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GEOTHERMAL SPACE HEATING PROJECT INVOLVING IDAHO STATE OWNED BUILDINGS IN BOISE, IDAHO

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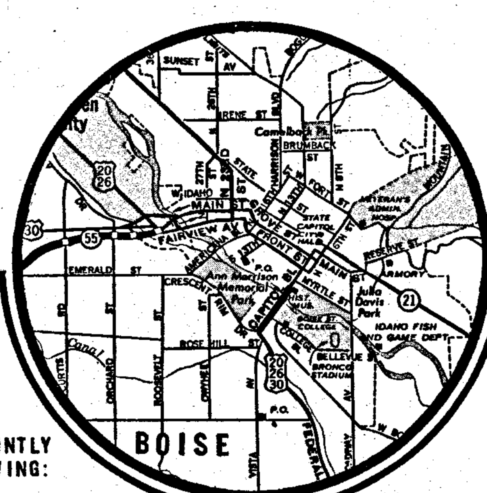
GEOTHERMAL SPACE HEATING PROJECT INVOLVING IDAHO STATE OWNED BUILDINGS IN BOISE, IDAHO

INTERIM REPORT, PREPARED MARCH 10, 1975

AEROJET NUCLEAR COMPANY



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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
IDAHO OPERATIONS OFFICE
UNDER CONTRACT NO. AT(10-1)-1375

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ABSTRACT

A pilot demonstration project to be located in the City of Boise, Idaho has been initiated to heat by geothermal water the Idaho State Capitol Building, several Idaho State Office Buildings, the Idaho Veteran's Home and portions of the Boise State University buildings. It is anticipated that this will be a joint Federal-State Project. The Federal effort is being directed toward the locating and developing of the resource as well as the feasibility and conceptual design studies. The State effort will encompass the final design and construction stages. This interim report was presented to the Resources and Environmental Committee of the Idaho State Senate to inform them of the current status of the project.

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The above project personnel are coordinating their research and development activity with:

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Idaho Department of Public Works	Max Boesiger, Commissioner Harry Stone, Assistant to Commissioner

Idaho State Capitol Building

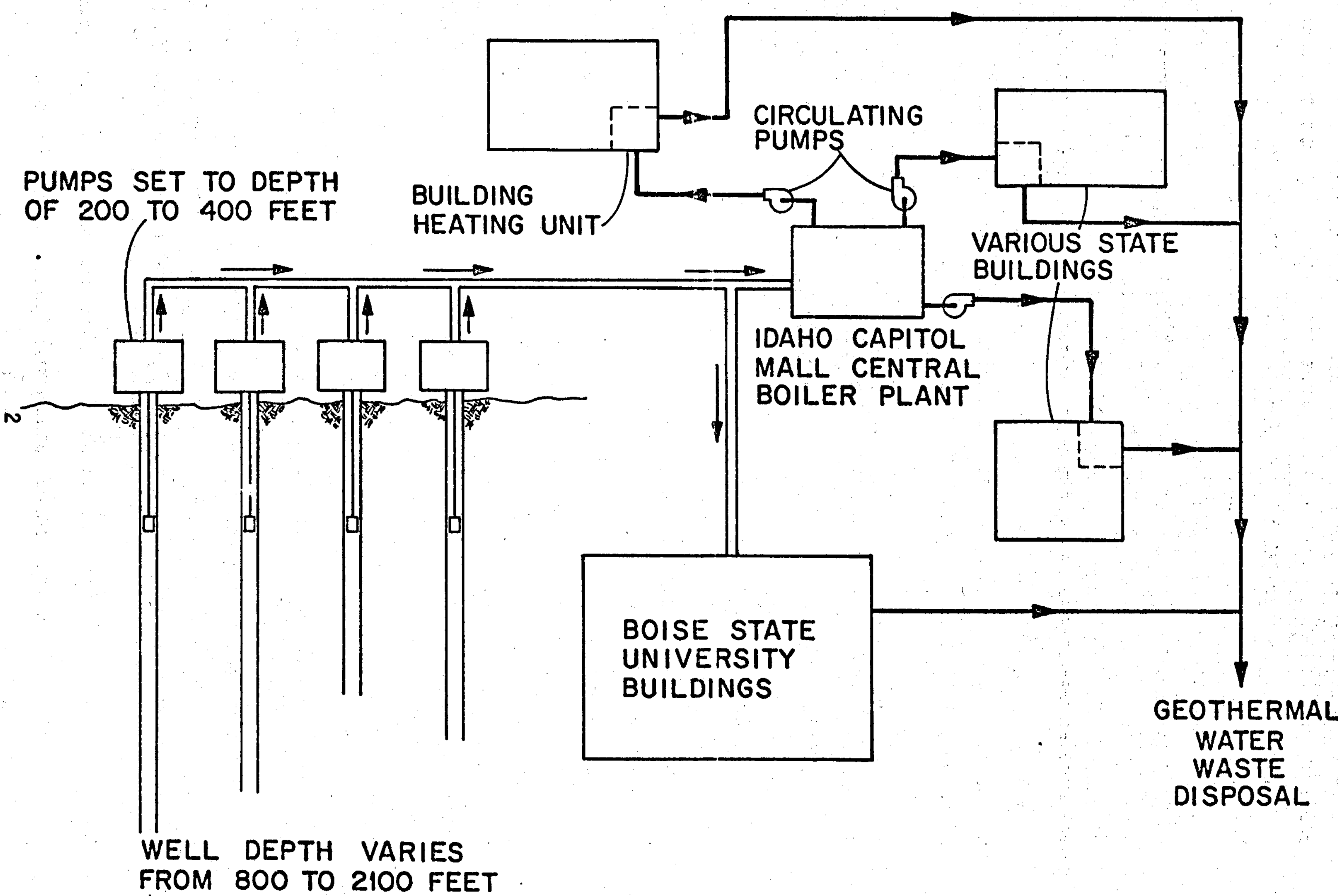
Geothermal waters of moderate temperature (<$200^{\circ}F$) have seen a few applications for space heating throughout the world. Perhaps the most significant is the capital city of Rekyjavik, Iceland where 85,000 people have virtually all of their space heat provided from hot water geothermal wells. In general, unless the hot water was already available, geothermal heating systems in this country have seldom been viewed as an economic alternative, at least until the 1973 oil embargo. It is believed that direct, deliberate efforts to employ such energy for space heating will lead to its eventual widespread use and a significant savings to the nation's fossil fuel budget. Several pilot demonstration programs are believed necessary before the systems receive general acceptance in community planning considerations throughout the West.

It is proposed that one such pilot demonstration project (such as depicted in Figure 1) be in the city of Boise, Idaho, where a joint federal-state effort could lead to the heating, by geothermal waters, the State Capitol, several state office buildings, the Veterans Home, and part of the buildings of Boise State University.

The downtown area and the adjacent capitol complex are situated within one mile of the Foothills Fault. As can be seen in Figure 2, many of the state buildings are located within 1/2 mile of reported thermal occurrences. (A well on the capitol grounds produces warm water.) At a slightly greater distance is the campus of Boise State University. The proposed project will deal specifically with the identification of the resource, testing of the resource, the conceptual design and construction of a distribution system, and the design of conversion of conventional heating systems in present buildings so that these can use geothermal water. The economic analysis of the design relative to operating costs of the current systems and the planned additions will determine if indeed the geothermal heating system is a viable alternative.

The geothermal resource at Boise is strategically located immediately adjacent to this capital site of about 120,000 residents. Growth of the region has been dynamic and the Ada County Council of Governments (ACOG)

Figure 1
CONCEPTUAL GEOTHERMAL SYSTEM



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BOISE, IDAHO, GEOTHERMAL SPACE HEATING PROJECT

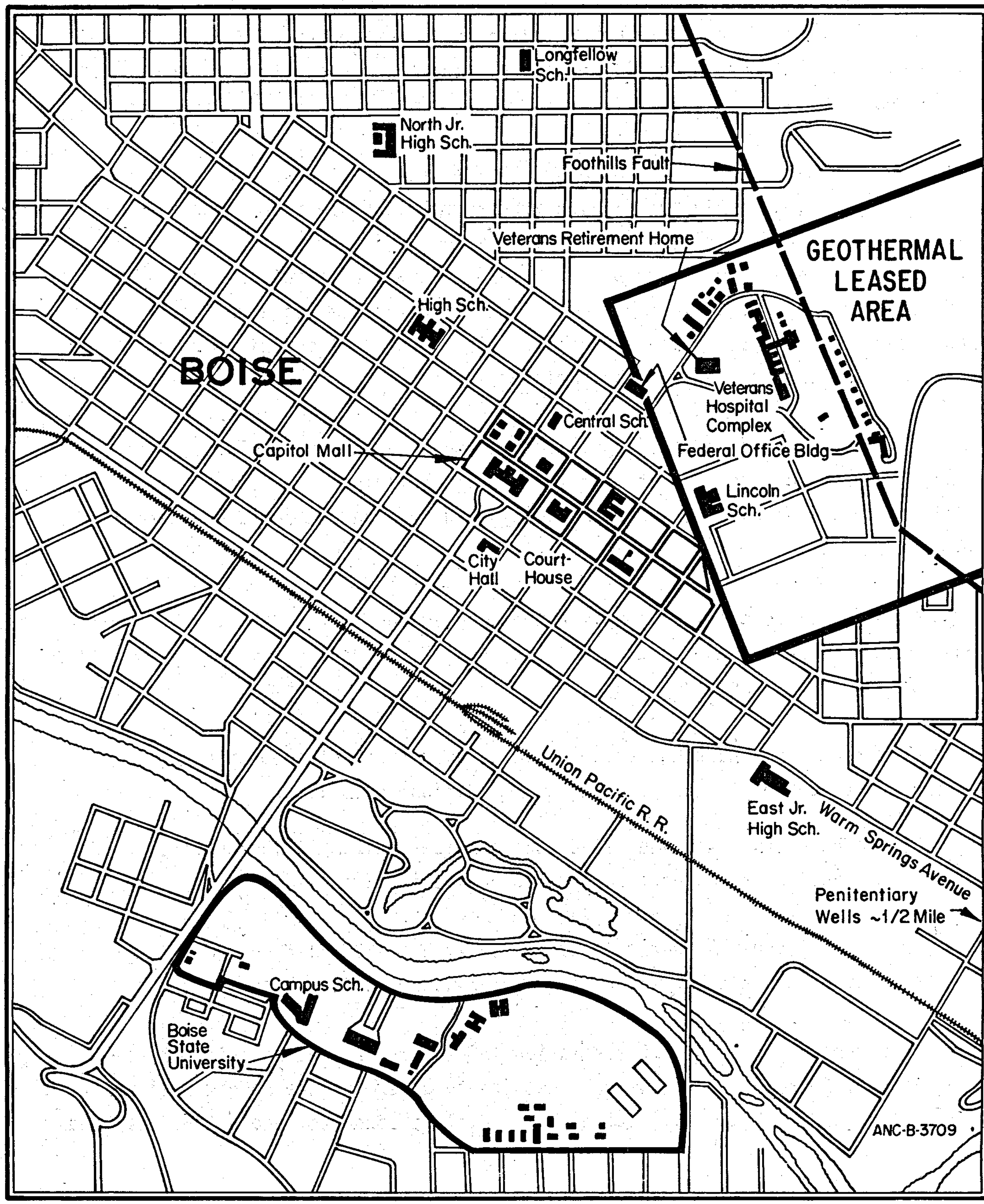

Figure 2. Boise, Idaho, Geothermal Space Heaters Project

has been instituted to meet the planning needs of the greater Boise area. An "urban renewal" project has been initiated in the center of Boise and land clearing has been accomplished but planned major reconstruction has only just started.

The state government operations in Boise are expected to undergo a continual growth, involving building improvements and additions approximately as outlined in the report prepared by CH_2M Engineers-Planners-Economists, Project No. B4998.0, March 1970. That report outlines phased additions spanning a 20 year period. In addition, Boise State University continues to undergo a rapid expansion. The addition of buildings to that present complex can therefore be anticipated.

Figure 3 summarizes the approximate design heating loads (1974), 9 years and 15 years from the present, for those state buildings and Boise State University buildings that should be considered for conversion to geothermal heating.

The annual fossil fuel cost for these buildings for both heat and domestic hot water is approximately $225,000 based on 1975 natural gas costs. The latter is estimated as 1/4 of this total.

The geothermal heating system would be used to supply domestic hot water provided one of the following two conditions exist:

1. The geothermal water is potable, below maximum solids content specifications of 1000 ppm (65 grains of hardness).

or

2. The geothermal water is sufficiently hot (200^{o}F) to provide the domestic hot water via a water-water heat exchange system.

For the purposes of cost estimation for this proposed project, a heating load of 60 x 10^6 Btu/hr will be assumed to determine the needed well water production, while the distribution system will be sized to handle the 1990 load

Figure 3

PREDICTED DESIGN HEATING REQUIREMENTS

	DESIGN HEATING REQUIREMENTS (Btu/hr)		
	PRESENT	1984	1990
STATE OFFICE BUILDING COMPLEX	30×10^6	40×10^6	54×10^6
BOISE STATE UNIV. COMPLEX (forced air system only)	25×10^6	40×10^6	60×10^6
TOTAL	55×10^6	80×10^6	114×10^6

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of 114 x 10^6 Btu/hr. The former figure will require 1,200,000 lb/hr (2500 gpm) of water from which a 50°F drop in temperature will be extracted. This assumes the water is delivered at 180°F or above. The 1990 load value will require nearly twice this flow. Heat loss in transmission from the wells to the buildings will be negligible, if appropriately insulated piping is used.

The well requirements to achieve these flows are difficult to predict. The reported artesian flow from the present penitentiary wells (400 ft deep, 170°F) is the order of 200 to 250 gpm. Elsewhere, (in Iceland and Mexico, and more recently at Raft River) deeper wells, 3000 to 5000 ft deep, at higher reservoir temperatures (approximately 300 to 400°F) are delivering 1500 to 2000 gpm from a single well. For purposes of estimation, 500 gpm from a depth of 2100 ft will be assumed. Thus, five wells would be needed for present loads, twice this number for 1990 projections.

Piping to carry 5500 gpm (8 ft^3/sec) should be about 16 in. I.D. pipe, giving a water velocity of 10 ft/sec. Pressure drop over 2 miles will be approximately 40 psi, and pumping power will be approximately 90 hp, or 65 kW, using about $1/hour of electricity at present rates.

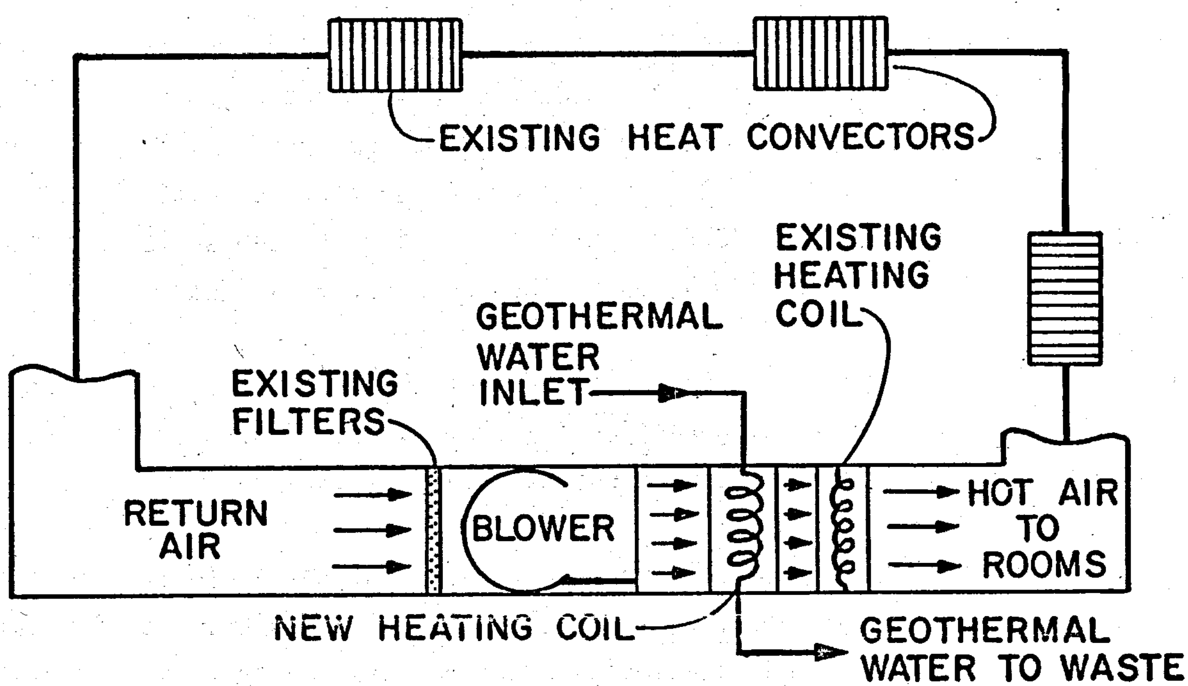
Heat transfer to the buildings can generally be accomplished without major modifications. Many buildings now have forced air heating operating from steam tube heat exchangers. The addition of large-tube hot water heat exchangers will accommodate the geothermal system, perhaps also utilizing the existing heat exchangers to carry the geothermal water as well. Figure 4 indicates possible ways of introducing geothermal heat into existing heating systems. Installations will be made in such a manner that the current fossil fuel based systems will be operable and available for use as booster or back-up systems as needed.

The primary objective of this project is the construction of a demonstration geothermal space-heating system serving state owned buildings in Boise, Idaho. Referring again to Figure 2, the proximity of these public

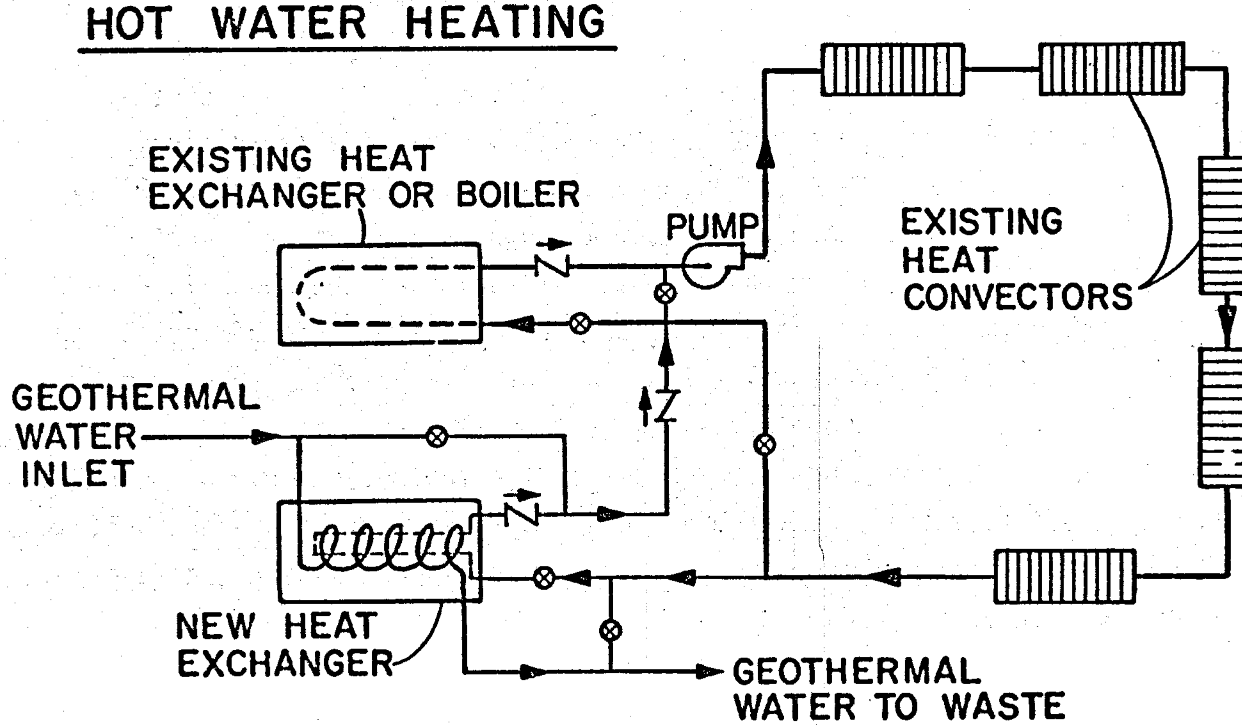
Figure 4

CONVERSIONS REQUIRED FOR BUILDING HEATING SYSTEMS

FORCED AIR HEATING



HOT WATER HEATING



buildings to a major, low-temperature geothermal system provides an ideal setting for research on all aspects of this use of the geothermal resource. The results of the research and development should, if successful, stimulate similar projects by commercial interests in likely geothermal areas throughout the nation.

Geothermal space heating has been attempted on a modest scale at only two United States localities, the oldest of which is the geothermal heating system in Boise, which has served the Warm Springs residential area since 1890. This system, which at present is utilized for the heating of about 120 homes with water at 170°F pumped from two 400-ft deep wells. At one time this system served 400 homes and business establishments.

The space heating demonstration project which we are proposing is independent of the existing residential system, but a cooperative working relationship with the citizens group has been established.

This project will involve an investigation of the geologic, engineering, economic, and environmental factors relevant to the replacement of fossil fuel-based hot water and low-temperature steam heating systems in various state owned buildings with geothermal energy. As mentioned earlier, these facilities consume approximately $225,000 of fossil fuel/year (typical 1975 prices).

Detailed conceptual design has only recently commenced, and hence a reliable engineering cost estimate is not available as of this writing. However, using the recent well drilling experience at the Raft River Valley as a guide, plus present materials costs, a rough estimate of the cost of construction the system can be made. The cost estimates are shown in Figure 5. Represented in two parts, the first column shows the costs of installing geothermal heat for the present hot water or hot air systems. The second shows the additional costs of installing geothermal heat instead of gas-fired steam boilers in the buildings to be built in the future. As can be seen from Figure 5, the anticipated total project cost is to supply the present buildings is about $2 to $2-1/2 million. Compared to the fuel cost savings, a favorable amortization period is predicted.

Figure 5

MAJOR COST - BREAKDOWN ESTIMATES*

	FOR PRESENT SYSTEM 2500 gpm REQUIRED (55×10^6 Btu/hr)		ADDITIONAL COST FOR 1990 SYSTEM 5500 gpm REQUIRED (add 60×10^6 Btu/hr)	
WELLS (800 TO 2100 FT DEPTH, 13" CASING)	(4 WELLS)	$300,000	(8 WELLS)	$400,000
HOT WATER DISTRIBUTION, 2 MILES, INSULATED AND BURIED	(10" PIPE)	300,000	(14" PIPE)	100,000
DISPOSAL LINE, 1 MILE, UNINSULATED BUT BURIED		100,000		40,000
DISPOSAL SYSTEM **		300,000		200,000
PUMPS	(6 PUMPS)	150,000	(11 PUMPS)	125,000
HEATING SYSTEM MODIFICATIONS ***		165,000		——
ADDITIONAL COSTS OF HEAT EXCHANGE CAPACITY IN NEW BUILDINGS, COMPARED TO A STEAM — FOSSIL FUELED SYSTEM		——		170,000
SUB - TOTAL		$ 1,315,000		$ 1,035,000
DESIGN AND CONSTRUCTION ENGINEERING (25%)		330,000		260,000
CONTINGENCY 25%		415,000		325,000
		$ 2,060,000		$ 1,620,000
APPROXIMATE ANNUAL FUEL BILL FOR CONVENTIONAL GAS SYSTEM		$ 225,000		$ 210,000 ****

* BASED ON 1975 DOLLARS, ROUGH ESTIMATES, WITHOUT ESCALATION FOR MONETARY INFLATION.

** ASSUMING WELL DISPOSAL IS REQUIRED, RIVER DISPOSAL SHOULD BE LESS EXPENSIVE.

*** ASSUMING ADDITIONAL HEAT-EXCHANGERS FOR HALF THE PRESENT CAPACITY, AT $6,000/ M Btu.

**** ASSUMES NEW BUILDINGS WOULD HAVE MORE EFFICIENT HEATING SYSTEMS.

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As the cost of fuel is expected to continue to rise significantly, the economic justification will become even stronger. In addition to this direct economic benefit, the proposed replacement of fossil fuel-based heating with geothermal space heating will effect a significant long-term conservation of fossil fuel which may be practical in many other localities.

Figure 6 lists the objectives of the proposed R&D effort.

The objectives of the demonstration project will be accomplished in four stages. Phase I will be a study of the feasibility of converting the state buildings and selected Boise State University buildings to geothermal heating. Phase II, which will proceed concurrently with Phase I, will be involved with geologic, geophysical, and geochemical investigations leading to site-selection of the geothermal wells. This phase of the work will include the initiation of the conceptual design and environmental analysis of the production, distribution, heating, and waste discharge systems. Phase III will be the drilling and testing of initial exploratory wells to confirm the distribution of the geothermal resource and subsequent production wells. This phase will include the completion of conceptual design of the system. Phase IV will proceed pending the successful results from the previous phases. It will represent the principal objective and expenditures centered on the drilling of additional wells as well as construction of the distribution and discharge systems and installation of the heat exchange systems in the various heating plants. It is proposed that much of this construction phase will be undertaken with non-federal funding (at least that portion which can be considered direct construction costs as opposed to research and development costs.)

Environmental investigations centered on the impact of geothermal exploration and development in the urban environment will begin during Phase II and continue throughout the duration of the project. Current status of the various activities and the agencies performing the work are shown in Figure 7.

Figure 6

OBJECTIVES OF THE BOISE SPACE HEATING PROJECT

- DETERMINE IF THE PROPOSED GEOTHERMAL RESOURCE AREA IS ADEQUATE
- DETERMINE THE COSTS AND PRACTICALITY OF RETROFITTING EXISTING HEATING SYSTEMS FOR USE WITH LOW TEMPERATURE (probability less than 200°F or 93°C) GEOTHERMAL WATER
- DESIGN THE DISTRIBUTION SYSTEM AND, IN PARTICULAR, THE GEOTHERMAL WASTE WATER DISCHARGE SYSTEM
- CONSTRUCT AND TEST THE PROPOSED SYSTEM TO DEMONSTRATE THE ACTUAL COSTS OF CONSTRUCTION AND OPERATION

Figure 7

CURRENT STATUS OF BOISE DEMONSTRATION SPACE HEATING PROJECT

PHASE	ACTIVITIES	BY WHOM	STATUS
I	FEASIBILITY STUDIES	IDAHO NATIONAL ENGR. LABORATORY	EVALUATION OF ALL PUBLIC BUILDINGS IN BOISE CURRENTLY UNDERWAY-- DETAILED STUDY OF STATE BUILDINGS START MAR 1,1975
II	GEOLOGIC MAPPING, GEOPHYSICAL AND GEOCHEMICAL STUDIES	BOISE STATE UNIV. AND IDAHO NATIONAL ENGR. LABORATORY	ASSEMBLING EQUIPMENT CONCENTRATED ACTIVITY TO START APRIL, 1975
II	EVALUATION OF EXISTING WELLS	IDAHO BUREAU OF MINES AND GEOLOGY	IN PROGRESS — WELL IN BASEMENT OF STATE CAPITOL BUILDING CURRENTLY UNDER EVAL.
II	SHALLOW WELL HYDROLOGY	IDAHO BUREAU OF MINES AND GEOLOGY	DRILLING WILL BEGIN IN MARCH

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Figure 7 (con't)

CURRENT STATUS OF BOISE DEMONSTRATION SPACE HEATING PROJECT (CONT'D)

PHASE	ACTIVITIES	BY WHOM	STATUS
II	MATERIALS OF CONSTRUCTION STUDIES	IDAHO NATIONAL ENGR. LABORATORY	SAMPLES FROM EXISTING SYSTEMS COLLECTED AND UNDER EVALUATION
II	CONCEPTUAL DESIGN	IDAHO NATIONAL ENGR. LABORATORY	WILL BE INITIATED IN MARCH
II	ENVIRONMENTAL ANALYSIS	IDAHO NATIONAL ENGR. LABORATORY	UNDERWAY
III	EXPLORATORY WELLS	IDAHO BUREAU OF MINES AND GEOLOGY	NOT STARTED
IV	FINAL DESIGN	STATE OF IDAHO	NOT STARTED
IV	CONSTRUCT SYSTEM	STATE OF IDAHO	NOT STARTED
IV	TEST AND OPERATE SYSTEM	STATE OF IDAHO AND IDAHO NATIONAL ENGR. LABORATORY	NOT STARTED

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Phase I

Preliminary studies have indicated that certain portions of the heating and ventilation systems of the various public buildings in Boise could be modified, with a minimum of alterations, for converstion to geothermal heating. Because of the variety of heating systems currently in existence in these buildings, a detailed feasibility study is necessary to determine which systems could most readily be converted and to appraise the economics of such conversion. Results of the preliminary feasibility study are as follows:

Buildings having steam convectors in each room do not readily lend themselves to geothermal heating without major modifications including piping and convector replacement and the installation of new fresh air supply systems. The new fresh air systems would be required such that air is not drawn directly over the hot water coil which could cause freeze problems during very cold months.

These systems presently return condensate at approximately 155°F. Little would be gained by attempting to utilize geothermal water at 170°F to preheat the condensate feed.

Buildings or facilities having steam systems include:

Idaho Capitol Mall Physical Plant
Marion Hall (Capitol Mall Grounds)
Boise State University Central Boiler Plant

Buildings having forced air systems could be directly converted to geothermal heating using a new hot water coil installed in the existing duct work. (See Figure 4) Modifications to existing systems to allow this installation vary in complexity with the worst situation requiring only considerable duct work rerouting.

The installation of these new coils would not replace existing steam systems but would augment or relieve the load on existing boilers and use the steam system as back-up.

Buildings having forced air heating systems which could be converted include:

Len B. Jordan State Office Building (Figure 8)
Idaho Supreme Court Building (Figure 9)
Idaho State Library and Archives
School of Business - Boise State University (Figure 10)
Library - Boise State University (Figure 11)
Liberal Arts - Boise State University (Figure 12)
Student Union - Boise State University

The Idaho State Capitol and the Idaho Veteran's Home buildings have hot water heating systems which could be directly converted to geothermal heating using a new heat exchanger installed in the existing systems. (See Figure 4) Such an installation would be a back-up to the existing steam heated hot water system presently installed.

Design of the new State Office Building, currently under construction, calls for a steam heated, forced circulation hot air system similar to the one in the Len B. Jordan Building. Conversion of this design to utilize geothermal heat should be initiated as soon as possible.

Phase II

The geological, hydrologic, and geophysical investigations necessary for optimum siting of the geothermal wells are being performed. Site selection for initial geophysical investigation are being made on the basis of previous geologic mapping, supplemented by additional field work, known geothermal occurrences along the Boise Front, the availability of land suitable for geophysical exploration and hydrologic data.

Data from existing wells situated within critical areas is being compiled and, as necessary, additional data will be collected through well testing. This data will be examined for evidence of geothermal contribution as indicated by water chemistry. Water quality and hydrologic data will also be utilized to establish a data base for comparison in the event of future geothermal production. Water quality is expected to be similar to that of the penitentiary well. Chemical analysis of this source is shown in Figure 13.

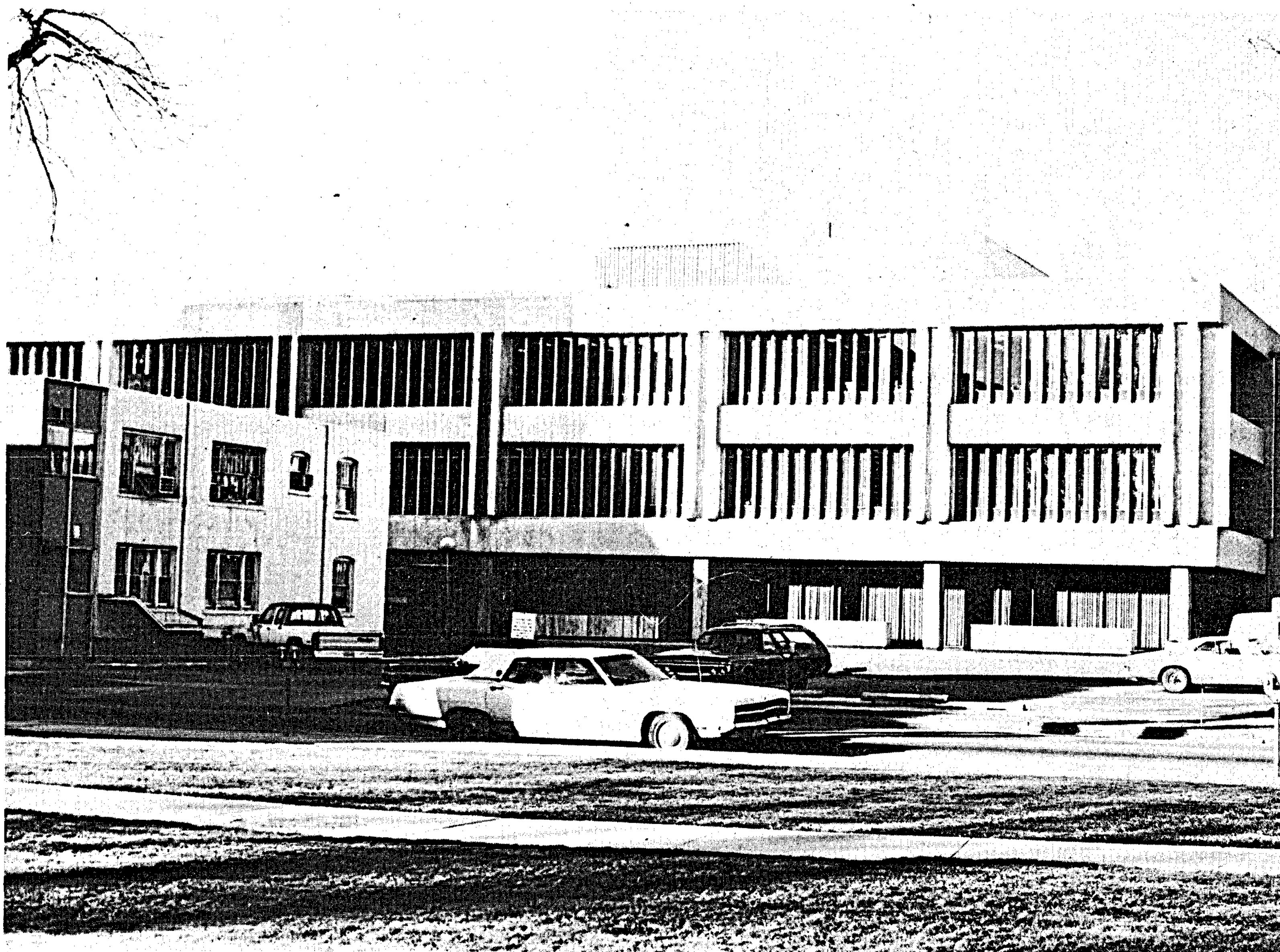


Figure 8 Len B. Jordan State Office Building

Fig. 9 Idaho State Supreme Court Building

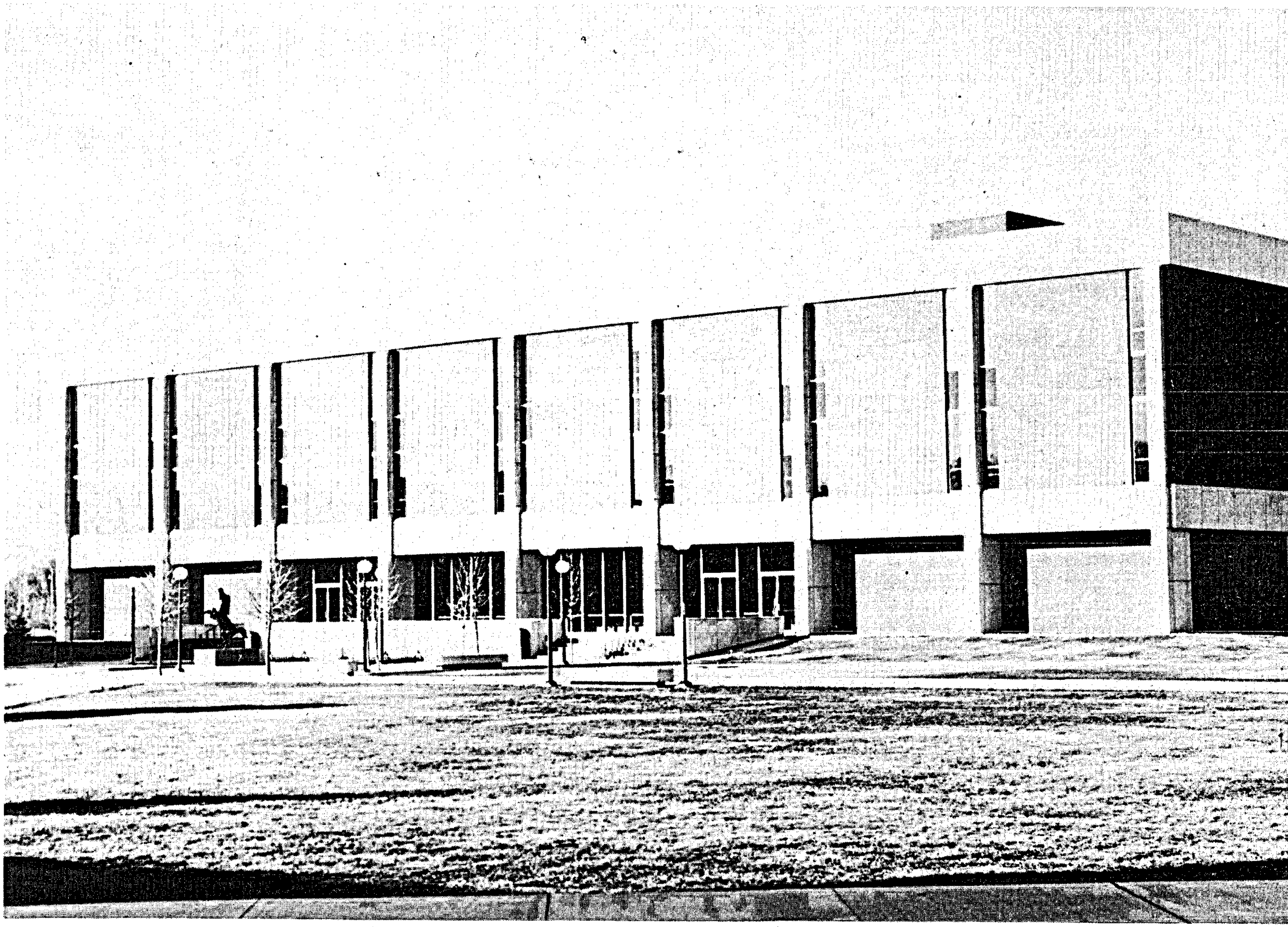


Figure 10 School of Business Building, Boise State University

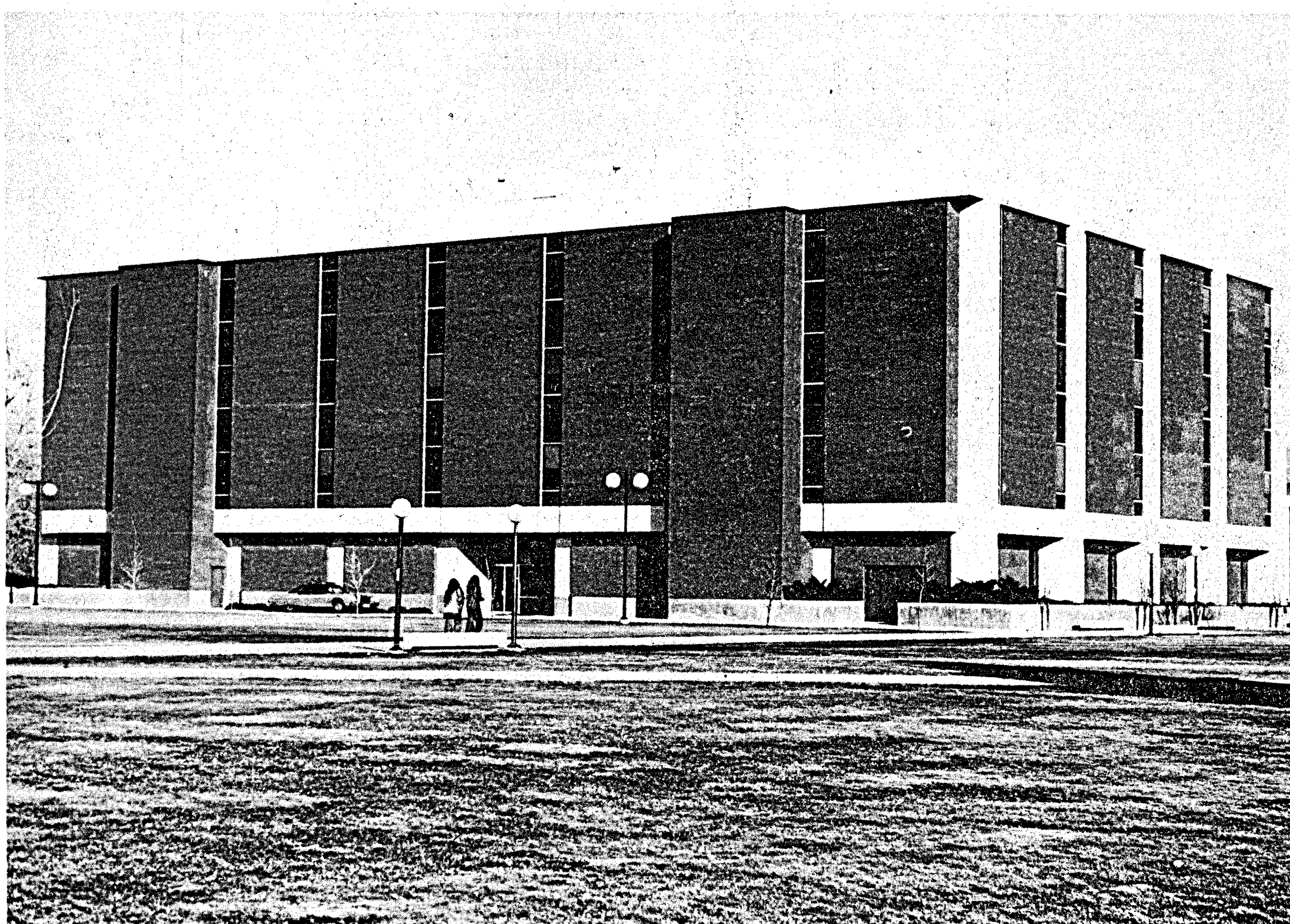


Figure 11   Library, Boise State University

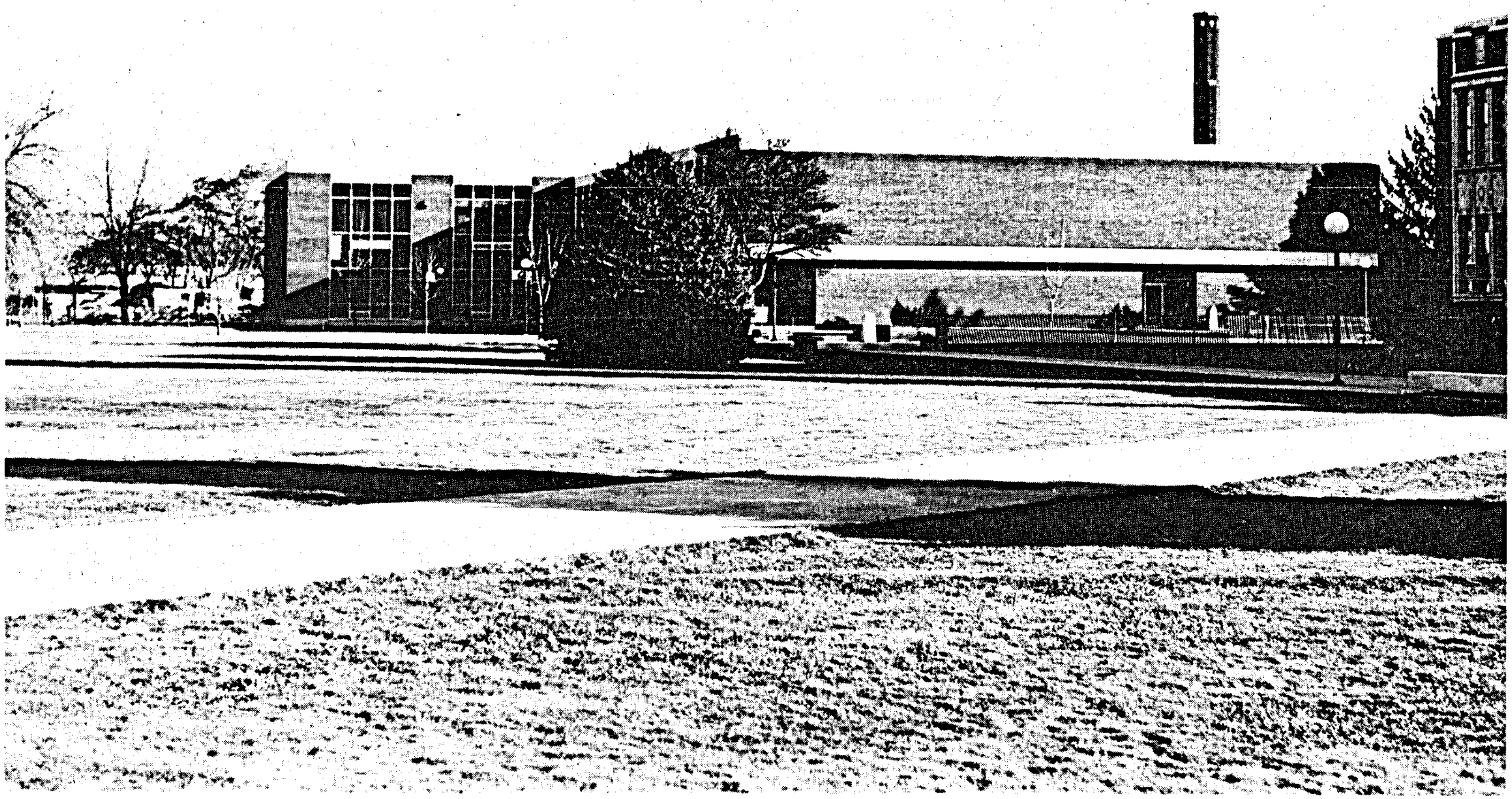


Figure 12   Liberal ARts Building, Boise State University

Figure 13

CHEMICAL ANALYSIS OF THERMAL WATER FROM PENITENTIARY WELL BOISE, IDAHO

	PPM
SiO_2	78
Ca	2
Mg	0
Na	75
K	1.3
HCO_3	141
CO_3	4
SO_4	23
P	0.01
Cl	9.3
F	24
NO_3	0.08

- DISSOLVED SOLIDS (calculated) 299
- SPECIFIC CONDUCTANCE 386
- T = 75°C
- ANALYSIS FROM YOUNG AND MITCHELL, 1973, p. 23
- WELL LOCATION SE 1/4 OF SW 1/4 SEC. 12, T3N, R2E

Refraction seismic profiling will be employed in order to locate more accurately the faulting and other structural features such as depth to granitic basement rock which will affect well placement. A mechanical energy source will be utilized for seismic surveys in this urban environment in order to minimize cultural effects. Electrical methods will be utilized in order to locate specific portions of the fault zone which appear to contain thermal fluids. Dipole-bipole resistivity mapping and Self Potential (SP) surveys will be conducted on portions of the fault zone known to bear thermal fluids and these results will be compared with data from other promising, but as yet undrilled portions of the Boise Front.

Considerable geological data, including a geologic map of the Boise Front, is available as a result of the investigations by Hollenbaugh (1973) for the Ada County Council of Governments. This geologic mapping will be supplemented by additional field work using false-color infrared photographic interpretation designed to aid in the geologic interpretation and selection of specific sites for detailed geophysical surveys. Engineering and environmental investigations have been initiated and will continue throughout the investigation. The environmental studies will monitor the effects of the geothermal program on the environment and provide guidance as to environmentally-sound courses of action. Preliminary engineering investigations will consider the efficiency and cost effective utilization of various heat transfer techniques including the use of hot water heating to heat exchangers for forced air systems. The engineering studies of the distribution system will begin as soon as the geologic investigations and tentative site selections are made.

<u>Phase III</u>

The dominant activity of Phase III will be the drilling of sites chosen during Phase II on the basis of geologic indications, geographic proximity to the areas to be served and availability of land for drilling. The drilling will be performed by persons experienced in geothermal operations. Drilling operations will be supervised by qualified Aerojet Nuclear Company personnel. The state geothermal drilling regulations will be followed for this drilling operation. A complete logging and testing program will be developed in order to derive the maximum from the drilling effort. Wells producing thermal fluids will be carefully monitored to guard against the uncontrolled release of these fluids. Water quality data and hydrologic tests will provide the data for firm planning of the construction phase. This phase will also see the completion of the conceptual engineering design of the system. The waste discharge system will be most critical to overall systems costs. Alternative methods of warm water disposal would be compared. Surface flow, after cooling, into the Boise River, infiltration through ponding in pre-existing gravel and sand pits near the Boise River, and reinjection will all be considered. Environmental aspects of geothermal fluid production in an urban area and warm water disposal will receive particular attention. Figure 14 is a sketch which indicates the various waste geothermal water disposal proposals. Relatively reliable cost estimates will be made, from which the deicision on cost effectiveness and overall feasibility can be made before becoming committed to Phase IV.

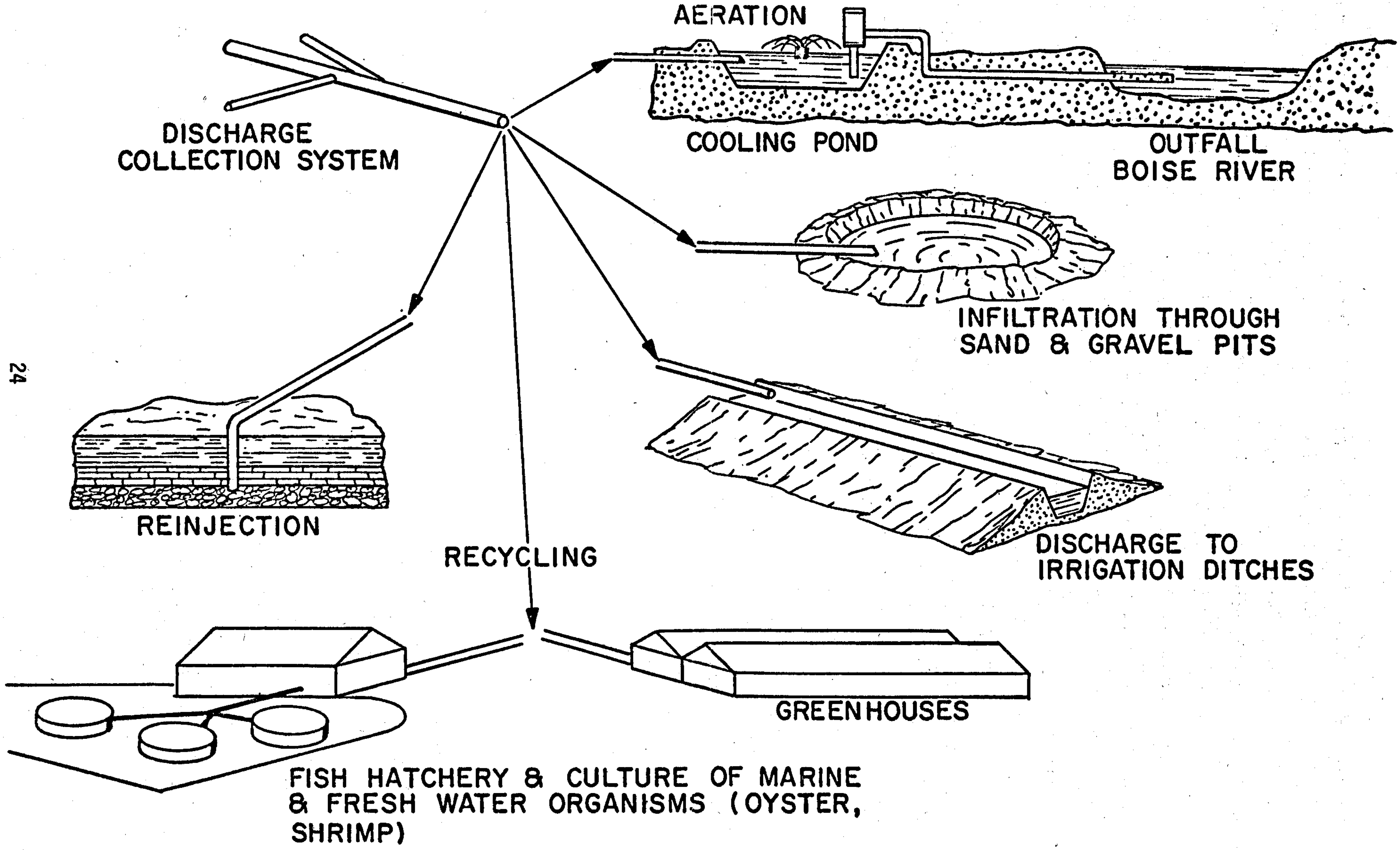
Phase IV

The fourth phase will be concerned with the construction of the distribution system capable of delivering up to 5500 gpm of thermal fluids near the boiling point to the various users in the Capitol area. Engineering investigations of comparative efficiencies utilizing various heat extraction processes will have been conducted, enabling final design of conversion modifications to be undertaken.

Alternative methods of warm water disposal will have been compared. Surface flow, after cooling, into the Boise River, infiltration through ponding into pre-existing gravel and sand pits near the Boise River, and reinjection into wells will all have been considered. Environmental aspects of geothermal fluid production in an urban area and warm water disposal will be particular important. Based on the previous work, the geothermal disposal system will be selected and constructed. The monitoring of surface elevation changes and microseismic activity will begin before actual long-term production from the geothermal wells and continue on a permanent basis. The effects of the geothermal production on both the shallow and deep ground water systems will be carefully observed.

Figure 14

DISPOSAL ALTERNATIVES



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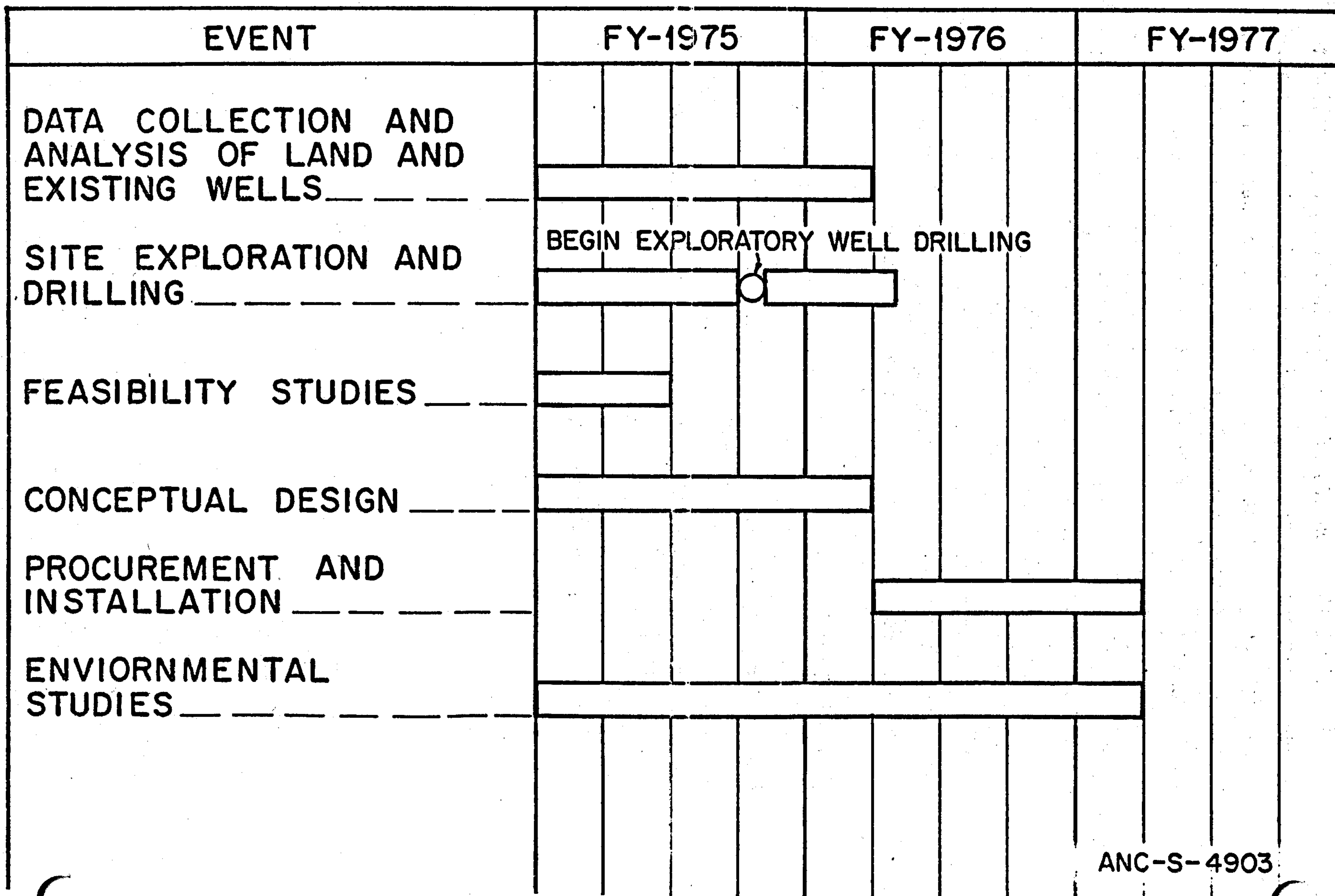
The first three phases of the work involving exploration for the resource, exploratory drilling to discover and verify its suitability, and conceptual design of heating system is an Energy Research and Development Administration funded research and development project. The work is being administered through the Idaho Operations Office of ERDA, to the Idaho National Engineering Laboratory (INEL) (prime contractor, Aerojet Nuclear Company.) INEL has subcontracted appropriate portions of the work to Boise State University and the Idaho Bureau of Mines and Geology. INEL will have principal management responsibility during Phase I, II, and III. At the completion of the first three phases, a complete summary report will be prepared, both to serve the purpose of an ERDA research and development report and to provide the State of Idaho with the necessary design and cost information from which it can proceed into Phase IV.

The actual construction and installation of the system, Phase IV, should logically be managed by the appropriate state agency, the Department of Public Works. Commercially available services should be used for this phase with assistance as appropriate from INEL. Once the system is installed and ready for operation, INEL personnel will participate with state personnel in the initial checkout and testing of the system. The system performance results will then be appended to the Phase I, II, and III report so as to provide a complete project record to be used as a reference when geothermal heating systems are to be designed elsewhere.

The schedule for completion of this project is shown in Figure 15.

Figure 15

SCHEDULE OF EVENTS



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