economics; e.g., wall heating and walk way deicing were eliminated due to poor economics.

Based upon the design efforts, construction planning was conducted. Costs were obtained through quotes, catalogs, and authoritative estimating sources, (Chapter 3). Using data excerpted from the engineering and construction plan studies, an economic assessment of the facility was prepared, (Chapter 4).

Findings and Conclusions

1. Modern confined swine raising techniques, at a nominal 1,360 sow complex size, can efficiently utilize a hydrothermal, direct-energy geothermal resource. The 1,360 sow size was chosen to be large enough to utilize the output of a commercial feed mill, which is essential to the economics of swine raising in other than the mid-west. Further, economic methane generation facilities require a facility of at least 500-600 sow operation[9].

2. The waste management system, utilizing methane generation, has been a focal point for in-depth engineering analysis and design, economic analysis and a major consideration for operational permitting. In this project, consideration of a form of co-generation with the local utility developed from the waste management studies. This is being explored further. The use of moderate temperature geothermal heat was found

essential to the economic generation of methane. It was determined that sales of the methane to the utility, rather than generating power in-plant, would result in more profitability, less technical risk and less operational complexity.

3. The purifying action of methane generation greatly simplifies permitting.

4. A field experiment with phased programming and a separate design effort, as undertaken here, ruled out consideration of other novel approaches under development and use elsewhere. These include large commercial turnkey contractors on one hand, and low-cost farmer built and operated facilities. However, the totally confined (capital-intensive) concepts considered herein represent the trends in swine raising in the U.S. and reflect technology developed and utilized extensively in the Scandinavian countries, Western and Eastern Europe and Canada. This type of facility is utilized to produce premium fresh pork with a maximum in quality, productivity and animal health.

5. The operational philosophy utilized greatly affects and in many cases controls final design direction. The operational methodology upon which this design is based is controlled by these major characteristics:

- Total confinement with complete environment control
- Maximum automation and minimum labor for uniform high productivity, quality and animal health
- Concentration of labor in the areas of productivity, preventive health practices, quality and economic production
- Breeding and weaning cycle timing and genetics management
- Maximization of feed conversion efficiencies through environment control
- Cost-effective feed-production practices
- Minimizing animal stress through optimum animal management practices
- Maximum utilization of geothermal energy to permit

cost-effective complete environment control -- which permits higher product quality than that being achieved with current fossil-fueled systems

Utilization of geothermal energy in the waste management system permitting more economic production of methane with its contribution to sales.

CHAPTER 2 -- ENGINEERING

I. CRITERIA

A. Resource and Site Criteria - The preliminary design described herein is based on Site 6 as shown in Figure 1-1.

The preliminary design has been based on an assumed geothermal supply well flow of 325 gallons per minute (gpm) at 208°F*at the well-head (English units are used in order to be consistent with current agribusiness practices). Water chemistry has been assumed to not present any major problems in operation of the Kelley Hot Spring Agricultural Center (KHSAC), although it is assumed not suitable for domestic use. The pH is assumed to be between 7.4 and 8.6 (Kelley Hot Spring measurements).

Climatic design conditions are based on recommendations of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) for Alturas, the nearest listed town. Alturas' elevation is 4365 feet above sea level, nominally the same as that of the KHSAC. The climatic design conditions used are the so-called 2½% limits and are: -2°F Dry Bulb (DB) for heating (occurs 2½% or less of the time during December, January, and February); and 93°F DB and 64°F Wet Bulb (WB) for cooling (occurs 2½% or less of the time during June through September).[4]

The site is exposed to strong winds. The Alturas Public Works Department (PWD) recommends a wind loading criterion of 15 pounds/square foot (psf) and advises use of 20 psf.

Based on National Oceanographic and Atmospheric Agency (NOAA) data for Alturas, annual total precipitation is 13.0 inches and annual snowfall is 40.1 inches. The Alturas PWD recommends a snow loading criterion of 30 psf.

The footing depth criterion of 18 inches below grade is also based on Alturas PWD information.

*English units are used in order to be consistent with current agribusiness practices.

B. Agriscience Criteria

1. Swine Production - Swine production criteria result from the management plan summarized in Table 2-1 below.

TABLE 2-1

SWINE PRODUCTION MANAGEMENT

Item	Plan	
Average live and weaned births per farrowing	9.0	or 8.8*
Farrowings per sow per year	2.4	or 2.36*
Number of breeding sows	1,360	1415
Marketable hogs per year	29,353	29,386
Average market weight per hog, pounds	228	228
Total market weight of hogs per year, pounds	6,692,484	6,700,172

*operational options in the same facility.

National averages for current practices in totally confined, totally environment-controlled swine raising range from 8.5 to 9.4 average live and weaned births per farrowing. (References 51, 64, 87 and 94). This is in contrast with a figure of 7.4 for open range or unconfined, lower quality pork. These references are verbal reports of actual practices at a western swine raising facility, the USDA Animal Research Center, a western brood sow supplier and a midwestern agricultural college. Some commercial facilities in the U.S. are achieving average live farrowing rates significantly higher than these figures. The actual rates and management practices are considered proprietary to the specific operators. Average farrowings per sow per year in the U.S. range from 2.0 to 2.56 (References 15, 19, 23, 33, 51, 64, 87, 94). Again, these references are verbal reports of actual practices at commercial facilities and research institutions as well as published literature. The farrowings-per-year are primarily an animal handling management procedure geared to the design of the facility, while the number of piglets per farrowing are highly dependent upon genetics, feed formulae, degree of environment control and minimization of animal stress.

2. Building Size and Shape - The sizes and shapes of swine buildings for this 1,360 breeding sow complex are chiefly based on the following criteria.

Breeding should be designed to: maximize boar/sow proximity to maximize heat cycle detection, insemination, and conception; maximize operator visual contact with animals; and minimize animal movement.

Gestation buildings require: optimized animal density allowing sow lounging capability; and feeding methods to eliminate boss sow type pecking order.

Farrowing building layout must allow for: standardized pen equipment; pen scheduling flexibility; piglet heating and separate sow heating; disease control, sanitation, and isolation capabilities; and specialized air movement considerations.

Nursery buildings should be designed to: utilize standardized pen equipment; provide floor heating; provide ease of sanitation; and maximize operator visual contact with the animals.

Growing and finishing building layouts require: automated drop feeding; minimization of operation personnel; maximum operator observational capability, particularly during feeding; maximum animal density in standardized pens, and design for dunging capability to maximize cleanliness.

Table 2-2 summarizes current national design criteria on a square foot per animal basis: (References 33, 51, 64, 94, 95). The size range is built into the facility to permit a range in management practices from 13 farrowing groups/year to 15 farrowing groups/year. This range is affected by programming a farrowing period of 28 days (13 groups) vs. 21 days (15 groups). The facility production for the economic analysis is based upon the 13 group/year production of 29,353 marketed animals/year. The inherent maximum capacity of the facility as designed, using all surge, is on the order of 33,000 animals/year. This would require excellent, intensive management practices.

TABLE 2-2

CURRENT ANIMAL SPACE CRITERIA

Building	Square Feet/Animal
Breeding	11.5 - 13.0
Gestation	25 - 30
Farrowing (per sow & litter)	35
Nursery	2.25 - 3.25
Growing	4.25 - 4.5
Finishing	7.2 - 8.0

3. Feed Distribution - Feed distribution is to be automated within the buildings in order to: maximize production with minimum social stress; maximize animal observation with minimum labor; minimize waste; promote even animal weights; and optimize health and sanitation practices.

C. Civil, Electrical, and Mechanical Engineering Criteria

1. Heating and Cooling - A key consideration in KHSAC design is the range of design temperatures for the buildings in heating and cooling modes. Table 2-3 summarizes these temperatures, a result of combining agriscience and engineering criteria. (References 3, 4, 23, 36, 65, 73, 91).

TABLE 2-3

HEATING AND COOLING TEMPERATURES

Building	Air Temperatures, °F DB Heating	Cooling
Breeding	65±5	75±5
Gestation	65±5	75±5
Farrowing*	65±5	80±5
Nursery*	73±3	77±3
Growing	65±5	80±5
Finishing	65±5	80±5
Feed Activities	65±5	80±5
Support Facilities	65±5	80±5

*The piglet area is maintained at temperatures up to 90°F through supplemental floor heating.

2. Building Classification and Codes - Buildings are classified as agricultural under Uniform Building Code (UBC) rules. California's Energy Conservation Code (Title 24) does not apply to agricultural buildings.

3. Building Access - Reasonable access to all buildings for fire fighting and maintenance dictated that the structures be spaced 20 feet apart in directions perpendicular to product flow and 30 feet apart in directions parallel to product flow. The 20-foot separation minimum also precludes fan interferences between buildings, an important health consideration.

4. Building Construction Features - Design of the buildings will be normal commercial practice for 20-year life as a minimum.

Interior surfaces of animal enclosures are to be smooth-finished with no descructible protrusions below 6 feet from the floor (where animals would have a tendency to destroy objects).

Inside surfaces of the farrowing building shall be impervious to water.

All building plywood, if used, is to be marine type to withstand washdowns.

Flytraps and screens on exhaust openings are not required as a negative pressure system is used. Screens are required on air inlets.

Flexible electrical cable use inside the buildings is acceptable.

Each building will require 480 volt, 3-phase power and 220 volt and 110 volt, single phase power (alternating current).

5. Lighting - Lighting levels for the project are: 30 foot-candles (F.C.) in the gestation building, 20 F.C. in all other buildings, and 1/10 F.C. for outside areas.

6. Power Supply - Power generation/supply modes will be transferred manually -automatic switching is not required.

7. Employee Facilities - Showers, sinks and toilets for both sexes will be provided.

Human waste disposal will be by septic tank with leach field per local codes.

8. Swine Waste Management - Swine manure is to be used in the production of methane gas and saleable fertilizer using a biogas generation subsystem.

9. Emergency Backup - An engine-generator set will be used as standby power in case of main power supply failure. This standby power will be manually switched to provide power for critical functions.

10. Site Facilities - Site will utilize security wire mesh fencing 6 feet high with top strands of barbed wire.

Visitors facilities are not required. KHSAC is to be closed to the general public for sanitation and disease control.

Walkways between buildings for swine traffic will utilize deicing.

II. CRITERIA APPLICATIONS

A. Agriscience

Table 2-4 following summarizes the design parameters (applications) resulting from the agriscience criteria and published data on swine production. These parameters are for a 1,360 breeding sow complex.

TABLE 2-4

AGRISCIENCE CRITERIA APPLICATIONS

Building	Number of Buildings	Total Population Design	Total Population Operational	Weeks in Building	Average Weight, Pounds
Breeding	2	448	448 / 448	5.5	350
Gestation	2	1024	1024 /1024	13	325
Farrowing, sows	1	288	246 / 246	4	360
piglets		2592	2304 /2152	4	9
Nursery	1	4224	4212 /4212	5	30
Growing	3	4278	4196 /4196	7	85
Finishing	3	4284	4196 /4196	7	175*

*average market weight is 228 pounds.

B. Civil, Electrical, and Mechanical Engineering

1. Heating and Cooling - The application of design dry

bulb temperatures results in the following minimum air change requirements to preclude building inside moisture buildup exceeding 75 percent relative humidity:

- heating - 8 minutes per building air change except 5 minutes per air change in the nursery and 4 minutes per air change in the growing buildings.
- cooling - 3 minutes per building air change except for 2 minutes per air change in breeding and nursery buildings. Feed and support buildings will be gravity ventilated.

Air flow will be down from longitudinal plenums in the ceilings and will be controlled for temperature and volume.

Floor heating will be provided for piglets in farrowing and nursery buildings.

2. Building Features - The following are direct applications of criteria regarding animal building construction features:

- floors - brush finish concrete throughout to prevent slipping except smooth trowel finish concrete in farrowing creep area to prevent piglet abrasion.
- gutters - flat across with gradual slope lengthwise for drainage and with radii at vertical intersections.

III. TRADE STUDIES

A. Introduction

In the course of the early stages of KHSAC design, extensive trade studies were performed for key aspects of this project. The reader should note that many of the trade studies were performed in an iterative manner with conceptual design and preliminary design developments. Results are hence not always the same as trade studies performed without respect to the ongoing overall design process. The Trade Studies results are summarized in the following sections, and Appendix A describes the options and scope of these studies in more detail.

B. Agriscience

The reader should note that, besides cost, operational practices are the main determinant of agriscience trade study outcomes. Table 2-5 summarizes the trade studies applicable to the preliminary design configuration reported on herein.

TABLE 2-5

AGRISCIENCE PRELIMINARY DESIGN OPTIONS SELECTED

Trade Study	Design Option Selected	Key Selection Factors
Gutter Type	flush gutter under slats	health, sanitation, cost
Slat Material	aligned fiber composites	commercial, sanitation, durability, cost
Feed Source	mill on site	cost
Growth of Feed Sprouts	selected	economics
Feed Contents	existing non-proprietary formulations	economics
Finish Hog Weight	228 pounds	current practice and facilities design
Water Disposal	field irrigation	environmental, conservation, cost

C. Civil, Electrical, and Mechanical Engineering

Subject to criteria and criteria applications previously discussed, alternative design arrangements were evaluated for the civil, electrical, and mechanical engineering features of the project buildings, utilities, and energy systems. Commercial practice, low cost, technical merit, and practical constructability were major factors considered in selecting the most appropriate alternative in each trade study case. Table 2-6 summarizes key preliminary design options resulting from trade studies. "Programmatic direction" includes those decisions reached by the Program Office after consideration of the degree of commercialization, risk and especially overall economics. Certain decisions involving conditions and characteristics of the expected geothermal fluid were made based upon the characteristics of Kelley Hot Spring fluid and the relatable well data from Kelley Hot Spring Well #1. Additional field data will be required for the final construction design, (see Chapter 5).

IV. PRELIMINARY DESIGN

A. Agriscience

The agriscience aspects of the preliminary design are summarized in Table 2-7, with swine building details depicted in Figure 2-1 through 2-4, following.

B. Facilities Layout

Figure 2-5 depicts the plot plan for the KHSAC preliminary design located at Site 6. The active site depicted is about 11 acres.

Facility arrangement is a result of several major factors, the most important of which is ease and efficiency of the swine growing operations. This operational factor is combined with requirements of the following systems: geothermal; potable and recycled water; and waste, including methane generation.

Previously noted criteria for access, health and safety factors are also taken into consideration.

Established engineering practice for site work requires that:

- The site will be leveled to a slope of not more than 3 percent. Terracing between buildings is permissible

TABLE 2-6

(SHEET 1 of 2)

CIVIL, ELECTRICAL AND MECHANICAL PRELIMINARY DESIGN OPTIONS SELECTED

Trade Study	Design Option Selected	Key Selection Factors
Building Type	pre-engineered metal with steel panels	cost
Insulation Type	loose fill cellulose, fireproofed	cost, building type
Insulation Thickness	7-1/2" in walls, 8" in ceilings	R factor, building type, insulation type
Floor Type	brush and smooth finish concrete	agriscience criteria applications
Gutters	flat cross section, sloped	efficiency, cost, ease of construction, sanitation and maintenance
Swine Effluent Ponding	matched cut and fill, film sheet liners	normal practice, cost
Swine Waste Solids Separation	mechanical separator	cost, ease of operation
Manure Transport	flush with recycled water	agriscience criteria, cost, conservation
Human Wastes Disposal	septic tank and leach field	cost, local practice
Pig Carcass Disposal	gas fired incinerator	health, efficiency
Floor Heating	black steel pipe in concrete	agriscience criteria, thermal design
Space Heating	fin tube in supply air plenum	cost, compatability
Wall Heating	not selected	cost
Exhaust Air Heat Recovery	not selected	cost, "essentially unlimited" heat supply
Cascade Heating System	space heating, floor heating, methanation	cost, thermal requirements
Type of Geothermal Piping	uninsulated asbestos cement	cost, experience
Thermal Storage	not selected	cost
Primary Heat Exchanger	not selected	expected clean water,programmatic direction
Deicing of Sidewalks	rock salt	cost
Geothermal Supply Pump	vertical turbine	engineering experience

TABLE 2-6

(SHEET 2 OF 2)

CIVIL, ELECTRICAL AND MECHANICAL PRELIMINARY DESIGN OPTIONS SELECTED

Trade Study	Design Option Selected	Key Selection Factors
Geothermal Reinjection Pump	split case horizontal centrifugal	local hydrology, programmatic direction
Methanation Tank	metal roof, concrete base, metal or concrete walls	cost, design factors
Methanation Heating	recirculation through heat exchanger	agitation method, existing practice, cost
Methane Slurry Agitation	recirculation	existing practice, cost
Methane Storage	steel tank with compressor	economics, programmatic direction
Methane Water Usage	recycling except farrowing and nursery	cost, conservation, agriscience criteria
Methane Gas Cleaning	compressor aftercooler condensing	cost, end use
Methane Use	internal combustion engine generators	economics, programmatic direction
Methane Backup system	purchase of electricity	cost, reliability
Air Handling	ceiling entrance, exhaust fans	agriscience criteria application
Humidity Control	air changes	cost
Cooling Method	evaporative	cost, suitability, practice
Geothermal Backup System	electrical with manual control, backup well and pump	economics, programmatic direction
Site Work	normal agricultural practice	cost, suitability
Lighting	fluorescent	cost, practice
Wiring	flexible metallic sheathed cable	cost, agricultural practice
Power System	480 volt, 3 phase, 60 Hz	loads, standards, utility preference
Engine Generators	internal combustion	practice
Transformers	utility provided	cost
Hazardous Electrical Areas	methane and grain handling	safety
Outside Wiring	buried	cost, ease of operation

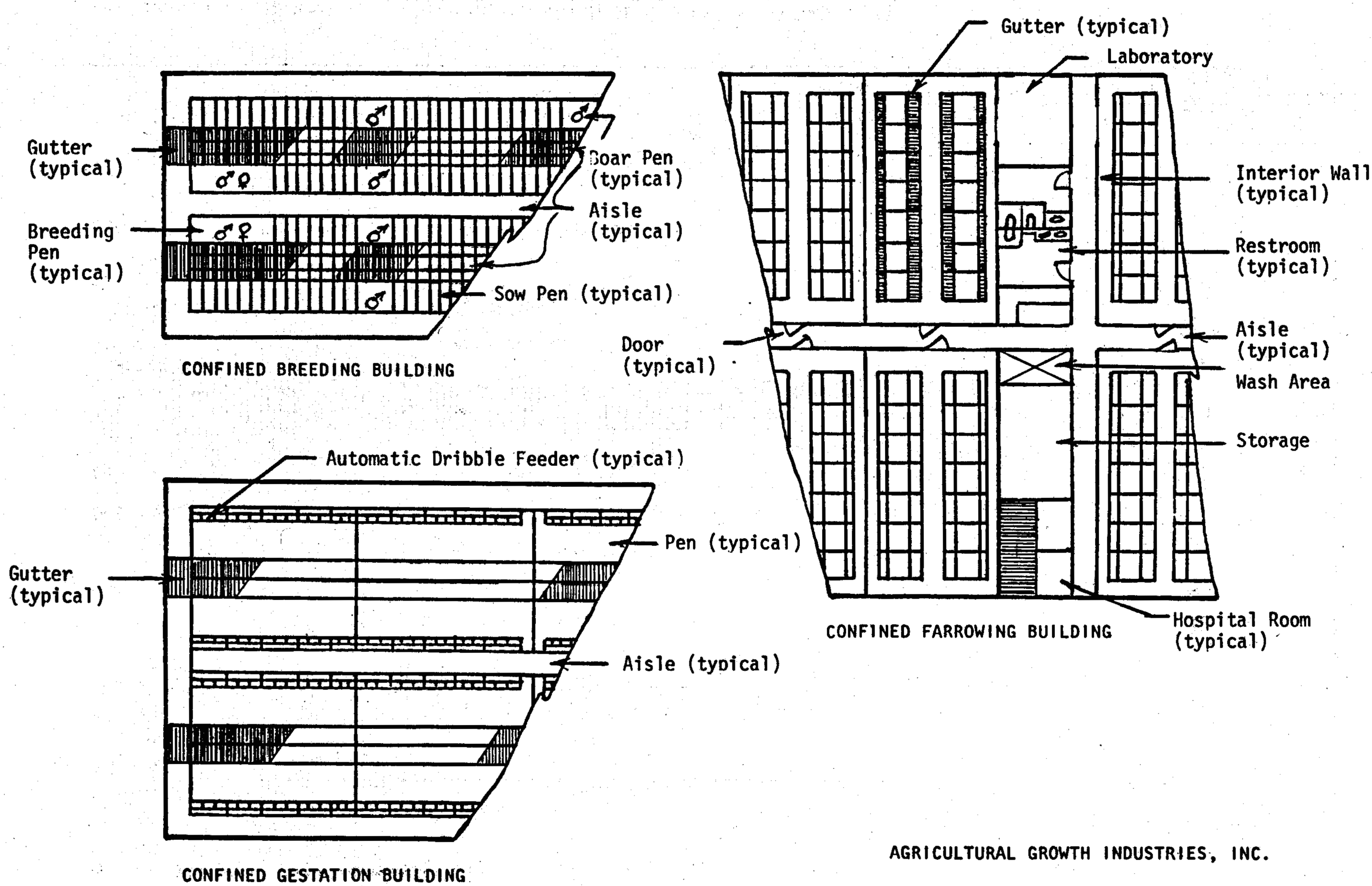


Figure 2-1 - ENVIRONMENTALLY CONTROLLED CONFINED GEOTHERMAL SWINE COMPLEX - BUILDING LAYOUTS (I)

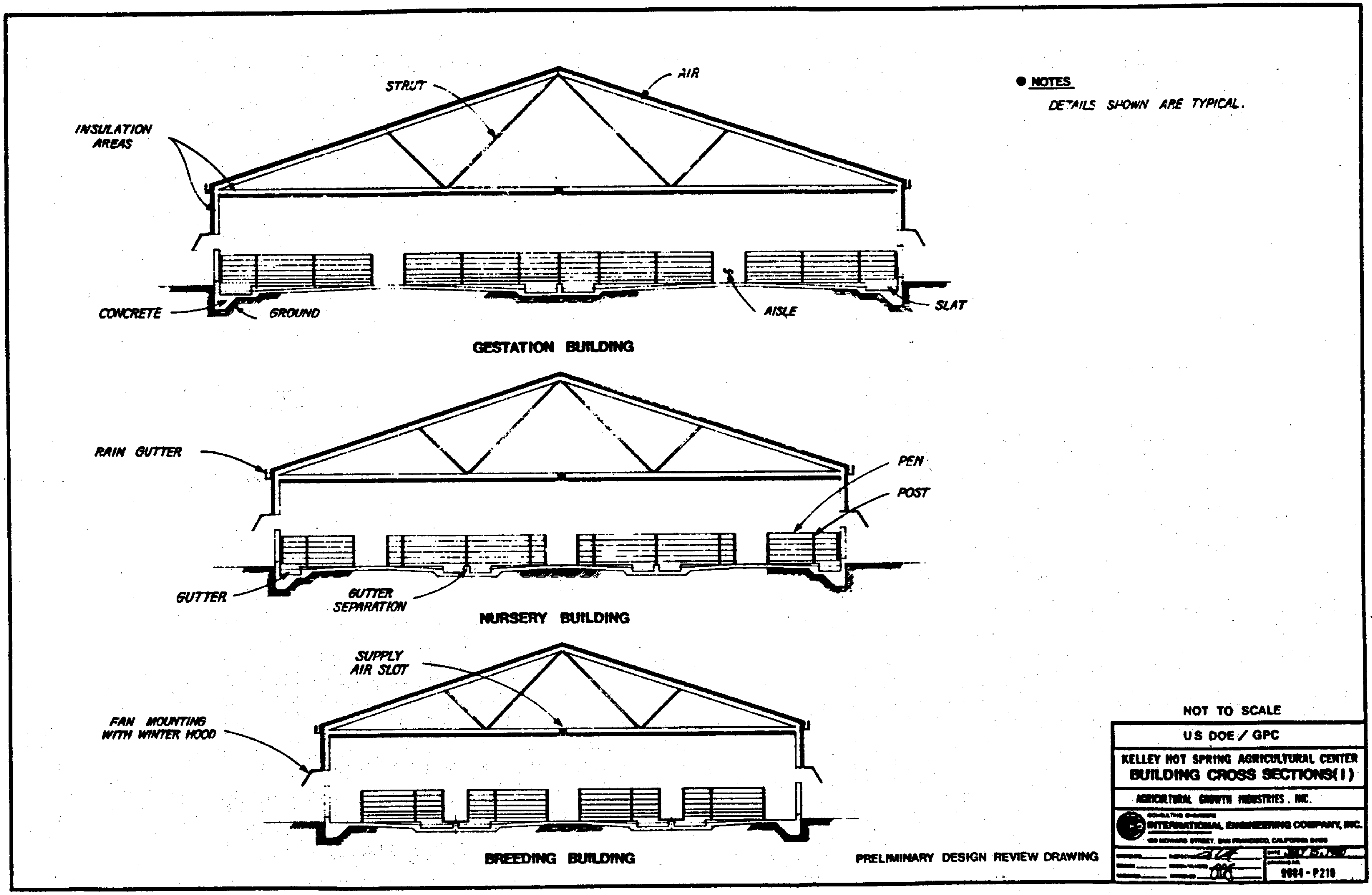


Figure 2-2 - SWINE BUILDING CROSS SECTIONS (I)

AGRICULTURAL GROWTH INDUSTRIES, INC.

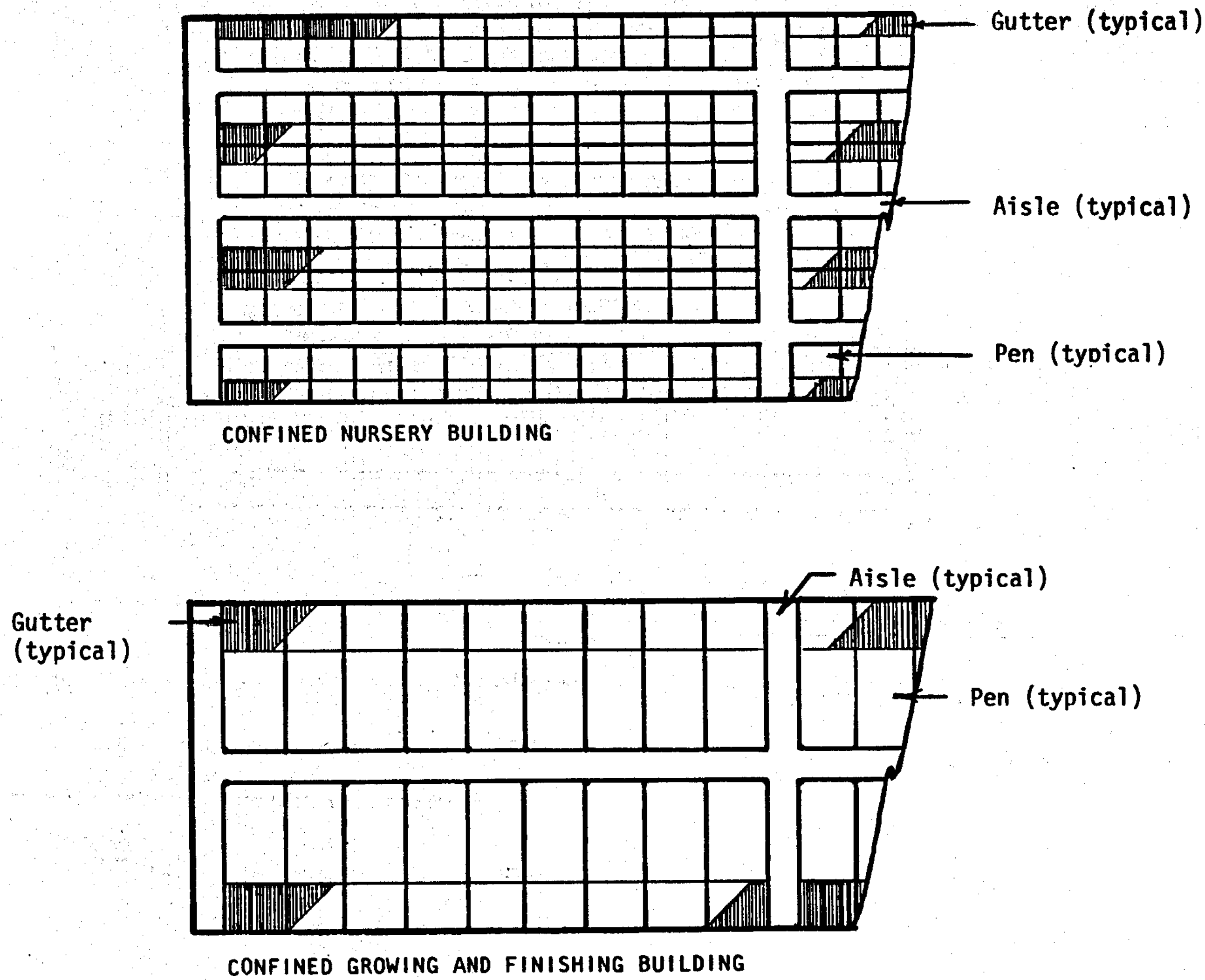


Figure 2-3 - ENVIRONMENTALLY CONTROLLED CONFINED GEOTHERMAL SWINE COMPLEX - BUILDING LAYOUTS (II)

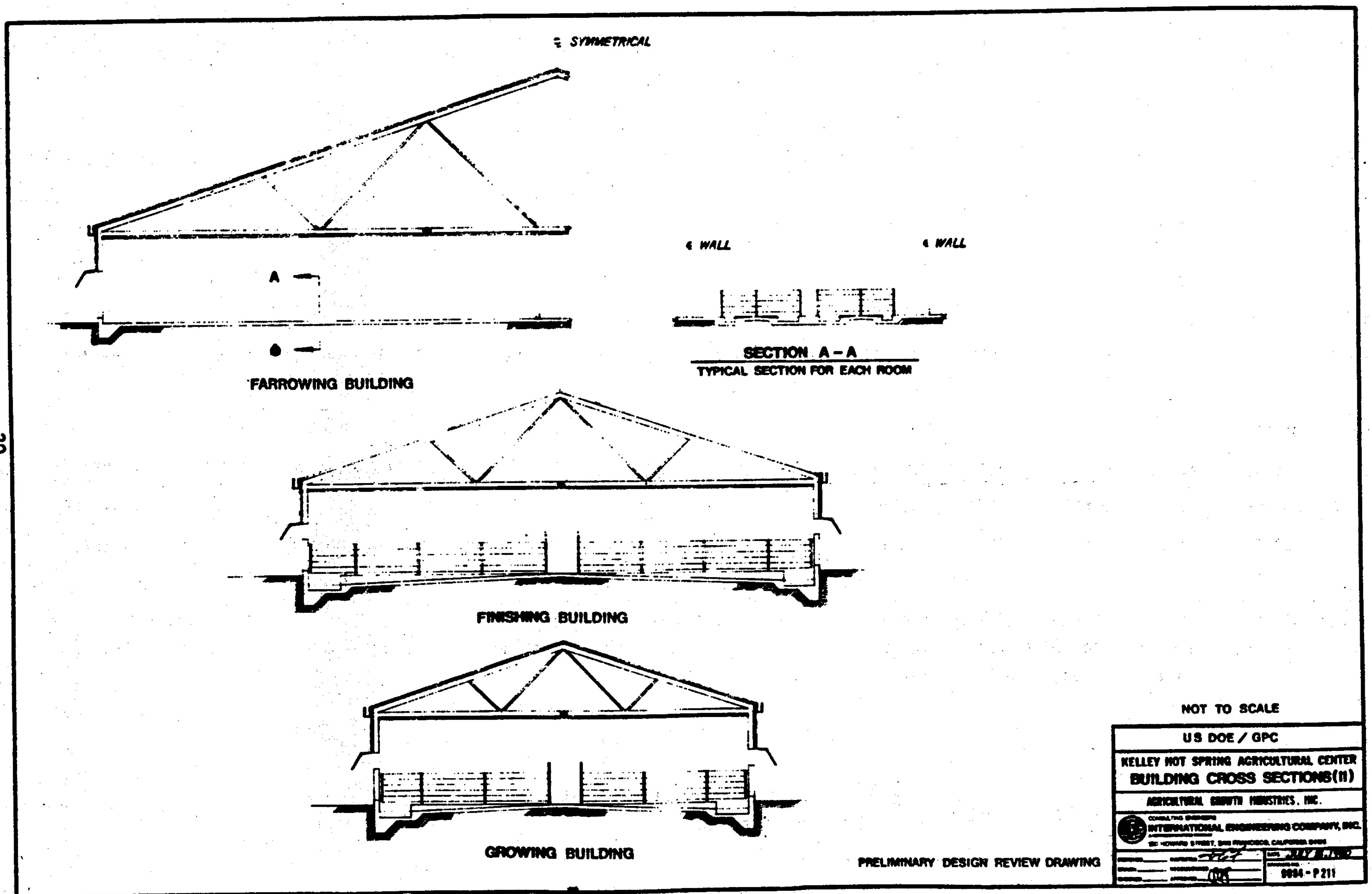


Figure 2-4 - SWINE BUILDINGS CROSS SECTIONS (II)

TABLE 2-7

AGRISCIENCE PRELIMINARY DESIGN SUMMARY

Building	Number of Buildings	Building Dimensions	Building Population	Pen Dimensions	Square Feet per Animal	Animal Weight pounds	Water Use gallons per day Drink	Water Use gallons per day Flush	Feed pounds per day	Manure per day pounds*	Manure per day gallons
Breeding	2	44'-3" x 142'-3"	224	22" x 7'	12.8	156,800	1,568	3,460	3,010	12,293	1,568
Gestation	2	64'-7" x 220'-3"	512	14' x 25'	25	332,800	5,072	3,460	6,144	26,092	3,328
Farrowing	1	96'-7" x 226'-7"	246 sows	5' x 7'	35	88,560	1,599	2,070	2,337	6,943	886
			(2,152 piglets)			(19,368)	(646)	-	837	(1,518)	(194)
Nursery	1	52'-7" x 290'-3"	4,224	6' x 7'	2.3-2.6	126,360	4,212	1,800	6,231	9,690	1,264
Growing	3	35'-3" x 196'-3"	1,426	6' x 16'	4.4-4.8	356,660	5,665	7,800	20,448	27,962	3,567
Finishing	3	48'-3" x 282'-3"	1,428	8' x 20'	7.3-8.0	734,300	16,784	7,800	31,601	57,569	7,343
TOTAL	12	-		-	-	1,814,848	35,546	26,390	70,608	142,067	18,150
									(35.3 tons/day)		

* 75 percent water

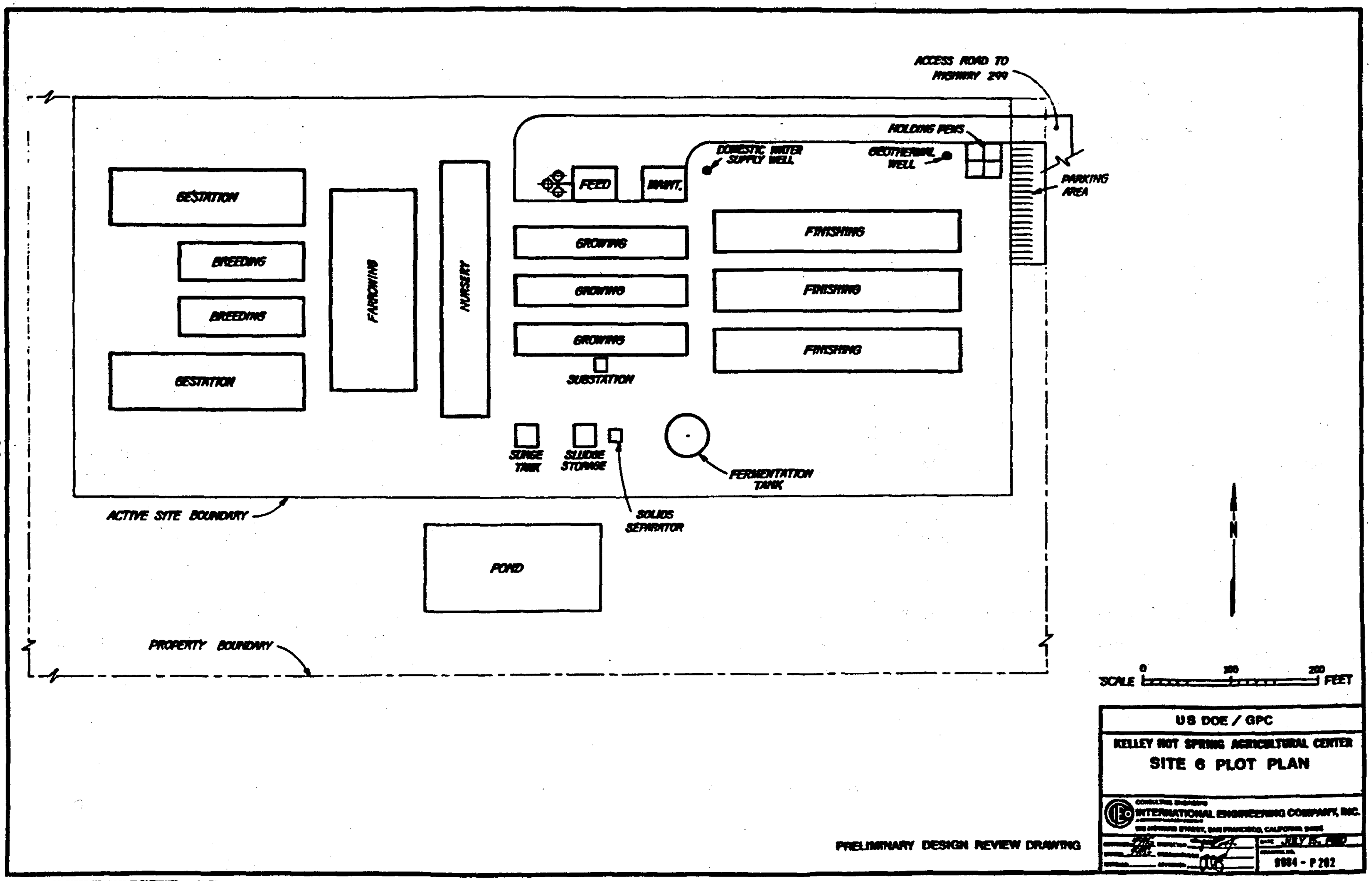


Figure 2-5 - SITE PLOT PLAN

and would be accomplished as required.

- Culverts required for surface water drainage will be prefabricated concrete pipe.
- All building foundations will be reinforced concrete.
- The access road and roads around the buildings will be constructed of crushed rock with a top sealer for dust control.
- Access roads are designed for twenty-ton load trucks and semi-trailers.

Established agricultural practice dictated natural vegetation for unoccupied areas with cleared surfaces for small trucks to deliver feed from the feed mill to the feed tanks at each building.

C. Process Flows

1. Animal Flows - Figure 2-6 depicts the concrete swine walkways between buildings. These walkways are surrounded by movable rails and provide for the following flow:

- Sows circulate continually through breeding to gestation to farrowing to breeding again.
- Piglets are born in farrowing and progress through nursery, growing, and finishing to pickup for slaughter at the end of finishing.
- Replacement gilts and boars are held in finishing or breeding.
- Animals at any particular stage may be moved to any building of the next developmental stage.

2. Feed Production Flows - Feed constituents are transferred from incoming trucks to the three bulk storage tanks adjacent to the feed mill by conveyor. In the mill, a mini-computer operated conveying scale system is used to properly meter the various ingredients into several ribbon type blenders. The blended feed is conveyed to trucks from which

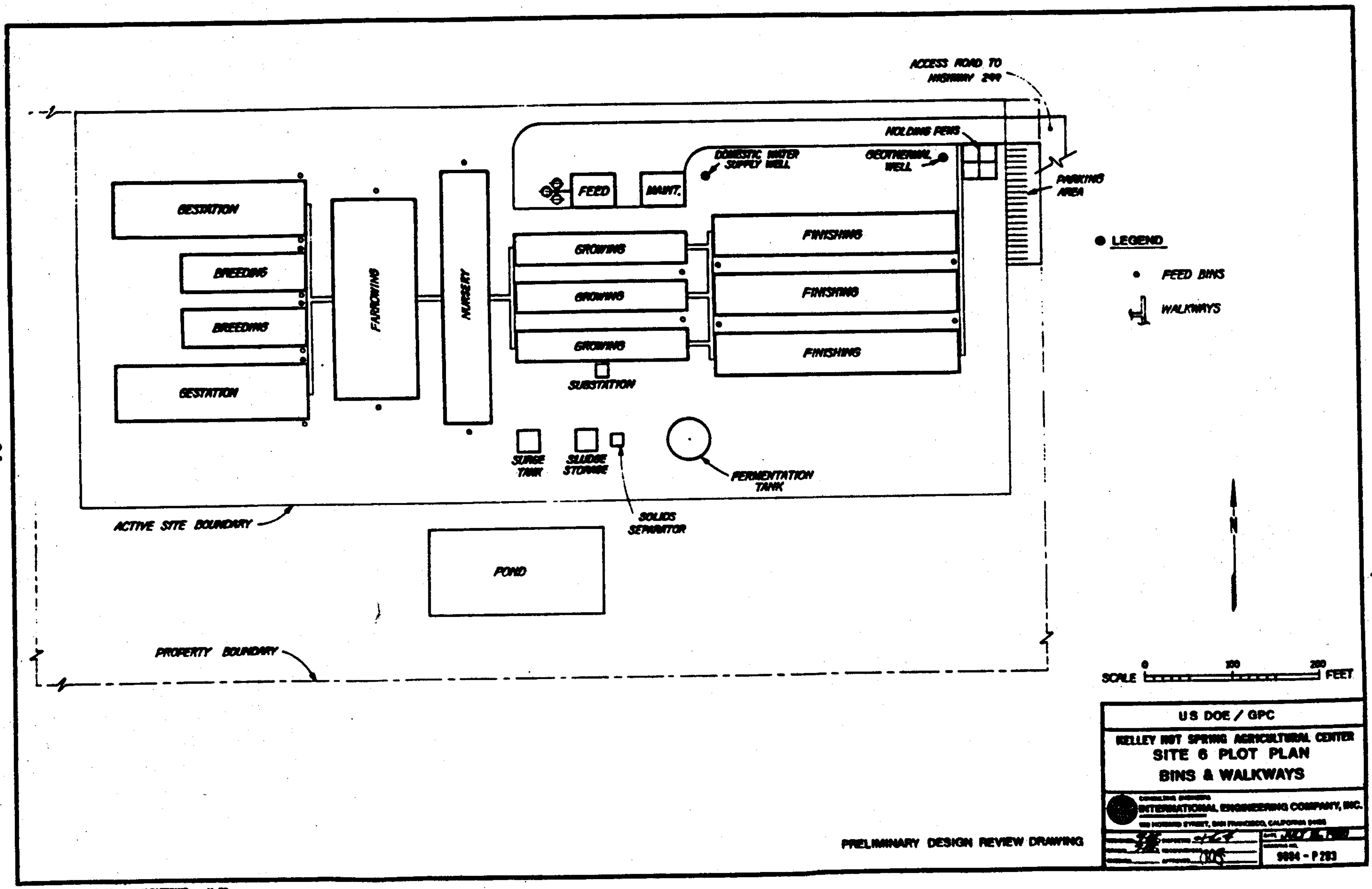


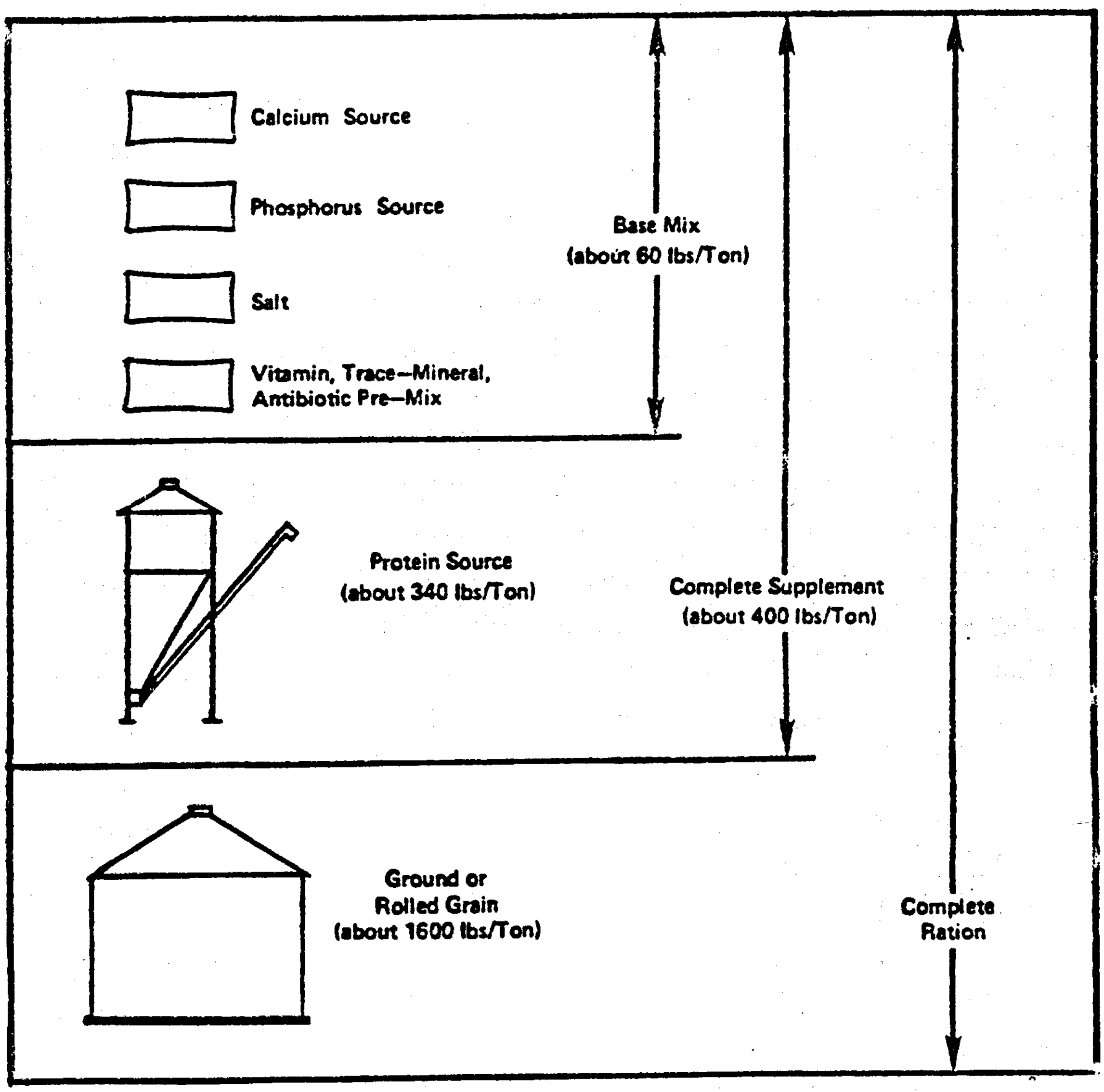
Figure 2-6 - BINS & WALKWAYS

it is distributed to building feed tanks shown in Figure 2-6. Distribution of feed to and throughout the buildings is by automatic conveying equipment.

The feed constituent tanks contain grain (corn, barley, grain sorghum, wheat, oats, etc.), protein meal (soybean, meat and bone meals, peanut, etc.), and bulk or roughage ingredients, (wheat bran, alfalfa meal etc.). The tanks, for this design and economic analysis, have been sized for a 45 day supply. In final design, tank sizing can be traded-off against storage at the various suppliers placed under supply contracts. Constituents for the base mix, (minerals, vitamins, trace minerals, antibiotic pre-mix, etc.) are stored in the mill building. The mill building is a pre-engineered metal building with 8 ft. eaves except in the mill area itself. The mill assembly requires a 30 ft. height ceiling to clear the stack-up of equipment and material conveyors.

Grain and other major constituents are received, cleaned and stored in the three tanks. Certain bulk constituents are ground after cleaning in order to facilitate storage and handling. Bucket elevators and grain chutes convey materials from storage to a four-compartment premixer hopper system above the mill. The four compartments handle the base mix, Figure 2-7a, in two compartments, the protein source in the third compartment and grain in the fourth compartment. The mill is a proportionate meter mixing mill composed of a proportionate blending hopper that meters ingredients on a volume basis, a hammer mill and a ribbon blender for homogenizing the formula. Bulk weighing of ingredients going into the hopper system plus the mill mini-computer-controlled weighing system are utilized in formulating seven to nine discrete formulae for the swine raising operation.

Figure 2-7a depicts, in gross terms, the major constituents and their approximate proportions for feed mixes. Figure 2-7b lists the nutrient requirements for swine depending upon their size/age and their function or principal activity. Also trace mineral needs and approximate ingredient needs are given. Figure 2-7c lists principal ingredients for seven different formulae using either corn or barley as the grain ingredient.



Approximate ration composition.

Ingredient	Gestation	Lactation	Creep	Growing	Finishing
	Ration*				
	(lb./ton)	(lb./ton)	(lb./ton)	(lb./ton)	(lb./ton)
Grain (corn, grain sorghum, wheat, oats, etc.)	1550	1450	1250	1550	1650
Protein meal (soybean, meat and bone, peanut, etc.)	300	300	550	400	300
Ingredients for bulk (wheat bran, alfalfa meal, etc.)	100	200	----	----	----
Macro-minerals (salt, calcium, phosphorus)	50	50	50	50	50
Milk by-products	----	----	150	----	----
Vitamin, trace-mineral, antibiotic premix	5-10	5-10	5-10	5-10	5-10

*This table **should not** be used to formulate rations.

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Figure 2-7a - Basic Feed Requirements

Liveweight class		Starting, Growing, and Finishing					Bred Gilts and Sows	Lactating Gilts and Sows	Young and Adult Boars
Pounds		10-25	25-45	45-75	75-135	135-220	240-550	240-550	240-550
Feed Intake	lb	1.30	2.75	3.75	5.50	7.75	4.4	11-12	4.4-5.5
Daily Gain	lb	.66	1.1	1.32	1.65	2.00	—	—	—
		Percentage or amount per pound of diet							
PROTEIN AND ENERGY									
Crude protein	%	22	18	16	14	13	14	15	14
Digestible energy	kcal	1,591	1,591	1,500	1,500	1,500	1,500	1,500	1,500
INORGANIC NUTRIENTS									
Calcium	%	0.80	0.65	0.65	0.50	0.50	0.75	0.75	0.75
Phosphorus	%	0.60	0.50	0.50	0.40	0.40	0.50	0.50	0.50
Sodium	%	—	0.10	0.10	—	—	—	—	—
Chlorine	%	—	0.13	0.13	—	—	—	—	—
Salt	%	—	—	—	—	—	0.50	0.50	0.50
VITAMINS									
Beta-Carotene	mg	2.0	1.59	1.18	1.18	1.18	3.7	3.0	3.7
Vitamin A	IU	1,100	795	591	591	591	1,864	1,500	1,864
Vitamin D	IU	100	91	91	56.8	56.8	125	100	125
Vitamin E	mg	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Thiamine	mg	.59	.5	.5	.5	.5	.6	.5	.6
Riboflavin	mg	1.36	1.36	1.18	1.0	1.0	1.9	1.5	1.9
Niacin	mg	10.0	8.18	6.36	4.54	4.54	10.0	8.0	10.0
Pantothenic acid	mg	5.9	5.0	5.0	5.0	5.0	7.5	6.0	7.5
Vitamin B_6	mg	.68	.68	.5	—	—	—	—	—
Choline	mg	500	409	—	—	—	—	—	—
Vitamin B_{12}	mcg	10.0	6.82	5.0	5.0	5.0	6.3	5.0	6.3
AMINO ACIDS									
Arginine	%	.28	.23	.20	.18	.16	—	.34	e
Histidine	%	.25	.20	.18	.16	.15	.20	.26	e
Isoleucine	%	.69	.56	.50	.44	.41	.37	.67	e
Leucine	%	.83	.68	.60	.52	.48	.66	.99	e
Lysine	%	.96	.79	.70	.61	.57	.42	.60	e
Methionine + cystine	%	.69	.56	.50	.44	.41	.28	.36	e
Phenylalanine + tyrosine	%	.69	.56	.50	.44	.41	.52	1.00	e
Threonine	%	.62	.51	.45	.39	.37	.34	.51	e
Tryptophan	%	.18	.15	.13	.11	.11	.07	.13	e
Valine	%	.69	.56	.50	.44	.41	46	.68	e

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Figure 2-7b - Nutrient and Feed Ingredients for Swine

TRACE MINERALS FOR HOGS

Mineral Element	Requirement ppm	Toxic Level ppm
Copper	6[a]	250
Iron	80[a]	5,000
Iodine	0.2	800
Manganese	20	4,000
Zinc	50[b]	2,000
Selenium	0.1	5-8

[a]Baby pig requirement.
[b]Higher levels may be needed if excess calcium is fed.

Ingredient	100 sow, farrow-to-finish continuous production, 200 litters, 1,600 hd/year			100 SOWS 240 litters, 2,160 head/yr		
	1 week	1 month	Annual	1 week	4 week	Annual
Grain	380 bu.	1,650 bu.	20,000 bu.	513 bu	2223 bu	26700 bu
Soybean meal	2.2 ton	9.6 ton	115 ton	2.97 tn	12.87tn	154 tn
Ingredients for bulk	550 lb.	1.2 ton	15 ton	743 lb	1.61tn	19.3tn
Macro-minerals	670 lb.	1.5 ton	17.5 ton	905 lb	1.96tn	23.5tn
Milk by-product	30 lb.	120 lb.	1,400 lb.	40 lb	173 lb	1 tn
Vitamin, trace-mineral, antibiotic pre-mix	70 to 140 lb.	300 to 600 lb.	1.8 to 3.6 ton	95 tn 190 lb	410 tn 825 lb	2.5tn 4.9tn
Totals	13.5 ton	58 ton	700 ton	18.2tn	79 tn	946 tn

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Figure 2-7b - Nutrient and Feed Ingredients for Swine

Suggested growing rations (40-125 lb.), with corn as the grain source.

Ingredient	Ration number 1	2	3	4	5	6	7
	pounds						
Corn, yellow	1,565	795	1,370	1,230	1,570	1,595	1,615
Wheat, hard winter	-----	800	-----	-----	-----	-----	-----
Oats	-----	-----	200	-----	-----	-----	-----
Wheat midds	-----	-----	-----	400	-----	-----	-----
Soybean meal, 44%	380	350	375	320	330	300	325
Meat and bone meal, 50%	-----	-----	-----	-----	65	-----	-----
Tankage	-----	-----	-----	-----	-----	60	-----
Lysine, 78% L-lysine	-----	-----	-----	-----	-----	-----	2
Calcium carbonate	15	20	12	20	10	12	17
Dicalcium phosphate	27	22	30	17	12	20	28
Salt	10	10	10	10	10	10	10
Vitamin-trace mineral mix*	3	3	3	3	3	3	3
Total	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Protein, %	15.20	16.10	15.50	15.60	15.80	15.40	14.30
Lysine, %	.75	.75	.75	.75	.75	.76	.76
Tryptophan, %	.17	.20	.17	.19	.17	.17	.16
Methionine + Cystine, %	.53	.51	.53	.51	.55	.53	.52
Calcium, %	.64	.68	.63	.64	.63	.64	.68
Phosphorus, %	.56	.55	.59	.57	.54	.55	.56
Metabolizable energy, kcal./lb.	1,454	1,454	1,425	1,418	1,457	1,446	1,451

Suggested growing rations (40-125 lb.) with barley or grain sorghum as the grain source.

Ingredient	Ration number 1	2	3	4	5	6	7
	pounds						
Barley	1,640	1,650	1,520	840	-----	-----	-----
Grain sorghum	-----	-----	-----	-----	1,545	800	1,555
Wheat, hard winter	-----	-----	-----	800	-----	790	-----
Soybean meal, 44%	310	235	330	310	400	355	345
Meat and bone meal, 45%	-----	100	-----	-----	-----	-----	-----
Meat and bone meal, 50%	-----	-----	-----	-----	-----	-----	60
Animal fat	-----	-----	100	-----	-----	-----	-----
Calcium carbonate	20	2	17	20	17	17	12
Dicalcium phosphate	17	-----	20	17	25	25	15
Salt	10	10	10	10	10	10	10
Vitamin-trace mineral mix*	3	3	3	3	3	3	3
Total	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Protein, %	16.40	17.10	16.10	16.60	15.70	16.20	16.10
Lysine, %	.75	.75	.75	.75	.75	.75	.75
Tryptophan, %	.22	.20	.21	.22	.20	.20	.17
Methionine + Cystine, %	.49	.49	.48	.49	.50	.48	.49
Calcium, %	.66	.64	.63	.66	.67	.66	.69
Phosphorus, %	.55	.63	.55	.54	.56	.59	.57
Metabolizable energy, kcal./lb.	1,274	1,280	1,388	1,365	1,396	1,424	1,395

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Figure 2-7c - Growing Rations Utilizing Corn or Barley as the Grain Constituent

This illustrates the quantities involved for use in least-cost-formula studies. The mill operator will run least-cost-formula studies to plan the purchasing ingredients in the area of operations. Since the cost of feed is 60% of the cost of operation and since ingredient costs have varied up and down by over 40% during this phase of the project, such analyses can have a major impact on the cost of operations. It is generally estimated that having a mill on site as part of the operation can save 17-22% over the cost of commercial feed (Reference 8, 12, 24). A number of authorities as well as a slaughter house operator have expressed a desire for barley raised pork (Reference 32, pg. 850). This is important in the barley raising areas of Canada and the U.S. Northwest including Northeastern California. The economics of this project have been based upon use of barley grain and an in-plant feed mill. Further, use of sprouted grains as a constituent in breeding, gestation and lactation formulae has been researched on an international basis. Use of sprouts is specifically discussed on page 852 in Reference 32. The economics of the project reflect the use of sprouts. The sprout raising equipment is commercially available and would be located in the mill building.

Figure 2-7d illustrates the essential amino acid contents in typical feed constituents. It may be noted that barley contains higher protein and higher or equivalent quantities of these amino acids than corn.

3. Geothermal System - Figure 2-8 presents a schematic diagram of the Site 6 geothermal system mains.

Geothermal fluids at a wellhead temperature of 208^{o}F flow at 325 gpm from the well in the northeastern corner of the site through buried 6-inch diameter Transite (asbestos cement) Class 150 pipe to the asbestos cement mains serving the buildings and methane system where, following heat exchange, the geo fluids are gathered and used in the waste system. Surplus fluids will be disposed of, as appropriate, per local regulations. All A/C pipe is buried at least 3 feet below the surface, depending on traffic, and is surrounded by sand.

Essential amino acid content of commonly used swine feeds.*

	Protein	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenylalanine	Tyrosine	Threonine	Tryptophan	Valine
							percent						
Grains													
Corn†	8.8	.42	.24	.31	.98	.26	.19	.20	.41	.35	.32	.09	.46
Sorghum‡	9.0	.36	.21	.38	1.13	.22	.17	.14	.46	.37	.29	.09	.70
Barley§	11.7	.58	.27	.54	.81	.36	.18	.19	.63	.36	.36	.16	.63
Corn, high lysine#	8.5	.53	.28	.27	.70	.37	.16	.18	.35	.27	.31	--------	.41
Oats§	12.0	.58	.15	.39	.66	.34	.18	.15	.39	.60	.33	.13	.46
Wheat§	12.2	.60	.28	.46	.88	.38	.20	.16	.62	.38	.37	.15	.55
Protein Sources§													
Soybean meal	44	3.20	1.21	2.32	3.62	2.88	.56	.66	2.35	1.46	1.87	.55	2.31
Soybean meal	50	3.54	1.30	2.49	3.88	3.14	.73	.82	2.52	1.56	2.00	.63	2.48
Alfalfa meal, dehydrated	17	.94	.29	.72	1.09	.80	.29	.29	.72	.43	.58	.36	.80
Blood meal	80	3.20	3.79	.88	9.89	5.37	1.04	1.40	5.17	1.78	3.87	1.02	6.91
Buttermilk, dry	32	1.08	.80	2.17	3.13	2.20	.72	.41	1.43	1.01	1.46	.47	2.40
Cottonseed meal, solvent	41	4.27	1.00	1.18	2.12	1.55	.49	.65	1.96	1.03	1.19	.48	1.60
Distillers dried solubles (corn)	27	1.03	.70	1.72	2.21	.77	.50	.36	1.72	.61	1.01	.18	1.61
Fish meal (menhaden)	60	4.06	1.55	2.99	4.79	4.60	1.88	.62	2.65	2.14	2.67	.71	3.42
Meat & bone meal	50	3.59	.90	1.71	3.12	2.50	.65	.62	1.81	.84	1.81	.29	2.42
Peanut meal, expeller	50	5.23	.94	1.47	2.62	1.35	.54	.34	2.17	1.72	1.13	.48	2.72
Tankage (meat meal)	60	3.69	1.95	1.95	5.26	3.89	.75	.52	2.78	.96	2.48	.58	4.32
Wheat bran	15	.95	.29	.56	.85	.56	.09	.29	.47	.38	.39	.29	.66
Wheat midds, standard	16	.83	.37	.73	1.10	.64	.16	.18	.63	.37	.54	.18	.73
Whey, dried whole	12	.27	.16	.72	1.00	.80	.16	.24	.28	.16	1.03	.13	.56
Yeast, brewers dried	45	2.22	1.11	2.12	3.23	3.02	.71	.50	1.82	1.52	2.12	.50	2.31

*All values on a 90% dry matter basis.
† Average for over 80 hybrids grown in Illinois, Virginia and Texas 1972-75.
‡ Average for 15 hybrids grown in Texas 1973-75.
§ Most values were obtained from "Atlas of Nutritional Data on United States and Canadian Feeds," National Academy of Sciences (1971), and adjusted to the indicated protein level.
# Average for 56 commercially grown opaque-2 corns in Virginia 1973-74 with adjusted cystine value.

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Figure 2-7d - Essential Amino Acid Content of Feed Constituents

Lysine, tryptophan, threonine, isoleucine and sulfur amino acid content of selected high protein feeds.*

		Lysine		Tryptophan		Threonine		Isoleucine		Methionine + cystine†	
	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein
	percent										
Fish meal, menhaden	60	4.60	7.67	.71	1.18	2.67	4.45	2.99	4.98	2.50	4.17
Buttermilk, dry	32	2.20	6.88	.47	1.47	1.46	4.56	2.17	6.78	1.12	3.50
Whey, dried whole	12	.80	6.66	.13	1.11	1.03	8.58	.72	6.00	.32	2.67
Soybean meal, solvent	44	2.88	6.55	.55	1.25	1.87	4.25	2.32	5.27	1.13	2.57
Tankage (meat meal)	60	3.89	6.48	.58	.97	2.48	4.13	1.95	3.25	1.27	2.12
Meat and bone meal	50	2.50	5.00	.29	.58	1.81	3.62	1.71	3.42	1.27	2.54
Cottonseed meal, solvent	41	1.55	3.79	.48	1.17	1.19	2.90	1.18	2.88	.96	2.34
Peanut meal, expeller	50	1.39	2.79	.48	.96	1.13	2.26	1.47	2.94	.87	1.74
Feather meal, hydrolyzed	85	1.94	2.28	.49	.58	3.75	4.41	3.59	4.22	1.19	1.40
Corn gluten meal	42	.80	1.92	.23	.55	1.51	3.60	2.49	5.93	1.77	4.21
Sorghum gluten meal	42	.68	1.62	.39	.93	1.38	3.28	2.23	5.31	1.17	2.79

*90% dry matter basis.

† Effective total sulfur amino acid value. If cystine content was higher than methionine value, it was reduced to the methionine value since cystine can provide only 50% of the total requirement for sulfur-bearing amino acids.

Purdue U.

Figure 2-7d - Essential Amino Acid Content of Feed Contituents

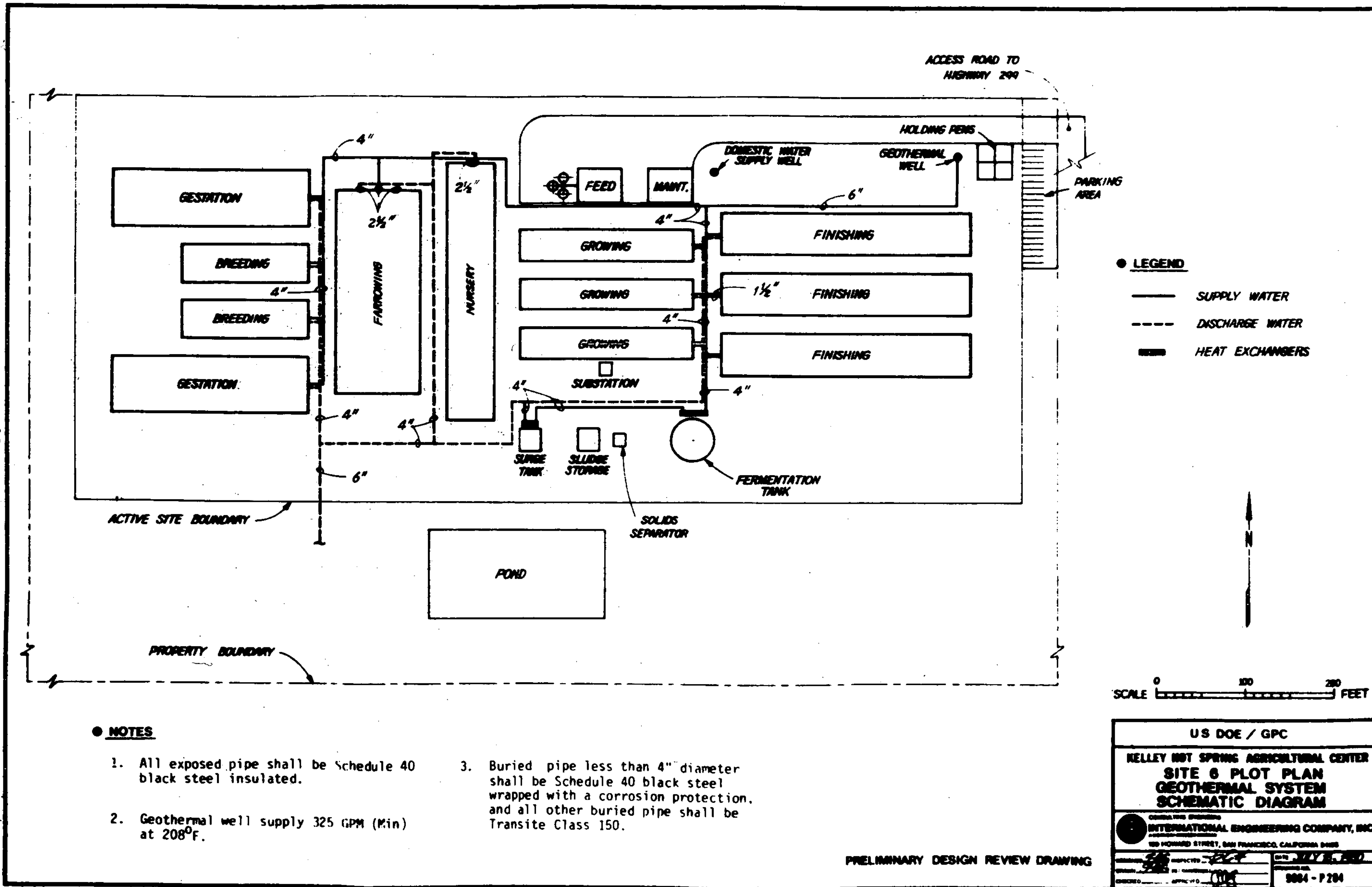


Figure 2-8 - GEOTHERMAL SYSTEM SCHEMATIC DIAGRAM

Inside the building hot water distribution piping is insulated (where exposed to human contact) Schedule 40 black steel.

Space heating is via exposed 1¼ and 2 inch diameter steel and copper finned tube piping in each building supply plenum, each building requiring roughly two lengthwise runs of finned tube. (All steel finned tube piping will be used in final design if the supply well water contains H_2S and/or sulfates in concentrations that will embrittle copper.) Water enters the runs at about 200°F. Figure 2-9 depicts a typical space heating sectional view.

The buildings utilize exhaust fans arranged four to a zone. In winter operation, one fan is on continuously. The geothermal flow through the finned tubes is activated by thermostat controlled motorized valves when the temperature drops below the lower thermostat setting and is halted in the same manner when the upper thermostat temperature is reached. Should temperatures rise higher than the zone upper thermostat setting, a second and, if needed, a third fan is activated, (with no geothermal flow).

In the summer operational mode, two fans are on continuously in each zone. The third fan is activated at building upper design temperature, and, should the building still be too warm, evaporative cooler operation is initiated along with the fourth fan.

Table 2-8 gives building peak heat loads based on a nominal 1,200 breeding sows. The specific numbers were based upon the 1200 sow operation. Increasing production to the 1,360 sow rate will increase the animal heat release and slightly reduce peak demand. The numbers were not changed in order to build in a degree of conservatism as well as to assure an adequate heating rate during the lower animal density period of herd build-up in the facility. The twelve swine buildings together require 7,718,000 Btuh at the peak heating load.

The methane fermentation tank is heated by heat exchange from the geothermal hot water loop at 180°F to the recirculating manure

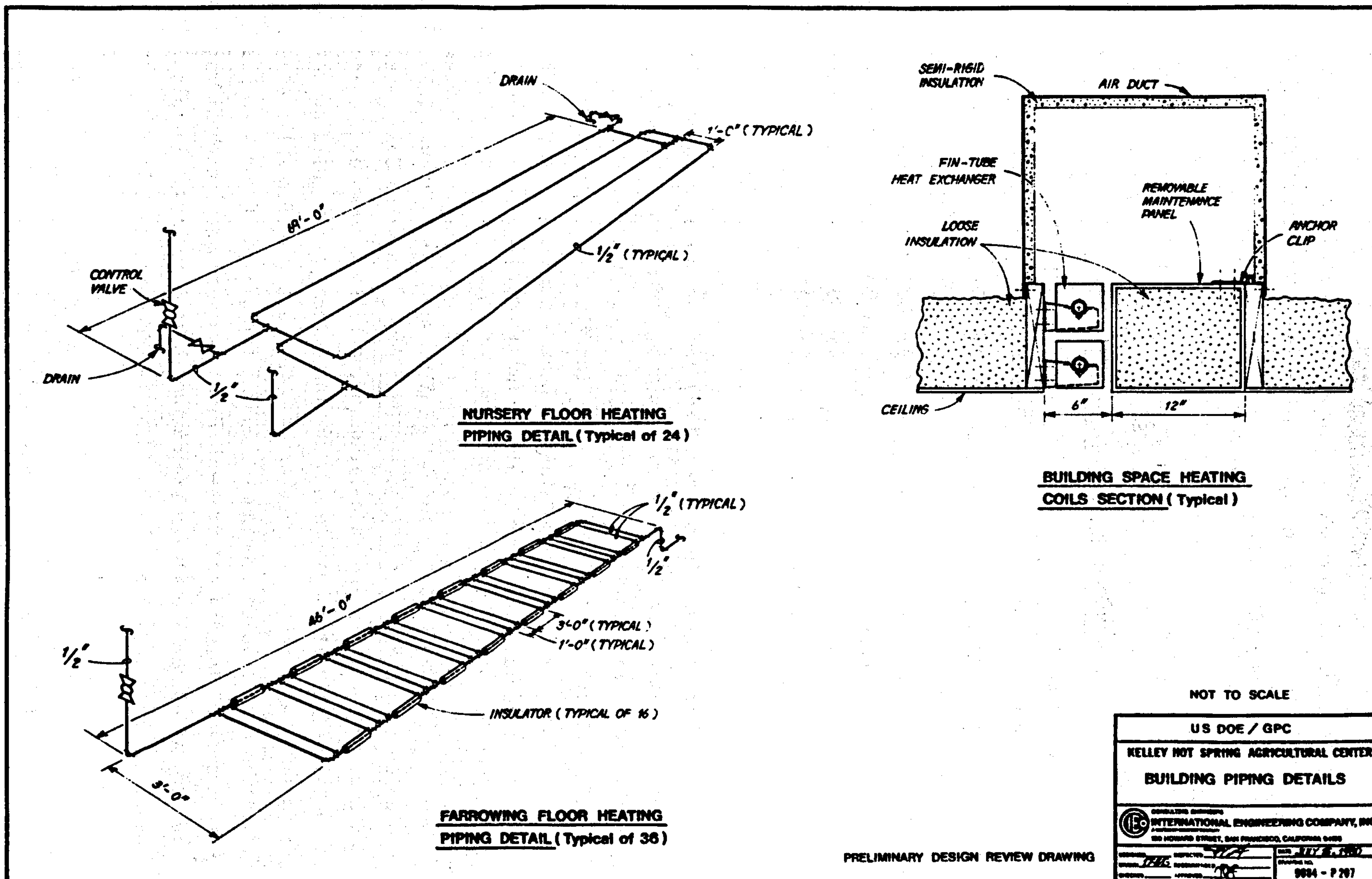


Figure 2-9 - BUILDING PIPING DETAILS

slurry to maintain the tank at an optimum 131°F. The heat exchanger is a tube-in-shell type (slurry in tubes). The peak methane system heat requirement is about 1,960,000 Btuh.

TABLE 2-8

SWINE BUILDING PEAK HEAT REQUIREMENTS

Building Type	Heat Required, Btuh/Building
Breeding	304,000
Gestation	668,000
Farrowing	1,386,000
Nursery	1,337,000
Growing	431,000
Finishing	586,000

Piglet areas in the farrowing and nursery areas have systems for heating the floor to 90°F as shown in Figure 2-9. This is accomplished by circulating 110°F hot water through ½ inch diameter Schedule 40 black steel pipe embedded in the floor concrete on 12 inch centers. This hot water is obtained by heat exchange with some of the building geothermal fluids exiting the finned tube heaters at about 140°F.

The design basis for the heating and cooling loads is in accordance with ASHRAE 1964 Guide and Data Book, pages 356-359. The peak heat requirements are calculated in the following manner. Using the outside design temperature of -2°F for Alturas and a building wall and ceiling heat loss resistance of R23, the heat loss for walls and ceilings are calculated. Using the ASHRAE formula for floor slab heat loss, the floor loss is calculated. Floor, wall and ceiling heat loss loads are added for a building ambient air heat loss load. To this ambient air heat loss from the building is added the heat loss due to air changes for a total building heat loss. From ASHRAE, the heat given off by the animals is calculated as a function total animal weight in the building. Then the geothermal heat requirement is equal to the building heat loss minus the animal heat production.

For cooling, the building heat gain plus the animal heat release is removed through air change which is supplemented, if necessary, by evaporative cooling. The heat and cooling calculations were checked using "Confinement Swine Housing", Agriculture Canada Publication 1451, Revised 1979, (Reference 23). This method considers supplemental heat per animal. This method does not take into account the more healthy, high air change rate permitted through use of geo heat. The ASHRAE heating requirements are higher and more conservative and hence have been used in this design.

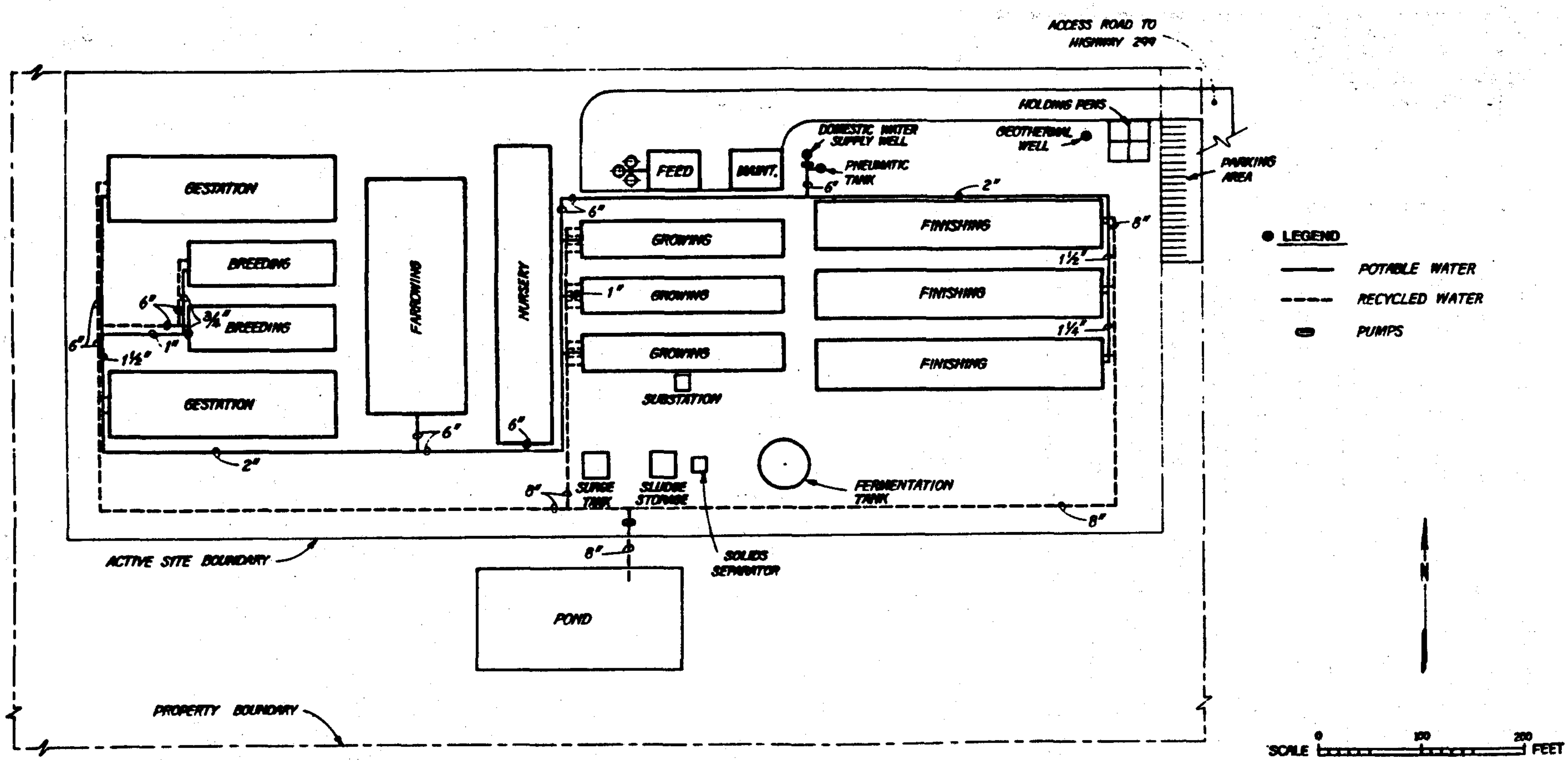
4. Potable and Recycled Water System - Figure 2-10 shows a schematic diagram of the main external-to-building features of the potable and recycled water systems.

Potable water is provided through buried piping to each building for animal consumption and washdown and, additionally, to the farrowing and nursery buildings for flush after pressurization in a pneumatic tank.

Recycled water from the methane system is pumped from a holding pond to a pneumatic pressurization tank from which it is distributed to all but the nursery and farrowing buildings for gutter flushing.

Buried potable water pipe 4 inches in diameter and larger and buried recycled effluent pipe is Class 150 Transite. Buried potable water pipe less than 4 inches in diameter is PVC.

Exposed piping for potable water is Schedule 40 black steel for diameters of 2½ to 4 inches and PVC for diameters of 2 inches and smaller. Exposed recycled water pipe will be fiberglass reinforced polyvinyl chloride (PVC). All exposed piping in these systems outside of buildings will be insulated.



NOTES

1. Recycled effluent pipe shall be Transite Class 150 for buried, and fiberglass reinforced PVC for exposed piping.
2. Potable water pipe shall be Transite Class 150 for buried 4" diameter and larger, reinforced PVC for less than 4" diameter pipe. Exposed pipe shall be reinforced PVC for 2" diameter and smaller, Schedule 40 black steel for 2½" diameter and larger. All outside exposed piping shall be insulated.

PRELIMINARY DESIGN REVIEW DRAWING

US DOE / GPC
KELLEY HOT SPRING AGRICULTURAL CENTER
SITE 6 PLOT PLAN
POTABLE & RECYCLED WATER
SCHEMATIC DIAGRAM
INTERNATIONAL ENGINEERING COMPANY, INC.
9994-P205

Figure 2-10 - POTABLE AND RECYCLED WATER SCHEMATIC DIAGRAM

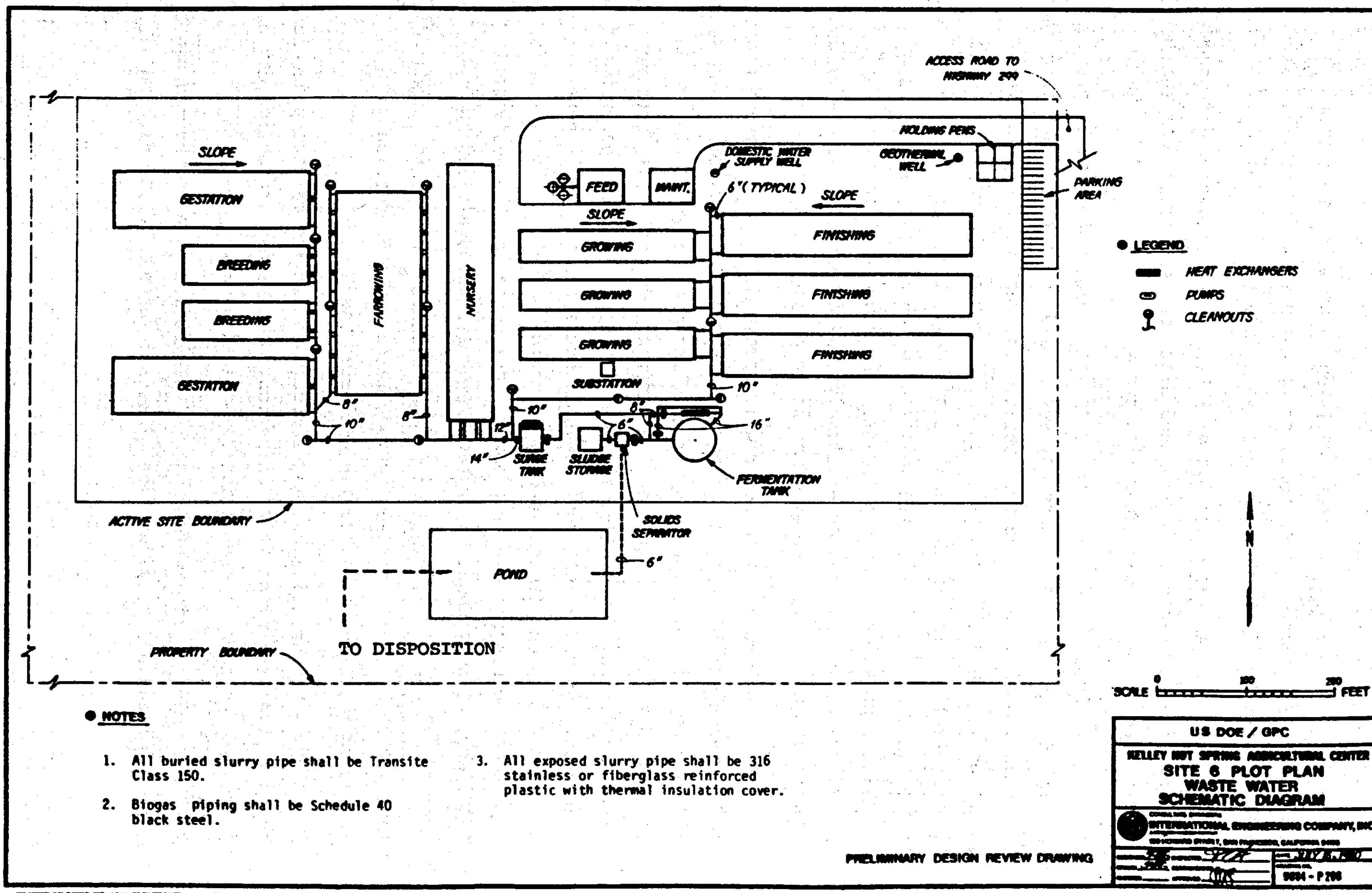


Figure 2-11 - WASTE WATER SCHEMATIC DIAGRAM

The method of water provision to animals is by animal controlled "automatic" water bowls to minimize flesh damage and tail biting associated with water nipple type systems.

5. <u>Animal Waste System</u> - Figure 2-11 schematically shows the animal waste water collection and distribution system from the swine houses through the biogas generation process.

From the flush gutters, animal sewage will flow by gravity through buried pipe to the one-day surge holding tank and then into the fermentation tank on a slug feed basis. The tank will provide for thermophilic anaerobic digestion at 131°F from geothermal heat. The fluid retention time in the tanks is six days, which produces biogas and a sterile liquid effluent, the solids of which may be utilized as a fertilizer or animal feed supplement. The roughly 60 tons per day of animal sewage inflow can conservatively produce a daily methane production of 105,000 cubic feet at atmospheric pressure.

A commercial scrubber will remove most of the carbon dioxide and hydrogen sulfide from the biogas, with the remaining gas being nearly all methane. The uncompressed methane, for preliminary design purposes, is assumed to be transmitted on the order of 100 feet to a Surprise Valley Electrical Cooperative facility wherein electrical power would be generated. An equivalent continuous 24 hours per day power generation of about 400 kW can be provided by the methane fuel. This is a major impact on the project electric power requirements as the equivalent total project continuous power requirements are roughly 560 kW.

Conservative estimates were used for the methane produced so that after the plant start-up period, methane gas production may be increased above the conservative estimates used.

Conservative estimates were used for the methane produced so that after the plant start-up period, methane gas production may be increased above the conservative estimates used.

Piping is as follows: Class 150 Transite for buried pipe; Type 316 stainless steel or fiberglass reinforced PVC for exposed slurry piping (with thermal insulation cover) and Schedule 40 black steel for biogas.

6. Electrical System - Figure 2-12 depicts the electrical single-line diagram.

Power from the local utility is brought into a substation. The incoming power line, transformers to step incoming power down to 480 volts, and protective equipment will be provided by the utility (except for the 480 V protective equipment). Power will be distributed from the substation by radial direct buried cables to each building at 480 V, from where it will be stepped down to 220 V or 110 V as required.

7. Flow Systems Summary - Figure 2-13 schematically summarizes the major flow systems and key equipment for the Kelley Hot Spring Agricultural Center preliminary design.

8. Energy Summary - The use of geothermal energy in the KHSAC displaces nearly 350,000 gallons of fuel oil yearly; use of biogas displaces about 300,000 gallons of fuel oil per year. Total yearly fossil fuel savings are approximately 650,000 gallons of fuel oil equivalent.

D. Costing

1. Capital Costs - Capital costs were estimated on an early 1980 basis without any contingency factors or inflationary multipliers. Costs were estimated by a variety of ways as appropriate:

- engineering estimating manuals including those of Means, Dodge, and Trade Service Publications; (References 28, 70, 71, 90).
- actual catalog prices; (References 2, 18, 67).
- manufacturers' budget estimates for major cost items; (References 49, 50, 83, 99, 105).
- similar experience of the agriscience and engineering firms; and

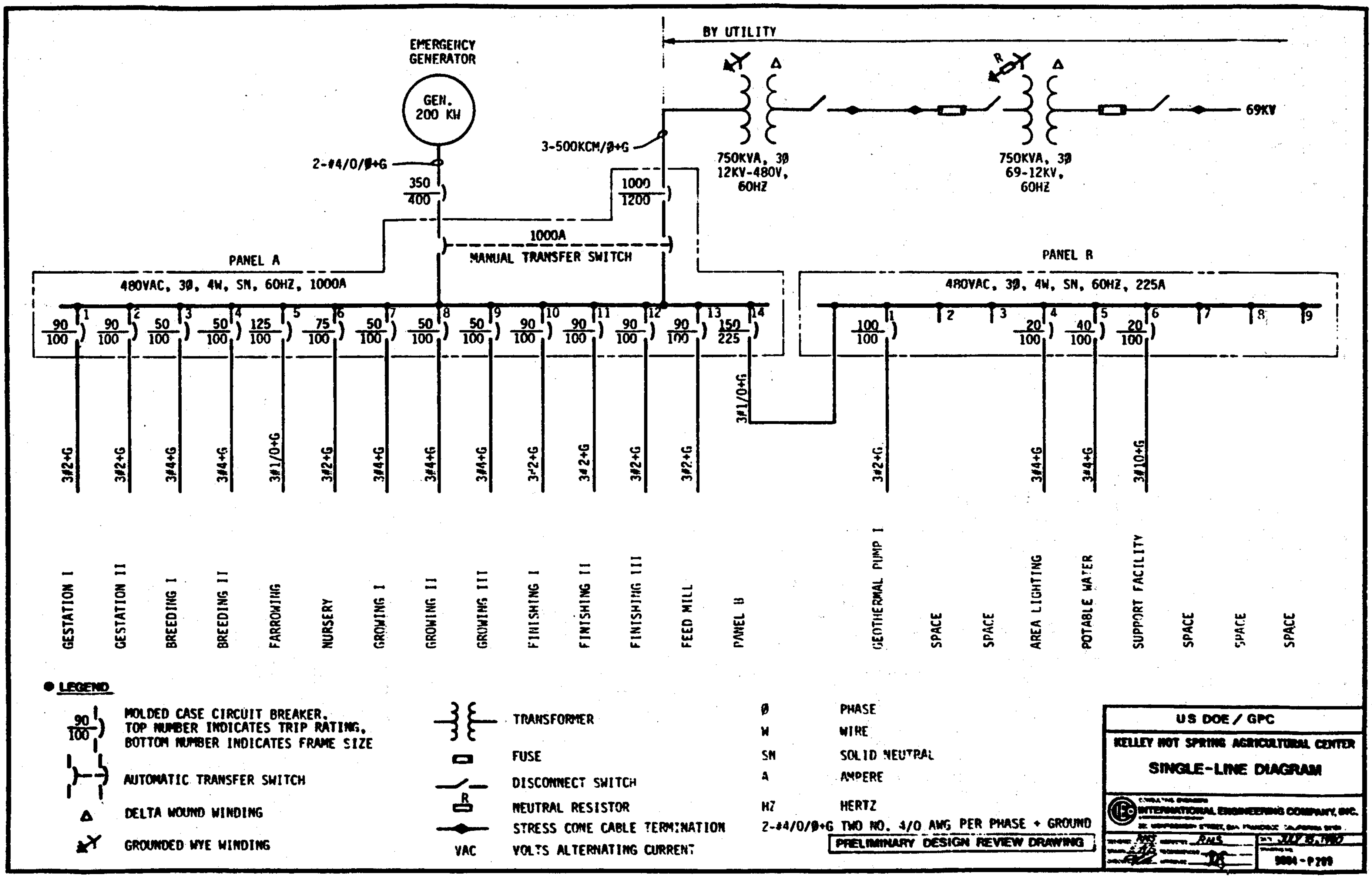


Figure 2-12 - ELECTRICAL SINGLE-LINE DIAGRAM

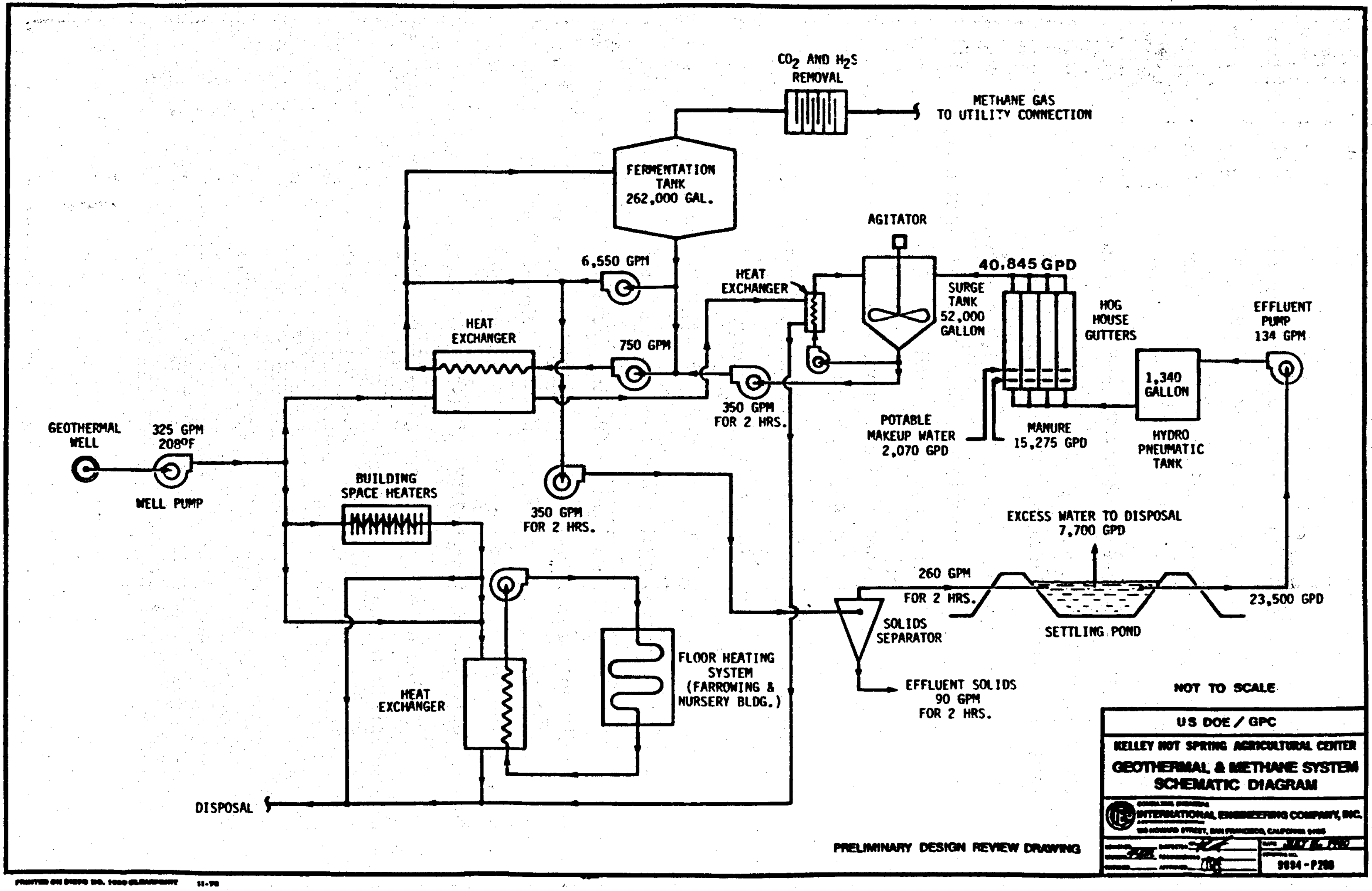


Figure 2-13 - GEOTHERMAL & METHANE SYSTEM SCHEMATIC DIAGRAM

- recently published similar experience. (References 27, 65, 72, 81, 92, 93, 94, 95).

Capital costs developed are summarized in Chapter 3 following.

2. Operating Costs - Operating costs are also estimated on an early 1980 basis without contingency factors or inflationary multipliers. Cost estimating bases included:

- recent experience of private operations (including some proprietary data used for guidance); (References 12, 38, 80, 85, 87).
- published feed and supply costs; (References 15, 24, 53, 69, 91A).
- comparable labor rate classifications;
- costs estimated by the electrical utility; and
- agriscience and engineering experience.

Operating costs developed are summarized in Chapter 4.

The employee loading for the facility has been based upon completely autonomous operation, i.e. no sharing of personnel with other operations. The employees shown in Table 2-9 are full time. Outside services and any part time or intermittent activities would be contracted; e.g., veterinary services.

The gross rate of principal flows through the facility are as summarized in Table 2-10.

TABLE 2-9

ON-SITE EMPLOYEES - 1,360 SOW COMPLEX

FUNCTION	NO.	PAY RATE
Feed Production		
Foreman	1	$1,150/mo.
Assistants	3	$5/hr.
Swine Production		
Supervisors	4	$1,150/mo.
Assistants	4	$950/mo.
Energy System		
Facility Technician	1	$1,000/mo.
Maintenance		
Foreman	1	$1,200/mo.
Assistant	1	$1,000/mo.
Management		
Business, Operations, Sales	1	$19,000/yr.
Accounting, Records, Purchasing	1	$900/mo.
TOTAL	17	$214,000/yr.

Notes:

1. Pay is direct without overhead, Spring 1980
2. Support activities; i.e., transport in and out is by contract.
3. Energy system includes: geothermal supply system, waste collection and transport within the complex, biogas generation and transport to the property line and manure/fertilizer separation.

TABLE 2-10

PRINCIPAL FLOWS THROUGH KHSAC

Item	Rate
Geothermal Fluid (peak)	325 gpm
Geo Heat (peak)	9.68×10^6 Btuh
Effluent Water (ave.)	5.4 gpm
Pork Production-Animals (design)	29,353/year
Pork Production-Animals (max)	33,000/year
Pork Production-Weight (design)	6.69×10^6 lb/year
Methane (design minimum)	105×10^3 scf/day
Manure slurry (75% water) (design)	71 ton/day
Feed (design)	35.5 ton/day
Fresh Water (design)	37,000 gal/day

CHAPTER 3 -- CONSTRUCTION PLAN

I. FACILITIES CONSTRUCTION COSTING

Construction costing has been based upon the Preliminary Design as designated in Chapter 2. For cost estimating, it has been assumed that the facility will be located in Site #6 immediately adjacent to the geothermal supply well. The access road would run northeast from U.S. 299 to the site gate for one-half mile.

A. Installed costs - Installed costs as of early 1980 have been used with normal contractor mark-up without any contingency or inflationary multipliers. Unit costs were determined by a combination of factors as follows:

- A fully contracted turnkey job at prevailing rates through a competitive bidding process has been assumed.
- Engineering costs have been based upon the experience of the engineering firm with backup estimates derived from estimating documentation[70], [71]. On virtually all major equipment items, quotes have been obtained directly from manufacturers.
- Agricultural equipment costing was obtained by utilizing quotes from equipment manufacturers, and current catalog data.
- Building construction and erection figures were obtained directly from Melco Steel Buildings and from the experience of John F. Otto, Inc., General Contractor, and Carson Development Co., Sacramento, California.
- Mechanical and plumbing costs were obtained from Luppen & Hawley, Inc., mechnical and plumbing contractors, Sacramento. Electrical costs were obtained from Rex Moore Co., electrical contractor, Sacramento.

- Geothermal well and equipment costs were developed by Geothermal Power Corporation from historical data and vendor quotes.
- Site work estimates were based upon Carson Development Co.'s experience plus consulting with Teichert Construction, Sacramento, Excavating and Engineering Contractors.

It should be noted in all cases the suppliers, subcontractors and construction firms were requested to consider the specific site in southern Modoc County when making their estimates.

The Preliminary Construction Costs are shown in Table 3-1. The first sheet summarizes the costs, delineates the software costs of engineering and management and allocates the geothermal related effort. The following sheets give the breakdown of the material costs, identifies the units and unit costs associated with the hardward elements and includes installation costs. The percentage of the elements that are geothermal-related have been estimated in these detailed sheets. In the summary, sheet 1, the geothermal-related software has been estimated on the same basis as the overall installed capital costs have been allocated; i.e., 29.9% of total software. The software has been estimated on the basis of the total construction plan and the specific elements and tasks required for the construction design, construction management, checkout and test of all systems.

II. PRELIMINARY CONSTRUCTION SCHEDULE

The Construction Schedule has been greatly affected by two major constraints. The first is the expected requirement that the geothermal resource must be proven by thoroughly testing a production well before any other construction work may proceed. With a projected drilling start date of September, 1980, and an interval of two months allotted for drilling, casing and testing, it is expected that little in the way of site work and no construction can be accomplished before the Spring of 1981. The second constraint is the severe winters of the Canby region of southern Modoc County in northeastern California. While heavy snow is not normal for the area, quite low temperatures are experienced from November through March, and early spring thawing results in muddy conditions that can bog down sitework equipment.

The principal construction activities, which will be laid out in CPM planning for the actual work, are summarized as follows:

- A production geothermal well will be drilled, completed and tested. With a late summer or early Fall, 1980, start on this well, it is assumed that only minor access road/sitework improvements (access and drainage) would commence before mid-Spring of 1981. As soon as the resource is proved out, long lead items, such as the geothermal pump, may be ordered for later delivery.
- While the gradual slope of the site is being terraced, underground utilities being placed, and the methane system drains and ponds installed, building pads will be prepared in appropriate sequence.
- Building foundations and concrete slabs will be poured and finished in an order that will allow building erection and completion in the same sequence that animals will flow through them. First completed will be one building each of breeding, gestation, farrowing, nursery, growing and finishing. Following this priority, the rest of the buildings will be poured, erected and completed.
- This building sequence will allow sows to arrive for breeding on site by December, 1981, at the rate of approximately 250 - 285 sows per month. At this rate, it will take some six months before the full breeding stock is attained, and the first hogs will be ready for market by mid-Summer of 1982.
- The final group of buildings can be finished off, under shelter, during the Winter and Spring of 1982 while initial animal production is atarting up. This sequence has the advantages of bringing hogs to market, representing income, at the

earliest date while at the same time allowing a smaller, more efficient crew to extend construction over a longer period, thus delaying capital outlay as long as possible.

Some minor finish sitework and special equipment items can be completed as required in the late Spring of 1982, along with final electrical, mechanical and interior work in the last scheduled buildings.

III. MANAGEMENT PLAN

The construction project will be managed through a Construction Management Agreement between the construction management firm, Lahontan, Inc., and Geothermal Power Corporation, the designated owner-operator. On the recommendation of its consultants, Lahontan would select the following sub-constractors through a qualifications process and competitive bidding procedure:

- Geothermal production well and testing.
- Sitework and buildings; including mechanical, plumbing, and electrical work and the installation of all associated equipment.
- Specialized equipment; such as the methane system, heat exchangers, etc.
- Feedmill and associated materials storage, handling and equipment.

As is common practice in agricultural complexes, the owner would reserve the right to complete the interior of buildings and install equipment using his operational personnel. Technical advice for this activitiy would be obtained from equipment suppliers. Through management planning and project scheduling, the construction would be sequenced to permit bringing of breedable sows on board as early as practical in the construction program. Detailed planning would have to be conducted to minimize stress on the animals and to maintain health conditions.

Table 3-1

KHSAC PRELIMINARY DESIGN AND CONSTRUCTION CONSTRUCTION COST SUMMARY

		TOTAL COST	GEOTHERMAL RELATED COST
I.	CONSTRUCTION COST		
	A. GEOTHERMAL RESOURCE	$ 406,000	$ 406,000
	B. SITEWORK	148,770	0
	C. BUILDING STRUCTURES	1,487,110	346,760
	D. BUILDING MECHANICAL	374,970	153,230
	E. BUILDING ELECTRICAL	469,240	60,010
	F. BUILDING AGRICULTURAL EQUIPMENT	898,880	0
	G. SPECIALIZED AGRICULTURAL EQUIPMENT	283,050	0
	H. SWINE WASTE SYSTEM	364,640	337,190
	I. SITE UTILITIES	112,770	54,010
	TOTAL CONSTRUCTION COST	$4,545,430	$1,357,200
II.	SOFTWARE COST		
	A. FINAL DESIGN & ENGINEERING SERVICES (8%)	$ 363,630	$ 108,730
	B. CONSTRUCTION MANAGEMENT (7%)	318,180	95,140
	C. PROGRAM MANAGEMENT SERVICES	250,000	74,750
	TOTAL SOFTWARE COST	$ 931,810	$ 278,620
III.	TOTAL COST	$5,477,240	$1,635,820

KHSAC CONSTRUCTION COST DETAIL

CONSTRUCTION ELEMENT	MATERIALS AND EQUIPMENT				INSTALLATION COST	TOTAL COST
	UNIT	COST/UNIT	NO. UNITS	SUBTOTAL		
A. Geothermal Resource Development						
1. Production Wells - Drill & Case	LS	$373,000	1	$ 373,000	-	$ 373,000*
2. Well Testing Pump & Completion	LS	33,000	1	33,000	-	33,000*
Subtotal				$ 406,000		$ 406,000
B. Sitework						
1. Land Cost	AC	750	16	12,000	-	12,000
2. Soils Testing & Surveying	LS	8,500	1	-	8,500	8,500
3. Grading and Site Preparation	CY	25,000	2.50	62,500	-	62,500
4. Roads - Within Site	SF	.20	30,000	6,000	4,500	10,500
Access - Assume 0.5 mi.	SF	.20	72,200	14,440	10,830	25,270
5. Fencing, Security	LF	6	3,000	18,000	12,000	30,000
Subtotal				$ 112,940	$ 35,830	$ 148,770
C. Building Structures						
1. Concrete Foundation and Slabs	CY	55	2,820	155,100	324,300	479,400**
2. Metal Buildings - Shell	LS	601,200	1	601,200	112,800	714,000
3. Building Doors and Windows	LS	16,420	1	16,420	12,310	28,730
4. Interior Walls and Epoxy	SF	.60	56,000	33,600	28,000	61,600*
5. Interior Ceilings and Epoxy	SF	.35	141,000	49,350	56,400	105,750*
6. Insulation - Blown Cellulose	SF	.424	197,000	83,530	-	83,530*

* 100% Geothermal Related items
** 20% Geothermal Related Item (proportion of heated floor)

KHSAC CONSTRUCTION DETAIL Cont.

MATERIALS AND EQUIPMENT

	UNIT	COST/UNIT	NO. UNITS	SUBTOTAL	INSTALLATION COST	TOTAL COST
7. Walkways - 4' X 1200 LF	CY	$ 55	64	$ 3,520	$ 6,080	$ 9,600
8. Railings	LF	1.75	1,200	2,100	2,400	4,500
Subtotal				$ 944,820	$ 542,290	$1,487,110
D. Building Mechanical						
1. Fin Tube Heat Exchangers	LF	6.80	5,768	39,220	25,200	64,420*
2. Floor Heating Exchanger	Ea	1,980	1	1,980	990	2,970*
3. Exhaust Fans	Ea	393	113	44,410	13,560	57,970
4. Evaporative Coolers	Ea	63,000	21	63,000	15,120	78,120
5. Evaporative Ducts & Piping	LS	11,510	1	11,510	11,690	23,200
6. Coldwater Piping & Fixtures	LS	20,570	1	20,570	41,140	61,710
7. Hot Water Piping	LS	28,860	1	28,860	57,720	86,580*
				$ 209,550	$ 165,420	$ 374,970
E. Building Electrical						
1. Distribution Panels	LS	101,500	1	101,500	19,230	120,730
2. Buried Cable	LF	4.77	5,000	23,850	17,830	41,680
3. Transformers (3o KVA)	Ea	1,000	14	14,000	6,440	20,440
4. Flourescent Fixtures	Ea	20	770	15,400	53,130	68,530
5. Wiring (Romex)	LF	1.254	50,000	62,700	28,890	91,590
6. Duplex Receptacles	Ea	10	270	2,700	8,690	11,390
7. Motor Starters	LS	14,300	1	14,300	40,570	54,870
8. Thermostats and Fittings	LS	36,350	1	35,170	24,840	60,010*
Subtotal				$ 269,620	$ 199,620	$ 469,240

	MATERIALS AND EQUIPMENT					
	UNIT	COST/UNIT	NO. UNITS	SUBTOTAL	INSTALLATION COST	TOTAL COST
F. Building Agricultural Equipment						
1. Pens, Gates, Waterers, etc.	LS	$496,510	1	$ 496,510	$ 49,650	$ 546,160
2. Slats (Plastic)	LS	140,300	1	140,300	5,000	145,300
3. Automated Feed System (Internal)	LS	130,150	1	130,150	13,020	143,170
4. Feed Storage (External)	LS	35,000	1	35,000	5,250	40,250
5. Special Areas (Lab, Office, Lounge)	LS	5	2,400	12,000	12,000	24,000
Subtotal				$ 813,960	$ 84,920	$ 898,880
G. Specialized Agricultural Equipment						
1. Feed Mill, Equipment & Storage	LS	149,500	1	149,500	22,400	171,900
2. Sprouted Grain Growing Equipment	Ea	16,500	4	66,000	9,900	75,900
3. Maintenance Equipment (Shop, Veh.)	LS	27,500	1	27,500	4,000	31,500
4. Caustic Tank and Foundation	Ea	2,500	1	2,500	1,250	3,750
Subtotal				$ 245,500	$ 37,550	$ 283,050
H. Swine Waste System						
1. Methane Fermentation Tank, Foundation, Insulation	LS	121,290	1	121,290	22,430	143,720*
2. Methane Equipment	LS	77,007	1	77,010	22,200	99,210
3. Methane Piping & Compressor	LS	3,620	1	3,620	1,810	5,430*
4. Waste Flushing System	LS	38,622	1	38,620	50,210	88,830
5. Ponds and Liners	LS	7,700	1	7,700	8,500	16,200
6. Temporary Manure Storage	LS	7,500	1	7,500	3,750	11,250
Subtotal				$ 255,740	$ 108,900	$ 364,640

* 100% Geothermal Related Items

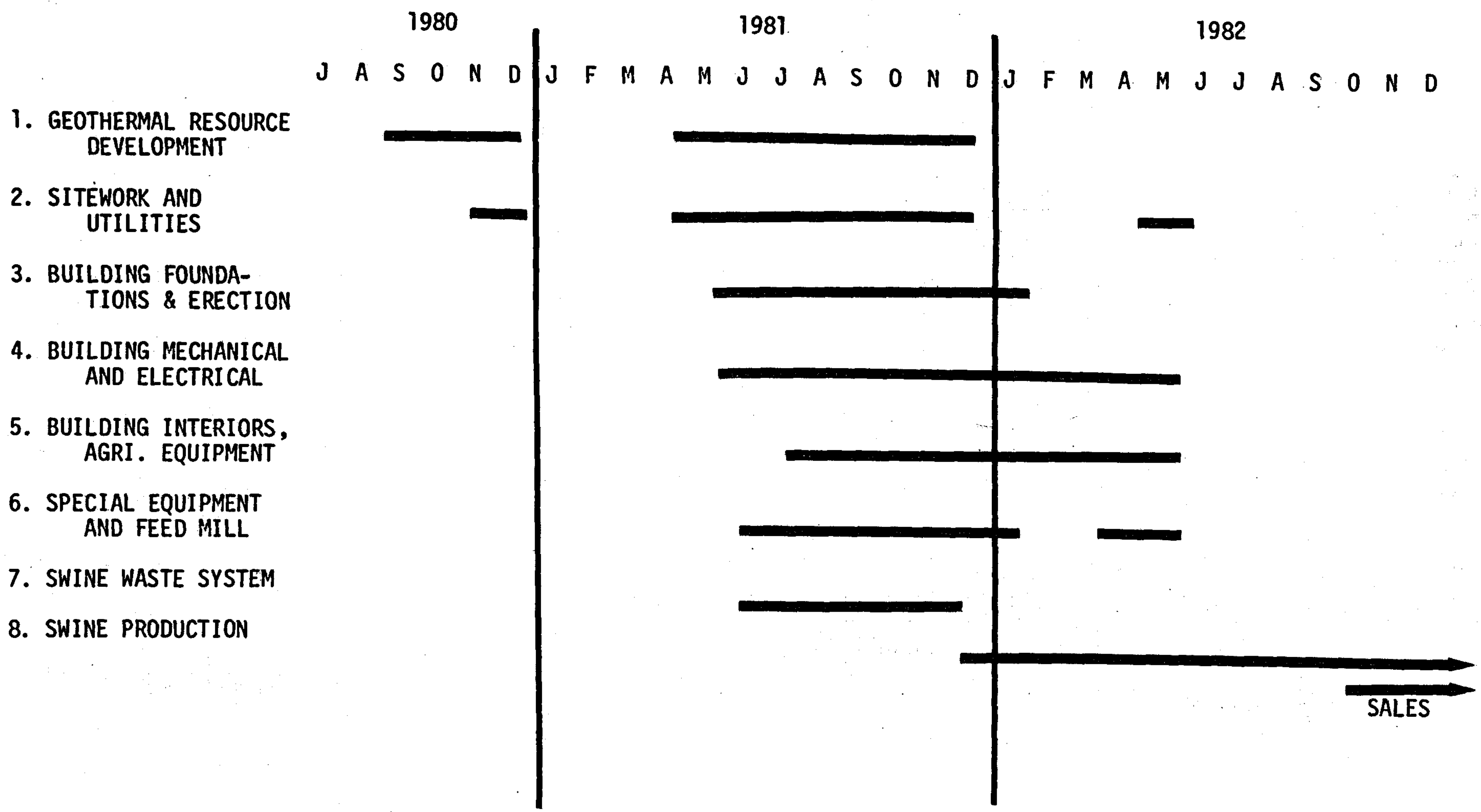
KHSAC CONSTRUCTION PLAN, Cont.

	MATERIALS AND EQUIPMENT					
	UNIT	COST/UNIT	NO. UNITS	SUBTOTAL	INSTALLATION COST	TOTAL COST
I. Site Utilities						
1. Domestic Water Well	LS	8,400	1	$ 8,400	$ -	$ 8,400
2. Domestic Water Pump & Tank	LS	3,490	1	3,490	1,800	5,290
3. Septic System (Human Waste)	LS	390	1	390	1,480	1,870
4. Hot Water Distribution Pipeline	LS	15,340	1	15,340	28,530	43,870*
5. Hot Water Supply Pumps	LS	1,300	1	1,300	980	2,280*
6. Hot Water Valves and Fittings	LS	4,450	1	4,450	3,410	7,860*
7. 200 KW Emergency Generator	LS	28,800	1	28,800	14,400	43,200
Subtotal				$ 62,170	$ 50,600	$ 112,770
TOTAL CONSTRUCTION COST				$3,320,300	$1,225,130	$4,545,430

* 100% Geothermal Related Items

Figure 3 - 1

KHSAC PRELIMINARY CONSTRUCTION SCHEDULE



CHAPTER 4 -- ECONOMIC ANALYSIS

I. MARKET CONSIDERATIONS

In 1978, California slaughtered over 1,600,000 hogs and pigs. Of these, California imported 1,337,000 head[13], up 37,000 from 1977. The proposed KHSAC output of 29,353 head is only 2% of the 1978 import figure and is less than the increase from 1977 to 1978. Therefore, the KHSAC impact on the import competition should be negligible. The KHSAC output represents only 1.8% of the hogs slaughtered in California.

Over 60% of the stock imported into California comes from Missouri and Nebraska. As transportation costs continue to rise faster than general inflation, these distant competitors will experience a greater profit squeeze on shipments to California.

Hog market economics revolve around feed cost conversion into revenue dollars. While KHSAC is close to a large pork market, it is also distant from traditional low cost corn-feed. The facility is designed to efficiently convert feed to meat, thus somewhat less feed to meat, thus somewhat less feed is required to produce a given hog weight relative to most competitors. But feed costs may still be relatively high. KHSAC is designed to counter potentially higher feed costs through:

- More efficient conversion of feed to prime, quality hogs (better environment).
- Higher financial leverage through geothermally related tax advantages and DOE support.
- Less marketing transportation costs.
- Reduced dependency on energy inflation.

From a marketing perspective, KHSAC output will not have a major impact on the market, and tradeoffs available to the agriculture complex indicate that it has the potential to be a viable project. Formal negotiation for feed purchase and transportation when compared to formal negotiations for hog sales and transportation will control the future economics of the project. Preliminary level information, as reflected in operating economics, is promising.

II. OPERATING ECONOMICS

A. Revenue - At the preliminary design level, revenue was calculated as design pounds of liveweight animals produced times anticipated revenue per pound plus an allowance for expected bio-gas sales. Chapter 2, "Engineering," provides the derivation of pounds produced. The revenue per pound projections were based on a long range assessment of historical hog prices and current expectations for hog prices over the next couple of years. Figure 4 - 1, "Hog Price Review," provides an overview relating projected hog prices with historical (trend line) events.

The hog price projection used for preliminary economic assessment is a series of prices escalating at 8% per year, shown in Figure 4 - 1. The first price used in the economic projection is 55.4¢ per pound in 1983. Published material and conversation sourced during this phase considered this projection conservative, especially for prime quality pork[37].

B. Operating Costs - At the preliminary level, operating costs were projected in twelve categories:

Feed - materials, additives, and sprout supplies
Labor - labor, management
Utilities - electricity, fuels
Materials - production supplies
Services - audit, legal, veterinarian
Tax and Insurance - property related
Depreciation - buildings, equipment, capitalized costs
Credit Line Interest - working capital funding

GPC - KHSAC

CALIFORNIA HOG PRICES AT STOCKTON

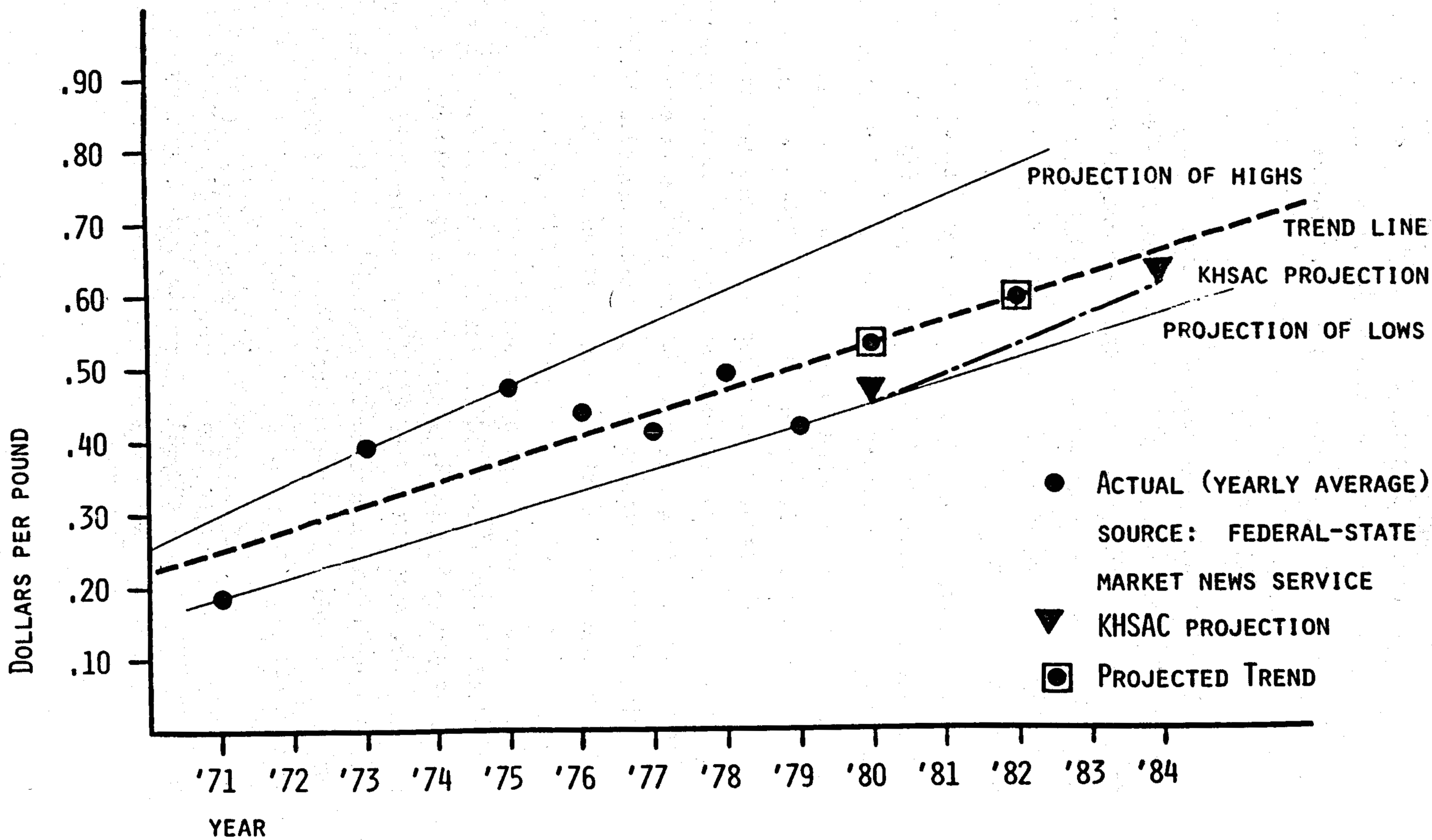


Figure 4-1, Hog Price Review

Amortized Construction Interest - 10 year
Amortized Working Capital Interest - 3 year
Long Term Interest - 20 year at 12.55%
Short Term Interest - 3 year at 6.17% (agriculture working capital)

Cost Estimates provided for each category were projected through 1986 to cover the equity payback period. These are presented in Table 4 - 1. The years after 1986 were projected by summary items only and are presented as Table 4 - 2. The preliminary data indicates an equity breakeven in 3.4 operating years and an equity internal rate of return of 28.4%.

The construction cost data available for the preliminary analysis had an early to middle 1980 base. This meant that escalation had to be applied against the cost estimates. Allowance for interest charges during construction also had to be made. Table 4 - 4 summarizes these calculations. Expenditures in mid-1980 dollars for each quarter were estimated. A 2½% escalation per quarter (compounded) was applied against the mid-1980 dollars to arrive at an expected construction cost per quarter. The analysis assumed that debt would be incurred at the beginning of the quarter and interest paid at the end of the quarter. Actually, interest was not paid, interest due was just added to the loan principal. Interest charges were 3% per quarter for a compounded rate of 12.55%. Total escalated construction costs amounted to $6,098,627. With interest added, the total was $6,696,945 with a loan of $3,952,562 to be paid from operations over 20 years. Annual debt services were $540,553. Interest during construction amounted to $598,318 and interest paid during repayment totalled $6,858,492. The repayment schedule is shown in Table 4 - 5. Contribution to construction costs were:

$1,344,000	Dept. of Energy (20%)
3,952,562	Debt (59%)
1,400,383	Equity (21%)
$6,696,945	Total (100%)

TABLE 4 -1

KELLEY HOT SPRING AGRICULTURAL CENTER - Operating Summary - 1st 4 Years

Revenues	1983	1984	1985	1986
Pounds pork	6692484	6692484	6692484	6692484
Price per pound	.554	.599	.647	.699
Pork Sales	$3707636	$4008798	$4330037	$4678046
Bio-gas Sales	148928	162332	176942	192866
	$3856564	$4171130	$4506979	$4870912
Costs of Production				
Feed	$2099940	$2267935	$2449369	$2645318
Labor	328886	355196	383612	441301
Utilities	73002	80302	88332	97167
Materials	15117	16326	17632	19042
Services	30233	32652	35264	38085
Tax & Insurance	79192	85527	92370	99759
Depreciation	404399	404399	404399	404399
Credit Line Interest	80000	86400	93312	100777
	$3110769	$3328737	$3564290	$3845848
Other Cost Items				
Amortization (10 year interest)	$ 59832	$ 59832	$ 59832	$ 59832
Amortization (3 year interest)	15323	15323	15323	-----
	$ 75155	$ 75155	$ 75155	$ 59832
Earnings Before Interest & Taxes (EBIT)				
EBIT	$ 670640	$ 767238	$ 867534	$ 965233
Long Term Interest	493395	487124	480020	471970
Short Term Interest	16490	10293	3714	------
Earnings Before Tax (EBT)				
EBT	$ 160755	$ 269821	$ 383800	$ 493263
Tax(46% Fed + 9% Cal)	88415	148402	211090	271295
Earnings After Tax*	$ 72340	$ 121419	$ 172710	$ 221968

* Does not consider tax credits which appear on cash sources and uses summary schedule.

TABLE 4 -2

KELLEY HOT SPRING AGRICULTURAL CENTER - Cash Sources and Uses Summary - Sources(Uses)(000's)

Year	EAT	ITC BEC	Depr.	Int. Amort.	DOE	Princ-ipal	Credit Line	Capital Assets	Working Capital	Equity	Equity Balance
1980	----	---	---	(7)	97	250	----	(442)	------	102	(102)
1981	----	---	---	(157)	947	2580	----	(4296)	(86)	1012	(1114)
1982	----	---	---	(480)	300	1443	1000	(1361)	(1756)	854	(1968)
1983	72	110	404	75	---	(148)	80	------	(147)	(446)	(1522)
1984	121	172	404	75	---	(160)	86	------	(159)	(539)	(983)
1985	173	237	404	75	---	(174)	93	------	(172)	(636)	(347)
1986	222	299	404	60	---	(69)	101	------	(186)	(831)	484
1987	288	382	404	60	---	(78)	109	(32)	(200)	(933)	1417
1988	352	---	404	60	---	(88)	118	------	(217)	(629)	2046
1989	423	2	404	60	---	(100)	127	(33)	(234)	(649)	2695
1990	501	---	404	60	---	(113)	137	------	(253)	(736)	3431
1991	587	16	404	60	---	(128)	148	(193)	(273)	(621)	4052
1992	682	---	404	60	---	(145)	160	------	(295)	(866)	4918
1993	818	170	404	-----	---	(164)	173	(1797)	(318)	714	4204
1994	941	---	404	-----	---	(186)	187	------	(344)	(1002)	5206
1995	1077	3	404	-----	---	(211)	201	(65)	(371)	(1038)	6244
1996	1299	---	404	-----	---	(239)	218	------	(401)	(1281)	7525
1997	1399	---	404	-----	---	(271)	235	------	(433)	(1334)	8859
1998	1416	51	404	-----	---	(307)	254	(514)	(467)	(837)	9696
1999	1800	16	404	-----	---	(348)	274	(193)	(505)	(1448)	11144
2000	2046	---	404	-----	---	(394)	296	------	(545)	(1807)	12951
2001	2311	2	404	-----	---	(446)	320	(33)	(589)	(1969)	14920
2002	2605	---	404	-----	---	(506)	345	------	(636)	(2212)	17132
2003	2920	305	404	-----	---	-----	373	(3315)	(687)	------	17132
2004	3253	---	404	-----	---	-----	403	------	(742)	(3318)	20450
2005	3623	---	404	-----	---	-----	435	------	(801)	(3661)	24111
2006	4036	---	404	-----	---	-----	470	------	(865)	(4045)	28156
2007	4496	19	404	-----	---	-----	507	(226)	(934)	(4266)	32422
2008	5009	---	404	-----	---	-----	548	------	(1009)	(4952)	37374
2009	5580	---	404	-----	---	-----	592	------	(1090)	(5486)	42860
2010	6216	---	404	-----	---	-----	639	------	(1177)	(6082)	48942
2011	6924	1	404	-----	---	-----	690	(32)	(1271)	(6716)	55658
2012	7713	---	404	-----	---	-----	745	------	(1373)	(7489)	63147
									Terminal Value:	25000	88147

Equity payback in 3.4 operating years
Equity Internal Rate of Return: 28.4%

EAT: Earnings after tax
ITC: Investment tax credit
BEC: Business energy credit
Depr.: Depreciation
Int.: Interest
Amort.: Amortization
DOE: Dept. of Energy

TABLE 4-3

COMPARISON OF OPERATING COSTS

	Basic Operating Costs Per Hundred Weight					
	Feed	Labor	Other	Total	Fixed	Total
KHSAC (1979)	23.06	3.61	3.05	29.72	10.87	40.59
A. (1978)	24.15	3.97	5.95	34.07	4.04	38.12
B. (1978)	18.42	2.76	3.84	25.02	5.78	30.81
C. (1979)	23.95	4.45	4.20	32.60	8.40	41.00
D. (1978)	20.08*	7.93*	1.28*	29.29*	5.83*	35.12

*Arrived at by using assumptions in the text of their material to allow for outside labor costs.

A. Missouri Cooperative Extension Service[84].

B. University of Minnesota[41] ($3.50/hr. labor charge added)

C. Government Statistics[96].

D. Iowa Cooperative Extension Service[34].

TABLE 4-4

CONSTRUCTION COSTS

Mo./Yr.	Quarter	1980 Cost Base	Escalation Factor	Construction	55% Bank	3%/Qtr. Interest	Cumulative
10/80	1	431,182	1.025	441,962	243,079	7,292	250,371
1/81	2	123,195	1.051	129,478	71,213	9,648	331,232
4/81	3	862,363	1.077	928,765	510,821	15,325	857,378
7/81	4	1,355,143	1.104	1,496,078	822,843	50,407	1,730,627
10/81	5	1,539,935	1.131	1,741,666	957,916	80,656	2,769,199
1/82	6	862,363	1.160	1,000,341	550,188	99,582	3,418,969
4/82	7	303,059	1.189	360,337	198,185	108,515	3,725,669
7/82	8		1.218			111,770	3,837,439
10/82	9		1.249			115,123	3,952,562

TABLE 4-5

LONG TERM DEBT SERVICE

Monthly Payment	$45,046.05
Annual Debt Service	$540,552.64

Year	Principal	Interest
1983 = 1	$47,158	$493,395
2	53,428	487,124
3	60,533	480,020
4	68,583	471,970
5	77,702	462,850
6	88,035	452,518
7	99,742	440,811
8	113,005	427,548
9	128,032	412,521
10	145,057	395,495
11	164,346	376,206
12	186,201	354,352
13	210,961	329,592
14	239,014	301,539
15	270,797	269,756
16	306,807	233,746
17	347,605	192,948
18	393,828	146,725
19	446,198	94,355
20	505,532	35,021

TABLE 4-6
CAPITAL ASSET CLASSIFICATIONS

Item (ADR Class)	Life	Cost	Annual Depreciation	% ITC Qual.	10% ITC	15% BEC
A. Geothermal Resource (13.1) ($373,000 IDC)	6	$ 33,000	$ 5,500	100	$ 2,200*	$ 4,950
B. Sitework (00.3) (12,000 land cost)	20	136,770	6,839	0	0	0
C. Building Structures (01.3)	20	1,487,110	74,356	90	133,840	200,760
D. Building Mechanical (01.1)	10	300,000	30,000	100	30,000	45,000
Building Mechanical (01.1)	8	74,970	9,371	100	7,497	11,246
E. Building Electrical (00.11)	10	400,000	40,000	90	36,000	54,000
Building Electrical (00.11)	8	69,240	8,655	90	6,232	9,347
F. Building Agriculture Equipment (01.1)	10	898,880	89,888	95	85,394	0
G. Specialized Agriculture Equipment (20.1)	15	251,550	16,770	100	25,155*	0
(00.241)	4	31,500	7,875	100	1,050	0
H. Swine Waste System (49.5)	10	102,510	10,251	100	10,251	15,377
(49.23)	15	262,130	17,475	100	26,213	39,320
I. Site Utilities (01.1)	10	95,470	9,547	90	8,592	7,160 (50%)
	8	17,300	2,163	90	1,557	1,298 (50%)
Software Costs (01.3)	20	465,905	23,295	90	41,932	62,897
(01.1,00.11,70.2)	10	232,953	23,295	90	20,966	31,449
(01.1,00.11,70.2)	8	232,952	29,119	90	20,966	31,449
		$5,092,240	$404,399		$457,845	$514,253

ADR: IRS class life Asset Depreciation Range system
BEC: Business Energy Credit
IDC: Intangible Drilling Costs
ITC: Investment Tax Credit

*Special tax rules apply for life under 7 years

Capital asset classification for depreciation, investment tax credits (ITC), and business energy credits (BEC), are presented in Table 4 - 6. Total annual straight line depreciation amounted to $404,399., ITC was $457,845., and BEC was $514,253.

The capital asset replacement and rehabilitation expense shown in Table 4 - 2 are allowances for asset rehabilitation and replacement over the life of the project. Replacements will be at a much higher cost, but only some of the equipment and fixtures, and buildings. To allow for these costs, at the end of each asset's life, a capital investment is made for the original 1980 cost value and the depreciation stream is repeated. ITC is taken, but BEC is not as it may expire in the next few years.

TABLE 4-7

REPLACEMENT-REHABILITATION SCHEDULE
(Does not include software costs)

Life	Costs	Depreciation	ITC
4*	31,500	7,875	1,050
6	33,000	5,500	2,200
8	161,510	20,189	15,286
10	1,796,860	179,686	170,237
15	513,680	34,245	51,368
20**	1,487,110	74,356	133,840

*Replacement only, rehabilitation less than 5 years does not qualify for ITC. Other lifes are a mix of replacement and qualifying rehabilitation.

**Sitework excluded. Fence, security, and roads rehabilitation is considered a part of the allowance for building structures.

Table 4 - 7 sorts the data from Table 4 - 6 (asset classification) by

life and is the basis for capital asset replacement and rehabilitation. There is a substantial project "overhaul" shown for the year 2003, $3,315,000. This would be a major project rehabilitation of equipment, fixtures, buildings, and grounds after 20 years of operation. While sounding high, the value discounted at 8% to its 1980 equivalent is only just over $520,000.

Working capital is made up of stock purchases, feed, labor, interest charge, and a required cash balance net of some biogas sales and stock sales before formal operating status January 1, 1983. The 1980 cost estimates were escalated 2% per quarter as shown in Table 4 - 9. The demand for the working capital item was expressed as an average loading factor for the quarter (100% being a fully loaded system) which resulted in a total escalated working capital need. Seventy percent of the required working capital funds were assumed borrowed with quarterly 1½% interest added to the principal until operating revenue began. There were some one time purchases made in the seventh quarter, see Table 4 - 8. Total working capital was $1,841,343:

$1,269,987	Buildup
550,600	One time feed and base herd purchases
12,000	Cash
45,970	Interest
(33,534)	Biogas sales
(3,680)	Base herd reject sales
$1,841,343	Net Working Capital

The total working capital debt amounted to $1,320,381. When operations began in 1983, an operational line of credit was opened for $1,000,000. and $320,381. was refinanced for a 3-year payback at a 6.2% interest rate. Interest on the line of credit was set at 8%, see Table 4 - 10.

TABLE 4-8

ONE TIME WORKING CAPITAL PURCHASES

One Time Quarter 7	Total	70% Loan	Interest	Bank Cumulative
280 sows X 5 mo. X $200. ea.	$280,000			
72 boars X $300 ea.	21,600			
Feed Inventory	249,000			
Q7	$550,600	385,420	5,781	391,201
Q8		-0-	5,868	397,069
Q9		-0-	5,956	403,025
			17,605	

As each herd member is replaced, the cost of the replacement is capitalized, an investment tax credit is taken immediately, depreciation is taken over the next few years, and depreciation recovery and salvage are realized when the animal is replaced. The net effect on this preliminary analysis is not significant. For this analysis, sales of replaced herd members are considered equal to the cost of replacement and not dealt with separately. Also, the cost of handling solid wastes was considered equal to solid waste revenue, and the costs associated with liquid waste disposal were considered equal to irrigation or irrigated crop revenues.

Because there are no hydrothermal sales, depletion was not considered within this analysis. If a separate hydrothermal entity owned and sold hydrothermal energy to the project, a depletion allowance for that entity might be established. The entity must have an at risk investment in intangible drilling cost items to qualify for the deduction. As Department of Energy funds are expected to fund the intangible drilling cost items in this project, the special deduction is not taken. Use of depletion and intangible drilling cost tax advantages would show little improvement in owner equity payback and only slight improvement in the owner equity internal

TABLE 4-9

WORKING CAPITAL BUILDUP

Mo./Yr.	Quarter	Escal. Factor	Total	Base Herd Feed	Inv. Herd Feed	Labor	Utilities	Materials	Services	Ins.	70% Loan	1½%/Qtr. Interest	Bank Cumm.
Annual Base Amount		1.000		$170974	$1496026	$261,080	$48000	$12000	$24000				
10/81	5	1.104	85651	9438(20)		36029(50)	13148(100)	3312(100)	6624(100)	17000	59956	899	60855
1/82	6	1.126	128701	28878(60)	21057(5)	55121(75)	13512(100)	3378(100)	6756(100)	0	90091	2264	153210
4/82	7	1.149	191210	49112(100)	42973(10)	74995(100)	13788(100)	3447(100)	6894(100)	0	133847	4306	291363
7/82	8	1.172	282704	50095(100)	131501(30)	76496(100)	14064(100)	3516(100)	7032(100)	0	197893	7339	496594
10/82	9	1.195	581721	51078(100)	357550(80)	77998(100)	14340(100)	3585(100)	7170(100)	70000	407205	13557	917356
			$1269987	$188601	$553081	$320639	$68952	$17238	$34476	$87000		$28365	$917356

TABLE 4-10

WORKING CAPITAL LOAN PAYBACK

Amount $320,381

Monthly Payment $24,958

Annual Payment $299,491

Year	Principal	Interest
1983 = 1	$100,470	$16,490
2	106,666	10,293
3	113,245	3,714

rate of return.

Operating costs estimates were compared to several published references to test for major variations. A summary of the comparisons is shown in Table 4 - 3. Costs were expected to be relatively higher because of current high construction costs. However, because the facility has been efficiently designed, uses energy efficient practices, and has energy supplied from geothermal, the facility operating costs are expected to be increasingly competitive over time.

Increasing competitiveness is expected to be a result of:

- Less dependence on energy inflation.
- Higher feed conversion than other operations which will be forced to conserve energy.
- Increasingly lower hog transportation costs relative to midwest shippers.
- Lower construction costs relative to those who must build or rebuild in future years.
- Tax advantages, especially until all tax credits have been taken.

C. <u>Sources and Uses of Cash</u> - A conceptual summary of major sources and uses of cash was prepared to determine the resulting payback period, see Table 4 - 2. The typical (ongoing) sources and uses consider earnings after tax as the major source. Depreciation and tax credits and interest amortization allowances are also sources to correct the non-cash expenses used in calculating after tax earnings. Increased funding from the credit line is also a cash source. Uses of cash are principal payments, capital asset replacement-rehabilitation, working capital increases, and equity draws.

Table 4 - 2 covers the sources and uses projection through the year 2012. The equity cash balance is shown at the right of the table and reflects an owner cash payback in 1986, a payback in 3.4 operating years. A payback of six to seven years was considered an upper limit[41].

D. <u>Preliminary Economic Assessment</u> - The preliminary level revenue and cost projections indicate that the project is viable with an expected owner cash payback within four years of operation. However, the actual outcome is very sensitive to revenue per pound, feed costs, and full production marketing.

Revenue per pound was projected conservatively over the projected period per Figure 4 - 1. Feed costs are at expected costs (neither optimistic nor pessimistic) and full production marketing is expected to be realized in the California market. Because optimistic projections were not used on any of the key variables and overall costs were in line with available comparisons, the preliminary economic projection appears reasonable.

The preliminary projections lack many details which will become available in the next phases of the project. Cogeneration revenues, throughput, and interest rate changes may change operating earnings and payback. Once building and equipment lists are complete, accelerated depreciation schedules can also be run to delay tax payments even further (an improvement in the long term but not significant within the owner cash payback period). Specific equity structure will also allow more detailed scheduling and costing of the debt service and may even introduce favorable debt terms such as FMHA guarantees. If the equity holders have other earning to take immediate benefit of the tax credits, equity payback could be reduced to under 3 years.

Other significant favorable or unfavorable impacts will most likely occur: informal negotiation for feed costs (including transportation), formal marketing arrangements (including price per pound, transportation, and commissions or fees), and outside services. The level of outside services will be inverse to the caliber of inhouse people, that is, strong inhouse bookkeeping, animal husbandry, marketing, and purchasing capabilities will significantly reduce use of outside services and enhance operating profits. Inhouse weaknesses in these areas will reduce operating margins and increase needed outside services, a double penalty. Outside services include tax counsel, legal, counsel, audit, and veterinarian services.

Other details which must be identified or more clearly detailed during the next phase are:

- Verified costs by category
- Investment tax credit qualifications
- Business energy credit qualifications
- Depletion qualification
- First-year depreciation bonuses
- Accelerated depreciation schedules
- Inventory, personal property, and real estate taxes
- Separate state and federal tax calculations
- Licensing and insurance requirements
- Marketing agreement specifics
- Feed procurement specifics
- Hog and feed transportation costs
- Equipment and facility overhaul and replacement costs
- More firm construciton schedules
- More firm operations startup schedules
- More definite equity structure
- More clear financing requirements, fees, and rates
- Appropriate working capital levels and growth
- Production throughput levels

Using the 1983 and 1986 earnings before tax (EBT) information shown in Table 4 - 1, Operating Summary, per pound statistics can be broken out as follows:

	1983	1986
Sales	55.4¢	69.9¢
Feed	31.4¢	39.5¢
Non-Feed	21.6	23.0
Total Cost	53.0¢	62.5¢
EBT	2.4¢	7.4¢

An EBT breakeven means that all operating statement costs are covered including non-cash items. Calculating a sales EBT breakeven results in:

	1983	1986
Sales	53.0¢ (4.3%)*	62.5¢ (10.6%)*
Feed	31.4¢	39.5¢
Non-Feed	21.6	23.0
Total Cost	53.0¢	62.5¢
EBT	00.0¢	00.0¢

*Percent reduction until breakeven occurs.

Recalculating the Table 4 - 1 information for a feed cost EBT breakeven results in:

	1983	1986
Sales	55.4¢	69.9¢
Feed	33.8¢ (7.6%)*	46.9¢ (18.7%)
Non-Feed	21.6	23.0
Total Cost	55.4¢	69.9¢
EBT	00.0¢	00.0¢

*Percent increase until breakeven occurs.

For basic cash breakeven calculations, depreciation and amortization expenses are replaced by principal payments. The preliminary per pound cash statistics are:

For basic cash breakeven calculations, depreciation and amortization expenses are replaced by principal payments. The preliminary per pound cash statistics are:

	1983	1986
Sales	55.4¢	69.9¢
Feed	31.4¢	39.5¢
Non-Feed	16.6	17.1
Total Cost	48.0¢	56.6¢
Cash	7.4¢	13.3¢

Calculating a sales price cash breakeven results in

	1983	1986
Sales	48.0¢ (13.4%)*	56.6¢ (19.0%)*
Feed	31.4¢	39.5¢
Non-Feed	21.6	17.1
Total cash	48.0¢	56.6¢
Cash	00.0¢	00.0¢

*Percent reduction until breakeven occurs.

Recalculating for a feed cost cash breakeven results in:

	1983	1986
Sales	55.4¢	69.9¢
Feed	38.8¢ (23.6%)*	52.8¢ (33.7%)*
Non-Feed	16.6	17.1
Total cash	55.4¢	69.9¢
Cash	00.0¢	00.0¢

*Percent increase until breakeven occurs.

Given the preliminary status of the project as covered here, the economic assessment of the project appears favorable based on the data as collected, analized and presented by the Team Members. We have no reasonable grounds to believe, and do not believe at the time of preparing this preliminary design report, that any of the assumptions or information provided to us are unreasonable, unreliable, or untrue or that there has been an omission of any material fact important to the continuation of the project where many of the costs and parameters will be further identified and evaluated.

CHAPTER 5

CONSIDERATIONS FOR CONSTRUCTION DESIGN

In completing the Preliminary Design, specific data required for completion of final or construction design have been identified. These have been included here in order to assist in planning the final design and construction phase.

Data Required for Construction Design

- Tests for geothermal fluid temperature and flow rate.
- Site survey and soil sample tests for foundation design.
- Geothermal water analysis and material testing for corrosion and scaling and potential consumptive use.
- Fresh water analysis for potability and mineral content (affects feed formulation).
- Detailed methane yield analysis and/or testing.
- Maintenance Plan including spares inventory.
- Startup and Test Plan.
- Extend reviews of existing commercial operations and latest equipment developments in swine raising and methane production.
- Modification, if any, in pen layout, watering and other physical design impacts of specific animal management practices to be utilized by the permanent operator.

Planning Affecting Construction, Startup and Operations

- Negotiated cogeneration rates for sale of methane and purchase of electric power.
- Specific business structure and planning to affect optimum utilization of tax credits and to maximize earnings and rate of payback, (Chapter 4).
- Plan for optimum utilization of Federal share, private share; total project tax and finance planning.

- Negotiations for feed supplies contracts.
- Pork sales contracts.
- Purchase of brood stock for a common base of immunization to minimize health problems resulting from animals being supplied from multiple outside breeders. Care must be exercised in this area until the facility can develop its own Specific Pathogen Free (SPF) herd. This is a first priority effort to meet the delivery requirements from a minimum number of suppliers for project startup.
- Search for and development of competent in-facility permanent staff.
- Land use planning with the cognizant local government entity to assure normal local permitting and to mitigate potential socio-political barriers, if any.

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APPENDIX A

The following description of the Trade Studies has been excerpted from the Kelley Hot Spring Project Topical Report GT-27041-4, dated June 1980, unpublished. The information has been included in order to preclude unnecessary duplication of effort in the future applications of this project.

It should be noted that the Trade Studies conclusions/findings included herein were determined prior to completion of Conceptual Design. The results of the Conceptual Design and of the Economic Analysis of that design led to a review of these Trade Study conclusions. The criteria for the subsequent Preliminary Design, as defined by the Project Office, differ from certain Trade Study results as presented herein. Overall economics was the primary factor influencing the differences between the Conceptual and the Preliminary designs.

III. TRADE STUDIES

A. Agriscience

1. Introduction - The reader should note that, besides cost, operational practices are the main determinant of agriscience trade study outcomes. The scopes and methodoligies of agriscience trades are discussed as applicable in the following III.A.1. subsections; results are discussed in subsection III.C. The selected options are underlined for reference.

2. Gutter Type - Three types of gutter systems were compared: pit under slats; open flush gutter; and flush gutter under slats.

The pit under slats system is subject to manure buildup between labor intensive cleanings that results in gas buildup and threats to health and sanitation. This method requires more gutter space than the other alternatives.

The open flush gutter system, while the least expensive alternative, is the worst case for animal health as there is excess animal exposure to manure through wallowing, with consequent exposure to herd cross-contamination.

The flush gutter under slats system is best from health, sanitation, and operational efficiency standpoints. Of the gutter alternatives, the flush gutter under slats, results in the smallest sized and lowest gas and humidity buildups.

3. Slat Material - Materials considered were polyvinyl chloride (PVC), concrete, aligned fiber composites, and stainless steel. PVC slats have no commercial record of lasting performance.

Concrete slats are relatively difficult to install and maintain and are easily eroded in practice.

Aligned fiber composites have a proven commercial record, are easily sanitized and replaced, are sold with a 5-year warranty, and maintain surface finish such that animal defecation in the dunging area is maximized.

Stainless steel slats, while strong per unit weight, are expensive, have poor surface finish, and feel cold to hogs. Typically, they are only used in farrowing when used at all.

4. Aquaculture - The decision to not include this option was excluded by direction.

5. Feed Source - The cost of milling feed on site from purchased ingredients was compared to purchase of commercially formulated feed. Milling on site indicated a 17-22% cost saving over feed purchase. The actual saving is a function of raw material availability and cost, transportation cost, equipment sizing, and operational techniques. (References 24, 91A, 92, 94, 95, 8*, 12*).

6. Growth and Feed Sprouts - This option was eliminated by the Project Office on a programmatic basis at the conceptual design level; it has been reintroduced for the preliminary design as is described in Chapter 7.

7. Feed Contents - Existing non-proprietary formulations were compared. (References 6, 32).

8. Alcohol Production Byproduct Use - Grain alcohol by-products could be utilized in feed formulations if such a facility were built on-site or nearby. Alcohol production design was not in the scope of KHSAC effort. A power ethanol production facility sized for about 800,000 gal/year could furnish stillage for the feedmill of a 1200 sow complex.

9. Protein Extraction - The practice of manure solids separation and reutilization has been practiced in the beef industry, but has not yet been commercially demonstrated for swine. (References 9, 48, 16*, 45*).

10. Finish Hog Weight - Finish liveweight hogs of 220 to 240 pounds were considered in terms of production efficiency, commercial practice, and existing slaughter facilities. A nominal live weight of 228 lbs. has been used for the conceptual design.

11. Water Disposal - Flushing water disposal methods considered were: injection; disposal to waterways; evaporation and field irrigation.

B. Civil, Electrical, and Mechanical Engineering

1. Introduction - Subject to criteria and criteria applications previously discussed, alternative design arrangements were evaluated for the civil, electrical, and mechanical engineering features of the project buildings, utilities, and energy systems. Commercial practice, low cost, technical merit, and practical constructability were major factors considered in selecting the most appropriate alternative in each trade study case.

Scopes and methodologies of the trade studies are discussed as applicable in the following B. subsections; results of the trade studies are discussed under C following.

The reader should note that many of the trade studies are performed in an iterative manner with conceptual design and preliminary design developments. Hence results are not always the same as trade studies performed without respect to the ongoing overall design process.

2. Building Type - A comparative cost study was made for six types of building materials and construction methods for the project building:

- reinforced concrete poured-in-place
- precast concrete tilted up
- concrete blocks
- wood framed walls with exterior stucco
- metal stud walls with aluminum siding
- metal stud walls with galvanized iron siding

The cost study determined labor cost, material costs, and the total cost for each item required to construct the walls with each type of building material and method of construction. Since only comparative costs were required, comparisons were made only of relative costs for constructing the exterior walls of each building using the most economical and suitable roof and ceiling systems for each type of construction. Therefore, these studies reflect the relative costs per square foot of usable building space to construct the exterior walls of each building. The 1978 Dodge Construction Systems Costs Calculation Method incorporates a correction factor to account for the different shape and size of each building.

Although the comparative costs per square foot of building varied with building size and shape, metal stud walls with galvanized iron siding were consistently the least expensive option with exterior wall costs per square foot ranging from $0.69 (least expensive building) to $2.17 (most expensive building). Corresponding per-square-foot wall costs for least and most expensive buildings are: $1.65 - $5.23 for pour-in-place concrete; $2.00 - $6.33 for precast concrete; $1.12 - $3.54 for concrete blocks; $0.84 - $2.64 for wood with stucco; and $0.82 - $2.59 for metal stud with aluminum siding (References 28, 99).

3. Insulation Type - Comparative cost studies on a per square foot basis were performed for four types of insulation at various insulation ("R") values. The materials considered were:

- cellulose, fireproof (borate treated)
- sprayed on urethane
- fiberglass batt
- rigid polyurethane

Compatibility with building type was a factor that also impacted selection.

4. Insulation Thickness - Insulation thickness selection was based on a R value of 23 in accordance with the usable wall thickness.

5. Floor Type - Floor type, concrete, was the direct result of agriscience criteria applications.

6. Gutters - Open gutter drains were designed to be flat in cross section for economy of construction, having a curved radius at the intersection with vertical walls for ease of washdown and low maintenance, and of depths and slope sufficient to permit efficient,

sanitary flushing. These gutters will be covered with slats as selected from the trade studies. This trade was resolved through design process. (References 26, 52).

7. Swine Effluent Ponding - Normal matched cut and fill methodology was used for ponds. As ponds are to be lined to prevent groundwater pollution, costs per square foot for bentonite and sheet type film liners were compared.

8. Swine Waste Solids Separation - Three types of swine waste solids separation were studied:

- gravity settling
- screening
- mechanical separation

Gravity solids settling in ponds requires redundant ponds to allow for isolation from the inflow, a period for dewatering of each pond, and then the periodic removal, transport, and disposal of the remaining sludge. This method requires about 10 acres of additional land.

Screens for separation of residues require duplex or continuous operating strainers with a minimum of one operator in attendance. Maintenance work on the strainers would be extensive.

The mechanical separator is more or less a hybrid method of the other two alternatives. It consists of a conveyor belt located on the bottom and sloping sides of a small settling pond. Solids settling to the bottom are then removed by running the conveyors.

It should be noted that this option would be used if manure separation is retained in final design.

9. Manure Transport - Agriscience criteria applications directed use of flush gutters. The use of recycled water for flush was investigated for all buildings except farrowing and nursery (where disease control requires fresh flush water).

10. Human Wastes Disposal - Costs were compared for a

septic tank and leach field system versus a 1000 gallon per day sewage treatment plant.

11. Pig Carcass Disposal - Good "housekeeping" practice requires that the carcasses of occasional pig mortalities be disposed of as fast as possible. Alternatives studied included: a sodium hydroxide tank of precast concrete lined with coal tar; a gas fired incinerator; and use of a rendering truck service. The truck was ruled out because of its likelihood of introducing disease to the KHSAC complex.

12. Floor Heating - The nursery and farrowing areas are to have hot water floor heating for piglets. Floor heating for the other buildings was found to not be cost competitive with space heating.

13. Space Heating - Costs were compared for space, wall, and floor heating. Space heating modes investigated included fan coil units, bare pipe in the supply air plenum, and fin tube pipe in the supply plenum.

14. Wall Heating - Wall heating systems evaluated were: pipe in wall; exposed pipe, pipe with metal guards, and exposed fin tube pipe. None of these options were selected because of high cost.

15. Exhaust Air Heat Recovery - The costs of energy recovery utilizing air-to-air hear exchange methods for preheating building supply air were determined. However, the exhaust air is not discharged into a common duct in any of the buildings and extensive additional ductwork would be required to employ a waste heat recovery system. This was not selected.

16. Cascade Heating System - This system is effective in using geothermal heat for the three ranges of temperatures needed by the three subsystems. Systems are piped in series as applicable to utilize the progressively declining fluid temperatures. Consequently, the geothermal fluid flow is reduced, conserving the pumping energy required and the flow demand from the reservoir. Geothermal fluid will be pumped into a primary heat exchanger and then into the reinjection well to minimize possible scaling or corrosion resulting from geothermal fluid. A closed

loop heating system will be used to flow clean heated water for all subsystem heat applications: into the swine house space heating subsystems in parallel with the methanation subsystem, then to floor heating, and then back to the heat exchanger as is schematically shown in a later section.

17. Type of Buried Geothermal Piping - Four types of piping were compared for per-lineal-foot costs of 6 inch nominal diameter pipe: asbestos cement ($7.15); welded Schedule 40 black steel ($27.00); grooved Schedule 40 black steel (19.50); and "Temp-Tite", a preinsulated asbestos cement type ($11.40). (References 70, 71, 99).

It should be noted that insulation on buried piping is impractical for short runs of pipe where the heat source is effectively unlimited. The maximum heat loss for 6 inch diameter "Transite" (asbestos cement) pipe buried 3 feet deep in soil of high thermal conductivity is only $2^{\circ}F$ per 1000 linear feet for $180^{\circ}F$ water flowing at 325 gpm with the soil surface at $35^{\circ}F$ (Reference 99).

18. Thermal Storage - Costs of thermal storage to levelize loads were investigated. Thermal storage would require a 50,000 gallon insulated tank and appurtenances; these costs were compared to costs for standby geothermal pumping capability. This was not selected.

19. Primary Geothermal to Heating Water Heat Exchanger - Three types of heat exchangers were economically evaluated: shell and tube type; spiral type; and flat plate type heat exchanger.

The design flow for the heat exchangers is 325 gpm with fluid temperature changes of $60^{\circ}F$ on both primary and secondary sides of the exchanger. Maximum geothermal design water temperature is $208^{\circ}F$. Type 316 stainless steel in contact with geothermal fluids was selected to minimize corrosion.

The quality of the geothermal fluids has not been verified. In the event that the fluids have minimum scaling affinity and corrosive chemicals are not present in detrimental quantities, then the heat exchanger could be eliminated from the project at a later date with resultant cost savings.

20. Deicing of Sidewalks - The alternatives considered were: embedding 1-inch diameter black iron hot water pipe on 12-inch cneters in the concrete; and use of rock salt. PVC embedded pipe was excluded due to lack of structural integrity in cases of concrete cracking.

21. Geothermal Supply Pump - Engineering experience dictates that the supply geothermal water pumps shall be vertical turbines with oil lubricated drive lines. Each pump shall be capable of deliv-erying 325 gpm of 208^{o}F water at 250-foot total head. This pump should have a minimum 5-year life, depending upon corrosive effects of the fluids.

22. Geothermal Reinjection Pump - The pressure for reinjection at the disposal wells has not been determined. In the event that this pressure is low, no reinjection pump would be required. Nor-mally, the geothermal well pumps supply fluids at a pressure to overcome system friction losses, plus an overpressure which is maintained to reduce flashing of off-gases from the fluids. Off-gases could promote the depositing of carbonate scale. This maintained overpressure should, under normal design conditions, preclude need for a booster pump for well reinjection. However, because of the unknown reinjection strata, the conceptual design includes a reinjection well pump until it is veri-field as not required.

A split case horizontal pump was chosen to facilitate repairs or replacements of the pump. This pump should have a minimum 5-year design life and is sized at 325 gpm at 50-foot total head.

23. Methanation Tank - Thermophilic methane production was selected over mesophyllic production based on: intensive use of geothermal heat; smaller major equipment size; and higher yields.

Costs of tank construction were compared. The roof structure and cover of each methanation (or fermentation) tank will be of coated metal construction for minimum weight. The tank cylindrical side walls will be of reinforced concrete or of coated metal construction. The construction bid documents will allow these two competing bid alternatives to be received to determine which has the lowest total cost. The tank bottoms will be concrete sloped towards the fluid outlets. The tanks will be operated at 122-131°F inside design temperature and will have roof and wall insulation. (References 7, 47, 62, 63, 72, 88).

24. Methanation Heating - Alternatives for methane heating were: hot water coil in tank; hot water coil in tank wall; and heat exchange in the fermentation slurry line. (References 5*, 47, 63).

The selection of agitation method was a major impact in heating mode selection, as was existing practice.

25. Methane Slurry Agitation - The slurry must be agitated in order to promote the bacterial action that generates biogas. Methods considered were: recirculation by pump; mechnical stirring in the tank; and percolation of biogas up through the methanation tank from submerged piping headers which are supplied by a gas compressor unit. (References 7, 62, 63).

26. Methane Storage - Use of methane on site will require storage facilities. A compressor will be utilized to reduce storage tank size and cost.

27. Methane Water Usage - Alternatives considered were: recycling or not recycling. Agriscience criteria applications dictated excluding recycled water from the farrowing and nursery buildings.

28. Methane Gas Cleaning - Commercially available systems for removing hydrogen sulfide and carbon dioxide from the biogas were evaluated vis a vis end use of the methane.

29. Methane Use - The use of methane for electrical generation on site has been a programmatic goal for conceptual design.

30. Methane Backup System - The primary or continuous

electrical power will be supplied by the methane powered generator units, which are limited by the quantity of available methane. Additional project power supply alternatives considered were: propane based on-site generation and purchase of electricity from the local utility.

Only the critically needed pumping units will be operated during emergencies or power shortages. (For example, the heating systems must remain in operation in the farrowing and nursery buildings.) Two geothermal pumps are provided. One pump will be shut down during shortages.

31. Air Handling - Experience with swine houses indicates that all air should enter at the ceilings, have uniform distribution throughout the house, and use wall exhaust fans (negative pressure systems).

A primary air handling (positive pressure system) was considered as an alternative design. This system would have pressurized the pig houses and eliminated the wall exhaust fans, but was rejected due to the following:

- Balancing of the air flows to the various rooms and their resulting temperatures would be difficult.
- Air system redundancy could not be achieved (i.e., primary equipment failure could create an emergency).
- Pressurization of the building would cause migration of moisture into the cracks of the structure.

32. Humidity Control - Humidity control is required on this project only to the extent that water vapor is not to be condensed on the interior surfaces of the pig houses. Design was based on criteria applications previously discussed.

33. Cooling Method - Alternatives considered for swine house summer cooling were: evaporative cooling; spray cooling; geothermal absorption refrigeration; and domestic well water circulation. A key

factor in selection was that this area near Alturas has ideal climatological conditions for evaporative cooling systems due to the low ambient wet bulb temperatures that prevail.

34. Geothermal Backup System - Project programmatic decisions dictated that the geothermal heating system shall be supplied by two geothermal wells with either having the capacity for the emergency heat requirements of the complex. Failure of electrical power to critical areas or lack of flow from a geothermal well shall activate an alarm system. Manual controls shall be used to distribute the power to the critical areas of the heating systems in the event of an emergency.

35. Site Work - Conceptual design followed established engineering practice for site preparation with allowances for normal agricultural practice in currently existing swine facilities.

36. Lighting - Flourescent and incandescent lighting were compared on capital and operating cost bases. Emergency lighting will be battery powered.

37. Wiring - Flexible metallic sheathed cable was compared to wiring in rigid conduit.

38. Power System - Power system requirements were based on: total load; largest loads; industrial systems standards, and utility preference. All requirements dictated 480 volts, 3-phase, 60 Hz for distribution.

39. Engine Generators - Methane powered internal combustion generators were selected based on existing practices.

40. Transformers - Costs were compared for purchased versus utility provided transformers.

41. Hazardous Electrical Areas - Hazardous area equipment will be required for the methane and grain handling areas.

42. Outside Wiring - Overhead wiring was compared to buried cable for 480 volt power on the basis of cost and ease of operation.

TABLE 4-5

AGRISCIENCE CONCEPTUAL DESIGN OPTIONS SELECTED

Paragraph	Trade Study	Design Option Selected	Key Selection Factors
III. A.2.	Gutter Type	flush gutter under slats	health, sanitation, cost
III. A.3.	Slat Material	aligned fiber composites	commercial, sanitation, durability, cost
III. A.4.	Aquaculture	not selected	programmatic
III. A.5.	Feed Source	mill on site	cost
III. A.6.	Growth of Feed Sprouts	not selected	programmatic
III. A.7.	Feed Contents	existing non-proprietary formulations	commercial practice
III. A.8	Alcohol Production Byproduct Use	not selected	unavailable
III. A.9.	Protein Extraction	not selected	no commercial demonstration
III. A.10.	Finish Hog Weight	228 pounds	current practice and facilities
III. A.11.	Water Disposal	field irrigation	environmental, conservation, cost

TABLE 4-6 SHEET 1 OF 2

CIVIL, ELECTRICAL, AND MECHANICAL CONCEPTUAL DESIGN OPTIONS SELECTED

Paragraph	Trade Study	Design Option Selected	Key Selection Factors
III.B.2.	Building Type	pre-engineered metal with steel panels	cost
III.B.3.	Insulation Type	loose fill cellulose, fireproofed	cost, building type
III.B.4.	Insulation Thickness	7-1/2" in walls, 8" in ceilings	R factor, building type, insulation type
III.B.5.	Floor Type	brush and smooth finish concrete	agriscience criteria applications
III.B.6.	Gutters	flat cross section, sloped	efficiency, cost, ease of construction, sanitation and maintenance
III.B.7.	Swine Effluent Ponding	matched cut and fill, film sheet liners	normal practice, cost
III.B.8.	Swine Waste Solids Separation	mechanical separator	cost, ease of operation
III.B.9.	Manure Transport	flush with recycled water	agriscience criteria, cost, conservation
III.B.10	Human Wastes Disposal	septic tank and leach field	cost, local practice
III.B.11.	Pig Carcass Disposal	gas fired incinerator	health, efficiency
III.B.12.	Floor Heating	black steel pipe in concrete	agriscience criteria, thermal design
III.B.13.	Space Heating	fin tube in supply air plenum	cost, compatability
III.B.14.	Wall Heating	not selected	cost
III.B.15.	Exhaust Air Heat Recovery	not selected	cost, "essentially unlimited" heat supply
III.B.16.	Cascade Heating System	space heating, floor heating, methanation	cost, thermal requirements
III.B.17.	Type of Geothermal Piping	uninsulated asbestos cement	cost, experience
III.B.18.	Thermal Storage	not selected	cost
III.B.19.	Primary Heat Exchanger	stainless steel plate type	cost, ease of maintenance
III.B.20.	Deicing of Sidewalks	rock salt	cost
III.B.21.	Geothermal Supply Pump	vertical turbine	engineering experience

TABLE 4-6 SHEET 2 OF 2

CIVIL, ELECTRICAL, AND MECHANICAL CONCEPTUAL DESIGN OPTIONS SELECTED

Paragraph	Trade Study	Design Option Selected	Key Selection Factors
III.B.22.	Geothermal Reinjection Pump	split case horizontal centrifugal	ease of repair and replacement
III.B.23.	Methanation Tank	metal roof, concrete base, metal or concrete walls	cost, design factors
III.B.24.	Methanation Heating	recirculation through heat exchanger	agitation method, existing practice, cost
III.B.25.	Methane Slurry Agitation	recirculation	existing practice, cost
III.B.26.	Methane Storage	steel tank with compressor	cost, end use
III.B.27.	Methane Water Usage	recycling except farrowing and nursery	cost, conservation, agriscience criteria
III.B.28.	Methane Gas Cleaning	compressor aftercooler condensing	cost, end use
III.B.29.	Methane Use	internal combustion engine generators	programmatic goal, existing practice
III.B.30.	Methane Backup system	purchase of electricity	cost, reliability
III.B.31.	Air Handling	ceiling entrance, exhaust fans	agriscience criteria application
III.B.32.	Humidity Control	air changes	cost
III.B.33.	Cooling Method	evaporative	cost, suitability, practice
III.B.34.	Geothermal Backup System	electrical with manual control, backup well and pump	cost, safety
III.B.35.	Site Work	normal agricultural practice	cost, suitability
III.B.36.	Lighting	fluorescent	cost, practice
III.B.37.	Wiring	flexible metallic sheathed cable	cost, agricultural practice
III.B.38.	Power System	480 volt, 3 phase, 60 Hz	loads, standards, utility preference
III.B.39.	Engine Generators	internal combustion	practice
III.B.40.	Transformers	utility provided	cost
III.B.41.	Hazardous Electrical Areas	methane and grain handling	safety
III.B.42.	Outside Wiring	buried	cost, ease of operation

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